# 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 SLWRI action alternatives. 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 within the lake 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.[1] 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)*

The reach of the Sacramento River between Shasta Dam and Red Bluff has cool water temperatures because releases from Shasta and Keswick dams are regulated, and because the channel is stable and largely confined, with little meander. Riffle habitat with gravel substrates and deep pool habitats are more abundant than in 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 the regulated dam releases. The reaches of the Sacramento River immediately downstream from Shasta Dam support populations of resident rainbow trout and other resident fish while the reach immediately downstream from Keswick Dam supports an abundant resident rainbow trout population, other resident fish, and provides holding habitat, spawning habitat, and juvenile rearing habitat for Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*).

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

[1] Throughout this document, water year types are defined according to the Sacramento Valley Index Water Year Hydrologic Classification unless specified otherwise.

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. This gravel is derived mostly 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 (i.e., species that spawn in freshwater after migrating as adults from marine habitat). The Livingston Stone Hatchery, located immediately downstream from Shasta Dam produces winter-run Chinook salmon while the Coleman National Fish Hatchery, located on Battle Creek at tributary to the Sacramento River downstream from Keswick Dam, produces both Chinook salmon and steelhead. The reach of the Sacramento River downstream from Keswick Dam provides spawning and juvenile rearing habitat for winter-run, spring-run, fall-run, and late fall-run Chinook salmon and Central Valley steelhead. For this reason, the Sacramento River between Shasta Dam and Red Bluff is one of the most sensitive and important stream reaches in California.

Three water control structures – Keswick Dam, the Anderson-Cottonwood Irrigation District Dam, and Red Bluff Pumping Plant (RBPP) – are located along the Sacramento River in this reach. A new state-of-the-art positive barrier fish screen for the RBPP was completed in 2012. The fish screen allows the Red Bluff Diversion Dam gates to remain open most of the year to facilitate upstream and downstream passage by adult and juvenile Chinook salmon, steelhead, sturgeon, and other fish. A temperature control structure has been installed at Shasta Dam to improve cold-water pool management for salmonids spawning and rearing in the main stem river downstream from Keswick Dam. Instream flow regulation to meet habitat requirements and seasonal water temperatures for salmonids and other fish, flood control, and water supply deliveries are controlled primarily through managed releases of water from Shasta Dam that subsequently pass downstream through Keswick Dam into the main stem Sacramento River.

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 RBPP 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 River and Delta area are discussed separately because of differences in morphology, water temperature, and aquatic habitat functions.

**Sacramento River from Red Bluff 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 braided channels 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; the riparian corridor and oxbow lakes are still present in many locations. The channel remains active and has the potential to migrate during times of high water. Point bars, islands, high and low terraces, instream woody cover, growth of early successional riparian plants, and other evidence of river meander and erosion are common in this reach. The channel has varying widths, and aquatic habitats consist of shallow 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. Setback levees exist along portions of the river upstream from Colusa; however, the levees become much narrower along the river's edge as the river continues south to the Delta. Agricultural lands are located directly adjacent to the levees, which have cut the river off from most of its riparian corridor, especially on the east side of the river. Between Colusa and the Delta, Sacramento River levees are mostly lined with riprap, allowing the river no erodible substrate. Because the river is confined by levees, the trapezoidal channel width is fairly uniform (typically around 500 and 600 feet wide) and river bends are static. Depth profiles and substrate composition are fairly uniform throughout the reach, so aquatic habitats are fairly homogenous.

Several major flood control bypass facilities, including the Sutter and Yolo bypasses, are managed to provide flood protection for local municipalities and agricultural areas, and also provide important seasonal floodplain habitat that support juvenile salmonid rearing, habitat for Sacramento splittail (*Pogonichthys macrolepidotus*) spawning and larval rearing, and food production that passes downstream into the Sacramento River and Delta. Multiple water diversion structures move floodwaters into floodplain bypass areas during high-flow events. A large number of screened and unscreened agricultural irrigation diversions occur within the reach.

**Tributaries to the Lower Sacramento River** The lower reaches of primary tributaries to the lower Sacramento River are characterized here because of the potential for project effects on flows and associated flow-related effects on fish species of management concern. These potential flow changes, however, are minimized by upstream CVP and SWP reservoir operations and flow increases from tributary inflows and return flows from diversions and flood bypasses.

*Lower Feather River* Aquatic habitats found in the lower Feather River vary as the river flows from its release at the DWR Oroville Dam facilities down to the confluence with the Sacramento River at Verona. Included in the Oroville facilities are a low-flow channel and a high-flow channel. Under the Federal Energy Regulatory Commission license, DWR maintains an approximate 8-mile low-flow channel at 700 to 800 cfs. The low-flow channel at the upper extent of the lower Feather River contains mainly riffles and runs, which provide spawning habitat for the majority of Chinook salmon and steelhead. Also present in the low-flow channel is a series of remnant gravel pit pools/ponds that connect to the main channel.

This stretch of the Feather River is mostly confined by levees as it flows through the city of Oroville. Instream flows and water temperature management in the low-flow section of the river are managed by releases from Oroville Dam in compliance with the Federal Energy Regulatory Commission (Project 2100) requirements, and NMFS biological opinion (BO), and other regulatory requirements. From the downstream end of the low-flow channel, the river is fairly active and meanders its way south to Marysville. However, the high flow channel is bordered by active farmland, which confines the river to an incised channel in certain stretches. Some areas of adjacent farmlands have been restored to floodplain habitat with the construction of setback levee. The high flow channel that extends downstream to the Sacramento River also provides habitat for a variety of resident and migratory fish, as well as a migratory corridor, on the lower Feather River. The Feather River also supports wetland habitat for resident fish and wildlife. The Feather River Fish Hatchery, located immediately downstream from Oroville Dam, produces fall-run and spring-run Chinook salmon and steelhead.

*Lower American River* Flows in the lower American River (below Folsom and Nimbus dams) provide habitat for anadromous and resident fish species. The lower American River supports spawning and juvenile rearing by fall-run Chinook salmon and steelhead (although oversummering water temperatures limit juvenile steelhead rearing habitat) as well as a variety of resident fish and migratory fish, including American shad (*Alosa sapidissima*). The river is fairly low gradient and is composed of riffle, run, glide, and pool habitats. Folsom and Nimbus Dams, as well as a number of impoundments located further upstream in 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. Instream flows in the lower American River are managed by Reclamation through operations of Folsom and Nimbus Dams to provide instream flows for fishery habitat, maintenance of stream temperatures, flood control, and downstream water supplies and water quality management in the Delta.

Hatcheries located on the lower American River produce fall-run Chinook salmon, steelhead, and resident trout. Most 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 the geologic composition has allowed the river to incise deep into sediments, leaving tall cliffs and bluffs adjacent to the river.

**Sacramento River Floodplain Bypasses** There are three major floodplain bypasses – the Butte Basin, Sutter Bypass, and Yolo Bypass – along the main stem Sacramento River. These bypasses operate with a total of 10 overflow structures (6 weirs, 3 flood relief structures, and an emergency overflow roadway) primarily to provide flood control and secondarily to provide access to broad, inundated floodplain habitat for salmon rearing and splittail spawning during wet years. In high-flow periods, the stage of the Sacramento River is elevated and water flows over the weirs into the bypasses. Although the bypasses serve as important seasonal habitat for juvenile salmonid rearing and splittail spawning, an alternative migration pathway, and for the production and transport of organic matter downstream into the river and Delta, the bypasses are primarily operated and managed for flood control during the winter and for agricultural production during the spring and summer.

Unlike other Sacramento River and Delta habitats, floodplains and floodplain bypasses are dewatered seasonally as high flows recede between late spring and 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, such as Sacramento splittail, are adapted to spawn and rear in winter and early spring (Moyle 2002) during the winter flood pulse. Introduced fish typically spawn between late spring and summer, when most 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 that conveys 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 (when the stage exceeds 45.5 feet), Sacramento River water enters the bypass through the Butte Slough outfall and the Tisdale Weir 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 approximately 59,000-acre land area that conveys Sacramento River floodwaters around Sacramento during times of high runoff. Sacramento River flow is diverted into the bypass when the river stage exceeds 33.5 feet (corresponding to 56,000 cfs at Verona). Diversion of most floodwaters from the Sacramento River, Sutter Bypass, and Feather River into 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. The Yolo Bypass subsequently drains back into the Sacramento River in the vicinity of Cache Slough, which is located just upstream from Rio Vista. Cache Slough and the adjacent Sacramento Deep Water Ship Channel have been found to provide habitat year-round for delta smelt (*Hypomesus transpacificus*) as well as other fish. Efforts are currently underway to enhance aquatic habitat for juvenile salmonids, delta smelt, and other fish in the Yolo Bypass/Cache Slough complex.

**Sacramento Deep Water Ship Channel** The Sacramento Deep Water Ship Channel is a tidally influenced canal that is about 30 feet deep, 200 feet wide, and 43 miles long. It flows from the Port of Sacramento into the Sacramento River, which flows into San Francisco Bay. The channel was completed in 1969 and is primarily used to transport agricultural products. Due to manipulations to the channel, such as dredging, it tends to have low dissolved oxygen (DO) concentrations. Delta smelt spawn in and around the Sacramento Deep Water Ship Channel, and juvenile delta smelt are found in the channel (Baxter 2010).

**Lower San Joaquin and Stanislaus Rivers** The lower San Joaquin River is characterized by a relatively wide (approximately 300-foot) 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. The Stanislaus River provides habitat for fall-run Chinook salmon spawning and juvenile rearing as well as a small population of resident trout and steelhead. Instream flows on the river are managed by Reclamation through releases from New Melones Reservoir for fishery habitat, water temperature management, flood control, and water supplies. 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) that make little to no use of areas in the upper segment of the river (see the 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. There is no fish hatchery located on the Stanislaus River although salmonids produced in hatcheries on other rivers (e.g., Merced River Fish Hatchery) have periodically been released into the Stanislaus River.

Water temperature and flows in both the lower San Joaquin and Stanislaus river systems are highly altered and are managed for flood control and water supply purposes.

**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. The Delta's channels are used to transport water from upstream reservoirs to the south Delta, where Federal and State export 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 low salinity zone (LSZ), 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. The location of the LSZ in the estuary is typically denoted as the distance in kilometers upstream from the Golden Gate Bridge where the 2-practical-salinity-unit bottom salinity isohaline is located which is commonly referred to as the X2 location. The location of X2 is downstream in the Suisun Bay area (e.g., adjacent to Chipps or Roe Islands) when Delta outflow is relatively high and further upstream in the lower Sacramento and San Joaquin Rivers (e.g., Collinsville) when Delta outflow is reduced (Kimmerer 2004, Cloern and Jassby 2012). The location of X2 during the late winter and spring is managed in accordance with provisions of State Water Board Water Right Decision 1641 (D-1641). 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 Delta (Bay-Delta). Over the past several decades, the volume of the Bay-Delta's freshwater supply and Delta outflow from the estuary 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 (Kimmerer 2004).

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 (State Water Board 2012). 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 late winter and spring (e.g., February to 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 (*Spirinchus thaleichthys*), splittail, and others (Stevens and Miller 1983, Stevens et al. 1985, Herbold 1994, Meng and Moyle 1995, Rosenfield 2010, Rosenfield and Baxter 2007, MacNally et al. 2010, Thomson et al. 2010).

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 has been correlated to changes in the abundance and distribution of fish, such as green sturgeon and longfin smelt, and invertebrates in the bay through changes to salinity, currents, nutrient levels, and pollutant concentrations (Thomson et al. 2010, Mac Nally et al. 2010, Kimmerer 2002, Rosenfield and Baxter 2007, Rosenfield 2010). Delta smelt is a key species driving many of the ongoing water management decisions in the Delta (USFWS 2008).

**Trinity River** Sacramento River flow is augmented in average water years by the 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 areas 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 | CDFW | USFS | MSCS Goals | | |
| River lamprey *Lampetra ayresi* | | SSC | | | Anadromous species that spends relatively little time in the ocean. Spawns in freshwater gravel substrates from February through May. | Occurs in the extended study areas in the Delta and Sacramento River and tributaries. |
| Pacific lamprey *Entosphenus tridentatus* | | | S | | Anadromous species that spends 1-3 years in the ocean. Spawns in freshwater gravel substrates from March through July. | Occurs in portions of the primary study area in the Sacramento River below Keswick Dam and throughout the extended study area, including the Delta and major tributaries. |
| 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 Delta. |
| Central California Coast steelhead *Oncorhynchus mykiss* | T | | | | 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 lower Delta, Suisun Bay, and San Francisco Bay. |

**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 | CDFW | USFS | MSCS Goals | | |
| 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. |
| 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. |

**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 | CDFW | USFS | MSCS Goals | | |
| Delta smelt *Hypomesus transpacificus* | T | E | | R | Spawns in tidally influenced freshwater wetlands and seasonally submerged uplands; rears in tidal marsh and Delta. | Occurs in the extended study area in the lower Sacramento River and the Delta. |
| Longfin smelt *Spirinchus thaleichthys* | P | 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. |
| Sacramento splittail *Pogonichthys macrolepidotus* | DT | SSC | | R | Spawning and juvenile rearing occur from winter to early summer in shallow 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 areas in the Delta and Sacramento River, tributaries, and the Delta. |
| 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 shallow 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. |

**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 | CDFW | USFS | MSCS Goals | | |
| Rough sculpin *Cottus asperrimus* | | FP | | | 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, and tributaries. | Occurs in Shasta Lake, Keswick Reservoir, tributaries, and lakes. |
| Redband trout *Oncorhynchus mykiss stonei* | | | S | | Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, and 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, and tributaries. | Previously found in the McCloud River. Now considered extirpated from California. |
| California floater *Anodonta californiensis* | | | S | | Potentially occurs in shallow areas of clean, clear ponds, lakes and rivers with sandy and silty substrate. | Potentially occurs in Shasta Lake, Keswick Reservoir, and tributaries. |
| Kneecap lanx *Lanx patelloides* | | | S | | Potentially occurs in shallow areas of ponds, lakes, and rivers with sandy and silty substrate. | Potentially occurs in Shasta Lake, Keswick Reservoir, and tributaries. |
| Nugget pebblesnail *Fluminicola seminalis* | | | M | | Potentially occurs 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. |

**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 | CDFW | USFS | MSCS Goals | | |
| Potem pebblesnail *Fluminicola* sp. 14 | | | M | | Potentially occurs 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 occurs 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. |
| Shasta pebblesnail *Fluminicola* sp. 16 | | | M | | Potentially occurs 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 occurs 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 occurs 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 occurs 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. |
| Black Juga *Juga nigrina* | | | S | | Potentially occurs 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. |

**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 | CDFW | USFS | MSCS Goals | | |
| Canary duskysnail *Lyogyrus* sp. 3 | | | M | | Potentially occurs 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. |
| Knobby rams-horn *Vorticefex* sp. 1 | | | M | | Potentially occurs 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 Delisted from threatened status
- E Endangered (legally protected)
- T Threatened (legally protected)
- P Proposed for Federal Listing

State Listing Categories (CDFW)
- E Endangered (legally protected)
- SSC Species of Special Concern
- T Threatened (legally protected)
- FP Fully Protected

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

Multi-Species Conservation Strategy (MSCS) 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 2000a).

Key:
Delta = Sacramento-San Joaquin Delta
CDFW = California Department of Fish and Wildlife
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 11-2. 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 RBPP |
| 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 | *Entosphenus tridentata* | | | X |
| Western brook lamprey | *Lampetra richardsoni* | | | X |
| Sacramento sucker | *Catostomus occidentalis* | X | X | X |
| Sacramento pikeminnow | *Ptychocheilus grandis* | X | X | X |
| Sacramento splittail | *Pogonichthys macrolepidotus* | | | X |
| Hardhead | *Mylopharodon conocephalus* | X | X | X |
| Sacramento blackfish | *Orthodon microlepidotus* | X | X | |
| California roach | *Lavinia symmetricus* | X | | X |
| Speckled dace | *Rhinichthys osculus* | X | X | |
| Golden shiner | *Notemigonus crysoleucas* | X | 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 | X | X |
| Rough sculpin | *Cottus asperrimus* | X | | |
| Pit sculpin | *Cottus pitensus* | X | | |
| Bigeye marbled sculpin | *Cottus klamathensis macrops* | X | | |
| Largemouth bass | *Micropterus salmoides* | | X | X |
| Smallmouth bass | *Micropterus dolomieui* | X | X | X |
| Spotted bass | *Micropterus punctulatus* | X | X | X |
| Black crappie | *Pomoxis nigromaculatus* | | X | X |
| White crappie | *Pomoxis annulauris* | | X | X |
| Bluegill sunfish | *Lepomis macrochirus* | | X | X |
| Green sunfish | *Lepomis cyanellus* | X | X | X |
| Threadfin shad | *Dorosoma petenense* | | X | |
| Tule perch | *Hysterocarpus traski* | X | X | X |
| Tui chub | *Siphateles bicolor* | X | X | |

*Sources: Moyle 2002; Reclamation 2004; Reclamation 2014*
Key:
RBPP = Red Bluff Pumping Plant

**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 (*Salmo trutta*), and landlocked Chinook salmon may be found rearing throughout the lake; these species do not spawn in the lake, preferring to spawn in tributary streams though few Chinook salmon stocked in Shasta Lake have ever been observed to spawn in the reservoir tributaries (Zustak 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 (*Acipenser medirostris* and *A. transmontanus*), hardhead (*Mylopharodon conocephalus)*, riffle sculpin (*Cottus gulosus*), Sacramento sucker (*Catostomus occidentalis*), and Sacramento pikeminnow (*Ptychocheilus grandis*) 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 Sacramento River (upstream from Shasta Lake), 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 (*Oncorhynchus mykiss*) and about 50,000 subcatchable Chinook salmon are planted annually (Baumgartner 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 and downstream instream flow releases, water quality requirements, and inflow. WSEL can change within and among years based on hydrology within the watershed, 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 increases in surface area and aquatic habitat results in a greater total biomass and a greater abundance of plankton and fish, because available aquatic 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 (*Micropterus punctulatus*), smallmouth bass (*M. dolomieui*), largemouth bass (*M. salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), channel catfish (*Ictalurus punctatus*), and other warm-water species. Warm-water fish species are generally structure oriented and mostly occupy the littoral zone, however, some warm-water species like spotted bass will forage in the pelagic zone of Shasta Lake.

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 (Baumgartner 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 (*Dorosoma petenense*), 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 shallow 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 warm-water fish populations is not well understood but is believed to be small with catch-and-release practices, 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, Parkos and Wahl 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, 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, Gebhart, and Maughan 1982, Lee 1999, 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 before 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, CDFW 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, CDFW, 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 Shasta-Trinity National Forest (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 a 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 (Ratcliff 2006; Zustak 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. Accessible and suitable cold-water fish spawning habitat, including appropriate seasonal flows, depths, and gravel substrates, was observed in 5 percent of intermittent tributaries and nearly 70 percent of perennial tributaries to Shasta Lake surveyed in 2011 and 2012 (see *Fisheries and Aquatic Ecosystems Technical Report* for details). Most native fish species found in Shasta Lake may also inhabit the lower reaches of the tributaries. Several tributaries to Shasta Lake (e.g., Little Squaw Creek,[2] 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. No fish were observed during 2012 in watersheds known to be affected by a legacy of mining and acidic, metal-laden mine drainage, including Little Squaw Creek and Little Backbone Creek, both located in the watershed to the immediate northwest of Shasta Dam, and Town Creek, near the Bully Hill Mine located in the Squaw Creek arm (Reclamation 2014).

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

[2] 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.

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).

In addition to the four primary tributaries, there are 1,232 intermittent and perennial stream channels totaling about 2,962 miles of channel that contribute seasonal or year-round flows to Shasta Lake. Most of these channels 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. Many (64 percent) of these channels are intermittent and have stream slopes greater than 10 percent (mean gradient of 27 percent). Net Trace model results indicate that about 33 percent of these stream channels are perennial. About 20 percent of these channels (716) have gradients less than 10 percent and are likely to support fish and other aquatic organisms. In the Klamath Mountain and Cascade geomorphic provinces, 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, Bisson, and Dambacher 1998). Of the channels surveyed, about 79 percent of those that appeared to have good fish-bearing potential flow into the Sacramento, Squaw, and Pit Arms of Shasta Lake (see Chapter 4, “Geology, Geomorphology, Minerals, and Soils,” for more detail).

Aquatic habitat for resident and adfluvial fishes is generally limited in intermittent tributaries to Shasta Lake because a large percentage (92 percent) of these channels does not possess suitable hydrologic conditions (i.e., sufficient duration and amount of discharge) and/or are too steep to provide accessible habitat, even seasonally, for fish. 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 Net Trace based on Reclamation’s geographic information system (GIS) Digital Elevation Model (DEM) indicate that most barriers on the perennial tributaries occur near the reservoir. Fifty-four percent of all of the intermittent and 30 percent of the perennial tributaries surveyed in 2011 and 2012 contained partial or complete barriers to fish migration within the varial zones of the proposed reservoir enlargement. However, the estimated number of these perennial streams with complete passage barriers located between 1,070 feet and 1,090 feet msl is only 15, or 10 percent, of the 154 perennial tributaries to Shasta Lake (see Fisheries and Aquatic Ecosystems Technical Report for details).

The aquatic habitat composition of Shasta Lake's perennial tributaries is more diverse than in intermittent tributaries. Consequently, two percent of intermittent and 87 percent of perennial tributaries to Shasta Lake sampled in 2011 and 2012 were found to be inhabited by fish (see Fisheries and Aquatic Ecosystems Technical Report for details). Only cold-water species (trout) were observed in intermittent streams during periods of surface flow and in isolated pools after cessation of flow. Cold-water species inhabited 83 percent and warm-water species inhabited 48 percent of the sampled perennial tributaries. Warm-water species were mostly confined to portions of tributary channels within that portion of currently inundated areae. In the few perennial tributaries (less than 10 percent) where warm-water species were found upstream from the reservoir in 2012, the streams had low gradient channels (less than or equal to 2 percent) with an abundance of flatwater habitat (see Fisheries and Aquatic Ecosystems Technical Report for details).

The only special-status aquatic vertebrate species observed in some of these tributaries was the foothill yellow-legged frog; no special-status fish (e.g., hardhead) or invertebrate species were detected, although hardhead have previously been detected in some perennial tributaries (i.e., Sacramento and Pit rivers) (see *Fisheries and Aquatic Ecosystems Technical Report* for details).

#### *Upper Sacramento River (Shasta Dam to Red Bluff)*

**Keswick Reservoir** 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 program 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 the Recovery Plan for Sacramento River winter-run Chinook salmon (NMFS 2014)). Water is supplied to the hatchery from Shasta Dam.

Keswick Reservoir is operated by Reclamation as a reregulating facility. Water 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 11-2 includes the fish species known to occur in Keswick Reservoir. The aquatic habitat is mostly riverine in character in the upper reach of Keswick Reservoir and slow current, run-of-the-river habitat in the lower half of the 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 (Table 11-2).

Native species present in this reach of the river can be separated into anadromous and resident species. Native anadromous species include four runs of Chinook salmon, steelhead, green sturgeon (*Acipenser medirostris*), white sturgeon, and Pacific lamprey. Native resident species include Sacramento pikeminnow, Sacramento splittail, Sacramento sucker, hardhead, California roach (*Lavinia symmetricus*), and rainbow trout.

Nonnative resident species present in the upper Sacramento River include largemouth bass, smallmouth bass, white and black crappie (*Pomoxis annularis* and *P. nigromaculatus*), channel catfish (*Ictalurus punctatus*), white catfish (*Ameiurus catus*), black bullhead (*A. melas*), brown bullhead (*A. nebulosus*), bluegill (*Lepomis macrochirus*), green sunfish (*L. 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 habitats in the primary study area, habitats in the extended study area provide vital fish spawning, rearing, and/or migratory habitat for a diverse assemblage of native and nonnative species. Many of those species are the same as those found in the primary study area, including Chinook salmon, steelhead, and sturgeon (see the *Fisheries and Aquatic Ecosystems Technical Report*).

**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, riffle sculpin, brook trout

(*Salvelinus fontinalis*), brown trout, 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, while 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 for aquatic macroinvertebrates 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. Benthic macroinvertebrates (BMI) consist primarily of the larvae and nymphal forms of aquatic insects, mollusks, and worms, and serve as an important element of ecological communities and food chains for aquatic invertebrates, such as fish and amphibians. These organisms possess a wide array of life histories and preferences and tolerance of poor water quality. In general, published information on the taxonomy, distribution, and abundance of macroinvertebrates in the Sacramento River drainage is limited. In Shasta Lake, seasonal fluctuations in phytoplankton biomass regulate the abundance of the zooplankton, which form the base of the food chain for the lake’s fisheries. Typically, the spring phytoplankton bloom peaks in late-March and April at the on-set of thermal stratification, when nutrients are abundant in surface waters and available to the algae, and again in the fall coincident with the breakdown of the thermocline and mixing of the water column (Lieberman and Horn 1998). The zooplankton community of Shasta Lake is dominated by cladoceran and copepod species, with lower abundance of several rotifer species. Cladocera are most abundant during algae blooms and their abundance wanes, with a corresponding increase in copepod abundance, during the mid-summer (Lieberman and Horn 1998).

Surveys conducted in 2011 and 2012 in tributaries of Shasta Lake found that BMI communities, with a few exceptions, were generally indicative of good habitat and water quality conditions capable of supporting healthy, functioning, and productive ecosystems. The BMI community was largely dominated by cool/warm (eurythermal) taxa, which is expected as a function of the region's Mediterranean climate; taxa representing both pool and riffle specialists; and taxa representing the collector-filterer and collector-gatherer functional feeding guilds, which is also expected based on the relative position and trophic status of the tributary sampling sites within the watersheds (see *Fisheries and Aquatic Ecosystems Technical Report* for details). Tributaries to the Sacramento River arm exhibited among the highest BMI abundances and taxa richness and diversity, although Pit River arm tributaries also exhibited relatively high taxa diversity. Tributaries in legacy mining districts immediately north of Shasta Dam and in portions of the Squaw Creek arm exhibited very depauperate BMI communities, with a high proportion of taxa tolerant of polluted conditions (see *Fisheries and Aquatic Ecosystems Technical Report* for details).

A number of different aquatic mollusks (e.g., snails, limpets, mussels, and clams) are known to inhabit the principal tributaries and general vicinity of Shasta Lake, including several species of management importance (Frest and Johannes 1995, 1999; Howard 2010). Several species of hydrobiid "spring snails" are known to inhabit the upper reaches of the Sacramento and McCloud rivers upstream from Shasta Lake (Frest and Johannes 1995, 1999) in spring complexes and associated headwater areas. These snails require clear, cold-water streams with cobbly gravel beds and tend to be associated with submergent vegetation; however, none of these species has been reported in the reaches of tributaries near Shasta Lake. A number of these spring snails and other stream-dwelling snails are ecologically important and are managed by the USFS and BLM under guidelines for Survey and Manage Species (see Table 11-1).

The USFS sensitive freshwater mussel, the California floater (*Anodonta californiensis*), is also known historically to have occurred in Shasta Lake tributaries near the head of the lake (Howard 2010; Zustak 2007). However, surveys of historically occupied sites around Shasta Lake failed to find this species (Howard 2010) nor was it detected by casual surveys and benthic sampling of the smaller perennial and intermittent tributaries to Shasta Lake in 2012 (Reclamation 2014). This species has experienced significant population declines throughout its range, primarily because of hydromodification of its habitat (Howard 2010). Its preferred habitat is unpolluted, slow-moving rivers and large streams, with beds composed of balanced mixtures of gravel, sand, and silt; however, California floaters are sometimes found in lake shore areas with stable water levels and suitable water currents and substrates (Pennak 1989). Other freshwater mollusks commonly observed in the tributaries of Shasta Lake include another freshwater mussel of the genus *Gonidea* and freshwater limpets of the genus *Lanx* (Howard 2010). The kneecap lanx (*Lanx Patelloides*) has been recently added to the USFS sensitive species list and is known to occur in the vicinity of the McCloud River Bridge. Another mollusk, Black juga (*Juga nigrina*) was recently added to the USFS sensitive species list. It was not detected during the 2014 field surveys but Shasta Lake and its tributaries are within the known range of this species (Cordeiro and Perez 2011). The western pearlshell (*Margaritifera falcata*) is also historically known from the McCloud River, but its close dependence on migratory salmonids for its life cycle has undoubtedly resulted in a decline in its abundance since construction of Shasta Dam blocked anadromous fish migrations (Howard 2010).

**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 (*Prosopium williamsoni*) (Proctor, Kerans, and Clancey 2007). Unfortunately, snails are capable of passing through the digestive system of fish alive and intact (Bondesen and Kaiser 1949).

Possible pathways of introduction into Shasta Lake include contaminated recreational watercraft and trailers and recreational water users (Proctor, Kerans, and Clancey 2007). Introduced snails may also be transported in the feathers and mud adhering to waterbirds and wildlife as they move from one waterbody to another. 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 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 at depths of between 20 and 25 meters (m) in Lake Ontario (Proctor, Kerans, and Clancey 2007).

*Quagga and Zebra Mussel* Quagga mussels (*Dressenia bugensis*) and zebra mussels (*Dressenia polymorpha*), are invasive European aquatic mollusks introduced to North America in ship ballast water and first discovered in Lake Erie in 1989 (Spidle, Marsden, and May 1994), have not been found in Shasta Lake, to date, but were discovered in California at Lake Havasu in 2007 (Cohen 2007). The CDFW has begun monitoring at Lake Shasta for adult mussels and veligers (Baumgartner 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 dressenid 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 and zebra mussels.

In a 2007 report produced for CDFW, 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 portion of the Sacramento River watershed including Whiskeytown Reservoir and the watersheds above Shasta Dam, Cohen found that the McCloud River above Shasta Lake 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 on the Sacramento River from Keswick Dam to Verona, coordinated by DWR in 2001, 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).

Petrusso and Hayes (2001) examined the diurnal feeding habits of juvenile Chinook salmon in the Sacramento River between RM 193 and RM 275 (downstream and upstream from Red Bluff, respectively) in relation to drifting invertebrates. 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 composed 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 meters (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 and Delta are 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. As part of the Sacramento River Watershed Program, CDFW collected snag samples at two sites, one site near Colusa and one site near Hamilton City. Dominant taxa found in the fall of 1999 at the Hamilton City site included Orthocladiinae, Naididae, Ephemeroptera (*Baetis* and *Acentrella* sp.), and Trichoptera (*Hydropsyche* sp.) (Sacramento River Watershed Program 2002). Schaffter, Jones, and Karlton (1983) found no substantial 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 3 families in 72 percent of the guts sampled.

As mentioned above under “Upper Sacramento River (Shasta Dam to Red Bluff),” a large-scale monitoring effort by DWR on the river from Keswick Dam to Verona 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).

Also, as described previously, Petrusso and Hayes (2001) examined the diurnal feeding habits of juvenile Chinook salmon in the river between River Mile (RM) 193 and RM 275 (downstream and upstream from Red Bluff, respectively) in relation to drifting invertebrates. Petrusso and Hayes found that chironomids and baetids dominated both the drift and stomach contents; they concluded that there was reasonable feeding opportunity during the sampling period and that daily mean drift density appeared to show no spatial patterns.

The lower rivers and Delta support a diverse assemblage of zooplankton and macroinvertebrates. Many of these invertebrates are native to the Bay-Delta while many have been introduced into the estuary through ship ballast water discharges, oyster planting, and other processes. Many of the fish species forage on small zooplankton (e.g., copepods) during their early lifestages or throughout their life, while larger macroinvertebrates such as amphipods, shrimp, and crabs provide a forage source for many of the other fish species. Sturgeon and many of the flatfish, for example, forage extensively on shrimp (e.g., Cangon) while other fish such as largemouth bass forage extensively on crawfish. The macroinvertebrate communities are affected by changes in salinity gradients and other habitat factors as well as by filter feeding by other introduced nonnative species such as the Asian overbite clam that has extensively colonized areas of the estuary such as Suisun Bay.

Macroinvertebrate monitoring in the Delta has been focused on impacts to food web dynamics as a result of increases in phosphorous and nitrogen, and on loss of macroinvertebrate species diversity due to nonnative species introductions. The macroinvertebrate communities of the Delta are characterized by low diversity and are dominated by a minimal number of species (less than 10) (Nichols 1980). This is in part because of the predominately soft, silty substrate found throughout the Delta, and an ever-changing fresh and salt water (brackish) water mix (Nichols 1980).

## 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 or adversely affect its designated critical habitat. 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 fish and 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 through a Habitat Conservation Plan (HCP), or a Federal interagency consultation, under Section 7 of the ESA, is required. Section 7(a)(2) states that each Federal agency shall, in consultation with the Secretary of the Interior, ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. In the primary and extended study area, USFWS has regulatory jurisdiction over freshwater and estuarine fishes (such as delta smelt), while NMFS has jurisdiction over anadromous fish species that include Chinook salmon, steelhead, and green sturgeon, as well as marine fish and mammals.

Protection of these listed species is typically addressed through issuance of BOs and incidental take authorization by USFWS and NMFS, as well as designation of critical habitat. BOs have been issued for delta smelt by USFWS (2008) and for winter-run and spring-run Chinook salmon, Central Valley steelhead, and green sturgeon by NMFS (2009). These two most recent BOs were challenged in Federal court and remanded to the agencies for revisions. USFWS and NMFS have requested extensions on the deadlines for completing the revisions to the BOs required by the Federal court rulings.

#### *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 2014, NMFS published the *Final 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 2014). In this Recovery Plan, NMFS indicates that the recovery of winter-run Chinook salmon is affected by the Shasta cold-water pool by stating:

> *"Currently, winter-run Chinook salmon spawning is limited to the mainstem Sacramento River downstream of Shasta and Keswick dams where the naturally-spawning population is artificially maintained by cool water releases from the dams. Within the Sacramento River, the spatial distribution of spawners is largely governed by water year type and the ability of the CVP to manage water temperatures.*
>
> *The fact that this ESU is comprised of a single population with very limited spawning and rearing habitat increases its risk of extinction due to local catastrophe or poor environmental conditions. There are no other natural populations in the ESU to buffer it from natural fluctuations. A single catastrophe with effects persisting for four or more years could result in extinction of the Sacramento River winter-run Chinook salmon ESU (Lindley et al. 2007). Such potential catastrophes include volcanic eruption of Lassen Peak, prolonged drought which*

> *depletes the cold water pool in Shasta Reservoir or some related failure to manage cold water storage, a spill of toxic materials with effects that persist for four years, or a disease outbreak.*
>
> *After two years of drought, Shasta Reservoir storage would be insufficient to provide cold water throughout the winter-run Chinook salmon spawning and embryo incubation season, resulting in partial or complete year class failure. A severe drought lasting more than 3 years would likely result in the extinction of winter-run Chinook salmon. The probability of extended droughts is increasing as the effects of climate change continue (see Chapter 6)."*

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 for upstream reintroduction may not be achievable. Improving the cold-water pool could reduce impacts to the species recovery if the reintroduction process is not successful. Additionally, NMFS includes management actions to improve gravel augmentation programs downstream from Keswick Dam.

#### 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 species managed under Essential Fish Habitat by NMFS within the Bay-Delta include Pacific salmon, starry flounder, and English sole.

#### 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.

#### Federal Clean Water Act, Section 404

Section 404 of the Federal Clean Water Act (CWA) requires project proponents to obtain a permit from 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, including those in the primary and extended study area, meet the criteria for waters of the United States.

#### *Federal Clean Water Act, Section 402*

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

#### *Federal 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 TCD.

- Implementing fish passage measures at RBPP.
- Planning to increase water supplies for CVP deliveries.
- 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*

CDFW, USFWS, and NMFS are the implementing agencies for the Ecosystem Restoration Program (ERP). The ERP is a multi-agency effort to improve the ecological health of the Bay-Delta watershed by restoring and protecting habitats, ecosystem functions, and native species. Since the program's inception, ERP agencies have identified more than 600 programmatic actions and 119 milestones throughout the Bay-Delta watershed. The strategic plan objectives of the ERP include the following:

- Recover endangered and other at-risk species and native biotic communities.
- Rehabilitate ecological processes.
- Maintain or enhance populations of selected species for sustainable commercial or recreational harvest.
- Protect or restore functional habitat types.
- Prevent or reduce harmful impacts from nonnative species.
- Improve or maintain water quality and sediment quality conditions that support healthy ecosystems.

**Bay Delta Conservation Plan** The State and Federal water agencies are currently developing the Bay Delta Conservation Plan (BDCP). The BDCP consists of conservation measures that include components for water conveyance facilities combined with water conveyance operations; conservation components including land acquisition for major habitat restoration efforts in the Delta; and components related to reducing other stressors on the Bay-Delta ecosystem. The BDCP conservation measures are specific actions that would be implemented to achieve the biological goals and objectives of the proposed plan, and are a component of the BDCP conservation strategy. The conservation measures and effects assessment related to achieving the BDCP's overall planning goals are incorporated by reference into the EIR/EIS, which was publicly released in December 2013. The BDCP conservation strategy consists of multiple components that are designed to collectively achieve the overall BDCP planning goals of ecosystem conservation and water supply reliability. The conservation strategy includes biological goals and objectives; conservation measures; avoidance and minimization measures; and a monitoring, research, and adaptive management program.

Four broad concepts have been studied to address urban water quality, water supply reliability, and environmental concerns in the Delta: physical barriers, hydraulic barriers, through-Delta facilities, and isolated facilities. Several alternative Delta conveyance facilities are being evaluated as part of the plan. Depending on the alternative, the water conveyance facility components would create a new conveyance mechanism to divert water from the north Delta to existing SWP and CVP export facilities in the south Delta, interacting with operational guidelines to achieve the planning goal outlined above.

#### *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 State Water Board superseded those requirements. Evolution of the CWA over time has also impacted the implementation of the COA.

**ESA Consultation on CVP and SWP Long Term Operation** In June 2004, Reclamation prepared the 2004 Operations Criteria and Plan (OCAP) to provide a description of facilities and the operating environment of the CVP and SWP. Using operational information presented in the 2004 OCAP, Reclamation and DWR developed the 2004 OCAP Biological Assessment (BA), prepared as part of the consultation process required by Section 7 of the ESA.

Reclamation consulted with NMFS and USFWS on the 2004 OCAP, and the two agencies issued the 2004 NMFS BO (NMFS 2004) and 2005 USFWS BO (USFWS 2005), respectively. In 2007, the District Court for the Eastern District of California (District Court), in *Natural Resources Defense Council v. Kempthorne*, found the 2005 USFWS BO to be unlawful and inadequate. In May 2008, in *Pacific Coast Federation of Fishermen's Associations v. Gutierrez,* the District Court found the 2004 NMFS BO to be unlawful and inadequate. The District Court remanded both BOs to the agencies.

In 2008, Reclamation provided the USFWS and NMFS the *Biological Assessment on the Continued Long-Term Operations of the CVP and SWP* (2008 Long-Term Operation BA). USFWS and NMFS released their BOs in 2008 and 2009, respectively.

In the 2008 USFWS BO, the USFWS concluded that the long-term operations of the CVP and SWP would jeopardize the continued existence of delta smelt and adversely modify its critical habitat. Consequently, the USFWS developed a Reasonable and Prudent Alternative (RPA) to avoid jeopardy.

In the 2009 NMFS BO, NMFS similarly concluded that the long-term operations of the CVP and SWP would jeopardize the continued existence of listed salmonids, steelhead, green sturgeon, and killer whales; it also developed an RPA to avoid jeopardy to the species. The RPA included conditions for revised water operations, habitat restoration and enhancement actions, and fish passage actions. Actions were brought challenging the USFWS and NMFS BOs (2008 and 2009) under ESA and the Administrative Procedure Act (APA), concerning the effects of the CVP and SWP on endangered fish species.

*2008 USFWS BO Litigation* On December 27, 2010, the District Court entered an "Amended Order on Cross-Motions for Summary Judgment" (Doc. 761), remanding the 2008 USFWS BO to the USFWS without vacatur. On May 4, 2011, the District Court issued an amended Final Judgment, ordering the USFWS to complete a final revised BO by December 1, 2013.

In August 2011, the District Court enjoined implementation of USFWS RPA Component 3 (Action 4), the fall X2 requirements, which require a monthly average position of not greater than 74 km in wet years or 81 km in above normal water years eastward of the Golden Gate Bridge. That injunction is no longer in-effect.

The United States and NRDC appealed the District Court's decision invalidating the 2008 USFWS BO. NRDC also challenged the District Court's finding that Reclamation was required to prepare an EIS on its provisional acceptance of the RPA included in the 2008 USFWS BO. Water user plaintiffs cross-appealed the District Court's opinion. On March 13, 2014, the Ninth Circuit Court of Appeals reversed that part of the District Court's opinion that questioned the validity of the 2008 USFWS BO, but affirmed the District Court's finding that Reclamation violated in NEPA in failing to prepare an EIS on its provisional acceptance of the RPA included in the 2008 USFWS BO.

*2009 NMFS BO Litigation* In September 2011, the District Court remanded the 2009 BO to NMFS, without vacatur, finding in favor of the Federal government on some counts and in favor of water contractor plaintiffs on other counts. The District Court has ordered NMFS to prepare a draft BO no later than October 1, 2016. To meet that schedule, Reclamation must issue a draft EIS evaluating the environmental impacts associated with implementing the draft NMFS BO by April 1, 2017 (six months after receiving the draft BO), and a final EIS no later than March 28, 2018. Reclamation must prepare an EIS on any RPA included in the draft NMFS BO by February 1, 2018; NMFS must release a final BO by that same date. Reclamation must issue a ROD, deciding whether to accept the RPA or an alternative, by April 29, 2018. The United States has appealed the District Court's decision, and that appeal is still pending in the Ninth Circuit Court of Appeals.

*Summary* In February 2013, Reclamation requested reinitiation of ESA Section 7 consultation, to which USFWS and NMFS agreed.

Currently, although the Ninth Circuit Court of Appeals upheld the validity of the 2008 USFWS BO, the USFWS is obligated to issue (or reissue) a BO by December 1, 2015. On that same date, Reclamation must issue a Final EIS analyzing the environmental impacts associated with operating the CVP and SWP under the USFWS BO.

On the NMFS side, NMFS must issue a draft BO to Reclamation no later than October 1, 2016. Reclamation must issue a final EIS no later than February 1,

2018. On that same date, February 1, 2018, NMFS must release a final BO. Reclamation has until April 29, 2018 to issue a ROD.

#### *Real-Time Decision-Making to Assist Fishery Management*

Reclamation and DWR work closely with USFWS, NMFS, CDFW, 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 CDFW. The WOMT meets frequently to provide oversight and decision making that must routinely occur within the CALFED Bay-Delta Program (CALFED) Ops Group process. The WOMT relies heavily on other teams and work groups for recommendations on fishery actions. It also uses 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.

**Delta Operations for Salmonids and Sturgeon Group** The Delta Operations for Salmonids and Sturgeon (DOSS) was established from Action IV.5 in the NMFS BO. The responsibilities of DOSS are to provide advice to the WOMT and NMFS on measures to reduce adverse effects from Delta operations of the CVP and the SWP to salmonids and green sturgeon. DOSS coordinates the work of other technical teams to provide expertise on issues pertinent to Delta water quality, hydrology, and environmental parameters. The 2009 NMFS BO states the DOSS will:

1. Provide recommendations for real-time management of operations to WOMT and NMFS, consistent with implementation procedures provided in this RPA;

2. Review annually project operations in the Delta and the collected data from the different ongoing monitoring programs;

3. Track the implementation of Actions IV.1 through IV.4;

4. Evaluate the effectiveness of Actions IV.1 through IV.4 in reducing mortality or impairment of essential behaviors of listed species in the Delta;

5. Oversee implementation of the acoustic tag experiment for San Joaquin fish provided for in Action IV.2.2;

6. Coordinate with the Smelt Working Group to maximize benefits to all listed species; and

7. Coordinate with the other technical teams identified in this RPA to ensure consistent implementation of the RPA.

**CALFED Ops Group** The CALFED Ops Group consists of participants from Reclamation, DWR, USFWS, NMFS, CDFW, State Water Board, and EPA. 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 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.

*Interagency Fish Passage Steering Committee* The Interagency Fish Passage Steering Committee (IFPSC) was established in 2010 because of the NMFS 2009 BO, and consists of members from Reclamation, NMFS, USFWS, CDFW, DWR, RWQCB, USFS, and academia. The IFPSC's role is to provide insight and technical, management, and policy direction for a Fish Passage Program to evaluate the potential reintroduction of listed fish species upstream from Shasta, Folsom, and New Melones dams. The IFPSC provides a stabilizing influence so organizational concepts and directions are established and maintained with a visionary view, and provides insight on long-term strategies in support of implementation of the fish passage RPA.

*The Sacramento River Temperature Task Group* The Sacramento River Temperature Task Group (SRTTG) is a multiagency group formed pursuant to State Water Board 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, and then recommends an operations plan for temperature control to the WOMT. Reclamation then submits a report to the State Water Board, generally on or before June 1 each year.

After the operations 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 State Water Board.

*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, CDFW, 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.

#### *National Forest Management Act*

The National Forest Management Act requires the USFS to prepare a Land and Resource Management Plan (LRMP) for each National Forest. The LRMPs provide the direction to manage the lands and resources that are associated with National Forest System lands managed by the USFS. In addition to the requirement for LRMPs, the National Forest Management Act also has a specific requirement to "provide for a diversity of plant and animal communities" (16 U.S Code 1604(g)(3)(B)) as part of their multiple use mandate. The USFS must maintain "viable populations of existing native and desired nonnative species in the planning area" (36 Code of Federal Regulations 219.19). In its decision making process, the USFS must also consider impacts to management indicator species (assemblages). These are defined as any species or assemblage of plants or animals that has been identified as representative of a larger group of species with special habitat requirements. The Shasta-Trinity and Mendocino National Forest LRMPs are directly applicable to efforts related to the SLWRI.

#### *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 to prevent it from becoming threatened or endangered.

#### *Shasta-Trinity and Mendocino National Forest Land and Resource Management Plans*

Both the STNF and Mendocino LRMPs incorporate the applicable elements of 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. These LRMPs encompasses all the goals, standards, and guidelines established in the 1994

ROD for the Northwest Forest Plan, as a well as the goals, standards, and guidelines designed to guide the management of these National Forests. As part of the STNF LRMP, the USFS is required to implement any recovery plans established under the ESA Section 7(a)(1). As signed in 1995, the STNF LRMP incorporates the following goals, standards, and guidelines related to aquatic and fisheries resource issues associated with the project site, which 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 indicator species or assemblages.

- 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. RODs to modify the Survey and Manage rule were published in 2004 and 2007; however, both of these RODs were set aside by the courts. As a result of a court-mandated settlement agreement in litigation on the 2007 ROD (Conservation Northwest v. Sherman Case No. C08-1067-JCC (W.D. Wash. July 5, 2011)), modifications to the Survey and Manage Standards and Guidelines were again made; however, the 2011 Settlement Agreement was set aside by the Ninth Circuit Court of Appeals in 2013, and the 2001 ROD was reinstated.

#### *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 CDFW 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 CDFW 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; proposed activities must meet a no-net-loss standard for CESA listed species). 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 Codes***
Additional sections of the California Fish and Game Code that are subject to regulation by CDFW include Section 1505 covering spawning areas on state-owned lands; Sections 5930 through 5948 covering dams and obstructions; and Section 7261 recognizing native trout.

Section 1602 handles streambed alteration agreements. 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 CDFW 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 CDFW: 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. CDFW's jurisdiction within altered or artificial waterways is based on the value of those waterways to fish and wildlife. A CDFW 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 (PRC) 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 California Wild and Scenic Rivers System. As described in Section 5093.50 of the PRC, rivers or river segments included in the California 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 California 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 California 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 California 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 semi-wild 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 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 San Francisco Bay Area from

Sacramento, and integrating green spaces into its communities (Yolo County 2009).

### 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 the 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 (CBDA) 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. The July 2000 CALFED *Final Programmatic EIS/EIR* (CALFED 2000b) identified and analyzed a range of alternatives to address these needs and included a Multi-Species Conservation Strategy (MSCS) to provide a framework for compliance with ESA, CESA, and Natural Community Conservation Planning Act. The August 2000 CALFED Programmatic ROD identified 12 action plans, including Ecosystem Restoration, Watersheds, and Water Supply Reliability, among others (CALFED 2000c). The CALFED ERP 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. In 2009, the California Legislature passed sweeping water reform legislation, including the establishment of the Delta Stewardship Council (DSC). The DSC was transferred all the responsibilities, programs, staff and most of the funding from the CBDA, and the CBDA was dissolved. The DSC was also given additional mandates, including the development of a Delta Plan to guide activities and programs of State and local programs in the legal Delta through a consistency determination process. The Delta Plan is currently undergoing the final public review.

#### *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 CDFW, USFWS, the CVRWQCB, 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 U.S. Natural 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. Districts in the vicinity of Shasta Lake and the Sacramento River upstream from Shasta Lake 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 Offstream 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 Forum*

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–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 the Red Bluff Diversion Dam (completed)
- 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 completed)
- Measures to reduce acute toxicity caused by acid mine drainage and heavy metals (ongoing)
- Various fisheries improvements on Clear Creek (partially completed)
- Flow increases, fish screens, and revised gravel removal practices on Battle Creek (ongoing)
- Control of gravel mining, improvement of spawning areas, improvement of land management practices in the watershed, and protection and restoration of riparian vegetation along Cottonwood Creek (ongoing)

***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 by strategically acquiring land 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 CDFW for long-term management. Lower in the Sacramento River basin, TNC has been instrumental in acquiring and restoring lands for 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 modeling of hydrologic conditions, water temperature, and salmon production and mortality was performed to provide a quantitative basis from which to assess potential operational 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, Version 3.8 (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. These monthly values are then converted to daily values for use in water temperature modeling, which gives 6-hour interval river water temperatures. The period of record is based on records from 1921 through 2003. Outputs on river flow and water temperature were put into weekly form for use 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 to predict 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. Output on reservoir storage, river flows, water temperature, and salmon survival 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 simulation of the Existing Condition (2005) and No-Action Alternative (future 2030) to determine the following:

- Whether reservoir storage or river flows and water temperatures would be expected to change with implementation of the SLWRI alternatives
- The months in which changes to reservoir storage and river flow and water temperatures could occur
- The 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 region

The models used, though mathematically precise, should be viewed as having reasonable detection limits. Establishing reasonable detection limits is useful when interpreting modeling output for an impact assessment; establishing such limits prevents the user from making inferences beyond the capabilities of the models and beyond the ability to actually measure changes.

The Modeling Appendix provides a more detailed discussion of the modeling process and its application to the project analysis. The appendix describes (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** As described in Section 11.2, "Regulatory Fraemwork," a process exists to make decisions about CVP and SWP operations in real time. This process allows for fishery management that involves flexible decision-making and adjustments for uncertainties as the outcomes of management actions and other events become better understood.

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

For example, both the NMFS BO for the CVP/SWP long-term operations and various State Water Board 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. The 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, following the guidelines provided in State Water Board 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 the period from 1921 to 2003 using data outputs from CalSim-II. Values were produced for six alternative dam raise scenarios (project alternatives) using a 2005 water supply demand, and a projected 2030 water supply demand for a total of 12 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. Because this ratio relates cold-water volume to the surface area of the reservoir, the metric is sensitive to disproportionate changes in surface area without concomitant changes in the cold-water pool. 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 vegetation and structural habitat enhancement features installed around the reservoir also leads to increased structural diversity and availability of spawning substrate and cover for juvenile fishes (Miranda, Shelton, and Bryce 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). Loss of access to inundated shoreline vegetation and habitat enhancement structures during reservoir drawdown in the summer increases predation mortality of juvenile bass and other sport fish (Lee 1999, Ploskey 1986, Ratliff 2006).

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, CP4, and CP4A 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, CP4, CP4A, and CP5 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 existing data on the aquatic resources occurring in many of the tributaries to Shasta Lake are limited. Early in the SLWRI planning process, 12 representative tributary streams to Shasta Reservoir were selected for focused examination as part of this assessment, including five tributaries to Shasta Lake: Sacramento River, McCloud River, Pit River, Squaw Creek, and Big Backbone Creek. Subsequently, to support ongoing analyses of potential impacts of the proposed enlargement of Shasta Dam and Reservoir, Reclamation, USFS, and CDFW collaboratively developed a study plan to obtain additional data on other important tributary streams. Data were collected by surveying 132 representative tributaries to Shasta Lake between November 2011 and August 2012. The primary objectives of this study were to document:

1. The composition, distribution, and relative abundance of native and nonnative fish species.
2. The condition of aquatic habitat.
3. The condition of benthic macroinvertebrate communities.
4. The occurrence of special-status species.
5. The occurrence of invasive aquatic species.

***Chinook Salmon Between Keswick Dam and Red Bluff Pumping Plant***

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 RBPP. SALMOD was applied to this project because:

1. SALMOD had been previously used on the upper Sacramento River (from Keswick Dam to Battle Creek) (Kent 1999, Bartholow 2003). John Bartholow and John Heasley (contractor to the U.S. Geological Survey (USGS)) were instrumental in extending SALMOD to assess fish production and mortality between Keswick Dam and the RBPP. 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.
2. SALMOD 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 CDFW fisheries biologists (Bartholow 2003; Modeling Appendix, Chapter 5). The USGS completed a thorough review and update of model parameters and techniques on the Klamath River that enabled a smooth transfer of relevant model parameters to the Sacramento River (Bartholow and Henriksen 2006).
3. Resource agency personnel agreed that using SALMOD was the appropriate means of evaluating potential conditions after being presented with the model's capabilities by John Bartholow (formerly with USGS) under contract by Reclamation.
4. SALMOD was peer reviewed by Lisa Thompson and Chris Mosser of University of California (UC) Davis (Thompson and Mosser 2011).

5. SALMOD was approved for use in several other Federal-level studies, including the Reclamation's 2008 Biological Assessment on the Continued Long-Term Operations of the CVP and SWP for compliance with Section 7 of the ESA (Reclamation 2008) and resulting NMFS 2009 BO (NMFS 2009).

**Comprehensive Plans Evaluated** SALMOD used weekly streamflow and water temperature to evaluate multiple scenarios: the Existing Condition, No-Action Alternative, CP1, CP2, CP3, CP4, CP4A, and CP5. 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 18.5-foot dam raise. CP4 and CP4A were developed based on an 18.5-foot dam raise with operations modified to create a more "fish-friendly" environment, with a portion of the reservoir storage dedicated to fish, to either improve flows or water temperatures, and adds spawning and rearing habitat restoration. CP5 is based on an 18.5-foot dam raise that adds spawning and habitat restoration.

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 RBPP (Table 11-3). 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.

SALMOD was also conducted using a spawning population based on the 1999 to 2006 average adult return provided by CDFW (2014), 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 Chinook 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.

Populations of 500 or more spawning Chinook 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 CDFW and USFWS, the spawning population was left at 207 fish for purposes of the model.

While steelhead are not evaluated directly in SALMOD, effects for late fall-run Chinook salmon are considered representative for steelhead since NMFS, in their 2009 BO, assumed late fall-run Chinook salmon could be used as a surrogate for steelhead because they have similar life history stages, including spawning at the same time of the year (NMFS 2009).

Production numbers generated by SALMOD are not intended to be used as actual population estimates, but as a basis of comparison between alternatives. There are multiple reasons why the juvenile production results should not be used as strict population estimates, including the fact that each year, the same spawning population is used. That is, any increase or decrease in production at the end of a cohort year is not carried forward into another set of spawners. In other words, SALMOD is not a life-cycle model, and only takes into account the environmental and biological factors that affect survival of Chinook salmon between Keswick Dam and RBPP. Because each alternative starts with the same number of spawners each year, the differences between the effects of alternatives on each run of Chinook salmon become clear and easy to evaluate. Additionally, the use of SALMOD allows the focus of impacts to be where the greatest direct effects of the project occur – that is, the Sacramento River upstream from RBPP.

**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 | 66 |
| 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 RBPP Inundation Zone | 5,044 | 67 | 0 | 0 |
| **Total Adult Spawners** | **64,565** | **13,697** | **8,591** | **207** |
| **Potential Eggs** | **154,956,000** | **32,872,800** | **12,371,040** | **496,800** |

**Table 11-3. Number of Spawning Fish Incorporated into SALMOD Model (contd.)**

| Reach | Fall-Run | Late Fall-Run | Winter-Run | Spring-Run |
|---|---|---|---|---|
| **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 RBPP 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** |

Notes:

Spawners include 52 percent males and 48 percent females.

Number of eggs for late fall-, fall- and spring-run equals 5,000 eggs per female. Winter-run Chinook salmon were assumed to have a lower fecundity of 3,000 eggs per female.

Key:
ACID = Anderson-Cottonwood Irrigation District
AFRP = Anadromous Fish Restoration Program
RBPP = Red Bluff Pumping Plant

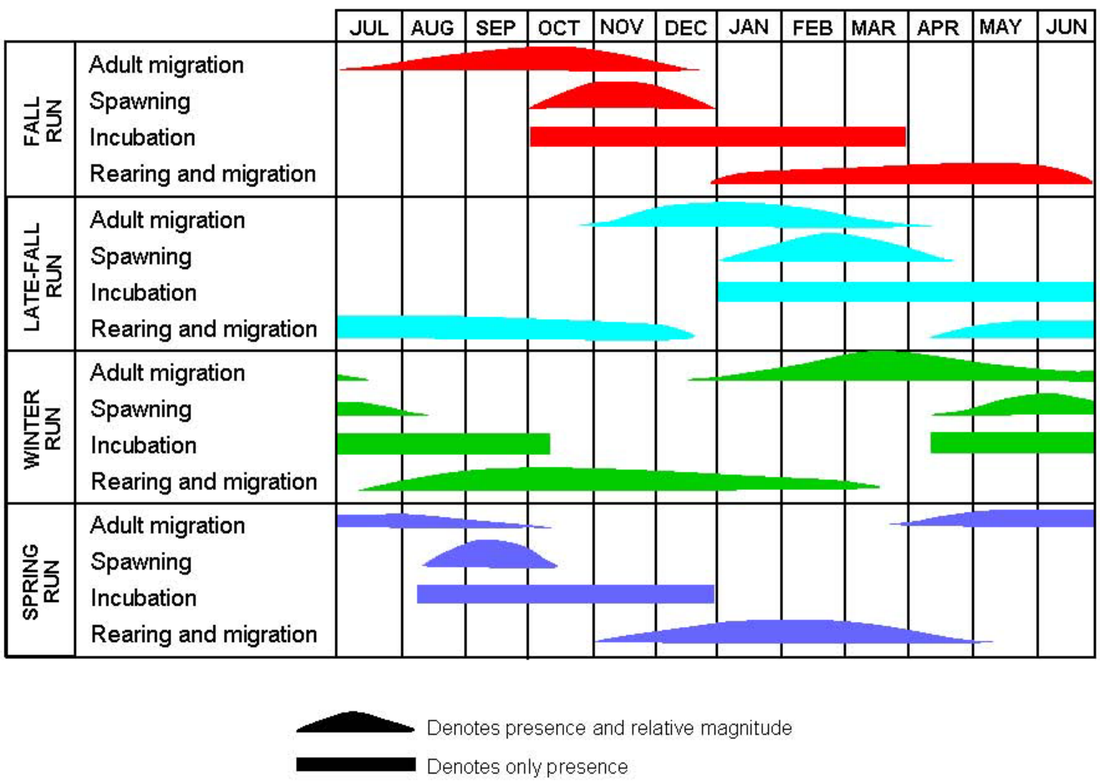
For purposes of evaluating the potential effect of changes in Sacramento River flow and temperature on Chinook Salmon populations between Keswick Dam and Red Bluff Pumping Plant, it was assumed that simulated changes in average annual production that were less than 5 percent (plus or minus) relative to the basis-of-comparison (No-Action Alternative and Existing Conditions) would not be expected to result in a significant (detectable) effect on long term Chinook Salmon production potential. The 5 percent significance threshold was selected to account for the inherent limitations and uncertainties associated with SALMOD, as well as the limitations and uncertainties in the hydrologic model (CalSim-II) and temperature model (Sacramento River water temperature model) used to develop inputs to SALMOD.

**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.

Production derived with SALMOD is the number of immature smolts that survive to pass the RBPP. Because of the uncertainties and limitations inherent in SALMOD, the simulated production should be interpreted as an index which can be used to make relative comparisons between alternatives, and should not be treated as a prediction of absolute numbers of fish production under any alternative.

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 RBPP
- 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 RBPP) 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, 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:

- **Flow- and Water Temperature-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.
  - **Pre-Spawn** – Includes both lost egg mortality and *in vivo* mortality.
  - **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 before 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.

- **Nonoperations Mortality**

  - **Base** – 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 and disease. While these factors may be exacerbated by project operations, they cannot be directly quantified.

  - **Seasonal** – Extra outmigration mortality of presmolts or immature smolts, including diversion-related mortality.

*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 CDFW Grandtab table (CDFW 2014), 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.

SALMOD computes mortality by lifestage from various sources, including water temperature and habitat availability. For this evaluation, the lifestage-specific mortalities were converted to smolt equivalent mortality by using annual survival rates for the lifestages later than those at which the mortality occurred. This was an attempt to provide information on the relative effect of water temperature versus habitat availability (as affected by flow volume) on juvenile production. Smolt equivalents were calculated as follows:

**Prespawn/Egg Mortality to Immature Smolt Equivalent Prespawn/ Egg Mortality**

$$Immature\ Smolt\ Equivalent\ Mortality_i = Mortality_i \times \%\ Survival_{Eggs\ to\ Fry} \times \%\ Survival_{Fry\ to\ Presmolt} \times \%\ Survival_{Preolt\ to\ Immature\ Smolt}$$

Where: *i = Prespawn Base, Prespawn Temperature, Incubation, Superimposition, Eggs-Base, or Eggs-Temperature Mortality*

**Fry Mortality to Immature Smolt Equivalent Fry Mortality**

$$Immature\ Smolt\ Equivalent\ Mortality_i = Mortality_i \times \%\ Survival_{Fry\ to\ Presmolt} \times \%\ Survival_{Presmolt\ to\ Immature\ Smolt}$$

Where: *i = Base, Temperature, or Habitat Mortality*

**Presmolt Mortality to Immature Smolt Presmolt Mortality**

$$Immature\ Smolt\ Equivalent\ Mortality_i = Mortality_i \times \%\ Survival_{Pre-Smolt\ to\ Immature\ Smolt}$$

Where: *i = Base, Temperature, Habitat, or Seasonal Mortality*

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.

The action alternatives are meant to provide the greatest benefits to anadromous fish in critical and dry water years, when anadromous fish are generally at highest risk of flow- and temperature-related mortality. According to NMFS (2009b), Chinook salmon populations, especially winter-run Chinook, are highly vulnerable to global and localized climate changes, including prolonged drought conditions. This is caused by reduced volumes of cold water that can be released from reservoirs, including Shasta Lake, thus affecting spawning and rearing habitat conditions.

Moreover, an evolutionarily significant unit (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. Although the status of winter-run Chinook salmon is improving, there is only one population, and it depends on cold water releases from Shasta Dam, which would be vulnerable to a prolonged drought.

The 2009 NMFS BO RPA Action Suite I.2 indicate that the Shasta cold water pool must be managed to maintain suitable water temperatures and habitat for winter-run Chinook salmon downstream from Shasta Dam, particularly in critical water years, extended drought years, and under future conditions, which will be affected by increased downstream water demands and climate change (NMFS 2009). Therefore, critical and dry water years are the most important water year types for the survival of the anadromous fishes, particularly when there is a series of critical and dry water years in succession, because the low storage levels caused by multiple dry years result in warmer waters available for release. These warmer waters increase mortality and reduce production.

Increasing storage, particularly in the cold water pool, and targeting the release of the cold water for critical and dry water years, is expected to improve survival and production of Chinook salmon and steelhead during those periods when they are most vulnerable to temperature- and flow-related mortality. The SLWRI is not intended or expected to significantly increase production during wet, above normal or below normal water year types, because the existing cold water pool is generally sufficient to provide adequate flows and temperatures for Chinook and Steelhead during those years. As a result, the analysis of project impacts on anadromous fish focuses on the impacts in critical and dry years, in addition to considering the average impact for all years combined. In the simulated 81 years modeled in CalSim-II, 13 years were identified as critical water years, and 17 were identified as dry water years.

#### *Riverine Fisheries*

Riverine fish, including steelhead and green sturgeon, were evaluated based on differences between monthly mean flows at various modeling locations on the lower Sacramento River and tributaries under each Comprehensive Plan and the monthly mean flows simulated for Existing Conditions and No-Action Alternative conditions. Modeling for the lower American River occurred at Verona and Freeport; for the lower Feather River, modeling occurred below Thermalito Afterbay; and American River modeling occurred near the H Street Bridge in Sacramento. Modeling also occurred on the Trinity River. Additionally, flow changes were used to evaluate the potential change in ecologically important geomorphic processes such as channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

Changes in river flow for each alternative, relative to the basis-of-comparison, were used to reflect and evaluate potential impacts to juvenile salmonid rearing habitat that could result from altered flow regimes. For purposes of evaluating the potential effects of changes in flows on fish habitat, 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 (i.e., detectable) effect on habitat quality or availability.

#### *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 (State Water Board 2012). 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 February through 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, Rosenfield 2010, Rosenfield and Baxter 2007).

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 affects 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 the 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.

**Low Salinity 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 (Kimmerer 2002, Kimmerer 2004, State Water Board 2012). 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 (State Water Board 2012).

Salinity is an important habitat factor in the Bay-Delta (Baxter et al. 1999). 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 (Unger 1994, Kimmerer 2002).

The transition area between saline waters within the Bay and freshwater within the rivers, frequently referred to as the LSZ, is located within Suisun Bay and the western Delta. The LSZ has also been associated with the 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 isohaline (X2), but actually occurs over a broader range of salinities (Kimmerer 1992, Kimmerer 2004). 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, studies have shown that gravitational circulation does not occur in the LSZ 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 within the estuary.

As a consequence of higher levels of particulates, the LSZ 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, introduced species have cropped much of the primary production in the Bay-Delta and there has been virtually no enhancement of phytoplankton production or biomass in the LSZ (CUWA 1994, Lund et al. 2012).

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 LSZ 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 evidence suggests that vertical migration does not provide a complete explanation (Kimmerer et al. 2002).

Although evidence indicates that X2 and the LSZ 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 LSZ 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. X2 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.

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 and September through November.

**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 and salmonid mortality at the CVP and SWP fish facilities within recent years (Simi and Ruhl 2005, USFWS 2008, NMFS 2009, Wanger 2007). 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 delta and longfin smelt, striped bass, splittail, and on Chinook salmon smolts, 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 the Existing Condition, No-Action and action alternatives, by month and water year type. The most biologically sensitive 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. Per the RPAs in the USFWS 2008 and NMFS 2009 BOs, any reduction in Old and Middle River reverse flows (i.e., flows that are more negative) that result in flows greater than (i.e., flows that are more negative) -5,000 cfs are considered to be a significant impact. Additionally, a 5 percent reduction in Old and Middle River flows making them more negative is also considered a significant impact.

**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 delta smelt, longfin 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 (April to 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 by Reclamation 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 exports, and average exports 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 index 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 export rate (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

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

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

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

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

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

$D_C$ = ∑ (*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 an above-normal 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 normal 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 below-normal 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 dry 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 critical 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 LSZ 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

The analysis assessed potential effects on fish species of primary management concern and important aquatic ecological processes from construction activities and/or operations occurring in the primary study area or the extended study area. Species of primary management concern are special-status, ecologically important, and recreationally or commercially important fish species. For the upper Sacramento River (Shasta Dam to Red Bluff) portion of the primary study area, fish species of primary management concern consist of the following:

- Four runs of Chinook salmon (winter-, spring-, fall-, and late fall-run)

- Steelhead
- Green sturgeon
- Sacramento splittail
- American shad
- Striped bass

For the lower Sacramento River to the Delta portion of the extended study area, fish species of primary management concern include the same fish identified above, as well as delta smelt and longfin smelt, and exclude American shad.

For the Trinity River portion of the extended study area, fish species of primary management concern consist of 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 population growth, changes in local land use, 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 EIRs 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 supply deliveries relative to the entire CVP and SWP service areas would be small, however. Assuming increased deliveries 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 CDFW, 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.

The extent, location, and timing of induced growth are currently highly uncertain; the effects of this growth would be analyzed and mitigated during future land use planning and environmental review for specific projects. Therefore, 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 EIS 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 (CEQA Section 15382). CEQA also requires that the environmental document propose feasible measures to avoid or substantially reduce significant environmental effects (CEQA 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 CEQA; 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 CEQA, 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 CDFW, USFWS, or NMFS.
- Conflict with the provisions of an adopted HCP, natural community conservation plan, or other approved local, regional, or State HCP 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 Condition (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 reasonably foreseeable actions, including actions with current authorization, secured funding for design and construction, and environmental permitting and compliance activities that are substantially complete. However, the Federal Government would not take additional actions toward implementing a plan to raise Shasta Dam to help increase anadromous fish survival in the Sacramento River between Shasta Dam and Red Bluff, nor help address the growing water reliability issues in California. Shasta Dam would not be modified, and the CVP would continue operating similar to the Existing Condition. Changes in regulatory conditions and water supply demands would result in differences in flows on the Sacramento River and at the Delta between existing and future conditions. Possible changes include the following:

- Firm Level 2 Federal refuge deliveries
- SWP deliveries based on full Table A amounts
- Full implementation of the Grassland Bypass Project
- Implementation of salinity management actions similar to the Vernalis Adaptive Management Plan
- Implementation of the South Bay Aqueduct Improvement and Enlargement Project
- Increased San Joaquin River diversions for water users in the Stockton metropolitan area associated with the Delta Water Supply Project
- Increased Sacramento River diversions by Freeport Regional Water Project agencies
- San Joaquin River Restoration Program Full Restoration Flows

This alternative is used as a basis of comparison for future condition comparisons.

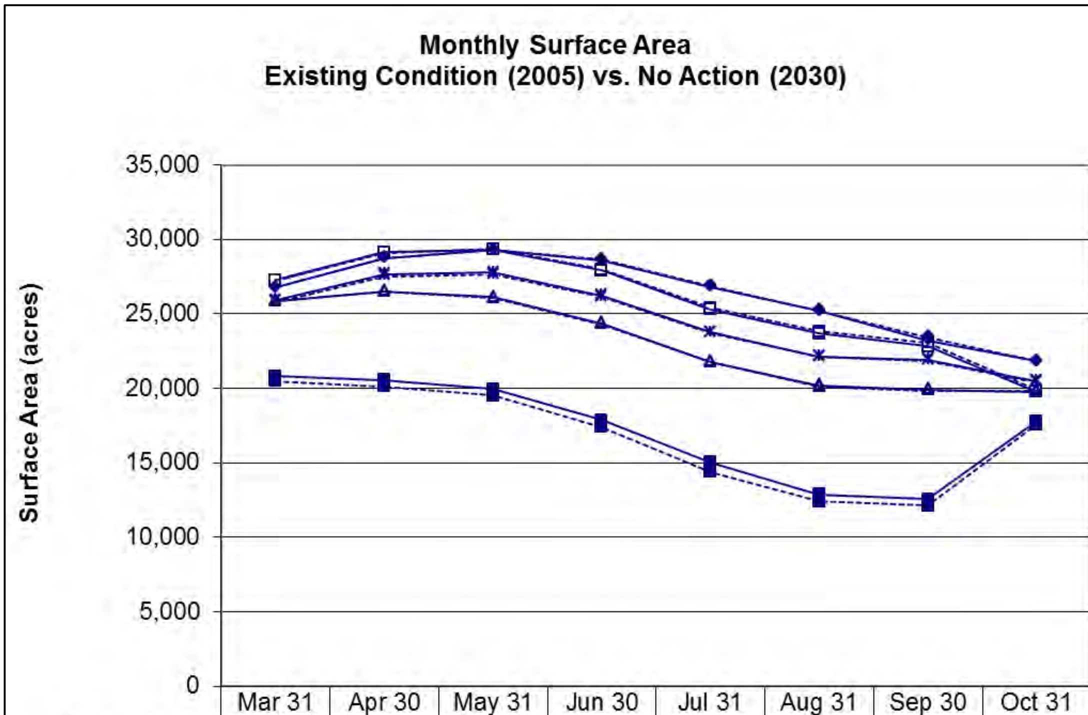
### Shasta Lake and Vicinity

*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. Such fluctuations could have an adverse effect on the quality and quantity of nearshore, warm-water habitat in the lake.

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, except critical years, would be slightly less than under the Existing Condition. The greatest potential decreases would be experienced from September through November in above-normal water years (Figure 11-2). Fluctuations in WSELs are similar for the No-Action Alternative and the Existing Condition and differ by no more than ± 1-foot in any month under all hydrologic conditions (Figure 11-3). Therefore, this impact would be less than significant. Mitigation is not required for the No-Action Alternative.

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-water habitat in the lake. Therefore, this impact would be potentially significant. Mitigation is not required for the No-Action Alternative.

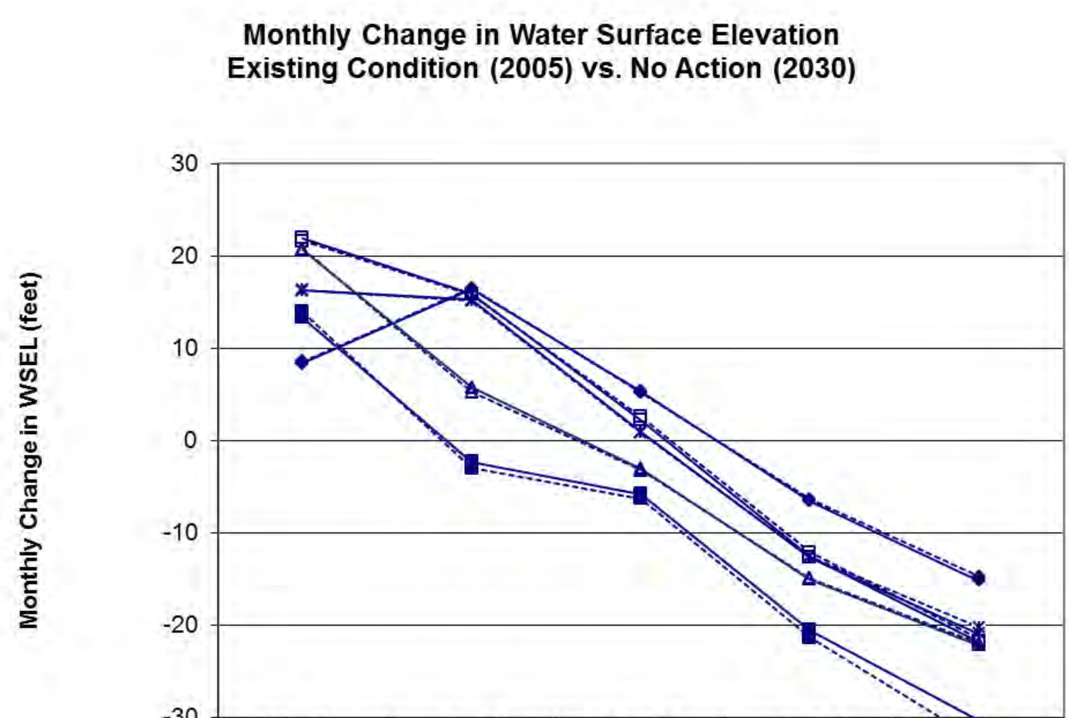
*Impact Aqua-2 (No-Action): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction* Under the No-Action Alternative, dam enlargement activities would not be implemented and no new facilities would be constructed within the vicinity of Shasta Lake. There would be no impact.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




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 |
|---|---|---|---|---|---|---|---|---|
| EC W | 26,790 | 28,748 | 29,277 | 28,624 | 26,872 | 25,226 | 23,413 | 21,827 |
| EC AN | 27,245 | 29,082 | 29,336 | 27,992 | 25,400 | 23,826 | 23,061 | 19,906 |
| EC BN | 25,807 | 27,534 | 27,621 | 26,104 | 23,714 | 22,114 | 21,837 | 20,425 |
| EC D | 25,850 | 26,467 | 26,058 | 24,300 | 21,754 | 20,093 | 19,840 | 19,828 |
| EC C | 20,467 | 20,142 | 19,500 | 17,381 | 14,400 | 12,418 | 12,111 | 17,572 |
| NA W | 26,775 | 28,735 | 29,273 | 28,604 | 26,797 | 25,183 | 23,205 | 21,808 |
| NA AN | 27,258 | 29,117 | 29,325 | 27,921 | 25,294 | 23,687 | 22,800 | 19,759 |
| NA BN | 25,918 | 27,662 | 27,770 | 26,239 | 23,764 | 22,137 | 21,923 | 20,469 |
| NA D | 25,843 | 26,514 | 26,134 | 24,346 | 21,780 | 20,209 | 19,910 | 19,728 |
| NA C | 20,801 | 20,548 | 19,942 | 17,866 | 15,026 | 12,873 | 12,556 | 17,800 |

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

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




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 |
|---|---|---|---|---|---|
| EC W | 9 | 16 | 5 | -6 | -15 |
| EC AN | 22 | 16 | 3 | -12 | -21 |
| EC BN | 16 | 15 | 1 | -13 | -20 |
| EC D | 21 | 5 | -3 | -15 | -22 |
| EC C | 14 | -3 | -6 | -21 | -32 |
| NA W | 8 | 16 | 5 | -7 | -15 |
| NA AN | 22 | 16 | 2 | -13 | -22 |
| NA BN | 16 | 15 | 1 | -13 | -21 |
| NA D | 21 | 6 | -3 | -15 | -22 |
| NA C | 13 | -2 | -6 | -21 | -30 |

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. Average Monthly Change in WSEL (in feet) for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, the Existing Condition Versus 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 cold-water fishes, such as resident trout and stocked salmon. 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.

One special-status mollusk, the California floater, is known to have historically occurred in tributaries near the head of Shasta Lake. However, surveys of historically occupied sites around Shasta Lake failed to find this species (Howard 2010), and it was not detected during reconnaissance-level surveys of the smaller perennial and intermittent tributaries to Shasta Lake in 2012 (Reclamation 2014). Nine other special-status mollusks could occupy seeps, springs, or tributaries surrounding the reservoir. However, evidence from field surveys of the lower reaches of representative tributaries to the lake did not detect any special-status mollusks (see the *Fisheries and Aquatic Ecosystems Technical Report* for details).

Except for the California floater, the probability of occurrence of other special-status mollusks in Shasta Lake and the lower reaches of its tributaries is low. 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 the USFS, the hardhead minnow, 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.

Two other USFS sensitive species, rough sculpin (in the Pit River) and redband trout (*Oncorhynchus mykiss stonei* ) (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 Red Bluff)**

*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. No project-generated variation in the storage levels of CVP and SWP reservoirs along the upper Sacramento River or tributaries would occur. If none of the project alternatives were implemented, actions to protect fisheries and aquatic resources would likely continue under existing regulatory requirements. Such actions would include other restoration/management actions intended to protect and enhance fisheries resources. Therefore, no impact would occur. 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, no project construction–related contaminant exposure in the upper

Sacramento River or tributaries would occur. If none of the project alternatives were implemented, actions to protect fisheries and aquatic resources would likely continue under existing regulatory requirements. Such actions would include other restoration/management actions intended to protect and enhance fisheries resources. Therefore, no impact would occur. 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 and Steelhead* Flow releases would continue to be operated in compliance with existing BOs and regulatory and contractual requirements, 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, 2014), which could make it more difficult, especially in critical water years, to meet the water temperature requirements needs for all runs of Chinook salmon, particularly winter-run and spring-run Chinook salmon, as well as steelhead. As a result, the impact to Chinook salmon and steelhead in the upper Sacramento River would be potentially significant. 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 and other regulatory and contractual requirements, which represent the regulatory baseline. However, climate change would likely result in an increase in water temperatures (NMFS 2009, 2014). This could make it much more difficult, especially in critical water years, to meet the water temperature requirements for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass. As a result, this impact would be potentially significant. 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, no change to the ongoing geomorphic processes in the upper Sacramento River would occur. No impact would occur. Mitigation is not required for the No-Action Alternative.

**Lower Sacramento River, Tributaries, Delta and Trinity River** Under the No-Action Alternative, no project-related alteration of CVP and SWP reservoir storage levels, river flows, or water temperatures would occur in the lower Sacramento River, tributaries, and Delta. If none of the project alternatives were implemented, actions to protect fisheries and benefit aquatic environments would likely continue under existing regulatory requirements. Such actions would include other restoration/management actions intended to protect and enhance fisheries resources. Compliance with existing BOs would result in continued pumping curtailments, particularly in dry years. Reclamation and DWR would continue to attempt to reoperate the CVP and SWP, respectively, to avoid decreased deliveries to export users. Therefore, no change in impacts on fisheries and aquatic ecosystems in the lower Sacramento River, tributaries, and Delta would occur under the No-Action Alternative.

Under the No-Action Alternative, no project-related alteration of CVP and SWP reservoir storage levels, river flows, or water temperatures would occur in the Trinity River. Therefore, no change in impacts on aquatic resources in the Trinity River would occur under the No-Action Alternative.

**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 restoration/management 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 and increasing anadromous fish survival. This plan primarily consists of raising Shasta Dam by 6.5 feet, which, in combination with spillway modifications, would increase the height of the reservoir's full pool by 8.5 feet and enlarge the total storage capacity in the reservoir by 256,000 acre-feet. The existing TCD would also be extended to achieve efficient use of the expanded cold-water pool. Shasta Dam operational guidelines would continue essentially unchanged, except during dry years and critical years, when 70,000 acre-feet and 35,000 acre-feet, respectively, of the increased storage capacity in Shasta Reservoir would be reserved to specifically focus on increasing municipal and industrial (M&I) deliveries. CP1 would help reduce future water shortages through increasing drought year and average year water supply reliability for agricultural and M&I deliveries. In addition, the increased depth and volume of the cold-water pool in Shasta Reservoir would contribute to improving seasonal water temperatures for anadromous fish in the upper Sacramento River.

#### Shasta Lake and Vicinity

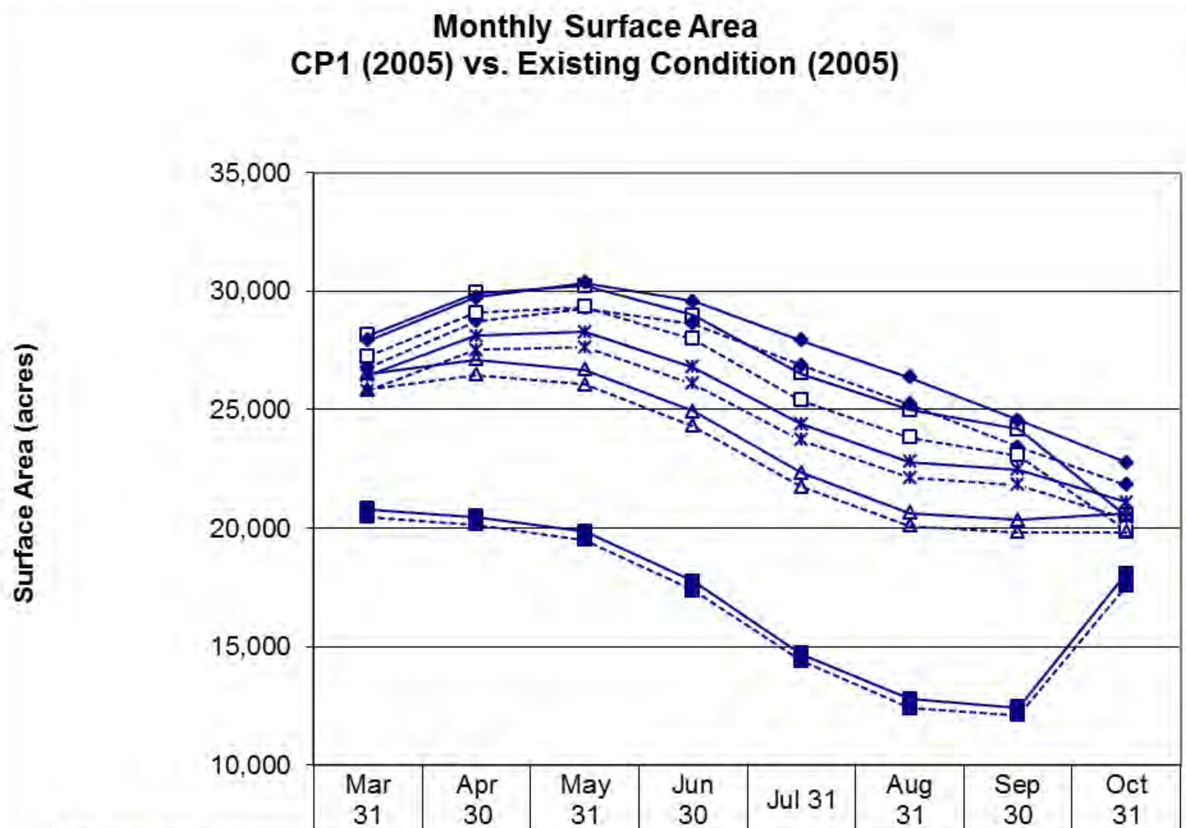
*Impact Aqua-1 (CP1): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations* Under CP1, project operations would contribute to an increase in the surface area and WSEL of Shasta Lake, which would in turn increase the area and productivity of nearshore, warm-water habitat. Project 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 installed 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. The environmental commitments described in Chapter 2, "Alternatives," include maintaining and enhancing brush structures and placing large woody debris and rock/boulder clusters within the CP1 innundation zone. 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 average reservoir pool elevation. 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 for all five water year types (Figure 11-4). The Shasta Lake surface area would be larger under CP1 with a 2030 water supply demand than under the No-Action Alternative in all five water years (Figure 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.

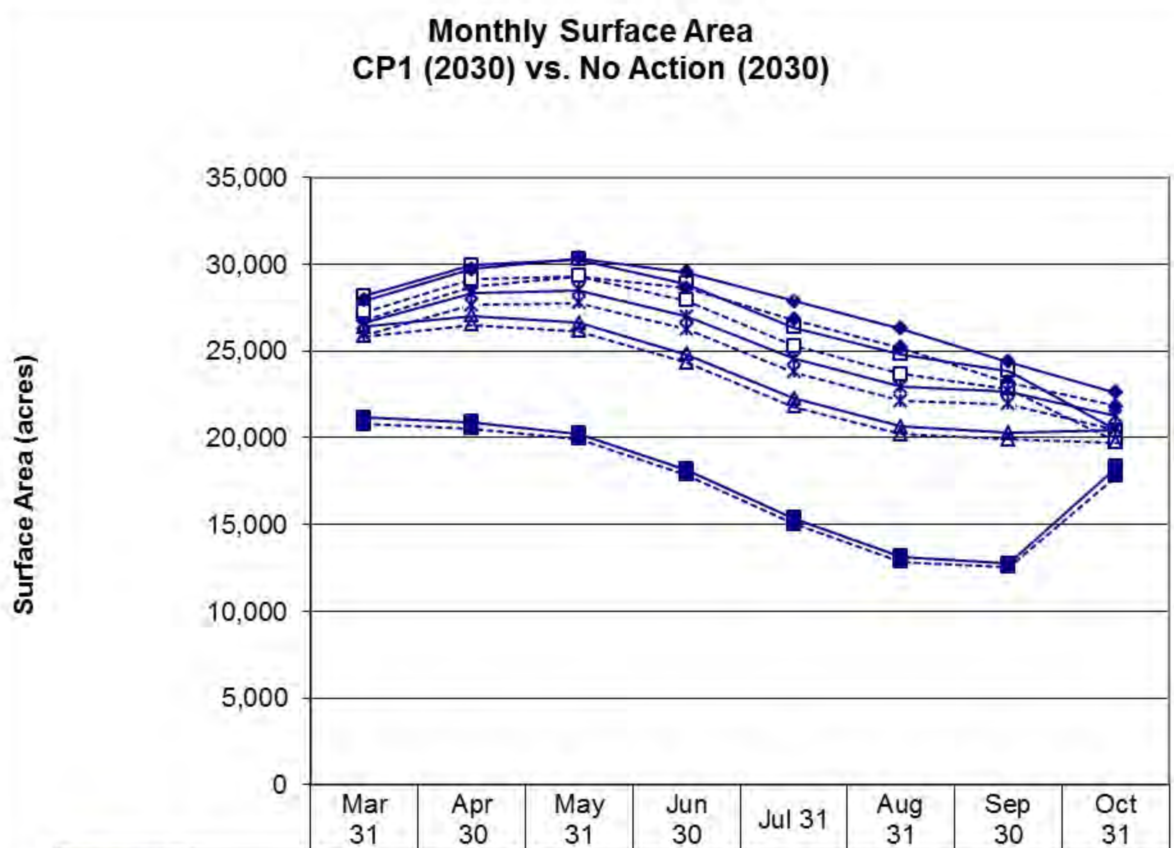
According to CalSim-II modeling, the Shasta Lake WSEL would be higher under CP1 with a 2005 water supply demand than under the Existing Condition for all five water year types. The Shasta Lake WSEL would also be higher under CP1 with a 2030 water supply demand than under the No-Action Alternative in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




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 |
|---|---|---|---|---|---|---|---|---|
| EC W | 26,790 | 28,748 | 29,277 | 28,624 | 26,872 | 25,226 | 23,413 | 21,827 |
| EC AN | 27,245 | 29,082 | 29,336 | 27,992 | 25,400 | 23,826 | 23,061 | 19,906 |
| EC BN | 25,807 | 27,534 | 27,621 | 26,104 | 23,714 | 22,114 | 21,837 | 20,425 |
| EC D | 25,850 | 26,467 | 26,058 | 24,300 | 21,754 | 20,093 | 19,840 | 19,828 |
| EC C | 20,467 | 20,142 | 19,500 | 17,381 | 14,400 | 12,418 | 12,111 | 17,572 |
| CP1 2005 W | 27,923 | 29,734 | 30,345 | 29,575 | 27,935 | 26,353 | 24,562 | 22,784 |
| CP1 2005 AN | 28,141 | 29,920 | 30,228 | 28,974 | 26,520 | 24,980 | 24,184 | 20,527 |
| CP1 2005 BN | 26,431 | 28,118 | 28,273 | 26,798 | 24,404 | 22,790 | 22,475 | 21,099 |
| CP1 2005 D | 26,520 | 27,106 | 26,682 | 24,934 | 22,347 | 20,633 | 20,348 | 20,615 |
| CP1 2005 C | 20,806 | 20,488 | 19,848 | 17,746 | 14,716 | 12,787 | 12,428 | 18,087 |

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




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 |
|---|---|---|---|---|---|---|---|---|
| NA W | 26,775 | 28,735 | 29,273 | 28,604 | 26,797 | 25,183 | 23,205 | 21,808 |
| NA AN | 27,258 | 29,117 | 29,325 | 27,921 | 25,294 | 23,687 | 22,800 | 19,759 |
| NA BN | 25,918 | 27,662 | 27,770 | 26,239 | 23,764 | 22,137 | 21,923 | 20,469 |
| NA D | 25,843 | 26,514 | 26,134 | 24,346 | 21,780 | 20,209 | 19,910 | 19,728 |
| NA C | 20,801 | 20,548 | 19,942 | 17,866 | 15,026 | 12,873 | 12,556 | 17,800 |
| CP1 2030 W | 27,913 | 29,722 | 30,342 | 29,548 | 27,861 | 26,284 | 24,361 | 22,615 |
| CP1 2030 AN | 28,164 | 29,959 | 30,258 | 28,879 | 26,366 | 24,810 | 23,840 | 20,432 |
| CP1 2030 BN | 26,626 | 28,325 | 28,490 | 26,992 | 24,551 | 22,929 | 22,688 | 21,244 |
| CP1 2030 D | 26,417 | 27,031 | 26,615 | 24,808 | 22,278 | 20,626 | 20,266 | 20,430 |
| CP1 2030 C | 21,154 | 20,891 | 20,244 | 18,157 | 15,377 | 13,136 | 12,759 | 18,334 |

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

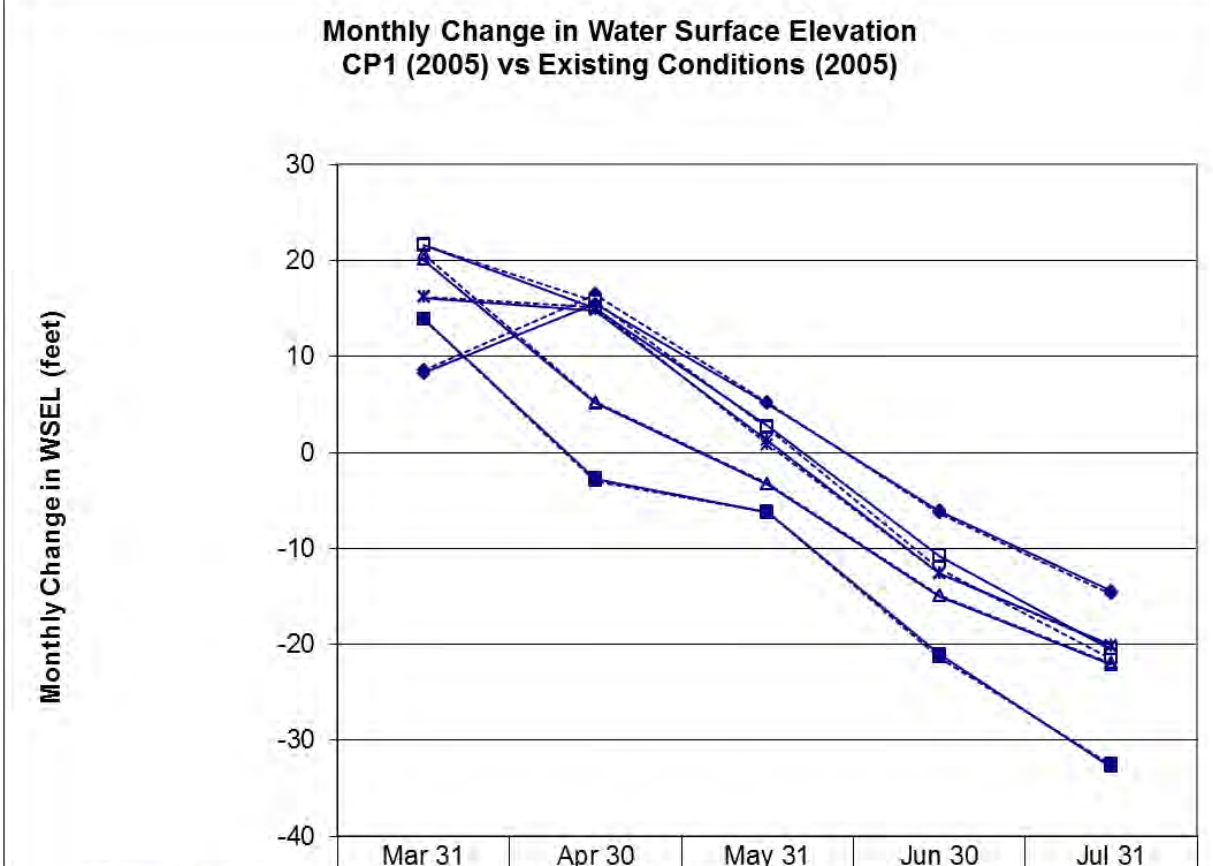
**Figure 11-5. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP1 (2030) Versus No-Action Alternative**

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; Lee 1999). Jones & 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, 24 percent of monthly changes in projected WSELs (i.e., 6 of the 25 total projections made for the 5 months from March through July for all five water year types) showed decreased monthly WSEL fluctuations relative to the Existing Condition and 4 percent showed a slight increase in monthly WSEL fluctuations (Figure 11-6). For CP1 with a projected 2030 water supply demand, 36 percent of monthly changes in projected WSELs showed decreased WSEL fluctuations relative to the No-Action Alternative and 4 percent showed a slight increase in monthly WSEL fluctuations (Figure 11-7).

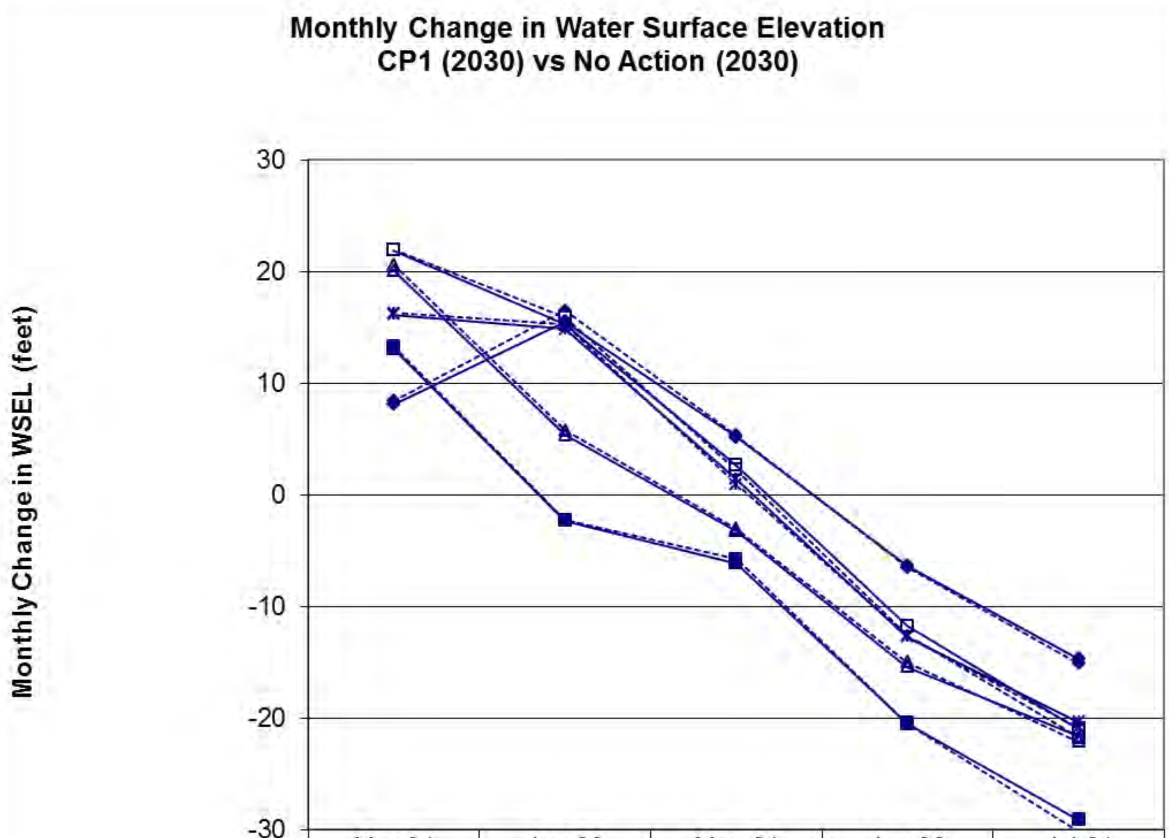
Increases in the overall surface area and WSEL under CP1 would increase the area of available warm-water habitat and stimulate biological productivity, including fish production, of the entire lake, although the value of structural and vegetative improvements that currently provide effective structural habitat at specific locations will be decreased to some extent. This effect will be offset by (1) using brush and trees cleared for other project purposes and placing them in the new inundation varial zone to provide structural fish habitat; (2) identifying locations for planting and monitoring of structural plants such as willows, buttonbrush and cottonwoods (See Chapter 2, “Alternatives,” for additional detailed descriptions of the environmental commitments); and (3) retaining newly inundated vegetation along more than 40 percent of the increased shoreline area. 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 | 16 | 5 | -6 | -15 |
| EC AN | 22 | 16 | 3 | -12 | -21 |
| EC BN | 16 | 15 | 1 | -13 | -20 |
| EC D | 21 | 5 | -3 | -15 | -22 |
| EC C | 14 | -3 | -6 | -21 | -32 |
| CP1 2005 W | 8 | 15 | 5 | -6 | -14 |
| CP1 2005 AN | 22 | 15 | 3 | -11 | -21 |
| CP1 2005 BN | 16 | 15 | 1 | -13 | -20 |
| CP1 2005 D | 20 | 5 | -3 | -15 | -22 |
| CP1 2005 C | 14 | -3 | -6 | -21 | -33 |

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
WSEL = water surface elevation

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




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 |
|---|---|---|---|---|---|
| NA W | 8 | 16 | 5 | -7 | -15 |
| NA AN | 22 | 16 | 2 | -13 | -22 |
| NA BN | 16 | 15 | 1 | -13 | -21 |
| NA D | 21 | 6 | -3 | -15 | -22 |
| NA C | 13 | -2 | -6 | -21 | -30 |
| CP1 2030 W | 8 | 15 | 5 | -6 | -15 |
| CP1 2030 AN | 22 | 15 | 3 | -12 | -21 |
| CP1 2030 BN | 16 | 15 | 1 | -13 | -20 |
| CP1 2030 D | 20 | 5 | -3 | -15 | -22 |
| CP1 2030 C | 13 | -2 | -6 | -21 | -29 |

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. Average Monthly Change in WSEL for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP1 Versus 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 described in Chapter 2, "Alternatives," for all action alternatives include the development and implementation of a Construction Management Plan, Erosion and Sediment Control Plan, Stormwater Pollution Prevention Plan (SWPPP), and Revegetation Plan as well as water quality and fisheries conservation measures (e.g., stockpiling of materials for future use as fish habitat structure or installation concurrent with construction activity) 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.

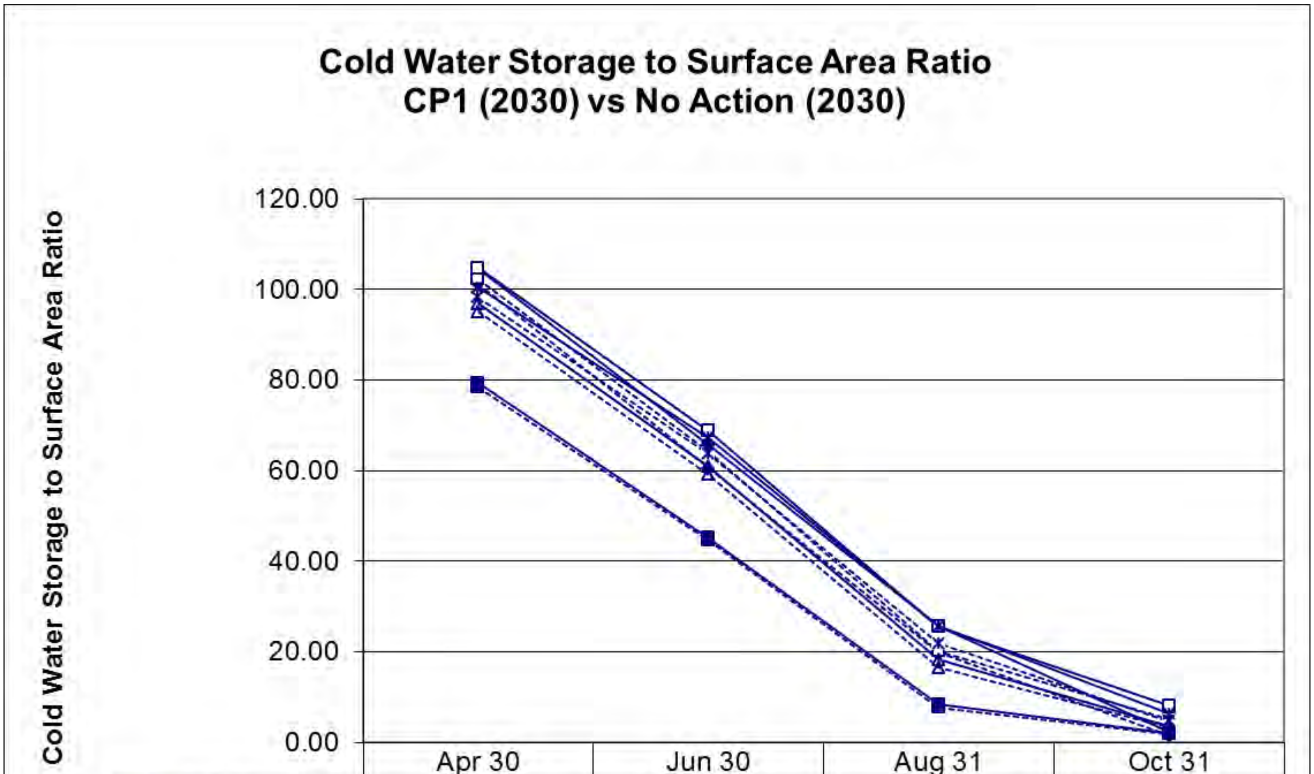
*Impact Aqua-3 (CP1): Effects on Cold-Water Habitat in Shasta Lake* Under CP1, operations-related changes in the ratio of the volume of cold-water storage to surface area would increase the availability of suitable habitat for cold-water fish in Shasta Lake, including rainbow trout. This impact would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

CalSim-II modeling showed that under CP1 with a 2030 water supply demand[3], 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 a critical rearing and oversummering period for cold-water fishes in reservoirs; the increases were highest in wet water years (Figure 11-8). The proportional increase in the cold-water storage to surface area ratio would result in increased cold-water fish productivity (Stables et al. 1990, Jones and Stokes Associates 1988).

CP1 would increase the availability of suitable habitat for cold-water fish in Shasta Lake and would increase cold-water fish production. 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.

[3] Only the 2030 water demand scenario is shown for this reservoir fishery metric because it illustrates the worst case benefit to cold-water fisheries of the water demand scenarios analyzed.




| | Apr 30 | Jun 30 | Aug 31 | Oct 31 |
|---|---|---|---|---|
| NA W | 101.33 | 60.49 | 19.89 | 1.43 |
| NA AN | 102.30 | 64.04 | 20.12 | 5.09 |
| NA BN | 98.27 | 63.71 | 21.84 | 4.64 |
| NA D | 95.13 | 59.14 | 16.50 | 3.38 |
| NA C | 78.43 | 44.58 | 7.66 | 1.82 |
| CP1 2030 W | 104.60 | 65.65 | 25.58 | 2.32 |
| CP1 2030 AN | 104.79 | 68.73 | 25.54 | 8.10 |
| CP1 2030 BN | 100.42 | 67.24 | 25.68 | 6.26 |
| CP1 2030 D | 96.84 | 60.84 | 18.29 | 3.64 |
| CP1 2030 C | 79.30 | 45.13 | 8.32 | 1.96 |

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

The occurrence of special-status mollusks in Shasta Lake and the lower reaches of its tributaries is unlikely. California floaters historically occurred in the tributaries, but have not been observed in recent surveys (Howard 2010, Reclamation 2014). Modification or loss of suitable habitat for the California floater would occur through 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, "Mitigation Measures."

*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 known to occur there, the hardhead. This impact would be less than significant.

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 fish 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, although high annual fluctuations in surface level and the abundance of warm-water predators, primarily sunfishes and basses, in the lake already likely limits the hardhead population there (Moyle 2002, J. Zustak 2007). Hardhead prefer low-gradient, clear and deep (greater than 2.5 feet) flatwater-stream habitat with sand-gravel-boulder substrates, 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 shift the transition reaches farther upstream in the tributaries.

No hardhead were detected in tributary stream fish surveys in 2011 or 2012 (see *Fisheries and Aquatic Ecosystems Technical Report* for details). Hardhead were not observed in surveys conducted in the Sacramento and McCloud rivers in the vicinity of Shasta Lake (Nevares and Liebig 2007, Weaver and Mehalik 2008), suggesting that this species may not occur in these tributaries or is very uncommon. Therefore, 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 approximately the 1,080-foot contour, the maximum inundation level under this alternative. This impact would be less than significant.

Potential impacts of reservoir enlargement may occur in areas where fish communities are currently impeded or isolated by passage barriers. Fifty-four percent of the intermittent and 30 percent of the perennial tributaries surveyed in 2012 contained partial or complete barriers to fish migration between the 1,070-foot and 1,090-foot elevation contours. Twenty-two percent of the perennial tributaries (34 total perennial tributaries) and 24 percent (259 total intermittent tributaries) of the intermittent tributaries (of which only 18 percent are potentially fish bearing and only 2 percent of those were fish-bearing in 2012) to Shasta Lake have partial or complete fish passage barriers between the 1,070 and 1,076-foot contours subject to full or partial inundation under CP1. Sixty-one percent of the streams with passage impediments between the 1,070-foot and 1,090-foot contours also had impediments upstream from 1,090-foot contour (i.e., even if downstream barriers were periodically inundated, the length of additional stream habitat that would be accessible to fish from Shasta Lake is limited, particularly in intermittent tributaries).

The likelihood of potential impacts is greater in perennial tributaries as the proportion of these streams bearing fish (87 percent) is much greater than intermittent streams (2 percent) and in tributaries where inundation may create fish passage conditions at existing complete passage barriers. However, the estimated number of streams with complete passage barriers between the 1,070-foot and 1,090-foot contours is only 15 of the 154 perennial tributaries to Shasta Lake (see *Fisheries and Aquatic Ecosystems Technical Report* for details). Five streams with fish passage impediments near the existing full reservoir elevation, including two unnamed intermittent tributaries and three perennial tributaries, Little Squaw Creek, Squaw Creek and Indian Creek. The CP1 reservoir enlargement scenario would at least partially inundate these barriers at a new full pool, potentially allowing fish from the reservoir to immigrate into these streams. This could have a small and localized beneficial effect for adfluvial cold-water fishes in Shasta Lake by increasing the amount of suitable spawning and rearing habitat available for these species.

Inundation of fish passage impediments in tributaries to Shasta Lake would not adversely affect hardhead because: (1) hardhead are uncommon; and (2) it would not facilitate fish passage of predatory warm-water fish species into streams where these species do not already both occur. Under CP1, inundation may create passage opportunities for warm-water fish species into some currently inaccessible portions of these tributaries, which could alter existing resident fish communities in those areas. However, the upstream extent of any colonization by warm-water species is expected to be limited primarily to the newly inundated reaches based on current distribution patterns. With the exception of the main river tributaries (i.e., Sacramento, Pit, and McCloud rivers, and Squaw Creek), less than 10 percent of the lake's currently accessible tributaries have been found to be colonized by warm-water fish upstream from the existing inundation zone.

CP1 would not result in the widespread c*reation or elimination of fish passage barriers in tributaries to Shasta Lake that would affect existing fish communities. However, inundation of a barrier near the mouth of Squaw Creek could potentially allow warm-water fish to move upstream and colonize previously inaccessible habitat with consequent effects on the native fish community and some mollusks, such as California floater, a USFS sensitive* *species. Environmental commitments to monitor fish communities in Squaw Creek and adaptively manage to prevent warm-water fish invasions in Squaw Creek, as described in Chapter 2, "Alternatives," would reduce this impact to a less than significant level.* 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 hydraulic 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.

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 and estimated suitable spawning habitat areas (both intermittent and perennial) that would be periodically affected are as follows:

- Sacramento Arm – 2.2 miles (7,040 square feet, excludes mainstem river)
- McCloud Arm – 1.1 miles (9,768 square feet)
- Pit Arm – 1.0 mile (355 square feet, excludes mainstem river)
- Big Backbone Arm – 0.5 miles (106 square feet)
- Squaw Arm – 0.6 miles (1,300 square feet)

Only 5.4 miles of low-gradient reaches that could potentially provide some spawning and rearing habitat for adfluvial salmonids (based on channel slope, and confirmed by surveys of representative stream reaches) would be affected by CP1, which is only about 1.4 percent of the low-gradient habitat upstream from Shasta Lake. Although a small proportion of total stream mileage would be affected by CP1, most of the suitable spawning habitat between the 1,070-foot and 1,090-foot contours was estimated to occur in this reach.

Only 7 percent of intermittent streams surveyed contained suitable salmonid spawning habitat between the 1,070-foot and 1,080-foot contours, while 71 percent of perennial streams contained suitable salmonid spawning habitat (see

*Fisheries and Aquatic Ecosystems Technical Report* for details). The cumulative estimated area of suitable cold-water spawning habitat in all intermittent tributaries to Shasta Lake between the 1,070-foot and 1,080-foot contours was only 205 square feet. Thus, the contribution of intermittent streams, of which only 2 percent are considered to be fish bearing, to spawning and rearing habitat for adfluvial salmonids in Shasta Lake is, collectively, very small. Conversely, approximately 23,253 square feet of suitable cold-water spawning habitat, exclusive of mainstem habitat in the Sacramento and Pit rivers, was estimated to occur within the projected varial zone of perennial tributaries under CP1. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

*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 intermittent tributaries to Shasta Lake. About 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 habitat upstream from Shasta Lake.

As described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils," CP1 would inundate intermittent 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 based on channel slope (greater than 7 percent) and confirmed by surveys of representative stream reaches for each arm of Shasta Lake that would be periodically inundated are as follows:

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

Surveys of representative tributaries determined that 52 percent of perennial tributaries to Shasta Lake were inhabited by special-status vertebrate species[4], but none occurred in the intermittent tributaries surveyed. No special-status invertebrates (e.g., aquatic mollusks) were detected by casual surveys and benthic sampling of the smaller perennial and intermittent tributaries to Shasta Lake in 2011 or 2012 (see *Fisheries and Aquatic Ecosystems Technical Report*

[4] Hardhead minnow, a USFS sensitive species and foothill yellow-legged frog, a USFS and CDFW sensitive species

for details). Field surveys indicate that few, if any of the non-fish-bearing streams, particularly intermittent ones, contain special-status invertebrate or vertebrate species that would be affected by increased connectivity to 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.

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

**Upper Sacramento River (Shasta Dam to Red Bluff)**

*Impact Aqua-10 (CP1): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities* Temporary construction-related increases in sediments and turbidity levels would adversely affect aquatic habitats and fish populations immediately downstream in the upper Sacramento River. However, environmental commitments would be in place to reduce the effects. This impact would be less than significant.

Increasing the height of Shasta Dam, constructing haul roads, using staging areas, and placing excavated material could disturb sediments and soils within and adjacent to waterways. Any construction-related erosion or disturbance of sediments and soils would temporarily increase downstream turbidity and sedimentation throughout the primary study area if soils were transported in river flows, stormwater runoff, or reservoir water. Such sedimentation and increased turbidity, or other contamination, would be most pronounced in the segment of river from Shasta Dam to Keswick Dam because of 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 fish migration; therefore, all anadromous fish species are downstream from this facility. (See Chapter 7, “Water Quality,” for additional discussion of this issue.)

The abundance, distribution, and survival of fish populations 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. Such exposure would also result in a thickening of the gills, potentially causing the loss of respiratory function; in clogging and abrasion of gills; and in increased stress levels, which in turn could reduce tolerance to disease and toxicants (Waters 1995, Clark and Wilber 2000, Newcombe and Jensen 1996, Wilber and Clark 2001). Turbidity also could result in increased water temperature and decreased DO levels, especially in low-velocity pools, which can cause stressed respiration.

High levels of suspended sediments could also cause redistribution and movement of fish populations in the upper Sacramento River, and could diminish the character and quality of the physical habitat important to fish survival. Deposited sediments can reduce water depths in stream pools and can contribute to a reduction in carrying capacity for juvenile and adult fish (Waters 1995). Increased sediment loading downstream from construction areas would degrade food-producing habitat, by interfering with photosynthesis of aquatic flora, and could displace aquatic fauna.

Many fish, including salmonids, are sight feeders; turbid waters reduce the ability of these fish to locate and feed on prey. Some fish, particularly juveniles, likely would become disoriented and leave the areas where their main food sources are located, ultimately reducing growth rates.

Prey of fish populations, such as macroinvertebrates, could be adversely affected by declines in habitat quality (water quality and substrate conditions) caused by increased turbidity, decreased DO content, an increased level of pollutants (Coull and Chandler 1992), and (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 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, increased turbidity attributed to construction activities could preclude fish from occupying habitat required for specific life stages. In some locations, few opportunities for escape from turbid waters may be available, particularly during low-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 best management practices (BMP), including a Construction Management Plan, Erosion and Sediment Control Plan, Storm Water Pollution Prevention Plan (SWPPP), and revegetation plan. Water quality and fisheries conservation measures would also be implemented and project activities would be in compliance with all required permit terms and conditions. With implementation of these environmental commitments, this impact would be less than significant. 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. Such exposure could adversely affect aquatic habitats, the aquatic food web, and fish populations, including special-status species, downstream in the primary study area. However, environmental commitments would be in place to reduce the effects. Therefore, this impact would be less than significant.

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

A potential release of hazardous materials into the upper Sacramento River could reduce aquatic habitats and fish populations if proper procedures were not implemented to contain the discharge. However, the environmental commitments for all action alternatives include the development and implementation of a Construction Management Plan, Emergency Response Plan, Erosion and Sediment Control Plan, SWPPP, and revegetation plan. They also include implementation of water quality and fisheries conservation measures and compliance with all required permit terms and conditions. With implementation of these environmental commitments, this impact would be less than significant. Mitigation for this impact is not needed, and thus is not proposed.

*Impact Aqua-12 (CP1): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon and Steelhead* CP1 operation would result in generally improved flow and water temperature conditions in the upper Sacramento River for Chinook salmon and steelhead relative to both the No-Action Alternative and the Existing Condition, but not all runs show a significant (greater than 5 percent) increase in production. This impact would be less than significant.

*Winter-Run Chinook Salmon*

<u>Production</u>

CP1 would have a less-than-significant (less than 5 percent) average decrease in winter-run Chinook salmon production relative to the Existing Condition and the No-Action Alternative. The maximum increase in simulated production relative to the No-Action Alternative for CP1 was nearly 23 percent (critical water year). The largest decrease in production relative to the No-Action

Alternative was less than 5 percent (Table 11-5, Figure 11-9, and Attachment 3 of the Modeling Appendix). The largest increase in production relative to the Existing Condition for CP1 was 54 percent, while the largest decrease was -27 percent (Table 11-4 and Attachment 4 of the Modeling Appendix).

Figure 11-9 shows the change in production relative to the No-Action Alternative for all water years and all comprehensive plans. Separating production by water year type to focus on critical water years (when water storage is more reliable) showed an average 0.6-percent increase over the No-Action Alternative, but 2 out of 10 critical water years resulted in a significant (greater than 5 percent) increase in winter-run production relative to the No-Action Alternative, ranging from 0.1 percent to almost 23 percent (Table 11-4).

**Table 11-4. Change in Production by Water Year Type Under CP1 for Winter-Run Chinook Salmon**

| Year Type | No. of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 81 | 3,792,084 | -9,031 | -0.2 | 22.7 | 2 | -4.9 | 0 |
| **Critical** | 13 | 3,397,023 | 19,067 | 0.6 | 22.7 | 2 | -4.8 | 0 |
| **Dry** | 17 | 3,973,270 | 940 | 0.0 | 3.3 | 0 | -3.9 | 0 |
| **Below Normal** | 14 | 3,943,663 | 5,104 | 0.1 | 2.0 | 0 | -2.0 | 0 |
| **Above Normal** | 11 | 3,837,410 | -21,520 | -0.6 | 0.9 | 0 | -1.4 | 0 |
| **Wet** | 26 | 3,770,350 | -31,928 | -0.8 | 2.2 | 0 | -4.9 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 3,770,537 | -10,710 | -0.3 | 54.0 | 2 | -27.3 | 2 |
| **Critical** | 13 | 3,225,352 | 14,413 | 0.4 | 54.0 | 2 | -27.3 | 1 |
| **Dry** | 17 | 3,975,760 | -8,101 | -0.2 | 4.0 | 0 | -1.9 | 0 |
| **Below Normal** | 14 | 3,946,894 | 6,745 | 0.2 | 3.0 | 0 | -1.4 | 0 |
| **Above Normal** | 11 | 3,839,788 | -12,894 | -0.3 | 3.4 | 0 | -3.9 | 0 |
| **Wet** | 26 | 3,784,684 | -33,452 | -0.9 | 2.2 | 0 | -5.3 | 1 |

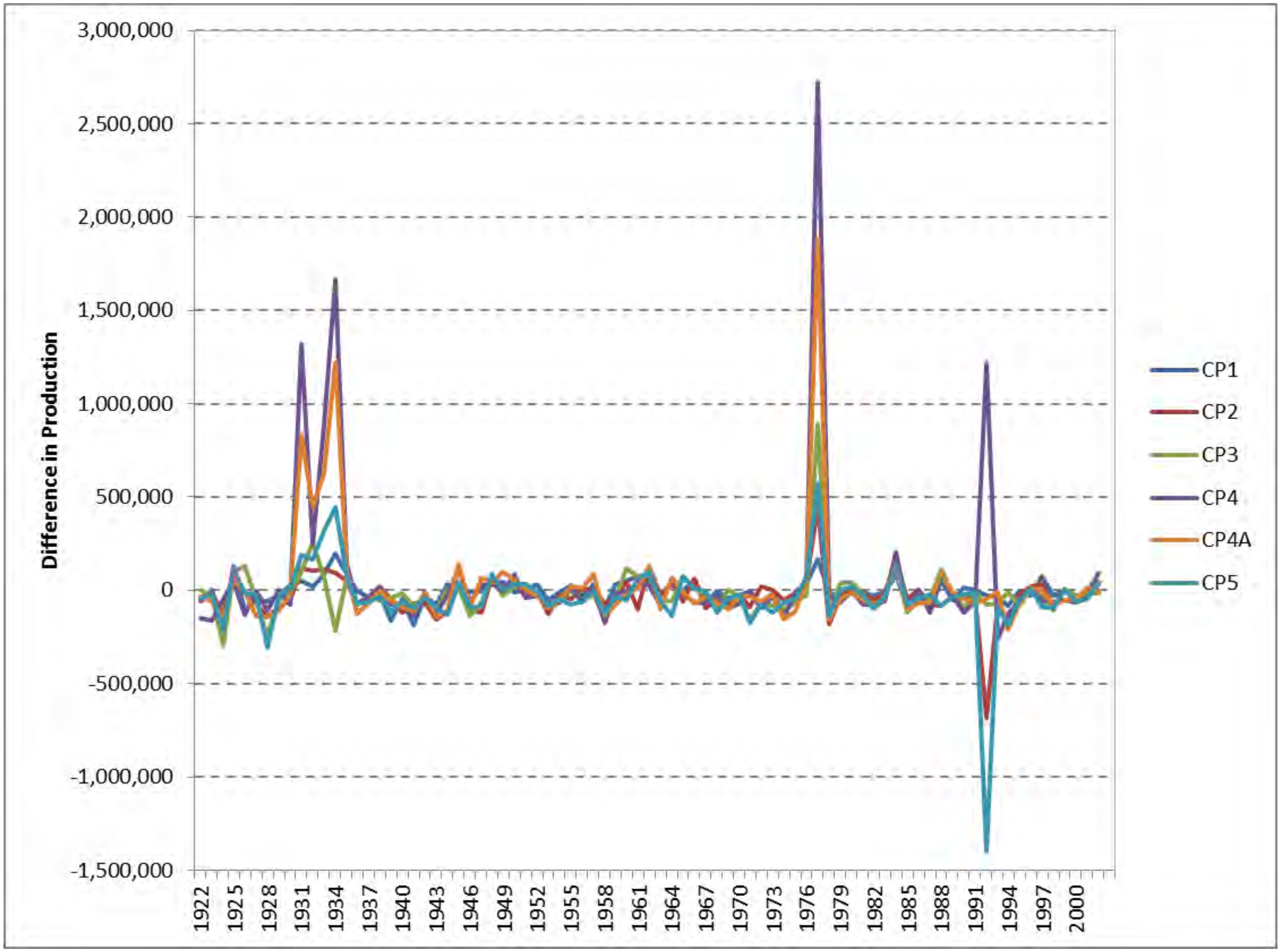
Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:

CP = Comprehensive Plan

No. = number




Key: CP = Comprehensive Plan

**Figure 11-9. Change in Production of Winter-Run Chinook Salmon Compared to the No-Action Alternative**

CP1 production under 2005 conditions was similar to the Existing Condition. The maximum increase in production was 54 percent for CP1, and the largest decrease in production was less than 5 percent for CP1 (Table 11-4 and Attachment 4 of the Modeling Appendix). Under CP1, 2 out of 10 critical water years resulted in a significant increase in winter-run production relative to the Existing Condition with a maximum of 54 percent; however, water year 1992 resulted in a -27-percent decrease in production. In all other water years, there was an insignificant change in production except for wet water year 1928, which decreased production by -5.3 percent.

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on winter-run Chinook salmon caused by the actions of the project (Attachments 3 and 4 of the Modeling Appendix). Nonoperations-related mortality are the base and seasonal mortality that would occur even without the effects of Shasta operations (such as disease, predation, and entrainment). Flow- and water temperature-related mortality is that caused by altering flow and water temperatures. In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)− around 86 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 3 and 4 of the Modeling Appendix). The greatest average mortality to winter-run Chinook salmon under CP1 in all water year types based on smolt equivalents would occur to the fry life stage, followed by eggs, then presmolts, and lastly to immature smolts. Table 11-5 displays the overall mortalities for each Comprehensive Plan that were caused by changes in operations (i.e., water temperature and flow) (Attachments 3 and 4 of the Modeling Appendix).

Years with the highest simulated flow- and water temperature-related mortality were the same for the No-Action Alternative, the Existing Condition, and CP1. Each of these years was a critical water year, and was preceded by either a critical (1976, 1991), or dry (1930, 1932). Years in which the project had the greatest effect, both as an increase and decrease in production were the years in which the lowest production occurs (Attachments 3 and 4 of the Modeling Appendix).

**Table 11-5. Average Annual Winter-Run Chinook Salmon Smolt Equivalent Mortality Under Each Base Condition and the Difference in Mortality Under Each Comprehensive Plan Caused by Changes in Flow and Water Temperature**

| Plan | Egg Count Based on Smolt Equivalent[1,2] | Difference in Mortality Factor from Baseline Condition (in Smolt Equivalents) | | | | | | | | | | Total (in Smolt Equivalents) | Percent Mortality[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pre-spawn | Incu-bation | Super-Imposition | Eggs Temp | Fry Temp | Fry Habitat | Pre-smolt Temp | Pre-smolt Habitat | Immature Smolt Temp | Immature Smolt Habitat | | |
| **Future Condition (2030)** | | | | | | | | | | | | | |
| **No-Action Alternative** | 7,534,801 | 8 | 71,606 | 2,777 | 36,693 | 11,848 | 360,066 | 13,991 | 2,750 | 0 | 302 | 500,040 | 6.6 |
| **CP1** | 7,519,462 | 0 | -3,684 | -133 | -147 | 1,306 | 5,518 | 524 | -229 | 0 | -10 | 3,143 | 6.7 |
| **CP2** | 7,489,492 | -1 | -4,661 | -68 | 2,453 | 783 | 12,023 | -1,355 | -382 | 0 | -29 | 8,763 | 6.8 |
| **CP3** | 7,500,867 | -1 | -4,102 | -256 | -1,547 | 958 | 4,333 | -519 | -410 | 0 | -55 | -1,600 | 6.6 |
| **CP4** | 7,617,894 | 0 | 593 | -175 | -23,972 | -8,403 | 9,078 | -9,165 | 162 | 0 | -95 | -31,976 | 6.1 |
| **CP4A** | 7,576,083 | -1 | -3,165 | -85 | -9,850 | -2,181 | 9,370 | -3,786 | -356 | 0 | -59 | -10,112 | 6.5 |
| **CP5** | 7,474,687 | -1 | -7,323 | 267 | 2,012 | 554 | 11,862 | -1,311 | -304 | 0 | -13 | 5,743 | 6.8 |
| **Existing Condition (2005)** | | | | | | | | | | | | | |
| **Existing Condition** | 7,496,582 | 8 | 73,885 | 2,127 | 43,031 | 12,704 | 347,547 | 13,581 | 2,560 | 0 | 282 | 495,724 | 6.6 |
| **CP1** | 7,474,164 | 0 | -3,725 | 20 | -2,847 | -1,404 | 9,423 | -1,568 | 41 | 0 | 9 | -52 | 6.6 |
| **CP2** | 7,486,271 | 0 | -3,597 | -97 | -9,890 | -2,013 | 20,242 | -3,413 | -142 | 0 | -26 | 1,063 | 6.6 |
| **CP3** | 7,508,897 | -1 | -1,823 | -69 | -4,143 | 535 | 8,189 | -2,577 | -135 | 0 | -9 | -31 | 6.6 |
| **CP4** | 7,626,344 | 0 | 708 | 119 | -28,096 | -9,099 | 14,407 | -9,017 | 26 | 1 | 4 | -30,948 | 6.1 |
| **CP4A** | 7,582,763 | 0 | -1,441 | -93 | -17,947 | -4,448 | 15,327 | -5,911 | -170 | 0 | -10 | -14,693 | 6.3 |
| **CP5** | 7,467,882 | 0 | -6,156 | 135 | -4,983 | -1,490 | 14,976 | -2,994 | -234 | 0 | -25 | -771 | 6.6 |

Notes:

[1] The potential number of smolt equivalent is based on the spawning population of 8,591 adults, using the formula:
Immature Smolt Equivalent Mortality = Mortality * % Survival $_{(eggs\ to\ fry)}$ * % Survival $_{(fry\ to\ presmolts)}$ * % Survival $_{(presmolts\ to\ immature\ smolts)}$

[2] Values in these two columns do not constitute a difference from the baseline condition.

Key:

CP = Comprehensive Plan

Because winter-run Chinook salmon would have an insignificant change (1 percent or less) in flow- and water temperature-related mortality under CP1, and an insignificant change in production (less than 5 percent overall), a less-than-significant impact to winter-run Chinook salmon would occur from actions taken in CP1. Mitigation for this impact is not needed, and thus not proposed.

*Spring-Run Chinook Salmon*

Production

Spring-run Chinook salmon production for the 81-year period does not change significantly between CP1 and the No-Action Alternative and the Existing Condition (Attachments 6 and 7 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was around 71 percent for CP1, while the largest decrease in production relative to the No-Action Alternative was -66 percent, both in critical water years (Table 11-6, Figure 11-10, and Attachment 6 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 256 percent for CP1, while the largest decrease in production relative to the Existing Condition was -41 percent, also both in critical water years (Table 11-6, Figure 11-10, and Attachment 7 of the Modeling Appendix).

Figure 11-10 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans. Separating production by water year type to focus on critical years in which production was the lowest under the No-Action Alternative typically had the largest increase under CP1 conditions, except for 1977 and 1992, which had 12 percent and 52 percent reductions, respectively (Attachment 6 of the Modeling Appendix).

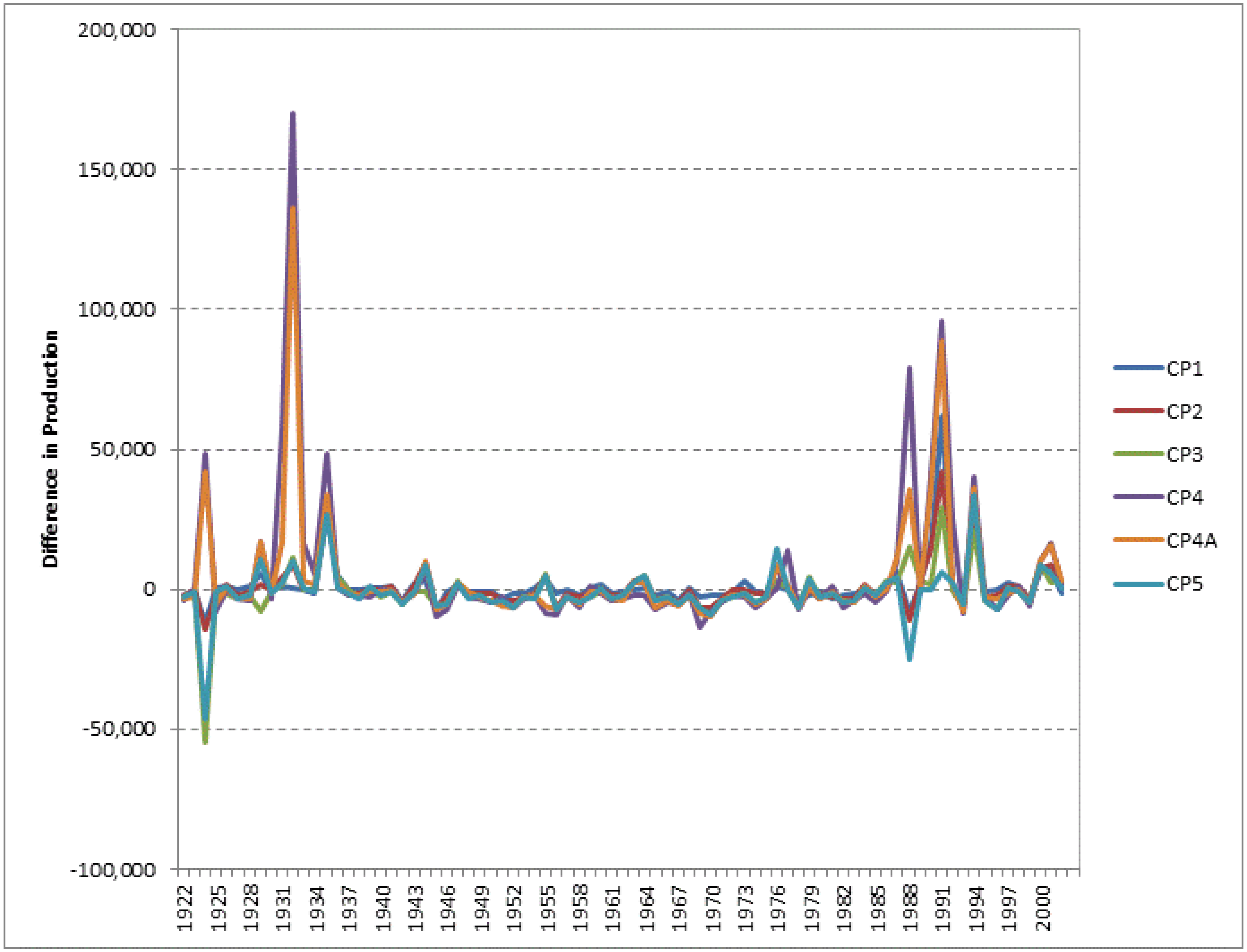
Compared to the No-Action Alternative, six critical, one dry, and one below-normal water years had significant increases in production, while three critical water years have a significant decrease in production (Table 11-6 and Attachment 6 of the Modeling Appendix). Compared to the Existing Condition, nine critical and two dry water years had significant increases in production, while one critical water years resulted in significant decreases in production (Table 11-6 and Attachment 7 of the Modeling Appendix).

**Table 11-6. Change in Production Under CP1 for Spring-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 81 | 165,227 | 1,172 | 0.7 | 70.6 | 8 | -66.3 | 3 |
| **Critical** | 13 | 88,867 | 7,677 | 9.5 | 70.6 | 6 | -66.3 | 3 |
| **Dry** | 17 | 170,150 | 698 | 0.4 | 7.2 | 1 | -2.1 | 0 |
| **Below Normal** | 14 | 178,425 | 1,245 | 0.7 | 19.8 | 1 | -4.3 | 0 |
| **Above Normal** | 11 | 183,396 | -370 | -0.2 | 3.3 | 0 | -2.5 | 0 |
| **Wet** | 26 | 185,393 | -1,158 | -0.6 | 1.1 | 0 | -2.2 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 164,198 | 990 | 0.6 | 256 | 11 | -41.3 | 1 |
| **Critical** | 13 | 83,012 | 8,950 | 12.1 | 256 | 9 | -41.3 | 1 |
| **Dry** | 17 | 170,380 | 1,519 | 0.9 | 16.5 | 2 | -1.0 | 0 |
| **Below Normal** | 14 | 177,394 | -636 | -0.4 | 1.7 | 0 | -2.1 | 0 |
| **Above Normal** | 11 | 182,943 | -1,170 | -0.6 | 2.2 | 0 | -2.3 | 0 |
| **Wet** | 26 | 185,713 | -1,546 | -0.8 | 1.7 | 0 | -3.1 | 0 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant




Key: CP = Comprehensive Plan

**Figure 11-10. Change in Production of Spring-Run Chinook Salmon Compared to the No-Action Alternative**

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on spring-run Chinook salmon caused by the actions of the project (Attachments 6 and 7). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)‒around 83 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 6 and 7 of the Modeling Appendix). Under both the 2030 and 2005 conditions, the greatest mortality to spring-run occurred to eggs, with minimal mortality to the other life stages. Table 11-7 displays the smolt-equivalent mortalities for each Comprehensive Plan that are caused by flow- and water-related factors (also see Attachments 6 and 7 of the Modeling Appendix). In both 2030 and 2005 conditions, only eggs and fry would be affected by operation of the Comprehensive Plans (Table 11-7 and Attachments 6 and 7 of the Modeling Appendix). In all but wet water years, mortality to eggs due to unsuitable water temperatures would be the primary cause of operations-related mortalities (Attachments 6 and 7 of the Modeling Appendix).

Years with the highest flow- and water temperature-related mortality were the same for all the Comprehensive Plans. 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) critical water year. However, years with the lowest mortality varied between all but critical water year types (Attachments 6 and 7 of the Modeling Appendix).

Spring-run Chinook salmon would have, overall, an insignificant change flow- and water temperature-related mortality, and an insignificant increase in production for all 82 years. However, spring-run Chinook salmon would have a significant increase in production in critical water years. Therefore, spring-run Chinook salmon would benefit from actions taken in CP1. Mitigation for this impact is not needed, and thus not proposed.

**Table 11-7. Average Annual Spring-Run Chinook Salmon Smolt Equivalent Mortality Under Each Base Condition and the Difference in Mortality Under Each Comprehensive Plan Caused by Changes in Flow and Water Temperature**

| Plan | Egg Count Based on Smolt Equivalent[1,2] | Difference in Mortality Factor from Baseline Condition (in Smolt Equivalents) | | | | | | | | | | Total (in Smolt Equivalents) | Percent Mortality[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pre-spawn | Incu-bation | Super-Impo-sition | Eggs Temp | Fry Temp | Fry Habitat | Pre-smolt Temp | Pre-smolt Habitat | Immature Smolt Temp | Immature Smolt Habitat | | |
| **Future Condition (2030)** | | | | | | | | | | | | | |
| **No-Action Alternative** | 302,510 | 106 | 1,328 | 0 | 6,189 | 0 | 29 | 0 | 0 | 0 | 0 | 7,653 | 2.5 |
| **CP1** | 304,299 | -7 | 82 | 0 | -1,382 | 0 | 1 | 0 | 0 | 0 | 0 | -1,306 | 2.1 |
| **CP2** | 303,633 | -3 | -35 | 0 | -1,467 | 0 | -2 | 0 | 0 | 0 | 0 | -1,507 | 2.0 |
| **CP3** | 301,437 | -8 | 17 | 0 | -1,170 | 0 | -5 | 0 | 0 | 0 | 0 | -1,166 | 2.2 |
| **CP4** | 313,315 | -23 | 415 | 0 | -2,829 | 0 | -3 | 0 | 0 | 0 | 0 | -2,440 | 1.7 |
| **CP4A** | 309,815 | -21 | 145 | 0 | -2,609 | 0 | -3 | 0 | 0 | 0 | 0 | -2,488 | 1.7 |
| **CP5** | 300,918 | 10 | -16 | 0 | -1,654 | 0 | -3 | 0 | 0 | 0 | 0 | -1,664 | 2.0 |
| **Existing Condition (2005)** | | | | | | | | | | | | | |
| **Existing Condition** | 300,637 | 126 | 1,124 | 0 | 6,155 | 0 | 27 | 0 | 0 | 0 | 0 | 7,432 | 2.5 |
| **CP1** | 302,611 | -4 | -40 | 0 | -861 | 0 | 3 | 0 | 0 | 0 | 0 | -902 | 2.2 |
| **CP2** | 304,787 | -14 | 44 | 0 | -1,548 | 0 | 2 | 0 | 0 | 0 | 0 | -1,517 | 1.9 |
| **CP3** | 303,602 | 1 | 128 | 0 | -1,308 | 0 | -3 | 0 | 0 | 0 | 0 | -1,181 | 2.1 |
| **CP4** | 313,736 | -45 | 305 | 0 | -2,754 | 0 | 5 | 0 | 0 | 0 | 0 | -2,489 | 1.6 |
| **CP4A** | 311,104 | -27 | 212 | 0 | -2,465 | 0 | -1 | 0 | 0 | 0 | 0 | -2,281 | 1.7 |
| **CP5** | 302,329 | -1 | 67 | 0 | -1,718 | 0 | -2 | 0 | 0 | 0 | 0 | -1,654 | 1.9 |

Note:
[1] The potential number of smolt equivalent is based on the spawning population of 207 adults, using the formula:
Immature Smolt Equivalent Mortality = Mortality * % Survival $_{(eggs\ to\ fry)}$ * % Survival $_{(fry\ to\ presmolts)}$ * % Survival $_{(presmolts\ to\ immature\ smolts)}$
[2] Values in these two columns do not constitute a difference from the baseline condition.
Key:
CP = Comprehensive Plan

*Fall-Run Chinook Salmon*

Production

The overall average fall-run Chinook salmon production for the 81-year period was similar for CP1 relative to the No-Action Alternative and the Existing Condition (Attachments 9 and 10 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 17 percent for CP1. The largest decrease in production relative to the No-Action Alternative was 51 percent for CP1 (Table 11-8 and Attachment 9 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 61 percent for CP1. The largest decrease in production relative to the Existing Condition was 5 percent for CP1 (Table 11-8 and Attachment 10 of the Modeling Appendix).

Figure 11-11 shows the annual change in production relative to the No-Action Alternative for all Comprehensive Plans.

Under CP1, three critical water years, two dry water years, and one below-normal water year resulted in increases in production relative to the No-Action Alternative greater than 5 percent. Only critical water year resulted in a significant decrease (more than 5 percent) in production relative to the No-Action (Attachment 9 of the Modeling Appendix).

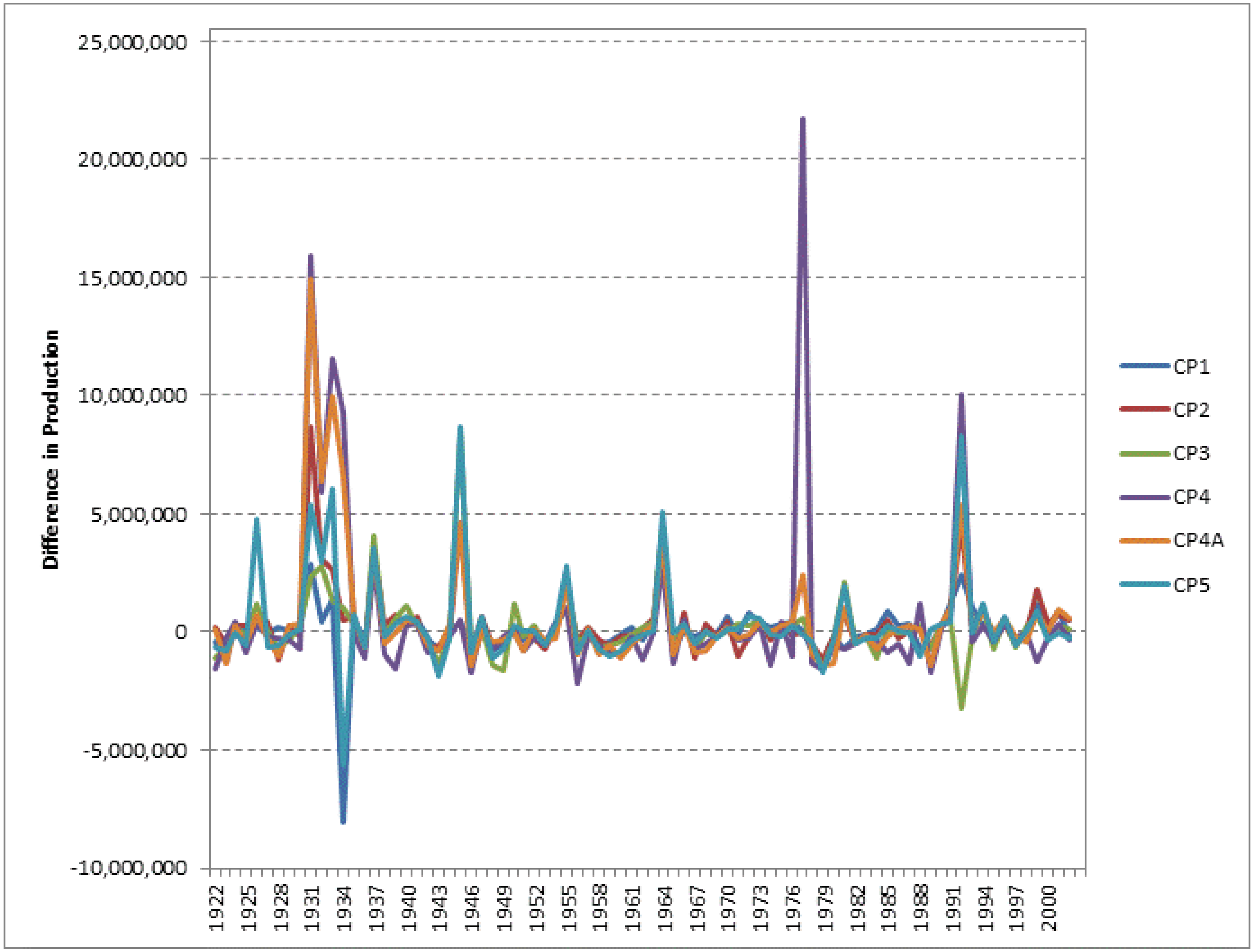
Under CP1, one critical and one dry water year resulted in significant increases in production relative to the Existing Condition greater than 5 percent. Critical water years 1977 and 1992 and wet water years 1929 and 1992 resulted in significant decreases in production relative to the Existing Condition greater than 5 percent.

**Table 11-8. Change in Production Under CP1 for Fall-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 81 | 29,597,665 | 79,258 | 0.3 | 17.2 | 6 | -51.3 | 1 |
| **Critical** | 13 | 26,551,960 | 107,131 | 0.4 | 14.6 | 3 | -51.3 | 1 |
| **Dry** | 17 | 29,819,701 | 279,541 | 0.9 | 12.7 | 2 | -3.3 | 0 |
| **Below Normal** | 14 | 31,090,422 | -7,489 | 0.0 | 17.2 | 1 | -4.6 | 0 |
| **Above Normal** | 11 | 31,088,575 | 55,565 | 0.2 | 4.1 | 0 | -2.3 | 0 |
| **Wet** | 26 | 29,540,778 | -8,898 | 0.0 | 4.8 | 0 | -4.3 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 29,743,213 | 314,871 | 1.1 | 61.1 | 8 | -4.5 | 0 |
| **Critical** | 13 | 27,135,675 | 959,539 | 3.7 | 61.1 | 3 | -3.6 | 0 |
| **Dry** | 17 | 29,933,697 | 473,296 | 1.6 | 12.1 | 3 | -2.4 | 0 |
| **Below Normal** | 14 | 31,504,560 | 486,298 | 1.6 | 24.3 | 2 | -3.6 | 0 |
| **Above Normal** | 11 | 30,856,686 | -13,710 | 0.0 | 2.5 | 0 | -1.9 | 0 |
| **Wet** | 26 | 29,502,932 | -64,339 | -0.2 | 3.8 | 0 | -4.5 | 0 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant




Key: CP = comprehensive Plan

**Figure 11-11. Change in Production of Fall-Run Chinook Salmon Compared to the No-Action Alternative**

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on fall-run Chinook salmon caused by the actions of the project (Attachments 9 and 10). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 64 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 9 and 10 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality based on the smolt equivalents to fall-run Chinook salmon under CP1 occurred to fry, followed by eggs, prespawn adults, presmolts, and lastly to immature smolts. Flow-related effects triggered a higher percentage of the operations-related mortality (Table 11-9). In all water year types, the greatest portion of mortality under CP1 occurred to fry caused by forced movement to downstream habitats. Other non-flow- and water temperature-related conditions were the primary causes of mortality for all life stages except fry (Attachments 9 and 10 in the Modeling Appendix).

Most differences in production and mortality are insignificant for fall-run Chinook salmon. Therefore, there would be a less-than-significant impact to fall-run Chinook salmon. Mitigation for this impact is not needed, and thus not proposed.

**Table 11-9. Average Annual Fall-Run Chinook Salmon Smolt Equivalent Mortality Under Each Base Condition and the Difference in Mortality Under Each Comprehensive Plan Caused by Changes in Flow and Water Temperature**

| Plan | Egg Count Based on Smolt Equivalent [1,2] | Difference in Mortality Factor from Baseline Condition (in Smolt Equivalents) | | | | | | | | | | Total (in Smolt Equivalents) | Percent Mortality[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pre-spawn | Incu-bation | Super-Impo-sition | Eggs Temp | Fry Temp | Fry Habitat | Pre-smolt Temp | Pre-smolt Habitat | Immature Smolt Temp | Immature Smolt Habitat | | |
| **Future Condition (2030)** | | | | | | | | | | | | | |
| **No-Action Alternative** | 53,997,584 | 532,611 | 698,320 | 1,098,998 | 130,219 | 1,098 | 7,297,067 | 6,839 | 191,817 | 3,554 | 15,051 | 9,975,575 | 18.5 |
| **CP1** | 54,020,735 | -82,771 | -7,088 | -29,273 | -14,950 | -77 | 60,531 | -594 | -7,185 | -283 | -1,168 | -82,858 | 18.3 |
| **CP2** | 54,623,098 | -66,868 | -13,920 | -9,913 | 4,390 | 95 | 83,271 | 657 | -19,704 | -416 | -1,198 | -23,605 | 18.2 |
| **CP3** | 54,307,062 | -10,196 | -18,624 | -44,357 | -16,910 | 188 | 91,866 | 52 | -16,532 | -585 | -2,444 | -17,543 | 18.3 |
| **CP4** | 55,174,850 | -196,088 | 1,013 | -35,321 | -29,663 | -46 | 417,965 | 284 | 8,577 | -867 | -595 | 165,258 | 18.4 |
| **CP4A** | 55,083,176 | -197,542 | -8,550 | -12,979 | -8,064 | 102 | 320,399 | 413 | -3,513 | -1,142 | -126 | 88,998 | 18.3 |
| **CP5** | 54,516,383 | -148,596 | -19,715 | -22,701 | 24,634 | 193 | 87,028 | 1,389 | -14,705 | -248 | -1,230 | -93,952 | 18.1 |
| **Existing Condition (2005)** | | | | | | | | | | | | | |
| **Existing Condition** | 53,773,316 | 508,244 | 691,873 | 1,107,388 | 119,149 | 1,144 | 7,272,250 | 6,199 | 192,979 | 3,408 | 14,665 | 9,917,299 | 18.4 |
| **CP1** | 54,339,007 | -2,695 | -6,984 | -8,457 | 7,564 | -90 | 55,007 | 1,207 | -4,141 | 414 | 805 | 42,629 | 18.3 |
| **CP2** | 54,186,119 | -203,671 | -12,659 | -8,650 | 15,915 | -78 | 74,966 | 860 | -8,525 | -310 | -1,349 | -143,502 | 18.0 |
| **CP3** | 54,439,932 | -40,503 | -12,017 | -35,451 | 3,131 | -93 | 76,845 | 260 | -9,640 | -691 | -1,242 | -19,400 | 18.2 |
| **CP4** | 55,250,903 | -212,958 | 1,638 | -15,390 | -11,051 | -77 | 317,170 | 1,956 | 5,951 | -371 | 2,284 | 89,152 | 18.1 |
| **CP4A** | 54,625,226 | -204,673 | -7,375 | -14,307 | -7,220 | -83 | 163,730 | 725 | -12,903 | -1,205 | 261 | -83,050 | 18.0 |
| **CP5** | 54,821,535 | 15,805 | -17,399 | -40,060 | 42,336 | -66 | 82,328 | 2,931 | -4,389 | 77 | -1,594 | 79,967 | 18.2 |

Notes:

[1] The potential number of smolt equivalent is based on the spawning population of 64,565 adults, using the formula:
Immature Smolt Equivalent Mortality = Mortality * % Survival $_{\text{(eggs to fry)}}$ * % Survival $_{\text{(fry to presmolts)}}$ * % Survival $_{\text{(presmolts to immature smolts)}}$

[2] Values in these two columns do not constitute a difference from the baseline condition.

Key:

CP = Comprehensive Plan

#### *Late Fall-Run Chinook Salmon and Steelhead*

Late fall-run Chinook salmon were evaluated directly using SALMOD and were considered to be a surrogate for steelhead; therefore, the following discussion regarding SALMOD results for late fall-run Chinook salmon are applicable to steelhead.

Production

Overall average late fall-run Chinook salmon production for the 80-year period was similar for CP1 relative to the No-Action Alternative. The maximum increase in production relative to the No-Action Alternative was almost 9 percent for CP1, while the largest decrease in production relative to the No-Action Alternative was less than 5 percent for CP1 (Table 11-10 and Attachment 12 of the Modeling Appendix).

Overall average late fall-run Chinook salmon production for the 80-year period was similar for CP1 relative to Existing Conditions. There were two critical water years with a significant increase (greater than 5 percent) in production, and no years with significant decreases in production relative to Existing Conditions (Table 11-10 and Attachment 13 of the Modeling Appendix).

Figure 11-12 and Table 11-10 display the annual differences in production for late fall-run Chinook salmon for all Comprehensive Plans.

**Table 11-10. Change in Production Under CP1 for Late Fall-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 80 | 7,408,364 | -10,122 | -0.1 | 8.8 | 1 | -3.8 | 0 |
| **Critical** | 13 | 7,038,385 | -25,783 | -0.4 | 3.6 | 0 | -3.7 | 0 |
| **Dry** | 16 | 7,394,185 | 39,817 | 0.5 | 8.8 | 1 | -1.7 | 0 |
| **Below Normal** | 14 | 7,598,833 | -13,785 | -0.2 | 2.6 | 0 | -2.5 | 0 |
| **Above Normal** | 11 | 7,543,667 | -42,417 | -0.6 | 3.1 | 0 | -2.6 | 0 |
| **Wet** | 26 | 7,442,276 | -17,388 | -0.2 | 3.6 | 0 | -3.8 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 80 | 7,425,077 | 38,516 | 0.5 | 9.4 | 2 | -4.0 | 0 |
| **Critical** | 13 | 7,029,066 | 65,770 | 0.9 | 5.3 | 1 | -2.5 | 0 |
| **Dry** | 16 | 7,443,310 | 83,042 | 1.1 | 9.4 | 1 | -2.7 | 0 |
| **Below Normal** | 14 | 7,642,832 | 31,738 | 0.4 | 4.6 | 0 | -2.9 | 0 |
| **Above Normal** | 11 | 7,578,729 | 19,056 | 0.3 | 1.5 | 0 | -0.6 | 0 |
| **Wet** | 26 | 7,429,604 | 9,372 | 0.1 | 3.8 | 0 | -4.0 | 0 |

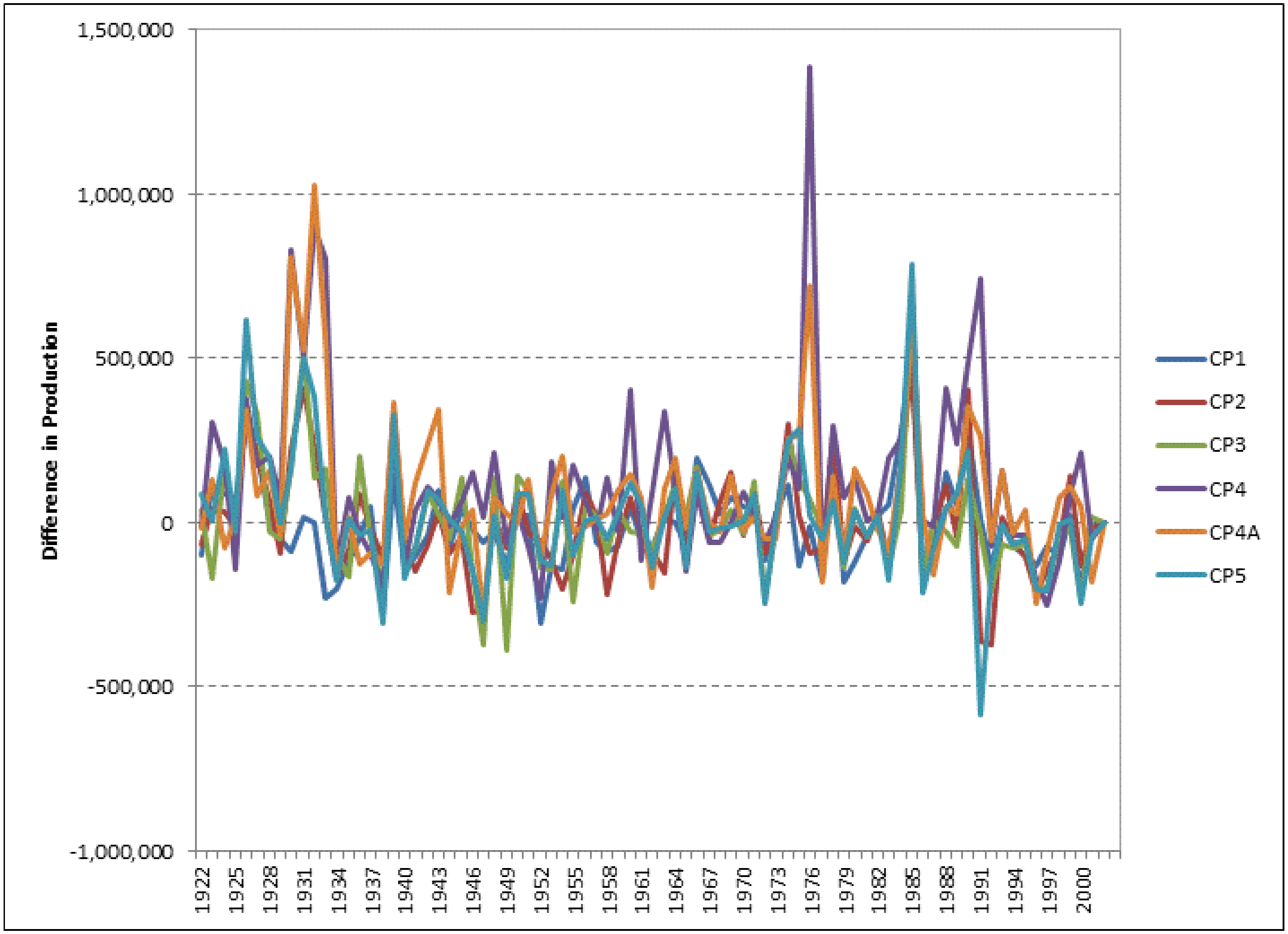
Notes:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Late fall-run Chinook salmon are used as a surrogate for steelhead

Key:

CP = Comprehensive Plan




Note: Late fall-run Chinook salmon are used as a surrogate for steelhead
Key: CP = Comprehensive Plan

**Figure 11-12. Change in Production of Late Fall-Run Chinook Salmon Compared to the No-Action Alternative**

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on late fall-run Chinook salmon caused by the actions of the project (Attachments 12 and 13 of the Modeling Appendix). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 78 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 12 and 13 of the Modeling Appendix). Under both 2030 and 2005 conditions, the largest mortality to late fall-run Chinook salmon under CP1 occurred to fry, followed by eggs, presmolts, immature smolts, and prespawn adults. Table 11-11 displays the overall mortalities for each Comprehensive Plan that are caused by changes in water temperature and flow (see also Attachments 12 and 13 of the Modeling Appendix).

When comparing mortality for flow- and water temperature-related activities only, fry are most affected, followed by eggs, presmolts, and immature smolts. Most mortality occurred as a result of flow conditions rather than water temperature (Table 11-11).

Years with the highest mortality under CP1 occurred in all water year types under both 2030 and 2005 conditions. Three years were preceded by a wet water year, one was preceded by an above-normal water year, and one was preceded by a dry water year (see also Attachments 12 and 13 of the Modeling Appendix).

Because SALMOD indicates an insignificant change in mortality and production index for late fall-run Chinook salmon, late fall-run Chinook salmon and steelhead (as represented by their surrogate late fall-run Chinook salmon) would experience a less-than-significant impact from actions taken in CP1. Mitigation for this impact is not needed, and thus not proposed.

**Table 11-11. Average Annual Late Fall-Run Chinook Salmon Smolt Equivalent Mortality Under Each Base Condition and the Difference in Mortality Under Each Comprehensive Plan Caused by Changes in Flow and Water Temperature**

| Plan | Egg Count Based on Smolt Equivalent[1,2] | Difference in Mortality Factor from Baseline Condition (in Smolt Equivalents) | | | | | | | | | | Total (in Smolt Equivalents) | Percent Mortality[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pre-spawn | Incu-bation | Super-Imposition | Eggs Temp | Fry Temp | Fry Habitat | Pre-smolt Temp | Pre-smolt Habitat | Immature Smolt Temp | Immature Smolt Habitat | | |
| **Future Condition (2030)** | | | | | | | | | | | | | |
| **No-Action** | 16,503,033 | 1,185 | 147,828 | 238,486 | 10,869 | 862 | 1,653,260 | 51,100 | 13,496 | 37,528 | 1,880 | 2,156,493 | 13.1 |
| **CP1** | 16,482,647 | -21 | -4,485 | -12,202 | 12 | 62 | 21,041 | 241 | 185 | 36,023 | 1,899 | 3,349 | 13.1 |
| **CP2** | 16,486,201 | 0 | -6,986 | -20,836 | 10 | 158 | 28,285 | -940 | 421 | 31,864 | 1,847 | -5,585 | 13.0 |
| **CP3** | 16,494,636 | 4 | -6,649 | -23,415 | -30 | -137 | 20,945 | -3,718 | -911 | 33,980 | 1,810 | -17,529 | 13.0 |
| **CP4** | 16,687,864 | 5 | -4,074 | -11,329 | 456 | -796 | 19,653 | -42,691 | 1,803 | 15,383 | 2,298 | -58,698 | 12.6 |
| **CP4A** | 16,624,011 | 12 | -6,261 | -20,225 | 389 | -649 | 18,736 | -25,719 | 150 | 24,662 | 2,062 | -46,250 | 12.7 |
| **CP5** | 16,505,875 | 6 | -7,951 | -23,658 | 109 | 24 | 17,280 | -1,925 | -612 | 33,042 | 1,818 | -21,276 | 12.9 |
| **Existing Condition (2005)** | | | | | | | | | | | | | |
| **Existing Condition** | 16,452,992 | 1,024 | 150,329 | 233,909 | 10,938 | 1,244 | 1,657,221 | 60,408 | 12,781 | 39,580 | 1,918 | 2,169,352 | 13.2 |
| **CP1** | 16,506,006 | 13 | -4,468 | -9,351 | 72 | 260 | 1,335 | -4,981 | 681 | -4,004 | 9 | -20,434 | 13.0 |
| **CP2** | 16,530,484 | 16 | -6,930 | -17,293 | -227 | -235 | 13,011 | -13,274 | 1,365 | -7,778 | 21 | -31,322 | 12.9 |
| **CP3** | 16,490,067 | 8 | -7,052 | -20,026 | 22 | -506 | 24,700 | -13,886 | 1,601 | -9,233 | -13 | -24,387 | 13.0 |
| **CP4** | 16,680,674 | 31 | -3,817 | -9,437 | 115 | -1,178 | 24,473 | -51,876 | 1,598 | -25,165 | 376 | -64,881 | 12.6 |
| **CP4A** | 16,605,665 | 24 | -7,228 | -17,421 | -133 | -986 | 25,362 | -38,438 | 1,887 | -17,463 | 192 | -54,205 | 12.7 |
| **CP5** | 16,509,915 | 10 | -7,789 | -20,075 | 64 | 41 | 14,598 | -13,820 | -475 | -10,547 | -17 | -38,010 | 12.9 |

Notes:

Late fall-run Chinook salmon are used as a surrogate for steelhead

1 The potential number of smolt equivalent is based on the spawning population of 13,697 adults, using the formula:
Immature Smolt Equivalent Mortality = Mortality * % Survival $_{\text{(eggs to fry)}}$ * % Survival $_{\text{(fry to presmolts)}}$ * % Survival $_{\text{(presmolts to immature smolts)}}$

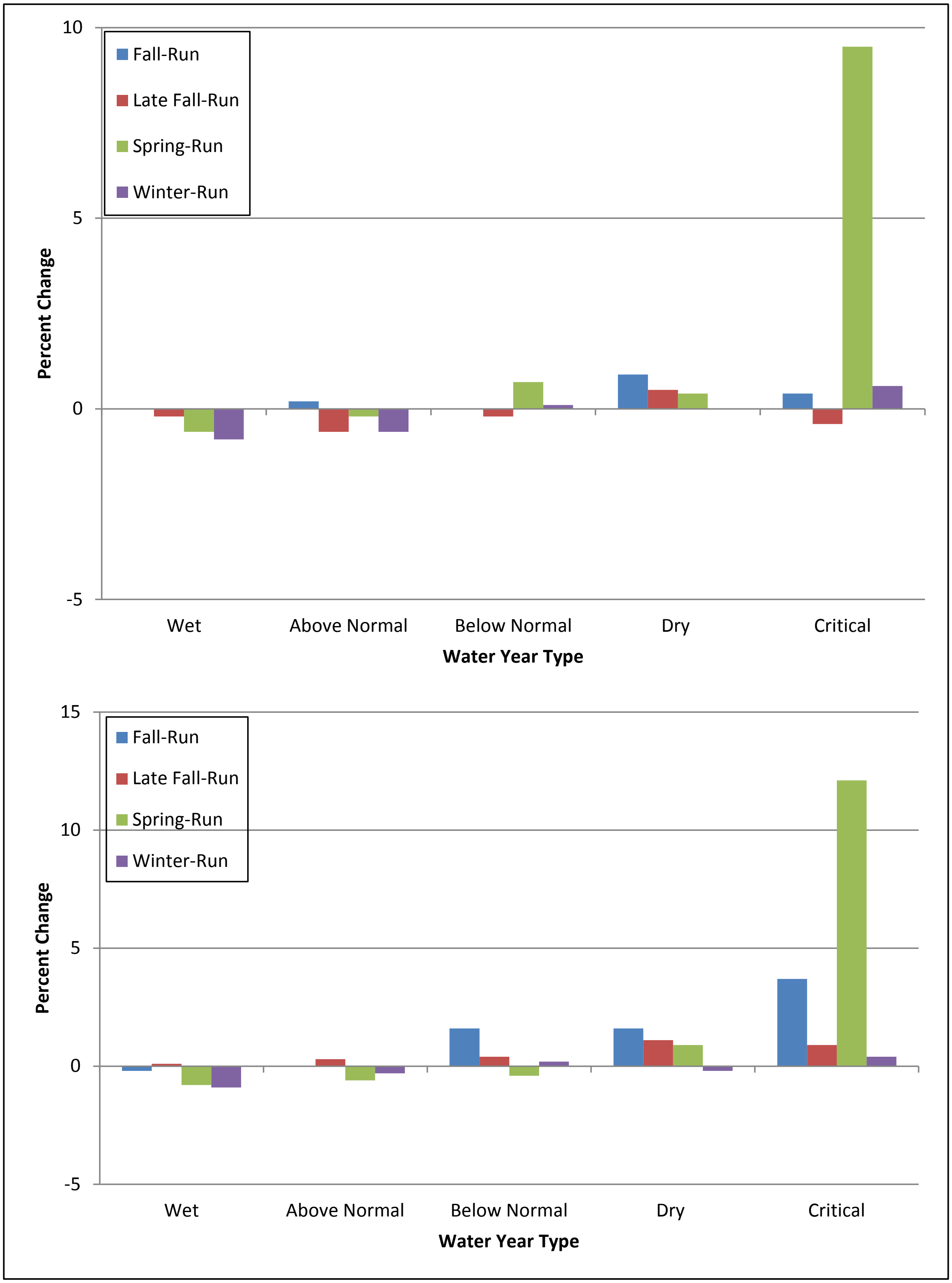
2 Values in these two columns do not constitute a difference from the baseline condition.

Key:

CP = Comprehsensive Plan

*All Chinook Runs Combined*

Raising Shasta Dam by 6.5 feet under CP1, in conjunction with spillway modifications, would result in an increase in full pool depth of 8.5 feet and an additional 256,000 acre-feet of storage capacity in Shasta Reservoir. The additional storage created by the dam raise would be used to improve the ability to meet water temperature objectives and habitat requirements for anadromous fish during drought years (see Figure 11-13). Under the 2030 conditions, overall production for all four runs of Chinook salmon combined would increase by over 61,000 immature smolts migrating below RDPP. Under the 2005 conditions, overall production for all four runs of Chinook salmon combined would increase by almost 344,000 immature smolts migrating below RDPP.




Note: Changes in outmigrating Chinook salmon simulated using SALMOD; Water Year Types based on the Sacramento Valley Water Year Hydrologic Classification

**Figure 11-13. Percent Change in Production of Chinook Salmon for CP1 Compared to the No-Action Alternative (top) and Existing Conditions (bottom)**

*Impact Aqua-13 (CP1): 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 generally 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.

*Flow-Related Effects* Under CP1, monthly mean flows at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBPP) would be essentially equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for all months. (See the Modeling Appendix for complete modeling results.)

Potential flow-related effects of CP1 on fish species of management concern in the upper Sacramento River would be minimal. During most years, releases from Shasta Lake would be unchanged. During average and wet years, river flows would decrease slightly from December through February in some years because of the use of increased capacity within Shasta Lake, usually after an extended dry period. Also, flows (and stages) would increase slightly from June through October in most years. Although small, increased flow would be most pronounced during dry periods as a result of increased releases from Shasta Dam for water supply reliability purposes. However, few to no changes would occur in water flows during dry years in winter and spring.

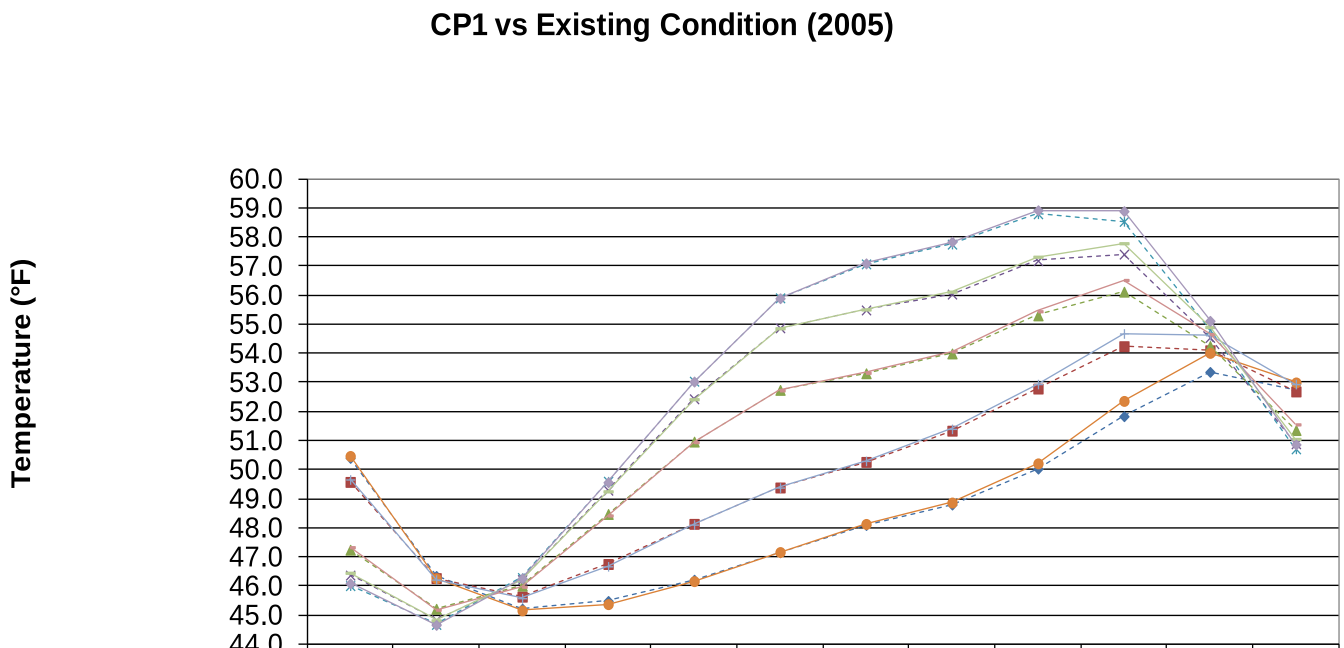
The average changes in monthly mean flow would be reductions or increases of several percent, although the changes in monthly mean flow would be greater in some years. Nonetheless, differences generally would be small (less than 2 percent). Potential changes in flows and stages would diminish downstream from RBPP because of increased effects from tributary inflows, diversions, and flood bypasses.

Changes in monthly mean flows under CP1 relative to the Existing Condition and No-Action Alternative would have no discernible effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for these species would be unchanged. Therefore, flow-related impacts on these species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

*Water Temperature–Related Effects* Under CP1, monthly mean water temperatures at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, Balls Ferry, above Bend Bridge, and above RBPP) would be the same as, or fractionally less than, water temperatures under the Existing Condition and No-Action Alternative conditions simulated for all months (Figures 11-14 and 11-15). See the Modeling Appendix 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. Potential water temperature–related effects of CP1 on fish species of management concern in the upper Sacramento River would be minimal.

The slightly cooler monthly mean water temperatures under CP1 relative to the Existing Condition and the No-Action Alternative would have very small effects on steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass in the upper Sacramento River. 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 impacts on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.



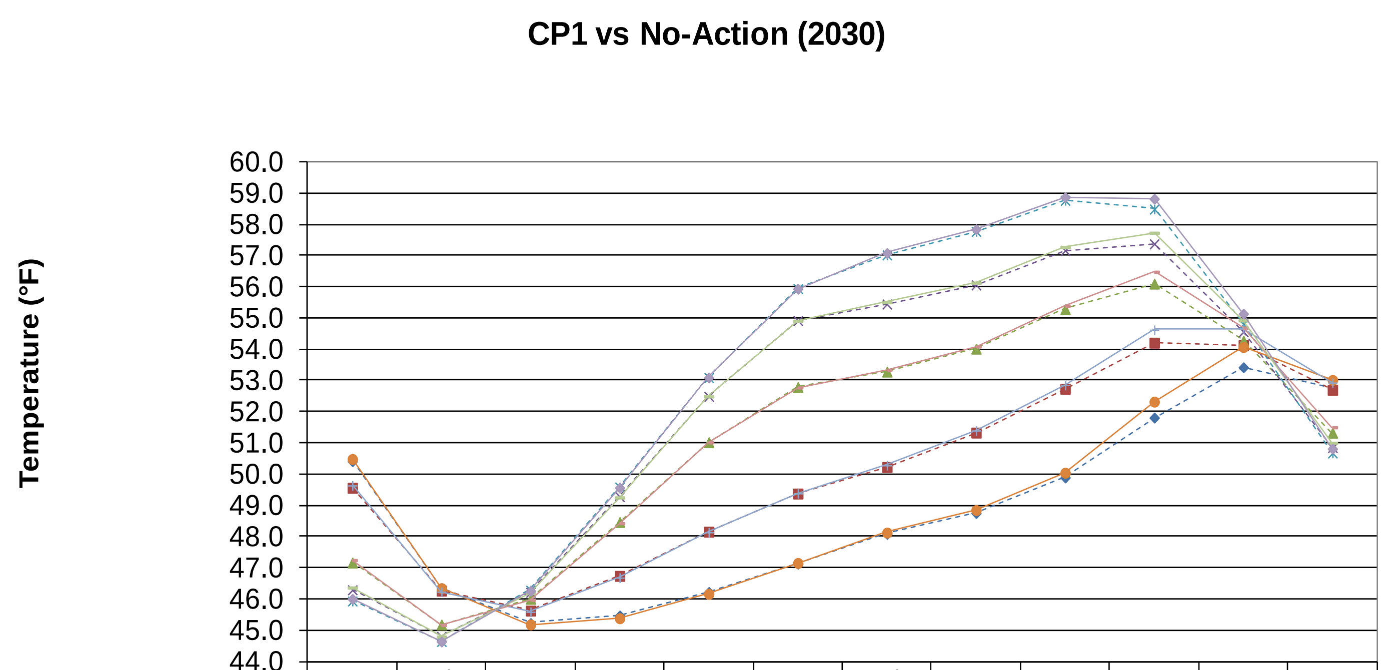

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP1 Below Shasta | 50.4 | 46.3 | 45.2 | 45.5 | 46.2 | 47.2 | 48.1 | 48.8 | 50.0 | 51.8 | 53.4 | 52.7 |
| CP1 Below Keswick | 49.6 | 46.3 | 45.6 | 46.8 | 48.1 | 49.4 | 50.3 | 51.3 | 52.8 | 54.2 | 54.1 | 52.7 |
| CP1 Balls Ferry | 47.2 | 45.2 | 46.0 | 48.5 | 51.0 | 52.7 | 53.3 | 54.0 | 55.3 | 56.1 | 54.3 | 51.4 |
| CP1 Bend Bridge | 46.4 | 44.8 | 46.2 | 49.3 | 52.4 | 54.9 | 55.5 | 56.0 | 57.2 | 57.4 | 54.5 | 50.9 |
| CP1 RBPP | 46.0 | 44.7 | 46.3 | 49.6 | 53.0 | 55.9 | 57.1 | 57.8 | 58.8 | 58.5 | 54.8 | 50.7 |
| EC Below Shasta | 50.5 | 46.3 | 45.2 | 45.4 | 46.2 | 47.2 | 48.1 | 48.9 | 50.2 | 52.4 | 54.0 | 53.0 |
| EC Below Keswick | 49.7 | 46.2 | 45.6 | 46.7 | 48.1 | 49.4 | 50.3 | 51.4 | 52.9 | 54.7 | 54.6 | 52.9 |
| EC Balls Ferry | 47.3 | 45.2 | 46.0 | 48.4 | 50.9 | 52.7 | 53.3 | 54.1 | 55.4 | 56.5 | 54.7 | 51.6 |
| EC Bend Bridge | 46.5 | 44.8 | 46.2 | 49.3 | 52.4 | 54.9 | 55.5 | 56.1 | 57.3 | 57.8 | 54.9 | 51.1 |
| EC RBPP | 46.1 | 44.7 | 46.3 | 49.6 | 53.0 | 55.9 | 57.1 | 57.8 | 58.9 | 58.9 | 55.1 | 50.9 |

Key:

°F = degrees Fahrenheit EC = Existing Condition

CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

**Figure 11-14. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP1 Versus Existing Condition)**




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP1 Below Shasta | 50.4 | 46.3 | 45.2 | 45.5 | 46.2 | 47.1 | 48.1 | 48.8 | 49.9 | 51.8 | 53.4 | 52.8 |
| CP1 Below Keswick | 49.6 | 46.3 | 45.6 | 46.7 | 48.2 | 49.4 | 50.2 | 51.3 | 52.7 | 54.2 | 54.1 | 52.7 |
| CP1 Balls Ferry | 47.2 | 45.2 | 46.0 | 48.5 | 51.0 | 52.8 | 53.3 | 54.0 | 55.3 | 56.1 | 54.3 | 51.3 |
| CP1 Bend Bridge | 46.3 | 44.8 | 46.2 | 49.3 | 52.5 | 54.9 | 55.4 | 56.1 | 57.2 | 57.4 | 54.6 | 50.9 |
| CP1 RBPP | 45.9 | 44.6 | 46.3 | 49.6 | 53.1 | 55.9 | 57.0 | 57.8 | 58.8 | 58.5 | 54.8 | 50.7 |
| NA Below Shasta | 50.5 | 46.3 | 45.2 | 45.4 | 46.2 | 47.2 | 48.1 | 48.9 | 50.0 | 52.3 | 54.1 | 53.0 |
| NA Below Keswick | 49.6 | 46.2 | 45.6 | 46.7 | 48.1 | 49.4 | 50.3 | 51.4 | 52.9 | 54.6 | 54.6 | 52.9 |
| NA Balls Ferry | 47.3 | 45.2 | 46.0 | 48.4 | 51.0 | 52.8 | 53.3 | 54.1 | 55.4 | 56.5 | 54.7 | 51.5 |
| NA Bend Bridge | 46.4 | 44.8 | 46.2 | 49.3 | 52.5 | 54.9 | 55.5 | 56.1 | 57.3 | 57.7 | 54.9 | 51.0 |
| NA RBPP | 46.0 | 44.6 | 46.3 | 49.6 | 53.1 | 55.9 | 57.1 | 57.8 | 58.9 | 58.8 | 55.1 | 50.8 |

Key:
°F = degrees Fahrenheit NA = No-Action Alternative
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

**Figure 11-15. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP1 Versus No-Action Alternative)**

*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 cause a reduction in the magnitude, duration, and frequency of intermediate to large flows both in the upper Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel formation and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

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. Relatively large floods provide the energy required to mobilize sediment from the riverbed, produce meander migration, and create seasonally inundated floodplains. Project operations could cause a reduction in the intermediate to large flows 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, Wolman, and Miller 1964). Although the recurrence interval of bankfull flow varies from river to river, it is often close to 1.5 to 2 years (Leopold, Wolman, and Miller 1964). This provides a rational basis for assuming that coarse sediment is routed as bedload during the 1.5-year flood (i.e., Q1.5). Flow regulation of the Sacramento River has reduced the river's Q1.5 by 30 percent from 86,000 cfs to 61,000 cfs (Kondolf et al. 2000).

Bankfull flow may provide a good first approximation for assessing the threshold for bed mobilization; however, it does not necessarily indicate the flow levels required to maintain the health of habitats in the alluvial system. For example, it has been estimated that a naturally occurring flood with a 5- to 10-year recurrence interval may often be required for maintenance of a mobile alternating bar-pool sequence (Trush, McBain, and Leopold 2000), which is 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 RBPP, 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 less able to adjust hydraulic geometry (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, so that typical recurrence intervals of mobilization and bedform alteration are much longer than they were before the dams reduced the magnitude of the 1.5-year and 10-year floods (i.e., Q1.5 and Q10). This implies that the bed and point bars may have become static in the post-dam era, and that only remnants of gravel from 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 have the potential to affect the lower reaches (confluence areas) of tributaries by reducing the mainstem river's backwater effect 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 an associated decrease in the stage elevation of the river surface, could increase the amount of downcutting in the lower reaches of the tributaries. Downcutting of the lower tributaries could result in bank erosion, channel widening, and disconnection of the channel from its floodplain, which in turn could affect riparian recruitment and succession processes.

*Meander Migration* Suitable spawning habitat on the mainstem Sacramento River 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. As a result, spawning habitat has been progressively reduced in the reach between Keswick Dam and Anderson Bridge, despite the effects of regular gravel augmentation.

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

3. The concentration of fine sediment below the surface has appeared to remain suitably low between Keswick Dam and Cottonwood Creek. It may have become higher in downstream reaches, however, because of a combination of factors: dam-related reductions in large flows, high sediment supply from Cottonwood Creek, and local hydraulic conditions (i.e., a break in slope) that promote local deposition. Thus, successful spawning of Chinook salmon in reaches below Cottonwood Creek may have been compromised.

The success of anadromous salmonids depends strongly on gravel dynamics in the mainstem river. However, 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 defined as the nearshore aquatic habitat occurring at the interface between a river and adjacent woody riparian habitat. SRA habitat is composed of vegetation and instream tree and shrub debris that provides important fish 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, alters 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 land 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. Thus, in the absence of human modifications, the overall pattern of planform geometry for migrating portions of rivers should approach a state of dynamic equilibrium. Studies indicate that the sinuosity of cutoff bends on the Sacramento River is decreasing over time (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-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. This supports the hypothesis that the erodibility of banks and floodplains has increased (thus enhancing the likelihood of cutoff) because of the effects of agricultural clearing of riparian forests on floodplains (Micheli, Kirchner, and Larsen 2004).

*Floodplain Inundation* Inundation of floodplains reduces the 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, Bayley, and Sparks 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, Wolman, and Miller 1964). Because bankfull flow typically has a recurrence interval of 1.5 to 2 years (Q1.5–2) on alluvial rivers, flow magnitudes greater than the 1.5-year (Q1.5) flow event are often assumed to initiate floodplain inundation.

These effects would likely occur throughout the upper Sacramento River portion of 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. Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

### 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 discernible change in monthly mean flows or water temperature conditions in the lower Sacramento River. However, predicted changes in flows in the Feather, American, and Trinity rivers could result in adverse effects on Chinook salmon, steelhead, Coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be potentially significant.

As described below, monthly mean flows at various modeling locations on the lower Sacramento River and tributaries under CP1 were compared with monthly mean flows simulated for the Existing Condition and No-Action Alternative conditions. Modeling for the lower American River occurred at Verona and Freeport; for the lower Feather River, modeling occurred below Thermalito Afterbay, and American River modeling occurred near the H Street Bridge in Sacramento. Modeling also occurred on the Trinity River. See the Modeling Appendix for complete CalSim-II modeling results.

*Lower Sacramento River* Under CP1, monthly mean flows at the lower Sacramento River modeling locations would be comparable to flows under the Existing Condition and No-Action Alternative conditions simulated for all months. Differences in modeled monthly mean flow were generally small (less than 2 percent) and within the existing range of variability. Potential changes in flows would diminish rapidly downstream from RBPP because of increased effects from tributary inflows, diversions, and flood bypasses. Thus, potential flow-related effects of CP1 on fish species of management concern in the lower Sacramento River would be minimal.

Mean monthly mean flows at all modeling locations on the lower Feather River and American River under CP1 would be essentially equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative conditions simulated for all months. 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 from tributary inflows, diversions, and flood bypasses. Potential flow-related effects of CP1 on fish species of management concern in the Feather River and American River would be minimal and within the existing range of variability. Potential changes in water temperatures in the lower Sacramento River caused by small changes in releases would diminish rapidly downstream because of the increasing effects 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. Mitigation for this impact is not needed, and thus not proposed.

The effects of altered flow regimes resulting from implementation of CP1 are unlikely to extend into the lower Sacramento River downstream from Verona and into the Delta because the Central Valley's reservoirs and diversions are managed as a single integrated system (consisting of the CVP and SWP). The operational requirements, including the 2008 USFWS BO and the 2009 NMFS BO, have been designed to maintain standards for flow to the lower Sacramento River and Delta. CVP and SWP operations must be consistent with these ESA BOs. Thus, implementation of CP1 would likely not alter flow to the Delta or water temperatures in the lower Sacramento River and its primary tributaries to a degree sufficient to affect 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 water temperature–related effects on these fish species in the lower Sacramento River and tributaries would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

*Lower Feather River and American River* Under CP1, monthly mean flows at modeling locations on the lower Feather River and American River would be essentially equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative conditions simulated for most months. However, simulations for several months within the modeling record show substantial changes to flows in tributaries. Potential changes in flows in these areas could be reduced by real-time operations to meet existing rules and operation of upstream CVP and SWP reservoirs (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 potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

*Trinity River* As with the lower Feather River and American River, monthly mean flows at all modeling locations within the Trinity River under CP1 would be essentially equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for most months. 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 potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

*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 cause a reduction in intermediate to large flows both in the lower Sacramento River and in the lowermost (confluence) areas of its tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

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 flows. Relatively large flows provide the energy required to mobilize sediment from the riverbed, produce meander migration, and create seasonally inundated floodplains. Project operations could cause a reduction in the intermediate to large flows necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains (including floodplain bypasses) along the lower Sacramento River.

There is substantially less bedrock control in the middle reach of the Sacramento River (between RBPP and Colusa) than along the Sacramento River between Keswick Dam and the RBPP. Consequently, sediment transport and meander migration processes are more pronounced in this more alluvial reach. This is supported by widespread evidence of frequent lateral migration in the middle reach of the Sacramento River (e.g., Micheli, Kirchner, and Larsen 2004). This implies that the middle reach of the Sacramento River experience much more frequent bed and bar mobilization than the Sacramento River between Keswick Dam and RBPP.

As discussed under Impact Aqua-14 (CP1), changes (reductions) in intermediate to large flows in the Sacramento River have the potential to affect the lower reaches (confluence areas) of tributaries by reducing the mainstem river's backwater effect 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 an associated decrease in the stage elevation of the river surface, could increase the amount of downcutting in the lower reaches of the tributaries. Downcutting of the lower tributaries could result in bank erosion, channel widening, and disconnection of the channel 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 RBPP is also bounded by high banks and terraces, limiting the 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 mostly set back from the mainstem channel, so that substantial flooding can occur within the river corridor. In the lower Sacramento River between RBPP 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). Numerous studies have shown that shallow 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 shallow 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, consisting of detrital material, insect larvae, crustaceans, and other invertebrates. Juvenile Chinook salmon and splittail apparently forage among a variety of vegetation types, such as trees, brush, and herbaceous vegetation; however, the relative importance of these vegetation types, 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 shallow water in this habitat. It also may be related to 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, implementation of CP1 could cause 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 effects 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. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

*Impact Aqua-17 (CP1): Effects to Delta Fisheries Resulting from Changes to Delta Outflow* Based on the results of hydrologic modeling comparing Delta outflow under the No-Action Alternative, Existing Condition, and CP1, CP1 would result in changes to average monthly Delta outflow of less than 5 percent in all year types (with the exception of November of above-normal water years under 2005 conditions). Delta outflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources.

This impact on Delta fisheries and hydrologic transport processed within the Bay-Delta would be less than significant.

Results of the comparison of Delta outflows are summarized by month and water year type in Table 11-12. Delta outflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources.

The comparison includes the estimated average monthly outflow under the Existing Condition, No-Action Alternative, and CP1, and the percentage change between base flows and CP1 operations. Results of the analysis (Table 11-12) show that Delta outflows would 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, only one of the simulated changes was greater than 5 percent (November of above-normal water years under 2005 conditions). Based on results of this analysis, 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 11-12. Delta Outflow Under the Existing Condition, No-Action Alternative, and CP1**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| Month | Water Year | Flow (cfs) | Flow (cfs) | Percent Change | Flow (cfs) | Flow (cfs) | Percent Change |
| January | Average | 42,078 | 42,002 | 0 | 42,169 | 41,971 | 0 |
| | W | 84,136 | 83,964 | 0 | 84,037 | 83,638 | 0 |
| | AN | 47,221 | 47,120 | 0 | 46,984 | 46,914 | 0 |
| | BN | 21,610 | 21,622 | 0 | 21,990 | 22,023 | 0 |
| | D | 14,166 | 14,038 | -1 | 14,452 | 14,302 | -1 |
| | C | 11,560 | 11,687 | 1 | 11,757 | 11,525 | -2 |
| February | Average | 51,618 | 51,526 | 0 | 51,430 | 51,274 | 0 |
| | W | 95,261 | 95,104 | 0 | 94,634 | 94,399 | 0 |
| | AN | 60,080 | 59,779 | -1 | 60,278 | 59,738 | -1 |
| | BN | 35,892 | 35,976 | 0 | 35,665 | 35,755 | 0 |
| | D | 20,978 | 20,924 | 0 | 20,946 | 20,869 | 0 |
| | C | 12,902 | 12,898 | 0 | 13,088 | 13,081 | 0 |
| March | Average | 42,722 | 42,651 | 0 | 42,585 | 42,582 | 0 |
| | W | 78,448 | 78,500 | 0 | 78,376 | 78,430 | 0 |
| | AN | 53,486 | 53,121 | -1 | 53,139 | 53,014 | 0 |
| | BN | 23,102 | 22,906 | -1 | 22,980 | 22,892 | 0 |
| | D | 19,763 | 19,848 | 0 | 19,559 | 19,621 | 0 |
| | C | 11,881 | 11,747 | -1 | 11,893 | 11,892 | 0 |
| April | Average | 30,227 | 30,236 | 0 | 30,743 | 30,757 | 0 |
| | W | 54,640 | 54,650 | 0 | 55,460 | 55,459 | 0 |
| | AN | 32,141 | 32,127 | 0 | 32,971 | 32,976 | 0 |
| | BN | 21,773 | 21,820 | 0 | 22,511 | 22,523 | 0 |
| | D | 14,347 | 14,343 | 0 | 14,538 | 14,559 | 0 |
| | C | 9,100 | 9,108 | 0 | 8,873 | 8,918 | 0 |
| May | Average | 22,619 | 22,567 | 0 | 22,249 | 22,196 | 0 |
| | W | 41,184 | 41,165 | 0 | 40,543 | 40,522 | 0 |
| | AN | 24,296 | 24,201 | 0 | 24,454 | 24,229 | -1 |
| | BN | 16,346 | 16,144 | -1 | 15,989 | 15,809 | -1 |
| | D | 10,554 | 10,580 | 0 | 10,116 | 10,170 | 1 |
| | C | 6,132 | 6,110 | 0 | 5,910 | 5,947 | 1 |
| June | Average | 12,829 | 12,776 | 0 | 12,660 | 12,620 | 0 |
| | W | 23,473 | 23,473 | 0 | 23,015 | 23,016 | 0 |
| | AN | 12,080 | 11,746 | -3 | 11,799 | 11,635 | -1 |
| | BN | 7,995 | 8,019 | 0 | 7,991 | 7,920 | -1 |
| | D | 6,691 | 6,656 | -1 | 6,764 | 6,743 | 0 |
| | C | 5,361 | 5,361 | 0 | 5,378 | 5,376 | 0 |
| July | Average | 7,864 | 7,864 | 0 | 7,864 | 7,869 | 0 |
| | W | 11,230 | 11,237 | 0 | 11,181 | 11,185 | 0 |
| | AN | 9,562 | 9,530 | 0 | 9,407 | 9,400 | 0 |
| | BN | 7,117 | 7,118 | 0 | 7,225 | 7,274 | 1 |
| | D | 5,005 | 5,006 | 0 | 5,052 | 5,042 | 0 |
| | C | 4,034 | 4,050 | 0 | 4,098 | 4,088 | 0 |

**Table 11-12. Delta Outflow Under the Existing Condition, No-Action Alternative, and CP1 (contd.)**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| August | Average | 4,322 | 4,337 | 0 | 4,335 | 4,349 | 0 |
| | W | 5,302 | 5,319 | 0 | 5,097 | 5,093 | 0 |
| | AN | 4,000 | 4,000 | 0 | 4,000 | 4,000 | 0 |
| | BN | 4,000 | 4,000 | 0 | 4,002 | 4,000 | 0 |
| | D | 3,906 | 3,896 | 0 | 4,142 | 4,189 | 1 |
| | C | 3,520 | 3,604 | 2 | 3,699 | 3,736 | 1 |
| September | Average | 9,841 | 9,840 | 0 | 9,844 | 9,858 | 0 |
| | W | 19,695 | 19,670 | 0 | 19,702 | 19,707 | 0 |
| | AN | 11,784 | 11,771 | 0 | 11,849 | 11,836 | 0 |
| | BN | 3,876 | 3,886 | 0 | 3,913 | 3,926 | 0 |
| | D | 3,508 | 3,516 | 0 | 3,442 | 3,496 | 2 |
| | C | 3,008 | 3,040 | 1 | 3,005 | 3,005 | 0 |
| October | Average | 6,067 | 6,063 | 0 | 6,000 | 6,003 | 0 |
| | W | 7,926 | 7,894 | 0 | 7,633 | 7,596 | 0 |
| | AN | 5,309 | 5,360 | 1 | 5,476 | 5,550 | 1 |
| | BN | 5,479 | 5,514 | 1 | 5,502 | 5,504 | 0 |
| | D | 5,228 | 5,234 | 0 | 5,236 | 5,238 | 0 |
| | C | 4,741 | 4,684 | -1 | 4,714 | 4,732 | 0 |
| November | Average | 11,706 | 11,549 | -1 | 11,675 | 11,525 | -1 |
| | W | 17,717 | 17,621 | -1 | 17,715 | 17,484 | -1 |
| | AN | 12,667 | 11,852 | -6 | 12,491 | 12,084 | -3 |
| | BN | 8,543 | 8,513 | 0 | 8,686 | 8,579 | -1 |
| | D | 8,482 | 8,468 | 0 | 8,414 | 8,414 | 0 |
| | C | 6,250 | 6,256 | 0 | 6,150 | 6,156 | 0 |
| December | Average | 21,755 | 21,601 | -1 | 21,745 | 21,592 | -1 |
| | W | 44,974 | 44,556 | -1 | 44,661 | 44,182 | -1 |
| | AN | 18,581 | 18,667 | 0 | 18,562 | 18,513 | 0 |
| | BN | 12,219 | 12,135 | -1 | 12,326 | 12,402 | 1 |
| | D | 8,531 | 8,453 | -1 | 8,803 | 8,710 | -1 |
| | C | 5,580 | 5,567 | 0 | 5,677 | 5,774 | 2 |

Note:
A negative percentage change reflects a reduction in Delta outflow
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 Fisheries Resulting from Changes to Delta Inflow* Based on the results of hydrologic modeling comparing Delta inflow under CP1 to the Existing Condition and No-Action Alternative, CP1 would result in changes to average monthly Delta inflow of less than 5 percent in all year types. This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

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.

Results of the comparison of Delta inflows between the Existing Condition, No-Action Alternative, and CP1 are summarized by month and water year type in Table 11-13. The comparison includes the estimated average monthly inflow under the 2005 and 2030 conditions, the average monthly Delta inflow under CP1, and the percent change in flows between the Existing Condition or No-Action Alternative and CP1. Delta inflows would be slightly lower under many of the CP1 operations and slightly higher than basis-of-comparison conditions, depending on month and water year type. The difference in simulated average monthly Delta inflow between CP1 and the Existing Condition and the No-Action Alternative did not exceed 5 percent. Based on the results of this analysis, CP1 would have a less-than-significant effect on Delta fisheries and hydrologic transport processes within the Bay-Delta as a consequence of changes in Delta inflow. Mitigation for this impact is not needed, and thus not proposed.

**Table 11-13. Delta Inflow Under the Existing Condition, No-Action Alternative, and CP1**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 47,426 | 47,352 | 0 | 47,457 | 47,275 | 0 |
| | W | 89,431 | 89,259 | 0 | 89,328 | 88,930 | 0 |
| | AN | 51,611 | 51,501 | 0 | 51,267 | 51,100 | 0 |
| | BN | 27,269 | 27,281 | 0 | 27,576 | 27,609 | 0 |
| | D | 20,125 | 20,017 | -1 | 20,371 | 20,221 | -1 |
| | C | 16,699 | 16,820 | 1 | 16,749 | 16,724 | 0 |
| February | Average | 57,835 | 57,703 | 0 | 57,623 | 57,478 | 0 |
| | W | 103,140 | 102,976 | 0 | 102,606 | 102,393 | 0 |
| | AN | 65,379 | 64,882 | -1 | 65,574 | 65,008 | -1 |
| | BN | 41,782 | 41,832 | 0 | 41,374 | 41,419 | 0 |
| | D | 26,530 | 26,459 | 0 | 26,431 | 26,356 | 0 |
| | C | 17,818 | 17,813 | 0 | 17,958 | 18,054 | 1 |
| March | Average | 49,829 | 49,786 | 0 | 49,713 | 49,699 | 0 |
| | W | 87,688 | 87,728 | 0 | 87,703 | 87,782 | 0 |
| | AN | 61,498 | 61,359 | 0 | 61,339 | 61,232 | 0 |
| | BN | 30,569 | 30,372 | -1 | 30,415 | 30,326 | 0 |
| | D | 24,943 | 24,943 | 0 | 24,640 | 24,610 | 0 |
| | C | 15,933 | 15,923 | 0 | 15,896 | 15,891 | 0 |
| April | Average | 33,962 | 33,971 | 0 | 34,783 | 34,798 | 0 |
| | W | 58,684 | 58,694 | 0 | 60,017 | 60,020 | 0 |
| | AN | 35,588 | 35,575 | 0 | 36,738 | 36,745 | 0 |
| | BN | 25,351 | 25,398 | 0 | 26,403 | 26,414 | 0 |
| | D | 17,962 | 17,959 | 0 | 18,315 | 18,336 | 0 |
| | C | 12,817 | 12,822 | 0 | 12,635 | 12,679 | 0 |
| May | Average | 27,383 | 27,332 | 0 | 27,091 | 27,044 | 0 |
| | W | 46,973 | 46,955 | 0 | 46,494 | 46,473 | 0 |
| | AN | 28,466 | 28,372 | 0 | 28,711 | 28,490 | -1 |
| | BN | 20,747 | 20,542 | -1 | 20,427 | 20,247 | -1 |
| | D | 14,882 | 14,908 | 0 | 14,534 | 14,591 | 0 |
| | C | 10,347 | 10,333 | 0 | 10,038 | 10,109 | 1 |
| June | Average | 22,171 | 22,116 | 0 | 22,090 | 22,068 | 0 |
| | W | 35,459 | 35,459 | 0 | 35,172 | 35,172 | 0 |
| | AN | 23,124 | 22,791 | -1 | 22,776 | 22,612 | -1 |
| | BN | 16,884 | 16,897 | 0 | 16,941 | 16,987 | 0 |
| | D | 14,095 | 14,059 | 0 | 14,337 | 14,312 | 0 |
| | C | 10,710 | 10,711 | 0 | 10,694 | 10,694 | 0 |

**Table 11-13. Delta Inflow Under the Existing Condition, No-Action Alternative, and CP1 (contd.)**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| Month | Water Year | Flow (cfs) | Flow (cfs) | Percent Change | Flow (cfs) | Flow (cfs) | Percent Change |
| July | Average | 23,099 | 23,111 | 0 | 22,839 | 22,876 | 0 |
| | W | 27,442 | 27,449 | 0 | 27,496 | 27,500 | 0 |
| | AN | 25,169 | 25,089 | 0 | 25,065 | 25,044 | 0 |
| | BN | 23,282 | 23,306 | 0 | 23,362 | 23,347 | 0 |
| | D | 20,937 | 20,980 | 0 | 20,082 | 20,160 | 0 |
| | C | 14,647 | 14,706 | 0 | 14,048 | 14,215 | 1 |
| August | Average | 17,147 | 17,180 | 0 | 17,026 | 17,068 | 0 |
| | W | 20,235 | 20,257 | 0 | 20,154 | 20,150 | 0 |
| | AN | 18,784 | 18,760 | 0 | 18,927 | 18,935 | 0 |
| | BN | 18,274 | 18,272 | 0 | 18,297 | 18,231 | 0 |
| | D | 15,066 | 15,274 | 1 | 14,371 | 14,580 | 1 |
| | C | 10,626 | 10,517 | -1 | 10,850 | 10,897 | 0 |
| September | Average | 20,946 | 21,049 | 0 | 21,145 | 21,292 | 1 |
| | W | 31,918 | 31,920 | 0 | 32,428 | 32,431 | 0 |
| | AN | 23,912 | 23,930 | 0 | 24,747 | 24,856 | 0 |
| | BN | 16,518 | 16,546 | 0 | 16,563 | 16,569 | 0 |
| | D | 14,440 | 14,703 | 2 | 14,233 | 14,683 | 3 |
| | C | 9,130 | 9,386 | 3 | 8,809 | 9,013 | 2 |
| October | Average | 14,407 | 14,445 | 0 | 14,175 | 14,236 | 0 |
| | W | 17,072 | 17,016 | 0 | 16,558 | 16,596 | 0 |
| | AN | 13,176 | 13,364 | 1 | 13,223 | 13,359 | 1 |
| | BN | 14,044 | 14,180 | 1 | 14,159 | 14,139 | 0 |
| | D | 13,133 | 13,243 | 1 | 12,846 | 12,987 | 1 |
| | C | 12,196 | 12,070 | -1 | 11,976 | 11,983 | 0 |
| November | Average | 19,512 | 19,531 | 0 | 19,463 | 19,442 | 0 |
| | W | 26,429 | 26,521 | 0 | 26,536 | 26,397 | 0 |
| | AN | 20,269 | 19,726 | -3 | 20,052 | 19,854 | -2 |
| | BN | 16,984 | 17,051 | 0 | 16,980 | 16,884 | -1 |
| | D | 15,771 | 15,942 | 1 | 15,705 | 15,909 | 1 |
| | C | 12,330 | 12,467 | 1 | 12,081 | 12,244 | -1 |

**Table 11-13. Delta Inflow Under the Existing Condition, No-Action Alternative, and CP1 (contd.)**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| December | Average | 30,984 | 30,833 | 0 | 30,988 | 30,838 | 0 |
| | W | 53,758 | 53,345 | -1 | 53,516 | 53,042 | -1 |
| | AN | 28,431 | 28,505 | 0 | 28,223 | 28,197 | 0 |
| | BN | 21,958 | 21,855 | 0 | 22,143 | 22,223 | 0 |
| | D | 18,560 | 18,501 | 0 | 18,837 | 18,743 | -1 |
| | C | 13,363 | 13,358 | 0 | 13,484 | 13,565 | 1 |

Note:
A negative percentage change reflects a reduction in Delta inflow
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* CP1 operation would result in a variable response in Sacramento River inflow, resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water year. Decreases in Sacramento River inflow would not equal or exceed 5 percent. 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. Sacramento River 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. 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 the Existing Condition, No-Action Alternative, and CP1 for Sacramento River inflow are presented in Table 11-14. Results of these analyses show a variable response in Sacramento River inflow with CP1 operations resulting in both increases and decreases in river inflow above the Existing Condition and the No-Action Alternative, depending on month and water year type. Under CP1, Sacramento River flow would not decrease by 5 percent or more. Based on these results 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 11-14. Sacramento River Inflow Under the Existing Condition, No-Action Alternative, and CP1**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 31,139 | 31,144 | 0 | 31,167 | 31,136 | 0 |
| | W | 50,173 | 50,145 | 0 | 50,164 | 50,098 | 0 |
| | AN | 38,122 | 38,073 | 0 | 38,006 | 37,960 | 0 |
| | BN | 22,370 | 22,461 | 0 | 22,540 | 22,654 | 1 |
| | D | 16,980 | 16,924 | 0 | 17,109 | 17,025 | 0 |
| | C | 14,384 | 14,505 | 1 | 14,322 | 14,291 | 0 |
| February | Average | 36,608 | 36,567 | 0 | 36,618 | 36,586 | 0 |
| | W | 56,740 | 56,763 | 0 | 56,637 | 56,661 | 0 |
| | AN | 44,453 | 44,104 | -1 | 44,672 | 44,295 | -1 |
| | BN | 30,911 | 31,023 | 0 | 30,780 | 30,909 | 0 |
| | D | 21,249 | 21,178 | 0 | 21,237 | 21,144 | 0 |
| | C | 14,830 | 14,824 | 0 | 15,075 | 15,168 | 1 |
| March | Average | 32,396 | 32,367 | 0 | 32,352 | 32,343 | 0 |
| | W | 49,248 | 49,287 | 0 | 49,403 | 49,461 | 0 |
| | AN | 44,060 | 44,017 | 0 | 43,972 | 43,939 | 0 |
| | BN | 23,188 | 22,992 | -1 | 23,068 | 22,978 | 0 |
| | D | 20,390 | 20,389 | 0 | 20,138 | 20,107 | 0 |
| | C | 12,971 | 12,961 | 0 | 12,942 | 12,938 | 0 |
| April | Average | 23,232 | 23,241 | 0 | 23,206 | 23,222 | 0 |
| | W | 37,918 | 37,929 | 0 | 38,019 | 38,024 | 0 |
| | AN | 26,053 | 26,041 | 0 | 26,039 | 26,048 | 0 |
| | BN | 17,518 | 17,565 | 0 | 17,439 | 17,450 | 0 |
| | D | 13,205 | 13,202 | 0 | 13,164 | 13,185 | 0 |
| | C | 10,295 | 10,300 | 0 | 10,067 | 10,111 | 0 |

**Table 11-14. Sacramento River Inflow Under the Existing Condition, No-Action Alternative, and CP1 (contd.)**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| May | Average | 19,417 | 19,369 | 0 | 19,114 | 19,069 | 0 |
| | W | 32,095 | 32,084 | 0 | 31,800 | 31,785 | 0 |
| | AN | 21,204 | 21,110 | 0 | 21,080 | 20,859 | -1 |
| | BN | 14,530 | 14,326 | -1 | 14,144 | 13,965 | -1 |
| | D | 11,226 | 11,252 | 0 | 10,836 | 10,893 | 1 |
| | C | 8,148 | 8,134 | 0 | 7,874 | 7,945 | 1 |
| June | Average | 16,508 | 16,454 | 0 | 16,511 | 16,488 | 0 |
| | W | 24,092 | 24,092 | 0 | 23,905 | 23,902 | 0 |
| | AN | 16,598 | 16,264 | -2 | 16,533 | 16,369 | -1 |
| | BN | 13,792 | 13,805 | 0 | 13,822 | 13,868 | 0 |
| | D | 12,283 | 12,247 | 0 | 12,569 | 12,544 | 0 |
| | C | 9,492 | 9,493 | 0 | 9,516 | 9,516 | 0 |
| July | Average | 19,518 | 19,531 | 0 | 19,266 | 19,303 | 0 |
| | W | 20,071 | 20,077 | 0 | 20,058 | 20,062 | 0 |
| | AN | 22,070 | 21,990 | 0 | 21,976 | 21,954 | 0 |
| | BN | 21,232 | 21,256 | 0 | 21,374 | 21,359 | 0 |
| | D | 19,577 | 19,620 | 0 | 18,788 | 18,866 | 0 |
| | C | 13,683 | 13,741 | 0 | 13,100 | 13,267 | 1 |
| August | Average | 14,710 | 14,743 | 0 | 14,596 | 14,637 | 0 |
| | W | 16,285 | 16,306 | 0 | 16,189 | 16,185 | 0 |
| | AN | 16,418 | 16,393 | 0 | 16,561 | 16,569 | 0 |
| | BN | 16,112 | 16,110 | 0 | 16,170 | 16,104 | 0 |
| | D | 13,632 | 13,841 | 2 | 12,968 | 13,177 | 2 |
| | C | 9,570 | 9,461 | -1 | 9,785 | 9,831 | 0 |
| September | Average | 18,211 | 18,313 | 1 | 18,417 | 18,563 | 1 |
| | W | 27,839 | 27,841 | 0 | 28,337 | 28,340 | 0 |
| | AN | 21,244 | 21,261 | 0 | 22,088 | 22,197 | 0 |
| | BN | 14,088 | 14,116 | 0 | 14,147 | 14,152 | 0 |
| | D | 12,522 | 12,779 | 2 | 12,341 | 12,792 | 4 |
| | C | 7,664 | 7,920 | 3 | 7,347 | 7,550 | 3 |
| October | Average | 11,309 | 11,389 | 1 | 11,117 | 11,184 | 1 |
| | W | 13,419 | 13,493 | 1 | 13,040 | 13,099 | 0 |
| | AN | 10,499 | 10,687 | 2 | 10,571 | 10,707 | 1 |
| | BN | 11,053 | 11,188 | 1 | 11,195 | 11,174 | 0 |
| | D | 10,150 | 10,260 | 1 | 9,830 | 9,972 | 1 |
| | C | 9,587 | 9,461 | -1 | 9,333 | 9,340 | 0 |

**Table 11-14. Sacramento River Inflow Under the Existing Condition, No-Action Alternative, and CP1 (contd.)**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| November | Average | 15,640 | 15,677 | 0 | 15,605 | 15,629 | 0 |
| | W | 20,726 | 20,866 | 1 | 20,832 | 20,821 | 0 |
| | AN | 16,893 | 16,375 | -3 | 16,666 | 16,506 | -1 |
| | BN | 13,755 | 13,819 | 0 | 13,793 | 13,695 | -1 |
| | D | 12,720 | 12,890 | 1 | 12,723 | 12,926 | 2 |
| | C | 9,948 | 10,086 | 1 | 9,653 | 9,815 | 2 |
| December | Average | 23,248 | 23,182 | 0 | 23,229 | 23,174 | 0 |
| | W | 37,645 | 37,420 | -1 | 37,434 | 37,236 | -1 |
| | AN | 22,604 | 22,694 | 0 | 22,461 | 22,468 | 0 |
| | BN | 16,930 | 16,961 | 0 | 17,103 | 17,193 | 1 |
| | D | 15,760 | 15,701 | 0 | 15,934 | 15,839 | -1 |
| | C | 11,303 | 11,299 | 0 | 11,310 | 11,390 | 1 |

Note:
A negative percentage change reflects a reduction in Sacramento River inflow
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* CP1 operation would result in no discernible 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. There would be no impact.

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. San Joaquin River 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. 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 hydrologic modeling, by month and year type, for the Existing Condition, No-Action Alternative, and CP1 for San Joaquin River flow are summarized in Table 11-15. Results of these analyses show that CP1 would have no effect on seasonal San Joaquin River flows compared with the Existing Condition and No-Action Alternative. Based on these results CP1 would have no impact on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta under CP1. Mitigation for this impact is not needed, and thus not proposed.

**Table 11-15. San Joaquin River Flow at Vernalis**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 4,770 | 4,770 | 0 | 4,764 | 4,764 | 0 |
| | W | 9,273 | 9,273 | 0 | 9,097 | 9,097 | 0 |
| | AN | 4,223 | 4,223 | 0 | 4,259 | 4,259 | 0 |
| | BN | 2,986 | 2,986 | 0 | 3,081 | 3,081 | 0 |
| | D | 2,084 | 2,084 | 0 | 2,160 | 2,160 | 0 |
| | C | 1,673 | 1,673 | 0 | 1,746 | 1,746 | 0 |
| February | Average | 6,265 | 6,265 | 0 | 6,143 | 6,143 | 0 |
| | W | 11,036 | 11,036 | 0 | 10,845 | 10,845 | 0 |
| | AN | 6,047 | 6,047 | 0 | 6,179 | 6,179 | 0 |
| | BN | 5,767 | 5,767 | 0 | 5,565 | 5,565 | 0 |
| | D | 2,642 | 2,642 | 0 | 2,528 | 2,528 | 0 |
| | C | 2,161 | 2,161 | 0 | 2,014 | 2,014 | 0 |
| March | Average | 7,133 | 7,133 | 0 | 7,003 | 7,003 | 0 |
| | W | 13,443 | 13,443 | 0 | 13,170 | 13,170 | 0 |
| | AN | 6,788 | 6,788 | 0 | 6,674 | 6,673 | 0 |
| | BN | 5,322 | 5,322 | 0 | 5,293 | 5,293 | 0 |
| | D | 2,963 | 2,963 | 0 | 2,895 | 2,895 | 0 |
| | C | 2,176 | 2,176 | 0 | 2,129 | 2,129 | 0 |
| April | Average | 6,720 | 6,720 | 0 | 7,533 | 7,533 | 0 |
| | W | 11,420 | 11,420 | 0 | 12,614 | 12,614 | 0 |
| | AN | 6,671 | 6,671 | 0 | 7,799 | 7,798 | 0 |
| | BN | 5,852 | 5,852 | 0 | 6,910 | 6,910 | 0 |
| | D | 3,726 | 3,726 | 0 | 4,112 | 4,112 | 0 |
| | C | 2,087 | 2,087 | 0 | 2,118 | 2,118 | 0 |

**Table 11-15. San Joaquin River Flow at Vernalis (contd.)**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| May | Average | 6,204 | 6,204 | 0 | 6,234 | 6,234 | 0 |
| | W | 11,268 | 11,268 | 0 | 11,135 | 11,135 | 0 |
| | AN | 5,611 | 5,611 | 0 | 5,987 | 5,987 | 0 |
| | BN | 5,010 | 5,010 | 0 | 5,108 | 5,108 | 0 |
| | D | 3,070 | 3,070 | 0 | 3,111 | 3,111 | 0 |
| | C | 1,920 | 1,920 | 0 | 1,862 | 1,862 | 0 |
| June | Average | 4,739 | 4,739 | 0 | 4,671 | 4,671 | 0 |
| | W | 9,451 | 9,451 | 0 | 9,390 | 9,390 | 0 |
| | AN | 5,608 | 5,609 | 0 | 5,326 | 5,326 | 0 |
| | BN | 2,424 | 2,424 | 0 | 2,471 | 2,470 | 0 |
| | D | 1,598 | 1,598 | 0 | 1,554 | 1,554 | 0 |
| | C | 1,076 | 1,076 | 0 | 1,035 | 1,035 | 0 |
| July | Average | 3,202 | 3,202 | 0 | 3,208 | 3,208 | 0 |
| | W | 6,556 | 6,556 | 0 | 6,660 | 6,660 | 0 |
| | AN | 2,783 | 2,784 | 0 | 2,767 | 2,768 | 0 |
| | BN | 1,775 | 1,775 | 0 | 1,733 | 1,733 | 0 |
| | D | 1,282 | 1,282 | 0 | 1,216 | 1,216 | 0 |
| | C | 898 | 898 | 0 | 880 | 880 | 0 |
| August | Average | 2,029 | 2,029 | 0 | 2,040 | 2,041 | 0 |
| | W | 3,099 | 3,099 | 0 | 3,158 | 3,159 | 0 |
| | AN | 2,020 | 2,020 | 0 | 2,014 | 2,015 | 0 |
| | BN | 1,828 | 1,828 | 0 | 1,817 | 1,816 | 0 |
| | D | 1,342 | 1,342 | 0 | 1,315 | 1,315 | 0 |
| | C | 984 | 984 | 0 | 993 | 993 | 0 |
| September | Average | 2,331 | 2,331 | 0 | 2,340 | 2,340 | 0 |
| | W | 3,274 | 3,274 | 0 | 3,317 | 3,317 | 0 |
| | AN | 2,328 | 2,328 | 0 | 2,312 | 2,312 | 0 |
| | BN | 2,109 | 2,109 | 0 | 2,119 | 2,119 | 0 |
| | D | 1,795 | 1,795 | 0 | 1,774 | 1,775 | 0 |
| | C | 1,358 | 1,358 | 0 | 1,355 | 1,355 | 0 |
| October | Average | 2,757 | 2,757 | 0 | 2,753 | 2,753 | 0 |
| | W | 3,112 | 3,112 | 0 | 3,107 | 3,107 | 0 |
| | AN | 2,446 | 2,446 | 0 | 2,424 | 2,424 | 0 |
| | BN | 2,749 | 2,749 | 0 | 2,718 | 2,718 | 0 |
| | D | 2,686 | 2,686 | 0 | 2,710 | 2,710 | 0 |
| | C | 2,416 | 2,416 | 0 | 2,423 | 2,423 | 0 |

**Table 11-15. San Joaquin River Flow at Vernalis (contd.)**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| November | Average | 2,633 | 2,633 | 0 | 2,603 | 2,603 | 0 |
| | W | 3,372 | 3,372 | 0 | 3,340 | 3,340 | 0 |
| | AN | 2,213 | 2,213 | 0 | 2,176 | 2,176 | 0 |
| | BN | 2,412 | 2,412 | 0 | 2,360 | 2,360 | 0 |
| | D | 2,388 | 2,388 | 0 | 2,355 | 2,355 | 0 |
| | C | 2,075 | 2,075 | 0 | 2,088 | 2,088 | 0 |
| December | Average | 3,199 | 3,199 | 0 | 3,263 | 3,263 | 0 |
| | W | 5,081 | 5,081 | 0 | 5,178 | 5,178 | 0 |
| | AN | 2,916 | 2,916 | 0 | 2,899 | 2,899 | 0 |
| | BN | 2,705 | 2,705 | 0 | 2,753 | 2,753 | 0 |
| | D | 2,047 | 2,047 | 0 | 2,123 | 2,123 | 0 |
| | C | 1,710 | 1,710 | 0 | 1,785 | 1,785 | 0 |

Note:
A negative percentage change reflects a reduction in San Joaquin River flow
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* CP1 operation would result in a less than 0.5 km movement upstream or downstream from the X2 location from its location during February through May or September through November under the Existing Condition or No-Action Alternative, and thus cause minimal reduction in low-salinity habitats. 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. X2 serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources. For purposes of evaluating changes in habitat quantity and quality for estuarine species, a significance criterion of an upstream change in X2 location less than 1 km of the location under either the Existing Condition or the No-Action Alternative 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 and September through November.

Results of the comparison of X2 position under the Existing Condition, No-Action Alternative, and CP1 are summarized in Table 11-16. The results showed that changes in X2 location under CP1 as compared with the Existing Condition would be 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. Changes in X2 location between the No-Action Alternative and CP1 assuming future operating conditions would also be small (less than 0.2 km). These results are consistent with model results for Delta outflow that showed a less-than-significant change in flows under CP1. Based on these results, 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 11-16. X2 Under the Existing Condition, No-Action Alternative, and CP1**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Location (km)** | **Location (km)** | **Difference (km)** | **Location (km)** | **Location (km)** | **Difference (km)** |
| January | Average | 67.5 | 67.5 | 0.0 | 67.3 | 67.3 | 0.0 |
| | W | 53.6 | 53.6 | 0.0 | 53.7 | 53.7 | 0.0 |
| | AN | 61.7 | 61.7 | 0.0 | 61.6 | 61.6 | 0.0 |
| | BN | 72.1 | 72.0 | -0.1 | 71.7 | 71.6 | -0.1 |
| | D | 77.9 | 78.0 | 0.1 | 77.4 | 77.6 | 0.1 |
| | C | 82.2 | 82.0 | -0.1 | 81.9 | 82.1 | 0.2 |
| February | Average | 60.9 | 60.9 | 0.0 | 60.8 | 60.9 | 0.0 |
| | W | 50.4 | 50.4 | 0.0 | 50.4 | 50.4 | 0.0 |
| | AN | 54.8 | 54.8 | 0.0 | 54.6 | 54.6 | 0.1 |
| | BN | 61.0 | 60.9 | 0.0 | 60.9 | 60.9 | 0.0 |
| | D | 70.1 | 70.1 | 0.0 | 69.9 | 70.0 | 0.0 |
| | C | 76.2 | 76.2 | 0.0 | 75.9 | 76.1 | 0.2 |
| March | Average | 60.9 | 60.9 | 0.0 | 60.9 | 60.9 | 0.0 |
| | W | 52.1 | 52.1 | 0.0 | 52.1 | 52.1 | 0.0 |
| | AN | 53.6 | 53.7 | 0.0 | 53.7 | 53.7 | 0.0 |
| | BN | 63.3 | 63.4 | 0.1 | 63.3 | 63.4 | 0.0 |
| | D | 67.1 | 67.0 | -0.1 | 67.2 | 67.1 | 0.0 |
| | C | 75.2 | 75.3 | 0.1 | 75.1 | 75.1 | 0.1 |
| April | Average | 63.5 | 63.5 | 0.0 | 63.4 | 63.4 | 0.0 |
| | W | 54.5 | 54.5 | 0.0 | 54.3 | 54.3 | 0.0 |
| | AN | 58.6 | 58.6 | 0.0 | 58.4 | 58.4 | 0.0 |
| | BN | 64.5 | 64.5 | 0.0 | 64.1 | 64.1 | 0.0 |
| | D | 69.9 | 69.9 | 0.0 | 69.9 | 69.8 | -0.1 |
| | C | 77.5 | 77.5 | 0.0 | 77.6 | 77.6 | 0.0 |

**Table 11-16. X2 Under the Existing Condition, No-Action Alternative, and CP1 (contd.)**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Location (km)** | **Location (km)** | **Difference (km)** | **Location (km)** | **Location (km)** | **Difference (km)** |
| May | Average | 67.5 | 67.5 | 0.0 | 67.7 | 67.7 | 0.0 |
| | W | 57.6 | 57.6 | 0.0 | 57.7 | 57.7 | 0.0 |
| | AN | 62.7 | 62.7 | 0.0 | 62.6 | 62.6 | 0.1 |
| | BN | 68.3 | 68.4 | 0.1 | 68.3 | 68.4 | 0.1 |
| | D | 74.4 | 74.4 | 0.0 | 74.8 | 74.7 | -0.1 |
| | C | 82.5 | 82.5 | 0.0 | 82.9 | 82.8 | -0.1 |
| June | Average | 74.5 | 74.6 | 0.0 | 74.7 | 74.7 | 0.0 |
| | W | 65.0 | 65.0 | 0.0 | 65.2 | 65.2 | 0.0 |
| | AN | 72.6 | 72.8 | 0.2 | 72.7 | 72.8 | 0.1 |
| | BN | 76.6 | 76.6 | 0.0 | 76.7 | 76.8 | 0.1 |
| | D | 80.4 | 80.5 | 0.0 | 80.7 | 80.7 | 0.0 |
| | C | 85.9 | 85.9 | 0.0 | 86.0 | 86.0 | 0.0 |
| July | Average | 80.5 | 80.5 | 0.0 | 80.5 | 80.5 | 0.0 |
| | W | 74.4 | 74.4 | 0.0 | 74.5 | 74.5 | 0.0 |
| | AN | 78.1 | 78.2 | 0.1 | 78.4 | 78.4 | 0.1 |
| | BN | 81.7 | 81.7 | 0.0 | 81.6 | 81.6 | 0.0 |
| | D | 84.8 | 84.9 | 0.0 | 84.8 | 84.8 | 0.0 |
| | C | 88.1 | 88.1 | 0.0 | 88.0 | 88.0 | 0.0 |
| August | Average | 85.6 | 85.6 | 0.0 | 85.6 | 85.5 | 0.0 |
| | W | 82.7 | 82.6 | 0.0 | 82.8 | 82.8 | 0.0 |
| | AN | 83.7 | 83.8 | 0.0 | 83.9 | 83.9 | 0.0 |
| | BN | 85.6 | 85.6 | 0.0 | 85.5 | 85.4 | 0.0 |
| | D | 87.8 | 87.8 | 0.0 | 87.5 | 87.5 | 0.0 |
| | C | 90.4 | 90.3 | -0.1 | 90.2 | 90.2 | 0.0 |
| September | Average | 83.7 | 83.7 | 0.0 | 83.7 | 83.6 | 0.0 |
| | W | 73.4 | 73.4 | 0.0 | 73.5 | 73.5 | 0.0 |
| | AN | 81.4 | 81.4 | 0.0 | 81.4 | 81.4 | 0.0 |
| | BN | 88.8 | 88.8 | 0.0 | 88.8 | 88.8 | 0.0 |
| | D | 90.2 | 90.2 | 0.0 | 90.0 | 89.9 | -0.1 |
| | C | 92.5 | 92.4 | -0.1 | 92.3 | 92.3 | 0.0 |
| October | Average | 83.9 | 83.9 | 0.0 | 83.9 | 83.9 | 0.0 |
| | W | 73.6 | 73.6 | 0.0 | 73.7 | 73.7 | 0.0 |
| | AN | 79.8 | 79.8 | 0.0 | 79.8 | 79.8 | 0.0 |
| | BN | 88.9 | 88.9 | 0.0 | 88.9 | 88.9 | 0.0 |
| | D | 91.4 | 91.4 | 0.0 | 91.3 | 91.2 | -0.1 |
| | C | 93.3 | 93.2 | -0.1 | 93.1 | 93.0 | -0.1 |

**Table 11-16. X2 Under the Existing Condition, No-Action Alternative, and CP1 (contd.)**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Location (km)** | **Location (km)** | **Difference (km)** | **Location (km)** | **Location (km)** | **Difference (km)** |
| November | Average | 82.2 | 82.3 | 0.1 | 82.2 | 82.3 | 0.1 |
| | W | 73.1 | 73.1 | 0.0 | 73.2 | 73.2 | 0.0 |
| | AN | 78.4 | 78.4 | 0.0 | 78.4 | 78.5 | 0.1 |
| | BN | 84.8 | 85.3 | 0.5 | 84.8 | 85.2 | 0.4 |
| | D | 88.9 | 89.0 | 0.0 | 88.8 | 88.9 | 0.1 |
| | C | 92.6 | 92.7 | 0.0 | 92.8 | 92.6 | -0.1 |
| December | Average | 76.1 | 76.2 | 0.1 | 76.0 | 76.0 | 0.0 |
| | W | 62.9 | 63.0 | 0.1 | 63.0 | 63.1 | 0.1 |
| | AN | 76.4 | 76.7 | 0.3 | 76.4 | 76.6 | 0.2 |
| | BN | 81.4 | 81.3 | 0.0 | 81.1 | 81.1 | 0.0 |
| | D | 82.8 | 82.9 | 0.1 | 82.6 | 82.7 | 0.1 |
| | C | 87.9 | 87.9 | 0.0 | 87.8 | 87.7 | -0.1 |

Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
D = dry
km = kilometer
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* CP1 operation would result in minimal changes to reverse flows in Old and Middle rivers. The increases in reverse flows under CP1 do not exceed -5,000 cfs; thus, the increases in reverse flows are not expected to contribute to an increase in the vulnerability of delta smelt, longfin smelt, Chinook salmon, juvenile striped bass, or threadfin shad—but summer Old and Middle river flows could contribute to an increase in vulnerability of other resident warm-water fish to increased salvage and potential losses. This impact would be less than significant.

Results of the analysis show two occurrences relative to the Existing Condition, and one compared with the No-Action Alternative when reverse flows within Old and Middle rivers would increase by more than 5 percent; however, neither change resulted in a flow greater (more negative) than -5,000 cfs. Two of these events occurred in critical water years, which would be expected as a result of greater export operations under CP1. During January, operations under CP1 would result in an increase in reverse flow of 5 percent during critical years under future conditions (Table 11-17). Based on results of the delta smelt analysis of the relationship between reverse flows and delta smelt salvage, the increase from approximately 3,900 cfs in January under the basis-of-comparison in a critical water year to approximately 4,100 cfs under CP1would not be expected to result in a significant increase in adverse impacts to delta smelt or longfin smelt.

**Table 11-17. Old and Middle River Reverse Flows for the Existing Condition, No-Action Alternative, and CP1**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | -3,542 | -3,544 | 0 | -3,553 | -3,568 | 0 |
| | W | -2,034 | -2,034 | 0 | -2,151 | -2,151 | 0 |
| | AN | -3,654 | -3,645 | 0 | -3,574 | -3,488 | -2 |
| | BN | -4,240 | -4,240 | 0 | -4,240 | -4,240 | 0 |
| | D | -4,773 | -4,791 | 0 | -4,772 | -4,772 | 0 |
| | C | -4,033 | -4,029 | 0 | -3,940 | -4,131 | 5 |
| February | Average | -3,293 | -3,255 | -1 | -3,358 | -3,367 | 0 |
| | W | -2,745 | -2,738 | 0 | -2,950 | -2,970 | 1 |
| | AN | -3,248 | -3,061 | -6 | -3,165 | -3,139 | -1 |
| | BN | -3,335 | -3,303 | -1 | -3,291 | -3,250 | -1 |
| | D | -4,016 | -4,001 | 0 | -4,045 | -4,044 | 0 |
| | C | -3,391 | -3,393 | 0 | -3,482 | -3,573 | 3 |
| March | Average | -2,784 | -2,810 | 1 | -2,877 | -2,867 | 0 |
| | W | -1,792 | -1,780 | -1 | -2,023 | -2,046 | 1 |
| | AN | -4,021 | -4,227 | 5 | -4,260 | -4,272 | 0 |
| | BN | -4,005 | -4,001 | 0 | -3,982 | -3,983 | 0 |
| | D | -2,951 | -2,873 | -3 | -2,918 | -2,834 | -3 |
| | C | -2,023 | -2,138 | 6 | -1,994 | -1,991 | 0 |
| April | Average | 955 | 955 | 0 | 1,060 | 1,059 | 0 |
| | W | 2,706 | 2,706 | 0 | 2,798 | 2,793 | 0 |
| | AN | 1,087 | 1,087 | 0 | 1,314 | 1,314 | 0 |
| | BN | 697 | 697 | 0 | 898 | 898 | 0 |
| | D | -244 | -244 | 0 | -207 | -205 | -1 |
| | C | -874 | -874 | 0 | -872 | -872 | 0 |
| May | Average | 491 | 490 | 0 | 416 | 412 | -1 |
| | W | 2,077 | 2,077 | 0 | 1,781 | 1,781 | 0 |
| | AN | 562 | 562 | 0 | 646 | 646 | 0 |
| | BN | 277 | 277 | 0 | 270 | 270 | 0 |
| | D | -674 | -674 | 0 | -696 | -696 | 0 |
| | C | -1,018 | -1,026 | 1 | -936 | -966 | 3 |
| June | Average | -3,654 | -3,652 | 0 | -3,718 | -3,736 | 0 |
| | W | -4,226 | -4,226 | 0 | -4,354 | -4,354 | 0 |
| | AN | -4,825 | -4,825 | 0 | -4,818 | -4,818 | 0 |
| | BN | -4,137 | -4,126 | 0 | -4,119 | -4,227 | 3 |
| | D | -3,079 | -3,079 | 0 | -3,205 | -3,204 | 0 |
| | C | -1,542 | -1,542 | 0 | -1,542 | -1,542 | 0 |

**Table 11-17. Old and Middle River Reverse Flows for the Existing Condition, No-Action Alternative, and CP1 (contd.)**

| | | Existing Condition | CP1 (2005) | | No-Action Alternative | CP1 (2030) | |
|---|---|---|---|---|---|---|---|
| Month | Water Year | Flow (cfs) | Flow (cfs) | Percent Change | Flow (cfs) | Flow (cfs) | Percent Change |
| July | Average | -9,502 | -9,514 | 0 | -9,292 | -9,325 | 0 |
| | W | -8,948 | -8,947 | 0 | -8,905 | -8,904 | 0 |
| | AN | -9,993 | -9,949 | 0 | -9,929 | -9,916 | 0 |
| | BN | -10,886 | -10,907 | 0 | -10,903 | -10,859 | 0 |
| | D | -10,998 | -11,038 | 0 | -10,419 | -10,504 | 1 |
| | C | -6,355 | -6,397 | 1 | -5,928 | -6,089 | 3 |

Note:
A positive percentage change reflects more negative reverse flows under CP1 when compared to the Existing Condition or the No-Action Alternative.

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

Juvenile Chinook salmon and steelhead are migrating through the Delta during January, and an increase in average monthly reverse flows of around 200 cfs would be expected to increase the potential risk of increased mortality to these species. 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 January 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 January.

The increase in reverse flows estimated to occur under CP1 in critical and above-normal water years in March would exceed 5 percent, but would not increase the flows beyond -5,000 cfs. The potential change in Old and Middle river flows of approximately 100 to 200 cfs may result in a small increase in vulnerability of fish, particularly delta smelt and longfin smelt, to CVP and SWP salvage, resulting in a potentially significant impact. The increased reverse flows would not result in a significant increase in risk of mortality for Chinook salmon. The potential change in Old and Middle river flows would result in a less-than-significant impact to juvenile striped bass, threadfin shad, and other resident warm-water fish inhabiting the south Delta, due mainly to larger resident populations of these species.

The potential increase in losses during January and March is considered to be less than significant for Chinook salmon, steelhead, delta smelt, longfin smelt, and Chinook salmon, but potentially significant for other resident warm-water fish. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species.

*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* CP1 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. 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 CDFW. The resulting impact to Chinook salmon, steelhead, longfin smelt, striped bass, and splittail would be less than significant; the resulting impact to delta smelt would be potentially significant. Overall, this impact would be potentially significant.

Results of entrainment loss modeling at the CVP and SWP export facilities are presented in Table 11-18 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 analyses. 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 1 of the *Fisheries and Aquatic Ecosystems Technical Report.* The difference between the nonoperations-related and operations-related fish mortality is represented as the entrainment index, shown in Table 11-18, to represent the effect of project operations on each fish species for the CVP and SWP.

**Table 11-18. Indices of Entrainment at the CVP and SWP facilities Under the Existing Condition, No-Action Alternative, and CP1**

| Species | Water Year | CP1 Minus Existing Condition | Percent Change | CP1 Minus No-Action Alternative | Percent Change |
|---|---|---|---|---|---|
| Delta Smelt | Average | 6 | 0.0 | 111 | 0.3 |
| | W | -6 | -0.0 | 7 | 0.0 |
| | AN | -16 | -0.0 | -29 | -0.1 |
| | BN | -33 | -0.1 | 273 | 0.8 |
| | D | 1 | 0.0 | 1 | 0.0 |
| | C | 105 | 0.4 | 452 | 2.0 |
| Chinook Salmon | Average | -8 | -0.0 | 88 | 0.2 |
| | W | -23 | -0.0 | 66 | 0.1 |
| | AN | -8 | -0.0 | -92 | -0.2 |
| | BN | -59 | -0.1 | 83 | 0.2 |
| | D | -88 | -0.2 | -98 | -0.2 |
| | C | 206 | 0.6 | 597 | 1.8 |
| Longfin Smelt | Average | 3 | 0.0 | 14 | 0.2 |
| | W | -1 | -0.0 | 2 | 0.0 |
| | AN | 2 | 0.0 | -1 | -0.0 |
| | BN | 0 | -0.0 | 3 | 0.1 |
| | D | -1 | -0.0 | -2 | -0.0 |
| | C | 22 | 0.4 | 93 | 1.8 |
| Steelhead | Average | -4 | -0.1 | 4 | 0.1 |
| | W | -4 | -0.1 | 10 | 0.2 |
| | AN | -10 | -0.2 | -18 | -0.4 |
| | BN | -9 | -0.2 | -10 | -0.2 |
| | D | -15 | -0.4 | -16 | -0.4 |
| | C | 22 | 0.8 | 57 | 2.1 |
| Striped Bass | Average | 2533 | 0.2 | 5,666 | 0.4 |
| | W | 1518 | 0.1 | 1,399 | 0.1 |
| | AN | 837 | 0.1 | 1,533 | 0.1 |
| | BN | 1092 | 0.1 | 8,237 | 0.6 |
| | D | 6826 | 0.6 | 8,789 | 0.8 |
| | C | 1671 | 0.3 | 11,359 | 1.9 |
| Splittail | Average | 503 | 0.2 | 967 | 0.4 |
| | W | -6 | -0.0 | 11 | 0.0 |
| | AN | -380 | -0.1 | -110 | -0.0 |
| | BN | -182 | -0.1 | 3,141 | 1.2 |
| | D | 435 | 0.2 | 796 | 0.4 |
| | C | 451 | 0.4 | 1,835 | 1.9 |

Note:
Negative percentage change reflects a reduction in entrainment risk while a positive percentage change reflects an increase in entrainment risk.

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

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 would increase, especially during February and summer months. Entrainment indices under CP1 operations indicate 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 be less affected by CP1 operations, with entrainment indices typically 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, would experience increased risk of mortality due to higher exports during June and July, as these species are generally collected at their highest abundances during these months. Under CP1, the risk of entrainment of juvenile Chinook salmon, whose occurrence at the facilities is highest during February through May, would increase as a result of generally higher project export rates during these months when compared to the Existing Condition.

Results of the entrainment risk calculations for delta smelt showed a change of less than 1 percent from the Existing Condition in all water year types and up to a 2-percent increase during critical water years (Table 11-18). The risk of increased losses of delta smelt would be greatest in critical 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 would be 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 would also contribute to cumulative factors affecting the survival of delta smelt.

The estimated change in the risk of losses for Chinook salmon under CP1 follows a similar pattern to that described for delta smelt (Table 11-18). Overall, CP1 would result in a small increase in the risk of losses relative to both the Existing Condition and 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 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 CP1 compared with the Existing Condition and No-Action Alternative include small positive and negative changes (less than 2 percent), depending on water year type (Table 11-18). Given the greater abundance of longfin smelt, when compared to delta smelt, their 2-year life history, and geographic distribution within the estuary, 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 11-18. The increase in risk of steelhead losses in wet years (as compared with the No-Action Alternative) and critical water years (as compared with the Existing Condition) would be less than significant based on the abundance of Sacramento and San Joaquin river 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 critical water years represents an initial estimate of the change (percentage) between the CP1 and the Existing Condition and No-Action Alternatives and does not allow the predicted losses to be evaluated at the population level (see Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report).*

The change in risk to juvenile striped bass for entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-18. The changes in risk in all water year types of less than 2 percent would be less than significant to striped bass but would contribute to the cumulative factors affecting striped bass survival and population dynamics in the Delta. The increased losses, particularly in drier water years when juvenile striped bass production is lower, would 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 11-18). The increased risk index of less than 2 percent was considered to be a less-than-significant impact. The simulated loss index increased during dry and critical water years. Higher risk of entrainment/salvage losses in drier water years has a potentially greater effect on abundance of juvenile splittail since reproductive success and overall juvenile abundance is typically lower in the Delta in dry years. The increased risk of losses in drier years would not be potentially significant, but the increased losses would contribute to cumulative factors affecting survival of juvenile splittail within the Delta.

Impact Aqua-23 (CP1) is considered to be less than significant for all species except delta smelt which could experience potentially significant effects. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species.

**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* CP1 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 to tributaries and reservoirs with CVP and SWP dams, as well as the conveyances south of the Delta would be substantially 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 would not 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.

CP1 implementation could result in modified flow regimes that would shift the frequency and magnitude of high winter flows along the Sacramento River; however, the hydrologic effects in tributaries (e.g., San Joaquin River, canals), reservoirs (e.g., New Melones and San Luis) with CVP and SWP dams, and conveyances are expected to be substantially less than impacts on the lower Sacramento River. The change in hydrology and reservoir levels could affect aquatic habitats for local resident fish communities, but these changes would not 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.

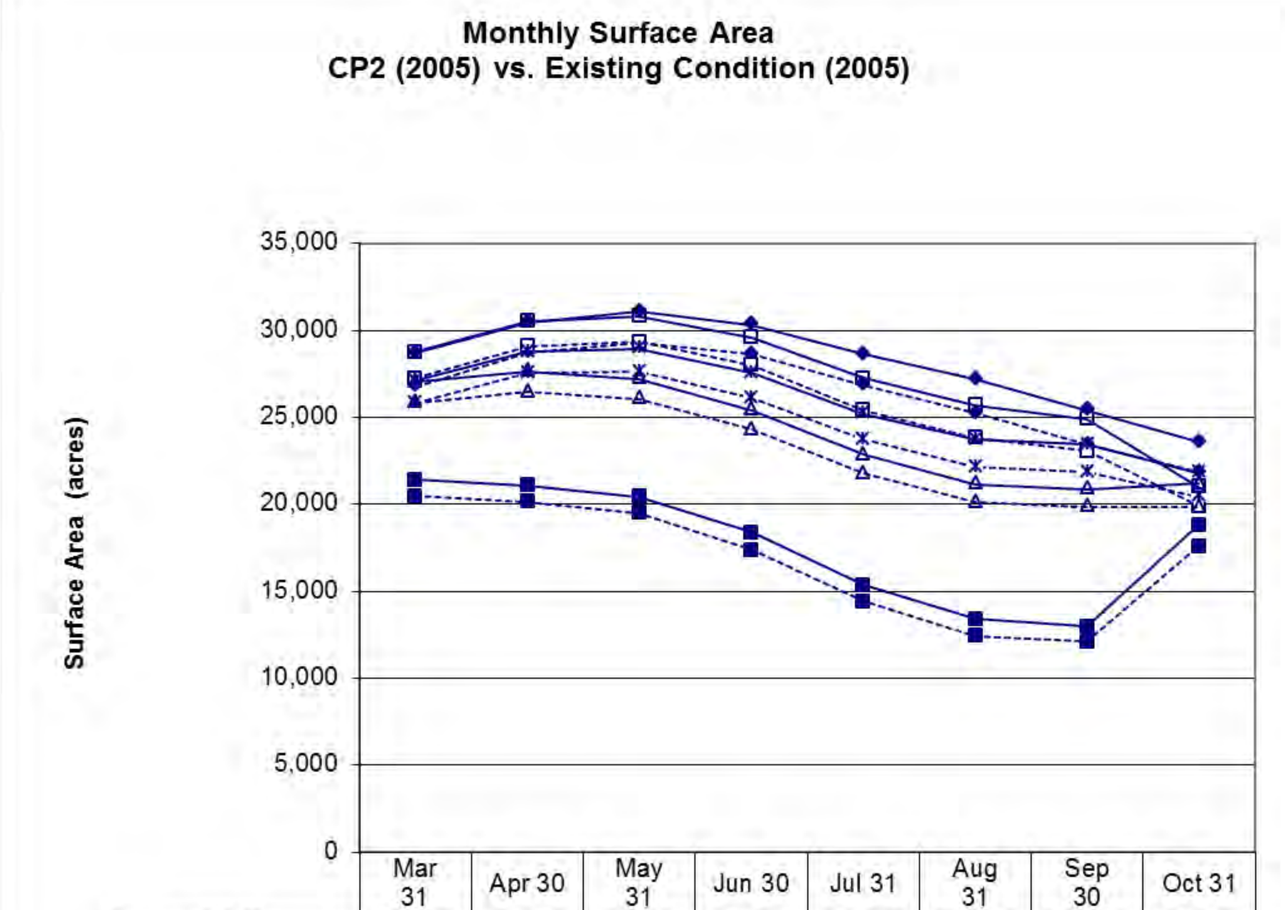
#### *CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability*

As with CP1, CP2 focuses on increasing water supply reliability and increasing anadromous fish survival. CP2 primarily consists of raising Shasta Dam by 12.5 feet, which, in combination with spillway modifications, would increase the height of the reservoir's full pool by 14.5 feet and enlarge the total storage capacity in the reservoir by 443,000 acre-feet. The existing TCD would also be extended to achieve efficient use of the expanded cold-water pool. Shasta Dam operational guidelines would continue essentially unchanged, except during dry years and critical years, when 120,000 acre-feet and 60,000 acre-feet, respectively, of the increased storage capacity in Shasta Reservoir reserved to specifically focus on increasing M&I deliveries. CP2 would help reduce future water shortages through increasing drought year and average year water supply reliability for agricultural and M&I deliveries. In addition, the increased depth and volume of the cold-water pool in Shasta Reservoir would contribute to improving seasonal water temperatures for anadromous fish in the Sacramento River between Shasta Dam and Red Bluff.

#### 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 habitat improvements (e.g., piles, willow plantings) would be diminished; however, the existing habitat-enhancement features would become functional during reservoir drawdowns later in the season and during normal and drier years; however, environmental commitments during construction, which include placing brush in the new inundation varial zone to extend and enhance existing fish habitat structures, would offset this effect (See Chapter 2, “Alternatives,” for additional detailed descriptions of the environmental commitments). Additionally, large areas of the shoreline would not be cleared, and the vegetation along these sections would be inundated periodically. In the short term, this newly inundated vegetation will initially increase warm-water fish habitat, with decay expected to occur over several decades. This impact would be less than significant.

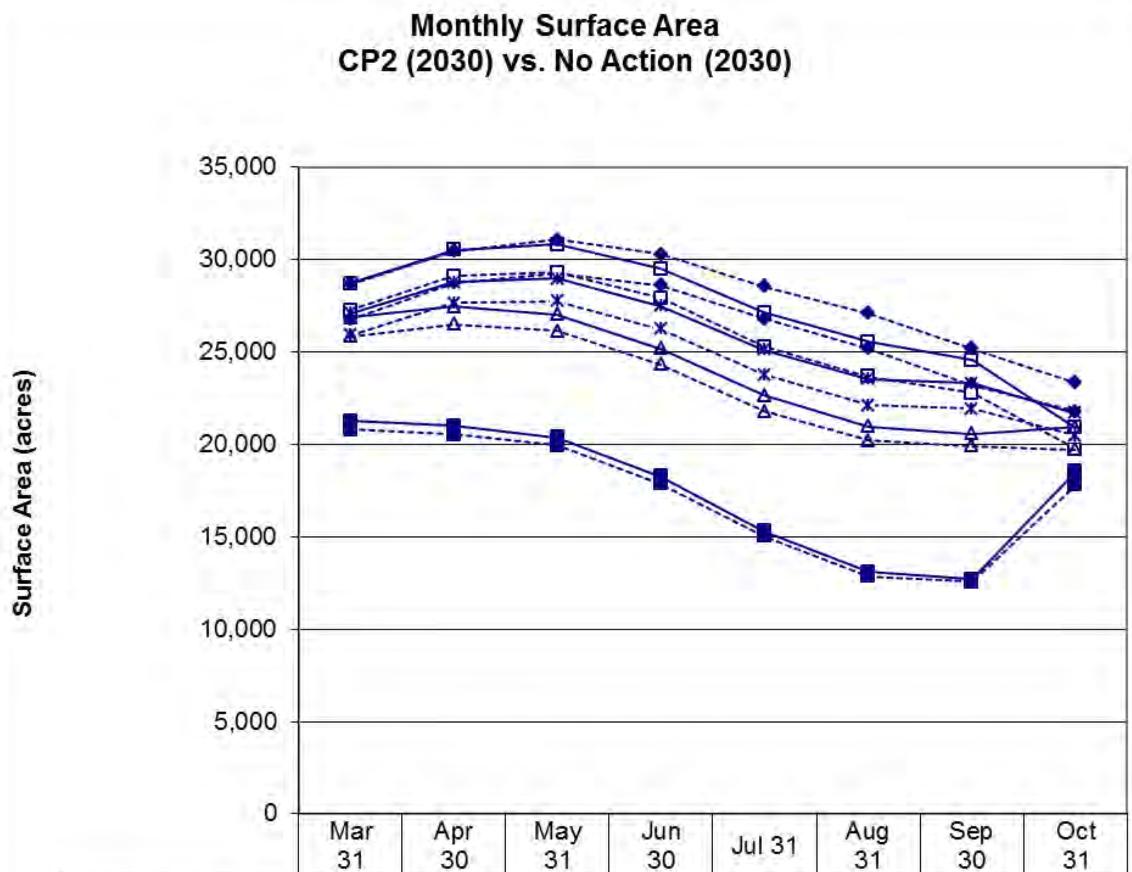
This impact would be similar to Impact Aqua-1 (CP1), but the surface area would be larger under the 12.5-foot dam raise than under the 6.5-foot dam raise. CalSim-II modeling shows that the surface area of Shasta Lake would be larger under the CP2 than the Existing Condition or No-Action Alternative in all five water year types (Figures 11-16 and 11-17).




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 |
|---|---|---|---|---|---|---|---|---|
| EC W | 26,790 | 28,748 | 29,277 | 28,624 | 26,872 | 25,226 | 23,413 | 21,827 |
| EC AN | 27,245 | 29,082 | 29,336 | 27,992 | 25,400 | 23,826 | 23,061 | 19,906 |
| EC BN | 25,807 | 27,534 | 27,621 | 26,104 | 23,714 | 22,114 | 21,837 | 20,425 |
| EC D | 25,850 | 26,467 | 26,058 | 24,300 | 21,754 | 20,093 | 19,840 | 19,828 |
| EC C | 20,467 | 20,142 | 19,500 | 17,381 | 14,400 | 12,418 | 12,111 | 17,572 |
| CP2 2005 W | 28,683 | 30,458 | 31,083 | 30,334 | 28,625 | 27,177 | 25,409 | 23,590 |
| CP2 2005 AN | 28,750 | 30,541 | 30,832 | 29,595 | 27,244 | 25,710 | 24,895 | 21,007 |
| CP2 2005 BN | 27,113 | 28,780 | 28,964 | 27,542 | 25,197 | 23,700 | 23,425 | 21,813 |
| CP2 2005 D | 27,028 | 27,636 | 27,226 | 25,428 | 22,865 | 21,169 | 20,879 | 21,210 |
| CP2 2005 C | 21,404 | 21,076 | 20,452 | 18,375 | 15,342 | 13,395 | 12,971 | 18,813 |

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 11-16. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 Versus the Existing Condition**



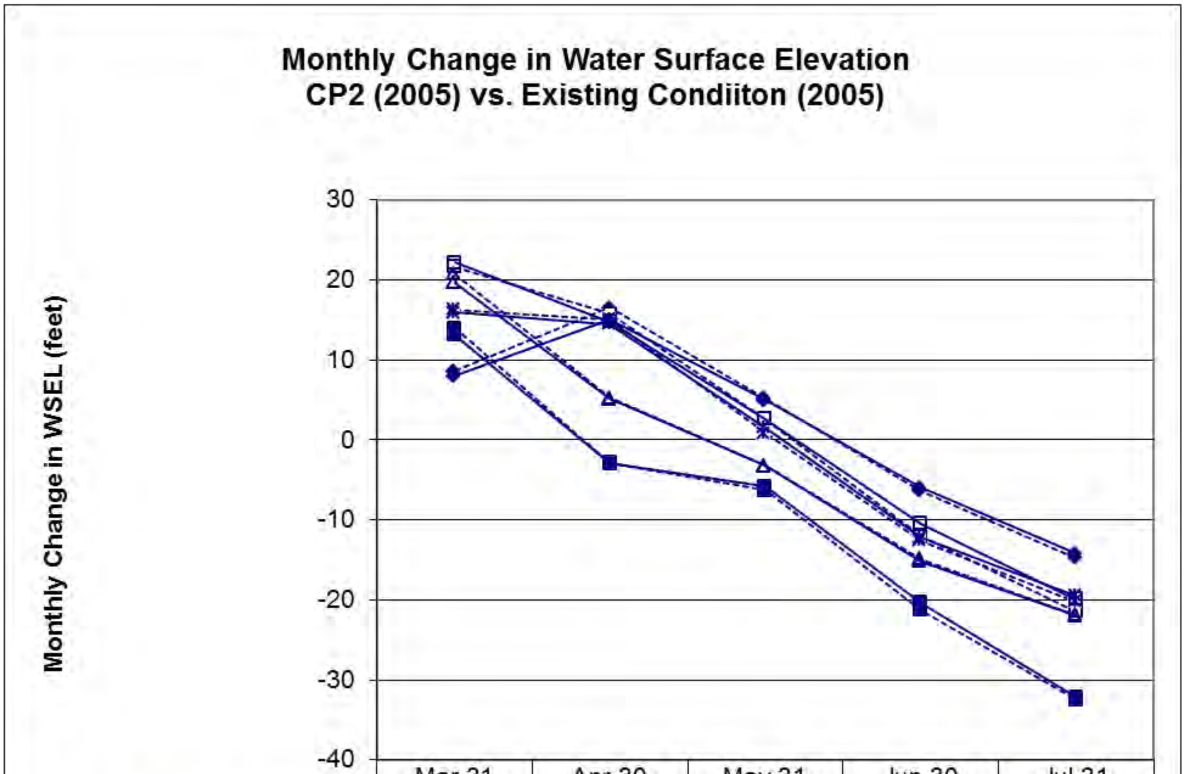

| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 |
|---|---|---|---|---|---|---|---|---|
| NA W | 26,775 | 28,735 | 29,273 | 28,604 | 26,797 | 25,183 | 23,205 | 21,808 |
| NA AN | 27,258 | 29,117 | 29,325 | 27,921 | 25,294 | 23,687 | 22,800 | 19,759 |
| NA BN | 25,918 | 27,662 | 27,770 | 26,239 | 23,764 | 22,137 | 21,923 | 20,469 |
| NA D | 25,843 | 26,514 | 26,134 | 24,346 | 21,780 | 20,209 | 19,910 | 19,728 |
| NA C | 20,801 | 20,548 | 19,942 | 17,866 | 15,026 | 12,873 | 12,556 | 17,800 |
| CP2 2030 W | 28,670 | 30,446 | 31,078 | 30,287 | 28,541 | 27,085 | 25,189 | 23,343 |
| CP2 2030 AN | 28,727 | 30,540 | 30,824 | 29,523 | 27,130 | 25,553 | 24,563 | 20,891 |
| CP2 2030 BN | 27,085 | 28,777 | 28,968 | 27,497 | 25,110 | 23,530 | 23,305 | 21,689 |
| CP2 2030 D | 26,863 | 27,455 | 27,043 | 25,202 | 22,650 | 20,971 | 20,561 | 20,933 |
| CP2 2030 C | 21,267 | 21,006 | 20,364 | 18,273 | 15,299 | 13,085 | 12,712 | 18,527 |

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 11-17. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 Versus No-Action**

Monthly WSEL fluctuations were compared with projections for water supply demand. For CP2, with a 2005 water supply demand, 44 percent of monthly changes in projected WSEL (i.e., 11 of the 25 total projections made for the 5 months from March through July for all five water year types) showed decreased monthly WSEL fluctuations relative to the Existing Condition and 4 percent showed increased monthly WSEL fluctuations (Figure 11-18). For CP2, with a projected 2030 water supply demand, 36 percent of monthly changes in projected WSEL showed decreased WSEL fluctuations relative to the No-Action Alternative and 16 percent showed increased monthly WSEL fluctuations (Figure 11-19). 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.

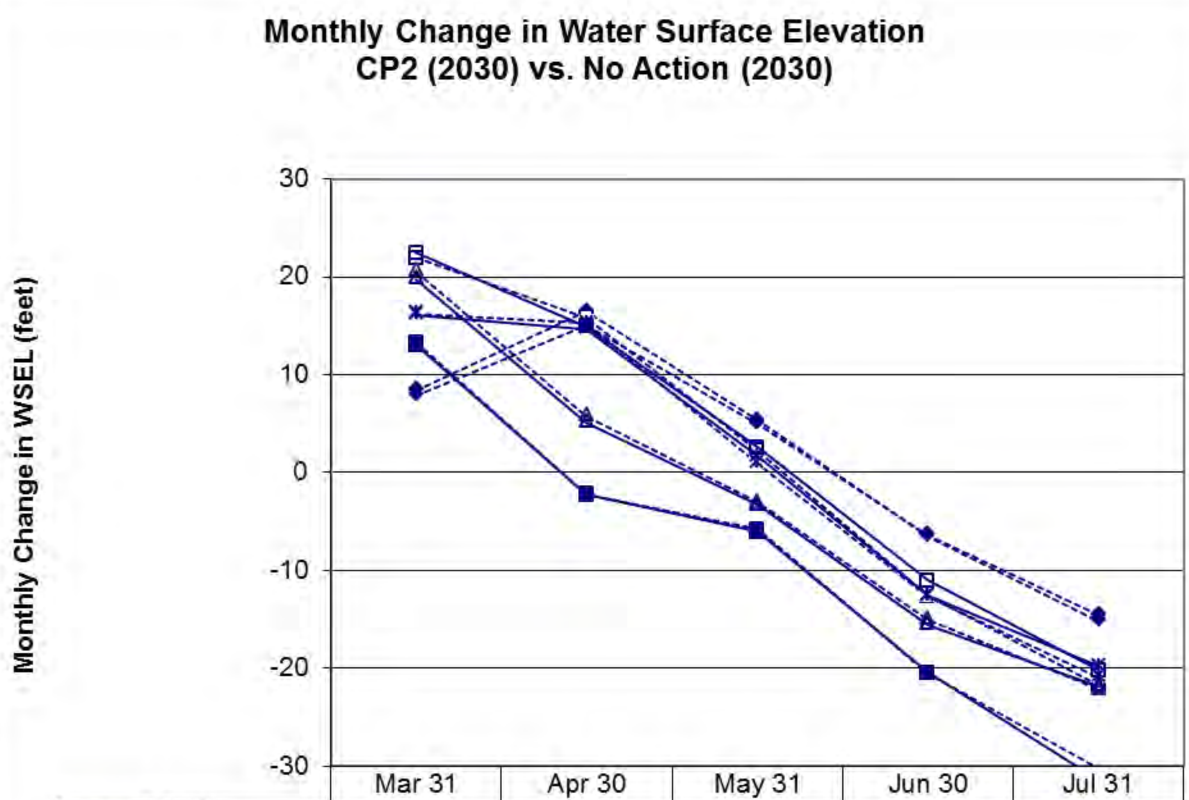
Increases in the overall surface area and WSEL under CP2 would increase the area of available warm-water habitat and stimulate biological productivity, including fish production, of the entire lake for a period of time, possibly for several decades. Furthermore, reductions in the magnitude of monthly WSEL fluctuations, along with the environmental commitment to install and extend existing habitat brush piles and structures, 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 |
|---|---|---|---|---|---|
| EC W | 9 | 16 | 5 | -6 | -15 |
| EC AN | 22 | 16 | 3 | -12 | -21 |
| EC BN | 16 | 15 | 1 | -13 | -20 |
| EC D | 21 | 5 | -3 | -15 | -22 |
| EC C | 14 | -3 | -6 | -21 | -32 |
| CP2 (2005) W | 8 | 15 | 5 | -6 | -14 |
| CP2 (2005) AN | 22 | 15 | 3 | -10 | -20 |
| CP2 (2005) BN | 16 | 15 | 2 | -12 | -19 |
| CP2 (2005) D | 20 | 5 | -3 | -15 | -22 |
| CP2 (2005) C | 13 | -3 | -6 | -20 | -32 |

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 11-18. Average Monthly Change in Water Surface Elevation for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 Compared with the Existing Condition**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 |
|---|---|---|---|---|---|
| NA W | 8 | 16 | 5 | -7 | -15 |
| NA AN | 22 | 16 | 2 | -13 | -22 |
| NA BN | 16 | 15 | 1 | -13 | -21 |
| NA D | 21 | 6 | -3 | -15 | -22 |
| NA C | 13 | -2 | -6 | -21 | -30 |
| CP2 (2030) W | 8 | 15 | 5 | -6 | -15 |
| CP2 (2030) AN | 22 | 15 | 3 | -11 | -20 |
| CP2 (2030) BN | 16 | 15 | 2 | -13 | -20 |
| CP2 (2030) D | 20 | 5 | -3 | -16 | -22 |
| CP2 (2030) C | 13 | -2 | -6 | -20 | -31 |

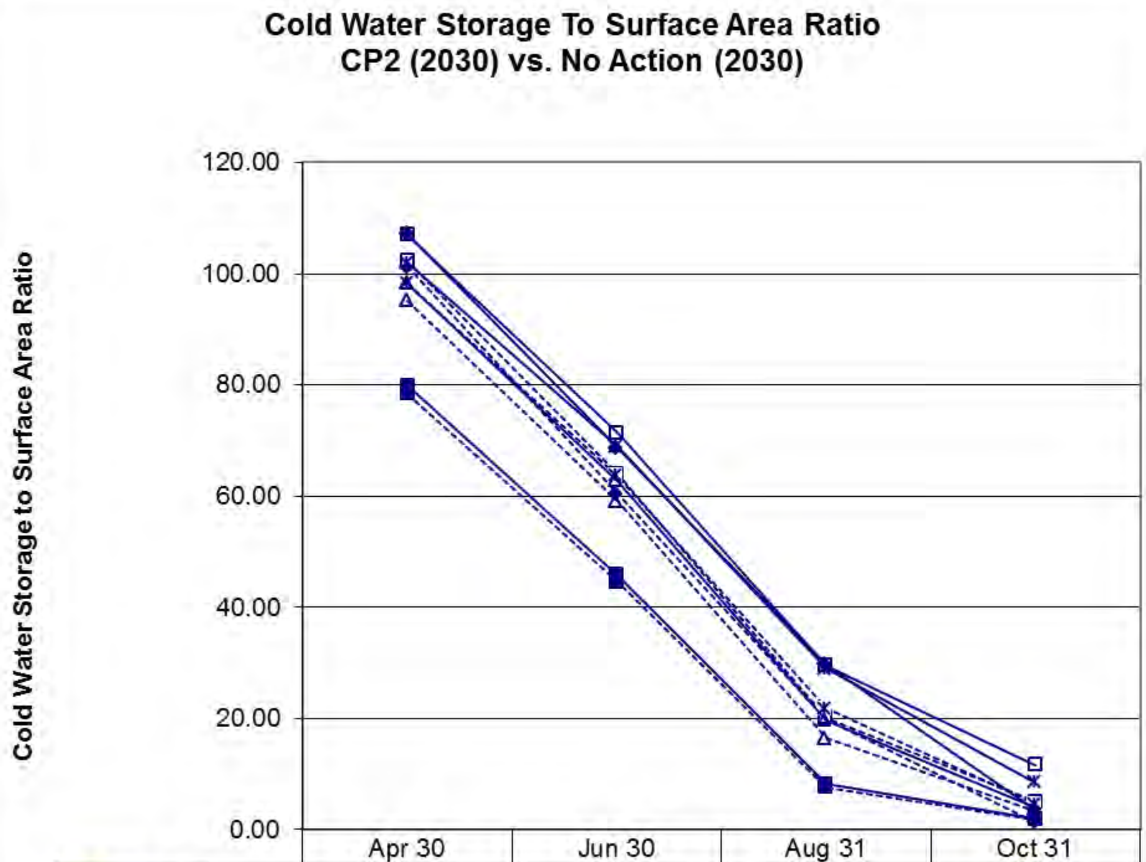
Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years
WSEL = water surface elevation

**Figure 11-19. Average Monthly Change in Water Surface Elevation for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 Compared with No-Action**

*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 a critical rearing and oversummering period for cold-water fishes in reservoirs, and the increases are greatest in wet and above-normal water years (Figure 11-20).




| | Apr 30 | Jun 30 | Aug 31 | Oct 31 |
|---|---|---|---|---|
| NA W | 101.33 | 60.49 | 19.89 | 1.43 |
| NA AN | 102.30 | 64.04 | 20.12 | 5.09 |
| NA BN | 98.27 | 63.71 | 21.84 | 4.64 |
| NA D | 95.13 | 59.14 | 16.50 | 3.38 |
| NA C | 78.43 | 44.58 | 7.66 | 1.82 |
| CP2 2030 W | 107.24 | 68.75 | 29.70 | 3.60 |
| CP2 2030 AN | 106.94 | 71.41 | 29.47 | 11.66 |
| CP2 2030 BN | 102.01 | 68.96 | 28.99 | 8.58 |
| CP2 2030 D | 98.28 | 62.83 | 19.64 | 3.90 |
| CP2 2030 C | 79.90 | 45.87 | 8.14 | 1.89 |

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 11-20. Average Monthly Cold-water Storage to Surface Area Ratio for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 Compared with the Existing Condition**

CP2 would increase the availability of suitable habitat for cold-water fish in Shasta Lake, particularly in dry to wetter water year, with a slight improvement in critical years. 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 adversely affect special-status aquatic mollusks and their habitat in or near Shasta Lake and its tributaries. This impact would be similar to Impact Aqua-4 (CP1). However, a larger area would be inundated under CP2, which could result in an increase in impacts to these species and their habitat. Except for the California floater, the occurrence of special-status mollusks in Shasta Lake and the lower reaches of its tributaries is unlikely. Modification or loss of suitable habitat for the California floater would occur through increased WSEL and seasonal fluctuations in the surface area under CP2. Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

*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. However, available data suggest that hardhead do not currently occur or are very uncommon in the primary tributaries to Shasta Lake, other than the Pit River above the Pit 7 Afterbay.

The 14.5-foot increase in full pool elevation of Shasta Lake would inundate partial or complete fish passage barriers in approximately 68 perennial and 400 intermittent tributaries (greater than 98 percent of which are non-fish-bearing), including the 15-foot high cascade in Squaw Creek that could expand access to Squaw Creek for hardhead; expanded access could be locally beneficial to this special-status species, although the increase may also permit access by predatory warm-water fishes. Access to, and the availability of, suitable riverine habitat among all the main tributaries to the reservoir would not likely become any more limiting than under current conditions, nor would it greatly expand. Therefore, 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. This impact would be less than significant.

This impact would be similar to Impact Aqua-6 (CP1) (i.e., creation and elimination of fish passage barriers in tributaries to Shasta Lake would primarily be limited to non-fish-bearing intermittent streams). However, the maximum inundation level would be higher under CP2, which would inundate (eliminate) partial or complete fish barriers in approximately 34 perennial tributaries, only 15 of which have complete barriers, and the most important of which is a 15-foot boulder cascade in Squaw Creek. Potential impacts of reservoir enlargement to fish communities above passage barriers would be greatest among perennial tributaries as the proportion of fish-bearing perennial streams (87 percent) is much greater than for intermittent streams (2 percent). This could have a small and localized beneficial effect for adfluvial cold-water fish in Shasta Lake by increasing the amount of suitable spawning and rearing habitat available to these species.

Conversely, the potential for access of warm-water fish species into some tributaries, with a potential to alter existing resident fish communities, would be extended by inundation of passage barriers under CP2. However, except for the main river tributaries (i.e., Sacramento, Pit, and McCloud rivers), less than 10 percent of the lake's other accessible tributaries have been found to be colonized by warm-water fish above the varial zone and any further access is expected to be limited primarily to the newly inundated reaches of some streams.

CP2 would not result in the widespread c*reation or elimination of fish passage barriers in tributaries to Shasta Lake. One exception is Squaw Creek, where inundation of a barrier at the current head of the reservoir would potentially allow warm-water fish to move upstream and colonize previously inaccessible habitat with consequent effects on the native fish community and sensitive invertebrates (e.g., mollusks). Environmental commitments, described in Chapter 2, "Alternatives," to monitor fish communities in Squaw Creek and adaptively manage to prevent warmwater fish invasions would reduce this impact to a less than significant level.* 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* Similar to CP1, CP2 would result in additional periodic inundation of potential spawning and rearing habitat for adfluvial salmonids in low-gradient tributaries. In addition to modification of the hydraulic regimes of these affected reaches, changes in the WSEL as a result of CP2 will affect the character and location of substrate (e.g., spawning gravel) at some locations, thereby influencing the suitability.

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 and estimated suitable spawning habitat areas (both intermittent and perennial) that would be periodically affected are as follows:

- Sacramento Arm – 3.1 miles (16,430 Square feet, excludes mainstem river)
- McCloud Arm – 1.4 miles (9,990 square feet)
- Pit Arm – 1.4 miles (523 square feet, excludes mainstem river)
- Big Backbone Arm – 0.6 miles (144 square feet)
- Squaw Arm – 0.9 miles (1,300 square feet)

A total of 7.4 miles of low-gradient reaches (based on channel slope and confirmed by surveys of representative stream reaches) that could provide some spawning and rearing habitat for adfluvial salmonids (estimated as 31,500 square feet for all tributaries) would be affected by CP2, which is only about 1.8 percent of the low-gradient habitat upstream from Shasta Lake. An additional 8,285 square feet of suitable cold-water spawning habitat is estimated to be periodically inundated under CP2 compared to CP1. Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, “Mitigation Measures.”

*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, intermittent non-fish-bearing tributaries to Shasta Lake. About 17.3 miles of non-fish-bearing tributary habitat (based on channel slope and confirmed by surveys of representative stream reaches) would be affected by CP2, which is only about 0.7 percent of this habitat upstream from Shasta Lake.

As described in Chapter 4, “Geology, Geomorphology, Minerals, and Soils,” 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 Arm – 3.9 miles
- McCloud Arm – 2.8 miles
- Pit Arm – 2.5 miles
- Big Backbone Arm – 1.8 miles
- Squaw Arm – 1.3 miles

- Main Body – 5.0 miles

This impact would be similar to Impact 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 non-fish-bearing tributary habitat (based on channel slope) upstream from the lake and no special-status aquatic vertebrate or invertebrate species have been detected in these reaches. 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 Red Bluff)**

*Impact Aqua-10 (CP2): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities* Temporary construction-related increases in sediments and turbidity levels would adversely affect aquatic habitats and fish populations immediately downstream in the upper Sacramento River. However, environmental commitments would be in place to reduce the effects. This impact would be less than significant.

This impact would be similar to Impact Aqua-10 (CP1). The impact could be greater under CP2 than under CP1 because of the increased activity associated with a 12.5-foot raise compared to a 6.5-foot raise. However, as under CP1, environmental commitments for all actions would be in place to reduce the effects. Therefore, this impact would be less than significant. 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. Such exposure could adversely affect aquatic habitats, the aquatic food web, and fish populations, including special-status species, downstream in the primary study area. However, environmental commitments would be in place to reduce the effects. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-11 (CP1). The impact could be greater under CP2 than under CP1 because of the increased activity associated with a 12.5-foot raise compared to a 6.5-foot raise. A potential release of hazardous materials into the upper Sacramento River could cause a reduction in aquatic habitats and fish populations if proper procedures were not implemented to contain the discharge. However, as under CP1, environmental commitments for all actions would be in place to reduce the effects. Therefore, this impact would be less than significant. 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 and Steelhead* CP2 operation under CP2 would generally result in improved flow and water temperature conditions in the upper Sacramento River for Chinook salmon and steelhead, but not all runs have an increase in production. This impact would be beneficial.

*Winter-Run Chinook Salmon*

<u>Production</u>

The overall average winter-run production for the 81-year period was similar for CP2 relative to the No-Action Alternative and the Existing Condition (Attachments 3 and 4 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 61 percent in a critical water year for CP2, while the largest decrease in production relative to the No-Action Alternative was around 24 percent, also in a critical water year (Table 11-19 and Attachment 3 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 45 percent for CP2, while the largest decrease in production relative to the Existing Condition was around 27 percent under CP2 (Table 11-19 and Attachment 4 of the Modeling Appendix). Figure 11-9 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP2, only two critical water years had significant increases (greater than 5 percent) in production relative to the No-Action Alternative for winter-run Chinook salmon. No other water year type had a significant increase in production. One critical water year had a significant decrease in production.

Under CP2, four critical, one dry water, and one below-normal water years had significant increases in production relative to the Existing Condition for winter-run Chinook salmon. Three years (one each in critical, dry and above-normal water year types) had significant decreases in production greater than 5 percent.

**Table 11-19. Change in Production Under CP2 for Winter-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 81 | 3,772,931 | -28,184 | -0.7 | 61.1 | 2 | -23.8 | 1 |
| **Critical** | 13 | 3,343,654 | -34,302 | -1.0 | 61.1 | 2 | -23.8 | 1 |
| **Dry** | 17 | 3,953,711 | -18,620 | -0.5 | 2.9 | 0 | -2.9 | 0 |
| **Below Normal** | 14 | 3,941,590 | 3,032 | 0.1 | 3.6 | 0 | -2.6 | 0 |
| **Above Normal** | 11 | 3,799,691 | -59,239 | -1.5 | 0.5 | 0 | -4.7 | 0 |
| **Wet** | 26 | 3,767,230 | -35,048 | -0.9 | 4.4 | 0 | -3.9 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 3,776,950 | -4,297 | -0.1 | 44.5 | 6 | -5.8 | 2 |
| **Critical** | 13 | 3,357,691 | 146,752 | 4.6 | 44.5 | 4 | -5.6 | 1 |
| **Dry** | 17 | 3,965,107 | -18,754 | -0.5 | 15.2 | 1 | -5.0 | 0 |
| **Below Normal** | 14 | 3,941,118 | 968 | 0.0 | 5.2 | 1 | -4.4 | 0 |
| **Above Normal** | 11 | 3,782,121 | -70,562 | -1.8 | 2.3 | 0 | -5.8 | 1 |
| **Wet** | 26 | 3,772,968 | -45,168 | -1.2 | 1.5 | 0 | -4.4 | 0 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on winter-run Chinook salmon caused by the actions of the project (Attachments 3 and 4). Nonoperations-related mortality are the base and seasonal mortality that would occur even without the effects of Shasta operations (such as disease, predation, and entrainment). Flow- and water temperature-related mortality is that caused by altering flow and water temperatures. In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 86 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 3 and 4 of the Modeling Appendix). The greatest average mortality to winter-run Chinook salmon under CP1 in all water year types based on smolt equivalents would occur to the fry life stage, followed by eggs, then presmolts, and lastly immature smolts. Table 11-5 displays the overall mortalities for each Comprehensive Plan that were caused by changes in water temperature and flow) (Attachments 3 and 4 of the Modeling Appendix).

Years with the highest flow- and water temperature-related mortality were the same for the No-Action Alternative, the Existing Condition, and CP2. Each of these years was a critical water year, and was preceded by either a critical (1933, 1976, 1991), or dry (1930, 1932) 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 3 and 4).

Although winter-run Chinook salmon have, under both 2030 and 2005 conditions, an insignificant change in productivity, there is a decrease in project-related mortality under 2005 conditions (4.4 percent) and an increase in project-related mortality under 2030 conditions (0.9 percent). Additionally, there would not be a significant improvement in production during critical water years. Therefore, the actions taken in CP2 would result in less-than-significant impacts to winter-run Chinook salmon under both 2030 and 2005 conditions. Mitigation for this impact is not needed, and thus not proposed.

*Spring-Run Chinook Salmon*

Production

The overall 81-year average production for spring-run Chinook salmon under CP2 is insignificantly higher relative to the No-Action Alternative and insignificantly lower than the Existing Condition (Attachments 6 and 7 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 97 percent in a critical water year for CP2, while the largest decrease in production relative to the No-Action Alternative was -17 percent, also in a critical water year (Table 11-20 and Attachment 6 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 375 percent for CP2 and the largest decrease in production was less than -5 percent under CP2 in 1977 (Table 11-20 and Attachment 7 of the Modeling Appendix). Figure 11-10 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP2, five critical, two dry, and one below-normal water years had significant increases in production relative to the No-Action Alternative. Production significantly decreased in five critical water years (between -11 and -17 percent). No other water year type had a significant decrease in production.

Under CP2, nine critical, two dry, and one below-normal water years had significant increases in production relative to the Existing Condition. No water years had significant decrease in production relative to the Existing Condition.

**Table 11-20. Change in Production Under CP2 for Spring-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 81 | 164,655 | 601 | 0.4 | 97.4 | 8 | -17.4 | 5 |
| **Critical** | 13 | 87,341 | 6,152 | 7.6 | 97.4 | 5 | -17.4 | 5 |
| **Dry** | 17 | 171,229 | 1,777 | 1.0 | 96.7 | 2 | -1.7 | 0 |
| **Below Normal** | 14 | 177,935 | 754 | 0.4 | 21.1 | 1 | -3.8 | 0 |
| **Above Normal** | 11 | 182,449 | -1,317 | -0.7 | 4.2 | 0 | -2.9 | 0 |
| **Wet** | 26 | 184,335 | -2,215 | -1.2 | 1.6 | 0 | -3.9 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 165,357 | 2,149 | 1.3 | 375 | 12 | -4.2 | 0 |
| **Critical** | 13 | 89,925 | 15,863 | 21.4 | 151 | 9 | -4.2 | 0 |
| **Dry** | 17 | 171,694 | 2,833 | 1.7 | 375 | 2 | -2.4 | 0 |
| **Below Normal** | 14 | 178,901 | 872 | 0.5 | 29.6 | 1 | -2.5 | 0 |
| **Above Normal** | 11 | 182,404 | -1,709 | -0.9 | 3.3 | 0 | -2.8 | 0 |
| **Wet** | 26 | 184,424 | -2,834 | -1.5 | 1.9 | 0 | -4.2 | 0 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on spring-run Chinook salmon caused by the actions of the project (Attachments 6 and 7 of the Modeling Appendix). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 83 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 6 and 7 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality to spring-run Chinook salmon under CP2 (as with CP1) in all water year types based on smolt equivalents would occur to eggs, with minimal mortality to the other life stages. Table 11-7 displays the smolt-equivalent mortalities for each Comprehensive Plan that are caused by flow- and water-related factors (also see Attachments 6 and 7 of the Modeling Appendix).

Years with the highest flow- and water temperature-related mortality were the same for the No-Action Alternative, the Existing Condition, and CP2. 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 (Attachments 6 and 7 of the Modeling Appendix).

Under both 2030 and 2005 conditions, spring-run Chinook salmon would experience a significant reduction in flow- and water temperature-related mortality, but an insignificant increase in overall production. However, spring-run would experience a significant increase in production overall for critical water years, especially in years in which the spring-run Chinook salmon could be extirpated from the Sacramento River due to such a low number of fish surviving to pass RBPP. Therefore, 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*

Production

Overall average fall-run Chinook salmon production for the simulation period was slightly higher for CP2 than for either the No-Action Alternative or Existing Condition (Attachments 9 and 10 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 44 percent for CP2 in a critical water year, while the largest decrease in production relative to the No-Action Alternative was -6 percent, also in a critical water year (Table 11-21 and Attachment 9 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 47 percent for CP2, and the largest decrease in production was around -27 percent under CP2 (Table 11-21 and Attachment 10 of the Modeling Appendix). Figure 11-11 shows the annual change in production relative to the No-Action Alternative for all Comprehensive Plans.

**Table 11-21. Change in Production Under CP2 for Fall-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **No-Action Alternative (2030)** | | | | | | | | |
| **All** | 81 | 29,926,852 | 408,446 | 1.4 | 44.0 | 10 | -6.0 | 1 |
| **Critical** | 13 | 27,955,633 | 1,510,805 | 5.7 | 44.0 | 4 | -1.4 | 0 |
| **Dry** | 17 | 30,244,797 | 704,637 | 2.4 | 18.4 | 3 | -1.7 | 0 |
| **Below Normal** | 14 | 31,488,759 | 390,848 | 1.3 | 22.1 | 2 | -4.4 | 0 |
| **Above Normal** | 11 | 31,022,573 | -10,437 | 0.0 | 4.9 | 0 | -3.4 | 0 |
| **Wet** | 26 | 29,399,974 | -149,702 | -0.5 | 7.2 | 1 | -6.0 | 1 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 29,770,129 | 341,787 | 1.2 | 47.4 | 10 | -26.8 | 3 |
| **Critical** | 13 | 27,223,572 | 1,047,436 | 4.0 | 47.4 | 3 | -26.8 | 1 |
| **Dry** | 17 | 30,168,009 | 707,608 | 2.4 | 27.5 | 5 | -2.9 | 0 |
| **Below Normal** | 14 | 31,401,051 | 382,789 | 1.2 | 36.4 | 2 | -6.0 | 1 |
| **Above Normal** | 11 | 30,916,415 | 46,018 | 0.1 | 2.7 | 0 | -2.8 | 0 |
| **Wet** | 26 | 29,420,098 | -147,172 | -0.5 | 4.3 | 0 | -6.4 | 1 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Except for 1977, 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 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, four critical, three dry, two below-normal, and one wet water year had significant increases in production relative to the No-Action Alternative. Only one year (1969) out of the 81 simulated years had a significant decrease in production (Table 11-21).

Under CP2, three critical, five dry, and two below-normal water years had significant increases in production relative to the Existing Condition. One critical (1977), one below-normal (1979), and one wet (1969) water years resulted in significantly decreased production relative to the Existing Condition (Table 11-21).

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on fall-run Chinook salmon caused by the actions of the project (Attachments 9 and 10). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)–around 65 percent of the total mortality.

Under both 2030 and 2005 conditions, the greatest mortality to fall-run Chinook salmon under CP2 (as with CP1) in all water year types based on smolt equivalents would occur to fry, then to eggs, prespawn adults, presmolts and then immature smolts. Table 11-9 displays the overall mortalities for each alternative that would be caused by flow and water temperature changes (Attachments 9 and 10 of the Modeling Appendix). Mortalities caused by operations-related activities would be lower for CP2 than for the No-Action Alternative (Table 11-9).

There was no real trend with respect to water year type with the greatest mortality.

Fall-run Chinook salmon have an insignificant increase in production and an insignificant reduction in project-related mortality, but would have a significant increase in production overall during critical water years. However, the 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*

Late fall-run Chinook salmon were evaluated directly using SALMOD and were considered to be a surrogate for steelhead; therefore, the following discussion regarding SALMOD results for late fall-run Chinook salmon are applicable to steelhead.

Production

Overall average late fall-run Chinook salmon production for the 80-year period was similar (less than 5 percent change) for CP2 relative to the No-Action Alternative and the Existing Condition (Attachments 12 and 13 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was almost 9 percent for CP2 in a dry water year, while the greatest decrease in production relative to the No-Action Alternative was -5 percent in a critical water year (Table 11-22 and Attachment 12 of the Modeling Appendix).

The maximum increase in production relative to the Existing Condition was 12 percent for CP2 in 1985. The largest decrease in production relative to the Existing Condition was less than almost -7 percent under CP2 (Table 11-22 and Attachment 13 of the Modeling Appendix). Figure 11-12 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP2, production significantly (greater than 5 percent) increased for two critical and two dry water years, while two critical water years had significant decreases in production relative to the No-Action Alternative.

**Table 11-22. Change in Production Under CP2 for Late Fall-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 80 | 7,416,831 | -1,656 | 0.0 | 8.7 | 3 | -5.1 | 1 |
| **Critical** | 13 | 7,044,042 | -20,127 | -0.3 | 5.9 | 2 | -5.1 | 1 |
| **Dry** | 16 | 7,429,076 | 74,707 | 1.0 | 8.7 | 1 | -3.2 | 0 |
| **Below Normal** | 14 | 7,588,598 | -24,020 | -0.3 | 1.6 | 0 | -3.4 | 0 |
| **Above Normal** | 11 | 7,574,775 | -11,309 | -0.1 | 3.6 | 0 | -2.6 | 0 |
| **Wet** | 26 | 7,436,378 | -23,286 | -0.3 | 4.3 | 0 | -2.9 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 80 | 7,445,153 | 58,592 | 0.8 | 12.3 | 4 | -6.6 | 1 |
| **Critical** | 13 | 7,058,132 | 94,836 | 1.4 | 8.6 | 1 | -2.2 | 0 |
| **Dry** | 16 | 7,498,737 | 138,469 | 1.9 | 12.3 | 3 | -3.4 | 0 |
| **Below Normal** | 14 | 7,657,874 | 46,780 | 0.6 | 3.2 | 0 | -2.3 | 0 |
| **Above Normal** | 11 | 7,616,470 | 56,796 | 0.8 | 2.6 | 0 | -2.3 | 0 |
| **Wet** | 26 | 7,418,665 | -1,566 | 0.0 | 3.5 | 0 | -6.6 | 1 |

Notes:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Late fall-run Chinook salmon are used as a surrogate for steelhead

Under CP2 compared with the Existing Condition, one critical and three dry water years had significant increases in production. One wet water year had a significant (greater than 5 percent) decreases in production.

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on late fall-run Chinook salmon caused by the actions of the project (Attachments 12 and 13). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 78 percent of the total mortality.

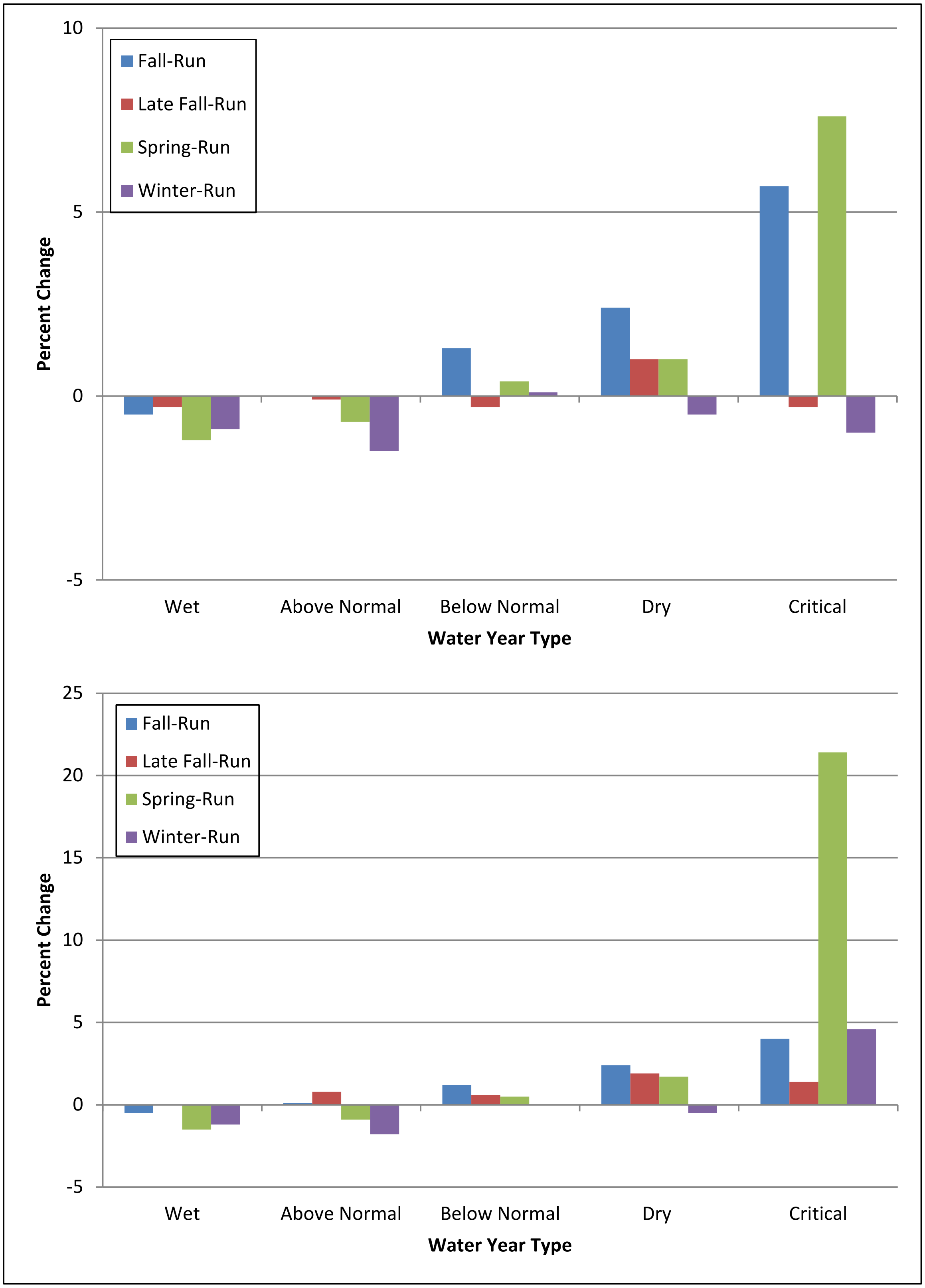
Under both 2030 and 2005 conditions, the greatest mortality to late fall-run Chinook salmon under CP2 (as with CP1) in all water year types based on smolt equivalents would occur to fry, then eggs, presmolts, immature smolts, and lastly to prespawn adults. Table 11-11 displays overall mortalities for each Comprehensive Plan that would be caused by changes in flow and water temperature (see also Attachments 12 and 13 of the Modeling Appendix).

Years with the highest operations-related mortality would be the same for CP2, the No-Action Alternative, and Existing Condition. All water year types were covered. Three years were preceded by a wet water year, and one preceded by an above-normal water year (Attachments 12 and 13 of the Modeling Appendix).

Because SALMOD indicates an insignificant change in mortality and production index for late fall-run Chinook salmon, late fall-run Chinook salmon and steelhead (as represented by late fall-run Chinook salmon as their surrogate) would experience a less-than-significant impact from actions taken in CP2. Mitigation for this impact is not needed, and thus not proposed.

*All Chinook Runs Combined*

Raising Shasta Dam by 12.5 feet, in conjunction with spillway modifications, would result in an increase in full pool depth of 14.5 feet and an additional 443,000 acre-feet of storage capacity in Shasta Reservoir. The additional storage created by the dam raise would be used to improve the ability to meet water temperature objectives and habitat requirements for anadromous fish during drought years (see Figure 11-21). Under the 2030 conditions, overall production for all four runs of Chinook salmon combined would increase by over 379,000 immature smolts migrating below RDPP. Under the 2005 conditions, overall production for all four runs of Chinook salmon combined would increase by over 398,000 immature smolts migrating below RDPP.




Note: Changes in outmigrating Chinook salmon simulated using SALMOD; Water Year Types based on the Sacramento Valley Water Year Hydrologic Classification

**Figure 11-21. Percent Change in Production of Chinook Salmon for CP2 Compared to the No-Action Alternative (top) and Existing Conditions (bottom)**

*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 generally 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 under CP2 than under CP1 because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow storage of additional water volume (and flows) behind the raised dam.

*Flow-Related Effects* As under CP1, monthly mean flows at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBPP) under CP2 would generally be equivalent to (less than 2-percent difference from, with more increases than decreases) flows under the Existing Condition and No-Action Alternative simulated for all months. (See the Modeling Appendix for complete modeling results.)

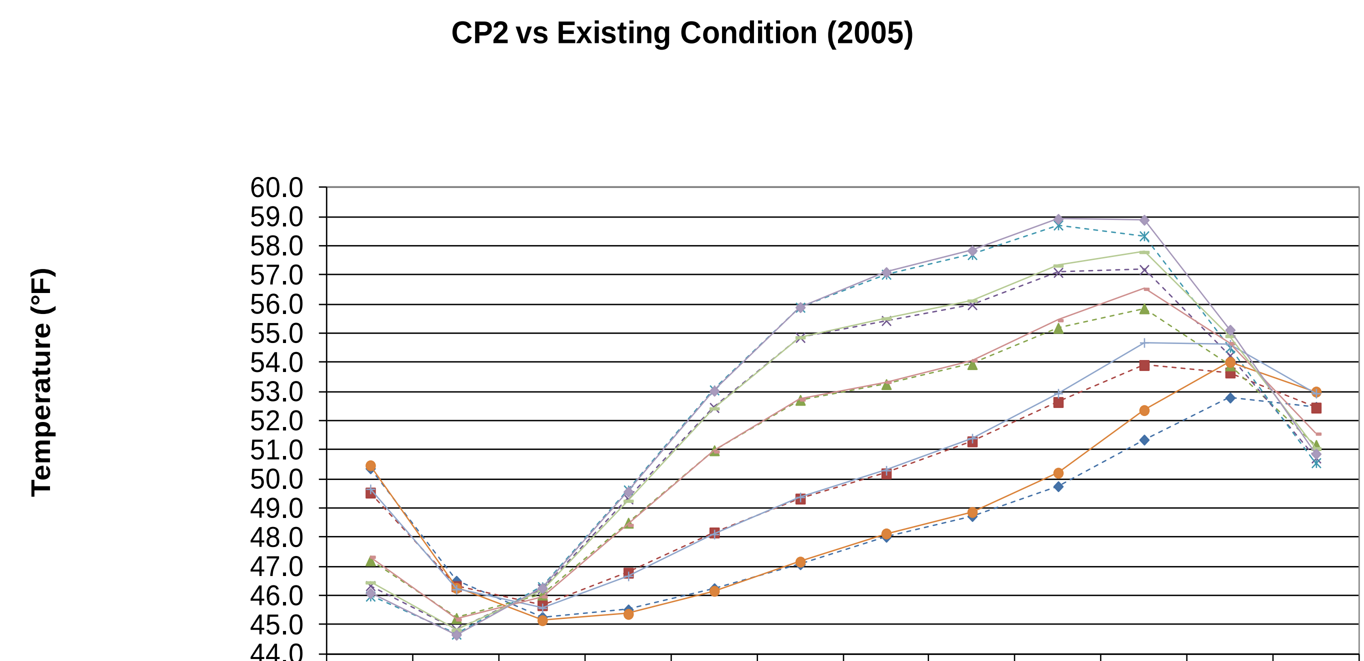
Potential flow-related effects of CP2 on fish species of management concern in the upper Sacramento River would be minimal. Potential changes in flows and stages would diminish rapidly downstream from RBPP because of increased effects from tributary inflows, diversions, and flood bypasses.

Changes in monthly mean flows under CP2 relative to the Existing Condition and No-Action Alternative would have no discernible effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for these species would be unchanged. Therefore, flow-related impacts on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

*Water Temperature–Related Effects* As under CP1, monthly mean water temperatures at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, Balls Ferry, above Bend Bridge, and above RBPP) under CP2 would be the same as, or fractionally less than, water temperatures under the Existing Condition and No-Action Alternative simulated for all months (Figures 11-22 and 11-23). (See the Modeling Appendix 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. Potential water temperature-related effects of CP2 on fish species of management concern in the upper Sacramento River would be minimal. During most years, releases from Shasta Lake would be unchanged.

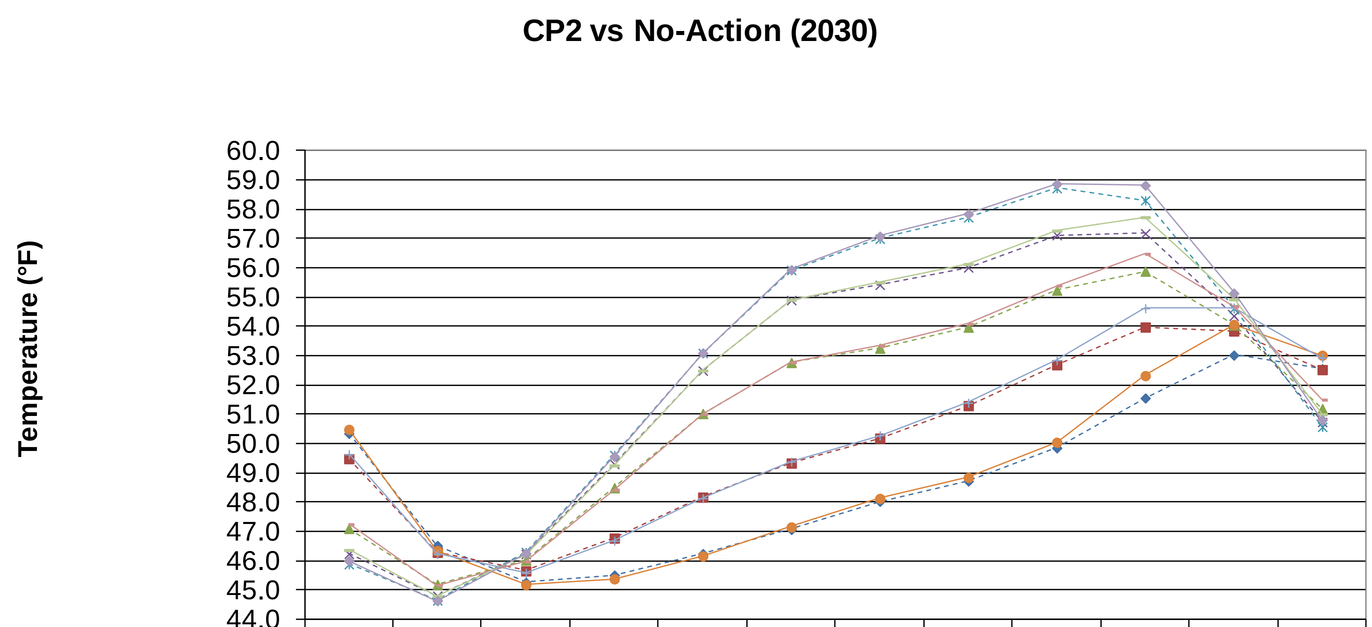
The slightly cooler monthly mean water temperatures under CP2 relative to the Existing Condition and the No-Action Alternative would have very small effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Monthly mean water temperatures would not rise above important thermal tolerances for the species life stages relevant to the upper Sacramento River. Therefore, water temperature–related impacts 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 | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP2 Below Shasta | 50.4 | 46.5 | 45.3 | 45.5 | 46.3 | 47.1 | 48.0 | 48.7 | 49.8 | 51.4 | 52.8 | 52.5 |
| CP2 Below Keswick | 49.5 | 46.3 | 45.7 | 46.8 | 48.2 | 49.3 | 50.2 | 51.3 | 52.6 | 53.9 | 53.7 | 52.5 |
| CP2 Balls Ferry | 47.2 | 45.2 | 46.0 | 48.5 | 51.0 | 52.7 | 53.3 | 53.9 | 55.2 | 55.9 | 53.9 | 51.2 |
| CP2 Bend Bridge | 46.3 | 44.8 | 46.2 | 49.3 | 52.5 | 54.9 | 55.4 | 56.0 | 57.1 | 57.2 | 54.2 | 50.7 |
| CP2 RBPP | 46.0 | 44.7 | 46.3 | 49.6 | 53.1 | 55.9 | 57.0 | 57.7 | 58.7 | 58.3 | 54.5 | 50.6 |
| EC Below Shasta | 50.5 | 46.3 | 45.2 | 45.4 | 46.2 | 47.2 | 48.1 | 48.9 | 50.2 | 52.4 | 54.0 | 53.0 |
| EC Below Keswick | 49.7 | 46.2 | 45.6 | 46.7 | 48.1 | 49.4 | 50.3 | 51.4 | 52.9 | 54.7 | 54.6 | 52.9 |
| EC Balls Ferry | 47.3 | 45.2 | 46.0 | 48.4 | 50.9 | 52.7 | 53.3 | 54.1 | 55.4 | 56.5 | 54.7 | 51.6 |
| EC Bend Bridge | 46.5 | 44.8 | 46.2 | 49.3 | 52.4 | 54.9 | 55.5 | 56.1 | 57.3 | 57.8 | 54.9 | 51.1 |
| EC RBPP | 46.1 | 44.7 | 46.3 | 49.6 | 53.0 | 55.9 | 57.1 | 57.8 | 58.9 | 58.9 | 55.1 | 50.9 |

Key: °F = degrees Fahrenheit EC = Existing Condition
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

**Figure 11-22. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP2 Versus the Existing Condition)**




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP2 Below Shasta | 50.4 | 46.5 | 45.3 | 45.5 | 46.2 | 47.1 | 48.0 | 48.7 | 49.9 | 51.6 | 53.0 | 52.6 |
| CP2 Below Keswick | 49.5 | 46.3 | 45.7 | 46.8 | 48.2 | 49.3 | 50.2 | 51.3 | 52.7 | 54.0 | 53.8 | 52.5 |
| CP2 Balls Ferry | 47.1 | 45.2 | 46.0 | 48.5 | 51.0 | 52.8 | 53.3 | 54.0 | 55.2 | 55.9 | 54.0 | 51.2 |
| CP2 Bend Bridge | 46.2 | 44.8 | 46.2 | 49.3 | 52.5 | 54.9 | 55.4 | 56.0 | 57.1 | 57.2 | 54.4 | 50.7 |
| CP2 RBPP | 45.9 | 44.7 | 46.3 | 49.6 | 53.1 | 55.9 | 57.0 | 57.7 | 58.7 | 58.3 | 54.6 | 50.6 |
| NA Below Shasta | 50.5 | 46.3 | 45.2 | 45.4 | 46.2 | 47.2 | 48.1 | 48.9 | 50.0 | 52.3 | 54.1 | 53.0 |
| NA Below Keswick | 49.6 | 46.2 | 45.6 | 46.7 | 48.1 | 49.4 | 50.3 | 51.4 | 52.9 | 54.6 | 54.6 | 52.9 |
| NA Balls Ferry | 47.3 | 45.2 | 46.0 | 48.4 | 51.0 | 52.8 | 53.3 | 54.1 | 55.4 | 56.5 | 54.7 | 51.5 |
| NA Bend Bridge | 46.4 | 44.8 | 46.2 | 49.3 | 52.5 | 54.9 | 55.5 | 56.1 | 57.3 | 57.7 | 54.9 | 51.0 |
| NA RBPP | 46.0 | 44.6 | 46.3 | 49.6 | 53.1 | 55.9 | 57.1 | 57.8 | 58.9 | 58.8 | 55.1 | 50.8 |

Key: °F = degrees Fahrenheit NA = No-Action Alternative
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

**Figure 11-23. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP2 Versus 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* Project operations could cause a reduction in the magnitude, duration, and frequency of intermediate to large flows both in the upper Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-14 (CP1). The impact could be greater under CP2 than under CP1 because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) 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 the associated stage elevation of the river surface also provide a backwater effect on the lowermost segment of tributaries, reducing the potential for downcutting. These processes are regulated by the magnitude and frequency of flow. Relatively large floods provide the energy required to mobilize sediment from the riverbed, produce meander migration, increase stage elevation, and create seasonally inundated floodplains. Operations under CP2 could result in a reduction in the intermediate to large flows necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains.

Implementation of CP2 would cause 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 effects 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 effects would likely occur throughout the upper Sacramento River portion of 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. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, “Mitigation Measures.”

**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 discernible change in monthly mean flows or water temperature conditions in the lower Sacramento River. However, predicted changes in flows in the Feather, American, and Trinity rivers could result in adverse effects on Chinook salmon, steelhead, Coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be potentially significant.

This impact would be similar to Impact Aqua-15 (CP1). The impact could be greater under CP2 than under CP1 because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and increased cold-water pool) behind the raised dam.

As described below, mean monthly flows at various modeling locations on the lower Sacramento River and tributaries under CP2 were compared with mean monthly flows simulated for the Existing Condition and No-Action Alternative conditions. See the Modeling Appendix for complete CalSim-II modeling results.

*Lower Sacramento River* As under CP1, monthly mean flows at the lower Sacramento River modeling locations under CP2 would be comparable to flows under the Existing Condition and No-Action Alternative conditions simulated for all months. Differences in monthly mean flow were generally small (less than 2 percent) and within the existing range of variability. Potential changes in flows would diminish rapidly downstream from RBPP because of increased effects from tributary inflows, diversions, and flood bypasses. Similarly, potential changes in water temperatures in the lower Sacramento River caused by 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 of CP2 on fish species in the lower Sacramento River would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Also, as under CP1, the effects of altered flow regimes resulting from implementation of CP2 are unlikely to extend into the lower Sacramento River downstream from Verona and into the Delta because the Central Valley's reservoirs and diversions are managed as a single integrated system (consisting of the SWP and the CVP). The operational requirements, including the 2008 USFWS BO and the 2009 NMFS BO, have been designed to maintain standards for flow to the lower Sacramento River and Delta. CVP and SWP operations must be consistent with these ESA BOs. Thus, implementation of CP2 would not likely alter flow to the Delta or water temperatures in the lower Sacramento River and its primary tributaries to a degree sufficient to affect 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 water temperature–related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

*Lower Feather River, American River, and Trinity River* Also, as under CP1, monthly mean flows at modeling locations on the lower Feather River, the American River, and the Trinity River under CP2 would generally be equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for most months. However, simulations for several months within the modeling record show substantial changes to flows in tributaries. Potential changes in flows could be reduced by real-time operations to meet existing rules and because of operation of upstream reservoirs (Lake Oroville, Folsom Lake, and Trinity Lake) and increasing effects from tributary inflows, diversions, and flood bypasses. Potential changes in water temperatures in the Feather River and American River caused by altered releases from reservoirs could diminish downstream because of the increasing effect of inflows, and atmospheric and groundwater influences. 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. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

*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* Project operation could cause a reduction in intermediate to large flows both in the lower Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-16 (CP1). The impact could be greater under CP2 than under CP1 because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) 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 the associated stage elevation of the river 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 flows. Relatively large floods provide the energy required to mobilize sediment from the riverbed, produce meander migration, increase stage elevation, create seasonally inundated floodplains, and inundate floodplain bypasses. Operations under CP2 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.

Implementation of CP2 would cause 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. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

*Impact Aqua-17 (CP2): Effects to Delta Fisheries 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 result in changes to average monthly Delta outflow of less than 5 percent in all year types (with the exception of December of critical years under 2005 conditions). This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

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. Delta outflow would increase by greater than 5 percent under CP2 only in December of critical water years. Based on the results of this analysis, CP2 would have a less-than-significant effect on Delta fisheries and hydrologic transport processes within the Bay-Delta. Mitigation for this impact is not needed, and thus not proposed.

**Table 11-23. Delta Outflow Under the Existing Condition, No-Action Alternative, and CP2**

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 42,078 | 41,860 | -1 | 42,169 | 41,892 | -1 |
| | W | 84,136 | 83,807 | 0 | 84,037 | 83,397 | -1 |
| | AN | 47,221 | 47,015 | 0 | 46,984 | 46,937 | 0 |
| | BN | 21,610 | 21,643 | 0 | 21,990 | 22,017 | 0 |
| | D | 14,166 | 13,955 | -1 | 14,452 | 14,174 | -2 |
| | C | 11,560 | 11,263 | -3 | 11,757 | 11,682 | -1 |

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

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| February | Average | 51,618 | 51,459 | 0 | 51,430 | 51,194 | 0 |
| | W | 95,261 | 94,989 | 0 | 94,634 | 94,259 | 0 |
| | AN | 60,080 | 59,683 | -1 | 60,278 | 59,494 | -1 |
| | BN | 35,892 | 35,856 | 0 | 35,665 | 35,782 | 0 |
| | D | 20,978 | 20,902 | 0 | 20,946 | 20,812 | -1 |
| | C | 12,902 | 12,954 | 0 | 13,088 | 13,142 | 0 |
| March | Average | 42,722 | 42,580 | 0 | 42,585 | 42,530 | 0 |
| | W | 78,448 | 78,493 | 0 | 78,376 | 78,446 | 0 |
| | AN | 53,486 | 52,768 | -1 | 53,139 | 52,656 | -1 |
| | BN | 23,102 | 22,799 | -1 | 22,980 | 22,825 | -1 |
| | D | 19,763 | 19,860 | 0 | 19,559 | 19,648 | 0 |
| | C | 11,881 | 11,740 | -1 | 11,893 | 11,899 | 0 |
| April | Average | 30,227 | 30,239 | 0 | 30,743 | 30,782 | 0 |
| | W | 54,640 | 54,645 | 0 | 55,460 | 55,478 | 0 |
| | AN | 32,141 | 32,130 | 0 | 32,971 | 32,977 | 0 |
| | BN | 21,773 | 21,868 | 0 | 22,511 | 22,538 | 0 |
| | D | 14,347 | 14,317 | 0 | 14,538 | 14,621 | 1 |
| | C | 9,100 | 9,119 | 0 | 8,873 | 8,942 | 1 |
| May | Average | 22,619 | 22,539 | 0 | 22,249 | 22,170 | 0 |
| | W | 41,184 | 41,155 | 0 | 40,543 | 40,532 | 0 |
| | AN | 24,296 | 24,237 | 0 | 24,454 | 24,215 | -1 |
| | BN | 16,346 | 15,984 | -2 | 15,989 | 15,645 | -2 |
| | D | 10,554 | 10,553 | 0 | 10,116 | 10,189 | 1 |
| | C | 6,132 | 6,134 | 0 | 5,910 | 5,927 | 0 |
| June | Average | 12,829 | 12,759 | -1 | 12,660 | 12,595 | -1 |
| | W | 23,473 | 23,471 | 0 | 23,015 | 23,027 | 0 |
| | AN | 12,080 | 11,650 | -4 | 11,799 | 11,446 | -3 |
| | BN | 7,995 | 7,992 | 0 | 7,991 | 7,939 | -1 |
| | D | 6,691 | 6,666 | 0 | 6,764 | 6,727 | -1 |
| | C | 5,361 | 5,361 | 0 | 5,378 | 5,376 | 0 |
| July | Average | 7,864 | 7,869 | 0 | 7,864 | 7,861 | 0 |
| | W | 11,230 | 11,243 | 0 | 11,181 | 11,177 | 0 |
| | AN | 9,562 | 9,538 | 0 | 9,407 | 9,386 | 0 |
| | BN | 7,117 | 7,124 | 0 | 7,225 | 7,259 | 0 |
| | D | 5,005 | 5,006 | 0 | 5,052 | 5,030 | 0 |
| | C | 4,034 | 4,053 | 0 | 4,098 | 4,097 | 0 |

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

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| Month | Water Year | Flow (cfs) | Flow (cfs) | Percent Change | Flow (cfs) | Flow (cfs) | Percent Change |
| August | Average | 4,322 | 4,343 | 0 | 4,335 | 4,357 | 1 |
| | W | 5,302 | 5,313 | 0 | 5,097 | 5,091 | 0 |
| | AN | 4,000 | 4,000 | 0 | 4,000 | 4,000 | 0 |
| | BN | 4,000 | 4,000 | 0 | 4,002 | 4,000 | 0 |
| | D | 3,906 | 3,895 | 0 | 4,142 | 4,198 | 1 |
| | C | 3,520 | 3,655 | 4 | 3,699 | 3,782 | 2 |
| September | Average | 9,841 | 9,845 | 0 | 9,844 | 9,882 | 0 |
| | W | 19,695 | 19,670 | 0 | 19,702 | 19,713 | 0 |
| | AN | 11,784 | 11,771 | 0 | 11,849 | 11,836 | 0 |
| | BN | 3,876 | 3,878 | 0 | 3,913 | 3,932 | 0 |
| | D | 3,508 | 3,554 | 1 | 3,442 | 3,591 | 4 |
| | C | 3,008 | 3,033 | 1 | 3,005 | 3,008 | 0 |
| October | Average | 6,067 | 6,081 | 0 | 6,000 | 6,000 | 0 |
| | W | 7,926 | 7,872 | -1 | 7,633 | 7,550 | -1 |
| | AN | 5,309 | 5,334 | 0 | 5,476 | 5,546 | 1 |
| | BN | 5,479 | 5,551 | 1 | 5,502 | 5,510 | 0 |
| | D | 5,228 | 5,250 | 0 | 5,236 | 5,243 | 0 |
| | C | 4,741 | 4,815 | 2 | 4,714 | 4,804 | 2 |
| November | Average | 11,706 | 11,549 | -1 | 11,675 | 11,500 | -1 |
| | W | 17,717 | 17,588 | -1 | 17,715 | 17,488 | -1 |
| | AN | 12,667 | 11,996 | -5 | 12,491 | 11,965 | -4 |
| | BN | 8,543 | 8,501 | 0 | 8,686 | 8,586 | -1 |
| | D | 8,482 | 8,483 | 0 | 8,414 | 8,375 | 0 |
| | C | 6,250 | 6,173 | -1 | 6,150 | 6,150 | 0 |
| December | Average | 21,755 | 21,621 | -1 | 21,745 | 21,471 | -1 |
| | W | 44,974 | 44,605 | -1 | 44,661 | 43,902 | -2 |
| | AN | 18,581 | 18,426 | -1 | 18,562 | 18,375 | -1 |
| | BN | 12,219 | 12,041 | -1 | 12,326 | 12,246 | -1 |
| | D | 8,531 | 8,494 | 0 | 8,803 | 8,678 | -1 |
| | C | 5,580 | 5,882 | 5 | 5,677 | 5,920 | 4 |

Note: A negative percentage change reflects a reduction in Delta outflow
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 Fisheries Resulting from Changes to Delta Inflow* Based on the results of hydrologic modeling comparing Delta inflow under CP2 to the Existing Condition and No-Action Alternative, CP2 would not decrease average monthly Delta inflow by 5 percent or more in any year type. This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

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. Under CP2, Delta inflow would not decrease by more than 5 percent during any month compared to either the Existing Condition or the No-Action Alternative. Based on the results of this comparison, CP2 would have a less-than-significant effect on Delta fisheries and hydrologic transport processes 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 the Existing Condition, No-Action Alternative, and CP2**

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| Month | Water Year | Flow (cfs) | Flow (cfs) | Percent Change | Flow (cfs) | Flow (cfs) | Percent Change |
| January | Average | 47,426 | 47,218 | 0 | 47,457 | 47,194 | -1 |
| | W | 89,431 | 89,103 | 0 | 89,328 | 88,690 | -1 |
| | AN | 51,611 | 51,349 | -1 | 51,267 | 51,113 | 0 |
| | BN | 27,269 | 27,305 | 0 | 27,576 | 27,603 | 0 |
| | D | 20,125 | 19,959 | -1 | 20,371 | 20,094 | -1 |
| | C | 16,699 | 16,457 | -1 | 16,749 | 16,872 | 1 |
| February | Average | 57,835 | 57,676 | 0 | 57,623 | 57,385 | 0 |
| | W | 103,140 | 102,862 | 0 | 102,606 | 102,252 | 0 |
| | AN | 65,379 | 64,734 | -1 | 65,574 | 64,768 | -1 |
| | BN | 41,782 | 41,822 | 0 | 41,374 | 41,385 | 0 |
| | D | 26,530 | 26,473 | 0 | 26,431 | 26,332 | 0 |
| | C | 17,818 | 18,017 | 1 | 17,958 | 18,035 | 0 |
| March | Average | 49,829 | 49,721 | 0 | 49,713 | 49,647 | 0 |
| | W | 87,688 | 87,726 | 0 | 87,703 | 87,793 | 0 |
| | AN | 61,498 | 61,010 | -1 | 61,339 | 60,883 | -1 |
| | BN | 30,569 | 30,281 | -1 | 30,415 | 30,256 | -1 |
| | D | 24,943 | 24,955 | 0 | 24,640 | 24,639 | 0 |
| | C | 15,933 | 15,916 | 0 | 15,896 | 15,895 | 0 |
| April | Average | 33,962 | 33,976 | 0 | 34,783 | 34,823 | 0 |
| | W | 58,684 | 58,688 | 0 | 60,017 | 60,025 | 0 |
| | AN | 35,588 | 35,578 | 0 | 36,738 | 36,745 | 0 |
| | BN | 25,351 | 25,447 | 0 | 26,403 | 26,429 | 0 |
| | D | 17,962 | 17,939 | 0 | 18,315 | 18,411 | 1 |
| | C | 12,817 | 12,837 | 0 | 12,635 | 12,707 | 1 |

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

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| May | Average | 27,383 | 27,305 | 0 | 27,091 | 27,021 | 0 |
| | W | 46,973 | 46,945 | 0 | 46,494 | 46,482 | 0 |
| | AN | 28,466 | 28,407 | 0 | 28,711 | 28,475 | -1 |
| | BN | 20,747 | 20,382 | -2 | 20,427 | 20,083 | -2 |
| | D | 14,882 | 14,881 | 0 | 14,534 | 14,609 | 1 |
| | C | 10,347 | 10,360 | 0 | 10,038 | 10,110 | 1 |
| June | Average | 22,171 | 22,118 | 0 | 22,090 | 22,042 | 0 |
| | W | 35,459 | 35,457 | 0 | 35,172 | 35,190 | 0 |
| | AN | 23,124 | 22,687 | -2 | 22,776 | 22,423 | -2 |
| | BN | 16,884 | 16,985 | 1 | 16,941 | 17,008 | 0 |
| | D | 14,095 | 14,067 | 0 | 14,337 | 14,278 | 0 |
| | C | 10,710 | 10,713 | 0 | 10,694 | 10,695 | 0 |
| July | Average | 23,099 | 23,131 | 0 | 22,839 | 22,906 | 0 |
| | W | 27,442 | 27,453 | 0 | 27,496 | 27,491 | 0 |
| | AN | 25,169 | 25,083 | 0 | 25,065 | 25,033 | 0 |
| | BN | 23,282 | 23,292 | 0 | 23,362 | 23,288 | 0 |
| | D | 20,937 | 20,930 | 0 | 20,082 | 20,300 | 1 |
| | C | 14,647 | 14,929 | 2 | 14,048 | 14,311 | 2 |
| August | Average | 17,147 | 17,158 | 0 | 17,026 | 17,094 | 0 |
| | W | 20,235 | 20,253 | 0 | 20,154 | 20,148 | 0 |
| | AN | 18,784 | 18,762 | 0 | 18,927 | 18,941 | 0 |
| | BN | 18,274 | 18,171 | -1 | 18,297 | 18,232 | 0 |
| | D | 15,066 | 15,288 | 1 | 14,371 | 14,688 | 2 |
| | C | 10,626 | 10,472 | -1 | 10,850 | 10,913 | 1 |
| September | Average | 20,946 | 21,074 | 1 | 21,145 | 21,396 | 1 |
| | W | 31,918 | 31,921 | 0 | 32,428 | 32,422 | 0 |
| | AN | 23,912 | 23,931 | 0 | 24,747 | 24,859 | 0 |
| | BN | 16,518 | 16,518 | 0 | 16,563 | 16,592 | 0 |
| | D | 14,440 | 14,839 | 3 | 14,233 | 15,081 | 6 |
| | C | 9,130 | 9,383 | 3 | 8,809 | 9,118 | 4 |
| October | Average | 14,407 | 14,455 | 0 | 14,175 | 14,260 | 1 |
| | W | 17,072 | 16,986 | -1 | 16,558 | 16,547 | 0 |
| | AN | 13,176 | 13,416 | 2 | 13,223 | 13,412 | 1 |
| | BN | 14,044 | 14,203 | 1 | 14,159 | 14,175 | 0 |
| | D | 13,133 | 13,270 | 1 | 12,846 | 13,115 | 2 |
| | C | 12,196 | 12,079 | -1 | 11,976 | 11,968 | 0 |

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

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| November | Average | 19,512 | 19,583 | 0 | 19,463 | 19,510 | 0 |
| | W | 26,429 | 26,528 | 0 | 26,536 | 26,428 | 0 |
| | AN | 20,269 | 19,859 | -2 | 20,052 | 19,788 | -2 |
| | BN | 16,984 | 17,053 | 0 | 16,980 | 16,986 | 0 |
| | D | 15,771 | 16,039 | 2 | 15,705 | 16,074 | 2 |
| | C | 12,330 | 12,530 | 2 | 12,081 | 12,339 | 0 |
| December | Average | 30,984 | 30,850 | 0 | 30,988 | 30,692 | -1 |
| | W | 53,758 | 53,401 | -1 | 53,516 | 52,765 | -1 |
| | AN | 28,431 | 28,303 | 0 | 28,223 | 28,079 | -1 |
| | BN | 21,958 | 21,784 | -1 | 22,143 | 22,046 | 0 |
| | D | 18,560 | 18,520 | 0 | 18,837 | 18,696 | -1 |
| | C | 13,363 | 13,607 | 2 | 13,484 | 13,560 | 1 |

Note: A negative percentage change reflects a reduction in Delta inflow
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 inflow, resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water year type. Decreases in Sacramento River inflow would not equal or exceed 5 percent. This impact would be less than significant.

Results of hydrologic modeling, by month and water year type, for the Existing Condition, No-Action Alternative, and CP2 for Sacramento River inflow are presented in Table 11-25. Results of these analyses show a variable response in Sacramento River inflow with CP2 operations resulting in both increases and decreases in river inflow above the Existing Condition and the No-Action Alternative, depending on month and water year type. Under CP2, Sacramento River inflow would not decrease by 5 percent or more. Based on these results 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 the Existing Condition, No-Action Alternative, and CP2**

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 31,139 | 31,061 | 0 | 31,167 | 31,107 | 0 |
| | W | 50,173 | 50,083 | 0 | 50,164 | 49,991 | 0 |
| | AN | 38,122 | 38,034 | 0 | 38,006 | 37,988 | 0 |
| | BN | 22,370 | 22,485 | 1 | 22,540 | 22,649 | 0 |
| | D | 16,980 | 16,886 | -1 | 17,109 | 16,929 | -1 |
| | C | 14,384 | 14,145 | -2 | 14,322 | 14,442 | 1 |
| February | Average | 36,608 | 36,596 | 0 | 36,618 | 36,563 | 0 |
| | W | 56,740 | 56,796 | 0 | 56,637 | 56,659 | 0 |
| | AN | 44,453 | 44,029 | -1 | 44,672 | 44,176 | -1 |
| | BN | 30,911 | 31,054 | 0 | 30,780 | 30,923 | 0 |
| | D | 21,249 | 21,192 | 0 | 21,237 | 21,120 | -1 |
| | C | 14,830 | 15,028 | 1 | 15,075 | 15,152 | 1 |
| March | Average | 32,396 | 32,332 | 0 | 32,352 | 32,319 | 0 |
| | W | 49,248 | 49,293 | 0 | 49,403 | 49,461 | 0 |
| | AN | 44,060 | 43,860 | 0 | 43,972 | 43,783 | 0 |
| | BN | 23,188 | 22,900 | -1 | 23,068 | 22,928 | -1 |
| | D | 20,390 | 20,400 | 0 | 20,138 | 20,135 | 0 |
| | C | 12,971 | 12,954 | 0 | 12,942 | 12,941 | 0 |
| April | Average | 23,232 | 23,246 | 0 | 23,206 | 23,247 | 0 |
| | W | 37,918 | 37,923 | 0 | 38,019 | 38,030 | 0 |
| | AN | 26,053 | 26,044 | 0 | 26,039 | 26,049 | 0 |
| | BN | 17,518 | 17,613 | 1 | 17,439 | 17,465 | 0 |
| | D | 13,205 | 13,182 | 0 | 13,164 | 13,261 | 1 |
| | C | 10,295 | 10,314 | 0 | 10,067 | 10,140 | 1 |
| May | Average | 19,417 | 19,341 | 0 | 19,114 | 19,046 | 0 |
| | W | 32,095 | 32,075 | 0 | 31,800 | 31,795 | 0 |
| | AN | 21,204 | 21,145 | 0 | 21,080 | 20,843 | -1 |
| | BN | 14,530 | 14,166 | -3 | 14,144 | 13,801 | -2 |
| | D | 11,226 | 11,225 | 0 | 10,836 | 10,911 | 1 |
| | C | 8,148 | 8,161 | 0 | 7,874 | 7,946 | 1 |
| June | Average | 16,508 | 16,455 | 0 | 16,511 | 16,462 | 0 |
| | W | 24,092 | 24,089 | 0 | 23,905 | 23,920 | 0 |
| | AN | 16,598 | 16,160 | -3 | 16,533 | 16,179 | -2 |
| | BN | 13,792 | 13,894 | 1 | 13,822 | 13,889 | 0 |
| | D | 12,283 | 12,256 | 0 | 12,569 | 12,509 | 0 |
| | C | 9,492 | 9,494 | 0 | 9,516 | 9,517 | 0 |
| July | Average | 19,518 | 19,551 | 0 | 19,266 | 19,333 | 0 |
| | W | 20,071 | 20,081 | 0 | 20,058 | 20,052 | 0 |
| | AN | 22,070 | 21,983 | 0 | 21,976 | 21,942 | 0 |
| | BN | 21,232 | 21,242 | 0 | 21,374 | 21,301 | 0 |
| | D | 19,577 | 19,571 | 0 | 18,788 | 19,006 | 1 |
| | C | 13,683 | 13,964 | 2 | 13,100 | 13,363 | 2 |
| August | Average | 14,710 | 14,721 | 0 | 14,596 | 14,663 | 0 |
| | W | 16,285 | 16,303 | 0 | 16,189 | 16,182 | 0 |
| | AN | 16,418 | 16,396 | 0 | 16,561 | 16,574 | 0 |
| | BN | 16,112 | 16,010 | -1 | 16,170 | 16,106 | 0 |
| | D | 13,632 | 13,855 | 2 | 12,968 | 13,284 | 2 |
| | C | 9,570 | 9,416 | -2 | 9,785 | 9,847 | 1 |

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

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| September | Average | 18,211 | 18,338 | 1 | 18,417 | 18,667 | 1 |
| | W | 27,839 | 27,841 | 0 | 28,337 | 28,331 | 0 |
| | AN | 21,244 | 21,262 | 0 | 22,088 | 22,200 | 1 |
| | BN | 14,088 | 14,088 | 0 | 14,147 | 14,175 | 0 |
| | D | 12,522 | 12,915 | 3 | 12,341 | 13,189 | 7 |
| | C | 7,664 | 7,917 | 3 | 7,347 | 7,655 | 4 |
| October | Average | 11,309 | 11,401 | 1 | 11,117 | 11,210 | 1 |
| | W | 13,419 | 13,472 | 0 | 13,040 | 13,056 | 0 |
| | AN | 10,499 | 10,738 | 2 | 10,571 | 10,760 | 2 |
| | BN | 11,053 | 11,211 | 1 | 11,195 | 11,211 | 0 |
| | D | 10,150 | 10,287 | 1 | 9,830 | 10,100 | 3 |
| | C | 9,587 | 9,471 | -1 | 9,333 | 9,325 | 0 |
| November | Average | 15,640 | 15,735 | 1 | 15,605 | 15,699 | 1 |
| | W | 20,726 | 20,893 | 1 | 20,832 | 20,854 | 0 |
| | AN | 16,893 | 16,497 | -2 | 16,666 | 16,449 | -1 |
| | BN | 13,755 | 13,823 | 0 | 13,793 | 13,798 | 0 |
| | D | 12,720 | 12,988 | 2 | 12,723 | 13,091 | 3 |
| | C | 9,948 | 10,149 | 2 | 9,653 | 9,911 | 3 |
| December | Average | 23,248 | 23,227 | 0 | 23,229 | 23,124 | 0 |
| | W | 37,645 | 37,487 | 0 | 37,434 | 37,188 | -1 |
| | AN | 22,604 | 22,586 | 0 | 22,461 | 22,378 | 0 |
| | BN | 16,930 | 16,956 | 0 | 17,103 | 17,134 | 0 |
| | D | 15,760 | 15,720 | 0 | 15,934 | 15,793 | -1 |
| | C | 11,303 | 11,547 | 2 | 11,310 | 11,386 | 1 |

Note: A negative percentage change reflects a reduction in Sacramento River inflow
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* CP2 operation would result in no discernible 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. There would be no impact.

Results of hydrologic modeling, by month and water year type, for the Existing Condition, No-Action Alternative, and CP2 for San Joaquin River flow are summarized in Table 11-26. Results of these analyses show that the proposed CP2 would have no effect on seasonal San Joaquin River flows compared with the Existing Condition and No-Action Alternative. Based on these results 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 the Existing Condition and CP2**

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 4,770 | 4,770 | 0 | 4,764 | 4,764 | 0 |
| | W | 9,273 | 9,273 | 0 | 9,097 | 9,097 | 0 |
| | AN | 4,223 | 4,223 | 0 | 4,259 | 4,259 | 0 |
| | BN | 2,986 | 2,986 | 0 | 3,081 | 3,081 | 0 |
| | D | 2,084 | 2,084 | 0 | 2,160 | 2,160 | 0 |
| | C | 1,673 | 1,673 | 0 | 1,746 | 1,746 | 0 |
| February | Average | 6,265 | 6,265 | 0 | 6,143 | 6,143 | 0 |
| | W | 11,036 | 11,036 | 0 | 10,845 | 10,845 | 0 |
| | AN | 6,047 | 6,047 | 0 | 6,179 | 6,179 | 0 |
| | BN | 5,767 | 5,767 | 0 | 5,565 | 5,565 | 0 |
| | D | 2,642 | 2,642 | 0 | 2,528 | 2,528 | 0 |
| | C | 2,161 | 2,161 | 0 | 2,014 | 2,014 | 0 |
| March | Average | 7,133 | 7,133 | 0 | 7,003 | 7,003 | 0 |
| | W | 13,443 | 13,443 | 0 | 13,170 | 13,170 | 0 |
| | AN | 6,788 | 6,788 | 0 | 6,674 | 6,673 | 0 |
| | BN | 5,322 | 5,322 | 0 | 5,293 | 5,293 | 0 |
| | D | 2,963 | 2,963 | 0 | 2,895 | 2,895 | 0 |
| | C | 2,176 | 2,176 | 0 | 2,129 | 2,129 | 0 |
| April | Average | 6,720 | 6,720 | 0 | 7,533 | 7,533 | 0 |
| | W | 11,420 | 11,420 | 0 | 12,614 | 12,614 | 0 |
| | AN | 6,671 | 6,671 | 0 | 7,799 | 7,798 | 0 |
| | BN | 5,852 | 5,852 | 0 | 6,910 | 6,910 | 0 |
| | D | 3,726 | 3,726 | 0 | 4,112 | 4,112 | 0 |
| | C | 2,087 | 2,087 | 0 | 2,118 | 2,118 | 0 |
| May | Average | 6,204 | 6,204 | 0 | 6,234 | 6,234 | 0 |
| | W | 11,268 | 11,268 | 0 | 11,135 | 11,135 | 0 |
| | AN | 5,611 | 5,611 | 0 | 5,987 | 5,987 | 0 |
| | BN | 5,010 | 5,010 | 0 | 5,108 | 5,108 | 0 |
| | D | 3,070 | 3,070 | 0 | 3,111 | 3,111 | 0 |
| | C | 1,920 | 1,920 | 0 | 1,862 | 1,862 | 0 |
| June | Average | 4,739 | 4,739 | 0 | 4,671 | 4,671 | 0 |
| | W | 9,451 | 9,451 | 0 | 9,390 | 9,390 | 0 |
| | AN | 5,608 | 5,609 | 0 | 5,326 | 5,326 | 0 |
| | BN | 2,424 | 2,424 | 0 | 2,471 | 2,470 | 0 |
| | D | 1,598 | 1,598 | 0 | 1,554 | 1,554 | 0 |
| | C | 1,076 | 1,076 | 0 | 1,035 | 1,035 | 0 |

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

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| July | Average | 3,202 | 3,202 | 0 | 3,208 | 3,208 | 0 |
| | W | 6,556 | 6,556 | 0 | 6,660 | 6,660 | 0 |
| | AN | 2,783 | 2,784 | 0 | 2,767 | 2,768 | 0 |
| | BN | 1,775 | 1,775 | 0 | 1,733 | 1,733 | 0 |
| | D | 1,282 | 1,282 | 0 | 1,216 | 1,216 | 0 |
| | C | 898 | 898 | 0 | 880 | 880 | 0 |
| August | Average | 2,029 | 2,029 | 0 | 2,040 | 2,041 | 0 |
| | W | 3,099 | 3,099 | 0 | 3,158 | 3,159 | 0 |
| | AN | 2,020 | 2,020 | 0 | 2,014 | 2,015 | 0 |
| | BN | 1,828 | 1,828 | 0 | 1,817 | 1,816 | 0 |
| | D | 1,342 | 1,342 | 0 | 1,315 | 1,315 | 0 |
| | C | 984 | 984 | 0 | 993 | 993 | 0 |
| September | Average | 2,331 | 2,331 | 0 | 2,340 | 2,340 | 0 |
| | W | 3,274 | 3,274 | 0 | 3,317 | 3,317 | 0 |
| | AN | 2,328 | 2,328 | 0 | 2,312 | 2,312 | 0 |
| | BN | 2,109 | 2,109 | 0 | 2,119 | 2,119 | 0 |
| | D | 1,795 | 1,795 | 0 | 1,774 | 1,775 | 0 |
| | C | 1,358 | 1,358 | 0 | 1,355 | 1,355 | 0 |
| October | Average | 2,757 | 2,757 | 0 | 2,753 | 2,753 | 0 |
| | W | 3,112 | 3,112 | 0 | 3,107 | 3,107 | 0 |
| | AN | 2,446 | 2,446 | 0 | 2,424 | 2,424 | 0 |
| | BN | 2,749 | 2,749 | 0 | 2,718 | 2,718 | 0 |
| | D | 2,686 | 2,686 | 0 | 2,710 | 2,710 | 0 |
| | C | 2,416 | 2,416 | 0 | 2,423 | 2,423 | 0 |
| November | Average | 2,633 | 2,633 | 0 | 2,603 | 2,603 | 0 |
| | W | 3,372 | 3,372 | 0 | 3,340 | 3,340 | 0 |
| | AN | 2,213 | 2,213 | 0 | 2,176 | 2,176 | 0 |
| | BN | 2,412 | 2,412 | 0 | 2,360 | 2,360 | 0 |
| | D | 2,388 | 2,388 | 0 | 2,355 | 2,355 | 0 |
| | C | 2,075 | 2,075 | 0 | 2,088 | 2,088 | 0 |

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

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| December | Average | 3,199 | 3,199 | 0 | 3,263 | 3,263 | 0 |
| | W | 5,081 | 5,081 | 0 | 5,178 | 5,178 | 0 |
| | AN | 2,916 | 2,916 | 0 | 2,899 | 2,899 | 0 |
| | BN | 2,705 | 2,705 | 0 | 2,753 | 2,753 | 0 |
| | D | 2,047 | 2,047 | 0 | 2,123 | 2,123 | 0 |
| | C | 1,710 | 1,710 | 0 | 1,785 | 1,785 | 0 |

Note:
A negative percentage change reflects a reduction in San Joaquin River flow.

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 from its location during February through May or September through November under the Existing Condition or No-Action Alternative, and thus cause minimal reduction in low-salinity habitats. This impact would be less than significant.

Results of the comparison of X2 position under the Existing Condition, No-Action Alternative, and CP2 are summarized in Table 11-27. The results showed that changes in X2 location under CP2 as compared with the Existing Condition during February through May and September through November would be less than 1 km (all were less than 0.3 km) with both variable upstream and downstream movement of the X2 location, depending on month and water year type. Changes in X2 location between the No-Action Alternative and CP2 assuming future operating conditions would also be small (less than 0.4 km). These results are consistent with model results for Delta outflow that showed a less-than-significant change in flows. Based on these results, 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.

**Table 11-27. X2 Under the Existing Condition, No-Action Alternative, and CP2**

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Location (km)** | **Location (km)** | **Difference (km)** | **Location (km)** | **Location (km)** | **Difference (km)** |
| January | Average | 67.5 | 67.5 | 0.0 | 67.3 | 67.3 | 0.0 |
| | W | 53.6 | 53.7 | 0.0 | 53.7 | 53.7 | 0.1 |
| | AN | 61.7 | 61.7 | 0.0 | 61.6 | 61.5 | 0.0 |
| | BN | 72.1 | 72.0 | -0.1 | 71.7 | 71.6 | -0.1 |
| | D | 77.9 | 78.0 | 0.1 | 77.4 | 77.6 | 0.2 |
| | C | 82.2 | 82.2 | 0.0 | 81.9 | 81.8 | -0.1 |
| February | Average | 60.9 | 60.9 | 0.0 | 60.8 | 60.9 | 0.0 |
| | W | 50.4 | 50.4 | 0.0 | 50.4 | 50.4 | 0.0 |
| | AN | 54.8 | 54.8 | 0.0 | 54.6 | 54.6 | 0.1 |
| | BN | 61.0 | 60.9 | 0.0 | 60.9 | 60.9 | 0.0 |
| | D | 70.1 | 70.1 | 0.0 | 69.9 | 70.0 | 0.0 |
| | C | 76.2 | 76.2 | 0.0 | 75.9 | 76.1 | 0.2 |
| March | Average | 60.9 | 60.9 | 0.0 | 60.9 | 60.9 | 0.0 |
| | W | 52.1 | 52.1 | 0.0 | 52.1 | 52.1 | 0.0 |
| | AN | 53.6 | 53.7 | 0.0 | 53.7 | 53.7 | 0.0 |
| | BN | 63.3 | 63.4 | 0.1 | 63.3 | 63.4 | 0.0 |
| | D | 67.1 | 67.0 | -0.1 | 67.2 | 67.1 | 0.0 |
| | C | 75.2 | 75.3 | 0.1 | 75.1 | 75.1 | 0.1 |
| April | Average | 63.5 | 63.5 | 0.0 | 63.4 | 63.4 | 0.0 |
| | W | 54.5 | 54.5 | 0.0 | 54.3 | 54.3 | 0.0 |
| | AN | 58.6 | 58.6 | 0.0 | 58.4 | 58.4 | 0.0 |
| | BN | 64.5 | 64.5 | 0.0 | 64.1 | 64.1 | 0.0 |
| | D | 69.9 | 69.9 | 0.0 | 69.9 | 69.8 | -0.1 |
| | C | 77.5 | 77.5 | 0.0 | 77.6 | 77.6 | 0.0 |
| May | Average | 67.5 | 67.5 | 0.0 | 67.7 | 67.7 | 0.0 |
| | W | 57.6 | 57.6 | 0.0 | 57.7 | 57.7 | 0.0 |
| | AN | 62.7 | 62.7 | 0.0 | 62.6 | 62.6 | 0.1 |
| | BN | 68.3 | 68.4 | 0.1 | 68.3 | 68.4 | 0.1 |
| | D | 74.4 | 74.4 | 0.0 | 74.8 | 74.7 | -0.1 |
| | C | 82.5 | 82.5 | 0.0 | 82.9 | 82.8 | -0.1 |
| June | Average | 74.5 | 74.6 | 0.0 | 74.7 | 74.7 | 0.0 |
| | W | 65.0 | 65.0 | 0.0 | 65.2 | 65.2 | 0.0 |
| | AN | 72.6 | 72.8 | 0.2 | 72.7 | 72.8 | 0.1 |
| | BN | 76.6 | 76.6 | 0.0 | 76.7 | 76.8 | 0.1 |
| | D | 80.4 | 80.5 | 0.0 | 80.7 | 80.7 | 0.0 |
| | C | 85.9 | 85.9 | 0.0 | 86.0 | 86.0 | 0.0 |

**Table 11-27. X2 Under the Existing Condition, No-Action Alternative, and CP2 (contd.)**

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Location (km)** | **Location (km)** | **Difference (km)** | **Location (km)** | **Location (km)** | **Difference (km)** |
| July | Average | 80.5 | 80.5 | 0.0 | 80.5 | 80.5 | 0.0 |
| | W | 74.4 | 74.4 | 0.0 | 74.5 | 74.5 | 0.0 |
| | AN | 78.1 | 78.2 | 0.1 | 78.4 | 78.4 | 0.1 |
| | BN | 81.7 | 81.7 | 0.0 | 81.6 | 81.6 | 0.0 |
| | D | 84.8 | 84.9 | 0.0 | 84.8 | 84.8 | 0.0 |
| | C | 88.1 | 88.1 | 0.0 | 88.0 | 88.0 | 0.0 |
| August | Average | 85.6 | 85.6 | 0.0 | 85.6 | 85.5 | 0.0 |
| | W | 82.7 | 82.6 | 0.0 | 82.8 | 82.8 | 0.0 |
| | AN | 83.7 | 83.8 | 0.0 | 83.9 | 83.9 | 0.0 |
| | BN | 85.6 | 85.6 | 0.0 | 85.5 | 85.4 | 0.0 |
| | D | 87.8 | 87.8 | 0.0 | 87.5 | 87.5 | 0.0 |
| | C | 90.4 | 90.3 | -0.1 | 90.2 | 90.2 | 0.0 |
| September | Average | 83.7 | 83.7 | 0.0 | 83.7 | 83.6 | 0.0 |
| | W | 73.4 | 73.4 | 0.0 | 73.5 | 73.5 | 0.0 |
| | AN | 81.4 | 81.4 | 0.0 | 81.4 | 81.4 | 0.0 |
| | BN | 88.8 | 88.8 | 0.0 | 88.8 | 88.8 | 0.0 |
| | D | 90.2 | 90.2 | 0.0 | 90.0 | 89.9 | -0.1 |
| | C | 92.5 | 92.4 | -0.1 | 92.3 | 92.3 | 0.0 |
| October | Average | 83.9 | 83.9 | 0.0 | 83.9 | 83.9 | 0.0 |
| | W | 73.6 | 73.6 | 0.0 | 73.7 | 73.7 | 0.0 |
| | AN | 79.8 | 79.8 | 0.0 | 79.8 | 79.8 | 0.0 |
| | BN | 88.9 | 88.9 | 0.0 | 88.9 | 88.9 | 0.0 |
| | D | 91.4 | 91.4 | 0.0 | 91.3 | 91.2 | -0.1 |
| | C | 93.3 | 93.2 | -0.1 | 93.1 | 93.0 | -0.1 |
| November | Average | 82.2 | 82.3 | 0.1 | 82.2 | 82.3 | 0.1 |
| | W | 73.1 | 73.1 | 0.0 | 73.2 | 73.2 | 0.0 |
| | AN | 78.4 | 78.4 | 0.0 | 78.4 | 78.5 | 0.1 |
| | BN | 84.8 | 85.3 | 0.5 | 84.8 | 85.2 | 0.4 |
| | D | 88.9 | 89.0 | 0.0 | 88.8 | 88.9 | 0.1 |
| | C | 92.6 | 92.7 | 0.0 | 92.8 | 92.6 | -0.1 |
| December | Average | 76.1 | 76.2 | 0.1 | 76.0 | 76.0 | 0.0 |
| | W | 62.9 | 63.0 | 0.1 | 63.0 | 63.1 | 0.1 |
| | AN | 76.4 | 76.7 | 0.3 | 76.4 | 76.6 | 0.2 |
| | BN | 81.4 | 81.3 | 0.0 | 81.1 | 81.1 | 0.0 |
| | D | 82.8 | 82.9 | 0.1 | 82.6 | 82.7 | 0.1 |
| | C | 87.9 | 87.9 | 0.0 | 87.8 | 87.7 | -0.1 |

Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
D = dry
km = kilometer
W = wet

*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 minimal changes to reverse flows in Old and Middle rivers. The increases in reverse flows under CP2 would not be expected to contribute to an increase in the vulnerability of Chinook salmon, delta smelt, longfin smelt striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses because the flows do not exceed (become more negative) -5,000 cfs. This impact would be less than significant.

Results of the analysis showed two occurrences relative to the Existing Condition when reverse flows within Old and Middle rivers would increase by more than 5 percent. Based on results of the delta smelt analysis of the relationship between reverse flows and delta smelt salvage in March, the increased reverse flows from approximately -4,000 cfs to -4,200 cfs in above-normal water years, and around -2,000 to -2,100 in critical water years would not be expected to result in a significant increase in adverse effects to delta smelt (Table 11-28). Additionally, given the tidal volumes and hydrodynamics of the Old and Middle river region, it is not expected that the change in reverse flows in March would result in detectable changes in fish survival, including for Chinook salmon, striped bass, and other anadromous and resident warm-water fishes.

**Table 11-28. Old and Middle River Reverse Flows for the Existing Condition, No-Action Alternative, and CP2**

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| Month | Water Year | Flow (cfs) | Flow (cfs) | Percent Change | Flow (cfs) | Flow (cfs) | Percent Change |
| January | Average | -3,542 | -3,550 | 0 | -3,553 | -3,566 | 0 |
| | W | -2,034 | -2,034 | 0 | -2,151 | -2,151 | 0 |
| | AN | -3,654 | -3,598 | -2 | -3,574 | -3,479 | -3 |
| | BN | -4,240 | -4,240 | 0 | -4,240 | -4,240 | 0 |
| | D | -4,773 | -4,813 | 1 | -4,772 | -4,771 | 0 |
| | C | -4,033 | -4,086 | 1 | -3,940 | -4,122 | 5 |
| February | Average | -3,293 | -3,289 | 0 | -3,358 | -3,351 | 0 |
| | W | -2,745 | -2,735 | 0 | -2,950 | -2,970 | 1 |
| | AN | -3,248 | -3,011 | -7 | -3,165 | -3,142 | -1 |
| | BN | -3,335 | -3,401 | 2 | -3,291 | -3,195 | -3 |
| | D | -4,016 | -4,028 | 0 | -4,045 | -4,065 | 0 |
| | C | -3,391 | -3,527 | 4 | -3,482 | -3,497 | 0 |

**Table 11-28. Old and Middle River Reverse Flows for the Existing Condition, No-Action Alternative, and CP2 (contd.)**

| | | Existing Condition | CP2 (2005) | | No-Action Alternative | CP2 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| March | Average | -2,784 | -2,814 | 1 | -2,877 | -2,867 | 0 |
| | W | -1,792 | -1,786 | 0 | -2,023 | -2,044 | 1 |
| | AN | -4,021 | -4,230 | 5 | -4,260 | -4,282 | 1 |
| | BN | -4,005 | -4,015 | 0 | -3,982 | -3,979 | 0 |
| | D | -2,951 | -2,873 | -3 | -2,918 | -2,834 | -3 |
| | C | -2,023 | -2,136 | 6 | -1,994 | -1,985 | 0 |
| April | Average | 955 | 954 | 0 | 1,060 | 1,061 | 0 |
| | W | 2,706 | 2,706 | 0 | 2,798 | 2,806 | 0 |
| | AN | 1,087 | 1,087 | 0 | 1,314 | 1,314 | 0 |
| | BN | 697 | 697 | 0 | 898 | 898 | 0 |
| | D | -244 | -247 | 1 | -207 | -214 | 4 |
| | C | -874 | -874 | 0 | -872 | -872 | 0 |
| May | Average | 491 | 490 | 0 | 416 | 409 | -2 |
| | W | 2,077 | 2,077 | 0 | 1,781 | 1,781 | 0 |
| | AN | 562 | 562 | 0 | 646 | 646 | 0 |
| | BN | 277 | 277 | 0 | 270 | 270 | 0 |
| | D | -674 | -674 | 0 | -696 | -696 | 0 |
| | C | -1,018 | -1,028 | 1 | -936 | -984 | 5 |
| June | Average | -3,654 | -3,669 | 0 | -3,718 | -3,734 | 0 |
| | W | -4,226 | -4,226 | 0 | -4,354 | -4,360 | 0 |
| | AN | -4,825 | -4,819 | 0 | -4,818 | -4,818 | 0 |
| | BN | -4,137 | -4,233 | 2 | -4,119 | -4,227 | 3 |
| | D | -3,079 | -3,079 | 0 | -3,205 | -3,184 | -1 |
| | C | -1,542 | -1,542 | 0 | -1,542 | -1,542 | 0 |
| July | Average | -9,502 | -9,526 | 0 | -9,292 | -9,361 | 1 |
| | W | -8,948 | -8,946 | 0 | -8,905 | -8,903 | 0 |
| | AN | -9,993 | -9,935 | -1 | -9,929 | -9,918 | 0 |
| | BN | -10,886 | -10,888 | 0 | -10,903 | -10,826 | -1 |
| | D | -10,998 | -10,992 | 0 | -10,419 | -10,638 | 2 |
| | C | -6,355 | -6,588 | 4 | -5,928 | -6,168 | 4 |

Note:
A positive percentage change reflects more negative reverse flows under CP2 when compared to the Existing Condition or the No-Action Alternative.
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Juvenile Chinook salmon and steelhead migrate through the Delta during January, and an increase in average monthly reverse flows of 100 to 200 cfs would be expected to increase the potential risk of increased mortality to these species. 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 January 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 January. Delta smelt would not be significantly affected by the slight increase in reverse flows in January because their presence in the region is minimal during this time. Longfin smelt larvae, however, are present in January, particularly in critical years, however, reverse flows do not exceed (become more negative) -5,000 cfs, and therefore, do not constitute a significant impact to longfin smelt.

Under 2030 conditions, the increase in reverse flows estimated to occur under CP2 in critical water years in May would be 5 percent, but the flows are less than 1,000 cfs. The increased reverse flows in May 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 could occur in the area in high numbers. However, changes to reverse flows in March and May would not exceed the -5,000 cfs criteria established by the USFWS and NMFS BOs, and would result in less-than-significant impacts to Chinook salmon and steelhead.

Juvenile delta smelt may occur in the area in May; 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 May, the majority of delta smelt move towards Suisun Bay where temperatures are more suitable. The increase in reverse flows in May of a critical year 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.

The potential increase in losses relative to the Existing Conditions during March and No-Action Alternative during January and May is considered to be less than significant. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species.

*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. 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 CDFW. The resulting impact to Chinook salmon, steelhead, and longfin smelt would be less than significant; the resulting impact to delta smelt, striped bass, and splittail would be potentially significant. Overall, this impact would be potentially significant.

Results of entrainment loss modeling at the CVP and SWP export facilities are presented in Table 11-29 for CP2. The estimated index of total numbers of fish lost annually, by species, are presented in Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report.* 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 Table 11-29, to represent the effect of project operations on each fish species at the CVP and SWP facilities.

**Table 11-29. Indices of Entrainment at the CVP and SWP Facilities Under the Existing Condition, No-Action Alternative, and CP2**

| Species | Water Year | CP2 Minus Existing Condition | Percent Change | CP2 Minus No-Action Alternative | Percent Change |
|---|---|---|---|---|---|
| Delta Smelt | Average | 68 | 0.2 | 138 | 0.3 |
| | W | -7 | -0.0 | 21 | 0.0 |
| | AN | -58 | -0.1 | -28 | -0.1 |
| | BN | 273 | 0.8 | 255 | 0.7 |
| | D | 0 | 0.0 | -19 | -0.1 |
| | C | 219 | 0.9 | 656 | 2.9 |
| Salmon | Average | 77 | 0.1 | 83 | 0.2 |
| | W | -20 | -0.0 | 34 | 0.0 |
| | AN | -118 | -0.2 | -84 | -0.2 |
| | BN | 223 | 0.5 | 6 | 0.0 |
| | D | -24 | -0.1 | -62 | -0.1 |
| | C | 464 | 1.3 | 665 | 2.0 |
| Longfin Smelt | Average | 5 | 0.1 | 22 | 0.3 |
| | W | -1 | -0.0 | -4 | -0.0 |
| | AN | 1 | 0.0 | 0 | -0.0 |
| | BN | 3 | 0.1 | 3 | 0.1 |
| | D | 1 | 0.0 | 2 | 0.0 |
| | C | 32 | 0.6 | 149 | 2.9 |
| Steelhead | Average | 7 | 0.2 | -1 | -0.0 |
| | W | -3 | -0.1 | 9 | 0.2 |
| | AN | -30 | -0.7 | -17 | -0.4 |
| | BN | 21 | 0.5 | -25 | -0.6 |
| | D | -4 | -0.1 | -9 | -0.3 |
| | C | 68 | 2.4 | 35 | 1.3 |
| Striped Bass | Average | 5,229 | 0.4 | 8,231 | 0.6 |
| | W | 1,762 | 0.1 | 2,140 | 0.1 |
| | AN | -322 | -0.0 | 2,527 | 0.2 |
| | BN | 10,781 | 0.8 | 7,230 | 0.5 |
| | D | 5,807 | 0.5 | 17,295 | 1.6 |
| | C | 10,946 | 1.8 | 14,704 | 2.5 |
| Splittail | Average | 766 | 0.3 | 1,247 | 0.5 |
| | W | -33 | -0.0 | 187 | 0.0 |
| | AN | -737 | -0.2 | -88 | -0.0 |
| | BN | 3,196 | 1.2 | 2,823 | 1.1 |
| | D | 13 | 0.0 | 1,479 | 0.7 |
| | C | 2,294 | 2.2 | 2,694 | 2.8 |

Note:
Negative percentage change reflects a reduction in entrainment risk while a positive percentage change reflects an increase in entrainment risk.
Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
D = dry
W = wet

Results of the entrainment risk calculations for delta smelt showed a change of less than 1 percent from the Existing Condition in all water years (Table 11-29). The greatest increase in risk (0.9 percent) was estimated for CP2 in a critical year. The entrainment risk for delta smelt relative to the No-Action Alternative would increase in critical years by almost 3 percent (Table 11-29). Although the incremental change in the risk of delta smelt losses resulting from CVP and SWP export operations would be 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 would also contribute to cumulative factors affecting the survival of delta smelt.

The estimated change in the risk of losses for Chinook salmon under CP2 follows a similar pattern to that described for delta smelt (Table 11-29). Overall, CP2 would result in a small increase in the risk of losses relative to both the Existing Condition and No-Action Alternative. The change in risk under CP2 would not exceed 2 percent in any year type as compared with the Existing Condition and the No-Action Alternative, and is considered to be less than significant. Given the numbers of juvenile Sacramento and San Joaquin river 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 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 Existing Condition and No-Action Alternative includes small positive and negative changes depending on water year type (Table 11-29). The increased risk of losses in drier years was considered to be potentially significant. These small changes in the risk of entrainment are considered to be less than significant in most water years, but potentially significant in critically dry years when juvenile longfin smelt production is typically low. The increased losses would also contribute to cumulative factors affecting survival of juvenile longfin smelt within the Delta.

The estimated change in the risk to steelhead of entrainment/salvage at the CVP and SWP export facilities under CP2 are summarized in Table 11-29. The small positive and negative changes in risk under most year types are considered to be less than significant. The increase in risk of steelhead losses in below-normal and critical water years (as compared with the Existing Condition) and in wet water years (as compared with the No-Action Alternative) is considered to be less than significant based on the abundance of juvenile Sacramento and San Joaquin river steelhead migrating through the Delta, but would contribute directly to cumulative factors affecting the survival and population dynamics of Central Valley steelhead. The increased risk of losses in drier years was considered to be potentially significant. The predicted increase in potential entrainment risk for steelhead under wet, below-normal, and critical water years represents an initial estimate of the change (percentage) between CP2 and the Existing Condition and the No-Action Alternative, and does not allow the predicted losses to be evaluated at the population level (see Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report)*. The increased losses would also contribute to cumulative factors affecting survival of juvenile steelhead within the Delta.

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 all water years is considered to be less than significant for 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. 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 risk index would increase by less than 3 percent under CP2 compared to the Existing Condition or the No-Action Alternative. Higher risk of entrainment/salvage losses in drier water years has a potentially greater effect on 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 (CP2) is considered to be less than significant for Chinook salmon, but potentially significant for delta smelt, steelhead, longfin 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 to reduce any impacts to listed fish species, and will thus benefit non-listed fishes as well.

### 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* CP2 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 to tributaries and reservoirs (e.g., New Melones and San Luis) with CVP and SWP dams, as well as the conveyances south of the Delta would be substantially less than impacts on the lower Sacramento River. The change in hydrology in the CVP and SWP service areas could affect aquatic habitats for the local resident fish community; however the changes would not result in substantial effects on their distribution or abundance. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-24 (CP1). The hydrologic effects to the CVP and SWP service areas would not result in substantial effects on the distribution or abundance of fish populations. 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, as described for Impact Aqua-24 (CP1). 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, Agricultural Water Supply Reliability and Anadromous Fish Survival*

CP3 focuses on increasing agricultural water supply reliability while also increasing anadromous fish survival. This plan primarily consists of raising Shasta Dam by 18.5 feet, which, in combination with spillway modifications, would increase the height of the reservoir's full pool by 20.5 feet and enlarge the total storage capacity in the reservoir by 634,000 acre-feet. The existing TCD would also be extended to achieve efficient use of the expanded cold-water pool. Because CP3 focuses on increasing agricultural water supply reliability, none of the increased storage capacity in Shasta Reservoir would be reserved for increasing M&I deliveries. Operations for water supply, hydropower, and environmental and other regulatory requirements would be similar to existing operations, with the additional storage retained for water supply reliability and to expand the cold-water pool for downstream anadromous fisheries.

Simulations of CP3 did not involve any changes to the modeling logic for deliveries or flow requirements; all rules for water operations were updated to include the new storage, but were not otherwise changed.

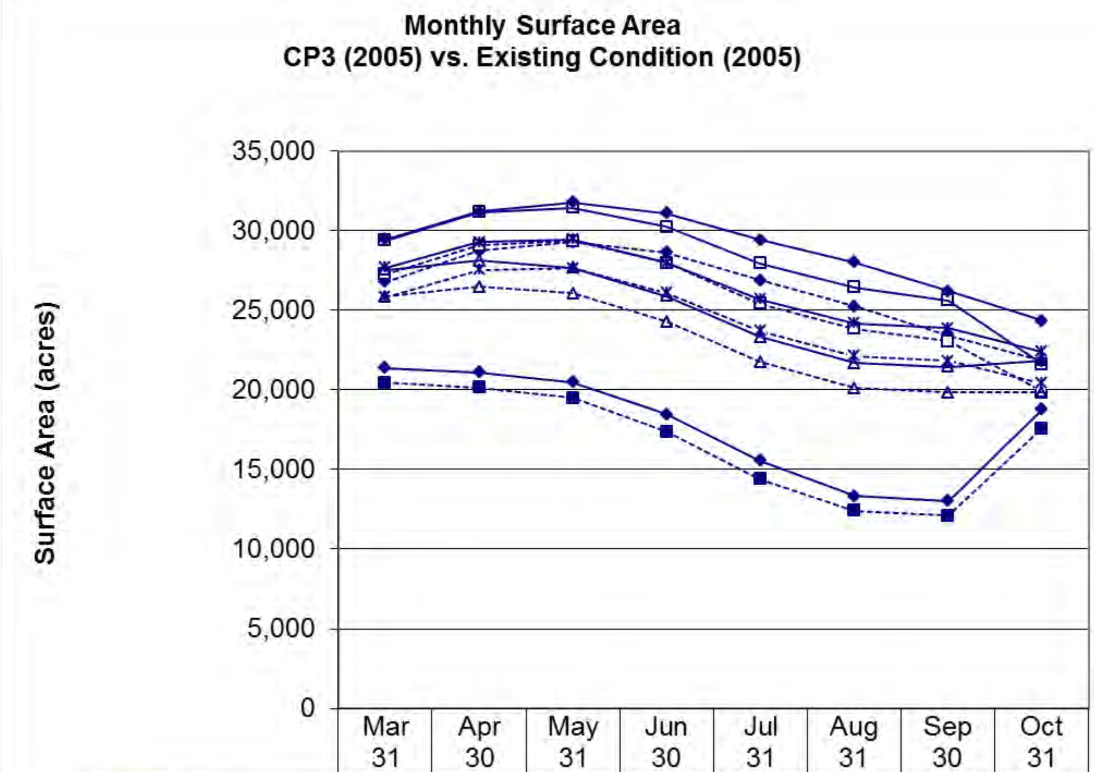
### Shasta Lake and Vicinity

*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 by deeper and longer periods of inundation to varying degrees; however, the existing habitat enhancement features would become functional during reservoir drawdowns later in the season and during below-normal and drier years; however, environmental commitments during construction, which include placing brush in the new inundation varial zone to extend and enhance existing fish habitat structures, would offset this effect (See Chapter 2, "Alternatives," for additional detailed descriptions of the environmental commitments). Additionally, large areas of the shoreline would not be cleared, and the vegetation along these sections would be inundated periodically. In the short term, this newly inundated vegetation will initially increase warm-water fish 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 11-24 and 11-25).

Monthly WSEL fluctuations were compared with projections for water supply demand. For CP3, with a 2005 water supply demand, 52 percent of monthly changes in projected WSELs (i.e., 13 of the 25 total projections made for the 5 months from March through July for all five water year types) showed decreased monthly WSEL fluctuations relative to the Existing Condition and 4 percent showed increased monthly WSEL fluctuations (Figure 11-26). For CP3, with a projected 2030 water supply demand, 52 percent of monthly changes in projected WSELs showed decreased WSEL fluctuations relative to the No-Action Alternative and 4 percent showed increased monthly WSEL fluctuations (Figure 11-27). 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.

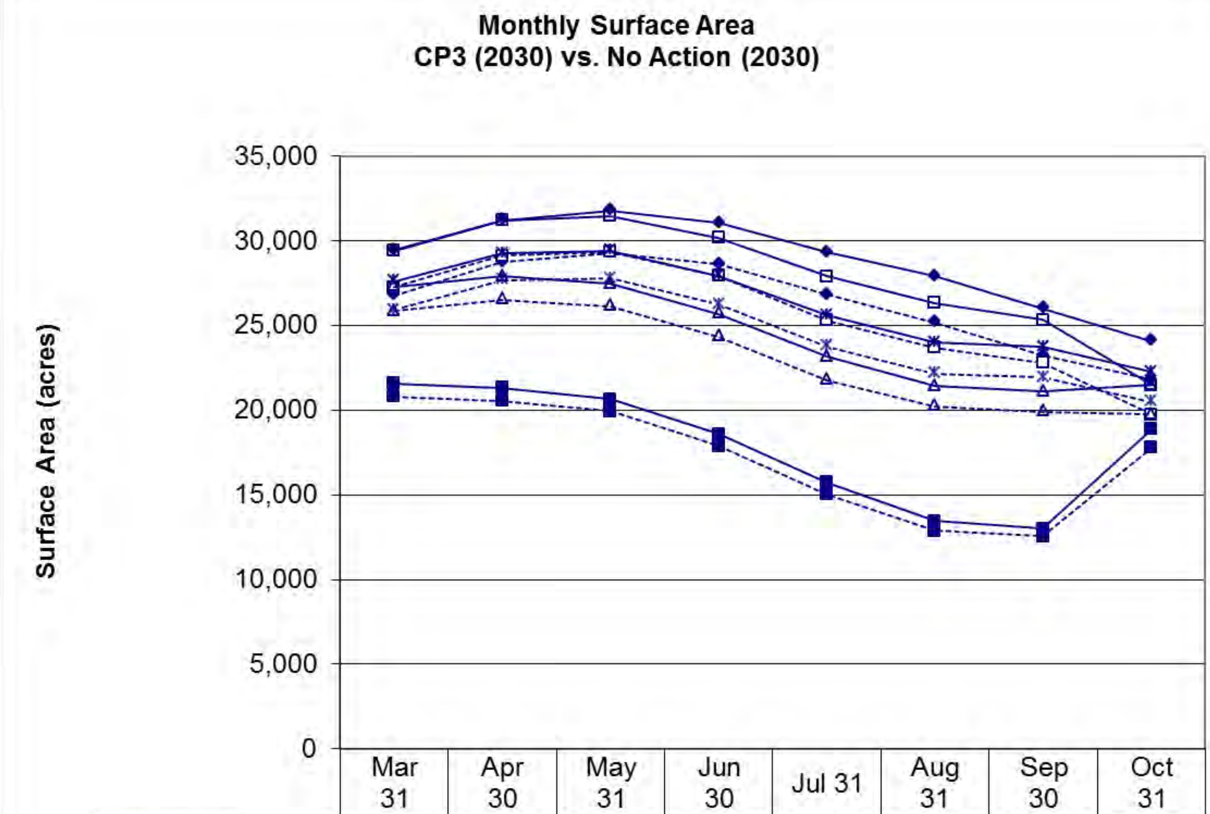
Increases in the overall surface area and WSEL under CP3 would increase the area of available warm-water habitat and stimulate biological productivity, including fish production, of the entire lake for a period of time, possibly for several decades. Furthermore, reductions in the magnitude of monthly WSEL fluctuations, along with the environmental commitment to install and extend existing habitat brush piles and structures, 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 | 26,790 | 28,748 | 29,277 | 28,624 | 26,872 | 25,226 | 23,413 | 21,827 |
| EC AN | 27,245 | 29,082 | 29,336 | 27,992 | 25,400 | 23,826 | 23,061 | 19,906 |
| EC BN | 25,807 | 27,534 | 27,621 | 26,104 | 23,714 | 22,114 | 21,837 | 20,425 |
| EC D | 25,850 | 26,467 | 26,058 | 24,300 | 21,754 | 20,093 | 19,840 | 19,828 |
| EC C | 20,467 | 20,142 | 19,500 | 17,381 | 14,400 | 12,418 | 12,111 | 17,572 |
| CP3 2005 W | 29,448 | 31,208 | 31,794 | 31,080 | 29,401 | 28,015 | 26,214 | 24,345 |
| CP3 2005 AN | 29,386 | 31,151 | 31,444 | 30,225 | 27,957 | 26,440 | 25,635 | 21,622 |
| CP3 2005 BN | 27,659 | 29,270 | 29,441 | 27,996 | 25,675 | 24,184 | 23,889 | 22,404 |
| CP3 2005 D | 27,536 | 28,121 | 27,669 | 25,892 | 23,340 | 21,666 | 21,430 | 21,859 |
| CP3 2005 C | 21,390 | 21,110 | 20,501 | 18,455 | 15,567 | 13,341 | 13,013 | 18,761 |

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

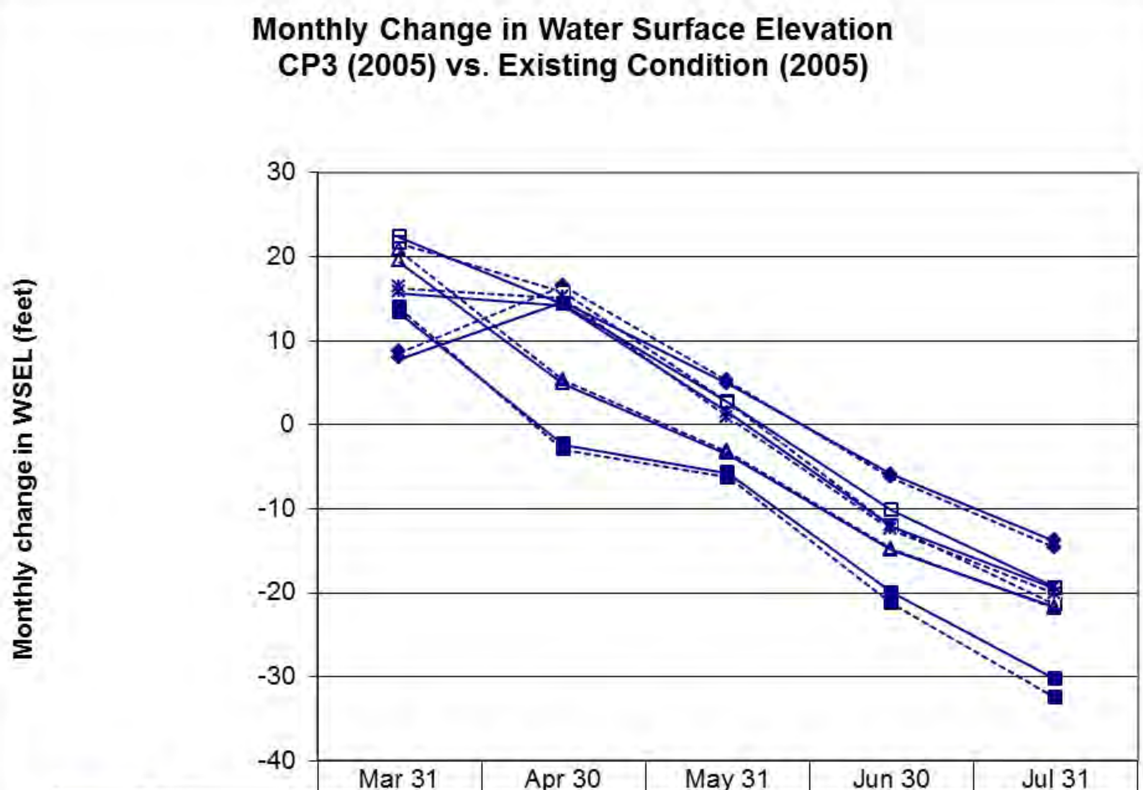
**Figure 11-24. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 Versus the Existing Condition**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 |
|---|---|---|---|---|---|---|---|---|
| NA W | 26,775 | 28,735 | 29,273 | 28,604 | 26,797 | 25,183 | 23,205 | 21,808 |
| NA AN | 27,258 | 29,117 | 29,325 | 27,921 | 25,294 | 23,687 | 22,800 | 19,759 |
| NA BN | 25,918 | 27,662 | 27,770 | 26,239 | 23,764 | 22,137 | 21,923 | 20,469 |
| NA D | 25,843 | 26,514 | 26,134 | 24,346 | 21,780 | 20,209 | 19,910 | 19,728 |
| NA C | 20,801 | 20,548 | 19,942 | 17,866 | 15,026 | 12,873 | 12,556 | 17,800 |
| CP3 2030 W | 29,435 | 31,196 | 31,789 | 31,038 | 29,303 | 27,905 | 25,998 | 24,089 |
| CP3 2030 AN | 29,416 | 31,202 | 31,473 | 30,163 | 27,881 | 26,335 | 25,322 | 21,473 |
| CP3 2030 BN | 27,596 | 29,232 | 29,397 | 27,935 | 25,584 | 23,992 | 23,732 | 22,261 |
| CP3 2030 D | 27,290 | 27,887 | 27,450 | 25,672 | 23,146 | 21,416 | 21,087 | 21,492 |
| CP3 2030 C | 21,574 | 21,303 | 20,651 | 18,580 | 15,745 | 13,443 | 12,996 | 18,870 |

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

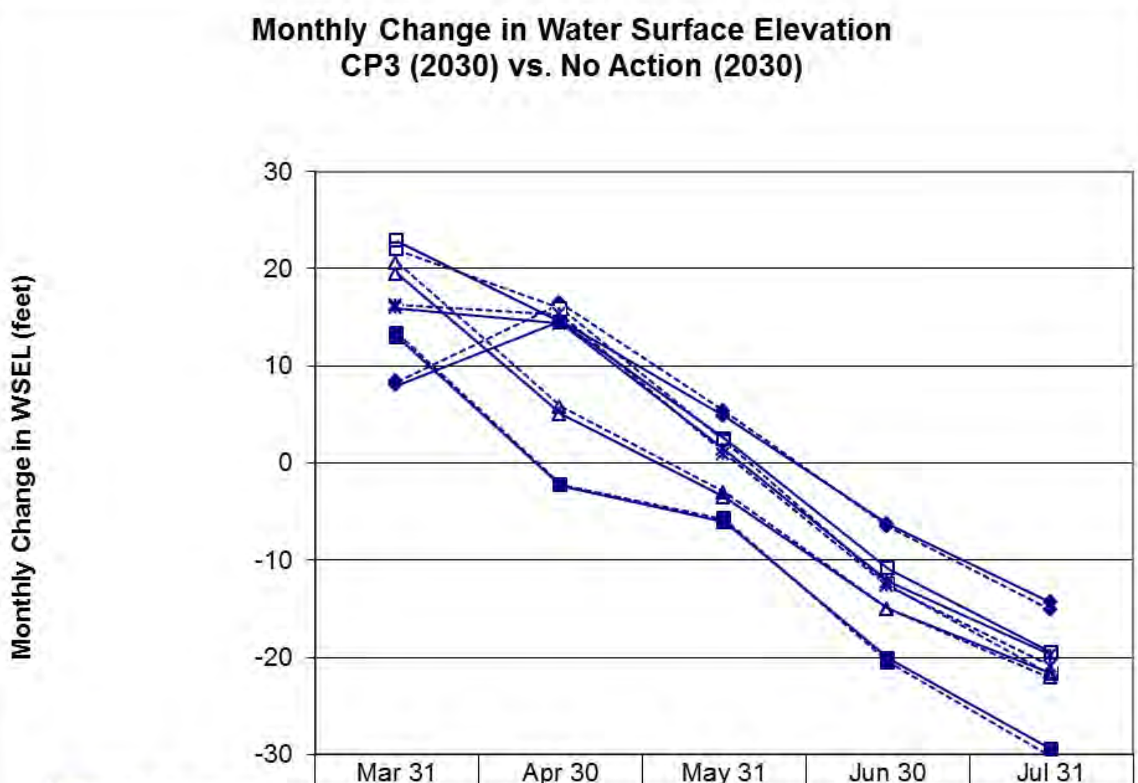
**Figure 11-25. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 Versus No-Action Alternative**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 |
|---|---|---|---|---|---|
| EC W | 9 | 16 | 5 | -6 | -15 |
| EC AN | 22 | 16 | 3 | -12 | -21 |
| EC BN | 16 | 15 | 1 | -13 | -20 |
| EC D | 21 | 5 | -3 | -15 | -22 |
| EC C | 14 | -3 | -6 | -21 | -32 |
| CP3 (2005) W | 8 | 15 | 5 | -6 | -14 |
| CP3 (2005) AN | 22 | 14 | 3 | -10 | -19 |
| CP3 (2005) BN | 16 | 14 | 1 | -12 | -20 |
| CP3 (2005) D | 19 | 5 | -4 | -15 | -22 |
| CP3 (2005) C | 13 | -2 | -6 | -20 | -30 |

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
WSEL = water surface elevation

**Figure 11-26. Average Monthly Change in Water Surface Elevation for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 Versus the Existing Condition**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 |
|---|---|---|---|---|---|
| NA W | 8 | 16 | 5 | -7 | -15 |
| NA AN | 22 | 16 | 2 | -13 | -22 |
| NA BN | 16 | 15 | 1 | -13 | -21 |
| NA D | 21 | 6 | -3 | -15 | -22 |
| NA C | 13 | -2 | -6 | -21 | -30 |
| CP3 (2030) W | 8 | 15 | 5 | -6 | -14 |
| CP3 (2030) AN | 23 | 15 | 2 | -11 | -20 |
| CP3 (2030) BN | 16 | 14 | 1 | -12 | -20 |
| CP3 (2030) D | 19 | 5 | -4 | -15 | -22 |
| CP3 (2030) C | 13 | -2 | -6 | -20 | -29 |

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 11-27. Average Monthly Change in Water Surface Elevation for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 Versus 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.

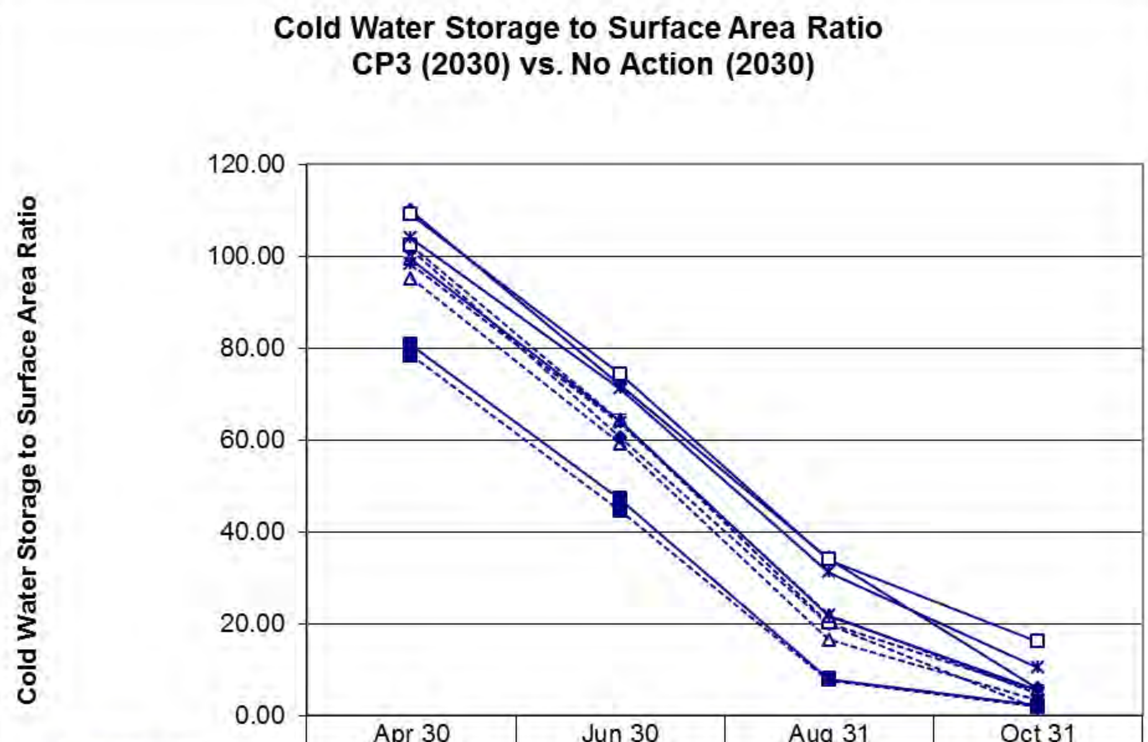
*Impact Aqua-3 (CP3): Effects on Cold-Water Habitat in Shasta Lake* Operations-related changes in the ratio of the volume of cold-water storage to surface area would increase the availability of suitable habitat for cold-water fish in Shasta Lake, including rainbow trout. This impact would be beneficial.

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 a critical rearing and oversummering period for cold-water fishes in reservoirs, and are greatest in wet, above-normal, and below-normal water years (Figure 11-28).

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 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.

Except for the California floater, the occurrence of special-status mollusks in Shasta Lake and the lower reaches of its tributaries is unlikely. Modification or loss of suitable habitat for California floater would occur through increased WSEL and seasonal fluctuations in the surface area under CP3. Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."




| | Apr 30 | Jun 30 | Aug 31 | Oct 31 |
|---|---|---|---|---|
| NA W | 101.33 | 60.49 | 19.89 | 1.43 |
| NA AN | 102.30 | 64.04 | 20.12 | 5.09 |
| NA BN | 98.27 | 63.71 | 21.84 | 4.64 |
| NA D | 95.13 | 59.14 | 16.50 | 3.38 |
| NA C | 78.43 | 44.58 | 7.66 | 1.82 |
| CP3 2030 W | 109.95 | 72.07 | 34.15 | 5.76 |
| CP3 2030 AN | 109.16 | 74.33 | 33.92 | 16.04 |
| CP3 2030 BN | 104.02 | 71.30 | 31.23 | 10.44 |
| CP3 2030 D | 99.41 | 64.23 | 21.58 | 5.57 |
| CP3 2030 C | 80.70 | 47.15 | 7.90 | 2.07 |

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. Average Monthly Cold-water Storage to Surface Area Ratio for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 Versus No-Action Alternative**

*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 similar to Impacts 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. This impact would be less than significant.

Hardhead do not currently occur or are very uncommon in the primary tributaries to Shasta Lake, except in the Pit River above the Pit 7 Afterbay. Access to and the availability of suitable riverine habitat among all the main tributaries to the reservoir would not likely become any more limiting than under current conditions, nor would it greatly expand. 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. This impact would be less than significant.

This impact would be similar to Impact Aqua-6 (CP2) (i.e., creation and elimination of fish passage barriers in tributaries to Shasta Lake would primarily be limited to non-fish-bearing intermittent streams). However, the maximum inundation level would be higher under CP3, which would inundate (eliminate) partial or complete fish barriers in approximately 13 more perennial tributaries than CP2.

Similar to CP2, implementation of CP3 could have small localized beneficial effects for adfluvial cold-water fishes and provide access to warm-water fish species, which would primarily be limited to the newly inundated reaches of the new varial zone of some streams. Impacts would not be expected to be much greater than under existing conditions. *Environmental commitments, described in Chapter 2, “Alternatives,” to monitor fish communities in Squaw Creek and adaptively manage to prevent warmwater fish invasions would reduce this impact to a less than significant level.* Therefore, this impact is considered to 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 (trout and land-locked salmon that spawn in streams and rear in lakes) in tributaries to Shasta Lake. It would also affect the character and location of substrate (e.g., spawning gravel) at some locations, influencing the suitability and availability of spawning and rearing habitat for adfluvial salmonids.

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 of Shasta Lake and estimated suitable spawning habitat areas (both intermittent and perennial) that would be periodically affected are as follows:

- Sacramento Arm – 4.0 miles (19,852 square feet, excludes mainstem river)
- McCloud Arm – 2.7 miles (13,601 square feet)
- Pit Arm – 1.9 miles (615 square feet, excludes mainstem river)
- Big Backbone Arm – 1.1 miles (175 square feet)
- Squaw Arm – 1.3 miles (1,300 square feet)

Eleven miles of low-gradient reaches that could potentially provide some spawning and rearing habitat for adfluvial salmonids (only about 2.8 percent of the low-gradient habitat upstream from Shasta Lake) would be affected by CP3. Although a small proportion of the total stream length would be affected by CP3, approximately 31,093 square feet of suitable cold-water spawning habitat, exclusive of mainstem habitat in the Sacramento and Pit rivers, was estimated to occur within the projected varial zone under CP3 during 2012 stream surveys.

This impact would be similar to Impacts Aqua-7 (CP1 and CP2); however, an additional 8,565 square feet (a total of 39,763 square feet) of suitable spawning habitat in low-gradient reaches to Shasta Lake would periodically be inundated. Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

*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, intermittent non-fish-bearing tributaries to Shasta Lake. Twenty-four miles of non-fish-bearing tributary habitat (based on channel slope and confirmed by surveys of representative stream reaches) would be affected by CP3, which is only about 1 percent of the total length of non-fish-bearing tributaries upstream from Shasta Lake. Field surveys suggest that few, if any of the non-fish bearing streams contain special-status invertebrate or vertebrate species that would be affected by increased connectivity to Shasta Lake. 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 Arm – 5.5 miles
- McCloud Arm – 4.1 miles
- Pit Arm – 3.5 miles
- Big Backbone Arm – 2.7 miles
- Squaw Arm – 1.9 miles
- Main Body – 6.3 miles

This impact would be similar to Impacts Aqua-8 (CP1 and CP2). It would periodically inundate a larger amount of habitat than under CP1 and CP2, but the total amount inundated would be only 1 percent of the intermittent non-fish-bearing tributary habitat (based on channel slope) upstream from the lake. No special-status aquatic vertebrate or invertebrate species have been detected in these reaches. 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 Red Bluff)**

*Impact Aqua-10 (CP3): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River during Construction Activities* Temporary construction-related increases in sediments and turbidity levels would adversely affect aquatic habitats and fish populations immediately downstream in the upper Sacramento River. However, environmental commitments would be in place to reduce the effects. This impact would be less than significant.

This impact would be similar to Impact Aqua-10 (CP1). The impact could be greater under CP3 than under CP1 because of the increased activity associated with an 18.5-foot dam raise compared to a 6.5-foot dam raise. However, as under CP1, environmental commitments for all actions would be in place to reduce the effects. Therefore, this impact would be less than significant. 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. Such exposure could adversely affect aquatic habitats, the aquatic food web, and fish populations, including special-status species, downstream in the primary study area. However, environmental commitments would be in place to reduce the effects. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-11 (CP1). The impact could be greater under CP3 than under CP1 because of the increased activity associated with an 18.5-foot raise compared to a 6.5-foot raise. However, as under CP1, environmental commitments for all actions would be in place to reduce the effects. Therefore, this impact would be less than significant. 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 and Steelhead* CP3 operation would result in improved overall flow and water temperature conditions in the upper Sacramento River for Chinook salmon and steelhead as well as other native fishes. This impact would be beneficial.

*Winter-Run Chinook Salmon*

Production

Overall average winter-run production for the 82-year period would be similar (less than 5 percent change) for CP3 relative to the No-Action Alternative and the Existing Condition (Attachments 3 and 4 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 121 percent for CP3, and the largest decrease in production relative to the No-Action Alternative was -14 percent (Table 11-30 and Attachment 3 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 191 percent for CP3, and the largest decrease in production relative to the Existing Condition was -7 percent (Table 11-30 and Attachment 4 of the Modeling Appendix). Figure 11-9 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP3, two critical and one dry water year had significant increases in production compared to the No-Action Alternative, while two critical and one above-normal water years had a significantly decreased production.

**Table 11-30. Change in Production Under CP3 for Winter-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | **81** | **3,784,037** | **-17,078** | **-0.4** | **121.0** | **2** | **-14.1** | **3** |
| **Critical** | 13 | 3,405,883 | 27,928 | 0.8 | 121.0 | 1 | -14.1 | 2 |
| **Dry** | 17 | 3,989,211 | 16,880 | 0.4 | 6.9 | 1 | -2.8 | 0 |
| **Below Normal** | 14 | 3,925,807 | -12,751 | -0.3 | 2.4 | 0 | -3.6 | 0 |
| **Above Normal** | 11 | 3,804,872 | -54,058 | -1.4 | 1.2 | 0 | -6.0 | 1 |
| **Wet** | 26 | 3,753,808 | -48,470 | -1.3 | 3.9 | 0 | -4.3 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 3,788,864 | 7,618 | 0.2 | 191.4 | 6 | -7.0 | 3 |
| **Critical** | 13 | 3,444,999 | 234,060 | 7.3 | 191.4 | 5 | -4.1 | 0 |
| **Dry** | 17 | 3,980,152 | -3,710 | -0.1 | 14.3 | 1 | -3.5 | 0 |
| **Below Normal** | 14 | 3,924,037 | -16,112 | -0.4 | 3.8 | 0 | -3.3 | 0 |
| **Above Normal** | 11 | 3,795,459 | -57,223 | -1.5 | 0.7 | 0 | -7.0 | 1 |
| **Wet** | 26 | 3,760,148 | -57,987 | -1.5 | 2.0 | 0 | -6.4 | 2 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:

CP = Comprehensive Plan

Under CP3, five out of 13 critical and one out of 17 dry water years had significant increases in production, compared to the Existing Condition. One above-normal (out of 11 years) and one wet (out of 26 years) water year had significant decreases in production.

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on winter-run Chinook salmon caused by the actions of the project (Attachments 3 and 4 of the Modeling Appendix). Nonoperations-related mortality is the base and seasonal mortality that would occur even without the effects of Shasta operations (such as disease, predation, and entrainment). Flow- and water temperature-related mortality is that caused by altering flow and water temperatures. In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 87 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 3 and 4 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality to winter-run Chinook salmon under CP3 (as with CP1 and CP2) in all water year types, based on smolt equivalents, would occur to fry, then eggs, presmolts, immature smolts, and prespawn adults. Table 11-5 displays the overall mortalities for each Comprehensive Plan that would be caused by changes in water temperature and flow (see also Attachments 3 and 4 of the Modeling Appendix).

Years with the highest mortality were the same for the No-Action Alternative and CP3. Each of these years was a critical water year, and was preceded by either a critical (1933, 1976, 1991) or dry (1930 and 1932) water year type (Attachments 3 and 4).

Winter-run Chinook salmon would have, overall, an insignificant change in project-related mortality relative to No-Action Alternative, but significant compared with the Existing Condition. They would also have an insignificant change in production (including in critical water years), winter-run Chinook salmon would have a less-than-significant impact from actions taken in CP3. Mitigation for this impact is not needed, and thus not proposed.

*Spring-Run Chinook Salmon*

Production

Overall average spring-run Chinook salmon production for the 81-year period remained relatively similar (less than 5 percent change) to the No-Action Alternative and Existing Condition. The maximum increase in production relative to the No-Action Alternative was 123 percent for CP3 in a dry water year, while the largest decrease in production was almost 44 percent in a critical water year (Table 11-31 and Attachment 6 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 602 percent for CP3. The largest decrease in production relative to the Existing

Condition was 9 percent for CP3 (Table 11-31 and Attachment 7 of the Modeling Appendix). Figure 11-10 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP3, five critical, one dry, and one below-normal water years had significant increases in production compared to the No-Action Alternative, while two critical water years had significant decreases in production (Attachment 6 of the Modeling Appendix).

Under CP3, eight critical, one dry, and one below-normal water years had significant increases in production compared to the Existing Condition. Only one critical water year had a significant decrease in production (Attachment 7 of the Modeling Appendix).

**Table 11-31. Change in Production Under CP3 for Spring-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 81 | 163,036 | -1,019 | -0.6 | 123 | 7 | -43.8 | 3 |
| **Critical** | 13 | 82,081 | 892 | 1.1 | 86.1 | 5 | -43.8 | 2 |
| **Dry** | 17 | 170,498 | 1,046 | 0.6 | 123 | 1 | -2.2 | 0 |
| **Below Normal** | 14 | 177,547 | 366 | 0.2 | 20.7 | 1 | -3.4 | 0 |
| **Above Normal** | 11 | 181,387 | -2,378 | -1.3 | 4.9 | 0 | -3.5 | 0 |
| **Wet** | 26 | 183,056 | -3,495 | -1.9 | 1.5 | 0 | -5.1 | 1 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 164,298 | 1,090 | 0.7 | 602 | 10 | -8.7 | 2 |
| **Critical** | 13 | 89,222 | 15,160 | 20.5 | 602 | 8 | -8.7 | 1 |
| **Dry** | 17 | 169,946 | 1,084 | 0.6 | 243 | 1 | -2.8 | 0 |
| **Below Normal** | 14 | 178,606 | 577 | 0.3 | 30.4 | 1 | -3.6 | 0 |
| **Above Normal** | 11 | 181,593 | -2,520 | -1.4 | 3.0 | 0 | -3.1 | 0 |
| **Wet** | 26 | 183,120 | -4,138 | -2.2 | 2.3 | 0 | -5.1 | 1 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:

CP = Comprehensive Plan

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on spring-run Chinook salmon caused by the actions of the project (Attachments 6 and 7). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−about 83 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 6 and 7 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality to spring-run Chinook salmon under CP3 (as with CP1 and CP2) in all water year types based on smolt equivalents, would occur to the eggs, then fry, followed by presmolts and lastly immature smolts. Nonoperational conditions would be the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-7 displays the smolt-equivalent mortalities for each Comprehensive Plan changes in water temperature and flow (Attachments 6 and 7 of the Modeling Appendix).

Years with the highest operations-related mortality were the same CP3, No-Action Alternative and the Existing Condition. These were each preceded by a critical or dry water year. However, years with the lowest mortality varied between all water year types (Attachments 6 and 7).

Because spring-run Chinook salmon have, overall, a significant reduction in project-related mortality under both 2030 and 2005 conditions, but insignificant increase in overall production. However, spring-run Chinook salmon would have a significant increase in production during critical water years–those years in which they are at greatest risk. Therefore, 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*

Production

Overall average fall-run Chinook salmon production for the 81-year period was similar between CP3 and the No-Action Alternative and the Existing Condition (Attachments 9 and 10 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 41 percent (below-normal water year) for CP3, while the largest decrease in production relative to the No-Action Alternative was around -14 percent (in a critical water year) (Table 11-32 and Attachment 9 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was just around 144 percent for CP3 in a critical water year, and the largest decrease in production relative to the Existing Condition was –less than 7 percent in a wet water year (Table 11-32 and Attachment 10 of the Modeling Appendix). Figure 11-11 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

**Table 11-32. Change in Production Under CP3 for Fall-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Conditions (2030)** | | | | | | | | |
| **All** | 81 | 29,737,538 | 219,131 | 0.7 | 40.9 | 12 | -13.8 | 3 |
| **Critical** | 13 | 26,803,488 | 358,660 | 1.4 | 17.1 | 5 | -13.8 | 1 |
| **Dry** | 17 | 30,186,998 | 646,837 | 2.2 | 19.8 | 5 | -4.7 | 0 |
| **Below Normal** | 14 | 31,748,386 | 650,475 | 2.1 | 40.9 | 2 | -5.9 | 1 |
| **Above Normal** | 11 | 30,879,929 | -153,081 | -0.5 | 4.9 | 0 | -2.9 | 0 |
| **Wet** | 26 | 29,344,601 | -205,074 | -0.7 | 4.7 | 0 | -6.4 | 1 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 29,905,352 | 477,011 | 1.6 | 144 | 13 | -6.8 | 3 |
| **Critical** | 13 | 27,963,775 | 1,787,639 | 6.8 | 144 | 6 | -1.6 | 0 |
| **Dry** | 17 | 30,111,299 | 650,898 | 2.2 | 25.3 | 4 | -3.6 | 0 |
| **Below Normal** | 14 | 31,784,514 | 766,252 | 2.5 | 59.4 | 2 | -6.7 | 1 |
| **Above Normal** | 11 | 30,762,948 | -107,448 | -0.3 | 3.6 | 0 | -3.3 | 0 |
| **Wet** | 26 | 29,366,799 | -200,472 | -0.7 | 5.9 | 1 | -6.8 | 2 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:

CP = Comprehensive Plan

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 (Attachments 9 and 10 of the Modeling Appendix).

Under CP3, five critical, five dry, and two below-normal water years had significant increases in production relative to the No-Action Alternative. Significant decreases in production occurred in one critical, one below-normal, and one wet water year (Attachment 9 of the Modeling Appendix).

Under CP3, six critical, four dry, two below-normal, and one wet water year had significant increases in production relative to the Existing Condition. Significant reductions in production occurred in one below-normal, and two wet water years (Attachment 10 of the Modeling Appendix).

<u>Mortality</u>

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on fall-run Chinook salmon caused by the actions of the project (Attachments 9 and 10). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)‒around 65 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 9 and 10 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality based on the smolt equivalents to fall-run Chinook salmon under CP3 (as with CP1 and CP2) occurs to fry, followed by egg, prespawn adults, presmolts, and lastly to immature smolts. Table 11-9 displays the overall mortalities for each Comprehensive Plan that were caused by changes in water temperature and flow (see also Attachments 9 and 10 of the Modeling Appendix).

There was no real trend with respect to years with the greatest mortality. Years with the lowest production were in all water years except above-normal water years, and were preceded by all water year types.

Fall-run Chinook salmon have a significant reduction in project-related mortality under CP3 but an insignificant increase in average production. However, fall-run Chinook salmon would benefit from actions taken in CP3, experiencing a significant increase in 15 percent of the years. Mitigation for this impact is not needed, and thus not proposed.

*Late Fall-Run Chinook Salmon and Steelhead*

Late fall-run Chinook salmon were evaluated directly using SALMOD and were considered to be a surrogate for steelhead; therefore, the following discussion regarding SALMOD results for late fall-run Chinook salmon are applicable to steelhead.

Production

Overall average late fall-run Chinook salmon production for the 80-year period was similar to CP3 and the No-Action Alternative and the Existing Condition (Attachments 12 and 13 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 12 percent in a dry water year for CP3, while the largest decrease in production relative to the No-Action Alternative was less than 5 percent for CP3 (Table 11-33 and Attachment 12 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was almost 13 percent for CP3 (in a dry water year), while the largest decrease in production relative to the Existing Condition was less than -5 percent (Table 11-33 and Attachment 13 of the Modeling Appendix). Figure 11-12 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP3, one critical and two dry water years had significant increases in production compared to the No-Action Alternative, and there were no significant decreases in production.

**Table 11-33. Change in Production Under CP3 for Late Fall-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 80 | 7,424,900 | 6,413 | 0.1 | 12.1 | 3 | -4.9 | 0 |
| **Critical** | 13 | 7,107,373 | 43,205 | 0.6 | 7.5 | 1 | -2.9 | 0 |
| **Dry** | 16 | 7,390,273 | 35,904 | 0.5 | 12.1 | 2 | -4.9 | 0 |
| **Below Normal** | 14 | 7,599,738 | -12,880 | -0.2 | 2.4 | 0 | -3.2 | 0 |
| **Above Normal** | 11 | 7,583,369 | -2,715 | 0.0 | 1.7 | 0 | -3.0 | 0 |
| **Wet** | 26 | 7,443,783 | -15,881 | -0.2 | 4.4 | 0 | -3.9 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 80 | 7,422,929 | 36,368 | 0.5 | 12.9 | 5 | -4.7 | 0 |
| **Critical** | 13 | 7,054,205 | 90,909 | 1.3 | 12.2 | 2 | -3.4 | 0 |
| **Dry** | 16 | 7,398,822 | 38,554 | 0.5 | 12.9 | 3 | -4.7 | 0 |
| **Below Normal** | 14 | 7,632,250 | 21,156 | 0.3 | 3.3 | 0 | -2.6 | 0 |
| **Above Normal** | 11 | 7,593,708 | 34,035 | 0.5 | 2.6 | 0 | -1.2 | 0 |
| **Wet** | 26 | 7,437,163 | 16,932 | 0.2 | 3.5 | 0 | -4.0 | 0 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Late fall-run Chinook salmon are used as a surrogate for steelhead

Key:

CP = Comprehensive Plan

Under CP3, two critical and three dry water years had significant increases in production compared to the Existing Condition, and there were no significant decreases in production.

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on late fall-run Chinook salmon caused by the actions of the project (Attachments 12 and 13 of the Modeling Appendix). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 78 percent of the total mortality.

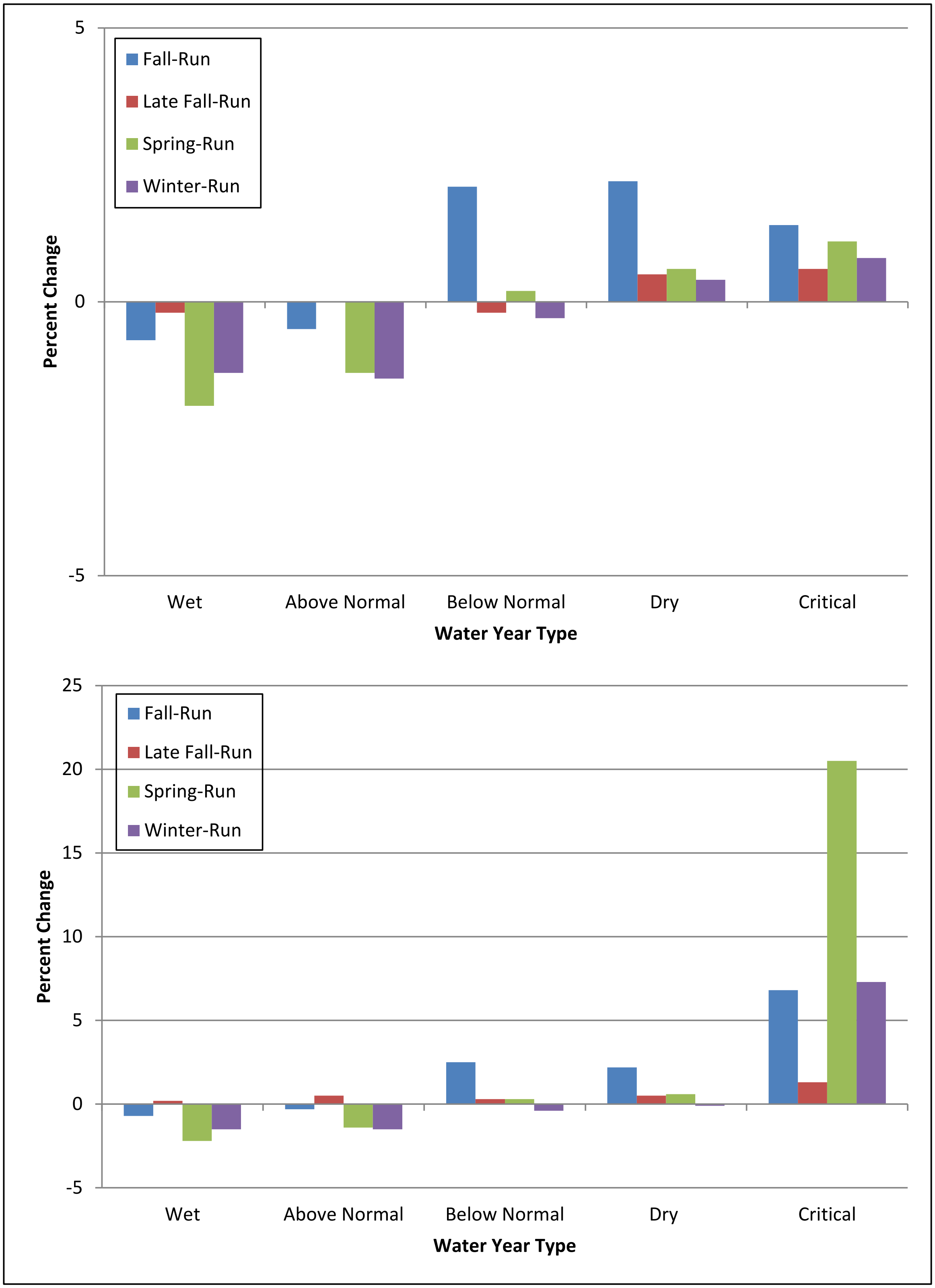
Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 12 and 13 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality to late fall-run under CP3 (as with CP1 and CP2) in all water year types based on smolt equivalents, would occur to fry, then eggs, presmolts, immature smolts, and lastly to prespawn adults. Table 11-11 displays the overall mortalities for each Comprehensive Plan that were caused by changes in water temperature and flow) (Attachments 12 and 13 of the Modeling Appendix).

Years with the highest mortality were the same for CP3, the No-Action Alternative and Existing Conditions. 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 12 and 13 of the Modeling Appendix).

Because SALMOD indicates an insignificant change in mortality and production index for late fall-run Chinook salmon, late fall-run Chinook salmon and steelhead (as represented by their surrogate, late fall-run Chinook salmon) would experience a less-than-significant impact from actions taken in CP3. Mitigation for this impact is not needed, and thus not proposed.

*All Chinook Runs Combined*

Raising Shasta Dam by 18.5 feet, in conjunction with spillway modifications, would result in an increase in full pool depth of 20.5 feet and an additional 634,000 acre-feet of storage capacity in Shasta Reservoir. The additional storage created by the dam raise would be used to improve the ability to meet water temperature objectives and habitat requirements for anadromous fish during drought years (see Figure 11-29). Under the 2030 conditions, overall production for all four runs of Chinook salmon combined would increase by over 207,000 immature smolts migrating below RDPP. Under the 2005 conditions, overall production for all four runs of Chinook salmon combined would increase by almost 522,000 immature smolts migrating below RDPP.




Note: Changes in outmigrating Chinook salmon simulated using SALMOD; Water Year Types based on the Sacramento Valley Water Year Hydrologic Classification

**Figure 11-29. Percent Change in Production of Chinook Salmon for CP3 Compared to the No-Action Alternative (top) and Existing Conditions (bottom)**

*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 generally 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 under CP3 than under CP1 because of the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise.

*Flow-Related Effects* As under CP1, monthly mean flows at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBPP) under CP3 would generally be equivalent to (less than 5-percent difference from) flows under the Existing Condition and No-Action Alternative conditions simulated for all months. (See the Modeling Appendix for complete modeling results.)

Potential flow-related effects of CP3 on fish species of management concern in the upper Sacramento River would be minimal. Potential changes in flows and stages would diminish rapidly downstream from RBPP because of increased effects from tributary inflows, diversions, and flood bypasses.

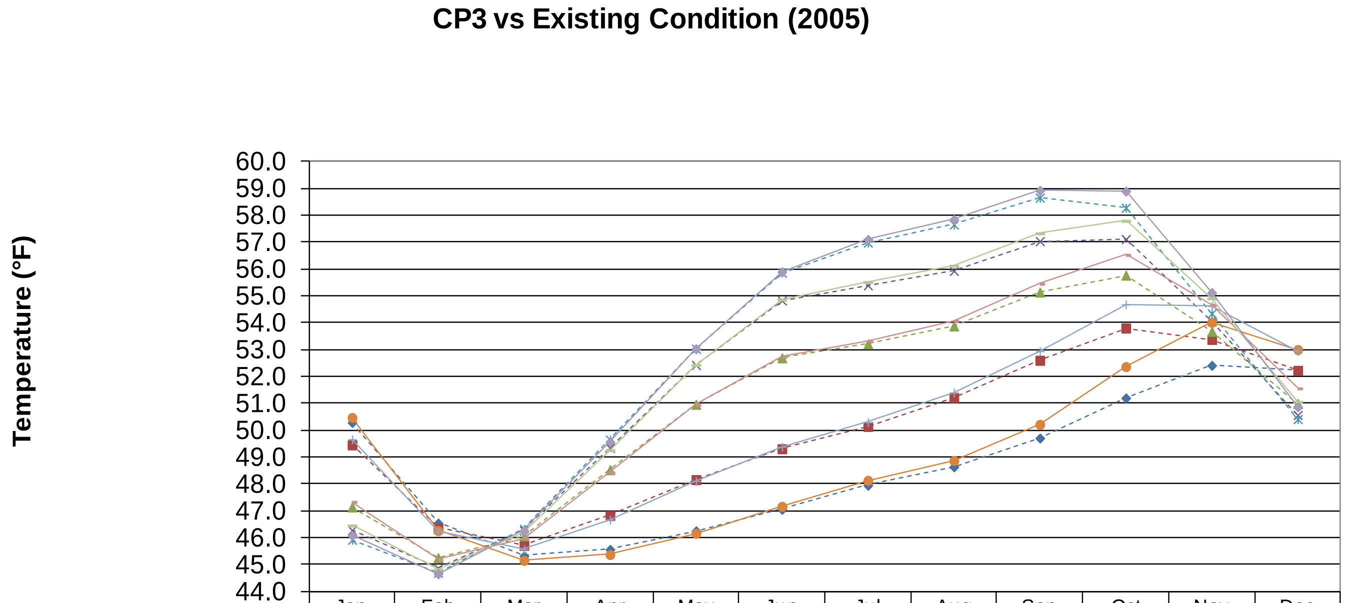
Changes in monthly mean flows under CP3 relative to the Existing Condition and No-Action Alternative would have no discernible effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for these species would be unchanged. Flow-related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

*Water Temperature–Related Effects* As under CP1, monthly mean water temperatures at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, Balls Ferry, above Bend Bridge, and above RBPP) under CP3 would be the same as, or fractionally lower than, water temperatures under the Existing Condition and No-Action Alternative simulated for all months (Figures 11-30 and 11-31). See the Modeling Appendix 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. Potential water temperature–related effects of CP3 on fish species of management concern in the upper Sacramento River would be minimal. During most years, annual releases from Shasta Dam would be unchanged.

Potential changes in flows and stages would diminish downstream from RBPP because of the increasing effect from tributary inflows, diversions, and flood bypasses.

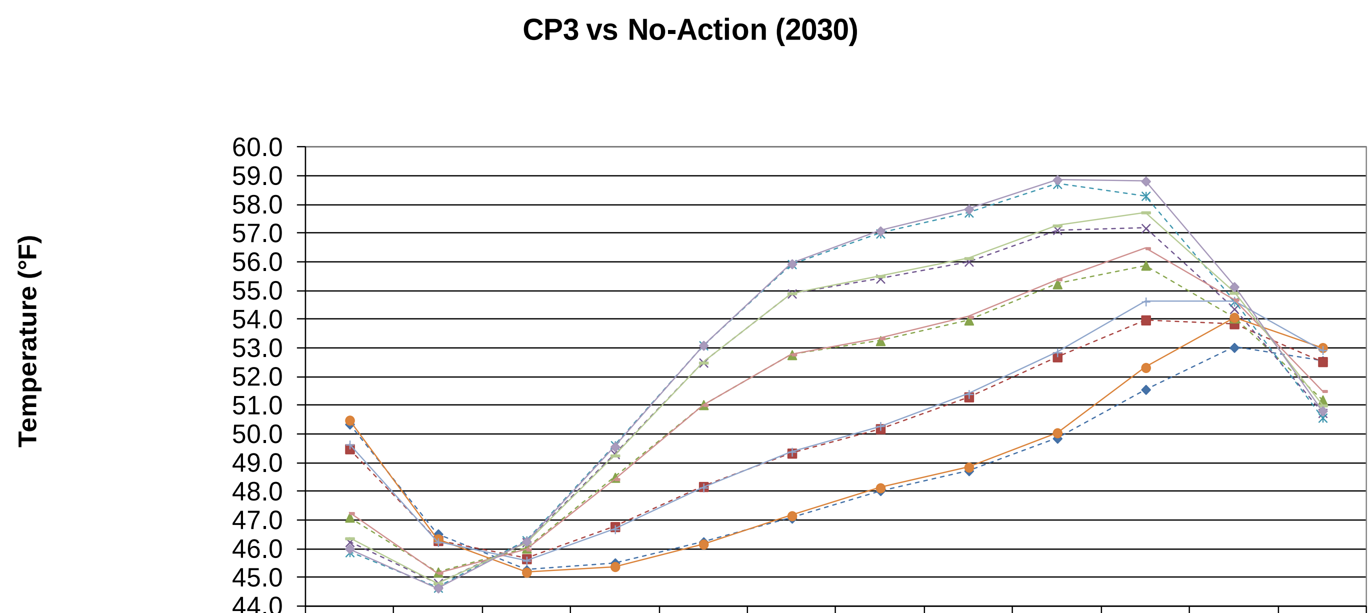
The slightly cooler monthly mean water temperatures under CP3 relative to the Existing Condition and the No-Action Alternative would have very small effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Monthly mean water temperatures 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.




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP3 Below Shasta | 50.3 | 46.5 | 45.3 | 45.6 | 46.3 | 47.1 | 48.0 | 48.6 | 49.7 | 51.2 | 52.4 | 52.2 |
| CP3 Below Keswick | 49.5 | 46.4 | 45.7 | 46.8 | 48.2 | 49.3 | 50.1 | 51.2 | 52.6 | 53.8 | 53.4 | 52.2 |
| CP3 Balls Ferry | 47.1 | 45.3 | 46.1 | 48.5 | 51.0 | 52.7 | 53.2 | 53.9 | 55.1 | 55.8 | 53.7 | 51.0 |
| CP3 Bend Bridge | 46.3 | 44.9 | 46.3 | 49.3 | 52.4 | 54.8 | 55.4 | 55.9 | 57.0 | 57.1 | 54.1 | 50.6 |
| CP3 RBPP | 45.9 | 44.7 | 46.3 | 49.6 | 53.0 | 55.9 | 57.0 | 57.7 | 58.7 | 58.3 | 54.3 | 50.4 |
| EC Below Shasta | 50.5 | 46.3 | 45.2 | 45.4 | 46.2 | 47.2 | 48.1 | 48.9 | 50.2 | 52.4 | 54.0 | 53.0 |
| EC Below Keswick | 49.7 | 46.2 | 45.6 | 46.7 | 48.1 | 49.4 | 50.3 | 51.4 | 52.9 | 54.7 | 54.6 | 52.9 |
| EC Balls Ferry | 47.3 | 45.2 | 46.0 | 48.4 | 50.9 | 52.7 | 53.3 | 54.1 | 55.4 | 56.5 | 54.7 | 51.6 |
| EC Bend Bridge | 46.5 | 44.8 | 46.2 | 49.3 | 52.4 | 54.9 | 55.5 | 56.1 | 57.3 | 57.8 | 54.9 | 51.1 |
| EC RBPP | 46.1 | 44.7 | 46.3 | 49.6 | 53.0 | 55.9 | 57.1 | 57.8 | 58.9 | 58.9 | 55.1 | 50.9 |

Key: °F = degrees Fahrenheit EC = Existing Condition
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

**Figure 11-30. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP3 Versus Existing Condition)**




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP3 Below Shasta | 50.4 | 46.5 | 45.3 | 45.5 | 46.2 | 47.1 | 48.0 | 48.7 | 49.9 | 51.6 | 53.0 | 52.6 |
| CP3 Below Keswick | 49.5 | 46.3 | 45.7 | 46.8 | 48.2 | 49.3 | 50.2 | 51.3 | 52.7 | 54.0 | 53.8 | 52.5 |
| CP3 Balls Ferry | 47.1 | 45.2 | 46.0 | 48.5 | 51.0 | 52.8 | 53.3 | 54.0 | 55.2 | 55.9 | 54.0 | 51.2 |
| CP3 Bend Bridge | 46.2 | 44.8 | 46.2 | 49.3 | 52.5 | 54.9 | 55.4 | 56.0 | 57.1 | 57.2 | 54.4 | 50.7 |
| CP3 RBPP | 45.9 | 44.7 | 46.3 | 49.6 | 53.1 | 55.9 | 57.0 | 57.7 | 58.7 | 58.3 | 54.6 | 50.6 |
| NA Below Shasta | 50.5 | 46.3 | 45.2 | 45.4 | 46.2 | 47.2 | 48.1 | 48.9 | 50.0 | 52.3 | 54.1 | 53.0 |
| NA Below Keswick | 49.6 | 46.2 | 45.6 | 46.7 | 48.1 | 49.4 | 50.3 | 51.4 | 52.9 | 54.6 | 54.6 | 52.9 |
| NA Balls Ferry | 47.3 | 45.2 | 46.0 | 48.4 | 51.0 | 52.8 | 53.3 | 54.1 | 55.4 | 56.5 | 54.7 | 51.5 |
| NA Bend Bridge | 46.4 | 44.8 | 46.2 | 49.3 | 52.5 | 54.9 | 55.5 | 56.1 | 57.3 | 57.7 | 54.9 | 51.0 |
| NA RBPP | 46.0 | 44.6 | 46.3 | 49.6 | 53.1 | 55.9 | 57.1 | 57.8 | 58.9 | 58.8 | 55.1 | 50.8 |

Key: °F = degrees Fahrenheit    NA = No-Action
CP = Comprehensive Plan    RBPP = Red Bluff Pumping Plant

**Figure 11-31. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP3 Versus 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* Project operations could cause a reduction in the magnitude, duration, and frequency of intermediate to large flows both in the upper Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-14 (CP1). The impact could be greater under CP3 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) 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 the associated stage elevation of the river surface also provide a backwater effect on the lowermost segment of tributaries, reducing the potential for downcutting. These processes are regulated by the magnitude and frequency of flow. Relatively large flows provide the energy required to mobilize sediment from the riverbed, produce meander migration, increase stage elevation, and create seasonally inundated floodplains. Operations under CP3 could result in a reduction in the intermediate to large flows necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

Implementation of CP3 would cause 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 effects 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 throughout the upper Sacramento River portion of 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. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, “Mitigation Measures.”

**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* Project operation would result in no discernible change in monthly mean flows or water temperature conditions in the lower Sacramento River. However, predicted changes in flows in the Feather, American, and Trinity rivers could result in adverse effects on Chinook salmon, steelhead, Coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be potentially significant.

This impact would be similar to Impact Aqua-15 (CP1). The impact could be greater under CP3 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and increased cold-water pool) behind the raised dam.

As described below, mean monthly flows at various modeling locations on the lower Sacramento River and tributaries under CP3 were compared with mean monthly flows simulated for Existing Conditions and No-Action Alternative conditions. See the Modeling Appendix for complete CalSim-II modeling results.

*Lower Sacramento River* As under CP1, monthly mean flows at the lower Sacramento River modeling locations under CP3 would be comparable to flows under the Existing Condition and No-Action Alternative conditions simulated for all months. Differences in monthly mean flow were generally small (less than 2 percent) and within the existing range of variability. Potential changes in flows diminished rapidly downstream from RBPP because of the increasing effect from tributary inflows, diversions, and flood bypasses. Similarly, potential changes in water temperatures in the lower Sacramento River caused by small changes in releases would diminish rapidly downstream because of the 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. Mitigation for this impact is not needed, and thus not proposed.

Also, as under CP1, the 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 operational requirements, including the USFWS BO and the 2009 NMFS BO, have been designed to maintain standards for flow to the lower Sacramento River and Delta. CVP and SWP operations must be consistent with these ESA BOs. Thus, implementation of CP3 would not likely alter flow to the Delta or water temperatures in the lower Sacramento River and its primary tributaries to a degree sufficient to affect 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 water temperature–related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

*Lower Feather River, American River, and Trinity River* Also, as under CP1, monthly mean flows at modeling locations on the lower Feather River, the American River, and the Trinity River under CP3 would generally be equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for most months. However, simulations for several months within the modeling record showed substantial changes to flows in tributaries. Potential changes in flows could be reduced by real-time operations to meet existing rules and because of operation of upstream reservoirs (Lake Oroville, Folsom Lake, and Trinity Lake) and increasing effects from tributary inflows, diversions, and flood bypasses. Potential changes in water temperatures in the Feather River and American River caused by altered releases from reservoirs could diminish downstream because of the increasing effect of inflows, and atmospheric and groundwater influences. 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. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

*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 cause a reduction in intermediate to large flows both in the lower Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-16 (CP1). The impact could be greater under CP3 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) 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 the associated stage elevation of the river 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 flows. Relatively large floods provide the energy required to mobilize sediment from the riverbed, produce meander migration, increase stage elevation, create seasonally inundated floodplains, and inundate floodplain bypasses. Operations under CP3 could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains.

Implementation of CP3 would cause 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 (mostly upstream from RBPP).

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. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

*Impact Aqua-17 (CP3): Effects to Delta Fisheries Resulting from Changes to Delta Outflow* Based on the results of hydrologic modeling comparing Delta outflow under the No-Action Alternative, Existing Condition, and CP3, CP3 would result in changes to average monthly Delta outflow of less than 5 percent in all year types (with the exception of November of above-normal water years under 2005 and 2030 conditions). This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

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 11-34. Only in November of above-normal water years (compared to the Existing Condition and No-Action Alternative) would changes in Delta outflow exceed 5 percent. Based on the results of this comparison, CP3 would have a less-than-significant impact on Delta fisheries and hydrologic transport processes 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 11-34. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP3**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| Month | Water Year | Flow (cfs) | Flow (cfs) | Percent Change | Flow (cfs) | Flow (cfs) | Percent Change |
| January | Average | 42,078 | 41,783 | -1 | 42,169 | 41,769 | -1 |
| | W | 84,136 | 83,571 | -1 | 84,037 | 83,211 | -1 |
| | AN | 47,221 | 46,936 | -1 | 46,984 | 46,680 | -1 |
| | BN | 21,610 | 21,584 | 0 | 21,990 | 22,027 | 0 |
| | D | 14,166 | 13,973 | -1 | 14,452 | 14,168 | -2 |
| | C | 11,560 | 11,366 | -2 | 11,757 | 11,501 | -2 |
| February | Average | 51,618 | 51,432 | 0 | 51,430 | 51,126 | -1 |
| | W | 95,261 | 94,991 | 0 | 94,634 | 94,196 | 0 |
| | AN | 60,080 | 59,591 | -1 | 60,278 | 59,405 | -1 |
| | BN | 35,892 | 35,791 | 0 | 35,665 | 35,669 | 0 |
| | D | 20,978 | 20,909 | 0 | 20,946 | 20,775 | -1 |
| | C | 12,902 | 12,924 | 0 | 13,088 | 13,089 | 0 |
| March | Average | 42,722 | 42,577 | 0 | 42,585 | 42,428 | 0 |
| | W | 78,448 | 78,457 | 0 | 78,376 | 78,402 | 0 |
| | AN | 53,486 | 52,493 | -2 | 53,139 | 52,224 | -2 |
| | BN | 23,102 | 22,943 | -1 | 22,980 | 22,668 | -1 |
| | D | 19,763 | 19,864 | 1 | 19,559 | 19,656 | 0 |
| | C | 11,881 | 11,892 | 0 | 11,893 | 11,900 | 0 |
| April | Average | 30,227 | 30,300 | 0 | 30,743 | 30,826 | 0 |
| | W | 54,640 | 54,671 | 0 | 55,460 | 55,482 | 0 |
| | AN | 32,141 | 32,225 | 0 | 32,971 | 33,053 | 0 |
| | BN | 21,773 | 21,952 | 1 | 22,511 | 22,645 | 1 |
| | D | 14,347 | 14,430 | 1 | 14,538 | 14,665 | 1 |
| | C | 9,100 | 9,115 | 0 | 8,873 | 8,961 | 1 |
| May | Average | 22,619 | 22,552 | 0 | 22,249 | 22,209 | 0 |
| | W | 41,184 | 41,155 | 0 | 40,543 | 40,526 | 0 |
| | AN | 24,296 | 24,171 | -1 | 24,454 | 24,255 | -1 |
| | BN | 16,346 | 15,983 | -2 | 15,989 | 15,703 | -2 |
| | D | 10,554 | 10,655 | 1 | 10,116 | 10,268 | 2 |
| | C | 6,132 | 6,134 | 0 | 5,910 | 5,975 | 1 |
| June | Average | 12,829 | 12,779 | 0 | 12,660 | 12,582 | -1 |
| | W | 23,473 | 23,473 | 0 | 23,015 | 23,028 | 0 |
| | AN | 12,080 | 11,666 | -3 | 11,799 | 11,431 | -3 |
| | BN | 7,995 | 8,004 | 0 | 7,991 | 7,865 | -2 |
| | D | 6,691 | 6,734 | 1 | 6,764 | 6,737 | 0 |
| | C | 5,361 | 5,363 | 0 | 5,378 | 5,372 | 0 |
| July | Average | 7,864 | 7,877 | 0 | 7,864 | 7,863 | 0 |
| | W | 11,230 | 11,270 | 0 | 11,181 | 11,190 | 0 |
| | AN | 9,562 | 9,525 | 0 | 9,407 | 9,381 | 0 |
| | BN | 7,117 | 7,130 | 0 | 7,225 | 7,244 | 0 |
| | D | 5,005 | 5,005 | 0 | 5,052 | 5,016 | -1 |
| | C | 4,034 | 4,054 | 1 | 4,098 | 4,126 | 1 |
| August | Average | 4,322 | 4,316 | 0 | 4,335 | 4,329 | 0 |
| | W | 5,302 | 5,307 | 0 | 5,097 | 5,088 | 0 |
| | AN | 4,000 | 4,000 | 0 | 4,000 | 4,000 | 0 |
| | BN | 4,000 | 4,000 | 0 | 4,002 | 4,002 | 0 |
| | D | 3,906 | 3,878 | -1 | 4,142 | 4,171 | 1 |
| | C | 3,520 | 3,509 | 0 | 3,699 | 3,631 | -2 |

**Table 11-34. 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** |
| September | Average | 9,841 | 9,836 | 0 | 9,844 | 9,864 | 0 |
| | W | 19,695 | 19,687 | 0 | 19,702 | 19,712 | 0 |
| | AN | 11,784 | 11,771 | 0 | 11,849 | 11,836 | 0 |
| | BN | 3,876 | 3,885 | 0 | 3,913 | 3,945 | 1 |
| | D | 3,508 | 3,484 | -1 | 3,442 | 3,491 | 1 |
| | C | 3,008 | 3,027 | 1 | 3,005 | 3,020 | 1 |
| October | Average | 6,067 | 6,056 | 0 | 6,000 | 5,981 | 0 |
| | W | 7,926 | 7,866 | -1 | 7,633 | 7,539 | -1 |
| | AN | 5,309 | 5,368 | 1 | 5,476 | 5,593 | 2 |
| | BN | 5,479 | 5,502 | 0 | 5,502 | 5,469 | -1 |
| | D | 5,228 | 5,247 | 0 | 5,236 | 5,235 | 0 |
| | C | 4,741 | 4,682 | -1 | 4,714 | 4,711 | 0 |
| November | Average | 11,706 | 11,541 | -1 | 11,675 | 11,484 | -2 |
| | W | 17,717 | 17,637 | 0 | 17,715 | 17,534 | -1 |
| | AN | 12,667 | 11,728 | -7 | 12,491 | 11,755 | -6 |
| | BN | 8,543 | 8,527 | 0 | 8,686 | 8,591 | -1 |
| | D | 8,482 | 8,479 | 0 | 8,414 | 8,384 | 0 |
| | C | 6,250 | 6,256 | 0 | 6,150 | 6,131 | 0 |
| December | Average | 21,755 | 21,427 | -2 | 21,745 | 21,386 | -2 |
| | W | 44,974 | 44,189 | -2 | 44,661 | 43,587 | -2 |
| | AN | 18,581 | 18,521 | 0 | 18,562 | 18,180 | -2 |
| | BN | 12,219 | 11,752 | -4 | 12,326 | 12,070 | -2 |
| | D | 8,531 | 8,477 | -1 | 8,803 | 8,933 | 1 |
| | C | 5,580 | 5,730 | -3 | 5,677 | 6,040 | 6 |

Note:
A negative percentage change reflects a reduction in Delta outflow
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 Fisheries Resulting from Changes to Delta Inflow* Based on the results of hydrologic modeling comparing Delta inflow under CP3 to the Existing Condition and No-Action Alternative, CP3 would not decrease average monthly Delta inflow by 5 percent or more in any year type. This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

Results of the comparison of Delta inflows between the Existing Condition, No-Action Alternative, and CP3 are summarized by month and water year type in Table 11-35. Under CP3, Delta inflow would not decrease by more than 5 percent during any month compared to either the Existing Condition or the No-Action Alternative. Based on the results of this comparison, CP3 would have a less-than-significant effect on Delta fisheries and hydrologic transport processes within the Bay-Delta as a consequence of changes in Delta inflow. Mitigation for this impact is not needed, and thus not proposed.

**Table 11-35. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP3**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 47,426 | 47,165 | -1 | 47,457 | 47,099 | -1 |
| | W | 89,431 | 88,863 | -1 | 89,328 | 88,512 | -1 |
| | AN | 51,611 | 51,258 | -1 | 51,267 | 51,016 | 0 |
| | BN | 27,269 | 27,243 | 0 | 27,576 | 27,612 | 0 |
| | D | 20,125 | 19,963 | -1 | 20,371 | 20,093 | -1 |
| | C | 16,699 | 16,774 | 0 | 16,749 | 16,701 | 0 |
| February | Average | 57,835 | 57,646 | 0 | 57,623 | 57,342 | 0 |
| | W | 103,140 | 102,862 | 0 | 102,606 | 102,190 | 0 |
| | AN | 65,379 | 64,639 | -1 | 65,574 | 64,664 | -1 |
| | BN | 41,782 | 41,823 | 0 | 41,374 | 41,367 | 0 |
| | D | 26,530 | 26,484 | 0 | 26,431 | 26,290 | -1 |
| | C | 17,818 | 17,886 | 0 | 17,958 | 18,065 | 1 |
| March | Average | 49,829 | 49,701 | 0 | 49,713 | 49,536 | 0 |
| | W | 87,688 | 87,695 | 0 | 87,703 | 87,713 | 0 |
| | AN | 61,498 | 60,733 | -1 | 61,339 | 60,449 | -1 |
| | BN | 30,569 | 30,414 | -1 | 30,415 | 30,086 | -1 |
| | D | 24,943 | 24,957 | 0 | 24,640 | 24,645 | 0 |
| | C | 15,933 | 15,964 | 0 | 15,896 | 15,936 | 0 |
| April | Average | 33,962 | 34,036 | 0 | 34,783 | 34,868 | 0 |
| | W | 58,684 | 58,715 | 0 | 60,017 | 60,029 | 0 |
| | AN | 35,588 | 35,673 | 0 | 36,738 | 36,823 | 0 |
| | BN | 25,351 | 25,531 | 1 | 26,403 | 26,537 | 1 |
| | D | 17,962 | 18,048 | 0 | 18,315 | 18,463 | 1 |
| | C | 12,817 | 12,832 | 0 | 12,635 | 12,726 | 1 |
| May | Average | 27,383 | 27,315 | 0 | 27,091 | 27,039 | 0 |
| | W | 46,973 | 46,945 | 0 | 46,494 | 46,477 | 0 |
| | AN | 28,466 | 28,341 | 0 | 28,711 | 28,514 | -1 |
| | BN | 20,747 | 20,384 | -2 | 20,427 | 20,140 | -2 |
| | D | 14,882 | 14,983 | 1 | 14,534 | 14,686 | 1 |
| | C | 10,347 | 10,341 | 0 | 10,038 | 10,027 | 0 |
| June | Average | 22,171 | 22,139 | 0 | 22,090 | 22,029 | 0 |
| | W | 35,459 | 35,459 | 0 | 35,172 | 35,190 | 0 |
| | AN | 23,124 | 22,703 | -2 | 22,776 | 22,408 | -2 |
| | BN | 16,884 | 17,003 | 1 | 16,941 | 16,932 | 0 |
| | D | 14,095 | 14,134 | 0 | 14,337 | 14,294 | 0 |
| | C | 10,710 | 10,710 | 0 | 10,694 | 10,686 | 0 |
| July | Average | 23,099 | 23,110 | 0 | 22,839 | 22,894 | 0 |
| | W | 27,442 | 27,477 | 0 | 27,496 | 27,501 | 0 |
| | AN | 25,169 | 25,070 | 0 | 25,065 | 25,015 | 0 |
| | BN | 23,282 | 23,400 | 1 | 23,362 | 23,371 | 0 |
| | D | 20,937 | 20,904 | 0 | 20,082 | 20,195 | 1 |
| | C | 14,647 | 14,661 | 0 | 14,048 | 14,283 | 2 |

**Table 11-35. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP3 (contd.)**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| August | Average | 17,147 | 17,132 | 0 | 17,026 | 17,122 | 1 |
| | W | 20,235 | 20,248 | 0 | 20,154 | 20,146 | 0 |
| | AN | 18,784 | 18,759 | 0 | 18,927 | 18,941 | 0 |
| | BN | 18,274 | 18,212 | 0 | 18,297 | 18,332 | 0 |
| | D | 15,066 | 15,066 | 0 | 14,371 | 14,680 | 2 |
| | C | 10,626 | 10,593 | 0 | 10,850 | 11,000 | 1 |
| September | Average | 20,946 | 20,993 | 0 | 21,145 | 21,272 | 1 |
| | W | 31,918 | 32,081 | 1 | 32,428 | 32,495 | 0 |
| | AN | 23,912 | 23,913 | 0 | 24,747 | 24,917 | 1 |
| | BN | 16,518 | 16,542 | 0 | 16,563 | 16,650 | 1 |
| | D | 14,440 | 14,329 | -1 | 14,233 | 14,437 | 1 |
| | C | 9,130 | 9,237 | 1 | 8,809 | 8,957 | 2 |
| October | Average | 14,407 | 14,469 | 0 | 14,175 | 14,268 | 1 |
| | W | 17,072 | 17,057 | 0 | 16,558 | 16,562 | 0 |
| | AN | 13,176 | 13,412 | 2 | 13,223 | 13,433 | 2 |
| | BN | 14,044 | 14,065 | 0 | 14,159 | 14,188 | 0 |
| | D | 13,133 | 13,241 | 1 | 12,846 | 13,100 | 2 |
| | C | 12,196 | 12,234 | 0 | 11,976 | 11,977 | 0 |
| November | Average | 19,512 | 19,550 | 0 | 19,463 | 19,534 | 0 |
| | W | 26,429 | 26,571 | 1 | 26,536 | 26,504 | 0 |
| | AN | 20,269 | 19,609 | -3 | 20,052 | 19,676 | -3 |
| | BN | 16,984 | 17,037 | 0 | 16,980 | 16,947 | 0 |
| | D | 15,771 | 16,027 | 2 | 15,705 | 16,163 | 2 |
| | C | 12,330 | 12,494 | 1 | 12,081 | 12,364 | 0 |
| December | Average | 30,984 | 30,666 | -1 | 30,988 | 30,568 | -1 |
| | W | 53,758 | 52,982 | -1 | 53,516 | 52,445 | -2 |
| | AN | 28,431 | 28,381 | 0 | 28,223 | 27,886 | -1 |
| | BN | 21,958 | 21,520 | -2 | 22,143 | 21,965 | -1 |
| | D | 18,560 | 18,516 | 0 | 18,837 | 18,715 | -1 |
| | C | 13,363 | 13,498 | 1 | 13,484 | 13,666 | 1 |

Note:
A negative percentage change reflects a reduction in Delta inflow
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* CP3 operation would result in a variable response in Sacramento River inflow, resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water year type. Decreases in Sacramento River inflow would not equal or exceed 5 percent. This impact would be less than significant.

Results of hydrologic modeling, by month and year type, for the Existing Condition, No-Action Alternative, and CP3 for Sacramento River inflow are presented in Table 11-36. Results of these analyses show a variable response in Sacramento River inflow with CP3 operations resulting in both increases and decreases in river inflow above the Existing Condition and the No-Action Alternative, depending on month and water year. Under CP3, Sacramento River inflow would not decrease by 5 percent or more. Based on these results, the impact 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 11-36. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP3**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 31,139 | 31,068 | 0 | 31,167 | 31,061 | 0 |
| | W | 50,173 | 50,005 | 0 | 50,164 | 49,930 | 0 |
| | AN | 38,122 | 38,012 | 0 | 38,006 | 37,955 | 0 |
| | BN | 22,370 | 22,422 | 0 | 22,540 | 22,658 | 1 |
| | D | 16,980 | 16,885 | -1 | 17,109 | 16,936 | -1 |
| | C | 14,384 | 14,459 | 1 | 14,322 | 14,274 | 0 |
| February | Average | 36,608 | 36,578 | 0 | 36,618 | 36,535 | 0 |
| | W | 56,740 | 56,783 | 0 | 56,637 | 56,660 | 0 |
| | AN | 44,453 | 43,988 | -1 | 44,672 | 44,089 | -1 |
| | BN | 30,911 | 31,056 | 0 | 30,780 | 30,838 | 0 |
| | D | 21,249 | 21,203 | 0 | 21,237 | 21,095 | -1 |
| | C | 14,830 | 14,897 | 0 | 15,075 | 15,179 | 1 |
| March | Average | 32,396 | 32,342 | 0 | 32,352 | 32,262 | 0 |
| | W | 49,248 | 49,279 | 0 | 49,403 | 49,448 | 0 |
| | AN | 44,060 | 43,726 | -1 | 43,972 | 43,573 | -1 |
| | BN | 23,188 | 23,053 | -1 | 23,068 | 22,758 | -1 |
| | D | 20,390 | 20,405 | 0 | 20,138 | 20,143 | 0 |
| | C | 12,971 | 13,002 | 0 | 12,942 | 12,982 | 0 |
| April | Average | 23,232 | 23,280 | 0 | 23,206 | 23,292 | 0 |
| | W | 37,918 | 37,951 | 0 | 38,019 | 38,035 | 0 |
| | AN | 26,053 | 25,963 | 0 | 26,039 | 26,128 | 0 |
| | BN | 17,518 | 17,697 | 1 | 17,439 | 17,573 | 1 |
| | D | 13,205 | 13,290 | 1 | 13,164 | 13,313 | 1 |
| | C | 10,295 | 10,309 | 0 | 10,067 | 10,158 | 1 |

**Table 11-36. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP3 (contd.)**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| May | Average | 19,417 | 19,352 | 0 | 19,114 | 19,064 | 0 |
| | W | 32,095 | 32,075 | 0 | 31,800 | 31,790 | 0 |
| | AN | 21,204 | 21,080 | -1 | 21,080 | 20,882 | -1 |
| | BN | 14,530 | 14,168 | -2 | 14,144 | 13,858 | -2 |
| | D | 11,226 | 11,327 | 1 | 10,836 | 10,987 | 1 |
| | C | 8,148 | 8,142 | 0 | 7,874 | 7,863 | 0 |
| June | Average | 16,508 | 16,475 | 0 | 16,511 | 16,449 | 0 |
| | W | 24,092 | 24,092 | 0 | 23,905 | 23,920 | 0 |
| | AN | 16,598 | 16,176 | -3 | 16,533 | 16,165 | -2 |
| | BN | 13,792 | 13,911 | 1 | 13,822 | 13,812 | 0 |
| | D | 12,283 | 12,323 | 0 | 12,569 | 12,525 | 0 |
| | C | 9,492 | 9,491 | 0 | 9,516 | 9,507 | 0 |
| July | Average | 19,518 | 19,529 | 0 | 19,266 | 19,320 | 0 |
| | W | 20,071 | 20,104 | 0 | 20,058 | 20,063 | 0 |
| | AN | 22,070 | 21,970 | 0 | 21,976 | 21,924 | 0 |
| | BN | 21,232 | 21,349 | 1 | 21,374 | 21,383 | 0 |
| | D | 19,577 | 19,544 | 0 | 18,788 | 18,900 | 1 |
| | C | 13,683 | 13,695 | 0 | 13,100 | 13,334 | 2 |
| August | Average | 14,710 | 14,695 | 0 | 14,596 | 14,690 | 1 |
| | W | 16,285 | 16,297 | 0 | 16,189 | 16,180 | 0 |
| | AN | 16,418 | 16,393 | 0 | 16,561 | 16,575 | 0 |
| | BN | 16,112 | 16,050 | 0 | 16,170 | 16,205 | 0 |
| | D | 13,632 | 13,632 | 0 | 12,968 | 13,276 | 2 |
| | C | 9,570 | 9,536 | 0 | 9,785 | 9,933 | 2 |
| September | Average | 18,211 | 18,257 | 0 | 18,417 | 18,544 | 1 |
| | W | 27,839 | 28,002 | 1 | 28,337 | 28,403 | 0 |
| | AN | 21,244 | 21,244 | 0 | 22,088 | 22,257 | 1 |
| | BN | 14,088 | 14,112 | 0 | 14,147 | 14,233 | 1 |
| | D | 12,522 | 12,404 | -1 | 12,341 | 12,545 | 2 |
| | C | 7,664 | 7,771 | 1 | 7,347 | 7,494 | 2 |
| October | Average | 11,309 | 11,416 | 1 | 11,117 | 11,219 | 1 |
| | W | 13,419 | 13,543 | 1 | 13,040 | 13,070 | 0 |
| | AN | 10,499 | 10,734 | 2 | 10,571 | 10,781 | 2 |
| | BN | 11,053 | 11,074 | 0 | 11,195 | 11,228 | 0 |
| | D | 10,150 | 10,258 | 1 | 9,830 | 10,085 | 3 |
| | C | 9,587 | 9,626 | 0 | 9,333 | 9,334 | 0 |

**Table 11-36. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP3 (contd.)**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| November | Average | 15,640 | 15,703 | 0 | 15,605 | 15,724 | 1 |
| | W | 20,726 | 20,936 | 1 | 20,832 | 20,929 | 0 |
| | AN | 16,893 | 16,259 | -4 | 16,666 | 16,344 | -2 |
| | BN | 13,755 | 13,809 | 0 | 13,793 | 13,759 | 0 |
| | D | 12,720 | 12,975 | 2 | 12,723 | 13,181 | 4 |
| | C | 9,948 | 10,113 | 2 | 9,653 | 9,935 | 3 |
| December | Average | 23,248 | 23,156 | 0 | 23,229 | 23,096 | -1 |
| | W | 37,645 | 37,341 | -1 | 37,434 | 37,045 | -1 |
| | AN | 22,604 | 22,634 | 0 | 22,461 | 22,287 | -1 |
| | BN | 16,930 | 16,871 | 0 | 17,103 | 17,196 | 1 |
| | D | 15,760 | 15,716 | 0 | 15,934 | 15,811 | -1 |
| | C | 11,303 | 11,439 | 1 | 11,310 | 11,492 | -2 |

Note:
A negative percentage change reflects a reduction in Sacramento River inflow
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 operation would result in no discernible 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. There would be no impact.

Results of hydrologic modeling, by month and water year type, for the Existing Condition, No-Action Alternative, and CP3 for San Joaquin River flow are summarized in Table 11-37. Results of these analyses show that CP3 would have no effect on seasonal San Joaquin River flows compared with the Existing Condition and No-Action Alternative. Based on these results CP3 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 11-37. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP3**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 4,770 | 4,770 | 0 | 4,764 | 4,764 | 0 |
| | W | 9,273 | 9,273 | 0 | 9,097 | 9,097 | 0 |
| | AN | 4,223 | 4,223 | 0 | 4,259 | 4,259 | 0 |
| | BN | 2,986 | 2,986 | 0 | 3,081 | 3,081 | 0 |
| | D | 2,084 | 2,084 | 0 | 2,160 | 2,160 | 0 |
| | C | 1,673 | 1,673 | 0 | 1,746 | 1,746 | 0 |
| February | Average | 6,265 | 6,265 | 0 | 6,143 | 6,143 | 0 |
| | W | 11,036 | 11,036 | 0 | 10,845 | 10,845 | 0 |
| | AN | 6,047 | 6,047 | 0 | 6,179 | 6,179 | 0 |
| | BN | 5,767 | 5,767 | 0 | 5,565 | 5,565 | 0 |
| | D | 2,642 | 2,642 | 0 | 2,528 | 2,528 | 0 |
| | C | 2,161 | 2,161 | 0 | 2,014 | 2,014 | 0 |
| March | Average | 7,133 | 7,133 | 0 | 7,003 | 7,003 | 0 |
| | W | 13,443 | 13,443 | 0 | 13,170 | 13,170 | 0 |
| | AN | 6,788 | 6,788 | 0 | 6,674 | 6,673 | 0 |
| | BN | 5,322 | 5,322 | 0 | 5,293 | 5,293 | 0 |
| | D | 2,963 | 2,963 | 0 | 2,895 | 2,895 | 0 |
| | C | 2,176 | 2,176 | 0 | 2,129 | 2,129 | 0 |
| April | Average | 6,720 | 6,720 | 0 | 7,533 | 7,533 | 0 |
| | W | 11,420 | 11,420 | 0 | 12,614 | 12,614 | 0 |
| | AN | 6,671 | 6,671 | 0 | 7,799 | 7,798 | 0 |
| | BN | 5,852 | 5,852 | 0 | 6,910 | 6,910 | 0 |
| | D | 3,726 | 3,726 | 0 | 4,112 | 4,112 | 0 |
| | C | 2,087 | 2,087 | 0 | 2,118 | 2,118 | 0 |
| May | Average | 6,204 | 6,204 | 0 | 6,234 | 6,234 | 0 |
| | W | 11,268 | 11,268 | 0 | 11,135 | 11,135 | 0 |
| | AN | 5,611 | 5,611 | 0 | 5,987 | 5,987 | 0 |
| | BN | 5,010 | 5,010 | 0 | 5,108 | 5,108 | 0 |
| | D | 3,070 | 3,070 | 0 | 3,111 | 3,111 | 0 |
| | C | 1,920 | 1,920 | 0 | 1,862 | 1,862 | 0 |
| June | Average | 4,739 | 4,739 | 0 | 4,671 | 4,671 | 0 |
| | W | 9,451 | 9,451 | 0 | 9,390 | 9,390 | 0 |
| | AN | 5,608 | 5,609 | 0 | 5,326 | 5,326 | 0 |
| | BN | 2,424 | 2,424 | 0 | 2,471 | 2,470 | 0 |
| | D | 1,598 | 1,598 | 0 | 1,554 | 1,554 | 0 |
| | C | 1,076 | 1,076 | 0 | 1,035 | 1,035 | 0 |
| July | Average | 3,202 | 3,202 | 0 | 3,208 | 3,208 | 0 |
| | W | 6,556 | 6,556 | 0 | 6,660 | 6,660 | 0 |
| | AN | 2,783 | 2,784 | 0 | 2,767 | 2,768 | 0 |
| | BN | 1,775 | 1,775 | 0 | 1,733 | 1,733 | 0 |
| | D | 1,282 | 1,282 | 0 | 1,216 | 1,216 | 0 |
| | C | 898 | 898 | 0 | 880 | 880 | 0 |

**Table 11-37. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP3 (contd.)**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| August | Average | 2,029 | 2,029 | 0 | 2,040 | 2,041 | 0 |
| | W | 3,099 | 3,099 | 0 | 3,158 | 3,159 | 0 |
| | AN | 2,020 | 2,020 | 0 | 2,014 | 2,015 | 0 |
| | BN | 1,828 | 1,828 | 0 | 1,817 | 1,816 | 0 |
| | D | 1,342 | 1,342 | 0 | 1,315 | 1,315 | 0 |
| | C | 984 | 984 | 0 | 993 | 993 | 0 |
| September | Average | 2,331 | 2,331 | 0 | 2,340 | 2,340 | 0 |
| | W | 3,274 | 3,274 | 0 | 3,317 | 3,317 | 0 |
| | AN | 2,328 | 2,328 | 0 | 2,312 | 2,312 | 0 |
| | BN | 2,109 | 2,109 | 0 | 2,119 | 2,119 | 0 |
| | D | 1,795 | 1,795 | 0 | 1,774 | 1,775 | 0 |
| | C | 1,358 | 1,358 | 0 | 1,355 | 1,355 | 0 |
| October | Average | 2,757 | 2,757 | 0 | 2,753 | 2,753 | 0 |
| | W | 3,112 | 3,112 | 0 | 3,107 | 3,107 | 0 |
| | AN | 2,446 | 2,446 | 0 | 2,424 | 2,424 | 0 |
| | BN | 2,749 | 2,749 | 0 | 2,718 | 2,718 | 0 |
| | D | 2,686 | 2,686 | 0 | 2,710 | 2,710 | 0 |
| | C | 2,416 | 2,416 | 0 | 2,423 | 2,423 | 0 |
| November | Average | 2,633 | 2,633 | 0 | 2,603 | 2,603 | 0 |
| | W | 3,372 | 3,372 | 0 | 3,340 | 3,340 | 0 |
| | AN | 2,213 | 2,213 | 0 | 2,176 | 2,176 | 0 |
| | BN | 2,412 | 2,412 | 0 | 2,360 | 2,360 | 0 |
| | D | 2,388 | 2,388 | 0 | 2,355 | 2,355 | 0 |
| | C | 2,075 | 2,075 | 0 | 2,088 | 2,088 | 0 |
| December | Average | 3,199 | 3,199 | 0 | 3,263 | 3,263 | 0 |
| | W | 5,081 | 5,081 | 0 | 5,178 | 5,178 | 0 |
| | AN | 2,916 | 2,916 | 0 | 2,899 | 2,899 | 0 |
| | BN | 2,705 | 2,705 | 0 | 2,753 | 2,753 | 0 |
| | D | 2,047 | 2,047 | 0 | 2,123 | 2,123 | 0 |
| | C | 1,710 | 1,710 | 0 | 1,785 | 1,785 | 0 |

Note:
A negative percentage change reflects a reduction in San Joaquin River flow
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 from its location under the Existing Condition or No-Action Alternative during February through May and September through November, and thus cause minimal reduction in low-salinity habitats. This impact would be less than significant.

The 1 km X2 criterion was applied to a comparison of hydrologic model results for the Existing Condition, No-Action Alternative, and CP3, by month and water year type, for the months from February through May and September through November. Results of the comparisons are summarized in Table 11-38. These results showed that changes in X2 location under CP3 were less than 1 km (all were less than 0.2 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. Based on these results, CP3 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 11-38. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP3**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Location (km)** | **Location (km)** | **Difference (km)** | **Location (km)** | **Location (km)** | **Difference (km)** |
| January | Average | 67.5 | 67.5 | 0.0 | 67.3 | 67.2 | 0.0 |
| | W | 53.6 | 53.7 | 0.1 | 53.7 | 53.7 | 0.1 |
| | AN | 61.7 | 61.7 | 0.0 | 61.6 | 61.6 | 0.0 |
| | BN | 72.1 | 72.0 | -0.1 | 71.7 | 71.6 | -0.1 |
| | D | 77.9 | 78.0 | 0.1 | 77.4 | 77.4 | -0.1 |
| | C | 82.2 | 82.2 | 0.1 | 81.9 | 81.9 | 0.0 |
| February | Average | 60.9 | 61.0 | 0.0 | 60.8 | 60.9 | 0.0 |
| | W | 50.4 | 50.4 | 0.0 | 50.4 | 50.4 | 0.0 |
| | AN | 54.8 | 54.8 | 0.0 | 54.6 | 54.6 | 0.1 |
| | BN | 61.0 | 61.0 | 0.0 | 60.9 | 60.9 | 0.0 |
| | D | 70.1 | 70.1 | 0.0 | 69.9 | 69.9 | 0.0 |
| | C | 76.2 | 76.3 | 0.1 | 75.9 | 76.1 | 0.2 |
| March | Average | 60.9 | 60.9 | 0.0 | 60.9 | 61.0 | 0.0 |
| | W | 52.1 | 52.1 | 0.0 | 52.1 | 52.1 | 0.0 |
| | AN | 53.6 | 53.7 | 0.1 | 53.7 | 53.7 | 0.1 |
| | BN | 63.3 | 63.3 | 0.1 | 63.3 | 63.5 | 0.2 |
| | D | 67.1 | 67.0 | -0.1 | 67.2 | 67.1 | 0.0 |
| | C | 75.2 | 75.2 | 0.0 | 75.1 | 75.1 | 0.1 |

**Table 11-38. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP3 (contd.)**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Location (km)** | **Location (km)** | **Difference (km)** | **Location (km)** | **Location (km)** | **Difference (km)** |
| April | Average | 63.5 | 63.5 | 0.0 | 63.4 | 63.3 | 0.0 |
| | W | 54.5 | 54.5 | 0.0 | 54.3 | 54.3 | 0.0 |
| | AN | 58.6 | 58.6 | 0.0 | 58.4 | 58.4 | 0.0 |
| | BN | 64.5 | 64.4 | -0.1 | 64.1 | 64.1 | 0.0 |
| | D | 69.9 | 69.8 | -0.1 | 69.9 | 69.7 | -0.1 |
| | C | 77.5 | 77.5 | 0.0 | 77.6 | 77.6 | 0.0 |
| May | Average | 67.5 | 67.5 | 0.0 | 67.7 | 67.6 | -0.1 |
| | W | 57.6 | 57.6 | 0.0 | 57.7 | 57.7 | 0.0 |
| | AN | 62.7 | 62.7 | 0.0 | 62.6 | 62.6 | 0.0 |
| | BN | 68.3 | 68.3 | 0.1 | 68.3 | 68.4 | 0.0 |
| | D | 74.4 | 74.2 | -0.2 | 74.8 | 74.6 | -0.2 |
| | C | 82.5 | 82.5 | 0.0 | 82.9 | 82.7 | -0.1 |
| June | Average | 74.5 | 74.5 | 0.0 | 74.7 | 74.7 | 0.0 |
| | W | 65.0 | 65.0 | 0.0 | 65.2 | 65.2 | 0.0 |
| | AN | 72.6 | 72.8 | 0.2 | 72.7 | 72.9 | 0.2 |
| | BN | 76.6 | 76.6 | 0.0 | 76.7 | 76.8 | 0.1 |
| | D | 80.4 | 80.3 | -0.1 | 80.7 | 80.6 | -0.1 |
| | C | 85.9 | 85.9 | 0.0 | 86.0 | 86.0 | -0.1 |
| July | Average | 80.5 | 80.5 | 0.0 | 80.5 | 80.5 | 0.0 |
| | W | 74.4 | 74.4 | 0.0 | 74.5 | 74.5 | 0.0 |
| | AN | 78.1 | 78.3 | 0.2 | 78.4 | 78.5 | 0.2 |
| | BN | 81.7 | 81.7 | 0.0 | 81.6 | 81.7 | 0.0 |
| | D | 84.8 | 84.8 | -0.1 | 84.8 | 84.8 | 0.0 |
| | C | 88.1 | 88.1 | 0.0 | 88.0 | 88.0 | 0.0 |
| August | Average | 85.6 | 85.6 | 0.0 | 85.6 | 85.5 | 0.0 |
| | W | 82.7 | 82.6 | 0.0 | 82.8 | 82.8 | 0.0 |
| | AN | 83.7 | 83.8 | 0.0 | 83.9 | 83.9 | 0.0 |
| | BN | 85.6 | 85.5 | 0.0 | 85.5 | 85.4 | 0.0 |
| | D | 87.8 | 87.8 | 0.0 | 87.5 | 87.5 | 0.0 |
| | C | 90.4 | 90.4 | 0.0 | 90.2 | 90.3 | 0.0 |
| September | Average | 83.7 | 83.7 | 0.0 | 83.7 | 83.6 | 0.0 |
| | W | 73.4 | 73.4 | 0.0 | 73.5 | 73.5 | 0.0 |
| | AN | 81.4 | 81.4 | 0.0 | 81.4 | 81.4 | 0.0 |
| | BN | 88.8 | 88.8 | 0.0 | 88.8 | 88.8 | 0.0 |
| | D | 90.2 | 90.2 | 0.0 | 90.0 | 90.0 | -0.1 |
| | C | 92.5 | 92.5 | 0.0 | 92.3 | 92.3 | 0.0 |

**Table 11-38. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP3 (contd.)**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Location (km)** | **Location (km)** | **Difference (km)** | **Location (km)** | **Location (km)** | **Difference (km)** |
| October | Average | 83.9 | 83.9 | 0.0 | 83.9 | 83.9 | 0.0 |
| | W | 73.6 | 73.5 | 0.0 | 73.7 | 73.7 | 0.0 |
| | AN | 79.8 | 79.8 | 0.0 | 79.8 | 79.8 | 0.0 |
| | BN | 88.9 | 88.9 | 0.0 | 88.9 | 88.9 | 0.0 |
| | D | 91.4 | 91.4 | 0.0 | 91.3 | 91.3 | 0.0 |
| | C | 93.3 | 93.2 | 0.0 | 93.1 | 93.0 | -0.1 |
| November | Average | 82.2 | 82.3 | 0.1 | 82.2 | 82.3 | 0.1 |
| | W | 73.1 | 73.1 | 0.0 | 73.2 | 73.2 | 0.0 |
| | AN | 78.4 | 78.4 | 0.0 | 78.4 | 78.5 | 0.1 |
| | BN | 84.8 | 85.4 | 0.6 | 84.8 | 85.3 | 0.6 |
| | D | 88.9 | 88.9 | 0.0 | 88.8 | 88.9 | 0.1 |
| | C | 92.6 | 92.7 | 0.0 | 92.8 | 92.7 | -0.1 |
| December | Average | 76.1 | 76.2 | 0.1 | 76.0 | 76.0 | 0.0 |
| | W | 62.9 | 63.1 | 0.1 | 63.0 | 63.2 | 0.1 |
| | AN | 76.4 | 76.8 | 0.4 | 76.4 | 76.8 | 0.4 |
| | BN | 81.4 | 81.4 | 0.0 | 81.1 | 81.1 | 0.0 |
| | D | 82.8 | 82.9 | 0.1 | 82.6 | 82.4 | -0.1 |
| | C | 87.9 | 87.7 | -0.2 | 87.8 | 87.5 | -0.4 |

Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
D = dry
km = kilometer
W = wet

*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* CP3 operation would result in minimal changes to reverse flows in Old and Middle rivers during January, March and April; however, flows do not exceed (become more negative) -5,000 cfs. Because the flows do not exceed -5,000 cfs, the increases in reverse flows are not expected to contribute to an increase in the vulnerability of delta smelt, longfin smelt, Chinook salmon, juvenile striped bass, or threadfin shad, but summer Old and Middle river flows could contribute to an increase in vulnerability of other resident warm-water fish to increased salvage and potential losses. This impact would be less than significant.

Results of the analysis showed several occurrences when reverse flows within Old and Middle rivers would be higher than under the Existing Condition or No-Action Alternative by more than 5 percent. These events would occur in critical, dry, and above-normal water years, which would be expected as a result of greater export operations under CP3.

During January (Table 11-39), operations under CP3 would result in an increase in reverse flow of greater than 5 percent during critical years compared with both Existing Conditions and the No-Action Alternative. Based on results of the delta smelt analysis of the relationship between reverse flows and delta smelt salvage, the increase of approximately 200 cfs in a critical water year would not be expected to result in a significant increase in adverse effects to delta smelt because their presence in the region is minimal during this time. Longfin smelt, however, are likely in the area during dry water years, but the flows do not exceed -5,000 cfs, so longfin smelt are not expected to experience significant impacts.

**Table 11-39. Old and Middle River Reverse Flows Under Existing Conditions, No-Action Alternative, and CP3**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | -3,542 | -3,575 | 1 | -3,553 | -3,592 | 1 |
| | W | -2,034 | -2,034 | 0 | -2,151 | -2,161 | 0 |
| | AN | -3,654 | -3,592 | -2 | -3,574 | -3,626 | 1 |
| | BN | -4,240 | -4,240 | 0 | -4,240 | -4,240 | 0 |
| | D | -4,773 | -4,802 | 1 | -4,772 | -4,777 | 0 |
| | C | -4,033 | -4,282 | 6 | -3,940 | -4,129 | 5 |
| February | Average | -3,293 | -3,287 | 0 | -3,358 | -3,375 | 1 |
| | W | -2,745 | -2,734 | 0 | -2,950 | -2,972 | 1 |
| | AN | -3,248 | -3,012 | -7 | -3,165 | -3,129 | -1 |
| | BN | -3,335 | -3,464 | 4 | -3,291 | -3,279 | 0 |
| | D | -4,016 | -4,033 | 0 | -4,045 | -4,063 | 0 |
| | C | -3,391 | -3,433 | 1 | -3,482 | -3,576 | 3 |
| March | Average | -2,784 | -2,799 | 1 | -2,877 | -2,860 | -1 |
| | W | -1,792 | -1,789 | 0 | -2,023 | -2,010 | -1 |
| | AN | -4,021 | -4,230 | 5 | -4,260 | -4,282 | 1 |
| | BN | -4,005 | -4,008 | 0 | -3,982 | -3,972 | 0 |
| | D | -2,951 | -2,872 | -3 | -2,918 | -2,834 | -3 |
| | C | -2,023 | -2,038 | 1 | -1,994 | -2,022 | 1 |
| April | Average | 955 | 955 | 0 | 1,060 | 1,059 | 0 |
| | W | 2,706 | 2,706 | 0 | 2,798 | 2,806 | 0 |
| | AN | 1,087 | 1,087 | 0 | 1,314 | 1,314 | 0 |
| | BN | 697 | 697 | 0 | 898 | 898 | 0 |
| | D | -244 | -242 | -1 | -207 | -220 | 6 |
| | C | -874 | -874 | 0 | -872 | -872 | 0 |

**Table 11-39. Old and Middle River Reverse Flows Under Existing Conditions, No-Action Alternative, and CP3 (contd.)**

| | | Existing Condition | CP3 (2005) | | No-Action Alternative | CP3 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| May | Average | 491 | 492 | 0 | 416 | 426 | 2 |
| | W | 2,077 | 2,076 | 0 | 1,781 | 1,781 | 0 |
| | AN | 562 | 562 | 0 | 646 | 646 | 0 |
| | BN | 277 | 277 | 0 | 270 | 271 | 0 |
| | D | -674 | -674 | 0 | -696 | -695 | 0 |
| | C | -1,018 | -1,012 | -1 | -936 | -867 | -7 |
| June | Average | -3,654 | -3,669 | 0 | -3,718 | -3,735 | 0 |
| | W | -4,226 | -4,226 | 0 | -4,354 | -4,359 | 0 |
| | AN | -4,825 | -4,819 | 0 | -4,818 | -4,818 | 0 |
| | BN | -4,137 | -4,233 | 2 | -4,119 | -4,227 | 3 |
| | D | -3,079 | -3,079 | 0 | -3,205 | -3,191 | 0 |
| | C | -1,542 | -1,542 | 0 | -1,542 | -1,542 | 0 |
| July | Average | -9,502 | -9,500 | 0 | -9,292 | -9,330 | 0 |
| | W | -8,948 | -8,942 | 0 | -8,905 | -8,901 | 0 |
| | AN | -9,993 | -9,935 | -1 | -9,929 | -9,906 | 0 |
| | BN | -10,886 | -10,982 | 1 | -10,903 | -10,908 | 0 |
| | D | -10,998 | -10,969 | 0 | -10,419 | -10,480 | 1 |
| | C | -6,355 | -6,343 | 0 | -5,928 | -6,121 | 3 |

Note:
A positive percentage change reflects more negative reverse flows under CP3 when compared to the Existing Condition or the No-Action Alternative.
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Juvenile Chinook salmon and steelhead are migrating through the Delta during January, and an increase in average monthly reverse flows of around 200 cfs would be expected to increase the potential risk of increased mortality to these species. 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 January 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 January.

The increase in reverse flows estimated to occur under CP3 in above-normal water years in March (under 2005 conditions) and in dry water years in April (under 2030 conditions) would exceed 5 percent. Juvenile and larval delta smelt occur in the area in March and April. A change in Old and Middle river flows of approximately 100 to 200 cfs does not increase the flows to beyond -5,000 cfs.

The potential increase in losses during January, March and April under CP3 is considered to be less than significant. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species, which would thus reduce impacts to non-listed species as well.

*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. 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 CDFW. The resulting impact to Chinook salmon would be less than significant; the resulting impact to delta smelt, longfin smelt, steelhead, striped bass, and splittail would be potentially significant. Overall, this impact would be potentially significant.

Results of entrainment loss modeling at the CVP and SWP export facilities are presented in Table 11-40 for CP3. The total numbers of fish lost annually, by species, are presented in Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report.* The difference between the nonoperations-related and operations-related fish mortality is represented as the entrainment index, shown in Table 11-40, to represent the effect of project operations on each fish species at the CVP and SWP facilities.

**Table 11-40. Indices of 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 | 42 | 0.1 | -49 | -0.1 |
| | W | -4 | -0.0 | 20 | 0.0 |
| | AN | -60 | -0.1 | 12 | 0.0 |
| | BN | 305 | 0.9 | 292 | 0.8 |
| | D | -6 | -0.0 | -43 | -0.1 |
| | C | 10 | 0.0 | -665 | -2.9 |
| Chinook Salmon | Average | 53 | 0.1 | -37 | -0.1 |
| | W | -16 | -0.0 | 8 | 0.0 |
| | AN | -123 | -0.2 | 33 | 0.1 |
| | BN | 302 | 0.6 | 116 | 0.2 |
| | D | -47 | -0.1 | -52 | -0.1 |
| | C | 235 | 0.7 | -360 | -1.1 |
| Longfin Smelt | Average | -2 | -0.0 | -29 | -0.4 |
| | W | 0 | -0.0 | -4 | -0.0 |
| | AN | 1 | 0.0 | 1 | 0.0 |
| | BN | 3 | 0.1 | 4 | 0.1 |
| | D | -2 | -0.0 | 5 | 0.1 |
| | C | -17 | -0.3 | -202 | -4.0 |

**Table 11-40. Indices of Entrainment at the CVP and SWP Facilities Comparing Existing Conditions, No-Action Alternative, and CP3 (contd.)**

| Species | Water Year | CP3 minus Existing Condition | Percent Change | CP3 Minus Future Condition | Percent Change |
|---|---|---|---|---|---|
| Steelhead | Average | 7 | 0.2 | 8 | 0.2 |
| | W | -3 | -0.1 | 4 | 0.1 |
| | AN | -31 | -0.7 | 4 | 0.1 |
| | BN | 36 | 0.9 | -3 | -0.1 |
| | D | -5 | -0.2 | -10 | -0.3 |
| | C | 55 | 2.0 | 57 | 2.1 |
| Striped Bass | Average | 3,981 | 0.3 | 7,305 | 0.6 |
| | W | 2,316 | 0.1 | 2,465 | 0.1 |
| | AN | -513 | -0.0 | 3,333 | 0.2 |
| | BN | 15,204 | 1.1 | 12,919 | 1.0 |
| | D | 1,563 | 0.1 | 8,672 | 0.8 |
| | C | 2,616 | 0.4 | 13,162 | 2.2 |
| Splittail | Average | 507 | 0.2 | 886 | 0.3 |
| | W | -36 | -0.0 | 158 | 0.0 |
| | AN | -738 | -0.2 | -171 | -0.1 |
| | BN | 4,107 | 1.6 | 3,650 | 1.4 |
| | D | -283 | -0.1 | 164 | 0.1 |
| | C | -83 | -0.1 | 1,378 | 1.4 |

Note: A negative percentage change reflects a reduction in entrainment risk while a positive percentage change reflects an increase in entrainment risk.

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

Results of 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 of less than 3 percent during critical water years under CP3 relative to the Existing Condition (Table 11-40). The risk of increased losses of delta smelt under CP3 compared to the No-Action Alternative (Table 11-40) would be greatest in the below-normal water 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 Chinook salmon increases during below-normal and critical water years under 2005 conditions, and above-normal and below-normal water years under 2030 conditions (Table 11-40). Given the numbers of juvenile Sacramento River 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 would be a less-than-significant direct 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 CP3 compared to the Existing Condition and the No-Action Alternative shows small positive and negative changes depending on water year type and alternative (Table 11-40). 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 are summarized in Table 11-40. 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 (approximately 2 percent) in risk of steelhead losses in critical water years are considered to be potentially significant based on the apparently low abundance of juvenile Sacramento and San Joaquin river 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 critical water years represents an initial estimate of the change (percentage) between CP3 and Existing Conditions and the No-Action Alternative, and does not allow the predicted losses to be evaluated at the population level (see Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report)*.

The change in risk to juvenile striped bass for entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-40. 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 and 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.

The increased risk index for splittail was less than 1 percent under both the Existing Condition and No-Action Alternative, and was considered to be less than significant. The loss index increased during dry and critical 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 (CP3) is considered to be less than significant for Chinook salmon,  and longfin smelt, but potentially significant for delta smelt, steelhead, striped bass, and splittail. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species, and thus, reduce impacts to non-listed fishes as well.

**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 to tributaries and reservoirs (e.g., New Melones and San Luis) with CVP and SWP dams, as well as the conveyances south of the Delta would be substantially less than impacts on the lower Sacramento River. The change in hydrology in the CVP and SWP service areas could affect aquatic habitats that provide habitat for the fish community; however, these changes would not result in substantial effects on their distribution or abundance. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-24 (CP1). The hydrologic effects to the CVP and SWP service areas would not result in substantial effects on the distribution or abundance of the fish 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 and CP4A – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability*

CP4 and CP4A focus on increasing anadromous fish survival while also increasing water supply reliability. By raising Shasta Dam 18.5 feet, in combination with spillway modifications, CP4 and CP4A would increase the height of the reservoir full pool by 20.5 feet and enlarge the total storage capacity in the reservoir by 634,000 acre-feet. The existing TCD would also be extended to achieve efficient use of the expanded cold-water pool. The additional storage created by the 18.5-foot dam raise would be used to improve the ability to meet temperature objectives and habitat requirements for anadromous fish during drought years and increase water supply reliability. CP4A is identical to CP4 except for the operations of Shasta Dam and reservoir. Both alternatives have similar reservoir operations in that they each dedicate a portion of the new storage in Shasta Lake for Sacramento River anadromous fish purposes (e.g., cold water pool); however, the portion of this dedicated storage varies.

For CP4, about 378,000 acre-feet of the increased reservoir storage space would be dedicated to increasing the supply of cold water for anadromous fish survival. Operations for the remaining portion of increased storage for CP4A (approximately 256,000 acre-feet) would be the same as in CP1, with 70,000 acre-feet reserved in dry years and 35,000 acre-feet reserved in critical years to specifically focus on increasing M&I deliveries.

For CP4A, about 191,000 acre-feet of the increased reservoir storage space would be dedicated to increasing the supply of cold water for anadromous fish survival. Operations for the remaining portion of increased storage for CP4A (approximately 443,000 acre-feet) would be the same as in CP2, with 120,000 acre-feet reserved in dry years and 60,000 acre-feet reserved in critical years to specifically focus on increasing M&I deliveries.

CP4 and CP4A both include an adaptive management plan for the cold-water pool, and augmenting spawning gravel and restoring riparian, floodplain, and side channel habitat at one or more sites in the upper Sacramento River.

**Shasta Lake and Vicinity** This section describes impacts on the Shasta Lake and vicinity portion of the primary study area for CP4 and CP4A.

*Impact Aqua-1 (CP4 or CP4A): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations* Under CP4 or CP4A, 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. CP4 or CP4A 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 CP3, the value of existing structural habitat improvements would be diminished to varying degrees; however, the existing habitat enhancement features would become functional during reservoir drawdowns later in the season and during below-normal and drier years, when the reservoir does not refill. Additionally, environmental commitments during construction include using brush and trees cleared for other project purposes to extend and enhance existing fish habitat structures into the new inundated varial zone. Large areas of the shoreline would not be cleared, and the vegetation along these sections will be inundated periodically, providing additional structural fish habitat. In the short term, this newly inundated vegetation will initially increase warm-water fish habitat, with decay expected to occur over several decades. This impact would be less than significant for alternatives CP4 and CP4A.

This impact would be similar to Impacts Aqua-1 (CP1, CP2, and CP3), but the surface area would be larger under the 18.5-foot dam raise than under CP1 and

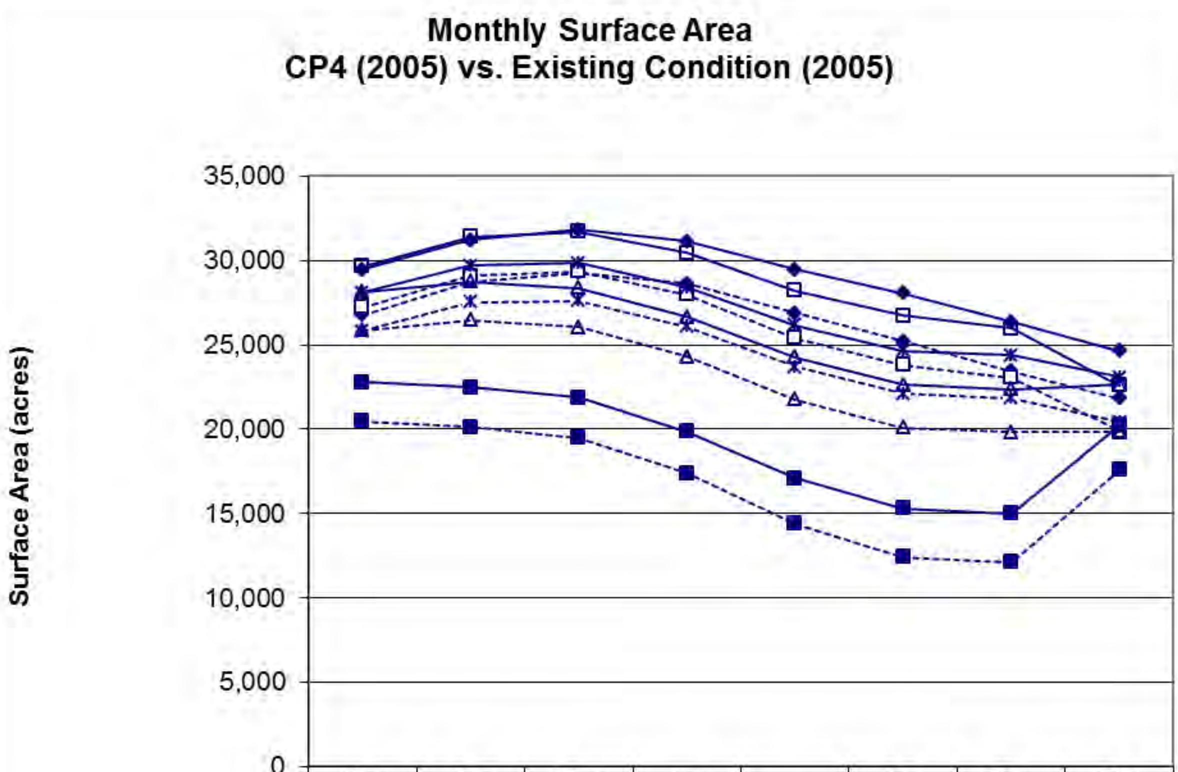
CP2, where the surface area under CP4 would be slightly greater than under CP4A (Figures 11-32 and 11-33). CalSim-II modeling shows that the surface area of Shasta Lake would be larger under CP4 and CP4A for both a 2005 and 2030 water supply demand than under the Existing Condition or the No-Action Alternative in all five water year types (Figures 11-32 through 11-35).

Monthly WSEL fluctuations were compared to projections for water supply demand. For CP4 or CP4A, with a 2005 water supply demand, 76 percent and 68 percent, respectively, of monthly changes in projected WSELs (i.e., 19 and 17 of the 25 total projections made for the 5 months from March through July for all five water year types) showed decreased monthly WSEL fluctuations relative to the Existing Condition and none showed an increased monthly WSEL fluctuation (Figure 11-36 and Figure 11-37). For CP4 or CP4A, with a projected 2030 water supply demand, 72 and 64 percent, respectively, of monthly changes in projected WSELs showed decreased WSEL fluctuations relative to the No-Action Alternative and none showed an increase in monthly WSEL fluctuation (Figure 11-38 and Figure 11-39). Under CP4 or CP4A, 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 or CP4A 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. Similar to CP1, CP2, and CP3, CP4 and CP4A include environmental commitments during construction to offset the effects on existing fish habitat enhancement structures (see Chapter 2, “Alternatives,” for additional detailed descriptions of the environmental commitments).

This impact for CP4 would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

This impact for CP4A would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

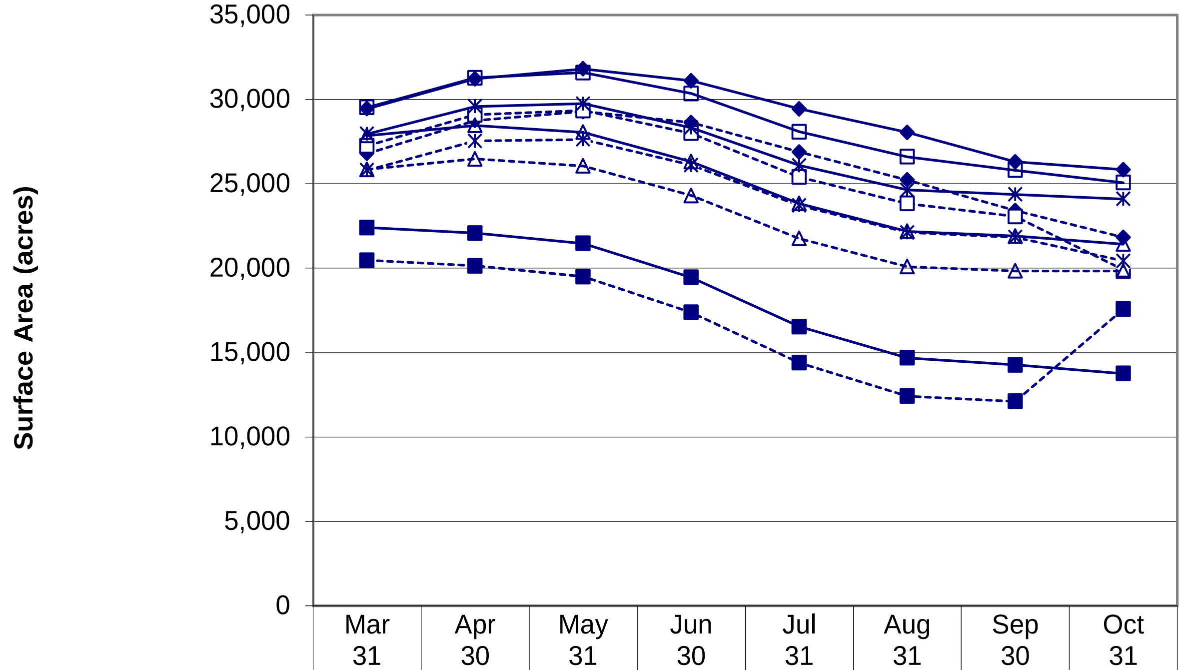



| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 |
|---|---|---|---|---|---|---|---|---|
| EC W | 26,790 | 28,748 | 29,277 | 28,624 | 26,872 | 25,226 | 23,413 | 21,827 |
| EC AN | 27,245 | 29,082 | 29,336 | 27,992 | 25,400 | 23,826 | 23,061 | 19,906 |
| EC BN | 25,807 | 27,534 | 27,621 | 26,104 | 23,714 | 22,114 | 21,837 | 20,425 |
| EC D | 25,850 | 26,467 | 26,058 | 24,300 | 21,754 | 20,093 | 19,840 | 19,828 |
| EC C | 20,467 | 20,142 | 19,500 | 17,381 | 14,400 | 12,418 | 12,111 | 17,572 |
| CP4 2005 W | 29,449 | 31,220 | 31,811 | 31,125 | 29,463 | 28,073 | 26,342 | 24,655 |
| CP4 2005 AN | 29,658 | 31,393 | 31,719 | 30,465 | 28,195 | 26,742 | 25,983 | 22,590 |
| CP4 2005 BN | 28,094 | 29,692 | 29,832 | 28,406 | 26,179 | 24,663 | 24,362 | 23,088 |
| CP4 2005 D | 28,155 | 28,742 | 28,351 | 26,665 | 24,248 | 22,630 | 22,360 | 22,625 |
| CP4 2005 C | 22,780 | 22,473 | 21,856 | 19,871 | 17,077 | 15,320 | 14,997 | 20,243 |

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 11-32. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 Versus Existing Condition (2005)**

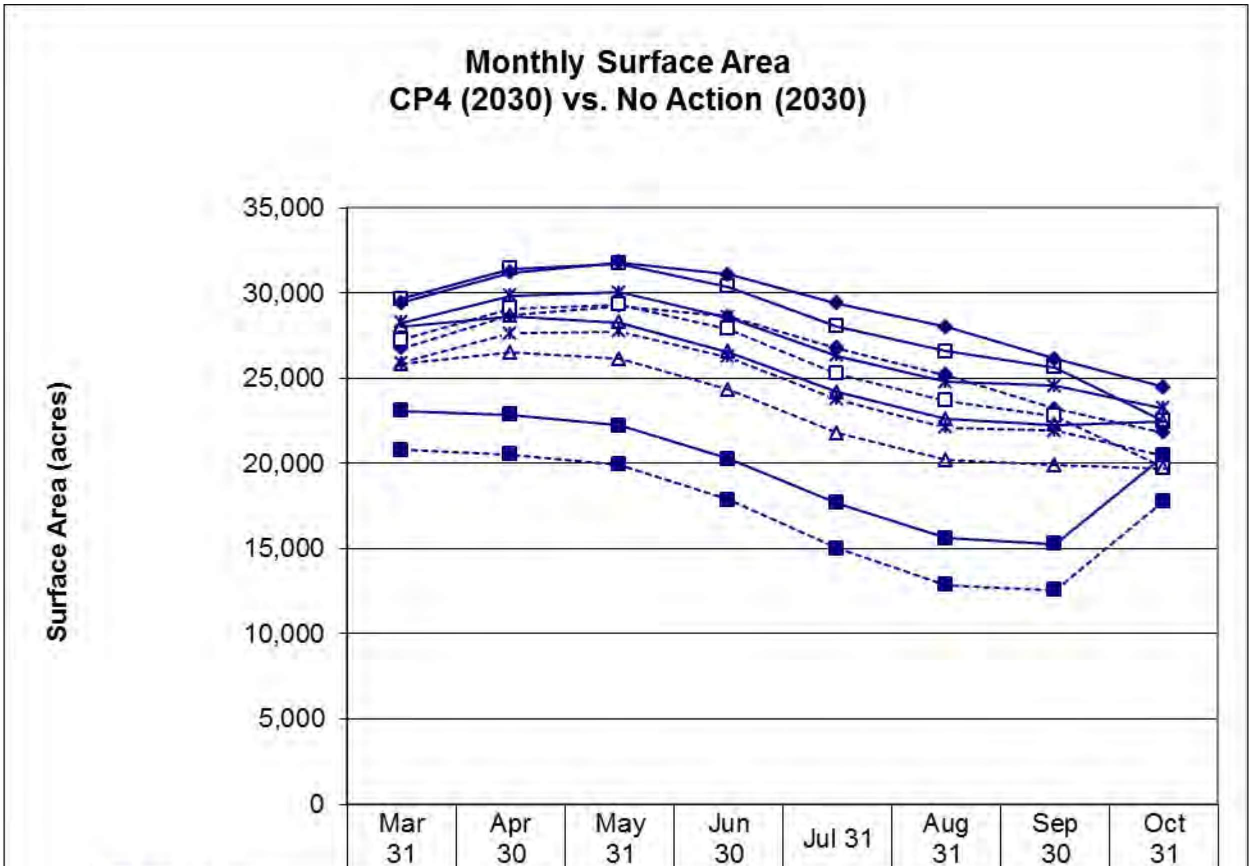
**Monthly Surface Area**
**CP4A (2005) vs. Existing Condition (2005)**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 |
|---|---|---|---|---|---|---|---|---|
| EC W | 26,790 | 28,748 | 29,277 | 28,624 | 26,872 | 25,226 | 23,413 | 21,827 |
| EC AN | 27,245 | 29,082 | 29,336 | 27,992 | 25,400 | 23,826 | 23,061 | 19,906 |
| EC BN | 25,807 | 27,534 | 27,621 | 26,104 | 23,714 | 22,114 | 21,837 | 20,425 |
| EC D | 25,850 | 26,467 | 26,058 | 24,300 | 21,754 | 20,093 | 19,840 | 19,828 |
| EC C | 20,467 | 20,142 | 19,500 | 17,381 | 14,400 | 12,418 | 12,111 | 17,572 |
| CP4A 2005 W | 29,448 | 31,213 | 31,802 | 31,103 | 29,429 | 28,044 | 26,301 | 25,829 |
| CP4A 2005 AN | 29,525 | 31,277 | 31,588 | 30,348 | 28,075 | 26,595 | 25,798 | 25,066 |
| CP4A 2005 BN | 27,954 | 29,579 | 29,744 | 28,324 | 26,084 | 24,635 | 24,366 | 24,101 |
| CP4A 2005 D | 27,852 | 28,458 | 28,052 | 26,304 | 23,826 | 22,177 | 21,896 | 21,429 |
| CP4A 2005 C | 22,400 | 22,076 | 21,464 | 19,451 | 16,536 | 14,682 | 14,273 | 13,758 |

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

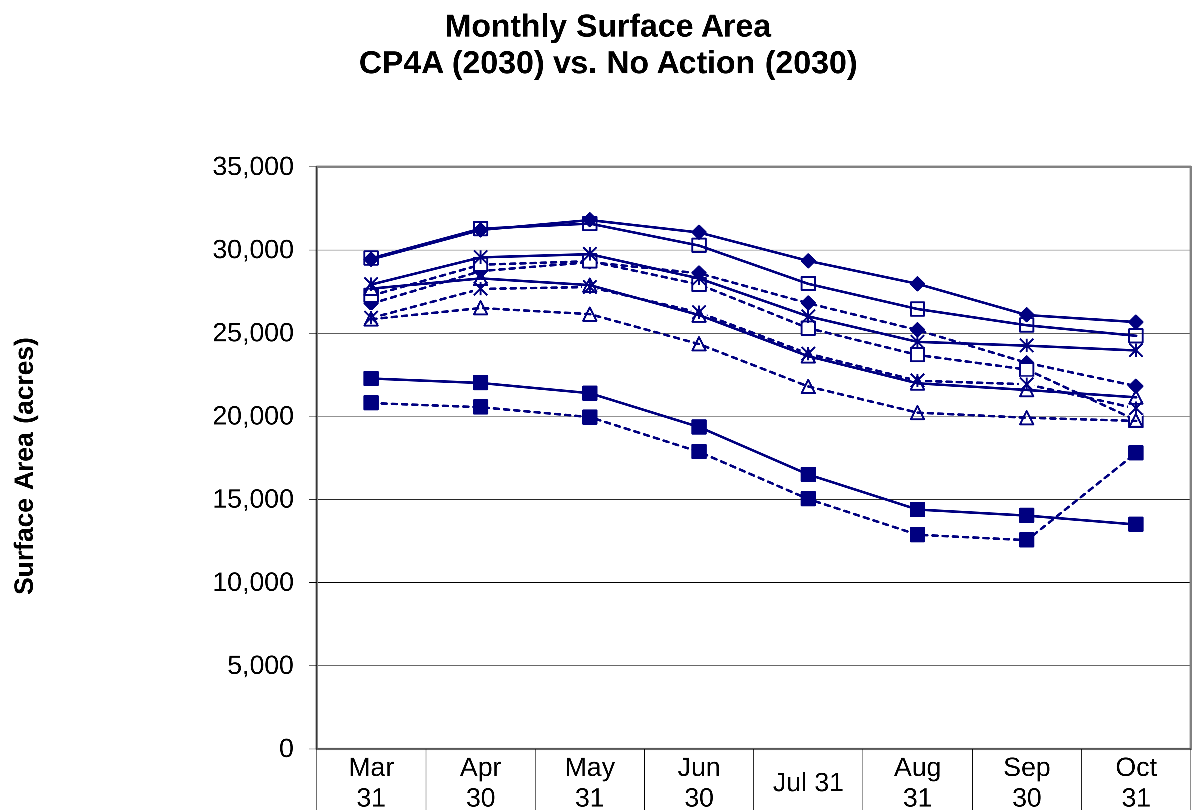
**Figure 11-33 Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4A Versus Existing Condition (2005)**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 |
|---|---|---|---|---|---|---|---|---|
| NA W | 26,775 | 28,735 | 29,273 | 28,604 | 26,797 | 25,183 | 23,205 | 21,808 |
| NA AN | 27,258 | 29,117 | 29,325 | 27,921 | 25,294 | 23,687 | 22,800 | 19,759 |
| NA BN | 25,918 | 27,662 | 27,770 | 26,239 | 23,764 | 22,137 | 21,923 | 20,469 |
| NA D | 25,843 | 26,514 | 26,134 | 24,346 | 21,780 | 20,209 | 19,910 | 19,728 |
| NA C | 20,801 | 20,548 | 19,942 | 17,866 | 15,026 | 12,873 | 12,556 | 17,800 |
| CP4 2030 W | 29,436 | 31,209 | 31,806 | 31,089 | 29,398 | 28,006 | 26,152 | 24,495 |
| CP4 2030 AN | 29,677 | 31,437 | 31,740 | 30,369 | 28,051 | 26,579 | 25,658 | 22,492 |
| CP4 2030 BN | 28,276 | 29,878 | 30,048 | 28,591 | 26,320 | 24,798 | 24,567 | 23,228 |
| CP4 2030 D | 28,045 | 28,663 | 28,287 | 26,552 | 24,182 | 22,623 | 22,283 | 22,451 |
| CP4 2030 C | 23,112 | 22,855 | 22,235 | 20,262 | 17,674 | 15,624 | 15,282 | 20,472 |

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

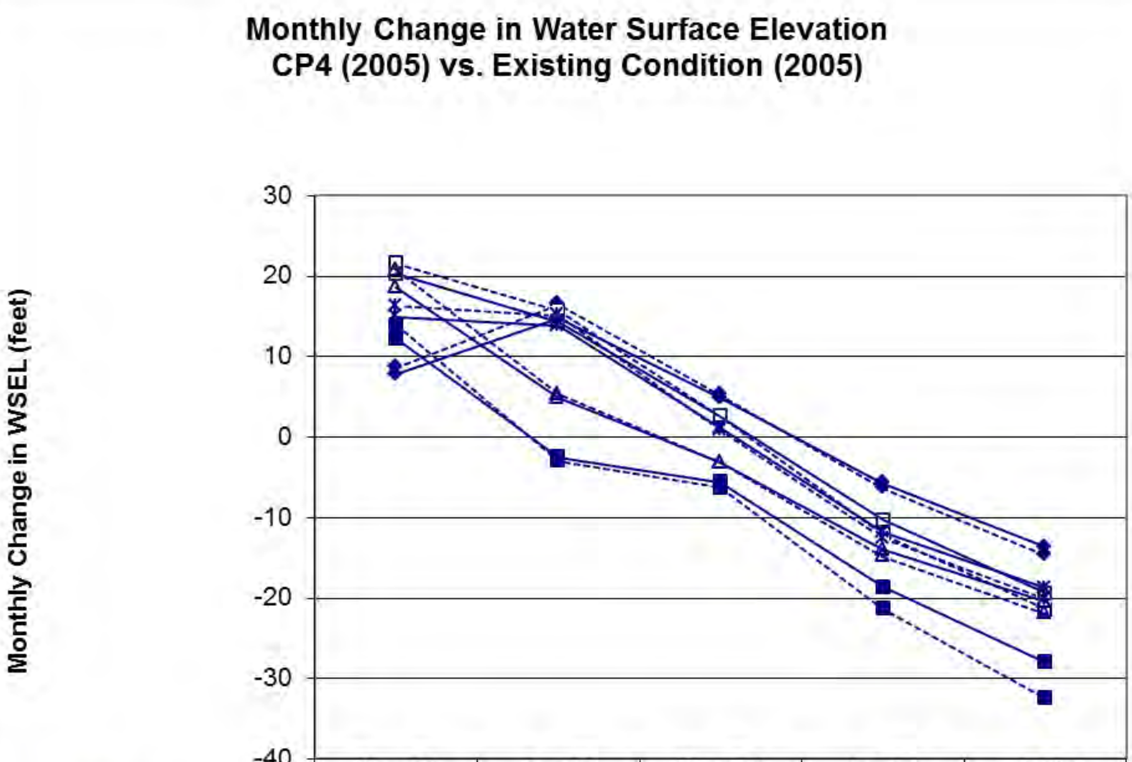
**Figure 11-34. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 Versus No-Action Alternative (2030)**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 |
|---|---|---|---|---|---|---|---|---|
| NA W | 26,775 | 28,735 | 29,273 | 28,604 | 26,797 | 25,183 | 23,205 | 21,808 |
| NA AN | 27,258 | 29,117 | 29,325 | 27,921 | 25,294 | 23,687 | 22,800 | 19,759 |
| NA BN | 25,918 | 27,662 | 27,770 | 26,239 | 23,764 | 22,137 | 21,923 | 20,469 |
| NA D | 25,843 | 26,514 | 26,134 | 24,346 | 21,780 | 20,209 | 19,910 | 19,728 |
| NA C | 20,801 | 20,548 | 19,942 | 17,866 | 15,026 | 12,873 | 12,556 | 17,800 |
| CP4A 2030 W | 29,436 | 31,202 | 31,797 | 31,057 | 29,342 | 27,954 | 26,086 | 25,660 |
| CP4A 2030 AN | 29,501 | 31,276 | 31,582 | 30,269 | 27,968 | 26,440 | 25,475 | 24,832 |
| CP4A 2030 BN | 27,926 | 29,555 | 29,746 | 28,288 | 25,998 | 24,470 | 24,250 | 23,965 |
| CP4A 2030 D | 27,676 | 28,279 | 27,879 | 26,083 | 23,617 | 21,985 | 21,587 | 21,142 |
| CP4A 2030 C | 22,266 | 22,009 | 21,378 | 19,350 | 16,490 | 14,381 | 14,026 | 13,496 |

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

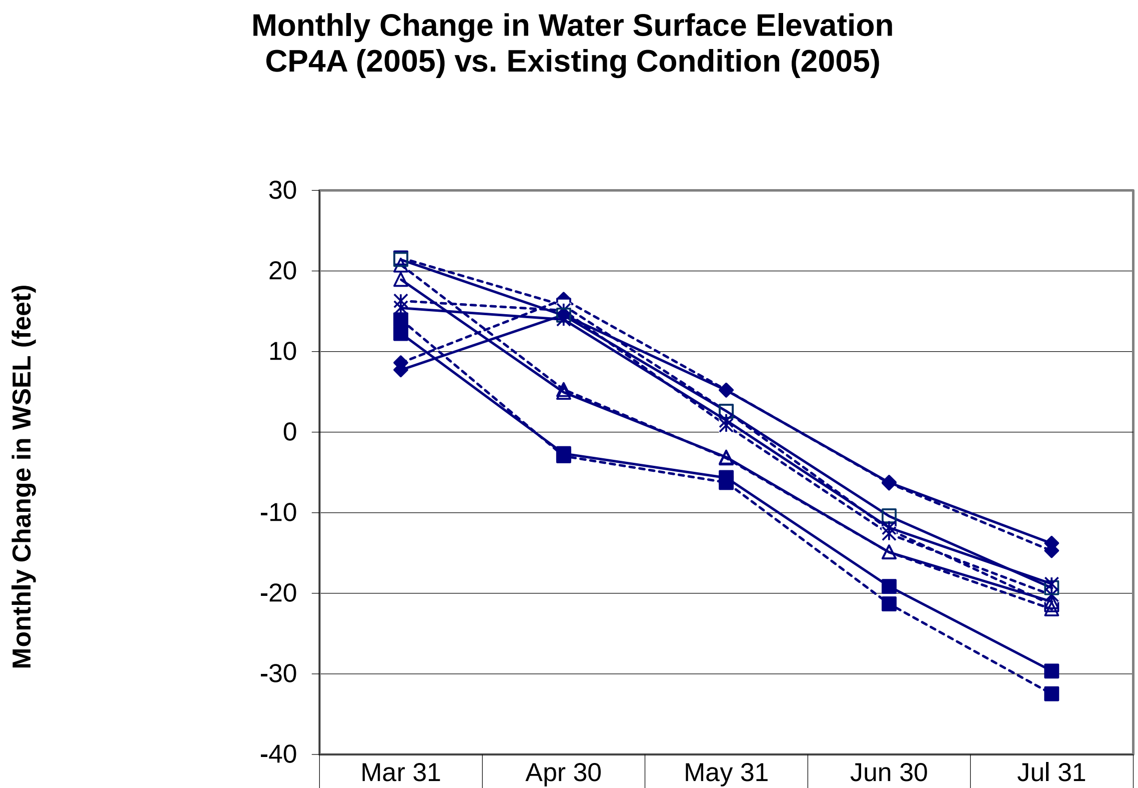
**Figure 11-35. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4A Versus No-Action Alternative (2030)**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 |
|---|---|---|---|---|---|
| EC W | 9 | 16 | 5 | -6 | -15 |
| EC AN | 22 | 16 | 3 | -12 | -21 |
| EC BN | 16 | 15 | 1 | -13 | -20 |
| EC D | 21 | 5 | -3 | -15 | -22 |
| EC C | 14 | -3 | -6 | -21 | -32 |
| CP4 (2005) W | 8 | 15 | 5 | -6 | -14 |
| CP4 (2005) AN | 20 | 14 | 3 | -10 | -19 |
| CP4 (2004) BN | 15 | 14 | 1 | -12 | -19 |
| CP4 (2005) D | 19 | 5 | -3 | -14 | -21 |
| CP4 (2005) C | 12 | -3 | -6 | -19 | -28 |

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
WSEL = water surface elevation

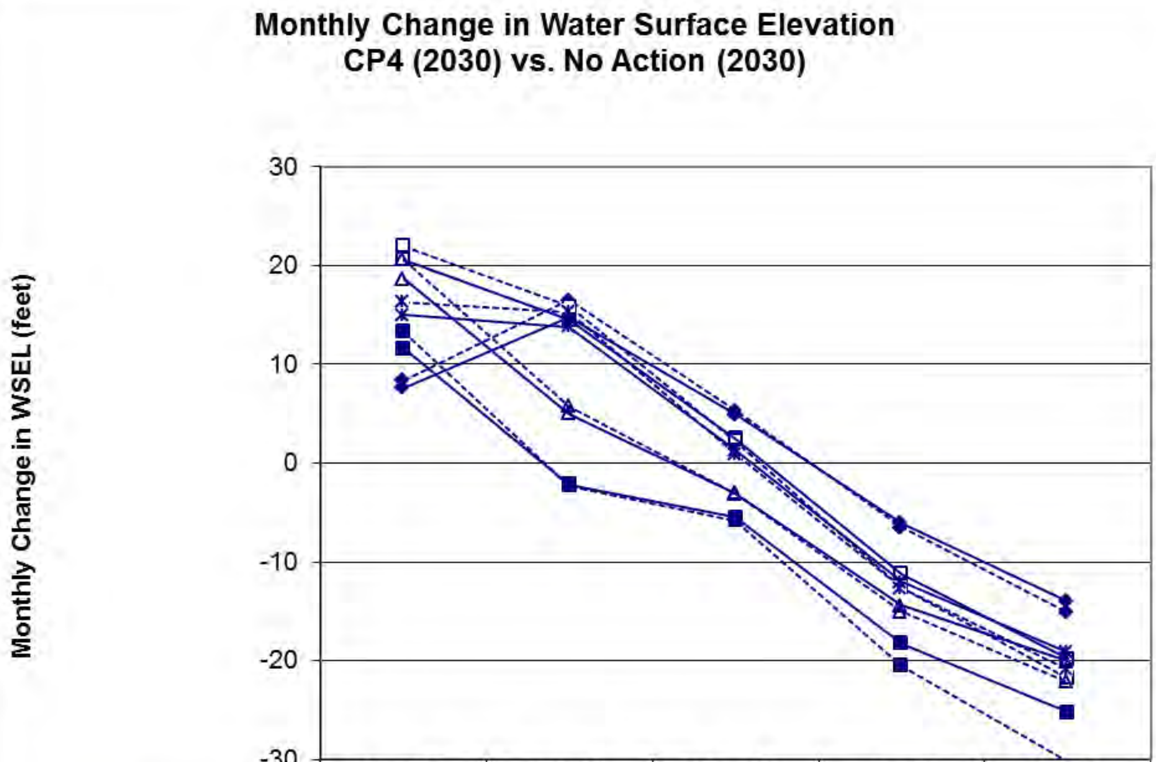
**Figure 11-36. Average Monthly Change in Water Surface Elevation for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 Versus Existing Condition (2005)**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 |
|---|---|---|---|---|---|
| EC W | 9 | 16 | 5 | -6 | -15 |
| EC AN | 22 | 16 | 3 | -12 | -21 |
| EC BN | 16 | 15 | 1 | -13 | -20 |
| EC D | 21 | 5 | -3 | -15 | -22 |
| EC C | 14 | -3 | -6 | -21 | -32 |
| CP4A (2005) W | 8 | 15 | 5 | -6 | -14 |
| CP4A (2005) AN | 21 | 15 | 3 | -10 | -19 |
| CP4A (2005) BN | 15 | 14 | 1 | -12 | -19 |
| CP4A (2005) D | 19 | 5 | -3 | -15 | -21 |
| CP4A (2005) C | 12 | -3 | -6 | -19 | -30 |

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
WSEL = water surface elevation

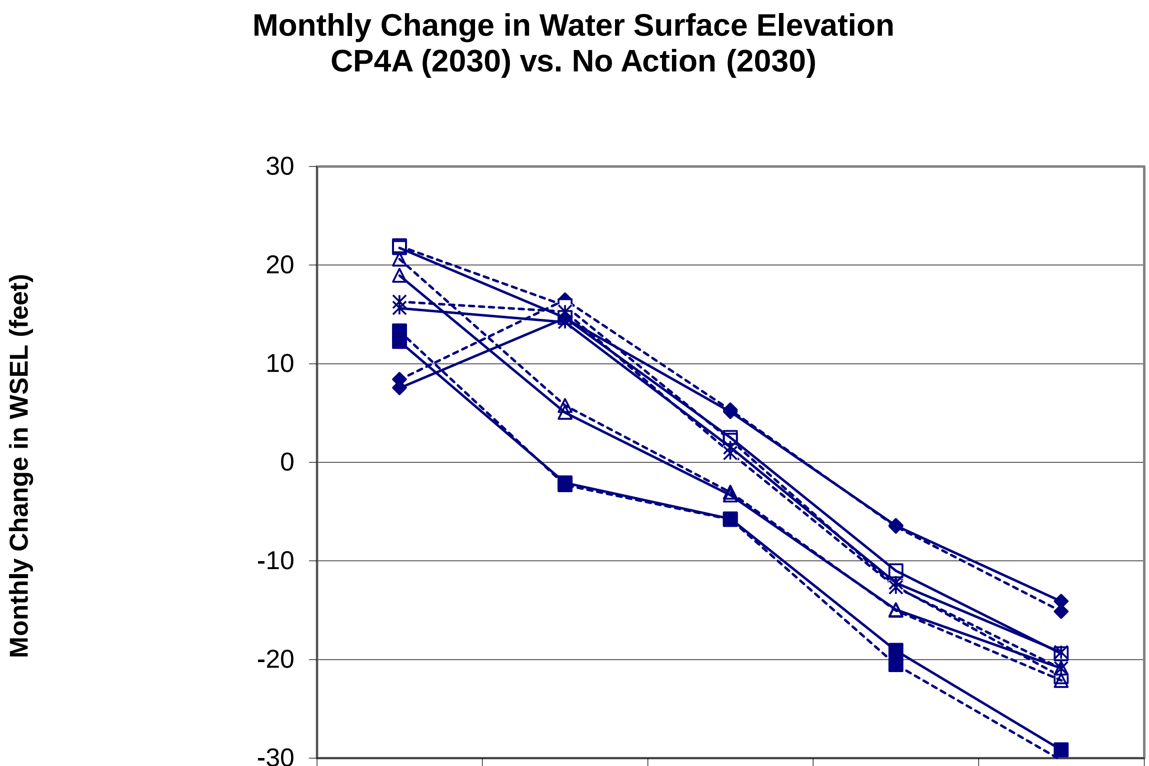
**Figure 11-37. Average Monthly Change in Water Surface Elevation for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4A Versus Existing Condition (2005)**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 |
|---|---|---|---|---|---|
| NA W | 8 | 16 | 5 | -7 | -15 |
| NA AN | 22 | 16 | 2 | -13 | -22 |
| NA BN | 16 | 15 | 1 | -13 | -21 |
| NA D | 21 | 6 | -3 | -15 | -22 |
| NA C | 13 | -2 | -6 | -21 | -30 |
| CP4 (2030) W | 8 | 15 | 5 | -6 | -14 |
| CP4 (2030) AN | 21 | 14 | 2 | -11 | -20 |
| CP4 (2030) BN | 15 | 14 | 1 | -12 | -19 |
| CP4 (2030) D | 19 | 5 | -3 | -14 | -20 |
| CP4 (2030) C | 12 | -2 | -6 | -18 | -25 |

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 11-38. Average Monthly Change in Water Surface Elevation for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 Versus No-Action Alternative (2030)**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 |
|---|---|---|---|---|---|
| NA W | 8 | 16 | 5 | -7 | -15 |
| NA AN | 22 | 16 | 2 | -13 | -22 |
| NA BN | 16 | 15 | 1 | -13 | -21 |
| NA D | 21 | 6 | -3 | -15 | -22 |
| NA C | 13 | -2 | -6 | -21 | -30 |
| CP4A (2030) W | 8 | 15 | 5 | -6 | -14 |
| CP4A (2030) AN | 22 | 15 | 3 | -11 | -19 |
| CP4A (2030) BN | 16 | 14 | 2 | -12 | -19 |
| CP4A (2030) D | 19 | 5 | -3 | -15 | -21 |
| CP4A (2030) C | 12 | -2 | -6 | -19 | -29 |

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 11-39. Average Monthly Change in Water Surface Elevation for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4A Versus No-Action Alternative (2030)**

*Impact Aqua-2 (CP4 or CP4A): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction* This impact would be similar to Impact Aqua-2 (CP3). 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 reduce potential impacts and result in less-than-significant impacts.

This impact for CP4 would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

This impact for CP4A would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

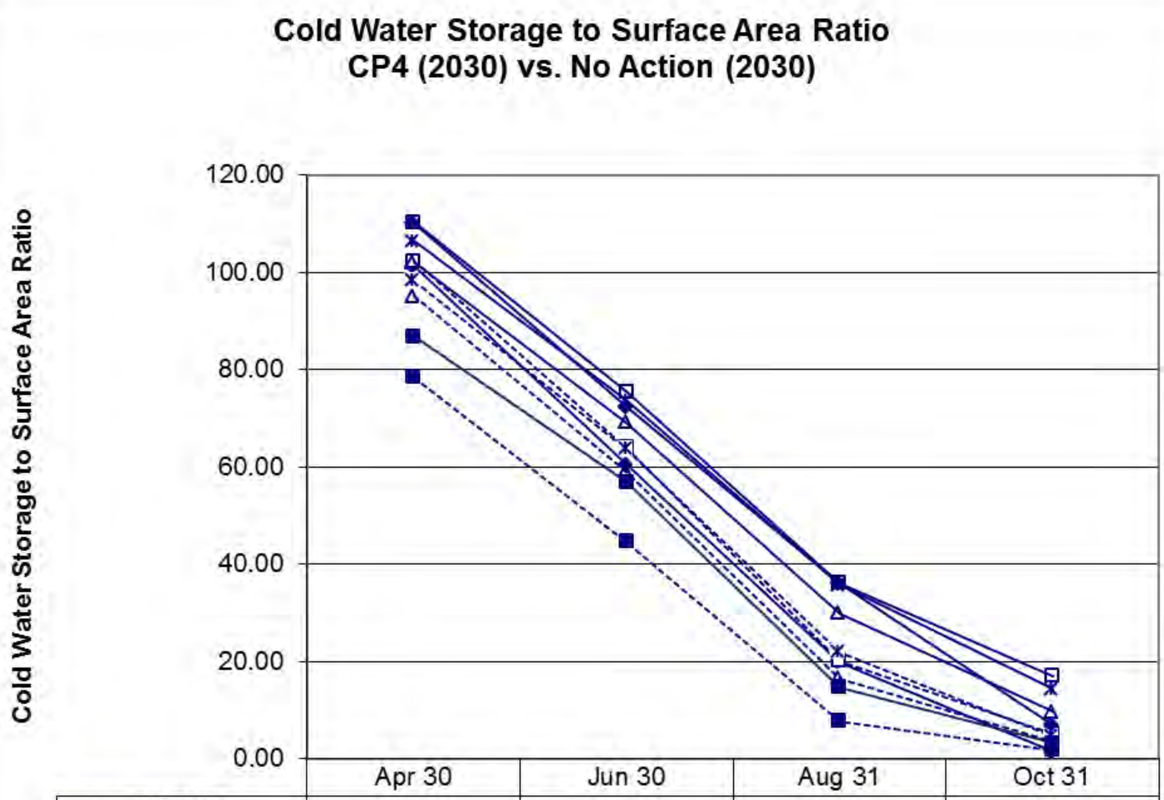
*Impact Aqua-3 (CP4 or CP4A): Effects on Cold-Water Habitat in Shasta Lake* Operations-related changes in the ratio of cold-water storage to surface area would increase the availability of suitable cold-water habitat in Shasta Lake. This impact would be beneficial for CP4 or CP4A.

This impact would be similar to Impacts Aqua-3 (CP1, CP2, and CP3) but would be of greater benefit to the reservoir cold-water fishery than Aqua-1 (CP3) owing to its focus on increasing the volume of cold water storage available to the TCD to benefit anadromous fish downstream from Shasta Dam.

CalSim-II modeling shows that under CP4 or CP4A, 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 (Figure 11-33 and Figures 11-34 and 11-35). The greatest projected increases over the No-Action Alternative occurred between June 30 and August 31, which is a critical rearing and oversummering period for cold-water fishes in reservoirs (Figure 11-40 and 11-41).

This impact would be beneficial for CP4. Mitigation for this impact is not needed, and thus not proposed.

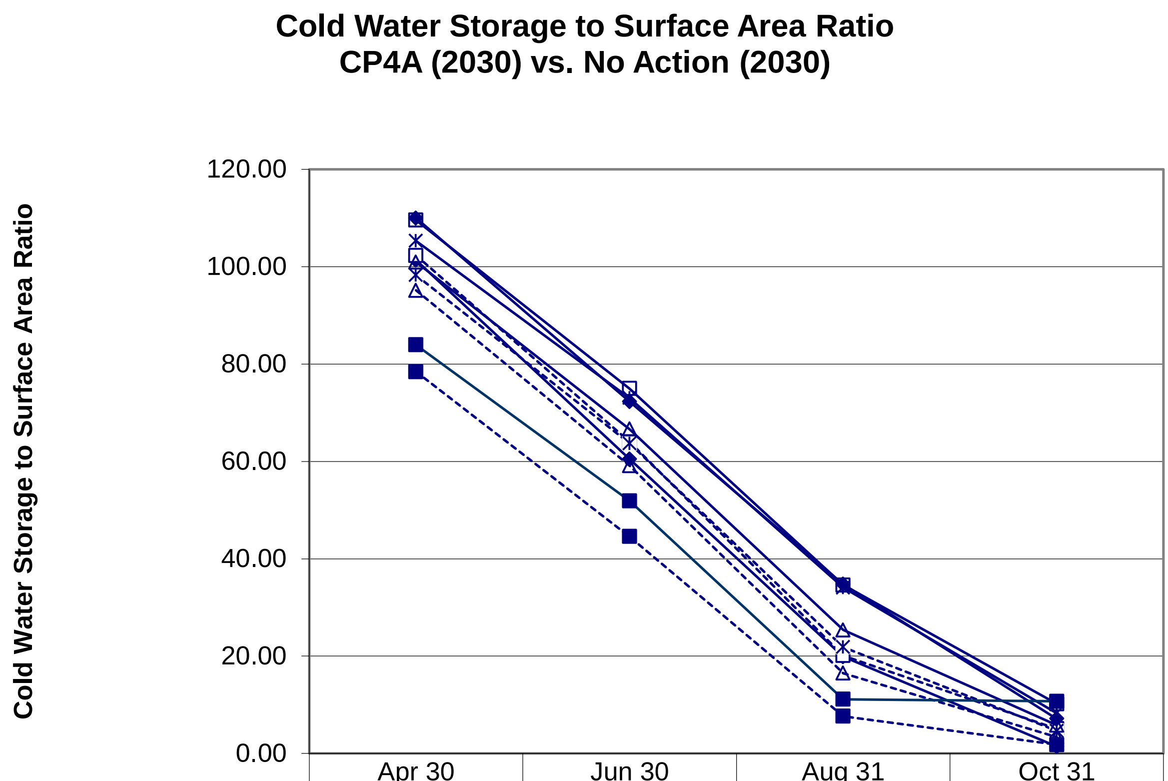
This impact would be beneficial for CP4A. Mitigation for this impact is not needed, and thus not proposed.




| | Apr 30 | Jun 30 | Aug 31 | Oct 31 |
|---|---|---|---|---|
| NA W | 101.33 | 60.49 | 19.89 | 1.43 |
| NA AN | 102.30 | 64.04 | 20.12 | 5.09 |
| NA BN | 98.27 | 63.71 | 21.84 | 4.64 |
| NA D | 95.13 | 59.14 | 16.50 | 3.38 |
| NA C | 78.43 | 44.58 | 7.66 | 1.82 |
| CP4 2030 W | 110.16 | 72.43 | 36.06 | 6.87 |
| CP4 2030 AN | 110.27 | 75.42 | 36.12 | 17.05 |
| CP4 2030 BN | 106.38 | 73.71 | 35.68 | 14.32 |
| CP4 2030 D | 102.04 | 69.13 | 29.86 | 9.68 |
| CP4 2030 C | 86.77 | 56.88 | 14.72 | 3.13 |

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 11-40. Average Monthly Cold-water Storage to Surface Area Ratio for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 Versus the No-Action Alternative (2030)**




| | Apr 30 | Jun 30 | Aug 31 | Oct 31 |
|---|---|---|---|---|
| NA W | 101.33 | 60.49 | 19.89 | 1.43 |
| NA AN | 102.30 | 64.04 | 20.12 | 5.09 |
| NA BN | 98.27 | 63.71 | 21.84 | 4.64 |
| NA D | 95.13 | 59.14 | 16.50 | 3.38 |
| NA C | 78.43 | 44.58 | 7.66 | 1.82 |
| CP4A 2030 W | 109.96 | 72.29 | 34.76 | 7.14 |
| CP4A 2030 AN | 109.55 | 74.97 | 34.60 | 10.22 |
| CP4A 2030 BN | 105.28 | 73.02 | 34.08 | 8.30 |
| CP4A 2030 D | 100.95 | 66.64 | 25.36 | 5.81 |
| CP4A 2030 C | 83.92 | 51.88 | 11.15 | 10.71 |

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 11-41. Average Monthly Cold-water Storage to Surface Area Ratio for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4A Versus the No-Action Alternative (2030)**

*Impact Aqua-4 (CP4 or CP4A): Effects on Special-Status Aquatic Mollusks* Under CP4 or CP4A, habitat for special-status mollusks could be inundated. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could adversely affect special-status aquatic mollusks that could occupy habitat in or near Shasta Lake and its tributaries. This impact would be similar to Aqua-4 (CP3).

Except for the California floater, the occurrence of special-status mollusks in Shasta Lake and the lower reaches of its tributaries is unlikely. Modification or loss of suitable habitat for California floater would occur through increased WSEL and seasonal fluctuations in the surface area under CP4 or CP4A. Therefore, this impact would be potentially significant for CP4 or CP4A. Mitigation for this impact would be the same for CP4 or CP4A and is included in Section 11.3.4, "Mitigation Measures."

*Impact Aqua-5 (CP4 or CP4A): Effects on Special-Status Fish Species* The expansion of the surface area of Shasta Lake and the inundation of additional tributary habitat (including inundation of fish passage barriers) under CP4 or CP4A would be similar to CP3 and could affect one species designated as sensitive by the USFS, the hardhead. Access to, and the availability of, suitable riverine habitat along all the main tributaries to the reservoir would not likely become any more limiting than under current conditions, nor would it greatly expand.

This impact would be less than significant for CP4. Mitigation for this impact is not needed, and thus not proposed.

This impact would be less than significant for CP4A. Mitigation for this impact is not needed, and thus not proposed.

*Impact Aqua-6 (CP4 or CP4A): Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake* Under CP4 or CP4A, 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. This impact would be less than significant.

Similar to CP3, implementation of CP4 or CP4A could have small localized beneficial effects for adfluvial cold-water fishes and provide access to warm-water fish species, with a potential to alter existing resident fish communities, which would primarily be limited to the newly inundated reaches of the new varial zone of some streams. Impacts would not be expected to be much greater than under existing conditions with implementation of environmental commitments to monitor and adaptively manage to prevent warm-water fish invasion of Squaw Creek (See Chapter 2, "Alternatives," for additional detailed descriptions of the environmental commitments).

This impact is considered to be less than significant for CP4. Mitigation for this impact is not needed, and thus not proposed.

This impact is considered to be less than significant for CP4A. Mitigation for this impact is not needed, and thus not proposed. *Impact Aqua-7 (CP4 or CP4A): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake* Similar to that described for CP3, CP4 or CP4A would result in additional periodic inundation of potentially suitable spawning and rearing habitat for adfluvial salmonids in the tributaries of 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 (estimated at 40,103 square feet for all tributaries) would be affected by CP4 or CP4A.

This impact would be potentially significant for CP4. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

This impact would be potentially significant for CP4A. Mitigation for this impact would be the same as that proposed for CP4, and is included in Section 11.3.4, "Mitigation Measures."

*Impact Aqua-8 (CP4 or CP4A): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake* Similar to CP3, CP4 or CP4A would result in periodic inundation of the lower reaches of intermittent high-gradient, non-fish-bearing intermittent tributaries to Shasta Lake. Twenty-four miles of non-fish-bearing tributary stream habitat (based on channel slope and confirmed by surveys of representative stream reaches) upstream from Shasta Lake could be affected by CP4 or CP4A, which is only about 1 percent of the total length of non-fish-bearing tributary habitat upstream from the lake. Field surveys suggest that few, if any, of the non-fish-bearing streams contain special-status invertebrate or vertebrate species that would be affected by increased connectivity to Shasta Lake.

This impact would be less than significant for CP4. Mitigation for this impact is not needed, and thus not proposed.

This impact would be less than significant for CP4A. Mitigation for this impact is not needed, and thus not proposed.

*Impact Aqua-9 (CP4 or CP4A): 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 or CP4A.

There would be no impact for CP4. Mitigation for this impact is not needed, and thus not proposed.

There would be no impact for CP4A. Mitigation for this impact is not needed, and thus not proposed.

### Upper Sacramento River (Shasta Dam to Red Bluff)

*Impact Aqua-10 (CP4 or CP4A): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities* Temporary construction-related increases in sediments and turbidity levels would adversely affect aquatic habitats and fish populations immediately downstream in the upper Sacramento River. However, environmental commitments would be in place to reduce the effects. This impact would be less than significant for CP4 or CP4A.

Construction activities for CP4 and CP4A are identical. The construction activities and potential borrow sources associated with CP4 or CP4A are described in Section 2.3.8 in Chapter 2, "Alternatives."

This impact would be similar to Impact Aqua-10 (CP1). The impact could be greater under CP4 or CP4A than under CP1 because of the increased activity associated with an 18.5-foot dam raise compared to a 6.5-foot dam raise. Also, CP4 and CP4A include implementation of a 10-year gravel augmentation program as an additional environmental commitment. Placing gravel along the Sacramento River channel and bank annually would release an additional source of fine sediment and expose it to the river and aquatic communities. However, the gravel augmentation activities would occur only during previously specified in-water work windows, which would minimize the potential for impacts associated with this activity.

CP4 and CP4A also include restoration of riparian, floodplain, and side-channel habitat in the upper Sacramento River at up to six potential restoration sites. Riparian, floodplain, and side-channel restoration at these sites 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.

The restoration actions and environmental commitments as proposed for either CP4 or CP4A are intended to reduce any potential negative effects.

This impact would be less than significant for CP4. Mitigation for this impact is not needed, and thus is not proposed.

This impact would be less than significant for CP4A. Mitigation for this impact is not needed, and thus is not proposed.

*Impact Aqua-11 (CP4 or CP4A): 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. Such exposure could adversely affect aquatic habitats, the aquatic food web, and fish populations, including special-status species, downstream in the primary study area. However, environmental commitments would be in place to reduce the effects. Therefore, this impact would be less than significant for CP4 or CP4A.

Construction activities for CP4 and CP4A are identical. The construction activities and potential borrow sources associated with CP4 or CP4A are described in Section 2.3.8 in Chapter 2, "Alternatives."

This impact would be similar to Impact Aqua-11 (CP1). The impact could be greater under CP4 or CP4A than under CP1 because of the increased activity associated with an 18.5-foot raise compared to a 6.5-foot raise. Additionally, as discussed above, CP4 and CP4A include implementation of 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 cause additional sources of equipment-related contaminants to be released and exposed to the river and aquatic communities. However, implementation of additional environmental commitments that call for in-water work windows and specific BMPs would minimize and/or avoid the potential for impacts associated with this activity. As under CP1, environmental commitments for all actions would be in place to reduce effects.

This impact would be less than significant for CP4. Mitigation for this impact is not needed, and thus not proposed.

This impact would be less than significant for CP4A. Mitigation for this impact is not needed, and thus not proposed.

*Impact Aqua-12 (CP4 or CP4A): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon and Steelhead* CP4 or CP4A operation would result in generally improved flow and water temperature conditions in the upper Sacramento River for Chinook salmon, steelhead and other native fishes. As well, the restoration actions proposed under CP4 would provide additional benefits to Chinook salmon and steelhead. This impact would be beneficial.

*Winter-Run Chinook Salmon*

Production

Overall average winter-run production for the 81-year period would be greater under CP4 conditions relative to the No-Action Alternative and Existing Condition (Attachments 3 and 4 of the Modeling Appendix). The maximum increase in simulated production relative to the No-Action Alternative was 369 percent (critical water year), while the largest decrease in production under CP4 relative to the No-Action Alternative was less than -7 percent (above-normal water year) (Table 11-41 and Attachment 3 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was around 392 percent in 1934 (critical water year) for CP4, while the largest decrease in production relative to the Existing Condition was less than -5 percent CP4 (Table 11-41 and Attachment 4 of the Modeling Appendix). Figure 11-9 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP4, five critical, one dry, and one wet water year had significant increases in production compared to the No-Action Alternative, while one above-normal water year had a significant decrease in production compared with the No-Action Alternative (Table 11-41 and Attachment 3 of the Modeling Appendix).

Under CP4, six critical and one dry water years had significant increases in production compared to the Existing Condition, while no water years had a significant decrease in production (Table 11-41 and Attachment 4 of the Modeling Appendix).

**Table 11-41. Change in Production Under CP4 for Winter-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 81 | 3,863,877 | 62,762 | 1.7 | 369 | 7 | -6.7 | 1 |
| **Critical** | 13 | 3,958,608 | 580,652 | 17.2 | 369 | 5 | -3.0 | 0 |
| **Dry** | 17 | 3,961,832 | -10,499 | -0.3 | 6.6 | 1 | -3.3 | 0 |
| **Below Normal** | 14 | 3,924,052 | -14,506 | -0.4 | 3.5 | 0 | -3.9 | 0 |
| **Above Normal** | 11 | 3,782,793 | -76,137 | -2.0 | 0.3 | 0 | -6.7 | 1 |
| **Wet** | 26 | 3,754,368 | -47,911 | -1.3 | 5.7 | 1 | -4.3 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 3,868,418 | 87,171 | 2.3 | 392 | 7 | -4.7 | 0 |
| **Critical** | 13 | 3,934,478 | 723,539 | 22.5 | 392 | 6 | -1.9 | 0 |
| **Dry** | 17 | 3,979,718 | -4,144 | -0.1 | 16.0 | 1 | -4.3 | 0 |
| **Below Normal** | 14 | 3,908,625 | -31,525 | -0.8 | 4.6 | 0 | -4.7 | 0 |
| **Above Normal** | 11 | 3,808,985 | -43,697 | -1.1 | 3.8 | 0 | -3.7 | 0 |
| **Wet** | 26 | 3,766,110 | -52,025 | -1.4 | 1.0 | 0 | -4.3 | 0 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:
CP = Comprehensive Plan

Under CP4A, overall average winter-run production for the 81-year period would be greater relative to the No-Action Alternative and Existing Condition (Attachments 3 and 4 of the Modeling Appendix). The maximum increase in simulated production relative to the No-Action Alternative was 255 percent (critical water year), while the largest decrease in production under CP4A relative to the No-Action Alternative was -5 percent (critical water year) (Table 11-42 and Attachment 3 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was around 258 percent (critical water year) for CP4A, while the largest decrease in production relative to the Existing Condition was less than -6 percent for CP4A (wet water year) (Table 11-42 and Attachment 4 of the Modeling Appendix). Figure 11-9 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP4A, four critical and one dry water year had significant increases in production compared to the No-Action Alternative, while one critical water year had a significant decrease in production compared with the No-Action Alternative (Table 11-42 and Attachment 3 of the Modeling Appendix).

Under CP4A, six critical and one dry water years had significant increases in production compared to the Existing Condition, while one wet water year had a significant decrease in production (Table 11-42 and Attachment 4 of the Modeling Appendix).

**Table 11-42. Change in Production Under CP4A for Winter-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 81 | 3,829,067 | 27,952 | 0.7 | 255.1 | 5 | -5.0 | 1 |
| **Critical** | 13 | 3,692,529 | 314,574 | 9.3 | 255.1 | 4 | -5.0 | 1 |
| **Dry** | 17 | 3,991,112 | 18,781 | 0.5 | 12.1 | 1 | -2.6 | 0 |
| **Below Normal** | 14 | 3,924,788 | -13,771 | -0.3 | 3.6 | 0 | -3.1 | 0 |
| **Above Normal** | 11 | 3,815,033 | -43,897 | -1.1 | 2.3 | 0 | -4.2 | 0 |
| **Wet** | 26 | 3,745,780 | -56,498 | -1.5 | 3.7 | 0 | -4.0 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 3,836,508 | 55,262 | 1.5 | 257.5 | 7 | -5.5 | 1 |
| **Critical** | 13 | 3,749,170 | 538,231 | 16.8 | 257.5 | 6 | -3.1 | 0 |
| **Dry** | 17 | 3,976,140 | -7,721 | -0.2 | 16.9 | 1 | -4.3 | 0 |
| **Below Normal** | 14 | 3,930,274 | -9,876 | -0.3 | 3.6 | 0 | -3.2 | 0 |
| **Above Normal** | 11 | 3,804,642 | -48,040 | -1.2 | 3.7 | 0 | -4.0 | 0 |
| **Wet** | 26 | 3,751,872 | -66,263 | -1.7 | 1.1 | 0 | -5.5 | 1 |

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:
CP = Comprehensive Plan

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on winter-run Chinook salmon caused by the actions of the project (Attachments 3 and 4 of the Modeling Appendix). Nonoperations-related mortality is the base and seasonal mortality that would occur even without the effects of Shasta operations (such as disease, predation, and entrainment). Flow- and water temperature-related mortality is that caused by altering flow and water temperatures. In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 89 percent of the total mortality under CP4 and around 88 percent of the total mortality under CP4A.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 3 and 4 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest average mortality to winter-run Chinook salmon under CP4 and CP4A (as with CP1 through CP3)  in all water year types, based on smolt equivalents, would occur to fry, followed by eggs, presmolts, immature smolts, and prespawn adults. Table 11-5 displays the overall mortalities for each Comprehensive Plan that would be caused by changes in water temperature and flow (see also Attachments 3 and 4 of the Modeling Appendix). Under CP4, years with the highest mortality were different between CP4, No-Action Alternative and Existing Conditions and included critical, dry and wet water year types. These years with highest mortality were preceded by three critical, and three dry water years. Years with the lowest mortality varied between all water year types (Attachments 3 and 4).

Under CP4A, years with the highest mortality were different between CP4A, No-Action Alternative and Existing Conditions and included critical, dry and wet water year types. These years with highest mortality were preceded by three critical, and three dry water years. Years with the lowest mortality varied between all water year types (Attachments 3 and 4).

Under CP4, winter-run Chinook salmon would have, overall, a significant reduction in project-related mortality relative to the No-Action Alternative and Existing Condition. Winter-run Chinook salmon would have an overall insignificant increase in production, but a significant increase in production during critical water years–those years in which they are at greatest risk. Therefore, 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 downstream restoration program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Under CP4A, winter-run Chinook salmon would have, overall, a significant reduction in project-related mortality relative to the No-Action Alternative (6 percent and the Existing Conditions. Winter-run Chinook salmon would have an overall insignificant increase in production, but a significant increase in production during critical water years–those years in which they are at greatest risk. Therefore, winter-run Chinook salmon would benefit from water temperature and flow conditions under in CP4A. Additionally, winter-run Chinook salmon will benefit from the downstream restoration program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

*Spring-Run Chinook Salmon*

Production

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 6 and 7 of the Modeling Appendix). The maximum increase in simulated production relative to the No-Action Alternative was 6,006 percent for CP4 (critical water year). The largest decrease in production relative to the No-Action Alternative was -8 percent for CP4 (wet water year) (Table 11-43 and Attachment 6 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 5,516 percent for CP4 (critical water year). The largest decrease in production relative to the Existing Condition was -8.5 percent for CP4 (wet water year) (Table 11-43 and Attachment 7 of the Modeling Appendix). Figure 11-10 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP4, 12 critical, two dry, one below-normal, and one above-normal water years had significant increases in production compared to the No-Action Alternative. One each dry, below-normal and wet water years had significant decreases in production (Table 11-43 and Attachment 6 of the Modeling Appendix).

Under CP4, 12 critical, one dry, and one below-normal water years had significant increases in production compared to the Existing Condition. Two wet water years had significant decreases in production (Table 11-43and Attachment 7 of the Modeling Appendix).

**Table 11-43. Change in Production Under CP4 for Spring-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 81 | 169,926 | 5,871 | 3.6 | 6006 | 16 | -8.1 | 3 |
| **Critical** | 13 | 116,448 | 35,259 | 43.4 | 6006 | 12 | 0.4 | 0 |
| **Dry** | 17 | 178,300 | 8,848 | 5.2 | 1844 | 2 | -5.2 | 1 |
| **Below Normal** | 14 | 178,039 | 859 | 0.5 | 36.3 | 1 | -5.3 | 1 |
| **Above Normal** | 11 | 181,294 | -2,472 | -1.3 | 5.5 | 1 | -4.6 | 0 |
| **Wet** | 26 | 182,011 | -4,539 | -2.4 | 0.5 | 0 | -8.1 | 1 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 170,326 | 7,119 | 4.4 | 5516 | 16 | -8.5 | 2 |
| **Critical** | 13 | 116,199 | 42,136 | 56.9 | 5516 | 12 | 4.9 | 0 |
| **Dry** | 17 | 179,369 | 10,508 | 6.2 | 2485 | 3 | -4.9 | 0 |
| **Below Normal** | 14 | 179,032 | 1,002 | 0.6 | 34.4 | 1 | -3.9 | 0 |
| **Above Normal** | 11 | 180,906 | -3,208 | -1.7 | 3.3 | 0 | -4.7 | 0 |
| **Wet** | 26 | 182,314 | -4,944 | -2.6 | 0.5 | 0 | -8.5 | 2 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:

CP = Comprehensive Plan

Overall average spring-run Chinook salmon production increased for the 82-year period under CP4A compared to the No-Action Alternative and the Existing Condition (Attachments 6 and 7 of the Modeling Appendix). The maximum increase in simulated production relative to the No-Action Alternative was 1,480 percent for CP4A (critical water year), while the largest decrease in production relative to the No-Action Alternative was -5 percent for CP4A (wet water year) (Table 11-44 and Attachment 6 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 2,258 percent for CP4A (dry water year), while the largest decrease in production relative to the Existing Condition was -8.3 percent for CP4A (wet water year) (Table 11-44 and Attachment 7 of the Modeling Appendix). Figure 11-10 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP4A, 12 critical, three dry, one below-normal, and one above-normal water years had significant increases in production compared to the No-Action Alternative. Two wet water years had significant decreases in production (Table 11-44 and Attachment 6 of the Modeling Appendix).

Under CP4A, 12 critical, three dry, and one below-normal water years had significant increases in production compared to the Existing Condition. Two wet water years had significant decreases in production (Table 11-44 and Attachment 7 of the Modeling Appendix).

**Table 11-44. Change in Production Under CP4A for Spring-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 81 | 168,055 | 4,000 | 2.4 | 1,480.1 | 17 | -5.2 | 2 |
| **Critical** | 13 | 104,764 | 23,575 | 29.0 | 672.6 | 12 | 4.9 | 0 |
| **Dry** | 17 | 177,719 | 8,267 | 4.9 | 1,480.1 | 3 | -3.9 | 0 |
| **Below Normal** | 14 | 177,251 | 71 | 0.0 | 25.3 | 1 | -3.9 | 0 |
| **Above Normal** | 11 | 181,171 | -2,595 | -1.4 | 5.4 | 1 | -4.2 | 0 |
| **Wet** | 26 | 182,879 | -3,672 | -2.0 | 1.2 | 0 | -5.2 | 2 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 168,752 | 5,544 | 3.4 | 2,258.4 | 16 | -8.3 | 2 |
| **Critical** | 13 | 106,842 | 32,779 | 44.3 | 1,412.9 | 12 | 4.2 | 0 |
| **Dry** | 17 | 179,095 | 10,234 | 6.1 | 2,258.4 | 3 | -3.3 | 0 |
| **Below Normal** | 14 | 178,145 | 115 | 0.1 | 30.3 | 1 | -3.4 | 0 |
| **Above Normal** | 11 | 180,926 | -3,188 | -1.7 | 3.2 | 0 | -4.3 | 0 |
| **Wet** | 26 | 182,736 | -4,522 | -2.4 | 1.5 | 0 | -8.3 | 2 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:

CP = Comprehensive Plan

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on spring-run Chinook salmon caused by the actions of the project (Attachments 6 and 7). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)‒around 89 percent of the total mortality under CP4 and 87 percent of the total mortality under CP4A.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 6 and 7 of the Modeling Appendix). Under both the 2030 and 2005 conditions, the greatest mortality to spring-run Chinook salmon under CP4 and CP4A (as with CP1 through CP3) in all water year types based on smolt equivalents, occurred to eggs, with minimal mortality to the other life stages. Table 11-7 displays the smolt-equivalent mortalities for each Comprehensive Plan that are caused by flow- and water-related factors (also see Attachments 6 and 7 of the Modeling Appendix).

Years with the highest operations-related mortality were different for CP4 and CP4A compared with No-Action Alternative and Existing Conditions with fewer years with high mortality. All years with the highest mortality were preceded by either a critical or dry water year. Years with the lowest mortality varied between all water year types (Attachments 6 and 7 of the Modeling Appendix).

Spring-run Chinook salmon would have significantly reduced flow- and water temperature-related mortality under CP4 and CP4A, but an insignificant increase in overall production. However, they would experience a significant increase in production during almost all critical water years, and a significant increase in average production during critical years, under CP4 and CP4A. Therefore, spring-run Chinook salmon would benefit from actions taken in CP4 and CP4A. Additionally, spring-run Chinook salmon will benefit from the downstream restoration program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

*Fall-Run Chinook Salmon*

Production

Overall average fall-run Chinook salmon production under CP4 increased for the 81-year period compared with the No-Action Alternative and Existing Condition (Attachments 9 and 10 of the Modeling Appendix). The maximum increase in simulated production relative to the No-Action Alternative was 617 percent (critical water year), while the largest decrease in production relative to the No-Action Alternative was -6.5 percent (wet water year) (Table 11-45 and Attachment 9 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 656 percent (critical water year). The largest decrease in production relative to the Existing Condition was -6.7 percent (wet water year) (Table 11-45 and Attachment 10 of the Modeling

Appendix). Figure 11-11 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP4, five critical, three dry, and one above-normal water years had significant increases in production relative to the No-Action Alternative. Significant reductions in production occurred in two dry, one below-normal, and three wet water years (Table 11-45 and Attachment 9 of the Modeling Appendix).

Under CP4, five critical, three dry, and two below-normal water years had significant increases in production relative to the Existing Condition. One dry, one below-normal, and two wet water years resulted in significant decreases in production relative to the Existing Condition (Table 11-45 and Attachment 10 of the Modeling Appendix).

**Table 11-45. Change in Production Under CP4 for Fall-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **No-Action Alternative** | | | | | | | | |
| **All** | 81 | 30,134,465 | 616,059 | 2.1 | 617 | 9 | -6.5 | 6 |
| **Critical** | 13 | 31,842,200 | 5,397,372 | 20.4 | 617 | 5 | -3.0 | 0 |
| **Dry** | 17 | 29,597,381 | 57,220 | 0.2 | 20.2 | 3 | -5.7 | 2 |
| **Below Normal** | 14 | 30,794,778 | -303,133 | -1.0 | 15.8 | 1 | -5.9 | 1 |
| **Above Normal** | 11 | 30,633,357 | -399,653 | -1.3 | 3.6 | 0 | -4.1 | 0 |
| **Wet** | 26 | 29,065,145 | -484,530 | -1.6 | 2.5 | 0 | -6.5 | 3 |
| **Existing Conditions** | | | | | | | | |
| **All** | 81 | 30,309,575 | 881,234 | 3.0 | 656 | 10 | -6.7 | 5 |
| **Critical** | 13 | 32,618,696 | 6,442,560 | 24.6 | 656 | 5 | -0.3 | 0 |
| **Dry** | 17 | 29,773,255 | 312,854 | 1.1 | 35.8 | 3 | -5.4 | 1 |
| **Below Normal** | 14 | 30,960,930 | -57,332 | -0.2 | 25.2 | 2 | -5.1 | 1 |
| **Above Normal** | 11 | 30,419,848 | -450,549 | -1.5 | 1.9 | 0 | -4.0 | 0 |
| **Wet** | 26 | 29,108,303 | -458,967 | -1.6 | 4.4 | 0 | -6.7 | 3 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:
CP = Comprehensive Plan

Overall average fall-run Chinook salmon production under CP4A increased for the 81-year period compared with the No-Action Alternative and Existing Condition (Attachments 9 and 10 of the Modeling Appendix). The maximum increase in simulated production relative to the No-Action Alternative was 75 percent (critical water year). The largest decrease in production relative to the No-Action Alternative was -6.4 percent (wet water year) (Table 11-46 and Attachment 9 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 148 percent (critical water year). The largest decrease in production relative to the Existing Condition was -6.7 percent (wet water year) (Table 11-46 and Attachment 10 of the Modeling Appendix). Figure 11-11 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP4A, six critical, three dry, and two below-normal water years had significant increases in production relative to the No-Action Alternative. Significant reductions in production occurred in one below-normal and one wet water years (Table 11-46 and Attachment 9 of the Modeling Appendix).

Under CP4A, six critical, four dry, one below-normal, and one wet water years had significant increases in production relative to the Existing Condition. Significant reductions in production occurred in one wet water year (Table 11-46 and Attachment 10 of the Modeling Appendix).

**Table 11-46. Change in Production Under CP4A for Fall-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **No-Action Alternative** | | | | | | | | |
| **All** | 81 | 30,109,242 | 590,836 | 2.0 | 75.5 | 11 | -6.4 | 2 |
| **Critical** | 13 | 29,789,070 | 3,344,242 | 12.6 | 75.5 | 6 | 0.4 | 0 |
| **Dry** | 17 | 30,223,299 | 683,138 | 2.3 | 21.7 | 3 | -4.1 | 0 |
| **Below Normal** | 14 | 31,239,907 | 141,996 | 0.5 | 22.1 | 2 | -5.3 | 1 |
| **Above Normal** | 11 | 30,736,255 | -296,755 | -1.0 | 4.0 | 0 | -3.8 | 0 |
| **Wet** | 26 | 29,320,660 | -229,016 | -0.8 | 4.6 | 0 | -6.4 | 1 |
| **Existing Conditions** | | | | | | | | |
| **All** | 81 | 30,072,774 | 644,433 | 2.2 | 148.2 | 12 | -6.7 | 1 |
| **Critical** | 13 | 30,021,716 | 3,845,580 | 14.7 | 148.2 | 6 | -1.7 | 0 |
| **Dry** | 17 | 30,024,883 | 564,482 | 1.9 | 35.1 | 4 | -3.6 | 0 |
| **Below Normal** | 14 | 31,215,490 | 197,228 | 0.6 | 37.5 | 1 | -4.1 | 0 |
| **Above Normal** | 11 | 30,663,690 | -206,707 | -0.7 | 1.5 | 0 | -4.4 | 0 |
| **Wet** | 26 | 29,264,305 | -302,965 | -1.0 | 5.7 | 1 | -6.7 | 1 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:

CP = Comprehensive Plan

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on fall-run Chinook salmon caused by the actions of the project (Attachments 9 and 10). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)‒around 66 percent of the total mortality under CP4 and around 65 percent of the total mortality under CP4A.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 9 and 10 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality based on the smolt equivalents to fall-run Chinook salmon under CP4 and CP4A (as with CP1 through CP3) in all water year types based on smolt equivalents occurred to fry, followed by eggs, prespawn adults, presmolts, and lastly to immature smolts. Flow-related effects triggered a higher percentage of the operations-related mortality (Table 11-9). In all water year types, the greatest portion of mortality under CP4 and CP4A occurred to fry caused by forced movement to downstream habitats. Other non-flow- and water temperature-related conditions were the primary causes of mortality for all life stages except fry (Attachments 9 and 10 in the Modeling Appendix).

There was no real trend with respect to years with the greatest mortality.

Fall-run Chinook salmon would have significantly reduced project-related mortality, but an insignificant increase in overall production However, fall-run Chinook salmon would experience a significant overall average increase in production during critical water years under CP4 and CP4A. Therefore, fall-run Chinook salmon would benefit from actions taken in CP4 and CP4A. Additionally, fall-run Chinook salmon will benefit from the downstream restoration program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

*Late Fall-Run Chinook Salmon and Steelhead*

Late fall-run Chinook salmon were evaluated directly using SALMOD and were considered to be a surrogate for steelhead; therefore, the following discussion regarding SALMOD results for late fall-run Chinook salmon are applicable to steelhead.

Production

Overall average late fall-run Chinook salmon production for the 80-year period under CP4 conditions was slightly greater than the No-Action Alternative and the Existing Condition (Attachments 12 and 13 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 23 percent (critical water year), while there were no significant decreases in production relative to the No-Action Alternative (Table 11-47 and Attachment 12 of the Modeling Appendix). The maximum increase in production relative to Existing Conditions was 27 percent (critical water year), there were no significant decreases in production relative to Existing Conditions (Table 11-47 and Attachment 13 of the Modeling Appendix). Figure 11-12 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP4, six critical and five dry water years had significant increases in production compared to the No-Action Alternative. Significant reductions in production did not occur in any years (Table 11-47 and Attachment 12 of the Modeling Appendix).

Under CP4, four critical, four dry, one below-normal, and two wet water years had significant increases in production compared to the Existing Condition. Significant reductions in production did not occur in any years (Table 11-47 and Attachment 13 of the Modeling Appendix).

**Table 11-47. Change in Production Under CP4 for Late Fall-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 80 | 7,546,347 | 127,861 | 1.7 | 23.0 | 11 | -4.7 | 0 |
| **Critical** | 13 | 7,382,128 | 317,959 | 4.5 | 23.0 | 6 | -1.8 | 0 |
| **Dry** | 16 | 7,577,473 | 223,104 | 3.0 | 13.5 | 5 | -1.7 | 0 |
| **Below Normal** | 14 | 7,671,893 | 59,275 | 0.8 | 3.8 | 0 | -1.4 | 0 |
| **Above Normal** | 11 | 7,658,120 | 72,036 | 0.9 | 3.8 | 0 | -1.7 | 0 |
| **Wet** | 26 | 7,494,413 | 34,749 | 0.5 | 4.4 | 0 | -4.7 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 80 | 7,539,887 | 153,326 | 2.1 | 27.0 | 11 | -3.5 | 0 |
| **Critical** | 13 | 7,333,049 | 369,753 | 5.3 | 27.0 | 4 | -2.6 | 0 |
| **Dry** | 16 | 7,587,721 | 227,453 | 3.1 | 15.8 | 4 | -3.3 | 0 |
| **Below Normal** | 14 | 7,652,128 | 41,034 | 0.5 | 5.9 | 1 | -3.5 | 0 |
| **Above Normal** | 11 | 7,649,290 | 89,617 | 1.2 | 4.6 | 0 | -1.4 | 0 |
| **Wet** | 26 | 7,507,147 | 86,915 | 1.2 | 6.7 | 2 | -2.1 | 0 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Late fall-run Chinook salmon are used as a surrogate for steelhead

Key:

CP = Comprehensive Plan

Overall average late fall-run Chinook salmon production for the 80-year period under CP4A conditions was slightly greater than the No-Action Alternative and the Existing Condition (Attachments 12 and 13 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 15 percent (dry water year), while there were no significant decreases in production relative to the No-Action Alternative (Table 11-48 and Attachment 12 of the Modeling Appendix). The maximum increase in production relative to Existing Conditions was 19 percent (dry water year), while the maximum decrease in production relative to Existing Condition was -6.3 percent (dry water year) (Table 11-48 and Attachment 12 of the Modeling Appendix). Figure 11-12 shows the change in production for CP4A relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP4A, three critical and four dry water years had significant increases in production compared to the No-Action Alternative. Significant reductions in production did not occur in any years (Table 11-48 and Attachment 12 of the Modeling Appendix).

Under CP4A, four critical, three dry, one below-normal, and two wet water years had significant increases in production compared to the Existing Condition. A significant reduction in production occurred in one dry water year (Table 11-48 and Attachment 13 of the Modeling Appendix).

**Table 11-48. Change in Production Under CP4A for Late Fall-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 80 | 7,505,702 | 87,215 | 1.2 | 15.4 | 7 | -3.6 | 0 |
| **Critical** | 13 | 7,198,719 | 134,550 | 1.9 | 12.0 | 3 | -2.3 | 0 |
| **Dry** | 16 | 7,544,632 | 190,263 | 2.6 | 15.4 | 4 | -3.6 | 0 |
| **Below Normal** | 14 | 7,605,476 | -7,142 | -0.1 | 2.1 | 0 | -2.6 | 0 |
| **Above Normal** | 11 | 7,667,964 | 81,880 | 1.1 | 2.6 | 0 | -0.8 | 0 |
| **Wet** | 26 | 7,512,863 | 53,199 | 0.7 | 4.3 | 0 | -3.2 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 80 | 7,495,910 | 109,349 | 1.5 | 18.5 | 10 | -6.3 | 1 |
| **Critical** | 13 | 7,216,641 | 253,345 | 3.6 | 14.5 | 4 | -3.4 | 0 |
| **Dry** | 16 | 7,566,038 | 205,770 | 2.8 | 18.5 | 3 | -6.3 | 1 |
| **Below Normal** | 14 | 7,605,024 | -6,070 | -0.1 | 6.3 | 1 | -4.9 | 0 |
| **Above Normal** | 11 | 7,597,778 | 38,105 | 0.5 | 2.3 | 0 | -3.0 | 0 |
| **Wet** | 26 | 7,490,537 | 70,305 | 0.9 | 7.1 | 2 | -4.1 | 0 |

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant
Late fall-run Chinook salmon are used as a surrogate for steelhead

Key:
CP = Comprehensive Plan

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on late fall-run Chinook salmon caused by the actions of the project (Attachments 12 and 13). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 79 percent of the total mortality under both CP4 and CP4A.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 12 and 13 of the Modeling Appendix). Under both 2030 and 2005 conditions, the largest mortality to late fall-run Chinook salmon under CP4 and CP4A (as with CP1 through CP3) in all water year types based on smolt equivalents, occurred to the egg life stage, followed by fry, then presmolts, and lastly to immature smolts. Most mortality occurred as a result of flow conditions rather than water temperature (Table 11-11).

Years with the highest mortality were the same for CP4 and CP4A and the No-Action Alternative and the Existing Condition, and occurred in all water year types. Four of these years were preceded by a wet water year, and the rest were each preceded by an above-normal, below-normal or dry water year (Attachments 12 and 13 of the Modeling Appendix).

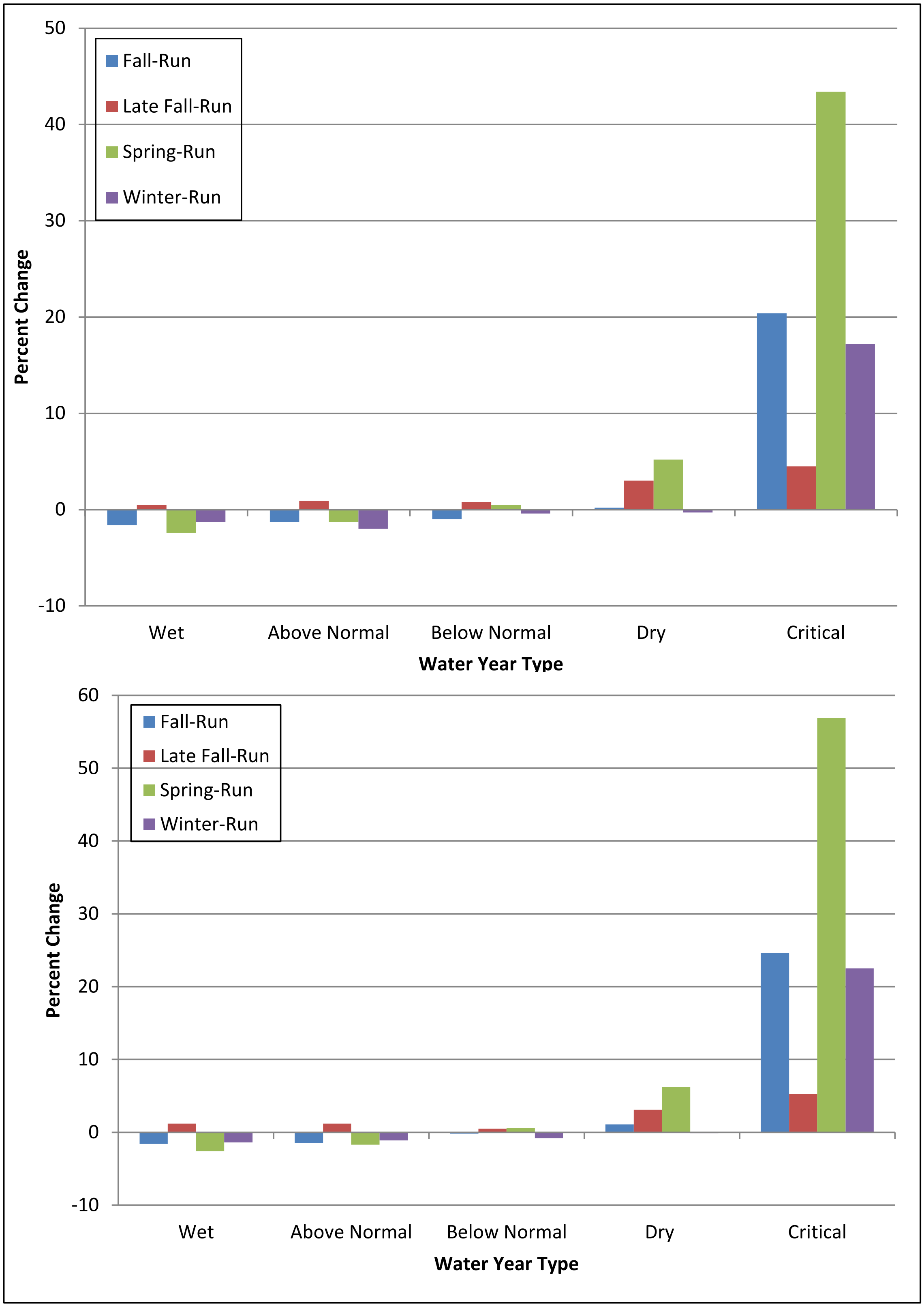
Because SALMOD indicates an insignificant change in mortality and production index for late fall-run Chinook salmon, late fall-run Chinook salmon and steelhead (as represented by their surrogate late fall-run Chinook salmon) would experience less-than-significant impacts from actions taken in CP4 and CP4A. Additionally, late fall-run Chinook salmon and steelhead would benefit from the downstream restoration program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

*All Chinook Runs Combined*

As with CP3, the raise for both CP4 and CP4A would increase the full pool depth by 20.5 feet and enlarge total reservoir storage capacity by 634,000 acre-feet. The additional storage created by the dam raise would be used to improve the ability to meet water temperature objectives and habitat requirements for anadromous fish during drought years (Figures 11-42 and 11-43) and increase water supply reliability. Of the increased reservoir storage space, about 378,000 acre-feet would be dedicated to increasing the supply of cold water for anadromous fish survival in CP4; 191,000 acre-feet would be dedicated in CP4A.

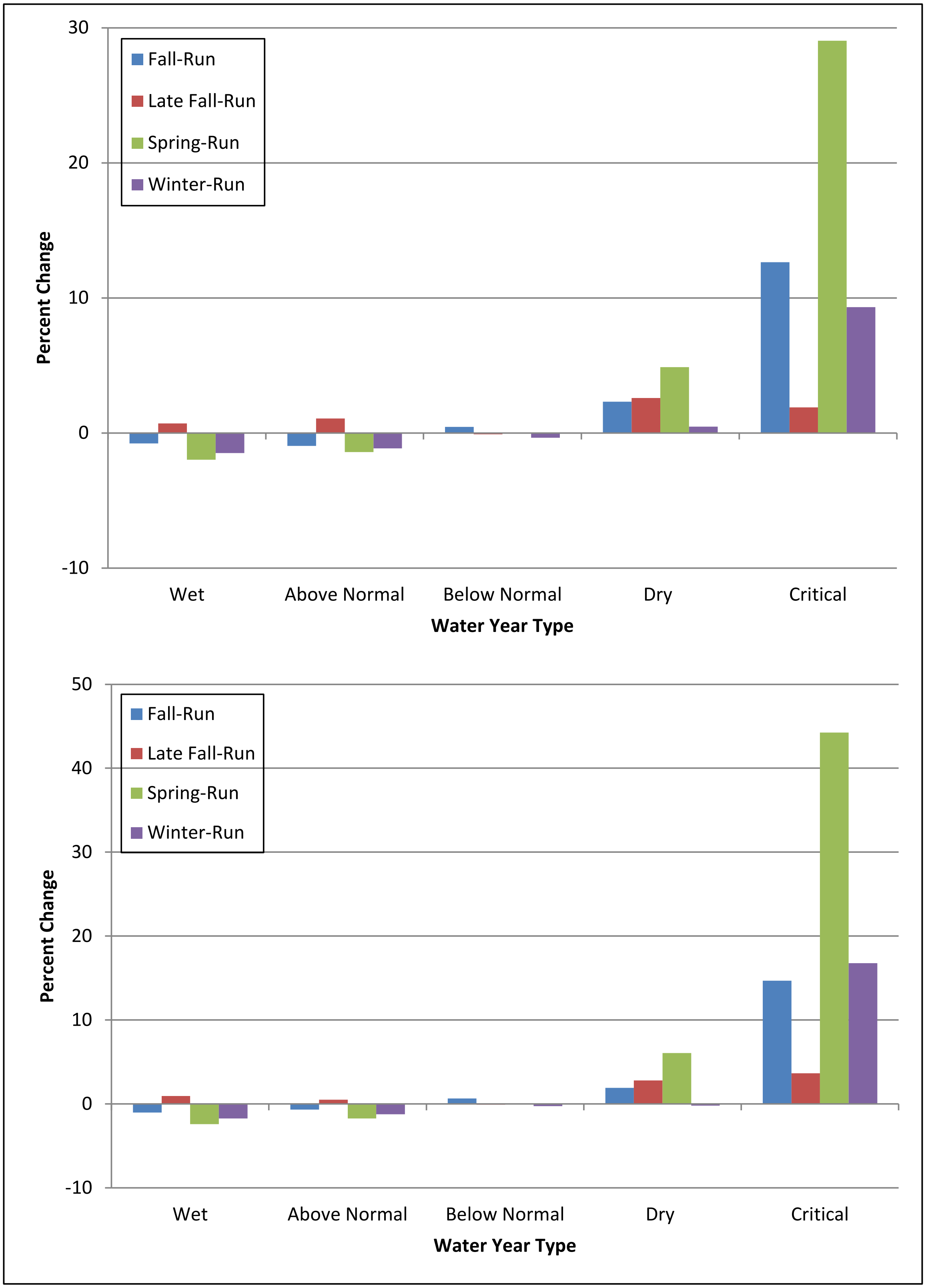
Under CP4 for the 2030 conditions, overall production for all four runs of Chinook salmon combined would increase by nearly 813,000 immature smolts migrating below RDPP. Under the CP4 2005 conditions, overall production for all four runs of Chinook salmon combined would increase by almost 1,129,000 immature smolts migrating below RDPP.

Under CP4A for the 2030 conditions, overall production for all four runs of Chinook salmon combined would increase by over 710,000 immature smolts migrating below RDPP. Under the CP4A 2005 conditions, overall production for all four runs of Chinook salmon combined would increase by almost 815,000 immature smolts migrating below RDPP.




Note: Changes in outmigrating Chinook salmon simulated using SALMOD; Water Year Types based on the Sacramento Valley Water Year Hydrologic Classification

**Figure 11-42. Percent Change in Production of Chinook Salmon for CP4 Compared to the No-Action Alternative (top) and Existing Conditions (bottom)**




Note: Changes in outmigrating Chinook salmon simulated using SALMOD; Water Year Types Based on the Sacramento Valley Water Year Hydrologic Classification

**Figure 11-43. Percent Change in Production of Chinook Salmon for CP4A Compared to the No-Action Alternative and Existing Conditions**

*Impact Aqua-13 (CP4 or CP4A): 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* CP4 and CP4A operations generally 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. Overall, potential flow changes resulting from the implementation of CP4 or CP4A would not be of sufficient frequency or magnitude to beneficially or adversely affect these species. However, potential water temperature changes (reductions) resulting from the implementation of CP4 or CP4A would result in beneficial effects on steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass in the 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 for both CP4 and CP4A. The benefits of the water temperature decrease outweigh the minimal effects of flow changes. Therefore, this impact would be beneficial for both CP4 and CP4A.

For CP4, this impact would be similar to Impact Aqua-13 (CP1). However, during certain years, the impact could be greater (beneficial) under CP4 than under CP1 because of the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise, and because of the additional volume of cold water that would be available for anadromous fish.

For CP4A, this impact would be similar to Impact Aqua-13 (CP2). However, during certain years, the impact could be greater (beneficial) under CP4A than under CP2 because of the increased reservoir capacity associated with an 18.5-foot raise compared to a 12.5-foot raise, and because of the additional volume of cold water that would be available for anadromous fish.

*Flow-Related Effects* As under CP1, monthly mean flows at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBPP) under CP4 would be similar to (generally less than 4-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for all months. (See the Modeling Appendix for complete modeling results.)

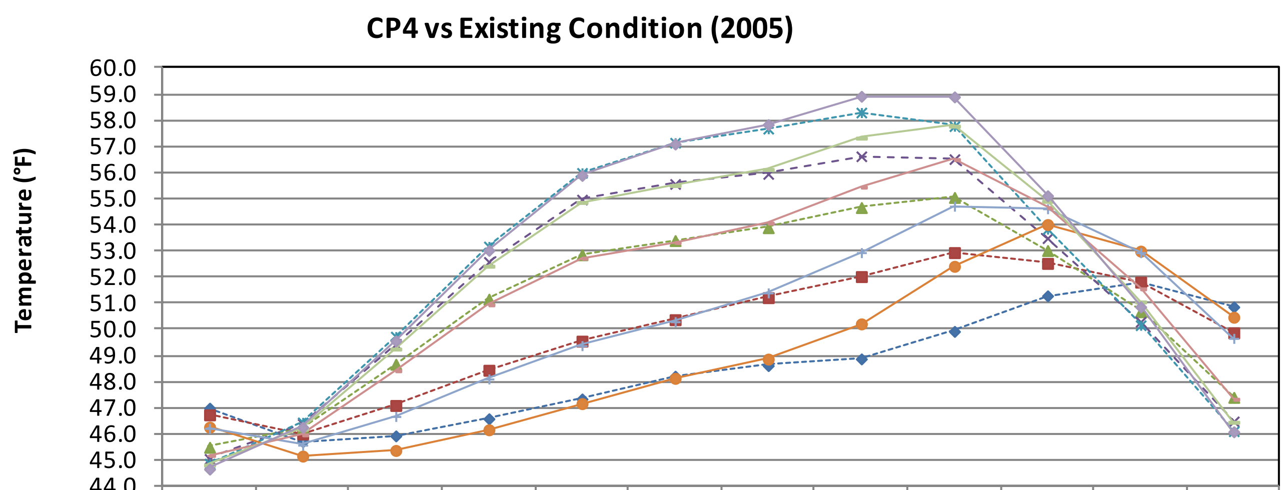
As under CP2, monthly mean flows at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBPP) under CP4A would be similar to (generally less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for all months. (See the Modeling Appendix for complete modeling results.)

Potential flow-related effects of CP4 or CP4A on fish species of management concern in the upper Sacramento River would be minimal. Potential changes in flows and stages would diminish rapidly downstream from RBPP because of increased effects from tributary inflows, diversions, and flood bypasses.

Changes in monthly mean flows under CP4 or CP4A relative to the Existing Condition and No-Action Alternative would have no discernible effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for these species would be unchanged. Therefore, flow-related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

*Water Temperature–Related Effects* Changes in monthly mean water temperatures at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, Balls Ferry, above Bend Bridge, and above RBPP) under CP4 would change fractionally when compared to water temperatures under the Existing Condition and No-Action Alternative for all months simulated (Figures 11-44 and 11-45; see the Modeling Appendix for complete modeling results).

Monthly mean water temperatures at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, Balls Ferry, above Bend Bridge, and above RBPP) under CP4A would change fractionally when compared to water temperatures under the Existing Condition and No-Action Alternative for all months simulated (Figures 11-46 and 11-47; see the Modeling Appendix for complete modeling results).

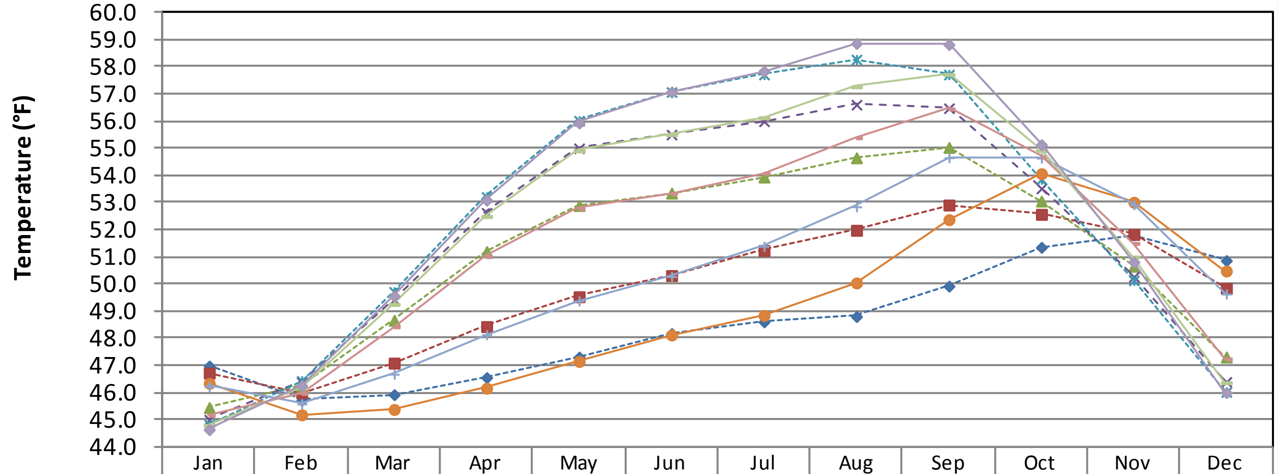



| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP4 Below Shasta | 47.0 | 45.7 | 45.9 | 46.6 | 47.3 | 48.2 | 48.6 | 48.9 | 49.9 | 51.3 | 51.8 | 50.9 |
| CP4 Below Keswick | 46.7 | 46.0 | 47.1 | 48.4 | 49.6 | 50.4 | 51.2 | 52.0 | 52.9 | 52.5 | 51.8 | 49.9 |
| CP4 Balls Ferry | 45.5 | 46.2 | 48.7 | 51.2 | 52.9 | 53.4 | 53.9 | 54.7 | 55.1 | 53.0 | 50.7 | 47.4 |
| CP4 Bend Bridge | 45.1 | 46.4 | 49.4 | 52.6 | 55.0 | 55.6 | 56.0 | 56.6 | 56.5 | 53.5 | 50.3 | 46.5 |
| CP4 RBPP | 44.9 | 46.4 | 49.7 | 53.2 | 56.0 | 57.1 | 57.7 | 58.3 | 57.8 | 53.8 | 50.2 | 46.1 |
| EC Below Shasta | 46.3 | 45.2 | 45.4 | 46.2 | 47.2 | 48.1 | 48.9 | 50.2 | 52.4 | 54.0 | 53.0 | 50.5 |
| EC Below Keswick | 46.2 | 45.6 | 46.7 | 48.1 | 49.4 | 50.3 | 51.4 | 52.9 | 54.7 | 54.6 | 52.9 | 49.7 |
| EC Balls Ferry | 45.2 | 46.0 | 48.4 | 50.9 | 52.7 | 53.3 | 54.1 | 55.4 | 56.5 | 54.7 | 51.6 | 47.3 |
| EC Bend Bridge | 44.8 | 46.2 | 49.3 | 52.4 | 54.9 | 55.5 | 56.1 | 57.3 | 57.8 | 54.9 | 51.1 | 46.5 |
| EC RBPP | 44.7 | 46.3 | 49.6 | 53.0 | 55.9 | 57.1 | 57.8 | 58.9 | 58.9 | 55.1 | 50.9 | 46.1 |

Key: °F = degrees Fahrenheit    EC = Existing Condition
CP = Comprehensive Plan    RBPP = Red Bluff Pumping Plant

**Figure 11-44. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP4 Versus Existing Condition)**

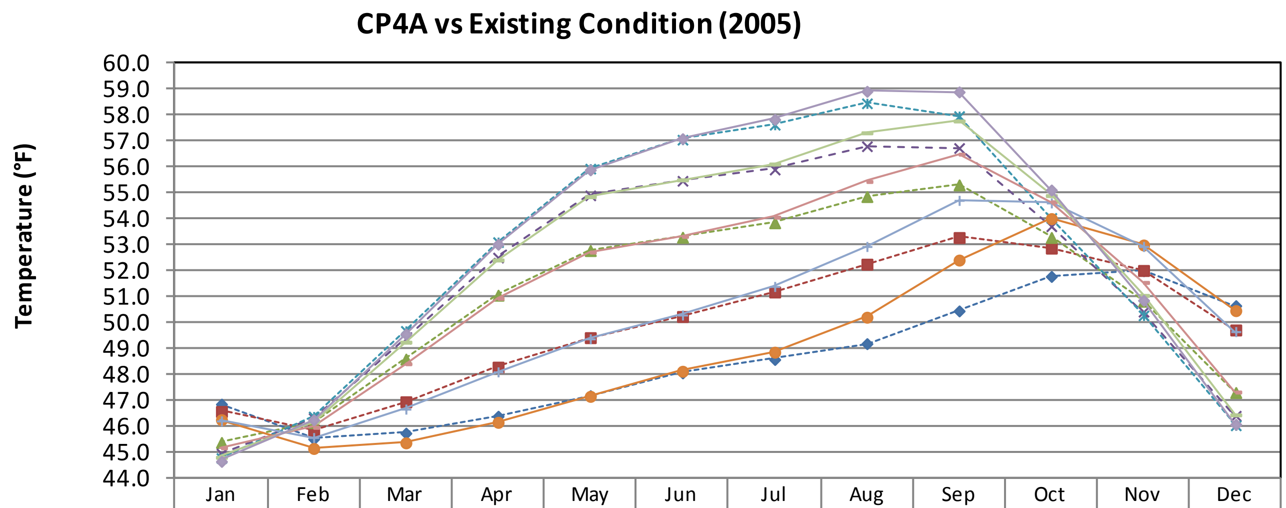
## CP4 vs No-Action (2030)




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP4 Below Shasta | 47.0 | 45.7 | 45.9 | 46.6 | 47.3 | 48.2 | 48.6 | 48.8 | 49.9 | 51.4 | 51.8 | 50.9 |
| CP4 Below Keswick | 46.7 | 46.0 | 47.1 | 48.4 | 49.5 | 50.3 | 51.2 | 52.0 | 52.9 | 52.6 | 51.8 | 49.8 |
| CP4 Balls Ferry | 45.5 | 46.2 | 48.7 | 51.2 | 52.9 | 53.4 | 53.9 | 54.7 | 55.0 | 53.1 | 50.7 | 47.3 |
| CP4 Bend Bridge | 45.0 | 46.4 | 49.4 | 52.6 | 55.0 | 55.5 | 56.0 | 56.6 | 56.5 | 53.5 | 50.3 | 46.4 |
| CP4 RBPP | 44.8 | 46.4 | 49.7 | 53.2 | 56.0 | 57.1 | 57.7 | 58.3 | 57.7 | 53.9 | 50.1 | 46.0 |
| NA Below Shasta | 46.3 | 45.2 | 45.4 | 46.2 | 47.2 | 48.1 | 48.9 | 50.0 | 52.4 | 54.1 | 53.0 | 50.5 |
| NA Below Keswick | 46.2 | 45.6 | 46.7 | 48.1 | 49.4 | 50.3 | 51.4 | 52.9 | 54.7 | 54.6 | 52.9 | 49.6 |
| NA Balls Ferry | 45.2 | 46.0 | 48.4 | 51.0 | 52.8 | 53.3 | 54.1 | 55.4 | 56.5 | 54.7 | 51.5 | 47.3 |
| NA Bend Bridge | 44.8 | 46.2 | 49.3 | 52.5 | 54.9 | 55.5 | 56.1 | 57.3 | 57.7 | 54.9 | 51.0 | 46.4 |
| NA RBPP | 44.6 | 46.3 | 49.6 | 53.1 | 55.9 | 57.1 | 57.8 | 58.9 | 58.8 | 55.1 | 50.8 | 46.0 |

Key: °F = degrees Fahrenheit NA = No-Action
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

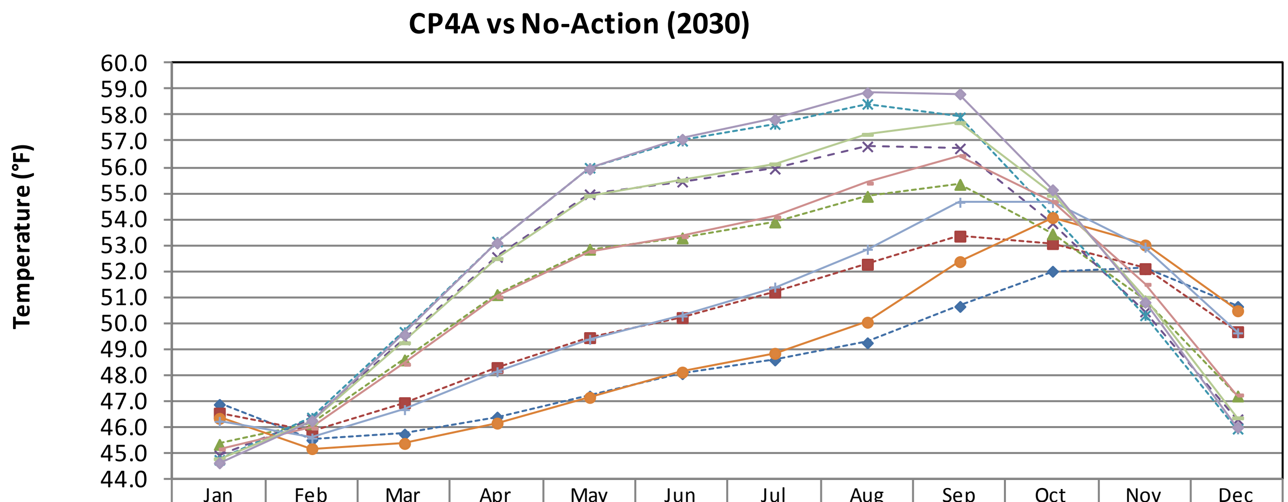
**Figure 11-45. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP4 Versus No-Action Alternative)**




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP4A Below Shasta | 46.9 | 45.5 | 45.7 | 46.4 | 47.2 | 48.1 | 48.6 | 49.2 | 50.5 | 51.8 | 52.0 | 50.7 |
| CP4A Below Keswick | 46.6 | 45.9 | 47.0 | 48.3 | 49.4 | 50.2 | 51.2 | 52.3 | 53.3 | 52.9 | 52.0 | 49.7 |
| CP4A Balls Ferry | 45.4 | 46.2 | 48.6 | 51.1 | 52.8 | 53.3 | 53.9 | 54.9 | 55.3 | 53.3 | 50.8 | 47.3 |
| CP4A Bend Bridge | 45.0 | 46.3 | 49.4 | 52.5 | 54.9 | 55.5 | 55.9 | 56.8 | 56.7 | 53.7 | 50.4 | 46.4 |
| CP4A RBPP | 44.8 | 46.4 | 49.7 | 53.1 | 55.9 | 57.1 | 57.6 | 58.5 | 58.0 | 54.0 | 50.3 | 46.0 |
| EC Below Shasta | 46.3 | 45.2 | 45.4 | 46.2 | 47.2 | 48.1 | 48.9 | 50.2 | 52.4 | 54.0 | 53.0 | 50.5 |
| EC Below Keswick | 46.2 | 45.6 | 46.7 | 48.1 | 49.4 | 50.3 | 51.4 | 52.9 | 54.7 | 54.6 | 52.9 | 49.7 |
| EC Balls Ferry | 45.2 | 46.0 | 48.4 | 50.9 | 52.7 | 53.3 | 54.1 | 55.4 | 56.5 | 54.7 | 51.6 | 47.3 |
| EC Bend Bridge | 44.8 | 46.2 | 49.3 | 52.4 | 54.9 | 55.5 | 56.1 | 57.3 | 57.8 | 54.9 | 51.1 | 46.5 |
| EC RBPP | 44.7 | 46.3 | 49.6 | 53.0 | 55.9 | 57.1 | 57.8 | 58.9 | 58.9 | 55.1 | 50.9 | 46.1 |

Key: °F = degrees Fahrenheit EC = Existing Condition
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

**Figure 11-46. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP4A Versus Existing Condition)**




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP4A Below Shasta | 46.9 | 45.5 | 45.7 | 46.4 | 47.2 | 48.1 | 48.6 | 49.3 | 50.7 | 52.0 | 52.1 | 50.7 |
| CP4A Below Keswick | 46.6 | 45.9 | 47.0 | 48.3 | 49.5 | 50.2 | 51.2 | 52.3 | 53.4 | 53.1 | 52.1 | 49.7 |
| CP4A Balls Ferry | 45.4 | 46.1 | 48.6 | 51.1 | 52.9 | 53.3 | 53.9 | 54.9 | 55.3 | 53.4 | 50.9 | 47.2 |
| CP4A Bend Bridge | 44.9 | 46.3 | 49.4 | 52.6 | 55.0 | 55.5 | 55.9 | 56.8 | 56.7 | 53.8 | 50.5 | 46.3 |
| CP4A RBPP | 44.8 | 46.4 | 49.7 | 53.1 | 56.0 | 57.0 | 57.7 | 58.4 | 57.9 | 54.2 | 50.3 | 46.0 |
| NA Below Shasta | 46.3 | 45.2 | 45.4 | 46.2 | 47.2 | 48.1 | 48.9 | 50.0 | 52.4 | 54.1 | 53.0 | 50.5 |
| NA Below Keswick | 46.2 | 45.6 | 46.7 | 48.1 | 49.4 | 50.3 | 51.4 | 52.9 | 54.7 | 54.6 | 52.9 | 49.6 |
| NA Balls Ferry | 45.2 | 46.0 | 48.4 | 51.0 | 52.8 | 53.3 | 54.1 | 55.4 | 56.5 | 54.7 | 51.5 | 47.3 |
| NA Bend Bridge | 44.8 | 46.2 | 49.3 | 52.5 | 54.9 | 55.5 | 56.1 | 57.3 | 57.7 | 54.9 | 51.0 | 46.4 |
| NA RBPP | 44.6 | 46.3 | 49.6 | 53.1 | 55.9 | 57.1 | 57.8 | 58.9 | 58.8 | 55.1 | 50.8 | 46.0 |

Key: °F = degrees Fahrenheit NA = No-Action
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

**Figure 11-47. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP4A Versus No-Action Alternative)**

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 are likely conservative and understated to some varying degree. Potential changes in flows and stages would diminish rapidly downstream from RBPP because of the increasing effect of tributary inflows, diversions, and flood bypasses.

The slight changes in monthly mean water temperatures under CP4 and CP4A relative to the Existing Condition and the No-Action Alternative would have very small effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Monthly mean 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 (CP4 or CP4A): 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 cause a reduction in the magnitude, duration, or frequency of intermediate to large flows both in the upper Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-14 (CP1) for CP4. The impact could be greater under CP4 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) behind the raised dam.

This impact would be similar to Impact Aqua-14 (CP2) for CP4A. The impact could be greater under CP4A than under CP2 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 12.5-foot raise would allow for storage of additional water volume (and flows) 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 the associated stage elevation of the river surface also provide a backwater effect on the lowermost segment of tributaries, reducing the potential for downcutting. These processes are regulated by the magnitude and frequency of flow. Relatively large floods provide the energy required to mobilize sediment from the riverbed, produce meander migration, increase stage elevation, and create seasonally inundated floodplains. Operations under CP4 or

CP4A could result in a reduction in the intermediate to large flows necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains.

Implementation of CP4 or CP4A would cause 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 effects 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 throughout the upper Sacramento River portion of the primary study area.

As discussed above, CP4 and CP4A both include a 10-year gravel augmentation program and the restoration of riparian, floodplain, and side-channel habitat at up to six potential restoration sites as additional environmental commitments. Placing gravel along the Sacramento River channel and bank annually and restoring riparian, floodplain, and side-channel habitat at up to six sites would result in benefits to ecological processes (e.g., sediment transport and deposition, floodplain inundation) that would partially offset the effects described above. Nevertheless, reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River.

This impact would be potentially significant for CP4. Mitigation for this impact is proposed in Section 11.3.4, “Mitigation Measures.”

This impact would be potentially significant for CP4A. Mitigation for this impact is identical to that proposed for CP4 in Section 11.3.4, “Mitigation Measures.”

### Lower Sacramento River and Delta

*Impact Aqua-15 (CP4 or CP4A): 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 discernible change in monthly mean flows or water temperature conditions in the lower Sacramento River. However, predicted changes in flows in the Feather, American, and Trinity rivers could result in adverse effects on Chinook salmon, steelhead, Coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be potentially significant for both CP4 and CP4A.

This impact would be similar to Impact Aqua-15 (CP1) for CP4. The impact could be greater under CP4 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and increased cold-water pool) behind the raised dam.

This impact would be similar to Impact Aqua-15 (CP2) for CP4A. The impact could be greater under CP4A than under CP2 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 12.5-foot raise would allow for storage of additional water volume (and increased cold water pool) behind the raised dam.

As described below, mean monthly flows at various modeling locations on the lower Sacramento River and tributaries under CP4 and CP4A were compared with mean monthly flows simulated for Existing Conditions and No-Action Alternative conditions. See the Modeling Appendix for complete CalSim-II modeling results.

*Lower Sacramento River* As under CP1, monthly mean flows at the lower Sacramento River modeling locations under CP4 or CP4A would be essentially equivalent to flows under the Existing Condition and No-Action Alternative simulated for all months. Differences in monthly mean flow were generally small (less than 2 percent) and within the existing range of variability. Potential changes in flows would diminish rapidly downstream from RBPP because of the increasing effect from tributary inflows, diversions, and flood bypasses. Similarly, potential changes in water temperatures in the lower Sacramento River caused by 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 for CP4 or CP4A. Mitigation for this impact is not needed, and thus not proposed.

As under CP1, the effects of altered flow regimes resulting from implementation of CP4 or CP4A 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 operational requirements, including the 2008 USFWS BO and the 2009 NMFS BO, have been designed to maintain standards for flow to the lower Sacramento River and Delta. CVP and SWP operations must be consistent with these ESA BOs. Thus, implementation of CP4 would not likely alter flow to the Delta or water temperatures in the lower Sacramento River and primary tributaries within the extended study area to a degree sufficient to cause discernible 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 water temperature–related effects on these fish species would be less than significant for CP4 or CP4A. Mitigation for this impact is not needed, and thus not proposed.

*Lower Feather River, American River, and Trinity River* Also, as under CP1, monthly mean flows at all modeling locations on the lower Feather River, the American River, and the Trinity River under CP4 or CP4A would be essentially equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for most months. However, simulations for several months within the modeling record show substantial changes to flows in tributaries. Potential changes in flows could be reduced by real-time operations to meet existing rules and because of operation of upstream reservoirs (Lake Oroville, Folsom Lake, and Trinity Lake) and increasing effects from tributary inflows, diversions, and flood bypasses. Potential changes in water temperatures in the Feather and American rivers caused by altered releases from reservoirs could diminish downstream because of the increasing effect of inflows, and atmospheric and groundwater influences. 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.

This impact would be potentially significant for CP4. Mitigation for this impact is proposed in Section 11.3.4, “Mitigation Measures.”

This impact would be potentially significant for CP4A. Mitigation for this impact is identical to that proposed for CP4 in Section 11.3.4, “Mitigation Measures.”

*Impact Aqua-16 (CP4 or CP4A): 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 cause a reduction in intermediate to large flows both in the lower Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-16 (CP1) for CP4 and CP4A. The impact could be greater under CP4 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) 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 the associated stage elevation of the river 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 flows. Relatively large floods provide the energy required to mobilize sediment from the bed, produce meander migration, increase stage elevation, create seasonally inundated floodplains, and inundate floodplain bypasses. Operations under CP4 or CP4A 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.

Implementation of CP4 or CP4A would cause 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.

This impact would be potentially significant for CP4. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

This impact would be potentially significant for CP4A. Mitigation for this impact is identical to that proposed for CP4 in Section 11.3.4, "Mitigation Measures."

*Impact Aqua-17 (CP4 or CP4A): Effects to Delta Fisheries Resulting from Changes to Delta Outflow* Delta outflow conditions under CP4 would be the same as those under CP1, and would result in changes to average monthly Delta outflow of less than 5 percent in all water year types (with the exception of December of critical years under 2005 conditions), as shown in Table 11-12. This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta for CP4 would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Delta outflow conditions under CP4A would be the same as those under CP2, and would result in changes to average monthly Delta outflow of less than 5 percent in all water year types (with the exception of December of critical years under 2005 conditions), as shown in Table 11-23. This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta for CP4A would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

*Impact Aqua-18 (CP4 or CP4A): Effects to Delta Fisheries Resulting from Changes to Delta Inflow* Delta inflow conditions under CP4 would be the same as those under CP1, and would not decrease average monthly Delta inflow by 5 percent or more in any year type, as shown in Table 11-13. This impact on

Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant for CP4. Mitigation for this impact is not needed, and thus not proposed.

Delta inflow conditions under CP4A would be the same as those under CP2, and would not decrease average monthly Delta inflow by 5 percent or more in any year type, as shown in Table 11-24. This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant for CP4A. Mitigation for this impact is not needed, and thus not proposed.

*Impact Aqua-19 (CP4 or CP4A): 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. Decreases in Sacramento River inflow would not equal or exceed 5 percent, as shown in Table 11-14. This impact would be less than significant for CP4. Mitigation for this impact is not needed, and thus not proposed.

CP4A operations would be the same as those under CP2 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. Decreases in Sacramento River inflow would not equal or exceed 5 percent, as shown in Table 11-25. This impact would be less than significant for CP4A. Mitigation for this impact is not needed, and thus not proposed.

*Impact Aqua-20 (CP4 or CP4A): 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 discernible change in San Joaquin River flows at Vernalis, as shown in Table 11-15. 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. There would be no impact for CP4. Mitigation for this impact is not needed, and thus not proposed.

CP4A operation would be the same as under CP2 and would result in no discernible change in San Joaquin River flows at Vernalis, as shown in Table 11-26. Therefore, CP4A 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. There would be no impact for CP4A. Mitigation for this impact is not needed, and thus not proposed.

*Impact Aqua-21 (CP4 or CP4A): Reduction in Low-Salinity Habitat Conditions Resulting from an Upstream Shift in X2 Location* CP4 operations would be the same as CP1 operations, and would result in a less than 0.5 km movement upstream or downstream from the X2 location from its location under the Existing Condition or No-Action Alternative, and thus cause minimal reduction in low-salinity habitats, as shown in Table 11-16. This impact would be less than significant for CP4. Mitigation for this impact is not needed, and thus not proposed.

CP4A operations would be the same as CP2 operations, and would result in a less than 0.5 km movement upstream or downstream from the X2 location from its location under the Existing Condition or No-Action Alternative, and thus cause minimal reduction in low-salinity habitats, as shown in Table 11-27. This impact would be less than significant for CP4A. Mitigation for this impact is not needed, and thus not proposed.

*Impact Aqua-22 (CP4 or CP4A): Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in Old and Middle Rivers* CP4 operations would be the same as CP1 operations, and would result in minimal changes to reverse flows in Old and Middle rivers, as shown in Table 11-17. The increases in reverse flows would be expected to contribute to a small increase in the vulnerability of Chinook salmon, delta smelt, striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses.

CP4A operations would be the same as CP2 operations, and would result in minimal changes to reverse flows in Old and Middle rivers, as shown in Table 11-28. The increases in reverse flows would be expected to contribute to a small increase in the vulnerability of Chinook salmon, delta smelt, striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses.

This impact would be less than significant for CP4 or CP4A for striped bass, threadfin shad, and other resident warm-water fish, and potentially significant for delta smelt and Chinook salmon. Overall, the impact for CP4 and CP4A would be potentially significant. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species, thus reducing effects to non-listed fish species as well.

*Impact Aqua-23 (CP4 or CP4A): 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 would be the same as CP1 operations, and 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, as shown in Table 11-18.

CP4A operations would be the same as CP2 operations, and 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, as shown in Table 11-29.

Therefore, the resulting impact of CP4 to Chinook salmon, steelhead, longfin smelt, striped bass, and splittail would be less than significant; the resulting impact to delta smelt would be potentially significant.

Under CP4A, however, the resulting impact would be less than significant for Chinook salmon, but potentially significant for delta smelt, steelhead, longfin smelt, striped bass, and splittail. Overall, this impact would be potentially significant for CP4 or CP4A. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species.

**CVP/SWP Service Areas**

*Impact Aqua-24 (CP4 or CP4A): Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow Regimes* The implementation of CP4 or CP4A 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 to tributaries and reservoirs (e.g., New Melones and San Luis) with CVP and SWP dams, as well as the conveyances south of the Delta would be substantially less than impacts on the lower Sacramento River. The change in hydrology in the CVP and SWP service areas could affect aquatic habitats that provide habitat for the fish community; however, the changes would not result in substantial effects on their distribution or abundance. Therefore, this impact of CP4 or CP4A would be less than significant.

The impact of CP4 would be similar to Impact Aqua-24 (CP1). The impact of CP4A would be similar to Impact Aqua-24 (CP2).

The hydrologic effects to the CVP and SWP service areas would not result in substantial effects on the distribution or abundance of the fish species in the CVP and SWP service areas. The effects from CP4 or CP4A 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.

This impact would be less than significant for CP4. Mitigation for this impact is not needed, and thus not proposed.

This impact would be less than significant for CP4A. Mitigation for this impact is not needed, and thus not proposed.

***CP5 – 18.5-Foot Dam Raise, Combination Plan***

CP5 primarily focuses on increasing water supply reliability, anadromous fish survival, Shasta Lake area environmental resources, and recreation opportunities. By raising Shasta Dam 18.5 feet, in combination with spillway modifications, CP5 would increase the height of the reservoir full pool by 20.5 feet and enlarge the total storage capacity in the reservoir by 634,000 acre-feet. The existing TCD would be extended to achieve efficient use of the expanded cold-water pool. Shasta Dam operational guidelines would continue essentially unchanged, except during dry years and critical years, when 150,000 acre-feet and 75,000 acre-feet, respectively, of the increased storage capacity in Shasta Reservoir would be reserved to specifically focus on increasing M&I deliveries. CP5 also includes constructing additional fish habitat in and along the shoreline of Shasta Lake and along the lower reaches of its tributaries; augmenting spawning gravel and restoring riparian, floodplain, and side channel habitat in the upper Sacramento River; and increasing recreation opportunities at Shasta Lake.

CP5 would help reduce future water shortages through increasing drought year and average year water supply reliability for agricultural and M&I deliveries. In addition, the increased depth and volume of the cold-water pool in Shasta Reservoir would contribute to improving seasonal water temperatures for anadromous fish in the upper Sacramento River.

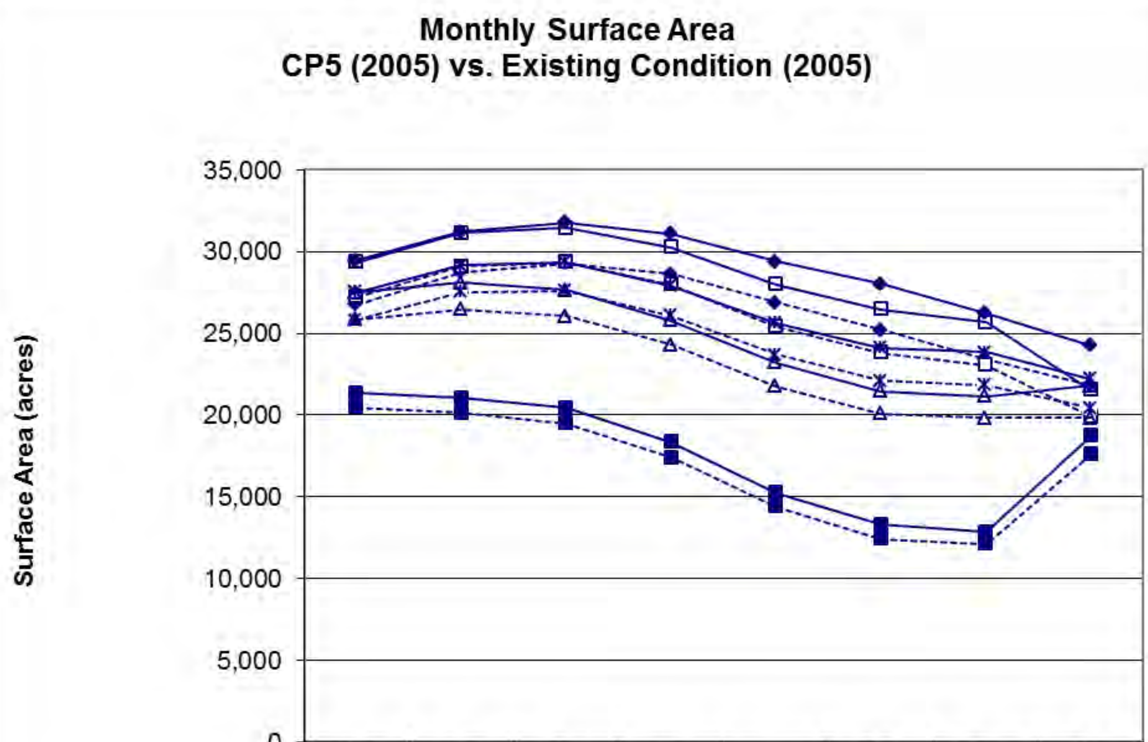
**Shasta Lake and Vicinity**

*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, with slightly less of an increase in warm-water fish habitat than CP3 because of differences in operations, but inclusion of nearshore fish habitat enhancement would result in a similar or greater increase than CP3. Warm-water fish habitat would be increased compared to the Existing Condition and the No-Action Alternative as measured by increased lake surface area and reductions in lake level fluctuations (Figures 11-48 through 11-51). 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 Impact Aqua-2 (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 (Figure 11-52). This impact would be beneficial.

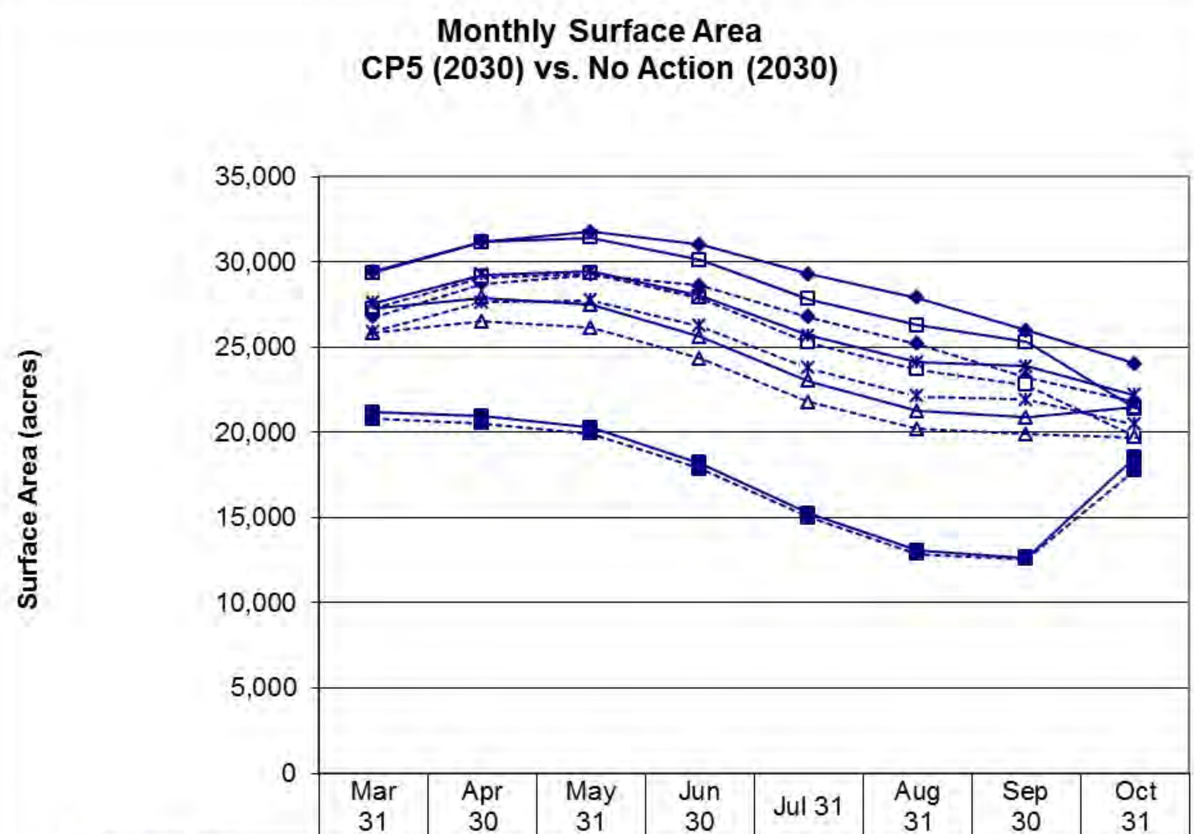
This impact would be beneficial, but slightly less than that provided under CP3. Mitigation for this impact is not needed, and thus not proposed.




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 |
|---|---|---|---|---|---|---|---|---|
| EC W | 26,790 | 28,748 | 29,277 | 28,624 | 26,872 | 25,226 | 23,413 | 21,827 |
| EC AN | 27,245 | 29,082 | 29,336 | 27,992 | 25,400 | 23,826 | 23,061 | 19,906 |
| EC BN | 25,807 | 27,534 | 27,621 | 26,104 | 23,714 | 22,114 | 21,837 | 20,425 |
| EC D | 25,850 | 26,467 | 26,058 | 24,300 | 21,754 | 20,093 | 19,840 | 19,828 |
| EC C | 20,467 | 20,142 | 19,500 | 17,381 | 14,400 | 12,418 | 12,111 | 17,572 |
| CP5 2005 W | 29,448 | 31,208 | 31,794 | 31,081 | 29,404 | 28,018 | 26,222 | 24,264 |
| CP5 2005 AN | 29,371 | 31,154 | 31,450 | 30,246 | 27,971 | 26,468 | 25,652 | 21,521 |
| CP5 2005 BN | 27,525 | 29,160 | 29,355 | 27,921 | 25,627 | 24,124 | 23,836 | 22,213 |
| CP5 2005 D | 27,499 | 28,088 | 27,639 | 25,800 | 23,210 | 21,473 | 21,142 | 21,790 |
| CP5 2005 C | 21,359 | 21,047 | 20,422 | 18,355 | 15,245 | 13,295 | 12,828 | 18,737 |

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

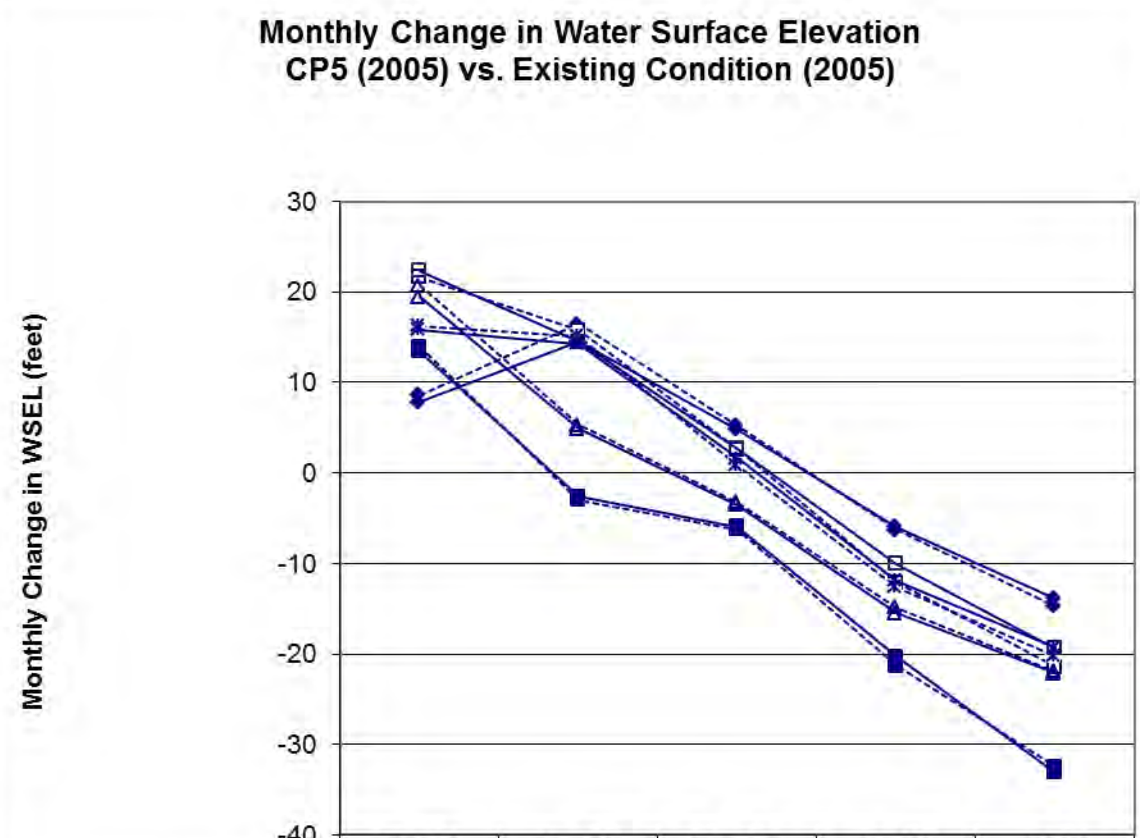
**Figure 11-48. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP5 Versus Existing Condition**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 | Aug 31 | Sep 30 | Oct 31 |
|---|---|---|---|---|---|---|---|---|
| NA W | 26,775 | 28,735 | 29,273 | 28,604 | 26,797 | 25,183 | 23,205 | 21,808 |
| NA AN | 27,258 | 29,117 | 29,325 | 27,921 | 25,294 | 23,687 | 22,800 | 19,759 |
| NA BN | 25,918 | 27,662 | 27,770 | 26,239 | 23,764 | 22,137 | 21,923 | 20,469 |
| NA D | 25,843 | 26,514 | 26,134 | 24,346 | 21,780 | 20,209 | 19,910 | 19,728 |
| NA C | 20,801 | 20,548 | 19,942 | 17,866 | 15,026 | 12,873 | 12,556 | 17,800 |
| CP5 2030 W | 29,435 | 31,196 | 31,789 | 31,040 | 29,305 | 27,909 | 26,001 | 24,052 |
| CP5 2030 AN | 29,355 | 31,158 | 31,429 | 30,120 | 27,832 | 26,297 | 25,298 | 21,414 |
| CP5 2030 BN | 27,600 | 29,249 | 29,439 | 28,012 | 25,678 | 24,121 | 23,875 | 22,176 |
| CP5 2030 D | 27,316 | 27,918 | 27,481 | 25,609 | 23,020 | 21,267 | 20,867 | 21,475 |
| CP5 2030 C | 21,189 | 20,934 | 20,294 | 18,198 | 15,233 | 13,069 | 12,642 | 18,553 |

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

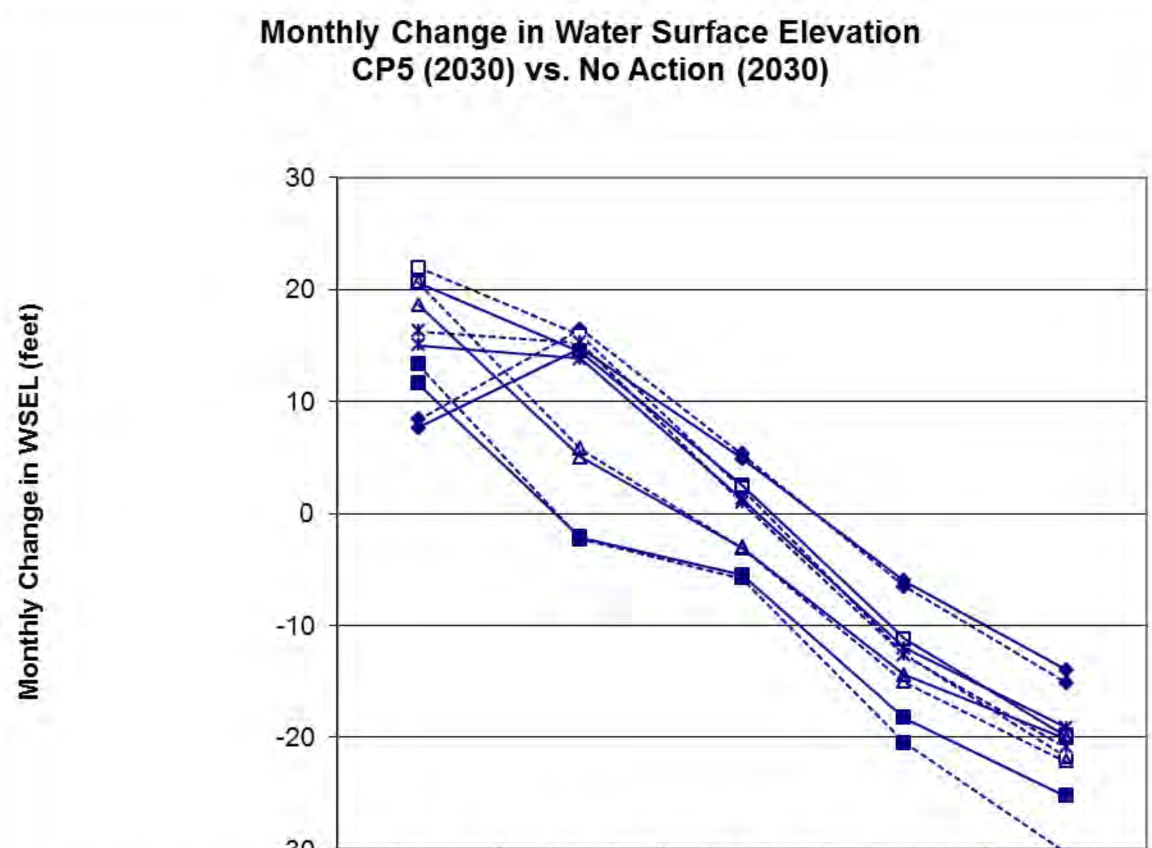
**Figure 11-49. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP5 Versus the No-Action Alternative**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 |
|---|---|---|---|---|---|
| EC W | 9 | 16 | 5 | -6 | -15 |
| EC AN | 22 | 16 | 3 | -12 | -21 |
| EC BN | 16 | 15 | 1 | -13 | -20 |
| EC D | 21 | 5 | -3 | -15 | -22 |
| EC C | 14 | -3 | -6 | -21 | -32 |
| CP5 (2005) W | 8 | 15 | 5 | -6 | -14 |
| CP5 (2005) AN | 22 | 15 | 3 | -10 | -19 |
| CP5 (2004) BN | 16 | 14 | 2 | -12 | -19 |
| CP5 (2005) D | 19 | 5 | -4 | -15 | -22 |
| CP5 (2005) C | 13 | -3 | -6 | -20 | -33 |

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
WSEL = water surface elevation

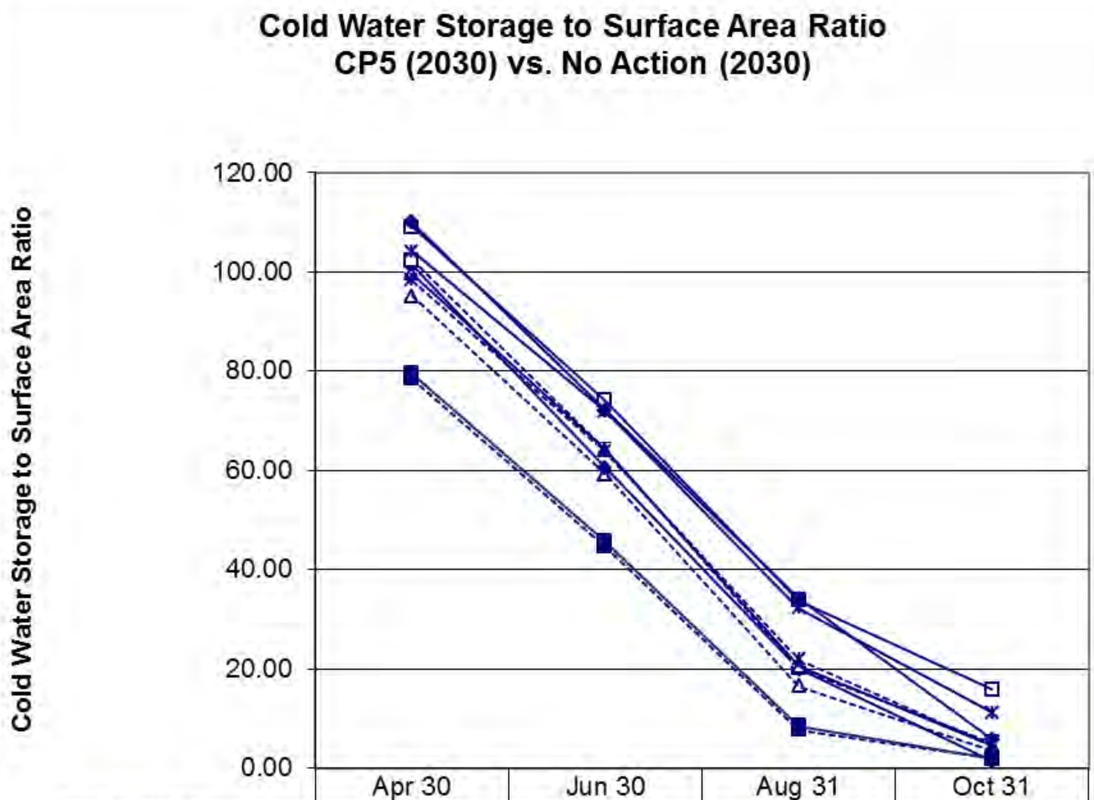
**Figure 11-50. Average Monthly Change in Water Surface Elevation for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP5 Versus the Existing Condition**




| | Mar 31 | Apr 30 | May 31 | Jun 30 | Jul 31 |
|---|---|---|---|---|---|
| NA W | 8 | 16 | 5 | -7 | -15 |
| NA AN | 22 | 16 | 2 | -13 | -22 |
| NA BN | 16 | 15 | 1 | -13 | -21 |
| NA D | 21 | 6 | -3 | -15 | -22 |
| NA C | 13 | -2 | -6 | -21 | -30 |
| CP4 (2030) W | 8 | 15 | 5 | -6 | -14 |
| CP4 (2030) AN | 21 | 14 | 2 | -11 | -20 |
| CP4 (2030) BN | 15 | 14 | 1 | -12 | -19 |
| CP4 (2030) D | 19 | 5 | -3 | -14 | -20 |
| CP4 (2030) C | 12 | -2 | -6 | -18 | -25 |

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 11-51. Average Monthly Change in Water Surface Elevation for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP5 Versus the No-Action Alternative**




| | Apr 30 | Jun 30 | Aug 31 | Oct 31 |
|---|---|---|---|---|
| NA W | 101.33 | 60.49 | 19.89 | 1.43 |
| NA AN | 102.30 | 64.04 | 20.12 | 5.09 |
| NA BN | 98.27 | 63.71 | 21.84 | 4.64 |
| NA D | 95.13 | 59.14 | 16.50 | 3.38 |
| NA C | 78.43 | 44.58 | 7.66 | 1.82 |
| CP5 2030 W | 109.95 | 72.09 | 34.16 | 5.78 |
| CP5 2030 AN | 109.05 | 74.02 | 33.71 | 15.89 |
| CP5 2030 BN | 104.10 | 71.89 | 32.26 | 11.23 |
| CP5 2030 D | 99.54 | 64.08 | 20.51 | 4.45 |
| CP5 2030 C | 79.50 | 45.61 | 8.44 | 1.91 |

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 11-52. Average Monthly Cold-water Storage to Surface Area Ratio for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP5 Versus the No-Action Alternative**

*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 adversely affect special-status aquatic mollusks that could occupy habitat in or near Shasta Lake and its tributaries. This impact would be similar to Impact Aqua-4 (CP3, CP4, and CP4A).

Except for the California floater, the occurrence of special-status mollusks in Shasta Lake and the lower reaches of its tributaries is unlikely. Modification or loss of suitable habitat for California floater would occur through increased WSEL and seasonal fluctuations in the surface area under CP5.

Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, “Mitigation Measures.”

*Impact Aqua-5 (CP5): Effects on Special-Status Fish Species* Similar to CP3, CP4, and CP4A, the expansion of the surface area of Shasta Lake and inundation of additional tributary habitat, including inundation of fish passage barriers, under CP5 could affect one species designated as sensitive by the USFS, the hardhead. Access to and the availability of suitable riverine habitat among all the main tributaries to the reservoir would not likely become any more limiting than under current conditions, nor would it greatly expand.

This impact would be similar to Impact Aqua-5 (CP3, CP4, or CP4A) 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. Similar to CP3, CP5 would have small localized beneficial effects for adfluvial cold-water fishes and provide access to warm-water fish species, which would primarily be limited to the newly inundated reaches of the new varial zone of some streams. Impacts would not be expected to be much greater than under existing conditions. *Environmental commitments, described in Chapter 2, “Alternatives,” to monitor fish communities in Squaw Creek and adaptively manage to prevent warmwater fish invasions would reduce this impact to a less than significant level.*

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* Similar to that described for CP3, CP5 would result in additional periodic inundation of potentially suitable spawning and rearing habitat for adfluvial salmonids in the tributaries of 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 (estimated as 40,103 square feet for all tributaries) would be affected by CP5.

This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, “Mitigation Measures.”

*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 intermittent 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. Field surveys suggest that few, if any of the non-fish-bearing streams contain special-status invertebrate or vertebrate species that would be affected by increased connectivity to Shasta Lake. 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 Red Bluff)**

*Impact Aqua-10 (CP5): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities* Temporary construction-related increases in sediments and turbidity levels would adversely affect aquatic habitats and fish populations immediately downstream in the upper Sacramento River. However, environmental commitments would be in place to reduce the effects. This impact would be less than significant.

This impact would be similar to Impact Aqua-10 (CP1). The impact could be greater under CP5 than under CP1 because of the increased activity associated with an 18.5-foot dam raise compared to a 6.5-foot dam raise.

Like CP4 and CP4A, CP5 includes a 10-year gravel augmentation program as an additional environmental commitment. Placing gravel along the Sacramento River channel and bank annually would release an additional source of fine sediment and expose it to the river and aquatic communities. However, the gravel augmentation activities would occur only during previously specified in-water work windows, which would minimize the potential for impacts associated with this activity.

Also, like CP4 and CP4A, CP5 includes restoration of riparian, floodplain, and side-channel habitat in the upper Sacramento River at up to six potential restoration sites. Riparian, floodplain, and side-channel restoration at these sites 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.

As under CP1, CP4, and CP4A, environmental commitments for all actions would be in place to reduce effects under CP5. Therefore, this impact would be less than significant. 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 could result in the release and exposure of contaminants. Such exposure could adversely affect aquatic habitats, the aquatic food web, and fish populations, including special-status species, downstream in the primary study area. However, environmental commitments would be in place to reduce the effects. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-11 (CP1). The impact could be greater under CP5 than under CP1 because of the increased activity associated with an 18.5-foot raise compared to a 6.5-foot raise. Like CP4 and CP4A, CP5 includes implementation of a gravel augmentation program and restoration of riparian, floodplain, and side-channel habitat at up to six potential restoration sites. Both of these construction activities could cause additional sources of equipment-related contaminants to be released and exposed to the river and aquatic communities. However, environmental commitments for all actions would be in place to reduce effects. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

*Impact Aqua-12 (CP5): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon and Steelhead* Project operation under CP5 would generally result in improved flow and water temperature conditions in the upper Sacramento River for Chinook salmon and steelhead, but not all runs have an increase in production. As well, restoration actions that are proposed under CP5 would additional benefit Chinook salmon and steelhead. This impact would be beneficial.

*Winter-Run Chinook Salmon*

<u>Production</u>

The overall average winter-run production for the 1-year period was similar for CP5 relative to the No-Action Alternative and the Existing Condition (Attachments 3 and 4 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 78 percent for CP5 (critical water year), while the largest decrease in production relative to the No-Action Alternative was around 49 percent (also a critical water year) (Table 11-49 and Attachment 3 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 144 percent (critical water year) for CP5, while the largest decrease in production relative to the Existing Condition was around 26 percent (critical water year) (Table 11-49 and Attachment 4 of the Modeling Appendix). Figure 11-9 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP5, four critical water years had significant increases in production relative to the No-Action Alternative for winter-run Chinook salmon. No other water year type had a significant increase in production. Two critical and one above-normal water year had a significant decrease in production.

Under CP5, four critical, one dry, and one below-normal water years had significant increases in production relative to the Existing Condition, while four years (one each in critical, dry, above-normal and wet water year types) had significant decreases in production greater than 5 percent.

**Table 11-49. Change in Production Under CP5 for Winter-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 81 | 3,765,847 | -35,268 | -0.9 | 77.8 | 4 | -48.7 | 3 |
| **Critical** | 13 | 3,348,152 | -29,804 | -0.9 | 77.8 | 4 | -48.7 | 2 |
| **Dry** | 17 | 3,950,128 | -22,202 | -0.6 | 4.5 | 0 | -3.5 | 0 |
| **Below Normal** | 14 | 3,929,045 | -9,514 | -0.2 | 2.8 | 0 | -3.1 | 0 |
| **Above Normal** | 11 | 3,784,945 | -73,985 | -1.9 | 0.8 | 0 | -7.4 | 1 |
| **Wet** | 26 | 3,758,247 | -44,032 | -1.2 | 3.8 | 0 | -4.5 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 3,767,299 | -13,948 | -0.4 | 144 | 6 | -26.3 | 4 |
| **Critical** | 13 | 3,312,821 | 101,881 | 3.2 | 144 | 4 | -26.3 | 1 |
| **Dry** | 17 | 3,971,126 | -12,736 | -0.3 | 10.9 | 1 | -6.6 | 1 |
| **Below Normal** | 14 | 3,940,814 | 665 | 0.0 | 5.1 | 1 | -3.2 | 0 |
| **Above Normal** | 11 | 3,788,962 | -63,720 | -1.7 | 0.3 | 0 | -5.5 | 1 |
| **Wet** | 26 | 3,758,670 | -59,466 | -1.6 | 1.7 | 0 | -5.4 | 1 |

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:
CP = Comprehensive Plan

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on winter-run Chinook salmon caused by the actions of the project (Attachments 3 and 4 of the Modeling Appendix). Nonoperations-related mortality are the base and seasonal mortality that would occur even without the effects of Shasta operations (such as disease, predation, and entrainment). Flow- and water temperature-related mortality is that caused by altering flow and water temperatures. In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 86 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 3 and 4 of the Modeling Appendix). The greatest average mortality to winter-run Chinook salmon under CP5 (as with CP1 through CP4) in all water year types based on smolt equivalents would occur to the fry life stage, followed by eggs, then presmolts, and lastly to immature smolts. Table 11-5 displays the overall mortalities for each Comprehensive Plan that were caused by changes in operations (i.e., water temperature and flow) (Attachments 3 and 4 of the Modeling Appendix).

Years with the highest mortality were the same for the No-Action Alternative and the Existing Condition and CP5. Each of these years was a critical water year, and was preceded by either a critical (1933, 1976, 1991), or dry (1930, 1932) 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 3 and 4).

Winter-run Chinook salmon have a less-than-significant change to production and project-related mortality under CP5. Therefore, the actions taken in CP5 would result in less-than-significant impacts to winter-run Chinook salmon under both 2030 and 2005 conditions. Winter-run Chinook salmon will, however, benefit from the downstream restoration efforts, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

*Spring-Run Chinook Salmon*

Production

Overall average spring-run Chinook salmon simulated production for CP5 is slightly higher relative to the No-Action Alternative and slightly lower than Existing Condition (Attachments 6 and 7 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 143 percent for CP5 (critical water year), and the largest decrease in production relative to the No-Action Alternative was -37 percent (also a critical water year) (Table 11-50 and Attachment 6 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 712 percent for CP5 and largest decrease in production was less than -27 percent (both in critical water years) (Table 11-50 and Attachment 7 of the Modeling Appendix).

Figure 11-10 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP5, seven critical, two dry and one below-normal water years had significant increases in production relative to the No-Action Alternative. Production significantly decreased in four critical water years and one wet year.

Under CP5, 10 critical, 2 dry, and 1 below-normal water years had significant increases in production relative to the Existing Condition, and two critical and one wet water years had significant decreases in production relative to Existing Conditions.

**Table 11-50. Change in Production Under CP5 for Spring-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 81 | 162,956 | -1,098 | -0.7 | 143 | 10 | -37.3 | 4 |
| **Critical** | 13 | 81,451 | 262 | 0.3 | 143 | 7 | -37.3 | 4 |
| **Dry** | 17 | 171,004 | 1,552 | 0.9 | 110 | 2 | -1.8 | 0 |
| **Below Normal** | 14 | 176,922 | -258 | -0.1 | 20 | 1 | -3.4 | 0 |
| **Above Normal** | 11 | 181,549 | -2,217 | -1.2 | 4.9 | 0 | -3.3 | 0 |
| **Wet** | 26 | 183,061 | -3,490 | -1.9 | 1.5 | 0 | -5.0 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 81 | 163,801 | 593 | 0.4 | 712 | 13 | -26.7 | 3 |
| **Critical** | 13 | 86,086 | 12,024 | 16.2 | 712 | 10 | -26.7 | 2 |
| **Dry** | 17 | 170,788 | 1,927 | 1.1 | 155 | 2 | -1.7 | 0 |
| **Below Normal** | 14 | 177,764 | -266 | -0.1 | 21.9 | 1 | -3.4 | 0 |
| **Above Normal** | 11 | 181,446 | -2,667 | -1.4 | 2.9 | 0 | -3.4 | 0 |
| **Wet** | 26 | 183,107 | -4,151 | -2.2 | 2.1 | 0 | -5.1 | 1 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:

CP = Comprehensive Plan

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on spring-run Chinook salmon caused by the actions of the project (Attachments 6 and 7). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 83 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 6 and 7 of the Modeling Appendix). Under both the 2030 and 2005 conditions, the greatest mortality to spring-run under CP5 (as with CP1 through CP4) in all water year types based on smolt equivalents, occurred to eggs, with minimal mortality to the other life stages. Table 11-7 displays the smolt-equivalent mortalities for each Comprehensive Plan that are caused by flow- and water-related factors (also see Attachments 6 and 7 of the Modeling Appendix).

Years with the highest operations-related mortality were the same for the No-Action Alternative, Existing Conditions, and CP5. 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 (Attachments 6 and 7 of the Modeling Appendix).

Under both 2030 and 2005 conditions, spring-run Chinook salmon would experience a significant reduction in project-related mortality and significant increase in production during critical water years. Therefore, spring-run Chinook salmon would benefit from actions taken in CP5. Additionally, spring-run Chinook salmon will benefit from the downstream restoration efforts, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

*Fall-Run Chinook Salmon*

Production

Overall average fall-run Chinook salmon simulated production for the simulation period was slightly higher for CP5 than for either the No-Action Alternative or Existing Condition (Attachments 9 and 10 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was almost 42 percent (in a below-normal water year) for CP5, and the largest decrease in was 36 percent (critical water year) (Table 11-47 and Attachment 9 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was around 162 percent (critical water year), and the largest decrease in production was 6.5 percent (wet water year) (Table 11-51 and Attachment 10 of the Modeling Appendix). Figure 11-11 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

**Table 11-51. Change in Production Under CP5 for Fall-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **No-Action Alternative** | | | | | | | | |
| **All** | 81 | 29,917,761 | 399,355 | 1.4 | 41.7 | 13 | -36.0 | 4 |
| **Critical** | 13 | 27,603,770 | 1,158,942 | 4.4 | 34.9 | 4 | -36.0 | 1 |
| **Dry** | 17 | 30,477,780 | 937,620 | 3.2 | 25.0 | 5 | -2.4 | 0 |
| **Below Normal** | 14 | 31,664,669 | 566,758 | 1.8 | 41.7 | 2 | -6.3 | 1 |
| **Above Normal** | 11 | 30,957,316 | -75,694 | -0.2 | 5.8 | 1 | -1.8 | 0 |
| **Wet** | 26 | 29,328,136 | -221,539 | -0.7 | 5.0 | 1 | -6.6 | 2 |
| **Existing Conditions** | | | | | | | | |
| **All** | 81 | 30,073,307 | 644,966 | 2.2 | 162 | 13 | -6.5 | 2 |
| **Critical** | 13 | 28,683,817 | 2,507,681 | 9.6 | 162 | 5 | -1.5 | 0 |
| **Dry** | 17 | 30,474,368 | 1,013,967 | 3.4 | 24.4 | 5 | -4.1 | 0 |
| **Below Normal** | 14 | 31,576,655 | 558,393 | 1.8 | 53.2 | 2 | -5.8 | 1 |
| **Above Normal** | 11 | 30,739,508 | -130,889 | -0.4 | 3.0 | 0 | -3.0 | 0 |
| **Wet** | 26 | 29,414,471 | -152,799 | -0.5 | 5.3 | 1 | -6.5 | 1 |

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Key:

CP = Comprehensive Plan

Under CP5, four critical, five dry, two below-normal, one above-normal, and one wet water year had significant increases in production relative to the No-Action Alternative. Significant decreases in production occurred in one critical, one below-normal, and two wet water years.

Compared with Existing Conditions, five critical, five dry, two below-normal, and one wet water year had significant increases in production. One below-normal and one wet water year resulted in significantly decreased production relative to the Existing Condition.

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on fall-run Chinook salmon caused by the actions of the project (Attachments 9 and 10). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)–around 65 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 9 and 10 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality based on the smolt equivalents to fall-run Chinook salmon under CP5 (as with CP1 through CP4) in all water year types based on smolt equivalents occurred to fry, followed by eggs, prespawn adults, presmolts, and lastly immature smolts. Flow-related effects triggered a higher percentage of the operations-related mortality (Table 11-9). In all water year types, the greatest portion of mortality under CP1 occurred to fry caused by forced movement to downstream habitats. Other non-flow- and water temperature-related conditions were the primary causes of mortality for all life stages except fry (Attachments 9 and 10 in the Modeling Appendix).

There was no real trend with respect to years with the greatest mortality. Years with the lowest production were in all water years except above-normal water years, and were preceded by all water year types.

Because fall-run Chinook salmon would have a significant reduction in mortality, but an insignificant change in average production, fall-run Chinook salmon would experience a less-than-significant impact from actions taken in CP5. Additionally, fall-run Chinook salmon would benefit from the downstream restoration efforts, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

*Late Fall-Run Chinook Salmon and Steelhead*

Late fall-run Chinook salmon were evaluated directly using SALMOD and were considered to be a surrogate for steelhead; therefore, the following discussion regarding SALMOD results for late fall-run Chinook salmon are applicable to steelhead.

Production

Overall average late fall-run Chinook salmon simulated production for the 80-year period was similar to CP5 and the No-Action Alternative and the Existing Condition (Attachments 12 and 13 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was around 14 percent for CP5, while the largest decrease in production relative to the No-Action Alternative was just over 8 percent for CP5 (Table 11-52 and Attachment 12 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 15 percent for CP5, while the largest decrease in production relative to the Existing Condition was less than 5 percent for CP5 (Table 11-52 and Attachment 13 of the Modeling Appendix). Figure 11-12 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP5, one critical and three dry water years had significant increases in production compared to the No-Action Alternative. One critical water year had a significant decrease in production.

Under CP5, three critical and two dry water years had greater significant increases in production compared to the Existing Condition. There were no water years in which there was a significant decrease in production.

**Table 11-52. Change in Production Under CP5 for Late Fall-Run Chinook Salmon**

| Year Type | Number of Years | Average Production | Change in Production from Baseline | Percent Change in Average Production | Maximum Percent Increase in Production | Number of Years with Significant Increase | Maximum Percent Decrease in Production | Number of Years with Significant Decrease |
|---|---|---|---|---|---|---|---|---|
| **Future Condition (2030)** | | | | | | | | |
| **All** | 80 | 7,433,301 | 14,815 | 0.2 | 13.8 | 4 | -8.4 | 1 |
| **Critical** | 13 | 7,060,574 | -3,595 | -0.1 | 7.2 | 1 | -8.4 | 1 |
| **Dry** | 16 | 7,474,409 | 120,040 | 1.6 | 13.8 | 3 | -3.7 | 0 |
| **Below Normal** | 14 | 7,580,922 | -31,696 | -0.4 | 2.0 | 0 | -3.2 | 0 |
| **Above Normal** | 11 | 7,601,343 | 15,259 | 0.2 | 2.5 | 0 | -3.2 | 0 |
| **Wet** | 26 | 7,443,786 | -15,878 | -0.2 | 3.6 | 0 | -3.9 | 0 |
| **Existing Condition (2005)** | | | | | | | | |
| **All** | 80 | 7,439,596 | 53,035 | 0.7 | 15.4 | 6 | -4.0 | 0 |
| **Critical** | 13 | 7,016,840 | 53,544 | 0.8 | 10.9 | 3 | -2.0 | 0 |
| **Dry** | 16 | 7,506,162 | 145,894 | 2.0 | 15.4 | 3 | -3.8 | 0 |
| **Below Normal** | 14 | 7,608,790 | -2,304 | 0.0 | 2.9 | 0 | -2.1 | 0 |
| **Above Normal** | 11 | 7,600,738 | 41,065 | 0.5 | 2.2 | 0 | -1.0 | 0 |
| **Wet** | 26 | 7,450,731 | 30,499 | 0.4 | 4.8 | 0 | -4.0 | 0 |

Notes:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Late fall-run Chinook salmon are used as a surrogate for steelhead

Key:

CP = Comprehensive Plan

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on late fall-run Chinook salmon caused by the actions of the project (Attachments 12 and 13). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 78 percent of the total mortality.

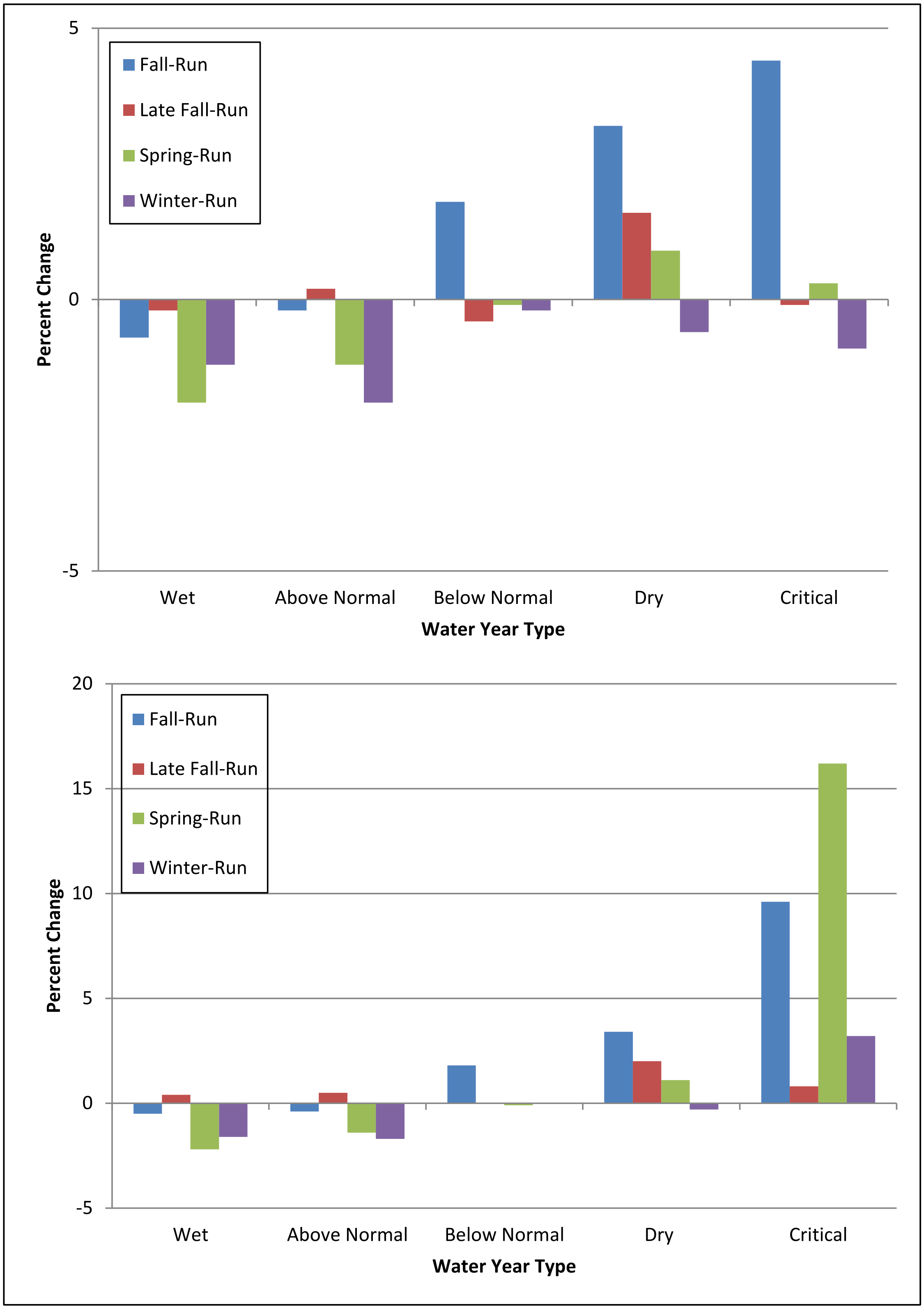
Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 12 and 13 of the Modeling Appendix). Under both 2030 and 2005 conditions, the largest mortality to late fall-run Chinook salmon under CP1 (as with CP1 and CP2) in all water year types based on smolt equivalents, occurred to the egg life stage, followed by fry, then presmolts, and lastly to immature smolts.

Years with the highest mortality were the same for CP5 and the No-Action Alternative and the Existing Condition, and occurred in all water year types. Four of these years were preceded by a wet water year, and the rest were each preceded by an above-normal, a below-normal, or a dry water year (Attachments 12 and 13 of the Modeling Appendix).

Because SALMOD indicates an insignificant change in mortality and production index for late fall-run Chinook salmon under CP5, late fall-run Chinook salmon and steelhead ( as represented by their surrogate late fall-run Chinook salmon) would experience a less-than-significant impact from actions taken in CP5. Additionally, late fall-run Chinook salmon and steelhead will benefit from the downstream restoration efforts, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

*All Chinook Runs Combined*

Raising Shasta Dam by 18.5 feet, in conjunction with spillway modifications, would result in an increase in full pool depth of 20.5 feet and an additional 634,000 acre-feet of storage capacity in Shasta Reservoir. The additional storage created by the dam raise would be used to improve the ability to meet water temperature objectives and habitat requirements for anadromous fish during drought years (see Figure 11-53). Under the 2030 conditions, overall production for all four runs of Chinook salmon combined would increase by nearly 378,000 immature smolts migrating below RDPP. Under the 2005 conditions, overall production for all four runs of Chinook salmon combined would increase by almost 685,000 immature smolts migrating below RDPP.




Note: Changes in outmigrating Chinook salmon simulated using SALMOD; Water Year Types based on the Sacramento Valley Water Year Hydrologic Classification

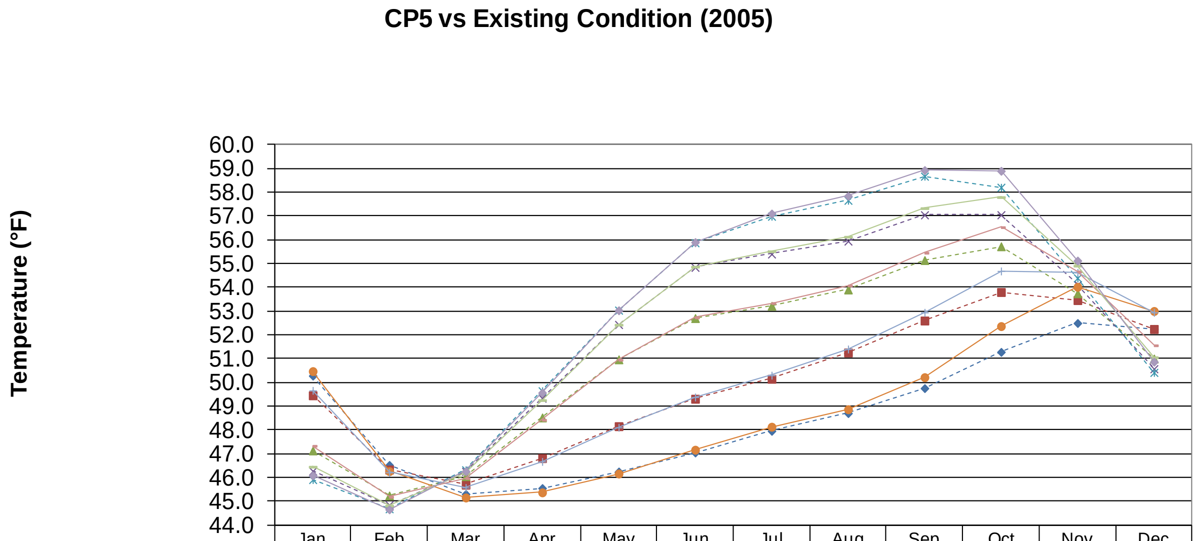
**Figure 11-53. Percent Change in Production of Chinook Salmon for CP5 Compared to the No-Action Alternative (top) and Existing Conditions (bottom)**

*Impact Aqua-13 (CP5): 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* CP5 operations generally 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). As under CP3, monthly mean flows at all modeling locations along the upper Sacramento River under CP5 would generally be equivalent to (less than 5-percent difference from) flows under the Existing Condition and No-Action Alternative conditions simulated for all months. Changes in monthly mean flows under CP5 would have no discernible effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for these species would be unchanged.

Also, as under CP3, monthly mean water temperatures at all modeling locations along the upper Sacramento River under CP5 would be the same as or fractionally lower than those under the Existing Condition and No-Action Alternative simulated for all months (Figures 11-54 and 11-55). The slightly cooler monthly mean water temperatures under CP5 relative to the Existing Condition and the No-Action Alternative would have very small effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass. Monthly mean water temperatures would not rise above important thermal tolerances for the species life stages relevant to the upper Sacramento River.

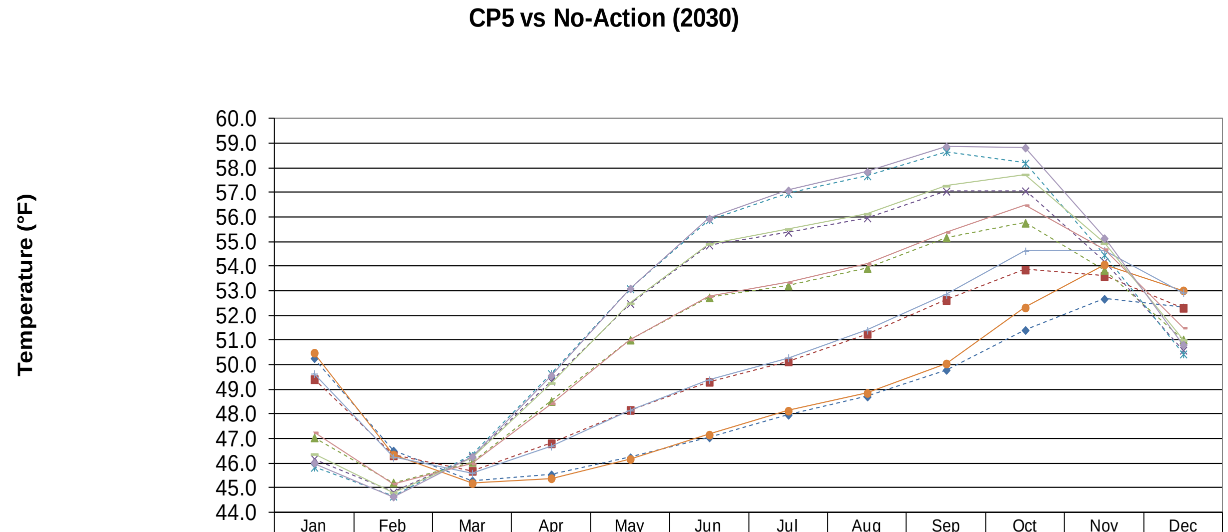
Therefore, with respect to both flow- and water temperature-related effects on fish species, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP5 Below Shasta | 50.3 | 46.5 | 45.3 | 45.6 | 46.3 | 47.1 | 48.0 | 48.7 | 49.8 | 51.3 | 52.5 | 52.2 |
| CP5 Below Keswick | 49.5 | 46.3 | 45.7 | 46.8 | 48.2 | 49.3 | 50.1 | 51.3 | 52.6 | 53.8 | 53.5 | 52.2 |
| CP5 Balls Ferry | 47.1 | 45.2 | 46.1 | 48.5 | 51.0 | 52.7 | 53.2 | 53.9 | 55.1 | 55.7 | 53.7 | 51.0 |
| CP5 Bend Bridge | 46.3 | 44.9 | 46.3 | 49.3 | 52.4 | 54.8 | 55.4 | 55.9 | 57.0 | 57.0 | 54.1 | 50.6 |
| CP5 RBPP | 45.9 | 44.7 | 46.3 | 49.6 | 53.0 | 55.9 | 57.0 | 57.7 | 58.7 | 58.2 | 54.4 | 50.4 |
| EC Below Shasta | 50.5 | 46.3 | 45.2 | 45.4 | 46.2 | 47.2 | 48.1 | 48.9 | 50.2 | 52.4 | 54.0 | 53.0 |
| EC Below Keswick | 49.7 | 46.2 | 45.6 | 46.7 | 48.1 | 49.4 | 50.3 | 51.4 | 52.9 | 54.7 | 54.6 | 52.9 |
| EC Balls Ferry | 47.3 | 45.2 | 46.0 | 48.4 | 50.9 | 52.7 | 53.3 | 54.1 | 55.4 | 56.5 | 54.7 | 51.6 |
| EC Bend Bridge | 46.5 | 44.8 | 46.2 | 49.3 | 52.4 | 54.9 | 55.5 | 56.1 | 57.3 | 57.8 | 54.9 | 51.1 |
| EC RBPP | 46.1 | 44.7 | 46.3 | 49.6 | 53.0 | 55.9 | 57.1 | 57.8 | 58.9 | 58.9 | 55.1 | 50.9 |

Key: °F = degrees Fahrenheit EC = Existing Condition
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

**Figure 11-54. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP5 Versus Existing Condition)**




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP5 Below Shasta | 50.3 | 46.5 | 45.3 | 45.5 | 46.2 | 47.0 | 48.0 | 48.7 | 49.8 | 51.4 | 52.7 | 52.3 |
| CP5 Below Keswick | 49.4 | 46.3 | 45.7 | 46.8 | 48.2 | 49.3 | 50.1 | 51.3 | 52.6 | 53.9 | 53.6 | 52.3 |
| CP5 Balls Ferry | 47.0 | 45.2 | 46.0 | 48.5 | 51.0 | 52.7 | 53.2 | 53.9 | 55.2 | 55.8 | 53.9 | 51.0 |
| CP5 Bend Bridge | 46.2 | 44.8 | 46.3 | 49.3 | 52.5 | 54.9 | 55.4 | 56.0 | 57.1 | 57.1 | 54.2 | 50.6 |
| CP5 RBPP | 45.8 | 44.7 | 46.3 | 49.6 | 53.1 | 55.9 | 57.0 | 57.7 | 58.7 | 58.2 | 54.5 | 50.4 |
| NA Below Shasta | 50.5 | 46.3 | 45.2 | 45.4 | 46.2 | 47.2 | 48.1 | 48.9 | 50.0 | 52.3 | 54.1 | 53.0 |
| NA Below Keswick | 49.6 | 46.2 | 45.6 | 46.7 | 48.1 | 49.4 | 50.3 | 51.4 | 52.9 | 54.6 | 54.6 | 52.9 |
| NA Balls Ferry | 47.3 | 45.2 | 46.0 | 48.4 | 51.0 | 52.8 | 53.3 | 54.1 | 55.4 | 56.5 | 54.7 | 51.5 |
| NA Bend Bridge | 46.4 | 44.8 | 46.2 | 49.3 | 52.5 | 54.9 | 55.5 | 56.1 | 57.3 | 57.7 | 54.9 | 51.0 |
| NA RBPP | 46.0 | 44.6 | 46.3 | 49.6 | 53.1 | 55.9 | 57.1 | 57.8 | 58.9 | 58.8 | 55.1 | 50.8 |

Key: °F = degrees Fahrenheit NA = No-Action
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

**Figure 11-55. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP5 Versus No-Action Alternative)**

*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 operations could cause a reduction in the magnitude, duration, and frequency of intermediate to large flows both in the upper Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-14 (CP1). The impact could be greater under CP5 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) 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 the associated stage elevation of the river surface also provide a backwater effect on the lowermost segment of tributaries, reducing the potential for downcutting. These processes are regulated by the magnitude and frequency of flow. Relatively large floods provide the energy required to mobilize sediment from the riverbed, produce meander migration, increase stage elevation, and create seasonally inundated floodplains. Operations under CP5 could result in a reduction in the intermediate to large flows necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

Implementation of CP5 would cause 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 effects 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 throughout the upper Sacramento River portion of 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 up to six potential restoration sites as additional environmental commitments. Placing gravel along the Sacramento River channel and bank annually and restoring riparian, floodplain, and side-channel habitat at up to six sites would result in benefits to ecological processes (e.g., sediment transport and deposition, floodplain inundation) that would partially offset the effects described above. Nevertheless, reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, "Mitigation Measures."

**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 discernible change in monthly mean flows or water temperature conditions in the lower Sacramento River. However, predicted changes in flow in the Feather, American, and Trinity rivers could result in adverse effects on Chinook salmon, steelhead, Coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be potentially significant.

This impact would be similar to Impact Aqua-15 (CP1). The impact could be greater under CP5 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and increased cold-water pool) behind the raised dam.

As described below, mean monthly flows at various modeling locations on the lower Sacramento River and tributaries under CP5 were compared with mean monthly flows simulated for Existing Conditions and No-Action Alternative conditions. See the Modeling Appendix for complete CalSim-II modeling results.

*Lower Sacramento River* As under CP3, monthly mean flows at the lower Sacramento River modeling locations under CP5 would be essentially equivalent to flows under the Existing Condition and No-Action Alternative conditions simulated for all months. Differences in monthly mean flow were generally small (less than 2 percent) and within the existing range of variability. Potential changes in flows would diminish rapidly downstream from RBPP because of the increasing effects of tributary inflows, diversions, and flood bypasses. Potential flow-related effects of CP5 on fish species of management concern in the lower Sacramento River would be minimal. Potential changes in water temperatures in the lower Sacramento River caused by 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. Mitigation for this impact is not needed, and thus not proposed.

*Lower Feather River, American River, and Trinity River* Also, as under CP3, monthly mean flows at all modeling locations on the lower Feather River, the American River, and the Trinity River under CP5 would be essentially equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for most months. However, simulations for several months within the modeling record show substantial changes to flows in tributaries. Potential changes in flows could be reduced by real-time operations to meet existing rules, and because of operation of upstream reservoirs (Lake Oroville, Folsom Lake, and Trinity Lake) and increasing effects from tributary inflows, diversions, and flood bypasses. 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. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, “Mitigation Measures.”

*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 cause a reduction in intermediate to large flows both in the lower Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-16 (CP1). The impact could be greater under CP5 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) 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 the associated stage elevation of the river 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 flows. Relatively large floods provide the energy required to mobilize sediment from the bed, produce meander migration, increase stage elevation, create seasonally inundated floodplains, and inundate floodplain bypasses. Operations under CP5 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.

Implementation of CP5 would cause 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. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4, “Mitigation Measures.”

*Impact Aqua-17 (CP5): Effects to Delta Fisheries Resulting from Changes to Delta Outflow* Based on the results of hydrologic modeling comparing Delta outflow under the No-Action Alternative, Existing Condition, and CP5, CP5 would result in changes to average monthly Delta outflow of less than 5 percent in all water year types (with the exception of September in dry years, November in above-normal years, and December of critical years). This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

Results of the comparison of Delta outflows under CP5 compared with the Existing Condition and No-Action Alternative are summarized by month and water year type in Table 11-53. Under 2030 and 2005 conditions, Delta outflows would decrease by greater than 5 percent only in November of above-normal water years, but would not result in an overall significant impact to Delta fisheries. Under 2030 conditions, Delta outflows would increase by 5 percent in September and December. An increase in Delta outflow by 200 to 300 cfs during dry and critical water years would not result in significant impacts to Delta fisheries, particularly at flows between 3,500 and 6,000, while a decrease in Delta outflow by around 700 cfs when outflows are higher in November would also not result in significant impacts to Delta fisheries. Based on the results of this comparison, it was concluded that CP5 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 11-53. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP5**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 42,078 | 41,817 | -1 | 42,169 | 41,806 | -1 |
| | W | 84,136 | 83,584 | -1 | 84,037 | 83,176 | -1 |
| | AN | 47,221 | 46,892 | -1 | 46,984 | 46,828 | 0 |
| | BN | 21,610 | 21,578 | 0 | 21,990 | 22,012 | 0 |
| | D | 14,166 | 13,956 | -1 | 14,452 | 14,174 | -2 |
| | C | 11,560 | 11,649 | 1 | 11,757 | 11,691 | -1 |
| February | Average | 51,618 | 51,340 | -1 | 51,430 | 51,033 | -1 |
| | W | 95,261 | 94,826 | 0 | 94,634 | 94,068 | -1 |
| | AN | 60,080 | 59,474 | -1 | 60,278 | 59,353 | -2 |
| | BN | 35,892 | 35,776 | 0 | 35,665 | 35,522 | 0 |
| | D | 20,978 | 20,804 | -1 | 20,946 | 20,694 | -1 |
| | C | 12,902 | 12,945 | 0 | 13,088 | 13,076 | 0 |
| March | Average | 42,722 | 42,532 | 0 | 42,585 | 42,469 | 0 |
| | W | 78,448 | 78,481 | 0 | 78,376 | 78,447 | 0 |
| | AN | 53,486 | 52,431 | -2 | 53,139 | 52,313 | -2 |
| | BN | 23,102 | 22,800 | -1 | 22,980 | 22,746 | -1 |
| | D | 19,763 | 19,873 | 1 | 19,559 | 19,659 | 1 |
| | C | 11,881 | 11,750 | -1 | 11,893 | 11,895 | 0 |
| April | Average | 30,227 | 30,282 | 0 | 30,743 | 30,794 | 0 |
| | W | 54,640 | 54,674 | 0 | 55,460 | 55,472 | 0 |
| | AN | 32,141 | 32,147 | 0 | 32,971 | 32,976 | 0 |
| | BN | 21,773 | 21,903 | 1 | 22,511 | 22,598 | 0 |
| | D | 14,347 | 14,429 | 1 | 14,538 | 14,665 | 1 |
| | C | 9,100 | 9,121 | 0 | 8,873 | 8,897 | 0 |
| May | Average | 22,619 | 22,547 | 0 | 22,249 | 22,179 | 0 |
| | W | 41,184 | 41,151 | 0 | 40,543 | 40,526 | 0 |
| | AN | 24,296 | 24,183 | 0 | 24,454 | 24,242 | -1 |
| | BN | 16,346 | 15,948 | -2 | 15,989 | 15,625 | -2 |
| | D | 10,554 | 10,660 | 1 | 10,116 | 10,265 | 1 |
| | C | 6,132 | 6,132 | 0 | 5,910 | 5,882 | 0 |

**Table 11-53. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP5 (contd.)**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| June | Average | 12,829 | 12,756 | -1 | 12,660 | 12,550 | -1 |
| | W | 23,473 | 23,471 | 0 | 23,015 | 23,027 | 0 |
| | AN | 12,080 | 11,625 | -4 | 11,799 | 11,433 | -3 |
| | BN | 7,995 | 7,977 | 0 | 7,991 | 7,727 | -3 |
| | D | 6,691 | 6,681 | 0 | 6,764 | 6,697 | -1 |
| | C | 5,361 | 5,360 | 0 | 5,378 | 5,376 | 0 |
| July | Average | 7,864 | 7,864 | 0 | 7,864 | 7,855 | 0 |
| | W | 11,230 | 11,223 | 0 | 11,181 | 11,144 | 0 |
| | AN | 9,562 | 9,519 | 0 | 9,407 | 9,384 | 0 |
| | BN | 7,117 | 7,131 | 0 | 7,225 | 7,275 | 1 |
| | D | 5,005 | 5,006 | 0 | 5,052 | 5,019 | -1 |
| | C | 4,034 | 4,074 | 1 | 4,098 | 4,130 | 1 |
| August | Average | 4,322 | 4,335 | 0 | 4,335 | 4,355 | 0 |
| | W | 5,302 | 5,274 | -1 | 5,097 | 5,060 | -1 |
| | AN | 4,000 | 4,000 | 0 | 4,000 | 4,000 | 0 |
| | BN | 4,000 | 4,000 | 0 | 4,002 | 4,008 | 0 |
| | D | 3,906 | 3,903 | 0 | 4,142 | 4,203 | 1 |
| | C | 3,520 | 3,676 | 4 | 3,699 | 3,811 | 3 |
| September | Average | 9,841 | 9,866 | 0 | 9,844 | 9,898 | 1 |
| | W | 19,695 | 19,717 | 0 | 19,702 | 19,736 | 0 |
| | AN | 11,784 | 11,771 | 0 | 11,849 | 11,836 | 0 |
| | BN | 3,876 | 3,862 | 0 | 3,913 | 3,950 | 1 |
| | D | 3,508 | 3,576 | 2 | 3,442 | 3,600 | 5 |
| | C | 3,008 | 3,061 | 2 | 3,005 | 3,029 | 1 |
| October | Average | 6,067 | 6,072 | 0 | 6,000 | 6,003 | 0 |
| | W | 7,926 | 7,870 | -1 | 7,633 | 7,558 | -1 |
| | AN | 5,309 | 5,293 | 0 | 5,476 | 5,536 | 1 |
| | BN | 5,479 | 5,559 | 1 | 5,502 | 5,546 | 1 |
| | D | 5,228 | 5,264 | 1 | 5,236 | 5,253 | 0 |
| | C | 4,741 | 4,765 | 1 | 4,714 | 4,757 | 1 |
| November | Average | 11,706 | 11,531 | -1 | 11,675 | 11,466 | -2 |
| | W | 17,717 | 17,590 | -1 | 17,715 | 17,494 | -1 |
| | AN | 12,667 | 11,767 | -7 | 12,491 | 11,755 | -6 |
| | BN | 8,543 | 8,509 | 0 | 8,686 | 8,557 | -1 |
| | D | 8,482 | 8,481 | 0 | 8,414 | 8,386 | 0 |
| | C | 6,250 | 6,266 | 0 | 6,150 | 6,132 | 0 |

**Table 11-53. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP5 (contd.)**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| Month | Water Year | Flow (cfs) | Flow (cfs) | Percent Change | Flow (cfs) | Flow (cfs) | Percent Change |
| December | Average | 21,755 | 21,437 | -1 | 21,745 | 21,324 | -2 |
| | W | 44,974 | 44,310 | -1 | 44,661 | 43,598 | -2 |
| | AN | 18,581 | 18,300 | -2 | 18,562 | 18,271 | -2 |
| | BN | 12,219 | 11,850 | -3 | 12,326 | 12,008 | -3 |
| | D | 8,531 | 8,517 | 0 | 8,803 | 8,678 | -1 |
| | C | 5,580 | 5,578 | 0 | 5,677 | 5,954 | 5 |

Note:
A negative percentage change reflects a reduction in Delta outflow
Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
cfs = cubic feet per second
D = dry
W = wet

*Impact Aqua-18 (CP5): Effects to Delta Fisheries Resulting from Changes to Delta Inflow* Based on the results of hydrologic modeling comparing Delta inflow under CP5 to the Existing Condition and No-Action Alternative, CP5 would not decrease average monthly Delta inflow by 5 percent or more in any year type (except in September of dry and critical years). This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

Results of the comparison of Delta inflows are summarized by month and water year type in Table 11-54. Delta inflows were observed to be slightly lower under many of the CP5 operations and slightly higher than either the Existing Condition or the No-Action Alternative depending on month and water year type. Average monthly Delta inflow would increase by more than 5 percent during September of critical years compared to the Existing Condition, and during September of dry and critical years compared to the No-Action Alternative. Average monthly Delta inflow would not decrease by more than 5 percent in any water year type. Based on the results of this comparison, it was concluded that CP5 would have a less-than-significant effect on Delta fisheries and hydrologic transport processes within the Bay-Delta as a consequence of changes in Delta inflow. Mitigation for this impact is not needed, and thus not proposed.

**Table 11-54. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP5**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 47,426 | 47,149 | -1 | 47,457 | 47,115 | -1 |
| | W | 89,431 | 88,880 | -1 | 89,328 | 88,469 | -1 |
| | AN | 51,611 | 51,213 | -1 | 51,267 | 51,053 | 0 |
| | BN | 27,269 | 27,240 | 0 | 27,576 | 27,598 | 0 |
| | D | 20,125 | 19,962 | -1 | 20,371 | 20,094 | -1 |
| | C | 16,699 | 16,677 | 0 | 16,749 | 16,882 | 1 |
| February | Average | 57,835 | 57,570 | 0 | 57,623 | 57,250 | -1 |
| | W | 103,140 | 102,698 | 0 | 102,606 | 102,066 | -1 |
| | AN | 65,379 | 64,552 | -1 | 65,574 | 64,598 | -1 |
| | BN | 41,782 | 41,781 | 0 | 41,374 | 41,253 | 0 |
| | D | 26,530 | 26,384 | -1 | 26,431 | 26,214 | -1 |
| | C | 17,818 | 18,008 | 1 | 17,958 | 18,014 | 0 |
| March | Average | 49,829 | 49,675 | 0 | 49,713 | 49,588 | 0 |
| | W | 87,688 | 87,738 | 0 | 87,703 | 87,801 | 0 |
| | AN | 61,498 | 60,673 | -1 | 61,339 | 60,540 | -1 |
| | BN | 30,569 | 30,264 | -1 | 30,415 | 30,183 | -1 |
| | D | 24,943 | 24,967 | 0 | 24,640 | 24,654 | 0 |
| | C | 15,933 | 15,916 | 0 | 15,896 | 15,884 | 0 |
| April | Average | 33,962 | 34,019 | 0 | 34,783 | 34,833 | 0 |
| | W | 58,684 | 58,717 | 0 | 60,017 | 60,019 | 0 |
| | AN | 35,588 | 35,595 | 0 | 36,738 | 36,744 | 0 |
| | BN | 25,351 | 25,482 | 1 | 26,403 | 26,490 | 0 |
| | D | 17,962 | 18,057 | 1 | 18,315 | 18,448 | 1 |
| | C | 12,817 | 12,838 | 0 | 12,635 | 12,663 | 0 |
| May | Average | 27,383 | 27,312 | 0 | 27,091 | 27,029 | 0 |
| | W | 46,973 | 46,941 | 0 | 46,494 | 46,476 | 0 |
| | AN | 28,466 | 28,354 | 0 | 28,711 | 28,502 | -1 |
| | BN | 20,747 | 20,349 | -2 | 20,427 | 20,062 | -2 |
| | D | 14,882 | 14,988 | 1 | 14,534 | 14,686 | 1 |
| | C | 10,347 | 10,351 | 0 | 10,038 | 10,065 | 0 |
| June | Average | 22,171 | 22,115 | 0 | 22,090 | 22,001 | 0 |
| | W | 35,459 | 35,457 | 0 | 35,172 | 35,190 | 0 |
| | AN | 23,124 | 22,662 | -2 | 22,776 | 22,410 | -2 |
| | BN | 16,884 | 16,971 | 1 | 16,941 | 16,796 | -1 |
| | D | 14,095 | 14,082 | 0 | 14,337 | 14,262 | -1 |
| | C | 10,710 | 10,711 | 0 | 10,694 | 10,696 | 0 |
| July | Average | 23,099 | 23,160 | 0 | 22,839 | 22,959 | 1 |
| | W | 27,442 | 27,430 | 0 | 27,496 | 27,455 | 0 |
| | AN | 25,169 | 25,065 | 0 | 25,065 | 25,018 | 0 |
| | BN | 23,282 | 23,351 | 0 | 23,362 | 23,338 | 0 |
| | D | 20,937 | 20,983 | 0 | 20,082 | 20,408 | 2 |
| | C | 14,647 | 15,042 | 3 | 14,048 | 14,544 | 4 |

**Table 11-54. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP5 (contd.)**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Flow (cfs)** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| August | Average | 17,147 | 17,154 | 0 | 17,026 | 17,128 | 1 |
| | W | 20,235 | 20,217 | 0 | 20,154 | 20,118 | 0 |
| | AN | 18,784 | 18,754 | 0 | 18,927 | 18,941 | 0 |
| | BN | 18,274 | 18,202 | 0 | 18,297 | 18,231 | 0 |
| | D | 15,066 | 15,348 | 2 | 14,371 | 14,976 | 4 |
| | C | 10,626 | 10,404 | -2 | 10,850 | 10,782 | -1 |
| September | Average | 20,946 | 21,184 | 1 | 21,145 | 21,461 | 1 |
| | W | 31,918 | 32,076 | 0 | 32,428 | 32,518 | 0 |
| | AN | 23,912 | 23,902 | 0 | 24,747 | 24,877 | 1 |
| | BN | 16,518 | 16,468 | 0 | 16,563 | 16,652 | 1 |
| | D | 14,440 | 14,960 | 4 | 14,233 | 15,039 | 6 |
| | C | 9,130 | 9,707 | 6 | 8,809 | 9,332 | 6 |
| October | Average | 14,407 | 14,469 | 0 | 14,175 | 14,278 | 1 |
| | W | 17,072 | 17,019 | 0 | 16,558 | 16,569 | 0 |
| | AN | 13,176 | 13,391 | 2 | 13,223 | 13,442 | 2 |
| | BN | 14,044 | 14,251 | 1 | 14,159 | 14,201 | 0 |
| | D | 13,133 | 13,264 | 1 | 12,846 | 13,135 | 2 |
| | C | 12,196 | 12,085 | -1 | 11,976 | 11,956 | 0 |
| November | Average | 19,512 | 19,554 | 0 | 19,463 | 19,503 | 0 |
| | W | 26,429 | 26,491 | 0 | 26,536 | 26,433 | 0 |
| | AN | 20,269 | 19,631 | -3 | 20,052 | 19,651 | -3 |
| | BN | 16,984 | 17,064 | 0 | 16,980 | 16,972 | 0 |
| | D | 15,771 | 16,056 | 2 | 15,705 | 16,116 | 2 |
| | C | 12,330 | 12,595 | 2 | 12,081 | 12,372 | 0 |
| December | Average | 30,984 | 30,673 | -1 | 30,988 | 30,568 | -1 |
| | W | 53,758 | 53,109 | -1 | 53,516 | 52,482 | -2 |
| | AN | 28,431 | 28,177 | -1 | 28,223 | 27,981 | -1 |
| | BN | 21,958 | 21,606 | -2 | 22,143 | 21,842 | -1 |
| | D | 18,560 | 18,550 | 0 | 18,837 | 18,696 | -1 |
| | C | 13,363 | 13,322 | 0 | 13,484 | 13,666 | 1 |

Note:
A negative percentage change reflects a reduction in Delta inflow

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

*Impact Aqua-19 (CP5): Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow* Project operation would result in a variable response in Sacramento River inflow, resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water year type. Decreases in Sacramento River inflow would not equal or exceed 5 percent. This impact would be less than significant.

Results of hydrologic modeling, by month and year type, for the Existing Condition, No-Action Alternative, and CP5 for Sacramento River inflow, are presented in Table 11-55. Results of these analyses show a variable response in Sacramento River inflow with CP5 operations resulting in both increases and decreases in river inflow above the Existing Condition and the No-Action Alternative, depending on month and water year. Under CP5, Sacramento River inflow would not decrease by 5 percent or more. Based on these results, the impact of CP5 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 11-55. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP5**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 31,139 | 31,046 | 0 | 31,167 | 31,076 | 0 |
| | W | 50,173 | 50,011 | 0 | 50,164 | 49,899 | -1 |
| | AN | 38,122 | 37,945 | 0 | 38,006 | 37,975 | 0 |
| | BN | 22,370 | 22,420 | 0 | 22,540 | 22,643 | 0 |
| | D | 16,980 | 16,884 | -1 | 17,109 | 16,929 | -1 |
| | C | 14,384 | 14,362 | 0 | 14,322 | 14,455 | 1 |
| February | Average | 36,608 | 36,559 | 0 | 36,618 | 36,490 | 0 |
| | W | 56,740 | 56,751 | 0 | 56,637 | 56,637 | 0 |
| | AN | 44,453 | 43,913 | -1 | 44,672 | 44,028 | -1 |
| | BN | 30,911 | 31,090 | 1 | 30,780 | 30,832 | 0 |
| | D | 21,249 | 21,103 | -1 | 21,237 | 21,002 | -1 |
| | C | 14,830 | 15,020 | 1 | 15,075 | 15,129 | 0 |
| March | Average | 32,396 | 32,301 | 0 | 32,352 | 32,284 | 0 |
| | W | 49,248 | 49,293 | 0 | 49,403 | 49,459 | 0 |
| | AN | 44,060 | 43,672 | -1 | 43,972 | 43,624 | -1 |
| | BN | 23,188 | 22,866 | -1 | 23,068 | 22,855 | -1 |
| | D | 20,390 | 20,414 | 0 | 20,138 | 20,151 | 0 |
| | C | 12,971 | 12,954 | 0 | 12,942 | 12,930 | 0 |
| April | Average | 23,232 | 23,290 | 0 | 23,206 | 23,257 | 0 |
| | W | 37,918 | 37,953 | 0 | 38,019 | 38,025 | 0 |
| | AN | 26,053 | 26,062 | 0 | 26,039 | 26,048 | 0 |
| | BN | 17,518 | 17,648 | 1 | 17,439 | 17,526 | 0 |
| | D | 13,205 | 13,300 | 1 | 13,164 | 13,297 | 1 |
| | C | 10,295 | 10,316 | 0 | 10,067 | 10,095 | 0 |
| May | Average | 19,417 | 19,349 | 0 | 19,114 | 19,054 | 0 |
| | W | 32,095 | 32,071 | 0 | 31,800 | 31,789 | 0 |
| | AN | 21,204 | 21,092 | -1 | 21,080 | 20,871 | -1 |
| | BN | 14,530 | 14,133 | -3 | 14,144 | 13,780 | -3 |
| | D | 11,226 | 11,332 | 1 | 10,836 | 10,987 | 1 |
| | C | 8,148 | 8,152 | 0 | 7,874 | 7,901 | 0 |

**Table 11-55. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP5 (contd.)**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| June | Average | 16,508 | 16,452 | 0 | 16,511 | 16,420 | -1 |
| | W | 24,092 | 24,090 | 0 | 23,905 | 23,920 | 0 |
| | AN | 16,598 | 16,136 | -3 | 16,533 | 16,166 | -2 |
| | BN | 13,792 | 13,879 | 1 | 13,822 | 13,677 | -1 |
| | D | 12,283 | 12,271 | 0 | 12,569 | 12,493 | -1 |
| | C | 9,492 | 9,493 | 0 | 9,516 | 9,517 | 0 |
| July | Average | 19,518 | 19,579 | 0 | 19,266 | 19,386 | 1 |
| | W | 20,071 | 20,058 | 0 | 20,058 | 20,016 | 0 |
| | AN | 22,070 | 21,966 | 0 | 21,976 | 21,927 | 0 |
| | BN | 21,232 | 21,301 | 0 | 21,374 | 21,350 | 0 |
| | D | 19,577 | 19,623 | 0 | 18,788 | 19,113 | 2 |
| | C | 13,683 | 14,077 | 3 | 13,100 | 13,596 | 4 |
| August | Average | 14,710 | 14,717 | 0 | 14,596 | 14,697 | 1 |
| | W | 16,285 | 16,266 | 0 | 16,189 | 16,152 | 0 |
| | AN | 16,418 | 16,388 | 0 | 16,561 | 16,575 | 0 |
| | BN | 16,112 | 16,040 | 0 | 16,170 | 16,105 | 0 |
| | D | 13,632 | 13,915 | 2 | 12,968 | 13,572 | 5 |
| | C | 9,570 | 9,348 | -2 | 9,785 | 9,716 | -1 |
| September | Average | 18,211 | 18,449 | 1 | 18,417 | 18,733 | 2 |
| | W | 27,839 | 27,997 | 1 | 28,337 | 28,426 | 0 |
| | AN | 21,244 | 21,234 | 0 | 22,088 | 22,218 | 1 |
| | BN | 14,088 | 14,038 | 0 | 14,147 | 14,236 | 1 |
| | D | 12,522 | 13,036 | 4 | 12,341 | 13,147 | 7 |
| | C | 7,664 | 8,241 | 8 | 7,347 | 7,869 | 7 |
| October | Average | 11,309 | 11,416 | 1 | 11,117 | 11,230 | 1 |
| | W | 13,419 | 13,506 | 1 | 13,040 | 13,080 | 0 |
| | AN | 10,499 | 10,714 | 2 | 10,571 | 10,790 | 2 |
| | BN | 11,053 | 11,259 | 2 | 11,195 | 11,242 | 0 |
| | D | 10,150 | 10,281 | 1 | 9,830 | 10,120 | 3 |
| | C | 9,587 | 9,477 | -1 | 9,333 | 9,313 | 0 |
| November | Average | 15,640 | 15,710 | 0 | 15,605 | 15,694 | 1 |
| | W | 20,726 | 20,867 | 1 | 20,832 | 20,860 | 0 |
| | AN | 16,893 | 16,281 | -4 | 16,666 | 16,319 | -2 |
| | BN | 13,755 | 13,833 | 1 | 13,793 | 13,784 | 0 |
| | D | 12,720 | 13,004 | 2 | 12,723 | 13,134 | 3 |
| | C | 9,948 | 10,214 | 3 | 9,653 | 9,944 | 3 |

**Table 11-55. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP5 (contd.)**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| December | Average | 23,248 | 23,143 | 0 | 23,229 | 23,090 | -1 |
| | W | 37,645 | 37,387 | -1 | 37,434 | 37,102 | -1 |
| | AN | 22,604 | 22,532 | 0 | 22,461 | 22,282 | -1 |
| | BN | 16,930 | 16,902 | 0 | 17,103 | 17,083 | 0 |
| | D | 15,760 | 15,750 | 0 | 15,934 | 15,792 | -1 |
| | C | 11,303 | 11,262 | 0 | 11,310 | 11,492 | 2 |

Note: A negative percentage change reflects a reduction in Sacramento River inflow
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

*Impact Aqua-20 (CP5): Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis* CP5 operation would result in no discernible 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. There would be no impact.

Results of hydrologic modeling, by month and water year type, for the Existing Condition, No-Action Alternative, and CP5 for San Joaquin River flow are summarized in Table 11-56. Results of these analyses show that CP5 would have no effect on seasonal San Joaquin River flows compared with the Existing Condition and No-Action Alternative. Based on these results CP5 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 11-56. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP5**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| January | Average | 4,770 | 4,770 | 0 | 4,764 | 4,764 | 0 |
| | W | 9,273 | 9,273 | 0 | 9,097 | 9,097 | 0 |
| | AN | 4,223 | 4,223 | 0 | 4,259 | 4,259 | 0 |
| | BN | 2,986 | 2,986 | 0 | 3,081 | 3,081 | 0 |
| | D | 2,084 | 2,084 | 0 | 2,160 | 2,160 | 0 |
| | C | 1,673 | 1,673 | 0 | 1,746 | 1,746 | 0 |

**Table 11-56. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP5 (contd.)**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| February | Average | 6,265 | 6,265 | 0 | 6,143 | 6,143 | 0 |
| | W | 11,036 | 11,036 | 0 | 10,845 | 10,845 | 0 |
| | AN | 6,047 | 6,047 | 0 | 6,179 | 6,179 | 0 |
| | BN | 5,767 | 5,767 | 0 | 5,565 | 5,565 | 0 |
| | D | 2,642 | 2,642 | 0 | 2,528 | 2,528 | 0 |
| | C | 2,161 | 2,161 | 0 | 2,014 | 2,014 | 0 |
| March | Average | 7,133 | 7,133 | 0 | 7,003 | 7,003 | 0 |
| | W | 13,443 | 13,443 | 0 | 13,170 | 13,170 | 0 |
| | AN | 6,788 | 6,788 | 0 | 6,674 | 6,673 | 0 |
| | BN | 5,322 | 5,322 | 0 | 5,293 | 5,293 | 0 |
| | D | 2,963 | 2,963 | 0 | 2,895 | 2,895 | 0 |
| | C | 2,176 | 2,176 | 0 | 2,129 | 2,129 | 0 |
| April | Average | 6,720 | 6,720 | 0 | 7,533 | 7,533 | 0 |
| | W | 11,420 | 11,420 | 0 | 12,614 | 12,614 | 0 |
| | AN | 6,671 | 6,671 | 0 | 7,799 | 7,798 | 0 |
| | BN | 5,852 | 5,852 | 0 | 6,910 | 6,910 | 0 |
| | D | 3,726 | 3,726 | 0 | 4,112 | 4,112 | 0 |
| | C | 2,087 | 2,087 | 0 | 2,118 | 2,118 | 0 |
| May | Average | 6,204 | 6,204 | 0 | 6,234 | 6,234 | 0 |
| | W | 11,268 | 11,268 | 0 | 11,135 | 11,135 | 0 |
| | AN | 5,611 | 5,611 | 0 | 5,987 | 5,987 | 0 |
| | BN | 5,010 | 5,010 | 0 | 5,108 | 5,108 | 0 |
| | D | 3,070 | 3,070 | 0 | 3,111 | 3,111 | 0 |
| | C | 1,920 | 1,920 | 0 | 1,862 | 1,862 | 0 |
| June | Average | 4,739 | 4,739 | 0 | 4,671 | 4,671 | 0 |
| | W | 9,451 | 9,451 | 0 | 9,390 | 9,390 | 0 |
| | AN | 5,608 | 5,609 | 0 | 5,326 | 5,326 | 0 |
| | BN | 2,424 | 2,424 | 0 | 2,471 | 2,470 | 0 |
| | D | 1,598 | 1,598 | 0 | 1,554 | 1,554 | 0 |
| | C | 1,076 | 1,076 | 0 | 1,035 | 1,035 | 0 |
| July | Average | 3,202 | 3,202 | 0 | 3,208 | 3,208 | 0 |
| | W | 6,556 | 6,556 | 0 | 6,660 | 6,660 | 0 |
| | AN | 2,783 | 2,784 | 0 | 2,767 | 2,768 | 0 |
| | BN | 1,775 | 1,775 | 0 | 1,733 | 1,733 | 0 |
| | D | 1,282 | 1,282 | 0 | 1,216 | 1,216 | 0 |
| | C | 898 | 898 | 0 | 880 | 880 | 0 |

**Table 11-56. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP5 (contd.)**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| August | Average | 2,029 | 2,029 | 0 | 2,040 | 2,041 | 0 |
| | W | 3,099 | 3,099 | 0 | 3,158 | 3,159 | 0 |
| | AN | 2,020 | 2,020 | 0 | 2,014 | 2,015 | 0 |
| | BN | 1,828 | 1,828 | 0 | 1,817 | 1,816 | 0 |
| | D | 1,342 | 1,342 | 0 | 1,315 | 1,315 | 0 |
| | C | 984 | 984 | 0 | 993 | 993 | 0 |
| September | Average | 2,331 | 2,331 | 0 | 2,340 | 2,340 | 0 |
| | W | 3,274 | 3,274 | 0 | 3,317 | 3,317 | 0 |
| | AN | 2,328 | 2,328 | 0 | 2,312 | 2,312 | 0 |
| | BN | 2,109 | 2,109 | 0 | 2,119 | 2,119 | 0 |
| | D | 1,795 | 1,795 | 0 | 1,774 | 1,775 | 0 |
| | C | 1,358 | 1,358 | 0 | 1,355 | 1,355 | 0 |
| October | Average | 2,757 | 2,757 | 0 | 2,753 | 2,753 | 0 |
| | W | 3,112 | 3,112 | 0 | 3,107 | 3,107 | 0 |
| | AN | 2,446 | 2,446 | 0 | 2,424 | 2,424 | 0 |
| | BN | 2,749 | 2,749 | 0 | 2,718 | 2,718 | 0 |
| | D | 2,686 | 2,686 | 0 | 2,710 | 2,710 | 0 |
| | C | 2,416 | 2,416 | 0 | 2,423 | 2,423 | 0 |
| November | Average | 2,633 | 2,633 | 0 | 2,603 | 2,603 | 0 |
| | W | 3,372 | 3,372 | 0 | 3,340 | 3,340 | 0 |
| | AN | 2,213 | 2,213 | 0 | 2,176 | 2,176 | 0 |
| | BN | 2,412 | 2,412 | 0 | 2,360 | 2,360 | 0 |
| | D | 2,388 | 2,388 | 0 | 2,355 | 2,355 | 0 |
| | C | 2,075 | 2,075 | 0 | 2,088 | 2,088 | 0 |
| December | Average | 3,199 | 3,199 | 0 | 3,263 | 3,263 | 0 |
| | W | 5,081 | 5,081 | 0 | 5,178 | 5,178 | 0 |
| | AN | 2,916 | 2,916 | 0 | 2,899 | 2,899 | 0 |
| | BN | 2,705 | 2,705 | 0 | 2,753 | 2,753 | 0 |
| | D | 2,047 | 2,047 | 0 | 2,123 | 2,123 | 0 |
| | C | 1,710 | 1,710 | 0 | 1,785 | 1,785 | 0 |

Note:
A negative percentage change reflects a reduction in San Joaquin River inflow
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

*Impact Aqua-21 (CP5): Reduction in Low-Salinity Habitat Conditions Resulting from an Upstream Shift in X2 Location* CP5 operation would result in less than 0.5 km movement upstream or downstream from the X2 location from its location under the Existing Condition or No-Action Alternative during February through May and September through November, and thus cause minimal reduction in low-salinity habitats. This impact would be less than significant.

The 1 km X2 criterion was applied to a comparison of hydrologic model results for the Existing Condition, No-Action Alternative, and CP5, by month and water year type, for the months from February through May and September through November. Results of the comparisons are summarized in Table 11-57. These results showed that changes in X2 location under CP5 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. Based on these results, CP5 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 11-57. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP5**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Location (km)** | **Location (km)** | **Difference (km)** | **Location (km)** | **Location (km)** | **Difference (km)** |
| January | Average | 67.5 | 67.5 | 0.0 | 67.3 | 67.3 | 0.0 |
| | W | 53.6 | 53.7 | 0.1 | 53.7 | 53.8 | 0.1 |
| | AN | 61.7 | 61.7 | 0.0 | 61.6 | 61.5 | 0.0 |
| | BN | 72.1 | 72.0 | -0.1 | 71.7 | 71.6 | -0.1 |
| | D | 77.9 | 78.0 | 0.1 | 77.4 | 77.6 | 0.2 |
| | C | 82.2 | 82.1 | -0.1 | 81.9 | 81.8 | -0.2 |
| February | Average | 60.9 | 61.0 | 0.0 | 60.8 | 60.9 | 0.1 |
| | W | 50.4 | 50.4 | 0.0 | 50.4 | 50.4 | 0.0 |
| | AN | 54.8 | 54.8 | 0.0 | 54.6 | 54.6 | 0.1 |
| | BN | 61.0 | 61.0 | 0.0 | 60.9 | 60.9 | 0.0 |
| | D | 70.1 | 70.2 | 0.1 | 69.9 | 70.0 | 0.1 |
| | C | 76.2 | 76.2 | 0.0 | 75.9 | 75.9 | 0.0 |
| March | Average | 60.9 | 61.0 | 0.0 | 60.9 | 60.9 | 0.0 |
| | W | 52.1 | 52.1 | 0.0 | 52.1 | 52.1 | 0.0 |
| | AN | 53.6 | 53.8 | 0.1 | 53.7 | 53.7 | 0.0 |
| | BN | 63.3 | 63.4 | 0.2 | 63.3 | 63.5 | 0.1 |
| | D | 67.1 | 67.0 | -0.1 | 67.2 | 67.1 | 0.0 |
| | C | 75.2 | 75.3 | 0.1 | 75.1 | 75.1 | 0.0 |
| April | Average | 63.5 | 63.5 | 0.0 | 63.4 | 63.4 | 0.0 |
| | W | 54.5 | 54.5 | 0.0 | 54.3 | 54.3 | 0.0 |
| | AN | 58.6 | 58.6 | 0.0 | 58.4 | 58.4 | 0.0 |
| | BN | 64.5 | 64.5 | 0.0 | 64.1 | 64.1 | 0.0 |
| | D | 69.9 | 69.8 | -0.1 | 69.9 | 69.7 | -0.1 |
| | C | 77.5 | 77.4 | 0.0 | 77.6 | 77.7 | 0.0 |

**Table 11-57. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP5 (contd.)**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Location (km)** | **Location (km)** | **Difference (km)** | **Location (km)** | **Location (km)** | **Difference (km)** |
| May | Average | 67.5 | 67.5 | 0.0 | 67.7 | 67.6 | 0.0 |
| | W | 57.6 | 57.6 | 0.0 | 57.7 | 57.7 | 0.0 |
| | AN | 62.7 | 62.7 | 0.0 | 62.6 | 62.6 | 0.0 |
| | BN | 68.3 | 68.4 | 0.1 | 68.3 | 68.4 | 0.1 |
| | D | 74.4 | 74.2 | -0.2 | 74.8 | 74.6 | -0.2 |
| | C | 82.5 | 82.5 | 0.0 | 82.9 | 82.9 | 0.0 |
| June | Average | 74.5 | 74.6 | 0.0 | 74.7 | 74.8 | 0.1 |
| | W | 65.0 | 65.0 | 0.0 | 65.2 | 65.2 | 0.0 |
| | AN | 72.6 | 72.8 | 0.2 | 72.7 | 72.9 | 0.2 |
| | BN | 76.6 | 76.6 | 0.0 | 76.7 | 76.9 | 0.3 |
| | D | 80.4 | 80.4 | -0.1 | 80.7 | 80.6 | -0.1 |
| | C | 85.9 | 85.8 | 0.0 | 86.0 | 86.1 | 0.0 |
| July | Average | 80.5 | 80.5 | 0.0 | 80.5 | 80.6 | 0.0 |
| | W | 74.4 | 74.4 | 0.0 | 74.5 | 74.5 | 0.0 |
| | AN | 78.1 | 78.3 | 0.2 | 78.4 | 78.5 | 0.1 |
| | BN | 81.7 | 81.7 | 0.0 | 81.6 | 81.7 | 0.1 |
| | D | 84.8 | 84.8 | 0.0 | 84.8 | 84.8 | 0.1 |
| | C | 88.1 | 88.0 | 0.0 | 88.0 | 88.0 | 0.0 |
| August | Average | 85.6 | 85.5 | 0.0 | 85.6 | 85.5 | 0.0 |
| | W | 82.7 | 82.7 | 0.0 | 82.8 | 82.9 | 0.0 |
| | AN | 83.7 | 83.8 | 0.0 | 83.9 | 83.9 | 0.0 |
| | BN | 85.6 | 85.5 | 0.0 | 85.5 | 85.4 | -0.1 |
| | D | 87.8 | 87.8 | 0.0 | 87.5 | 87.5 | 0.0 |
| | C | 90.4 | 90.2 | -0.2 | 90.2 | 90.1 | -0.1 |
| September | Average | 83.7 | 83.6 | 0.0 | 83.7 | 83.6 | -0.1 |
| | W | 73.4 | 73.4 | 0.0 | 73.5 | 73.5 | 0.0 |
| | AN | 81.4 | 81.4 | 0.0 | 81.4 | 81.4 | 0.0 |
| | BN | 88.8 | 88.9 | 0.0 | 88.8 | 88.7 | 0.0 |
| | D | 90.2 | 90.1 | -0.1 | 90.0 | 89.8 | -0.2 |
| | C | 92.5 | 92.3 | -0.2 | 92.3 | 92.2 | -0.1 |
| October | Average | 83.9 | 83.8 | -0.1 | 83.9 | 83.8 | -0.1 |
| | W | 73.6 | 73.5 | 0.0 | 73.7 | 73.7 | 0.0 |
| | AN | 79.8 | 79.8 | 0.0 | 79.8 | 79.9 | 0.0 |
| | BN | 88.9 | 88.9 | 0.0 | 88.9 | 88.9 | 0.0 |
| | D | 91.4 | 91.3 | -0.2 | 91.3 | 91.2 | -0.1 |
| | C | 93.3 | 93.1 | -0.2 | 93.1 | 92.7 | -0.4 |

**Table 11-57. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP5 (contd.)**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Location (km)** | **Location (km)** | **Difference (km)** | **Location (km)** | **Location (km)** | **Difference (km)** |
| November | Average | 82.2 | 82.3 | 0.1 | 82.2 | 82.3 | 0.1 |
| | W | 73.1 | 73.1 | 0.0 | 73.2 | 73.2 | 0.0 |
| | AN | 78.4 | 78.4 | 0.0 | 78.4 | 78.5 | 0.1 |
| | BN | 84.8 | 85.3 | 0.6 | 84.8 | 85.4 | 0.6 |
| | D | 88.9 | 88.9 | -0.1 | 88.8 | 88.9 | 0.1 |
| | C | 92.6 | 92.6 | -0.1 | 92.8 | 92.5 | -0.2 |
| December | Average | 76.1 | 76.2 | 0.1 | 76.0 | 76.1 | 0.1 |
| | W | 62.9 | 63.0 | 0.1 | 63.0 | 63.2 | 0.2 |
| | AN | 76.4 | 76.9 | 0.4 | 76.4 | 76.8 | 0.4 |
| | BN | 81.4 | 81.4 | 0.0 | 81.1 | 81.2 | 0.0 |
| | D | 82.8 | 82.8 | 0.0 | 82.6 | 82.7 | 0.1 |
| | C | 87.9 | 87.8 | 0.0 | 87.8 | 87.5 | -0.3 |

Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
D = dry
km = kilometer
W = wet

*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 operation would result in minimal increases in reverse flows in Old and Middle rivers during January, March and April; however, flows do not exceed (become more negative) -5,000 cfs. Because the flows do not exceed -5,000 cfs, the increases in reverse flows are not expected to contribute to an increase in the vulnerability of delta smelt, longfin smelt, Chinook salmon, juvenile striped bass, or threadfin shad, but summer Old and Middle river flows could contribute to an increase in vulnerability of other resident warm-water fish to increased salvage and potential losses. This impact would be less than significant.

Results of the analysis showed several occurrences when reverse flows within Old and Middle rivers would be higher than either 2005 or 2030 conditions by more than 5 percent. These events would mainly occur in critical water years, which would be expected as a result of greater export operations under CP5. An increase in average monthly reverse flows of 5 percent also would occur in March of above-normal years.

During January (Table 11-58), operations under CP5 resulted in an increase in reverse flow of 5 percent during critical years compared with the No-Action Alternative. Based on results of the delta smelt analysis of the relationship between reverse flows and delta smelt salvage, the increase of approximately 200 cfs in a critical water year would not be expected to result in a significant increase in adverse effects to delta smelt or longfin smelt.

**Table 11-58. Old and Middle River Reverse Flows Under Existing Conditions, No-Action Alternative, and CP5**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| Month | Water Year | Flow (cfs) | Flow (cfs) | Percent Change | Flow (cfs) | Flow (cfs) | Percent Change |
| January | Average | -3,542 | -3,526 | 0 | -3,553 | -3,572 | 1 |
| | W | -2,034 | -2,034 | 0 | -2,151 | -2,151 | 0 |
| | AN | -3,654 | -3,586 | -2 | -3,574 | -3,523 | -1 |
| | BN | -4,240 | -4,240 | 0 | -4,240 | -4,240 | 0 |
| | D | -4,773 | -4,814 | 1 | -4,772 | -4,771 | 0 |
| | C | -4,033 | -3,936 | -2 | -3,940 | -4,123 | 5 |
| February | Average | -3,293 | -3,300 | 0 | -3,358 | -3,374 | 0 |
| | W | -2,745 | -2,735 | 0 | -2,950 | -2,973 | 1 |
| | AN | -3,248 | -3,035 | -7 | -3,165 | -3,114 | -2 |
| | BN | -3,335 | -3,437 | 3 | -3,291 | -3,312 | 1 |
| | D | -4,016 | -4,036 | 0 | -4,045 | -4,065 | 0 |
| | C | -3,391 | -3,528 | 4 | -3,482 | -3,542 | 2 |
| March | Average | -2,784 | -2,817 | 1 | -2,877 | -2,869 | 0 |
| | W | -1,792 | -1,808 | 1 | -2,023 | -2,048 | 1 |
| | AN | -4,021 | -4,230 | 5 | -4,260 | -4,281 | 1 |
| | BN | -4,005 | -4,002 | 0 | -3,982 | -3,985 | 0 |
| | D | -2,951 | -2,872 | -3 | -2,918 | -2,838 | -3 |
| | C | -2,023 | -2,125 | 5 | -1,994 | -1,979 | -1 |
| April | Average | 955 | 954 | 0 | 1,060 | 1,063 | 0 |
| | W | 2,706 | 2,706 | 0 | 2,798 | 2,806 | 0 |
| | AN | 1,087 | 1,087 | 0 | 1,314 | 1,314 | 0 |
| | BN | 697 | 697 | 0 | 898 | 898 | 0 |
| | D | -244 | -249 | 2 | -207 | -206 | 0 |
| | C | -874 | -874 | 0 | -872 | -872 | 0 |
| May | Average | 491 | 491 | 0 | 416 | 409 | -2 |
| | W | 2,077 | 2,077 | 0 | 1,781 | 1,781 | 0 |
| | AN | 562 | 562 | 0 | 646 | 646 | 0 |
| | BN | 277 | 277 | 0 | 270 | 270 | 0 |
| | D | -674 | -674 | 0 | -696 | -695 | 0 |
| | C | -1,018 | -1,022 | 0 | -936 | -984 | 5 |

**Table 11-58. Old and Middle River Reverse Flows Under Existing Conditions, No-Action Alternative, and CP5 (contd.)**

| | | Existing Condition | CP5 (2005) | | No-Action Alternative | CP5 (2030) | |
|---|---|---|---|---|---|---|---|
| **Month** | **Water Year** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** | **Flow (cfs)** | **Flow (cfs)** | **Percent Change** |
| June | Average | -3,654 | -3,669 | 0 | -3,718 | -3,737 | 0 |
| | W | -4,226 | -4,226 | 0 | -4,354 | -4,359 | 0 |
| | AN | -4,825 | -4,819 | 0 | -4,818 | -4,818 | 0 |
| | BN | -4,137 | -4,233 | 2 | -4,119 | -4,227 | 3 |
| | D | -3,079 | -3,079 | 0 | -3,205 | -3,198 | 0 |
| | C | -1,542 | -1,542 | 0 | -1,542 | -1,542 | 0 |
| July | Average | -9,502 | -9,559 | 1 | -9,292 | -9,402 | 1 |
| | W | -8,948 | -8,943 | 0 | -8,905 | -8,901 | 0 |
| | AN | -9,993 | -9,936 | -1 | -9,929 | -9,906 | 0 |
| | BN | -10,886 | -10,937 | 0 | -10,903 | -10,853 | 0 |
| | D | -10,998 | -11,051 | 0 | -10,419 | -10,692 | 3 |
| | C | -6,355 | -6,672 | 5 | -5,928 | -6,354 | 7 |

Note:
A positive percentage change reflects more negative reverse flows under CP5 when compared to the Existing Condition or the No-Action Alternative.
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Juvenile Chinook salmon and steelhead are migrating through the Delta during January, and an increase in average monthly reverse flows of around 200 cfs would be expected to increase the potential risk of increased mortality to these species. 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 January 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 January.

The increase in average monthly reverse flows estimated to occur under CP5 in critical and above-normal water years in March (under 2005 conditions), in critical years in May (under 2030 conditions), and in critical years in July (under both 2005 and 2030 conditions) would exceed 5 percent. This increase could negatively affect resident warm water fish species.

Juvenile and larval delta smelt occur in the area in March through May, and juvenile and larval longfin smelt are present in March. A change in Old and Middle river flows of approximately 100 to 200 cfs may result in an increase in their vulnerability to CVP and SWP salvage, but this increase is expected to be less than significant. The increased reverse flows in May of critical water years would occur at a time of year when water temperatures in the Delta are typically increasing and juvenile Chinook salmon or steelhead may be more abundant in the area. However, changes to reverse flows in March and May would not exceed the -5,000 cfs criteria established by the USFWS and NMFS BOs, and would result in less-than-significant impacts to Chinook salmon and steelhead.

The increased average monthly reverse flows in July of critical years would 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 be present in the area. Longfin smelt would not be expected in the area, and low numbers of juvenile delta smelt may occur in the area in July. However, 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. Therefore, changes in reverse flows in July would result in less-than-significant impacts to Chinook salmon, steelhead delta smelt and longfin smelt.

The increase in reverse flows estimated from the modeling in July of a critical water year 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 small but less-than-significant increase in mortality for resident warm-water fish inhabiting the south Delta.

The potential increase in losses during January, March and May under CP5 is considered to be less than significant for Chinook salmon, steelhead, delta smelt and longfin smelt. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species, and thus reduce effects to non-listed fish species as well.

*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 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. 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 CDFW. The resulting impact to Chinook salmon and steelhead would be less than significant; the resulting impact to delta smelt, longfin smelt striped bass, and splittail would be potentially significant. Overall, this impact would be potentially significant.

Results of the entrainment loss modeling at the CVP and SWP export facilities are presented in Table 11-59 for CP5. The estimated index of total numbers of fish lost annually, by species, is presented in Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report.* The difference between the nonoperations related and operations related fish mortality is represented as the entrainment index, shown in Table 11-55, to represent the effect of project operations on each selected fish species at the CVP and SWP facilities.

**Table 11-59. Entrainment at the CVP and SWP Facilities Comparing Existing Conditions, No-Action Alternative, and CP5**

| Species | Water Year | CP5 minus Existing Condition | Percent Change | CP5 Minus Future Condition | Percent Change |
|---|---|---|---|---|---|
| Delta Smelt | Average | 60 | 0.1 | 162 | 0.4 |
| | W | -4 | -0.0 | 22 | 0.0 |
| | AN | -56 | -0.1 | -22 | -0.1 |
| | BN | 289 | 0.8 | 286 | 0.8 |
| | D | 15 | 0.0 | 30 | 0.1 |
| | C | 114 | 0.5 | 707 | 3.1 |
| Chinook Salmon | Average | 67 | 0.1 | 124 | 0.2 |
| | W | 4 | 0.0 | 42 | 0.1 |
| | AN | -96 | -0.2 | -79 | -0.2 |
| | BN | 257 | 0.6 | 169 | 0.4 |
| | D | -8 | -0.0 | -59 | -0.1 |
| | C | 255 | 0.7 | 728 | 2.2 |
| Longfin Smelt | Average | 2 | 0.0 | 21 | 0.3 |
| | W | -1 | -0.0 | -4 | -0.0 |
| | AN | 2 | 0.0 | 0 | -0.0 |
| | BN | 3 | 0.1 | 3 | 0.1 |
| | D | 2 | 0.0 | 0 | -0.0 |
| | C | 11 | 0.2 | 149 | 3.0 |
| Steelhead | Average | 7 | 0.2 | 7 | 0.2 |
| | W | 1 | 0.0 | 10 | 0.2 |
| | AN | -26 | -0.6 | -17 | -0.4 |
| | BN | 28 | 0.7 | 7 | 0.2 |
| | D | -2 | -0.1 | -8 | -0.2 |
| | C | 41 | 1.5 | 47 | 1.7 |
| Striped Bass | Average | 7,044 | 0.5 | 11,575 | 0.9 |
| | W | 1,854 | 0.1 | 2,393 | 0.1 |
| | AN | -214 | -0.0 | 2,958 | 0.2 |
| | BN | 13,841 | 1.0 | 9,181 | 0.7 |
| | D | 9,518 | 0.9 | 24,383 | 2.2 |
| | C | 13,907 | 2.2 | 23,669 | 4.0 |

**Table 11-59. Entrainment at the CVP and SWP Facilities Comparing Existing Conditions, No-Action Alternative, and CP5 (contd.)**

| Species | Water Year | CP5 minus Existing Condition | Percent Change | CP5 Minus Future Condition | Percent Change |
|---|---|---|---|---|---|
| Splittail | Average | 1,075 | 0.4 | 1,753 | 0.7 |
| | W | -31 | -0.0 | 171 | 0.0 |
| | AN | -727 | -0.2 | -195 | -0.1 |
| | BN | 3,671 | 1.4 | 3,108 | 1.2 |
| | D | 588 | 0.3 | 2,498 | 1.2 |
| | C | 2,976 | 2.9 | 4,432 | 4.6 |

Note:
Negative percentage change reflects a reduction in entrainment risk while a positive percentage change reflects an increase in entrainment risk.
Key:
AN = above-normal
BN = below-normal
C = critical
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 of less than 3 percent during critical water years under CP5 relative to the Existing Condition (Table 11-59). The risk of increased losses of delta smelt under CP5 compared to the No-Action Alternative (Table 11-59) would be greatest in the below-normal water 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 would also contribute to cumulative factors affecting the survival of delta smelt.

The estimated change in the risk of losses for salmon increases during below-normal and critical water years under 2005 conditions, and above-normal and below-normal water years under 2030 conditions (Table 11-59). 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 would be a less-than-significant direct 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 change in the risk of longfin smelt entrainment/salvage under CP5 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 11-59). These small changes in the risk of entrainment would be less than significant in most water years. The estimated 3 percent increase in entrainment risk in critically dry years is potentially significant given the trend of low longfin smelt juvenile production in dry years.

The change in the risk to steelhead of entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-59. 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 (less than 2 percent), 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 critical water years represents an initial estimate of the change (percentage) between CP5 and Existing Conditions and the No-Action Alternative, and does not allow the predicted losses to be evaluated at the population level (see Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report)*.

The estimated changes in risk to juvenile striped bass from entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-55. The change in risk in wet, above-normal, and below-normal water years are considered to be less than significant for 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 and is considered to be a potentially significant impact. The increased losses under CP5, 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.

The overall average increased risk index for splittail was less than 1 percent under both 2005 and 2030 conditions, and was considered to be less than significant. The loss index is, however, higher during dry and critical 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 (CP5) is considered to be less than significant for Chinook salmon and steelhead, but potentially significant for delta smelt, longfin 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 to reduce any impacts to listed fish species, thus reducing the impacts to non-listed fish species.

**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 to tributaries and reservoirs (e.g., New Melones and San Luis) from CVP and SWP dams, as well as the conveyances south of the Delta would be substantially less than impacts on the lower Sacramento River. The change in hydrology to the CVP and SWP service areas could affect aquatic habitats that provide habitat for the fish community; however these changes would not result in substantial effects on their distribution or abundance. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-24 (CP1). The hydrologic effects to the CVP and SWP service areas would not result in substantial effects on the distribution or abundance of the fish species. The effects from CP5 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 11-60 presents a summary of mitigation measures for fisheries and aquatic ecosystems.

### *No-Action Alternative*

No mitigation measures are required for this alternative.

**Table 11-60. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems**

| Impact | | No-Action Alternative | CP1 | CP2 | CP3 | CP4/CP4A | CP5 |
|---|---|---|---|---|---|---|---|
| Impact Aqua-1: Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations | 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-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 |
| 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 |

**Table 11-60. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)**

| Impact | | No-Action Alternative | CP1 | CP2 | CP3 | CP4/CP4A | CP5 |
|---|---|---|---|---|---|---|---|
| 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 | PS | PS | PS | PS | PS |
| | Mitigation Measure | None required. | Mitigation Measure Aqua-7: Implement Mitigation Measure Geo-2: Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact. | | | | None required. |
| | LOS after Mitigation | NI | LTS | LTS | LTS | LTS | LTS |
| 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 |

**Table 11-60. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)**

| Impact | | No-Action Alternative | CP1 | CP2 | CP3 | CP4/CP4A | CP5 |
|---|---|---|---|---|---|---|---|
| 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 |
| Impact Aqua-12: Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon and Steelhead | LOS before Mitigation | PS | LTS | B | B | B | B |
| | Mitigation Measure | None required. | None needed; thus, none proposed. | | | | |
| | LOS after Mitigation | PS | LTS | B | B | B | B |

**Table 11-60. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)**

| Impact | | No-Action Alternative | CP1 | CP2 | CP3 | CP4/CP4A | CP5 |
|---|---|---|---|---|---|---|---|
| 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: 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-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 |

**Table 11-60. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)**

| Impact | | No-Action Alternative | CP1 | CP2 | CP3 | CP4/CP4A | CP5 |
|---|---|---|---|---|---|---|---|
| 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: 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 Fisheries 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 |
| Impact Aqua-18: Effects to Delta Fisheries 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 |

**Table 11-60. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)**

| Impact | | No-Action Alternative | CP1 | CP2 | CP3 | CP4/CP4A | CP5 |
|---|---|---|---|---|---|---|---|
| Impact Aqua-20: Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis | 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-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 |
| 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 | 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-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 | PS | PS | PS | PS | PS |
| | Mitigation Measure | None required. | None proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species, and thus reduce impacts to non-listed fish species | | | | |
| | LOS after Mitigation | NI | LTS | LTS | LTS | LTS | LTS |

**Table 11-60. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)**

| Impact | | No-Action Alternative | CP1 | CP2 | CP3 | CP4/CPA4 | 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 |

Key:
B = beneficial
BO = Biological Opinion
CP = Comprehensive Plan
CVP = Central Valley Project
LOS = level of significance
LTS = less than significant
NI = No Impact
NMFS = National Marine Fisheries Service
PS = potentially significant
RPA = Reasonable and Prudent Alternative
S = significant
SWP = State Water Project
USFWS = U.S. Fish and Wildlife Service

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

No mitigation is required for Impacts Aqua-1 (CP1) through Aqua-3 (CP1), Impacts Aqua-5 (CP1) and Aqua-6 (CP1), Impacts Aqua-8 (CP1) through Aqua-13 (CP1), or Impacts Aqua-17 through Aqua-21 (CP1). No mitigation is proposed for Impact Aqua-22 (CP1) or Impact Aqua-23 (CP1) because operations will be guided by RPAs established by NMFS and USFWS BOs, which should reduce impacts to listed and non-listed fish species. 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): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habits in the Vicinity of the Impact** The loss of 18.5 miles of intermittent and perennial streams (including 6.2 miles of streams with a gradient less than 7 percent) will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. As described in Preliminary Environmental Commitments and Mitigation Plan Appendix, Reclamation convened an interagency working group to enhance mitigation measures presented in the DEIS. The environmental commitments described in Chapter 2, "Alternatives," of the EIS and the Preliminary Environmental Commitments and Mitigation Plan Appendix are intended to address impacts to channels within the existing drawdown zone (1070 msl).

An outcome of the interagency work group discussions was the agreement that this mitigation measure would encompass efforts within the channels actually affected by the comprehensive plan, but would also be expanded to restore degraded aquatic habitat in channels upstream from Shasta Lake. In general, this mitigation measure would follow the approach to characterize, prioritize, and identify specific restoration actions described in the *California Salmonid Stream Habitat Restoration Manual – Fourth Edition* (DFG 2010).

For CP1, this mitigation measure would result in result in restoration of up to 18.5 miles of channel, with an emphasis on low-gradient perennial channels to be identified by an interagency work group to be convened by Reclamation. This mitigation focuses on restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near reaches within the proposed inundation zone and upstream reaches.

The interagency working group would focus on identification of specific tributaries to Shasta Lake that may benefit from various mitigation techniques using available information. Examples of techniques that may be used include channel and bank stabilization, channel redirection, 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 the alternative. Implementation of this mitigation measure would reduce Impact Aqua-4 (CP1) to a less-than-significant level.

**Mitigation Measure Aqua-7 (CP1): Implement Mitigation Measure Aqua-4 (CP1): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habits in the Vicinity of the Impact** This mitigation measure is the same as Mitigation Measure Aqua-4 (CP1). Implementation of this mitigation measure would reduce Impact Aqua-7 (CP1) to a less-than-significant level.

**Mitigation Measure Aqua-14 (CP1): Implement Mitigation Measure Bot-7 (CP1): 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 (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): 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-16 (CP1) to a less-than-significant level.

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

No mitigation is required for Impacts Aqua-1 (CP2) through Aqua-3 (CP2), Impacts Aqua-5 (CP2) and Aqua-6 (CP2), Impacts Aqua-8 (CP2) through Aqua-13 (CP2), or Impacts Aqua-17 (CP2) through Aqua-21 (CP2). No mitigation is proposed for Impact Aqua-22 (CP2) or Impact Aqua-23 (CP2) because operations will be guided by RPAs established by NMFS and USFWS BOs, which should reduce impacts to listed and non-listed fish species. 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 25.5 miles of intermittent and perennial streams (including 8.2 miles of streams with a gradient less than 7 percent) 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 Shasta Lake and vicinity area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, 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-4 (CP2) to a less-than-significant level.

**Mitigation Measure Aqua-7 (CP2): Implement Mitigation Measure Aqua-4 (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 Aqua-4 (CP2). Implementation of this mitigation measure would reduce Impact Aqua-7 (CP2) to a less-than-significant level.

**Mitigation Measure Aqua-14 (CP2): Implement Mitigation Measure Bot-7(CP2): 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): 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." The riverine ecosystem mitigation and adaptive management plan will include mitigation measures from Shasta Dam downstream to Colusa (RM 144). The plan will be developed and implemented before project construction, and will be consistent with and will support implementation of the Senate Bill 1086 program. The plan will also be developed in coordination with USFWS, NMFS, CDFW, and the SRCA Forum. One of the goals of the plan will be to ensure that project implementation results in no net reduction in the amount (i.e., frequency and magnitude) of overbank inundation; this includes inundation of floodplains and bypasses. Therefore, implementation of this mitigation measure would reduce Impact Aqua-16 (CP2) to a less-than-significant level.

#### *CP3 – 18.5-Foot Dam Raise, Agricultural Water Supply Reliability and Anadromous Fish Survival*

No mitigation is required for Impacts Aqua-1 (CP3) through Aqua-3 (CP3), Impacts Aqua-5 (CP3) and Aqua-6 (CP3), Impacts Aqua-8 (CP3) through Aqua-13 (CP3), or Impacts Aqua-17 (CP3) through Aqua-21 (CP3). No mitigation is proposed for Impact Aqua-22 (CP3) or Impact Aqua-23 (CP3) because operations will be guided by RPAs established by NMFS and USFWS BOs, which should reduce impacts to listed and non-listed fish species. 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 36.5 miles of intermittent and perennial streams (including 12.1 miles of streams with a gradient less than 7 percent) 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 Shasta Lake and vicinity area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, 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-4 (CP3) to a less-than-significant level.

**Mitigation Measure Aqua-7 (CP3): Implement Mitigation Measure Aqua-4 (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 Aqua-4 (CP3).

Implementation of this mitigation measure would reduce Impact Aqua-7 (CP3) to a less-than-significant level.

**Mitigation Measure Aqua-14 (CP3): Implement Mitigation Measure Bot-7 (CP3): 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): 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 and CP4A – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability*

No mitigation is required for Impacts Aqua-1 (CP4/CP4A) through Aqua-3 (CP4/CP4A), Impacts Aqua-5 (CP4/CP4A) and Aqua-6 (CP4/CP4A), Impacts Aqua-8 (CP4) through Aqua-13 (CP4), or Impacts Aqua-17 (CP4/CP4A) through Aqua-21 (CP4/CP4A). No mitigation is proposed for Impact Aqua-22 (CP4/CP4A) or Impact Aqua-23 (CP4/CP4A) because operations will be guided by RPAs established by NMFS and USFWS BOs, which should reduce impacts to listed and non-listed fish species. Mitigation measures are provided below for other impacts of CP4 or CP4A on fisheries and aquatic ecosystems.

**Mitigation Measure Aqua-4 (CP4 or CP4A): Implement Mitigation Measure Geo-2 (CP4 or CP4A): 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 36.5 miles of intermittent and perennial streams (including 12.1 miles of streams with a gradient less than 7 percent) 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 Shasta Lake and vicinity area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, 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-4 (CP4 and CP4A) to a less-than-significant level.

**Mitigation Measure Aqua-7 (CP4 or CP4A): Implement Mitigation Measure Aqua-4 (CP4 or CP4A): 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 Aqua-4. Implementation of this mitigation measure would reduce Impact Aqua-7 (CP4 or CP4A) to a less-than-significant level.

**Mitigation Measure Aqua-14 (CP4 or CP4A): Implement Mitigation Measure Bot-7 (CP1): 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 (CP4 or CP4A), described in Chapter 12, “Botanical Resources and Wetlands.” Implementation of this mitigation measure would reduce Impact Aqua-14 (CP4 or CP4A) to a less-than-significant level.

**Mitigation Measure Aqua-15 (CP4 or CP4A): 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 or CP4A) to a less-than-significant level.

**Mitigation Measure Aqua-16 (CP4 or CP4A): Implement Mitigation Measure Bot-7 (CP1): 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 or CP4A) to a less-than-significant level.

#### *CP5 – 18.5-Foot Dam Raise, Combination Plan*

No mitigation is required for Impacts Aqua-1 (CP5) through Aqua-3 (CP5), Impacts Aqua-5 (CP5) through Aqua-13 (CP5), or Impacts Aqua-17 (CP5) through Aqua-21 (CP5). No mitigation is proposed for Impact Aqua-22 (CP5) or Impact Aqua-23 (CP5) because operations will be guided by RPAs established by NMFS and USFWS BOs, which should reduce impacts to listed and non-listed fish species. 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 36.5 miles of intermittent and perennial streams (including 12.1 miles of streams with a gradient less than 7 percent) 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 Shasta Lake and vicinity area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, 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 Aqua-4 (CP5) to a less-than-significant level.

**Mitigation Measure Aqua-7 (CP5): Implement Mitigation Measure Aqua-4 (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 Aqua-4. Implementation of this mitigation measure would reduce Impact Aqua-7 (CP5) to a less-than-significant level.

**Mitigation Measure Aqua-14 (CP5): Implement Mitigation Measure Bot-7 (CP3): 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: 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 methodology related to the action alternatives, including the relationship to the CALFED Bay-Delta Program Programmatic EIS/EIR cumulative impacts analysis, qualitative and quantitative assessment, past and future actions in the study area, and significance criteria. Table 3-1, "Present and Reasonably Foreseeable Future Actions Included in the Analysis of Cumulative Impacts, by Resource Area," in Chapter 3, lists the projects considered quantitatively and qualitatively within the cumulative impacts analysis. This cumulative impacts analysis accounts for potential project impacts combined with the impacts of existing facilities, conditions, land uses, and reasonably foreseeable actions expected to occur in the study area on a qualitative and quantitative level.

As described in Section 11.1, "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, pollution, and flood control modifications have resulted in altered and degraded habitat conditions and reduced this historical fishery throughout the primary and extended study areas. The combined effects of past and present projects have resulted in a significant adverse cumulative impact on fisheries and aquatic ecosystems of the Sacramento River and its watershed.

Many of the reasonably foreseeable future projects identified in Chapter 3 (see Table 3-1) under the Quantitative Analysis would involve changes to SWP and CVP water operations downstream from Shasta Dam. Also, projects listed in Table 3-1 under Qualitative Analysis would result in potential changes such as changes to operations of hydroelectric projects upstream from Shasta Dam, which would in turn be anticipated to affect fisheries and aquatic ecosystems. Example projects from Table 3-1 that may contribute to cumulative impacts include, but are not limited to, the CVPIA; Clear Creek Actions of the AFRP; CALFED ERP; BDCP; Fish Passage Programs at Shasta, Folsom, and Yuba Rivers; and the San Joaquin River Restoration Program. While some of these changes could result in beneficial effects compared to current conditions, aquatic habitat and fisheries resources would remain limited due to continuing effects from blockage of upstream fish habitat, blockage of spawning gravels, mortality due to water diversions, habitat alterations caused by large-scale modifications to hydrology (hydromodification), and high water temperatures due to lack of riparian vegetation and hydromodification.

The effects of climate change during this century on operations at Shasta Lake and downstream and upstream from the dam, could result in changes to water temperature, flow, and ultimately, fish populations under the No-Action Alternative. As described in the Climate Change Modeling 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, 2014). 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.

Climate change is also expected to result in sea-level rise during this century, which will have effects on Delta salinity levels due to greater tidal excursion. This in turn will affect the location of X2 (2 parts per thousand salinity concentration) position from February through June, moving X2 upstream, which will have adverse effects to native species in the Delta under the No-Action Alternative.

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 11.3.3, "Direct and Indirect Effects," 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 Sacramento

River downstream from Keswick Dam 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 of CP1 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 CVRWQCB. The SWPPP would require implementation of extensive BMPs during project construction, as well as postconstruction 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 project's contribution to cumulative construction-related impacts to a less-than-significant level.

Given major past alterations to the Sacramento River's aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP1 would be cumulatively considerable; specifically, (1) additional inundation of potential riverine habitat for special-status mollusk species above Shasta Lake, (2) additional inundation of cold-water riverine spawning and rearing habitat above Shasta Lake, and (3) reduction of the magnitude and frequency of flows for ecologically important geomorphic processes in the upper and lower Sacramento River below Shasta Dam. With implementation of Mitigation Measure Aqua-4 (CP1) (focused on Shasta Lake and vicinity) and Mitigation Measures Aqua-14 (CP1) through Aqua-16 (CP1) (focused on the Sacramento River downstream from Shasta Lake), adverse effects from CP1 would be reduced and would no longer result in a cumulatively considerable incremental contribution to significant 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 Chinook spawning. Additionally, habitat for both warm- and cold-water reservoir fisheries would be increased with an enlarged reservoir area. Under CP1, potential impacts to Sacramento River fish downstream from Shasta Dam would be beneficial.

Modeling conducted for the Climate Change Modeling Appendix was inconclusive about the effects of this alternative on Delta salinity. If exports are increased under this alternative, it could have an adverse effect on the location of X2, when considered along with other potential projects. However, if the location of X2 remains a water quality and regulatory requirement, then additional exports would not occur when X2 compliance would be violated. Therefore, no cumulative impact on X2 will occur under this alternative.

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

The cumulative effects of CP2 on special-status mollusks above Shasta Dam, cold-water fish spawning and rearing habitat above Shasta Dam, and ecologically important geomorphic processes below Shasta Dam would be associated with mechanisms similar to those of CP1. However, the magnitude of these impacts would be greater, in many cases, because of the greater inundation area and greater effects increased storage volume on the timing, magnitude, and duration of flows downstream than would occur under CP1.

Given the scale and duration of the project construction activities associated with CP2, the contribution of CP2 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 CVRWQCB. 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 project's contribution to cumulative construction-related impacts to a less-than-significant level.

Given major past alterations to the Sacramento River's aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP2 would be cumulatively considerable; specifically, (1) additional inundation of potential riverine habitat for special-status mollusk species above Shasta Dam, (2) additional inundation of cold-water riverine fish spawning and rearing habitat above Shasta Dam, and (3) reduction of the magnitude and frequency of flows for ecologically important geomorphic processes in the upper and lower Sacramento River below Shasta Dam. With implementation of Mitigation Measure Aqua-4 (CP2) (focused on Shasta Lake and vicinity) and Mitigation Measures Aqua-14 through Aqua-16 (CP2) (focused on the Sacramento River downstream from Shasta Lake), adverse effects from CP2 would be further reduced, in combination with the downstream geomorphic restoration program elements, and would no longer result in a cumulatively considerable incremental contribution to significant 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 Chinook spawning. Additionally, habitat for both warm- and cold-water reservoir fisheries would be increased with an enlarged reservoir area. Under CP2, potential impacts to Sacramento River fish below Shasta Dam would be beneficial.

Modeling conducted for the Climate Change Modeling Appendix was inconclusive about the effects of this alternative on Delta salinity. If exports are increased under this alternative, it could have an adverse effect on the location of X2, when considered along with other potential projects. However, if the location of X2 remains a water quality and regulatory requirement, then additional exports would not occur when X2 compliance would be violated. Therefore, no cumulative impact on X2 will occur under this alternative.

#### *CP3 – 18.5-Foot Dam Raise, Agricultural Water Supply Reliability and Anadromous Fish Survival*

The cumulative effects of CP3 on special-status mollusks above Shasta Dam, cold-water fish spawning and rearing habitat above Shasta Dam, and ecologically important geomorphic processes below Shasta Dam would be associated with mechanisms similar to those of CP1 and CP2. However, the magnitude of these impacts would be greater, in many cases, because of the greater inundation area and greater effects increased storage volume on the timing, magnitude, and duration of flows downstream than would occur under CP1 and CP2.

Given the scale and duration of the project construction activities associated with CP3, the contribution of CP3 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 CVRWQCB. The SWPPP would require implementation of extensive BMPs during project construction, as well as postconstruction 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 project’s contribution to cumulative construction-related impacts to a less-than-significant level.

Given major past alterations to the Sacramento River’s aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP3 would be cumulatively considerable; specifically, (1) additional inundation of potential riverine habitat for special-status mollusk species above Shasta Dam, (2) additional inundation of cold-water riverine fish spawning and rearing habitat above Shasta Dam, and (3) reduction of the magnitude and frequency of flows for ecologically important geomorphic processes in the upper and lower Sacramento River below Shasta Dam. With implementation of Mitigation Measure Aqua-4 (CP3) (focused on Shasta Lake and vicinity) and Mitigation Measures Aqua-14 (CP3) through Aqua-16 (CP3) (focused on the Sacramento River downstream from Shasta Lake), adverse effects from CP3 would be further reduced, in combination with the downstream geomorphic restoration program elements, and would no longer result in a cumulatively considerable incremental contribution to significant 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 Chinook salmon. Additionally, habitat for both warm- and cold-water reservoir fisheries would be increased with an enlarged reservoir area. Under CP3, potential impacts to Sacramento River fish below Shasta Dam would be beneficial.

Modeling conducted for the Climate Change Modeling Appendix was inconclusive about the effects of this alternative on Delta salinity. If exports are increased under this alternative, it could have an adverse effect on the location of X2, when considered along with other potential projects. However, if the location of X2 remains a water quality and regulatory requirement, then additional exports would not occur when X2 compliance would be violated. Therefore, no cumulative impact on X2 will occur under this alternative.

#### *CP4 and CP4A – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability*

The cumulative effects of CP4 or CP4A on special-status mollusks above Shasta Dam, cold-water fish spawning and rearing habitat above Shasta Dam, and ecologically important geomorphic processes below Shasta Dam would be associated with mechanisms similar to those of CP1, CP2, and CP3. However, the magnitude of these impacts would be greater, in many cases, because of the greater inundation area and greater effects increased storage volume on the timing, magnitude, and duration of flows downstream than would occur under CP1 and CP2, but similar to CP3. Some of these impacts would be partially offset with the implementation of the gravel augmentation program, floodplain and riparian restoration at six potential sites along the Sacramento River between Keswick Dam and Red Bluff, and cold-water supply for anadromous fish management.

Given the scale and duration of the project construction activities associated with CP4 or CP4A, the contribution of CP4 or CP4A 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 CVRWQCB. The SWPPP would require implementation of extensive BMPs during project construction, as well as postconstruction 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 project’s contribution to cumulative construction-related impacts to a less-than-significant level.

Given major past alterations to the Sacramento River’s aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP4 or CP4A would be cumulatively considerable; specifically, (1) additional inundation of potential riverine habitat for special-status mollusk species above Shasta Dam, (2) additional inundation of cold-water riverine fish spawning and rearing habitat above Shasta Dam, and (3) reduction of the magnitude and frequency of flows for ecologically important geomorphic processes in the upper and lower Sacramento River below Shasta Dam. With implementation of Mitigation Measure Aqua-4 (CP4/CP4A) (focused on Shasta Lake and vicinity) and Mitigation Measures Aqua-14 (CP4/CP4A) through Aqua-16 (CP4/CP4A) (focused on the Sacramento River downstream from Shasta Lake), adverse effects from CP4 or CP4A would be further reduced, in combination with the downstream geomorphic restoration program elements, and would no longer result in a cumulatively considerable incremental contribution to significant 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 or CP4A 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 Chinook salmon. Additionally, habitat for both warm- and cold-water reservoir fisheries would be increased with an enlarged reservoir area. Under CP4 or CP4A, potential impacts to Sacramento River fish below Shasta Dam would be beneficial.

Modeling conducted for the Climate Change Modeling Appendix was inconclusive about the effects of this alternative on Delta salinity. If exports are increased under this alternative, it could have an adverse effect on the location of X2, when considered along with other potential projects. However, if the location of X2 remains a water quality and regulatory requirement, then additional exports would not occur when X2 compliance would be violated. Therefore, no cumulative impact on X2 will occur under this alternative.

#### *CP5 – 18.5-Foot Dam Raise, Combination Plan*

The cumulative effects of CP5 on special-status mollusks above Shasta Dam, cold-water fish spawning and rearing habitat above Shasta Dam, and ecologically important geomorphic processes below Shasta Dam would be associated with mechanisms similar to those of CP1, CP2, CP3, CP4, and CP4A. However, the magnitude of these impacts would be greater, in many cases, because of the greater inundation area and greater effects increased storage volume on the timing, magnitude, and duration of flows downstream than would occur under CP1 and CP2, but similar to CP3 and CP4/CP4A. Some of these impacts would be partially offset with the implementation of the gravel augmentation program, and floodplain and riparian restoration at six potential sites along the Sacramento River between Keswick Dam and Red Bluff.

Given the scale and duration of the project construction activities associated with CP5, the contribution of CP5 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 CVRWQCB. The SWPPP would require implementation of extensive BMPs during project construction, as well as postconstruction 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 project's contribution to cumulative construction-related impacts to a less-than-significant level.

Given major past alterations to the Sacramento River's aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP5 would be cumulatively considerable; specifically, (1) additional inundation of potential riverine habitat for special-status mollusk species above Shasta Dam, (2) additional inundation of cold-water riverine fish spawning and rearing habitat above Shasta Dam, and (3) reduction of the magnitude and frequency of flows for ecologically important geomorphic processes in the upper and lower Sacramento River below Shasta Dam. With implementation of Mitigation Measure Aqua-4 (CP5) (focused on Shasta Lake and vicinity) and Mitigation Measures Aqua-14 (CP5) through Aqua-16 (CP5) (focused on the Sacramento River downstream from Shasta Lake), adverse effects from CP5 would be reduced, in combination with the downstream geomorphic restoration program elements, and would no longer result in a cumulatively considerable incremental contribution to significant 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 Chinook salmon. Additionally, habitat for both warm- and cold-water reservoir fisheries would be increased with an enlarged reservoir area. Under CP5, potential impacts to Sacramento River fish below Shasta Dam would be beneficial.

Modeling conducted to evaluate project effects on Delta salinity for the Climate Change Modeling Appendix was focused on CP5. Under this alternative Delta outflows are reduced by 15,000 to 100,000 acre-feet/year compared to the Baseline due to greater diversions. The changes are largest with the drier climate scenarios. If exports are increased under this alternative, it could have an adverse effect on the location of X2, when considered along with other potential projects. However, if the location of X2 remains a water quality and regulatory requirement, then additional exports would not occur when X2 compliance would be violated. Therefore, no cumulative impact on X2 will occur under this alternative.