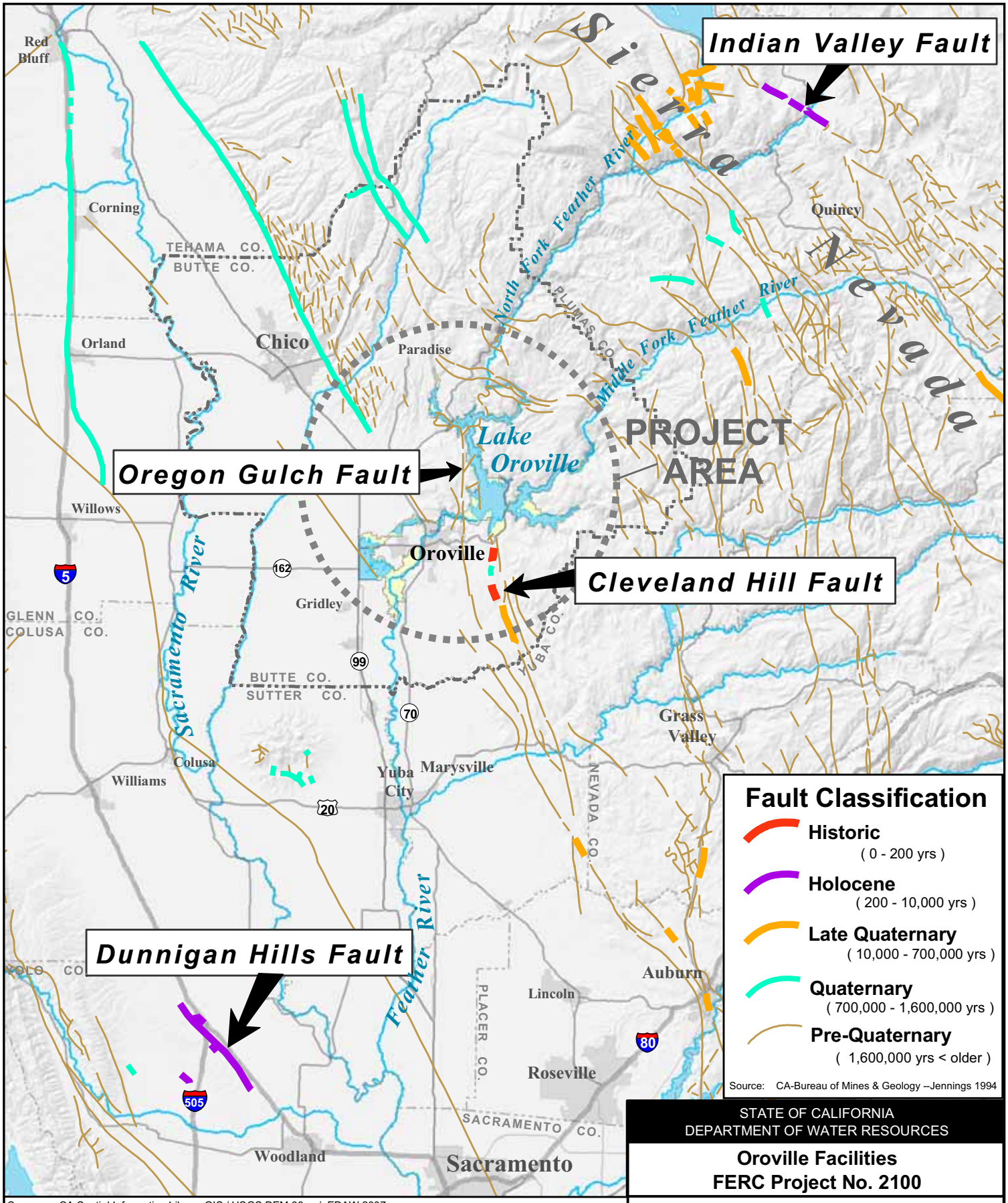

Source: CA Spatial Information Library GIS / USGS DEM 30m / EDAW 2007

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

Oroville Facilities
FERC Project No. 2100

DRAFT ENVIRONMENTAL IMPACT REPORT

FIGURE 4.1-3

Faults in the Project Area

Prepared by: PJ -- EDAW, Inc.
Date 2/1/07
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Inventory Report (USSCS 1989), estimated that 90 percent of the erosion in the report's 1,209-square-mile study area was accelerated erosion. Accelerated erosion is a soil loss rate greater than natural geologic rates and is caused by human activities such as road building, timber harvesting, overgrazing livestock, and agriculture. High sediment yield can reduce reservoir capacity, degrade water quality, and harm fish and wildlife. High sediment yields are captured by several reservoirs on the North Fork Feather River, upstream of Lake Oroville (DWR 1994).

A large amount of this sediment is captured by reservoirs upstream of Lake Oroville. Lake Oroville captures nearly all of the remaining sediment moving down the Feather River watershed. This in turn results in a sediment-starved river system below the dam. It is estimated that the trap efficiency of the reservoir is greater than 97 percent (USGS 1978). A portion of silt and clay is discharged to the Feather River below the dam, but no pebbles, gravel, or cobbles are transported by the river past Oroville Dam.

Past investigations of watershed instability, erosion, and sedimentation have focused largely on tributaries of the North Fork with little attention to the Middle Fork watershed. This focus on the North Fork and its tributaries reflects concern about excessive sedimentation and increased maintenance, which have been effectively reducing the operating efficiency and life span of reservoirs and power plants. In addition, landslides cause increased sedimentation and downstream cumulative effects. Erosion and downcutting of streams lowers groundwater levels and dewaters meadows. Reduced streamflow in the late summer and fall from dewatered meadows reduces hydropower generation capability. The dewatering of meadows high in the Feather River watershed has also resulted in their transformation from perennial grasses to dry-land vegetation such as sagebrush.

Based on the geomorphological assessment and habitat typing of the West Branch and the Middle Fork tributaries above the full pool level (i.e., 900 feet) of Lake Oroville completed as part of Oroville Facilities Relicensing Study Plan (SP) G-1, Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam, impacts of project operations were not observed. Fluctuating water levels discourage substantial delta and sediment deposits above the 900-foot level. At the time of the field investigation for SP-G1, upper portions of the fluctuation zone were exposed to fluvial (as opposed to lentic) conditions. Based on the geomorphological assessment and habitat typing of the four main tributaries within the fluctuation zone, the following preliminary conclusions were presented in SP-G1:

- The West Branch has instream gravel strata in the upper portion of the fluctuation zone, but silt accumulation on the downstream portions causes a degradation in gravel quality.
- Gravel deposition in the North Fork is affected by daily fluctuating flows from upstream hydroelectric facilities.
- The Middle Fork has abundant gravel sources from remnant sediment wedge lag deposits.

- The South Fork is gravel-starved above Sucker Run Creek and is subject to flow variations because of Ponderosa Dam. Gravel quality improves downstream of Sucker Run Creek but gradually becomes sandier from remnant sediment wedge deposits.

Based on calculations derived from cross section and bathymetry surveys, the total volume of sediment in storage is about 28,300 acre-feet (af). Of this amount, about 11,400 af was estimated to be derived from shoreline bank erosion, and the remaining 16,900 af was identified as incoming sediment from the upstream watersheds. Based on a 36-year time period since the initial filling of Lake Oroville, annual sediment yield is about 470 af. If this rate of sediment field were to remain constant, sediment would completely fill the reservoir in about 7,400 years.

Conditions Downstream of Oroville Dam

Below Lake Oroville, the Feather River emerges from the Sierra Nevada and enters the Sacramento Valley. Here the stream gradient is less and the topography is mostly flat, with the exception of overflow channels, multiple channel areas, and both artificial and natural levees occurring along the river course. Honcut Creek, the Yuba River, and the Bear River join the Feather River before it enters the Sacramento River at Verona. The elevation of the valley floor varies from about 150 feet above mean sea level (msl) at Oroville to about 25 feet msl at Verona.

The Feather River below Thermalito Diversion Dam to Verona is mostly an alluvial stream flowing across its own sedimentary deposits of clay, silt, sand, and gravel. The river shape, form, gradient, bed material, etc., are constantly changing in response to changes in sediment and streamflow. A typical normal, mature alluvial stream would meander across its floodplain, eroding the outside of river bends and depositing sand and gravel on the inside curve of the bends. Then, during flood events, the river would overtop its banks and silt and sand would be deposited across the floodplain. On the Feather River, a variety of human-induced changes have affected this balance between erosion and deposition.

By far, historic hydraulic mining of Eocene gold-bearing gravel deposits caused the largest impact on the Feather River channel. Massive amounts of erosional debris, including cobbles, gravel, sand, silt, and clay, were washed into the river. Mining debris still profoundly affects the present-day Feather River. Both the human-modified cobble banks and clay rich slickens have increased bank stability. Between the cities of Oroville and Gridley, cobbles and coarse gravel dredge tailings constitute most of the banks, slowing the bank erosion process. Between Honcut Creek and the mouth of the Feather River, the meandering process has slowed, and the river is wide and shallow, with low sinuosity and a sand bed. Most of the reach is mapped as glides or long pools, with low mesohabitat variability.

The lower Feather River meander belt consists of Recent alluvium (Qa) and stream channel deposits (Qsc). Of the two, the alluvium is older, but both consist of river deposits, including floodplain deposits, point bar deposits, channel fill, oxbow lake

deposits, tributary delta deposits, and hydraulic mining debris. The deposits range in size from clay, silt, and sand to gravel, cobbles, and boulders. Coarse deposits predominate near the City of Oroville and fine deposits predominate from Gridley downstream to the mouth of the Feather River.

Older alluvial deposits not directly linked to the present Feather River form terraces on both sides of the active stream channel. These deposits are typically higher in elevation, more resistant to erosion and define the boundaries of the active meander belt.

4.1.3 Soils

4.1.3.1 Upstream Project Area

Soil Conditions

Soils in the tributary areas upstream of Oroville Dam are derived from weathering of the parent rock material in each area: Mesozoic and Paleozoic metasedimentary and volcanic rocks, Mesozoic intrusive plutonic rocks, and Cenozoic volcanic and sedimentary rocks. Soil profiles in the metamorphic and igneous rocks underlying the central and western portions of Lake Oroville tend to be thick, while thin soil profiles developed on the intrusive igneous rocks underlying the eastern portion. Along the lower portions of the Middle Fork and South Fork Feather River, intrusive rocks that are exposed tend to decompose readily into their basic mineral assemblages. These rocks do not generally form deep soil profiles, but can be readily eroded by wave/wind action.

Slope Stability/Landsliding

Landslides are numerous along the banks of Lake Oroville and common along the North Fork and Middle Fork Feather River. The landslides occur in granitic and metamorphic rocks that form the hills and valleys of the westernmost portion of the Sierra Nevada. Many of the landslides continue into the depths of the reservoir.

The majority of the active landslides around Lake Oroville are the result of reactivation of inactive or ancient landslides. There are also a substantial number of small active landslides, particularly on the Middle Fork Feather River, that are likely caused by repeated wave action undercutting unstable areas, resulting in bank/toe failure.

The amount of material derived from active landslide activity is considered minimal when compared to the amount of incoming watershed sediment and material derived from shoreline erosion. Nonetheless, it should be noted that significant reactivation of inactive or ancient slide masses could introduce large volumes of material into the reservoir and could block portions of the upper arms of Lake Oroville. There is evidence that a large prehistoric landslide, the Bloomer Hill Landslide, temporarily blocked the North Fork Feather River (DWR 2004).

The total area of confirmed landslides mapped in the Lake Oroville area is approximately 4,154 acres. Of this total, 328 acres (8 percent) are considered active,

579 acres (14 percent) are considered inactive, and the remaining 3,246 acres (78 percent) are ancient landslides. Approximately 15 shoreline miles are mapped as landslide material, representing less than 9 percent of the 167 miles of total shoreline length.

4.1.3.2 Downstream Project Area

The soils in the project area downstream of Oroville Dam are found on relatively level floodplain, with most slopes ranging from 0 to 2 percent. The steepest slope, with the exception of riverbank and road cuts, is 5 percent. The most common parent material for the soils is river alluvium, with some soils derived from mining debris deposited during the hydraulic mining period.

The predominant soil types or textures in the 100-year floodplain are characterized as fine sandy loam, loamy sand, and loam to silt loam. Minor soil types are clay, clay loam, sandy clay loam, sandy loam, silt loam, silty clay, sand and gravel, and river wash. Many of the soils are further divided by occurrence of flooding, such as occasionally flooded to frequently flooded. The soils range from shallow to very deep, with most being moderately deep to very deep. Floodplain soils are conducive to agriculture and many areas of riparian floodplain and fluvial terraces have been converted to irrigated crops and orchards.

Soils formed on the upper member of the Modesto formation are designated as Wyman series soils and are brown loam or silt loam with strong brown colors, and a strong blocky structure. Soils formed on the lower Modesto member are diverse and difficult to map. Soils formed on distributary channels of the lower member are designated as Ryer coarse variants, and are weakly developed on the coarse, somewhat excessively drained materials. The finer soils of the Ryer series are moderately to strongly developed with horizons ranging from about 10 percent to 13 percent clay.

Soils formed on the surface of the Riverbank formation are locally referred to as “red clays,” and are deeper, redder, and more strongly developed than those found on Holocene alluvium and the Modesto formation. The Yokohl, San Joaquin, Kimball, Kimball deep variants, and Ramona series soils are all associated with the Riverbank formation.

The great age and complex depositional and erosional history of the Laguna formation produced a large array of soils on various parts of the formation. The soils found on little eroded parts of the uppermost gravel bed of the upper member are of the Redding or Red Bluff series, a yellowish-red, very gravelly loam and a red, gravelly clay. Around the Oroville Airport and the Thermalito Afterbay area the soils are Corning series. Other soils of the upper Laguna formation have been mapped as the Cometa series, the Agate variant, the Altamont, and the Burris series. The lower member of the Laguna has a variety of associated soils, commonly strong variants of the Redding and Corning series.

4.1.4 Paleontological Resources

The known fossil-bearing formations within the Oroville Facilities Project area are the Calaveras Limestone, the Monte del Oro formation, and the Laguna formation. These are ranked as C1 formations, according to BLM criteria, because they are known to contain noteworthy examples of invertebrate or plant fossils (Monte del Oro and Calaveras) or vertebrate fossils (Laguna). Also occurring within the project area are portions of the Ione and Tuscan formations. These are ranked as “C2” formations because they have the potential to contain vertebrate fossils or noteworthy examples of invertebrate or plant fossils. Other rock formations exposed within the project area are not expected to contain fossils because of their igneous or metamorphic nature.

Calaveras Limestone is exposed in scattered blocks within the Foothill Melange-Ophiolite Belt and contains invertebrate fossils in exposures near Lime Saddle. The Monte del Oro formation is exposed north of Oroville and contains plant and leaf impressions in the shale units. This formation is equivalent to the Mariposa formation, which is exposed along the length of the western Sierra Nevada and contains many fossil localities. Excavations into the Laguna formation have revealed Plio-Pleistocene vertebrate fauna in places.

4.2 SURFACE WATER QUANTITY AND QUALITY

This section describes surface water quantity and quality within the Project area shown in Figure 4.2-1 and includes a description of the regional setting, water use, flood management, surface water hydrology, and surface water quality. This section also describes the SWRCB Basin Plan Objectives as they apply to Project waters and the role of the Oroville Facilities in protecting these objectives. Oroville Facilities compliance with other regulatory requirements related to water quantity and quality is also included. This information is intended to provide a basis for comparison between the existing surface water quantity and quality conditions relative to the potential effects on these resources from the Project alternatives.

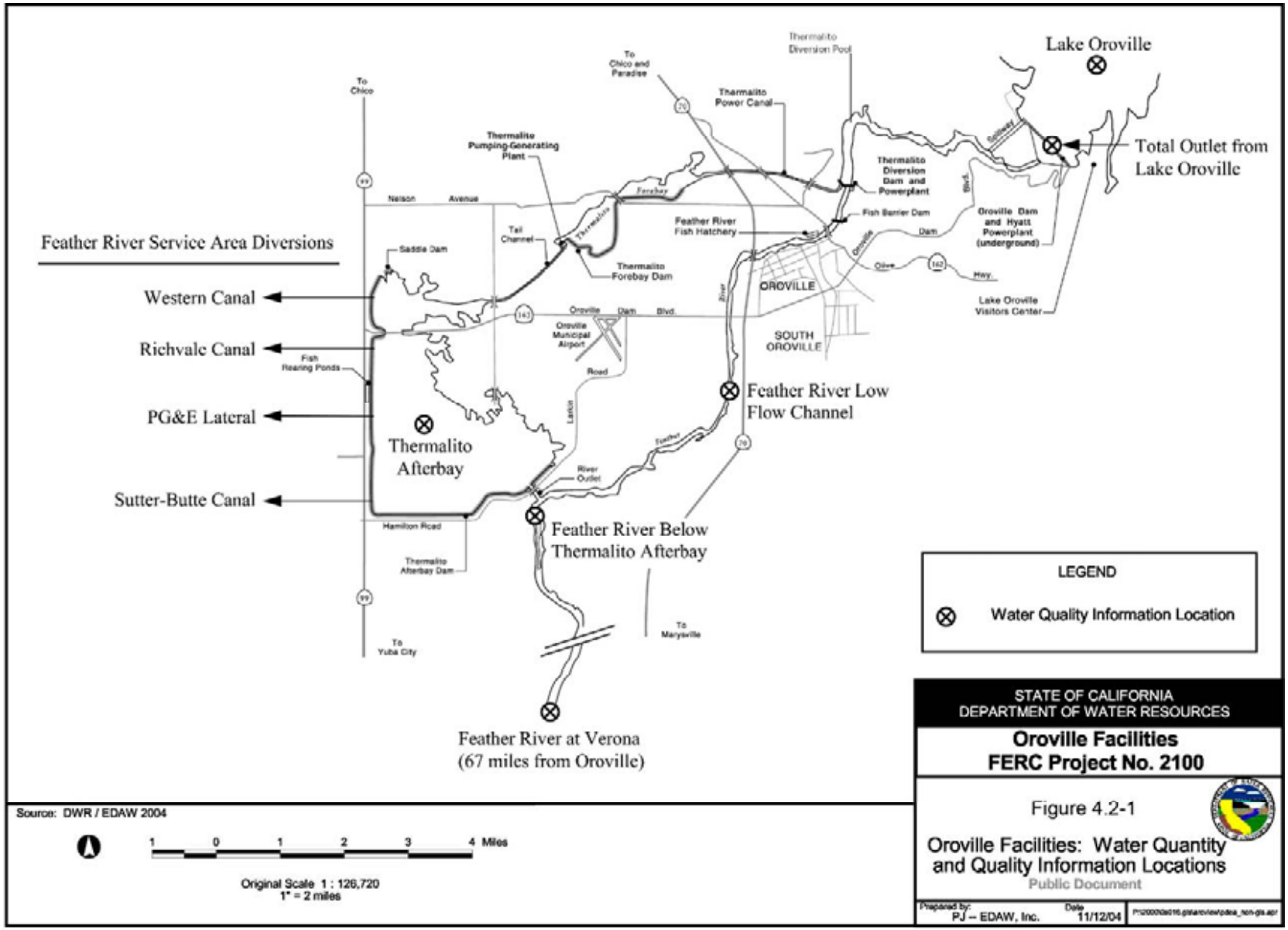
The Oroville Facilities allow DWR to meet a number of existing water supply and environmental commitments. These include the provision of entitlements for local irrigation diversions and SWP contract supply deliveries. Oroville Facilities operations for flood management, water supply, and environmental purposes affect downstream Feather River hydrology by altering flow magnitude, timing, and duration. These ongoing environmental requirements include minimum flow releases to benefit aquatic species downstream. The Oroville Facilities provide flood management and damage reduction benefits to many downstream communities (including Oroville, Yuba City, Marysville, and Sacramento), as well as to highly developed and productive agricultural areas along the Feather River and Sacramento River downstream of Oroville Dam.

4.2.1 Surface Water Quantity

4.2.1.1 Regional Overview

The Oroville Facilities were developed as part of the SWP and provide water storage, flood management, power generation, water quality improvement, and recreation, fish, and wildlife enhancement. The physical arrangement of the Oroville Facilities is illustrated in Figure 4.2-1.

The Oroville Facilities alter the streamflow in the Feather River through flow regulation that includes diversions for water supply, flood management, water quality requirements of the Sacramento–San Joaquin Delta (Delta), and instream flow requirements. Hydroelectric power operations do not further alter the streamflow in the Feather River downstream of the Thermalito Afterbay Outlet; hydroelectric power is generated from water released from Lake Oroville, and all of that water is essentially re-regulated in Thermalito Afterbay before it is released downstream. However, streamflow alterations in the lower Feather River do vary based on different hydrologic water year types. Water year types are determined according to the Sacramento Valley water year type definitions developed by the SWRCB as part of the regulatory activities for the San Francisco Bay/Sacramento–San Joaquin Delta (Bay-Delta). Water year type classifications include Critical, Dry, Below Normal, Above Normal, and Wet. Critical water years are sometimes referred to as Critically Dry water years.


Lake Oroville
Total Outlet from Lake Oroville
Feather River Service Area Diversions
Western Canal
Richvale Canal
PG&E Lateral
Sutter-Butte Canal
Thermalito Afterbay
Feather River Low Flow Channel
Feather River Below Thermalito Afterbay
Feather River at Verona (67 miles from Oroville)
OROVILLE
SOUTH OROVILLE
Thermalito Pumping-Generating Plant
Thermalito Power Canal
Thermalito Diversion Pool
Thermalito Diversion Dam and Powerplant
Fish Barrier Dam
Oroville Dam and Hyatt Powerplant (underground)
Lake Oroville Visitors Center
Feather River Fish Hatchery
Thermalito Forebay Dam
Thermalito Afterbay Dam
Oroville Municipal Airport
Saddle Dam
Fish Rearing Ponds
Tail Channel
Nelson Avenue
Hamilton Road
To Chico
To Chico and Paradise
To Yuba City
To Marysville
LEGEND
Water Quality Information Location
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
Oroville Facilities
FERC Project No. 2100
Figure 4.2-1
Oroville Facilities: Water Quantity and Quality Information Locations
Public Document
Source: DWR / EDAW 2004
1 0 1 2 3 4 Miles
Original Scale 1 : 126,720
1" = 2 miles
Prepared by: PJ – EDAW, Inc.
Date 11/12/04

Extensive computer simulation modeling of Oroville Facilities operations was performed to support the relicensing environmental study programs during the past 5 years or more. A complete description of the various modeling tools used, and results of the model runs are contained in Appendix C of the PDEA (DWR 2005). Model runs depicting Existing Conditions based on a year-2001 level of development were used to help define baseline conditions to support environmental impact assessments and comparisons between alternatives in the PDEA. Those same model runs are used to help define Existing Conditions for the purposes of this DEIR.

4.2.1.2 Water Use

The Oroville Facilities divert water for senior water rights holders in the Feather River Service Area (FRSA) and supply water to the SWP Water Contractors. Monthly irrigation diversions of up to 150,000 acre-feet (af) are made from the Thermalito Afterbay Complex to the FRSA during the May-through-August primary irrigation season. Average annual FRSA diversions are slightly less than 1 million acre-feet (maf).

Water diversions to meet FRSA entitlements occur primarily during the irrigation months, April–October. Under Existing Conditions (2001 Level of Development), the average annual diversion of water to meet FRSA entitlements is about 994 thousand acre-feet (taf). The minimum and maximum annual diversions over the modeling period (1922–1993) are 613 taf and 1,057 taf, respectively.

Water is required in all months of the year to meet SWP Water Contractors' requests, with the highest requests typically in June through August and the lowest in January. Water available for delivery varies depending on hydrologic conditions and operating requirements. The model information for Existing Conditions, indicates that the average annual delivery to meet SWP contractor requests is about 3,051 taf. The maximum and minimum annual deliveries over the modeling period were 3,914 taf and 761 taf, respectively.

Discharges into the lower Feather River continue into the Sacramento River and into the Delta. At the north end of the Delta, some of this water may be pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay, where the water is stored until it is pumped into the California Aqueduct. Additionally, flows through the Delta are maintained to meet Bay-Delta water quality standards.

More detailed information regarding water supply, including a monthly breakdown of deliveries, is included in PDEA Appendix C (DWR 2005).

4.2.1.3 Flood Management

Flood management is one of the major benefits of the Oroville Facilities. The facilities are an integral component of the flood management system for areas along the Feather and Sacramento Rivers downstream of Oroville Dam. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S.

Army Corps of Engineers (USACE). Flood management releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by USACE, whichever requires the greater release (see Figure 3.2-3, Lake Oroville Water Levels for Dry, Average, and Wet Water Years, for a depiction of the flood control space required by USACE). During flood events, Lake Oroville and Oroville Dam are operated to attenuate the peak inflow of the natural flood hydrograph, substantially reducing both the magnitude and the frequency of flooding for Oroville, Marysville, Yuba City, and many smaller communities near the Feather River.

Flood control space requirements are based primarily on USACE's goal to protect urban and agricultural areas along the Feather River below Lake Oroville. These requirements are established to be compatible with multiple uses of the available reservoir space. When flood control space is not required to accomplish flood management objectives, the reservoir space can be used to store water for other purposes. From October through March, the maximum allowable storage limit (the point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood inflows. This allows higher reservoir levels when the prevailing hydrology is dry while maintaining adequate flood protection under USACE requirements. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. Flood control space requirements, determined through planning studies, vary from a minimum of 375 taf to a maximum of 750 taf of storage, depending on hydrologic conditions.

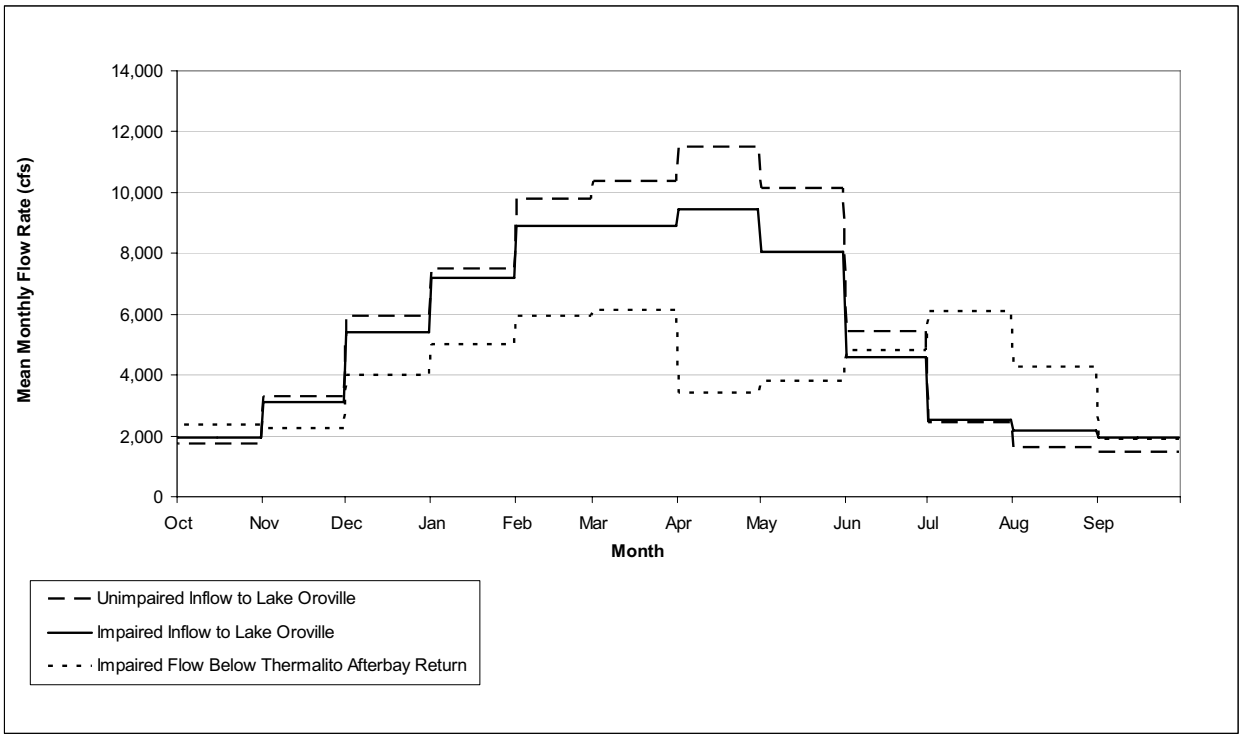
Decisions regarding flood releases are made in consultation with USACE. To fully utilize downstream channel capacities and storage space under various flood conditions, a maximum release capacity of 150,000 cubic feet per second (cfs) throughout the range of flood control space is desirable. However, since some reduction in this capacity in the lower range of the flood control space would not seriously reduce flood control accomplishments but would reduce cost appreciably, it was mutually agreed between the State of California and the United States that a smaller release capacity at the lower levels would be acceptable (Department of the Army 1970). The full 150,000-cfs release capacity must be provided when storage is within the upper half of the flood control space, and sufficient capacity exists in the lower levels to enable control of the standard project flood using the routing criteria found on the flood control diagram. A release capacity of 85,000 cfs occurs when the reservoir water surface elevation is at 848.5 feet (ft) (bottom of the flood control storage space), and the 150,000-cfs release capacity when the reservoir water surface elevation is at 863.5 ft.

4.2.1.4 Surface Water Hydrology

Flow in the Feather River is altered by other hydroelectric, water storage, and diversion projects upstream of the Oroville Facilities, Lake Oroville operation, and by diversions from Thermalito Afterbay to meet FRSA entitlements. Upstream projects alter Feather River flow through operation of storage facilities and by diversions from the river and its tributaries.

The average annual yield of the upstream Feather River basin at Oroville is about 4.2 maf. Much of the runoff occurs between January and June. Summer inflows into the reservoir are sustained at about 1,000 cfs by snowmelt and accretions from springs and groundwater in the upper watershed. Due to several diversions upstream, actual annual inflow into Lake Oroville is about 4.0 maf. Annual flows are variable and depend upon precipitation. From 1979 to 1999, annual inflows ranged from a minimum of 1.7 maf to as high as 10 maf.

Operation of Lake Oroville alters flow in the Feather River by storing inflows and making releases later in the year, or in subsequent years to meet downstream requirements. Mean monthly outflow from the project typically varies from 2,000 cfs to about 9,000 cfs. Mean monthly Feather River unimpaired and regulated (impaired) inflows to Lake Oroville, and flows below the Thermalito Afterbay Outlet are shown in Figure 4.2-2. In general, regulated inflows to Lake Oroville are reduced from unimpaired conditions during the months of November–June, primarily due to upstream diversions and storage operation. Conversely, regulated inflows to Lake Oroville tend to be slightly higher than under unimpaired conditions in the months of August–October due to releases from upstream projects during those months.



Source: DWR, California Data Exchange Center

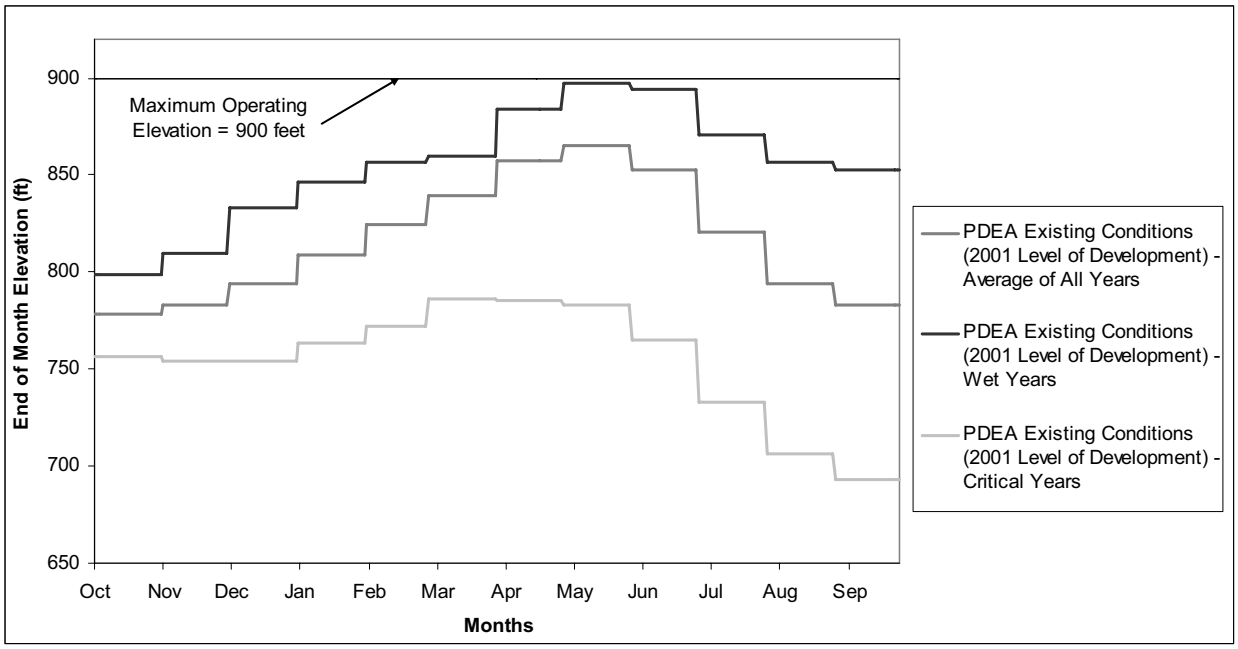
Figure 4.2-2. Mean monthly impaired and unimpaired inflow into Lake Oroville and flow below the Thermalito Afterbay Outlet under Existing Conditions.

The following sections provide a brief summary of existing (2001 Level of Development) surface-water hydrology conditions and related operating parameters.

Lake Oroville

Lake Oroville is generally operated to store water during the winter, (when most of the watershed's rainfall occurs) and the spring snowmelt period and make releases in the summer and fall to meet downstream requirements. Lake Oroville end-of-month reservoir water surface elevations were simulated during development of the PDEA using CALSIM II modeling and were used to describe reservoir operation under Existing Conditions.

Lake Oroville end-of-month elevations for Average, Wet, and Critically Dry year types are shown in Figure 4.2-3 for Existing Conditions. During the wetter years, Lake Oroville typically fills to capacity, or near capacity, in May or June. In drier years, the reservoir reaches its maximum elevation as early as March and does not fill to capacity, reducing DWR's ability to meet downstream requirements and fulfill SWP contractor requests. Reservoir storage typically reaches its minimum between September and January.

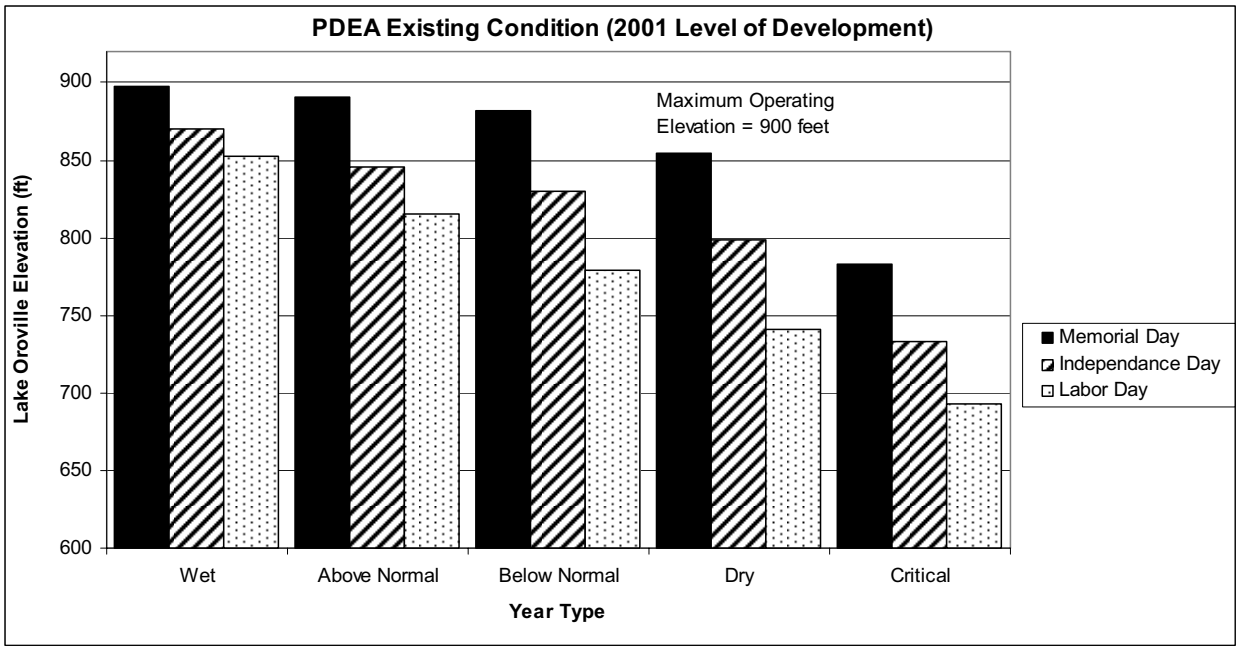


Source: DWR, 2004 OCAP Study 3 CALSIM II Modeling Results

Figure 4.2-3. Simulated Lake Oroville average end-of-month water surface elevation for All years, Wet years, Critical years.

Average Lake Oroville water surface elevations on Memorial Day, Independence Day, and Labor Day under different water year types for Existing Conditions are shown in Figure 4.2-4. On Memorial Day, in Wet years, Lake Oroville is typically at or near its maximum normal operating elevation of 900 ft above mean sea level (msl). In drier hydrologic years, the elevation of Lake Oroville is lower because the inflow to the reservoir is less. On Memorial Day, in Critical years, the surface elevation of Lake Oroville averages about 774 ft, representing a drawdown of about 126 ft from the

maximum normal operating elevation of 900 ft. The surface elevation of Lake Oroville is reduced through the summer season as releases from storage are required to meet downstream requirements, including instream flow, environmental requirements, in-basin uses, and FRSA and State Water Contractors (SWC) water supply requests. Under the Coordinated Operating Agreement (COA), the SWP and the federal CVP operate jointly to meet Delta water quality requirements and other water demands within the Sacramento River basin. These requirements are referred to as "in-basin" demands. On Labor Day Lake Oroville average elevation is about 707 ft in Critical years and 859 ft in Wet years, representing drawdowns of about 193 ft and 41 ft, respectively.

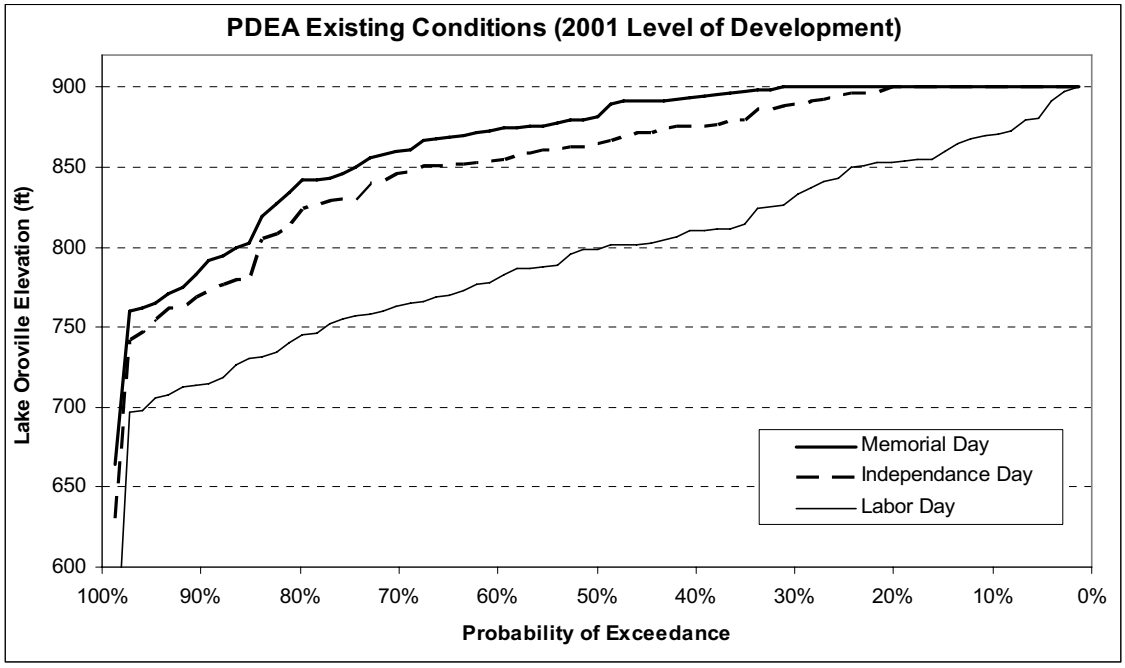


Source: DWR, 2004 OCAP Study 3 CALSIM II Modeling Results

Figure 4.2-4. Simulated average Lake Oroville water surface elevations, for specific days, by water year type, under Existing Conditions.

Elevation-frequency plots of Lake Oroville water surface elevation for Memorial Day, Independence Day, and Labor Day for Existing Conditions are shown in Figure 4.2-5. On Memorial Day, Lake Oroville has a 90 percent probability of being at elevation 787 ft or higher and a 50 percent probability of being at elevation 885 ft. These elevations represent drawdowns of about 137 ft and 15 ft from the maximum normal operating elevation of 900 ft.

Similarly, on Labor Day, water surface elevations at Lake Oroville have a 90 percent probability of being at elevation 725 ft and a 50 percent probability of being at elevation 791 ft. These elevations represent reservoir drawdowns of about 175 ft and 109 ft from the maximum normal operating elevation of 900 ft.



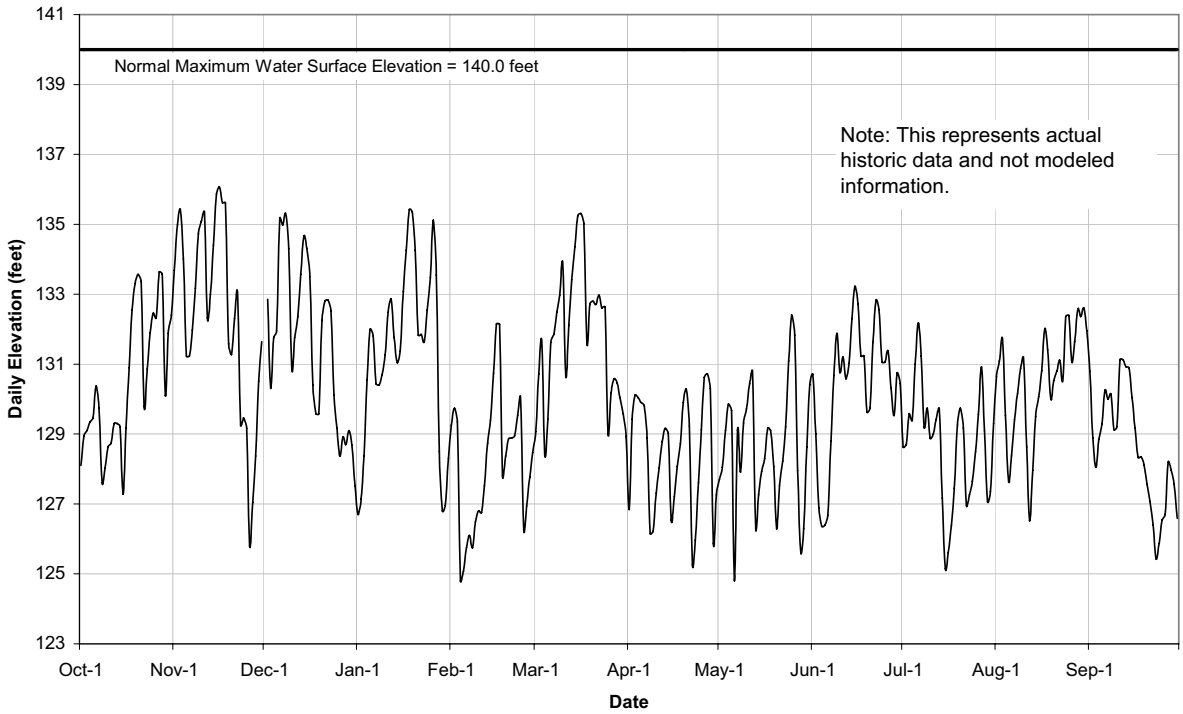
Source: DWR, 2004 OCAP Study 3 CALSIM II Modeling Results

Figure 4.2-5. Simulated monthly Lake Oroville water surface elevations, for specific days, under Existing Conditions.

Thermalito Afterbay

Thermalito Afterbay is operated to meet multiple requirements including regulation of inflow from the Thermalito Pumping-Generating Plant, provision of water for withdrawal during pump-back operation, and to make releases through the Thermalito Afterbay Outlet to the Feather River. Thermalito Afterbay is also the source of diversions for FRSA irrigation entitlements. A high degree of operational flexibility is required at Thermalito Afterbay to comply with all the existing flow release requirements for water supply, water quality, and instream flow needs, and to periodically recharge brood ponds to support nesting waterfowl. As a result, the elevation of Thermalito Afterbay fluctuates over short periods of time. Historical water levels for water year 2001 are shown in Figure 4.2-6. While actual fluctuations vary significantly from month to month and year to year, the 2001 water year provides an indication of the upper and lower bounds for an annual operating cycle.

Thermalito Afterbay operation is not affected by natural hydrologic conditions; it is primarily affected by operational requirements. Generally, there are no seasonal differences in the operation of Thermalito Afterbay and the water surface elevation varies from about 124 to 136 ft (msl) throughout the year. When peaking and/or pump-back power operations occur, Thermalito Afterbay tends to operate on a weekly cycle, and water surface elevations vary by approximately 3 feet during the Monday-through-Friday period. On Saturday and Sunday, the elevation is typically reduced by about 3 feet, with a majority of the elevation change occurring on Sunday.



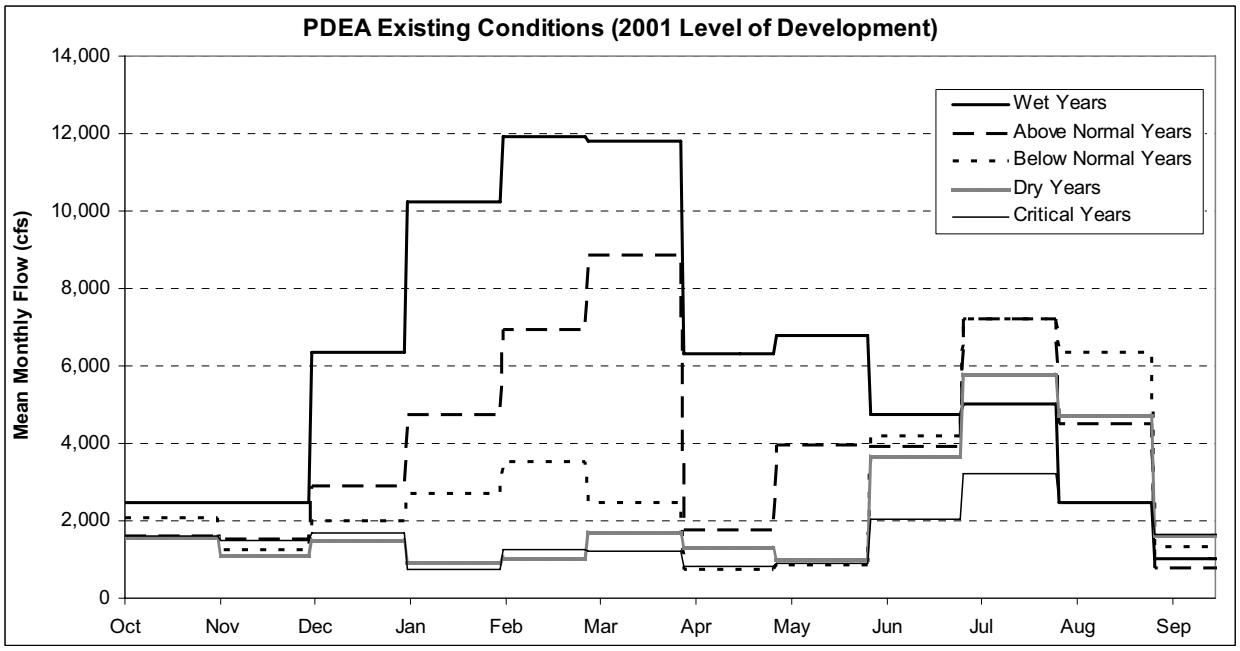
Source: California Data Exchange Center

Figure 4.2-6. Historic daily reservoir water surface elevations for the Thermalito Afterbay in water year 2001.

Feather River

Releases from Lake Oroville are made into the Diversion Pool below Oroville Dam, where water can be released through the Thermalito Diversion Dam Power Plant (or the Thermalito Diversion Dam spillway during flood release periods) to the Low Flow Channel (LFC) of the Feather River or diverted through the Thermalito Power Canal, through the Thermalito Pumping-Generating Plant and into Thermalito Afterbay. Flows can be diverted from Thermalito Afterbay to meet local FRSA requirements or released through the Thermalito Afterbay Outlet back into the Feather River, where they combine with flows passing through the LFC.

In Above-Normal and Wet years, the maximum total release from Lake Oroville typically occurs in February and March, due primarily to the requirement for large releases to meet flood control criteria and maintain adequate flood reservation storage volume in the reservoir (see Section 4.2.1.3, Flood Management, above). In Below-Normal, Dry, and Critically Dry years, the highest releases from Lake Oroville typically occur in July. Simulated average monthly releases from Lake Oroville under Existing Conditions are shown in Figure 4.2-7. A summary of simulated Feather River flows for Existing Conditions is presented in Table 4.2-1.



Source: DWR, 2004 OCAP Study 3 CALSIM II Modeling Results

Figure 4.2-7. Simulated monthly average total releases from Lake Oroville, by year type, under Existing Conditions.

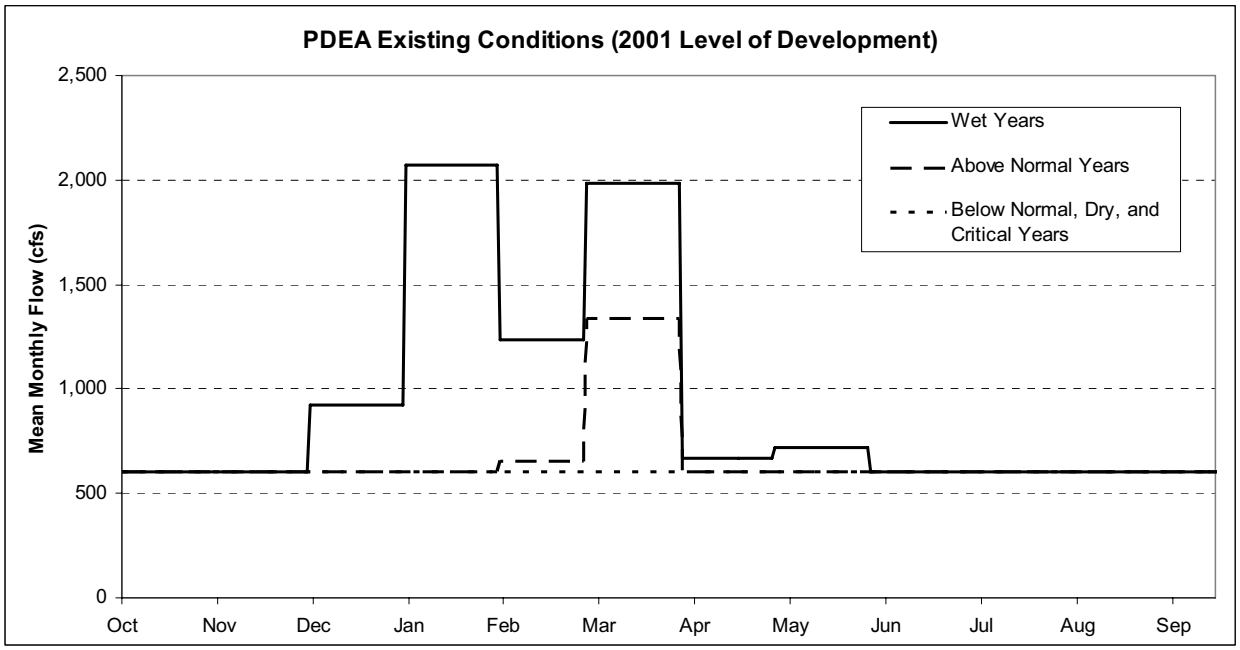
Table 4.2-1. Simulated average annual volumes of Feather River flow under Existing Conditions.

Total Release from Lake Oroville (taf)	
Mean	3,807
Max	8,648
Min	1,434
Low Flow Channel (taf)	
Mean	435
Max	436
Min	434
Feather River Below Thermalito Afterbay (taf)	
Mean	3,013
Max	7,898
Min	985
Feather River at Verona (taf)	
Mean	5,378
Max	14,216
Min	1,576

Note: taf = thousand acre-feet.

Sources: DWR, 2004 OCAP Study 3 CALSIM II Modeling Results

Flows in the LFC are currently required to be at least 600 cfs; however, this flow can be reduced if operating emergencies beyond the control of the Licensee necessitate lower flows. In some Above-Normal and Wet years, releases in excess of the power generating capacity of the Thermalito Pumping-Generating Plant, are occasionally required from Lake Oroville for flood management purposes. During these high-flow events, additional flows are released to the LFC. Typical mean monthly flows in the LFC under Existing Conditions are illustrated in Figure 4.2-8.

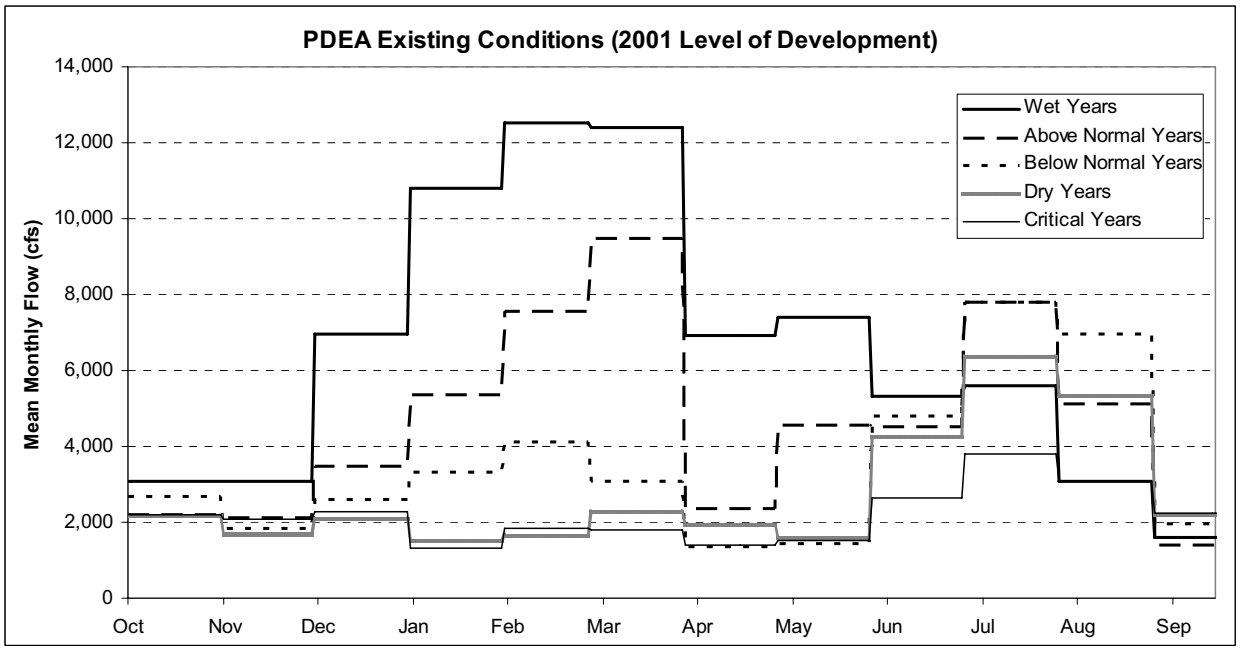


Source: DWR, 2004 OCAP Study 3 CALSIM II Modeling Results

Figure 4.2-8. Simulated monthly average flow in the LFC, by year-type, under Existing Conditions.

Flow in the Feather River below Thermalito Afterbay Outlet (the High Flow Channel (HFC)) varies with water released by the Oroville Facilities for the many commitments DWR has related to releases for downstream water quality control, flood management releases, SWP Water Contractor deliveries, and other purposes. The Feather River flow below Thermalito Afterbay for the simulated Existing Conditions is shown in Figure 4.2-9 for different water year types. As previously mentioned, a summary of simulated flows in the Feather River is shown in Table 4.2-1.

In Above-Normal and Wet years, maximum flows in the Feather River below Thermalito Afterbay typically occur in February or March due to high releases from Lake Oroville for flood management and to maintain adequate flood reservation storage volume in the reservoir. In Below-Normal, Dry, and Critical years, maximum flows in the Feather River below the Thermalito Afterbay Outlet typically occur during the month of July to meet downstream SWP Water Contractor demands. In these years, there are little or no releases made for flood management purposes. Minimum flows for all years typically occur in September.

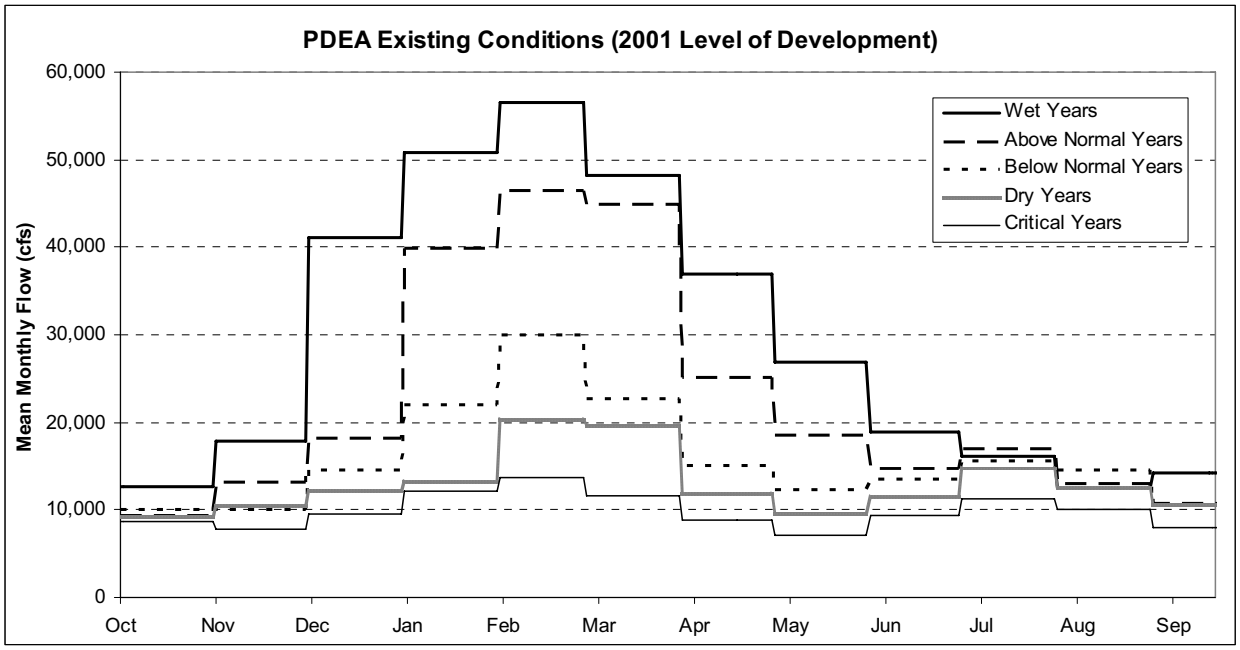


Source: DWR, 2004 OCAP Study 3 CALSIM II Modeling Results

Figure 4.2-9. Simulated monthly average Feather River flow below the Thermalito Afterbay, by year-type, under Existing Conditions.

Approximately 67 miles downstream of the Fish Barrier Dam, the Feather River flows into the Sacramento River near the town of Verona. Flow in the river at Verona is typically greater than the flow below Thermalito Afterbay, due to tributary accretions along the length of the river. The Feather River flow at Verona under the simulated Existing Conditions for different water year types are shown in Figure 4.2-10.

In most years, the maximum flow in the Feather River at Verona occurs during February or March due to the aforementioned reservoir releases from Lake Oroville for flood management purposes, and substantial flow accretions to the river downstream of the Oroville Facilities. Minimum flows for all year types typically occur between September and November.



Source: DWR, 2004 OCAP Study 3 CALSIM II Modeling Results

Figure 4.2-10. Simulated monthly average Feather River flow at Verona, by year type, under Existing Conditions.

4.2.2 Surface Water Quality

4.2.2.1 Regional Setting

DWR's Division of Operation and Maintenance, as part of the SWP, has conducted water quality monitoring for various inorganic, organic, and biological parameters regularly since 1968. Current water quality monitoring within project waters includes testing at Oroville Reservoir, Thermalito Forebay, and Thermalito Afterbay. Water quality monitoring is conducted on a regular schedule to confirm that the Oroville Facilities are reasonably protective of water quality objectives as described below.

Basin Plan—Beneficial Uses and Water Quality Objectives

Section 303 of the federal Clean Water Act requires states to adopt water quality standards that "consist of designated uses of the navigable waters involved and water quality criteria for such waters based upon such uses." The SWRCB carries out its water quality protection obligations and authority through the adoption of specific Basin Plans. The Basin Plans, developed by the regional water boards, establish water quality standards for particular water bodies by designating beneficial uses of those waters and water quality objectives to protect those uses. The Central Valley Regional Water Quality Control Board (RWQCB) provides additional protection of water quality within the Central Valley region by designating additional, water body–specific objectives in its Basin Plan, the *Water Quality Control Plan for the Sacramento and San Joaquin River Basins* (Central Valley RWQCB 2006; http://www.swrcb.ca.gov/quality.html). Guidelines in the Code of Federal Regulations state that beneficial uses, together with their corresponding water quality objectives, can be defined as water quality standards; therefore, Basin Plans encompass both federal and State requirements for water quality control.

Prior to issuance of a new license for the Oroville Facilities, federal law requires that the SWRCB issue a Section 401 water quality certification or a waiver of such certification. The certification requires a determination by the SWRCB that the project complies with appropriate requirements of the Central Valley RWQCB Basin Plan, which includes the water quality objectives for protection of designated beneficial uses.

The Central Valley RWQCB Basin Plan includes both numerical and narrative objectives. Numerical objectives have been established for some parameters that can be measured quantitatively (such as milligrams per liter [mg/L] of a chemical contaminant); narrative objectives have been established for parameters that may not be readily quantifiable (such as taste and odor) or have not been quantified in the Basin Plan (such as toxicity). Both numerical and narrative objectives are applicable when determining effects on beneficial uses. Demonstration of compliance with water quality standards and other appropriate requirements is needed in the application for water quality certification.

The beneficial uses specified by the Central Valley RWQCB Basin Plan for Lake Oroville are municipal and domestic supply, irrigation, power, contact recreation,

non-contact recreation, warmwater habitat, coldwater habitat, warmwater spawning habitat, coldwater spawning habitat, and wildlife habitat. The beneficial uses for the Feather River from the Fish Barrier Dam to the Sacramento River are municipal and domestic supply, irrigation, contact recreation, canoeing and rafting, non-contact recreation, warm freshwater habitat, cold freshwater habitat, warmwater migration, coldwater migration, warmwater spawning habitat, coldwater spawning habitat, and wildlife habitat (Table II-1 of the Basin Plan). The beneficial uses applicable to Lake Oroville and the Feather River from the Fish Barrier Dam to the Sacramento River are described below. Current operations of the Oroville Facilities supports and reasonably protects, or has no adverse effect on (as in the case of coldwater spawning in Lake Oroville), all beneficial uses specified in the Basin Plan for Project waters and are described below.

Lake Oroville

Municipal and Domestic Water Supply. (uses of water for community, military, or individual water supply systems, including drinking water). Lake Oroville is a key part of the SWP, providing supplemental water to two-thirds of California's population and over 750,000 acres of agricultural lands. Water is stored in and released from Lake Oroville to meet water supply, flood protection, water quality improvement, fish and wildlife enhancement, and recreation requirements.

Irrigation—Agriculture. (uses of water for farming, horticulture, or ranching). Water stored in Lake Oroville and rediverted in Thermalito Afterbay is used, in part, for irrigation. Monthly agricultural diversions of up to 190,000 af are made from Thermalito Afterbay and the Feather River during the May-through-August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf.

Industry—Power. (use of water for hydropower generation). The Oroville Facilities have a combined license generating capacity of approximately 762 megawatts (MW). Hyatt Pumping-Generating Plant has a capacity of 645 MW, while Thermalito Pumping-Generating Plant has a capacity of 114 MW and Diversion Dam Powerplant has a capacity of 3 MW. Average historical generation of Hyatt and Thermalito Pumping-Generating plants in a median water year is about 2.2 billion kilowatt-hours (kWh) (DWR 1999). Thermalito Diversion Dam Powerplant adds another 24 million kWh a year.

Recreation—Contact. (uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible). Water-contact recreation opportunities are provided at Lake Oroville, Thermalito Forebay, and Thermalito Afterbay. The majority of recreation facilities associated with the Oroville Facilities are within the Lake Oroville State Recreation Area (LOSRA). The most popular water-contact recreation activities include bank fishing, boat fishing, swimming, water skiing and wakeboarding, and use of personal watercraft. Lake Oroville has one developed swim area at Loafer Creek, but much of the swimming activity in the lake is more informal in nature. During normal operations, reservoir drawdown can affect the beaches and their accessibility, particularly when the water surface level decreases to

the point where steep and muddy shorelines are exposed. Formal and informal swimming opportunities are also provided at Thermalito Forebay and Thermalito Afterbay.

Recreation—Other Non-contact. (uses of water for recreational activities involving proximity to water, but where there is generally no body contact with water, nor any ingestion of water [e.g., picnicking, sunbathing, hiking, beachcombing, horseback riding, camping, boating, hunting, sightseeing, and aesthetic enjoyment]). The LOSRA provides numerous non-contact recreation opportunities. The most popular non-contact recreation activities include motorboating, tent camping, houseboating, horseback riding, picnicking, recreational vehicle camping, and hiking.

Freshwater Habitat—Warm Water.[1] (uses of water that support warmwater ecosystems including but not limited to preservation and enhancements of aquatic habitats, vegetation, fish, or wildlife, including invertebrates). The Lake Oroville warmwater fishery is a regionally important self-sustaining recreational fishery and is the site of several annual bass fishing tournaments. Thermalito Afterbay is also a popular largemouth bass fishery.

Freshwater Habitat—Cold Water. (uses of water that support coldwater ecosystems, including but not limited to preservation or enhancements of aquatic habitats, vegetation, fish, or wildlife, including invertebrates). Lake Oroville's coldwater fishery is primarily composed of coho salmon, although rainbow trout, brown trout, and lake trout are caught periodically. The coho salmon fishery is sustained by a "put-and-grow" hatchery stocking program. Thermalito Forebay provides habitat primarily for coldwater fish; a "put-and-take" trout fishery is managed in Thermalito Forebay.

Spawning—Warm Water. (uses of water that support high-quality aquatic habitats suitable for reproduction and early development of fish). During normal operations, reservoir water level fluctuations (in particular decreasing water levels) in Lake Oroville can affect black bass nest survival; however, as noted under Freshwater Habitat above, the warmwater fishery in Lake Oroville is self-sustaining.

Spawning—Cold Water. The Lake Oroville coldwater fishery is not self-sustaining, possibly due to insufficient spawning and rearing habitat in the reservoir and accessible tributaries. Coldwater spawning is not known to occur within Lake Oroville. The Oroville Facilities do not affect the suitability of upstream spawning habitat. The Oroville Facilities do not affect this beneficial use designation.

Wildlife Habitat. The wildlife and wildlife habitats in the project area are influenced by the project's proximity to the Sierra Nevada, the Sacramento Valley, an abundance of water associated with the project, and the Feather River. The project area supports 24 habitat types, all of which have undergone varying degrees of disturbance from both natural and human-induced changes. Overall, the Oroville Facilities support wildlife habitat in the project area.

[1] As noted in the Basin Plan, segments with both warmwater and coldwater beneficial use designations are considered coldwater bodies for the application of water quality objectives.

Feather River from Fish Barrier Dam to Sacramento River

Municipal and Domestic Water Supply. As a component of the SWP, the Oroville Facilities are operated to provide downstream water supply for municipal, industrial, and irrigation purposes, and water is exported to meet the requests of the SWP water contractors. In 2005 and 2006, the FRSA received 1,035 and 1,057 taf of water, respectively.

Irrigation—Agriculture. The majority of the water diverted from this reach of the Feather River is used for agriculture.

Recreation—Contact. Recreation management of about 10 miles of the Feather River, including the LFC, overlaps with the Oroville Wildlife Area (OWA). Flows in the LFC are provided for coldwater species and could be considered too cold for some water-contact recreation such as swimming and water skiing. During the 2002 and 2003 relicensing study period, no swimming was observed in the Diversion Pool and little was observed in the Feather River. Other contact recreation uses in this area include bank and boat fishing. In fact, most of the visitors entering this reach of the river are wading anglers.

Recreation—Canoeing and Rafting. Although specified as a beneficial use on the lower Feather River, canoeing and rafting are not typical activities on this reach of river. Informal and formal access is available.

Recreation—Other Non-contact. The primary non-water contact recreation activities on the Feather River are boating, hunting, and wildlife viewing. Other recreational opportunities include hiking on trails and camping.

Freshwater Habitat—Warm Water. Warmwater fishes in the lower Feather River include black bass (downstream of the LFC), Sacramento pikeminnow, hardhead, Sacramento sucker, striped bass, bluegill, green sunfish, redear sunfish, and tule perch. The lower Feather River is not managed for warmwater fish habitat; however, from May through August, the Basin Plan specifies that temperatures must be suitable for warmwater fish.

Freshwater Habitat—Cold Water. Coldwater fish species of primary concern in the lower Feather River include spring-run Chinook salmon, fall-run Chinook salmon, Central Valley steelhead, rainbow trout, brown trout, brook trout, green sturgeon, white sturgeon, river lamprey, and American shad. The LFC is managed to protect these species. Under a 1983 operating agreement between DWR and DFG (1983 Agreement), flows are regulated at 600 cfs in the LFC, except during flood events, when flows have reached as high as 150,000 cfs (DWR 1983).

The1983 Agreement specifies a narrative objective for water temperatures downstream of the Thermalito Afterbay Outlet and a numerical objective for temperatures of water provided to the Feather River Fish Hatchery (Table 4.2-2). Below the Thermalito Afterbay Outlet, temperatures must be suitable for fall-run Chinook salmon during the fall months (after September 15). As previously noted, from May through August,

temperatures must be suitable for shad, striped bass, and other warmwater fish. The 2004 Operations Criteria and Plan (OCAP) Biological Opinion issued by NMFS requires 65-degree Fahrenheit (°F) water, to the extent possible, at River Mile 61.6 (Robinson Riffle) from June 1 through September 30 (Section 4.4).

Table 4.2-2. Feather River Fish Hatchery temperature objectives (±4°F between April 1 and November 30).

Period	Temperature (°F)
April–May 15	51
May 16–31	55
June 1–15	56
June 16–August 15	60
August 16–31	58
September	52
October–November	51
December–March	No greater than 55

Source: DWR 2001

Migration—Warm Water. The Oroville Facilities do not inhibit warmwater fish migration.

Migration—Cold Water. The discharge and flow requirements described above for Freshwater Habitat—Cold Water support the migration of salmon and steelhead.

Spawning—Warm Water. The upper section of the lower Feather River is managed for coldwater fish, which reduces the spawning habitat suitability for warmwater fish in this section of the lower Feather River. The rest of the downstream extent of the lower Feather River remains suitable for warmwater spawning.

Spawning—Cold Water. Provision of the flows and water temperatures described under Freshwater Habitat—Cold Water generally supports the spawning of Chinook salmon in the fall and steelhead in the early winter.

Wildlife Habitat. The 11,000-acre OWA is managed for wildlife habitat and recreational activities. The OWA includes 5,000 acres adjacent to and straddling 12 miles of the Feather River. Wildlife enhancements in the OWA have included wetland habitat enhancements (brood ponds), a wood duck/wildlife nest box program, and dryland farming for nesting cover and improved wildlife forage. The Oroville Facilities reasonably protect this beneficial use designation.

Water Quality Monitoring and Objectives

DWR's Division of Operation and Maintenance, as part of the SWP, conducts water quality monitoring within Project waters. Nutrients are monitored twice a year, in April and November, within the reservoir at Oroville Dam. Aluminum, barium, cadmium, mercury, silver, chlorinated organics, organophosphorus pesticides, herbicides, carbamates, and other pesticides are monitored quarterly at Thermalito Forebay. At Thermalito Afterbay, nutrients are monitored twice a year while aluminum, barium, cadmium, mercury, and silver are monitored monthly and bromide and suspended

solids are monitored quarterly. This monitoring program was augmented to collect additional specific data as part of the Oroville Facilities Relicensing process.

The Oroville Facilities Relicensing studies evaluated water quality parameters potentially affected by the Oroville Facilities and for which the Central Valley RWQCB has established water quality objectives in the Basin Plan. These parameters include but are not limited to water temperature, dissolved oxygen (DO) and pH, conductivity and minerals, sediment, turbidity, suspended material, settleable material, metals, pesticides and other organic contaminants, petroleum byproducts, nutrients, bacteria (pathogens), tastes and odors, color, floating material, radioactivity, and toxicity. In addition, the benthic macroinvertebrate community was studied according to protocols endorsed by the SWRCB.

Results of the water quality studies conducted for the Oroville Facilities were used to determine compliance of the project with Basin Plan objectives. The water quality measurements were compared to the numerical value of the objectives, and other applicable criteria or standards that are recognized as levels protective of beneficial uses. Other applicable criteria or standards used to augment the evaluation of water quality were obtained from the following sources:

- Criteria of the U.S. Environmental Protection Agency (USEPA) California Toxics Rule (USEPA 2000a);
- *Compilation of National Recommended Water Quality Criteria* (USEPA 1999);
- Criteria of the nutrient criteria guidance documents (USEPA 2000b, 2000c, 2000d, 2001);
- *Drinking Water Standards and Health Advisories* (USEPA 2000e);
- Drinking-water criteria (DHS 2004);
- *Water Quality for Agriculture* (Ayers and Westcot 1985);
- *Draft Guidance for Freshwater Beaches* (DHS 2006); and
- Methylmercury tissue contaminant action levels established by the California Office of Environmental Health Hazard Assessment (OEHHA) pursuant to USEPA recommended criteria (USEPA 2001).

Table 4.2-3 lists the objectives, standards, and criteria in the Basin Plan.

Table 4.2-3. Basin Plan water quality objectives, standards, and criteria[1].

Constituent	Concentration	Standard
Chemical constituents	Less than maximum contaminant levels (MCLs) for inorganics, fluoride, organics, secondary MCL consumer acceptance levels, and secondary MCLs—ranges	Title 22 of California Code of Regulations (CCR); see Tables 64431-A, 64431-B, 64444-A, 644449-A, and 644449-B
Arsenic	≤ 0.01 milligrams per liter (mg/L)	Basin Plan
Barium	≤ 0.1 mg/L	Basin Plan
Cadmium	≤ 0.00022 mg/L	Basin Plan
Copper	≤ 0.0056 mg/L	Basin Plan
Cyanide	≤ 0.01 mg/L	Basin Plan
Iron	≤ 0.3 mg/L	Basin Plan
Lead	≤ 0.015 mg/L	Basin Plan
Manganese	≤ 0.05 mg/L	Basin Plan
Silver	≤ 0.01 mg/L	Basin Plan
Zinc	≤ 0.016 mg/L	Basin Plan
Dissolved Oxygen	≥ 8 mg/L [9/1–5/31] ≥ 7 mg/L [6/1–8/31]	Basin Plan
Bacteria	≤ 200 fecal coliform conc/100 milliliters (mL); 10% samples ≤ 400/100 mL in any 30-day period	Basin Plan
Biostimulatory Substances	Cannot promulgate aquatic growth that adversely affects beneficial uses	Basin Plan
Color	Free of discoloration causing nuisance or adversely affecting beneficial uses	Basin Plan
Floating Material	Amount not causing nuisance or adversely affecting beneficial uses	Basin Plan
Oil and Greases	Amount not causing nuisance or adversely affecting beneficial uses and no visible film	Basin Plan
pH	6.5 to 8.5 with change ≤ 0.5	Basin Plan
Pesticides	No adverse affect on beneficial uses; total identifiable persistent chlorinated hydrocarbon < detectable; < allowable by applicable antidegradation policies	Basin Plan and U.S. Environmental Protection Agency (USEPA) 40 Code of Federal Regulations (CFR) Section 131.12
Thiobencarb	≤ 1 microgram per liter (µg/L)	Basin Plan
Radionuclides	< concentrations harmful to human, plant, animal and aquatic life	Title 22 CCR, Table 4 of Section 64443
Electrical Conductivity (at 25 degrees Celsius [^{0}C])	≤ 150 micro-mhos per centimeter (µmhos/cm) (90th percentile)	Basin Plan

Table 4.2-3. Basin Plan water quality objectives, standards, and criteria[1].

Constituent	Concentration	Standard
Sediment Load and Suspended Sediment	Not altered to cause nuisance or adversely affect beneficial uses	Basin Plan
Settleable Material	Not contain substances resulting in deposition causing nuisance or adversely affecting beneficial uses	Basin Plan
Suspended Material	Not cause nuisance or adversely affect beneficial uses	Basin Plan
Tastes and Odors	Not contain taste or odor producing substances importing undesirable tastes or odors to water supply, fish flesh, or other edible products	Basin Plan
Temperature	Not alter natural receiving water to extent that beneficial uses are adversely affected; not increase water temperature by more than 5 degrees Fahrenheit (°F)	Basin Plan
Toxicity	Free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal or aquatic life	Basin Plan
Turbidity	Free of changes that cause nuisance or adversely affect beneficial uses	Basin Plan

[1] "Where compliance with these narrative objectives is required (i.e., where the objectives are applicable to protect specified beneficial uses), the Regional Board will, on a case-by-case basis, adopt numerical limitations in orders which will implement the narrative objectives." Basin Plan Chapter 4, Implementation.

Source: Central Valley RWQCB 2006

The Basin Plan states that the natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the RWQCB that such alteration in temperature does not adversely affect beneficial uses. Further, at no time or place shall the temperature of cold or warm intrastate waters be increased more than 5°F above natural receiving water temperature (Section III of the Basin Plan).

The 1983 Agreement established a narrative water temperature objective for the Feather River downstream of the Thermalito Diversion Dam and Thermalito Afterbay Outlet. This narrative objective requires water temperatures that are suitable for fall-run Chinook salmon during the fall (after September 15) and suitable downstream of the Thermalito Afterbay Outlet for shad, striped bass, and other warmwater species from May through August. This objective has no direct effect on operations because it is not well defined, but it has encouraged operators to seek opportunities to provide colder water to the HFC (i.e., the portion of the Feather River downstream of the Thermalito Afterbay Outlet) during the fall months.

In May 1969, DWR entered into an agreement with the water districts that now comprise the Joint Water District Board to provide them with water based upon prior rights. The agreement discusses the diversion season and an amount of diversion, but it does not set numerical criteria for water temperature of agricultural diversions. A similar agreement between DWR and the Western Canal Water District discusses the diversion season and amount of diversion without setting any specific temperature requirement.

4.2.2.2 Water Quality Parameters

Water quality studies were developed and conducted during relicensing with Study Plan (SP) SP-W1, Project Effects on Water Quality Designated Beneficial Uses for Surface Waters (DWR 2004b), which specifically focused on the relationship of Oroville Facilities operations to beneficial uses as specified in the Basin Plan. The following discussions summarize the results of SP-W1.

Water Temperature

Operation of the Oroville Facilities influences Feather River temperatures, which generally comply with the numeric water quality criteria established for the Feather River Fish Hatchery and Robinson Riffle. When temperature exceedances do occur, they are minor. The following subsections describe the relationship between temperature and beneficial uses, summarize the results of related relicensing studies, and provide more information regarding project effects.

Relationship to Beneficial Uses

Water temperature has effects on many of the Basin Plan–designated beneficial uses for the Feather River. The beneficial uses identified in the Basin Plan that temperature can potentially affect are irrigation, contact and non-contact water recreation, warm and cold freshwater habitat, migration, and spawning. Although the Basin Plan does not have a numerical temperature criterion for irrigation, water temperatures associated with irrigation water can potentially affect agriculture because crop growth can be temperature dependent. The potential effects of water temperatures on rice production are discussed in Sections 4.13 and 5.13, Agricultural Resources. Water temperatures also affect recreation, particularly water contact recreation. The potential of water temperatures in the Feather River and the Oroville Facilities to affect warm freshwater habitat, cold freshwater habitat, spawning, and fish migration is discussed in Section 4.4, Aquatic Resources.

Results of Relicensing Studies

This section describes existing water temperature conditions associated with the Oroville Facilities, upper watershed streams, and the lower Feather River. Information in this section is based on continuous data obtained from thermographs installed in the streams and rivers and monthly depth profiles from the reservoirs associated with the Oroville Facilities. Temperatures were monitored beginning in spring 2002; monitoring continues to the current day. A discussion of the results collected from spring 2002

through spring 2004 is discussed here and is available in the report for SP-W6, Project Effects on Temperature Regime (DWR 2004a).

Thermal Regime of Tributaries to Lake Oroville

Water temperature data collected from the West Branch and North, Middle, and South Forks of the Feather River, including tributaries to these streams such as Concow Creek, Fall River, and Sucker Run Creek, are similar and follow seasonal patterns. Water temperatures begin to warm in May and June and reach maximum temperatures ranging from 70 to 80°F in late July and early August. The waters begin cooling in late September, with water temperatures ranging from 40 to 50°F in November through March. Mean summer water temperatures range from 68°F at Fall River, upstream of Feather Falls, to 75°F at West Branch near Paradise.

Lake Oroville

Water temperatures in Lake Oroville's North, Middle, and South Fork arms, the main body of the reservoir, and near Oroville Dam follow seasonal patterns. Surface (epilimnion) water temperatures at these areas begin to warm in the early spring, and reach maximum temperatures approaching the mid-80s ^{o}F during late July, and then gradually decline to winter minimums. The transition zone between the upper warmer and lower colder waters (metalimnion) ranges from about 30 to 50 feet below the surface during midsummer. The deeper water (hypolimnion) reaches a temperature of about 44°F near the reservoir bottom. Drawdown of reservoir water levels and gradual cooling of surface waters through the fall extends the depth of the epilimnion, and by late winter, relatively uniform temperatures exist throughout the water column in Lake Oroville.

Diversion Pool, Fish Barrier Pool, and Thermalito Forebay

The temperature of the water released from Lake Oroville generally affects water temperatures in the Diversion Pool, the Fish Barrier Pool, and Thermalito Forebay. The water warms a few degrees during hot weather, especially at the surface, as the water flows downstream in these facilities. At certain times of the year, Diversion Pool water temperatures can also be influenced by inflows from the South Feather Water & Power Agency's Kelly Ridge Power Plant.

Thermalito Afterbay

Water temperatures in Thermalito Afterbay increase during the spring through summer and decrease in the winter in response to the temperature of water delivered from South Thermalito Forebay and atmospheric conditions. Thermalito Afterbay can be described as North Thermalito Afterbay (north of State Route [SR] 162) and South Thermalito Afterbay (south of SR 162). Water temperatures in North Thermalito Afterbay are very similar to those in South Thermalito Forebay throughout the year. During spring, however, water temperatures increase more rapidly in South Thermalito Afterbay than in North Thermalito Afterbay. Measured temperature differences between North

Thermalito Afterbay and South Thermalito Afterbay ranged from essentially no change in April to about 9°F or more in September.

Water Released from Thermalito Afterbay

Water is released from Thermalito Afterbay to several irrigation canals and to the Feather River through the Thermalito Afterbay Outlet. Water temperatures can vary from the northern to the southern part of Thermalito Afterbay. The Western Canal and Sutter Butte Canal are two of the principal irrigation canals that receive water from Thermalito Afterbay; the Western Canal receives its water from North Thermalito Afterbay and the Sutter Butte Canal receives its water from southern portion of the Thermalito Afterbay. Water temperatures are usually warmer at the outlet to the Feather River than at either the Western Canal or Sutter Butte Canal outlets. Based on water temperature monitoring in 2002 and 2003, temperatures at the Thermalito Afterbay Outlet were as much as 11.3°F warmer than those at the Western Canal diversion, and up to 7.2°F warmer than those at the Sutter Butte Canal diversion.

Feather River Downstream of the Fish Barrier Dam

Water temperatures in the Feather River downstream of the Fish Barrier Dam vary seasonally. The river temperature patterns are best described separately for the LFC and the HFC. The LFC is considered the Feather River between the Fish Barrier Dam and the confluence with the Thermalito Afterbay Outlet. The HFC is the Feather River downstream of the confluence of the LFC and the Thermalito Afterbay Outlet.

Low Flow Channel

Water temperatures in the LFC begin to warm in March and maximum temperatures are reached in July and early August with a range from 61°F upstream of the Feather River Fish Hatchery to 69°F upstream of the Thermalito Afterbay Outlet. This reach of the river begins cooling in September, with water temperatures dropping to 45°F throughout the reach by February. Temperatures of water released from the Feather River Fish Hatchery vary little from temperatures of river water near the hatchery.

The release temperatures from Oroville Dam are designed to meet Feather River Fish Hatchery and Robinson Riffle temperature schedules included in the 1983 DFG Agreement and OCAP while also conserving the coldwater pool in Lake Oroville. Current operation indicates that water temperatures at Robinson Riffle are almost always met when the hatchery objectives are met. Due to temperature requirements of endangered fish species and the hatchery and overriding meteorologic conditions, the temperature requests for agriculture can be difficult to satisfy.

Water is withdrawn from Lake Oroville at depths that will provide sufficiently cold water to meet the Feather River Fish Hatchery and Robinson Riffle temperature targets. The reservoir depth from which water is released initially determines the river temperatures, but atmospheric conditions, which fluctuate from day to day, modify downstream river temperatures. Altering the reservoir release depth requires installation or removal of

shutters at the intake structures. Shutters are held at the minimum depth necessary to release water that meets the Feather River Fish Hatchery and Robinson Riffle criteria.

Water released from Lake Oroville and used for power generation may be pumped back into the reservoir for reuse later. While pump-back operations can draw water that has warmed in Thermalito Forebay or Thermalito Afterbay back into the Diversion Pool and Lake Oroville, these activities are monitored to identify potential adjustments necessary to operations to provide cooler water to help achieve downstream water temperatures described in the agreements for the lower Feather River.

High Flow Channel (Feather River Below the Thermalito Afterbay Outlet)

Water temperatures in the HFC begin to warm in March, reaching maximum temperatures during July and August that range from 71 to 77°F. River cooling begins in late August, with minimum temperatures of 44 to 45°F reached by January or February.

Releases from the Thermalito Afterbay Outlet as well as flow contributions from Honcut Creek, the Yuba River, and the Bear River influence HFC water temperatures from April through October. Except during periods of high flow through Thermalito Afterbay, which occur frequently in July and August, releases from Thermalito Afterbay during the warm season generally raise the water temperature of the river. Honcut Creek and Bear River inflows also tend to increase Feather River temperatures downstream of their confluences during this period. Flows contributed by the Yuba River tend to cool the Feather River during the warmer spring and summer months.

Existing Conditions at the Feather River Fish Hatchery

Generally, water temperatures for the Feather River Fish Hatchery are in compliance with the 1983 Agreement. Monitoring data from April 2002 to March 2004 indicate general compliance with the Feather River Fish Hatchery's temperature requirements 95 percent of the time. Temperatures were below the temperature requirements 13 days (less than 2 percent of the monitoring period), and exceeded requirements on 24 days (slightly more than 3 percent of the monitoring period). The 13 days in which temperatures were below the temperature requirement all occurred within the warmer summer months (June 15–August 31). Except for one day in spring 2002, temperature requirements were exceeded for 23 days during an extended warm period in the fall of 2002 (Table 4.2-4) when temperature requirements are at their lowest (51°F).

Existing Conditions in the Low Flow Channel

The 2004 OCAP Biological Opinion issued by NMFS requires daily mean temperature of 65-degree water, to the extent possible, at River Mile 61.6 (Robinson Riffle) from June 1 through September 30. The water temperatures slightly exceeded the 65°F maximum value in 2002 and 2003: on June 19, 2002, the mean temperature was 65.5°F, and during July 2003 the objective was exceeded on 5 occasions, with a maximum daily mean temperature of 66.0°F. These exceedances were most likely

caused by the response time and river heating from the Fish Barrier Dam to Robinson Riffle. In order to conserve the coldwater pool during dry years, DWR has strived to meet the Robinson Riffle temperatures by increasing releases to the LFC rather than releasing colder water.

Table 4.2-4. Compliance with 1983 DFG fish hatchery temperature requirements, April 2002–March 2004.

Dates	Days Below Minimum Objective	Days Above Maximum Objective	% of Days Below Minimum	% of Days Above Maximum
Year 2002–2003				
April–May 15	0	1	0	2
May 16–31	0	0	0	0
June 1–15	0	0	0	0
June 16–August 15	7	0	11.5	0
August 16–31	2	0	12.5	0
September	0	0	0	0
October–November	0	23	0	37.7
December–March	0	0	0	0
Year 2003–2004				
April–May 15	0	0	0	0
May 16–31	1	0	6.3	0
June 1–15	0	0	0	0
June 16–August 15	2	0	3.2	0
August 16–31	1	0	5.9	0
September	0	0	0	0
October–November	0	0	0	0
December–March	0	0	0	0

Source: DWR measurements

Existing Conditions at Agricultural Diversion Points

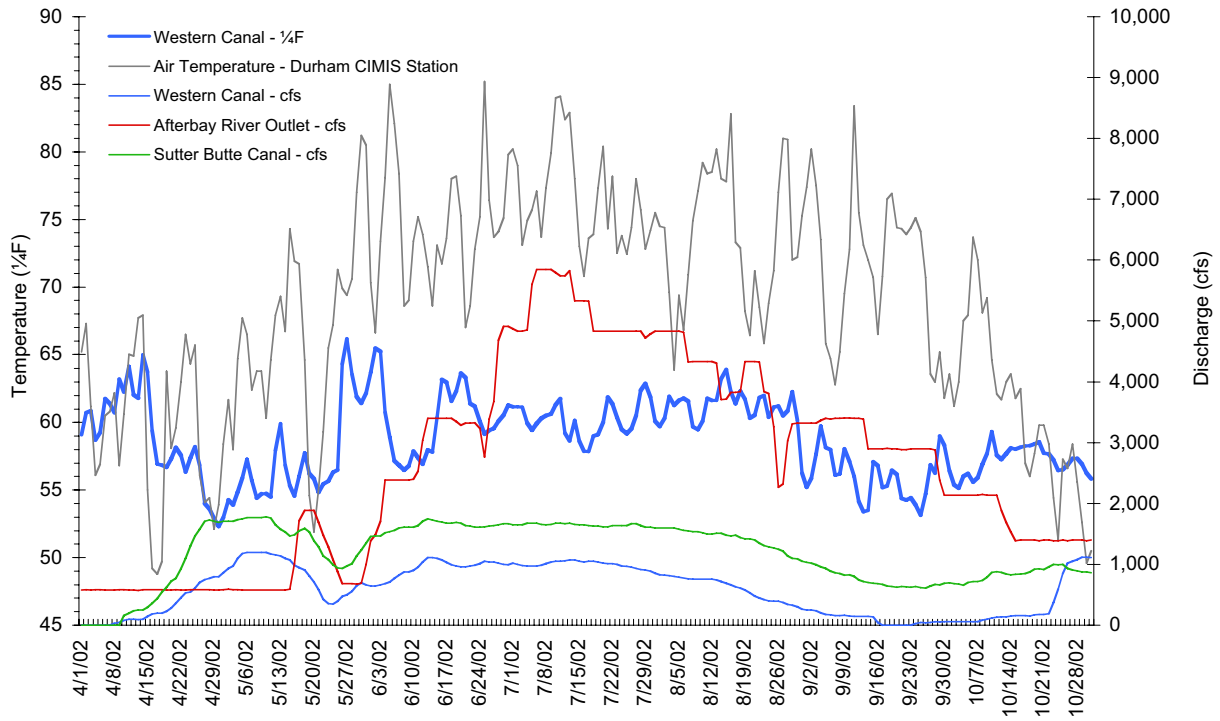
Agricultural water withdrawals are made directly from Thermalito Afterbay at several points. The project-related water temperature concern for agricultural users is the temperature of the water diverted from Thermalito Afterbay during the early part of the rice growing season, which generally begins in April or May. DWR has entered into a contractual agreement for the delivery of water to agricultural users and the concerns are discussed and resolved under the agreement. Water temperature, air temperature, the amount of water applied, and the varieties of rice planted are all factors that affect rice production. It should also be noted that agricultural users benefit from the late-season water reliability, which is greater during the latter part of the irrigation season than before the project was constructed.

Water temperatures at Thermalito Afterbay canal outlets can be influenced by several factors, including air temperatures, water temperatures of the Lake Oroville releases, meteorologic conditions, and operations that determine the residence time of water in Thermalito Afterbay. Residence time influences the amount of atmospheric warming that can occur in Thermalito Afterbay before the water reaches the agricultural

diversions. Oroville Facilities operations that determine the effective residence time of water in Thermalito Afterbay include:

- The volume of inflows compared to the total releases from Thermalito Afterbay, including the release to the river and agricultural diversions;
- The volume of water in Thermalito Afterbay; and
- The amount of peaking and pump-back operations.

As shown in Figure 4.2-11, when residence time is decreased due to increased diversions to the Western and Sutter Butte Canals and the Feather River, the temperature of water released from Thermalito Afterbay to the Western Canal also decreases.



Note: °F = Fahrenheit; cfs = cubic feet per second

Source: DWR Thermalito Afterbay ALP water temperature workshop (SP-W6, DWR, July 2004)

Figure 4.2-11. Effects of air temperatures and flows released from Thermalito Afterbay on Western Canal water temperatures during the 2002 growing season.

The location of an agricultural diversion in Thermalito Afterbay can affect travel and residence time for water in Thermalito Afterbay prior to reaching the diversion. The diversion locations for the Western Canal and the Richvale Canal are located opposite the Thermalito Afterbay inlet (i.e., the Thermalito Pumping-Generating Plant release point) in the northernmost portion of Thermalito Afterbay. This is an area with reduced circulation and exchange with the southern portions of Thermalito Afterbay. Water

entering Thermalito Afterbay from the Thermalito Pumping-Generating Plant tail canal flows directly toward these diversions, reducing residence time in Thermalito Afterbay. In contrast, the Sutter Butte Main Canal diversion is on the south side of Thermalito Afterbay, which allows water longer residence time in Thermalito Afterbay before it is diverted.

During Oroville Facilities pump-back operations, warmer water tends to be drawn from the southern, main body of Thermalito Afterbay into the more isolated northern portion, providing some warming of water at the Western Canal and Richvale diversion locations. Thermal imagery taken during pump-back operations shows a plume of warm water being drawn from the southern portion of Thermalito Afterbay through the constriction at the SR 162 bridge and into the northern portion of Thermalito Afterbay.

Effects of Pump-Back Operations

Data on recent pump-back operations were reviewed to evaluate effects of pump-back operations on Feather River Fish Hatchery temperatures and reservoir stratification. During pump-back operations, water is pumped from Thermalito Afterbay to Thermalito Forebay, then into the Thermalito Power Canal, to the Diversion Pool, and back into Lake Oroville. Pump-back operations have no effects on Lake Oroville water column temperatures but may affect the hatchery and LFC water temperatures. Pump-back operations are curtailed if hatchery temperatures would not otherwise be met.

Existing Water Temperature Conditions in the Feather River Downstream of the Thermalito Afterbay Outlet

Water temperatures in the Feather River downstream of Thermalito Afterbay Outlet are influenced by meteorological conditions, release rates and depths from Lake Oroville, and the relative volumes of flow either diverted to the Thermalito Complex or directed down the LFC. Water temperature increase in Thermalito Afterbay is related primarily to meteorological conditions (Figure 4.2-12) and residence time. Total releases from Thermalito Afterbay, including releases for agricultural diversions, determine the residence time of water in the Afterbay and, therefore, the opportunity for the water to warm under ambient climatic conditions. Based on relicensing workshop results reported in a series of documents (SP-E2), the volume of flow released from the Oroville Facilities potentially affects water temperatures downstream to the Honcut Creek confluence.

Dissolved Oxygen, pH

DO and pH levels within the project area were generally found to comply with the water quality objectives of the Basin Plan. When exceedances did occur, they were minor. The following subsections describe the relationship between DO and pH and beneficial uses, summarize the results of related relicensing studies, and provide information about potential existing project effects.

Relationship to Beneficial Uses

The beneficial uses identified in the Basin Plan that DO and pH can potentially affect are warm freshwater habitat and cold freshwater habitat.

Results of Relicensing Studies

The draft final report for SP-W1, Project Effects on Water Quality Designated Beneficial Uses for Surface Waters (DWR 2004b), provides seasonal information regarding DO and pH levels in the project area, including the upper watershed, Lake Oroville, the Thermalito Complex impoundments, and the lower Feather River. The Basin Plan objectives for DO and pH are provided in Table 4.2-3. The SP-W1 report also provides evaluations of the effects of decomposing salmon carcasses and discharges of non-Project related treated sewage on DO levels in the lower Feather River.

For upstream tributaries, within the FERC Project boundary, all DO concentrations met the Basin Plan objective for cold water (minimum of 7.0 mg/L). On the West Branch Feather River upstream of Lake Oroville and outside of the FERC Project boundary, a DO value of 4.9 mg/L was recorded. In upstream tributaries, all pH concentrations were within the range specified for the Basin Plan objective (i.e., 6.5–8.5).

In Lake Oroville, DO and pH levels at the monitoring stations generally met the Basin Plan objectives. Occasionally, when Lake Oroville thermally stratified during the summer, DO measured near the surface and bottom of the reservoir did not meet the objective. In February 2002, the pH at the Middle Fork area of Lake Oroville exceeded the objective.

DO and pH concentrations downstream of Oroville Dam are generally consistent with the Basin Plan objectives. The Basin Plan has a specific DO objective, 8.0 mg/L, for the Feather River from the Fish Barrier Dam to Honcut Creek from September through May. The DO concentrations in the lower Feather River dropped below this objective (to 5.4 mg/L) at the station downstream of the Feather River Fish Hatchery on October 27, 2003. This was during the salmon spawning period, when decomposing salmon carcasses were present. DO concentrations dropped slightly below the objective (with measurements of 6.5–7.6 mg/L) at 3 other stations during mid-December 2002. One pH value (6.3) obtained at Thermalito Afterbay Outlet was also slightly below the objective.

Conductivity and Minerals

Concentrations of dissolved inorganic minerals, and associated electrical conductivity, in the project area routinely comply with Basin Plan water quality objectives. However, use of salt at the Feather River Fish Hatchery was found to coincide with detectable changes in electrical conductivity in the LFC on one occasion. The following subsections describe the relationship between conductivity and minerals and beneficial uses, and summarize the results of related relicensing studies.

Relationship to Beneficial Uses

The beneficial uses identified in the Basin Plan that electrical conductivity and mineral contents can potentially affect are warm freshwater habitat and cold freshwater habitat.

Results of Relicensing Studies

The SP-W1 report (DWR 2004b) provides information regarding electrical conductivity and dissolved minerals in the study area, while the report for SP-W7, Land and Watershed Management Effects on Water Quality (DWR 2004c), provides more focused information regarding minerals in stormwater runoff. Results of both studies were used to determine compliance with water quality objectives or goals.

Electrical conductivity and minerals at most monitoring sites were routinely below objectives for the Feather River. On one date, in the LFC downstream of Feather River Fish Hatchery, the electrical conductivity was 151 micro-mhos per centimeter [µmhos/cm]), which is slightly higher than the Basin Plan objective of 150 µmhos/cm (see the SP-W1 report [DWR 2004b]).

Existing Conditions

The mineral and electrical conductivity values in the project area were routinely within Basin Plan water quality objectives.

Sedimentation, Turbidity, Suspended Solids, and Settleable Matter

Dams and reservoirs can affect the transport of sediment by trapping it and by reducing the size of the sediment that is released or spilled below the dam. The following subsections describe the relationship between related water quality parameters and beneficial uses, and summarize the results of related relicensing studies.

Relationship to Beneficial Uses

All of the beneficial uses identified in the Basin Plan can be affected when sedimentation, suspended solids, and settleable matter are excessive. The Basin Plan includes a narrative criterion for total suspended solids (TSS) designed to prevent impairment from nuisance conditions. The Basin Plan also contains numerical objectives for the allowable change in turbidity from background levels that may result from controllable factors.

Results of Relicensing Studies

The SP-W1 report (DWR 2004b) provides information regarding turbidity, TSS, and settleable matter in the project area based on monthly sampling. Results of the study were compared to the water quality objectives and criteria listed in Table 4.2-3 to determine compliance with the Basin Plan. Settleable matter concentrations were at trace or undetectable levels for the large majority of samples; therefore, they are not discussed further.

Results from SP-W1 indicate that the tributaries to Lake Oroville typically have very low levels of turbidity and TSS, except during storm events. Lake Oroville acts as a sediment trap, which results in low concentrations in Lake Oroville, the Feather River immediately downstream of Oroville Dam, and at the Thermalito Complex. Downstream of the Thermalito Afterbay Outlet, turbidity and TSS concentrations generally increase. This increase may be related to inputs from downstream tributaries to the lower Feather River. Approximately half of the samples from the Feather River at Shanghai Bend, the Feather River near Verona, and Honcut Creek failed to meet the Basin Plan turbidity objectives. The Bear River and Sacramento River stations each exceeded the turbidity objectives in all but one sample.

The U.S. Soil Conservation Service considers the upper Feather River watershed to be subject to accelerated erosion as a result of human-caused disturbances (United States Soil Conservation Service 1989). However, the numerous dams and reservoirs upstream of Lake Oroville are known to be effective traps of sediment, thereby reducing the quantity of sediment transported into Lake Oroville.

Wind and wave action within Lake Oroville can cause erosion along the shoreline, which in turn could contribute to minor sedimentation within the reservoir. Most shoreline erosion likely occurred during the first years following initial reservoir filling with scouring loss of the original topsoil.

Downstream of Oroville Dam, the release of “sediment-starved” water can cause scour and erosion of channel substrate and transport of additional suspended sediment. However, the reduction of larger channel-forming flows resulting from flood storage in Lake Oroville has had the opposite effect, reducing bank erosion and large channel meandering. In general, observations and modeling conducted for SP-G2, Effects of Project Operations on Geomorphic Processes Downstream of Oroville Dam, indicate that channel erosion downstream of Lake Oroville will slowly decrease over time.

Existing Conditions

The Oroville Facilities and project operations inhibit sediment transport and deposition. Due to the large size of Lake Oroville, most sediments that flow into the reservoir from the upper watershed are effectively retained, and only suspended material passes through to the lower Feather River basin. Wave and wind action causes some shoreline erosion.

Appropriate best management practices (BMPs) and other measures are typically implemented to avoid and minimize potential effects related to erosion from various ongoing operations and maintenance activities within the FERC Project boundary.

Sediment trapping behind Oroville Dam results in the release of relatively sediment-free water downstream of the reservoir. Fluvial modeling results for the lower Feather River indicate that channel erosion and scour will likely decrease over the long term as the supply of erodable sediment in the lower Feather River is depleted.

Metals

The Oroville Facilities are not a source of metals. However, they do affect metal loadings below Oroville Dam by trapping sediment from upstream historic mining sources behind the dam. Some fish tissue samples collected from fish in the project area exhibit accumulation of mercury above related public-health criteria. The following subsections describe the relationship between metals and beneficial uses, and summarize the results of related relicensing studies.

Relationship to Beneficial Uses

The beneficial uses identified in the Basin Plan that metals can potentially affect are contact water recreation (fishing), warm freshwater habitat, and cold freshwater habitat.

Results of Relicensing Studies

The SP-W1 report (DWR 2004b) provides information regarding metals concentrations in water in the project area. The report for SP-W2, Contaminant Accumulation in Fish, Sediments, and the Aquatic Food Chain (DWR 2004d), describes concentrations of metals in tissues collected from fish and crayfish in the project area. The report for SP-W3, Recreational Facilities and Operations Effects on Water Quality (DWR 2004e), gives information on levels of metals during the 2003 recreation season near developed recreational facilities and other locations in the project area with heavy recreation use. The SP-W7 report (DWR 2004c) examines concentrations of metals in stormwater drainage within and outside the FERC Project boundary.

The results from the studies were compared to the numerical limits used for Basin Plan objectives. The results from tissue sample analyses were compared to guidelines and criteria from various regulatory agencies and are contained in Appendix G-WQ2 of the PDEA.

Water Samples. The SP-W1 report (DWR 2004b) indicates that some water samples analyzed exceeded the Basin Plan objectives. Figure G-WQ2.5-1 in Appendix G-WQ2 of the PDEA depicts the location for each sampling station and the number of times any of the numerical limits were exceeded. The results also indicate that water samples that exceed objectives typically increased in frequency downstream of the FERC Project boundary.

The SP-W7 report (DWR 2004c) indicates that stormwater drainage samples from the city of Oroville and Kelly Ridge (a residential area outside the FERC Project boundary but near Oroville Dam) exceed the Basin Plan objectives for arsenic, aluminum, iron, manganese, and zinc. These results indicate that the Oroville Facilities are likely not a source of these constituents.

Tissue Samples. Analyses of metals contaminants in fish and crayfish tissues were conducted in two phases. In Phase 1, fish samples were collected from sites in Lake Oroville, the lower Feather River (the LFC and the HFC), the Thermalito Complex (Thermalito Forebay, Thermalito Afterbay, and Potters Pond), and two ponds in the

OWA. Crayfish tissue samples were obtained from the Diversion Pool, the Thermalito Complex, and the lower Feather River. Sediments were collected from sites where fish were collected. Phase 2 included supplementing fish tissue testing for mercury from additional sites from within the FERC Project boundary, upstream, and downstream from the project to broaden the scope of the study. Phase 2 also included the analyses of sediment samples collected during Phase 1.

The SP-W2 report (DWR 2004d) indicates that metal concentrations in tissue samples are generally below or occasionally above recommended levels included in the guidelines and criteria of various regulatory agencies. Phase 2 confirms that mercury consistently exceeds USEPA guidelines in most fish species and locations sampled for SP-W2. However, salmonids collected at the Feather River Fish Hatchery exhibited low levels of mercury in tissue.

In tributary waters upstream of the Project area, fish from some tributaries were insufficient in size or species to compare with Lake Oroville samples. Where tributary fish were collected, mercury levels in bass and trout were relatively low; however, several larger Sacramento pikeminnow collected in the North Fork Feather River near Poe Powerhouse contained mercury levels in excess of USEPA criteria.

Biomagnification apparently has resulted in elevated mercury levels in fish from all project waters. This is evidenced by the difference from coho Age-0 samples collected from the Feather River Fish Hatchery, when compared to Age-1 to 2 coho sample composites from Lake Oroville. Tissues from returning adult Chinook salmon and steelhead indicate that these fish do not bioaccumulate mercury during their life history away from the Project area to the same extent as do representative coho salmon in Lake Oroville. Mercury was detected in fish tissues from the lower Feather River at levels that exceeded criteria but at levels lower than in fish tissues sampled from areas of Lake Oroville.

Fish consumption advisories released by the California Environmental Protection Agency through its OEHHA are relatively common in the Sierra Nevada foothills, the Delta, and the Coastal Ranges of California where historic mercury ore mining and processing or gold mining activities occurred. There is a new Draft OEHHA consumption advisory for mercury in fish from the lower Feather River in Butte, Yuba, and Sutter Counties (OEHHA 2006). There is also a consumption advisory for the Bear and Yuba River watersheds (http://www.oehha.ca.gov), which are tributaries to the lower Feather River. However, OEHHA indicates that there have been no recorded incidences of mercury-related health effects from consumption of sport fish from California waters. The potential for health effects at the fish tissue mercury levels typically found in California is minimal unless a person is eating considerably greater quantities of fish than recommended (OEHHA 2003).

Analyses of sediment samples collected indicated that total mercury levels were below laboratory detection limits. However, methylmercury was found over the majority of sampling locations. Methylmercury concentration has a positive correlation with sediment total organic carbon (TOC) levels from sampled stations. Stations with

elevated TOC have higher methylmercury concentrations, signifying greater biomass availability and possibly leading to increased rates of mercury biotransformation.

Existing Conditions

Historical gold mining practices upstream of the Project area, as well as the development of municipal and industrial land uses in the upper watershed and along the lower Feather River, continue to be the primary sources for most of the metals found in the Project area. Because metals are usually associated with sediments, and Lake Oroville inhibits sediment transport, the Oroville Facilities act as a sink. Consequently, the Oroville Facilities likely affect the concentrations of metals in the project area both within Lake Oroville and downstream of Oroville Dam. The sources of excess metals in the watershed, particularly mercury, are unrelated to the Oroville Facilities.

Sediment from upstream sources is captured in Lake Oroville. A principal beneficial effect is to inhibit the transport of contaminated sediments to the lower Feather River and other water bodies. There is no evidence that operation of the Oroville Facilities has contributed to elevated concentrations of metals in fish tissues. However, the Oroville Facilities increase sportfishing opportunities in the project area. As discussed above, OEHHA has stated that there is a low potential health risk from consuming California sport fish from water bodies subject to fish advisories, unless the consumption rate is considerably higher than recommended.

Pesticides

The use of pesticides at the Oroville Facilities is minor. The Butte County Mosquito Abatement District is responsible for mosquito control within the OWA.

Relationship to Beneficial Uses

The beneficial uses identified in the Basin Plan that could potentially be affected by pesticide use are municipal and domestic water supply, warm freshwater habitat, cold freshwater habitat, and wildlife habitat. The California drinking-water standards are not applicable to ambient concentrations in source water supplies because the standards specifically apply to water after it has been treated.

Results of Relicensing Studies

The SP-W1 report (DWR 2004b) provides information regarding pesticide concentrations in water in the overall study area. The SP-W2 report (DWR 2004d) describes concentrations of pesticides in tissues collected from fish and crayfish in the project area, and the SP-W7 report (DWR 2004c) describes the results of sampling for pesticides following treatment for mosquito abatement in some OWA ponds.

The SP-W1 report indicates that the pesticide diuron was detected in one sample but that the concentration was well below USEPA criteria. The sample was collected upstream of the FERC Project boundary.

The SP-W2 report indicates that pesticides including chlordane, chlorpyrifos, dichlorodiphenyltrichloroethane (DDT) isomers, dieldrin, hexachlorobenzene, and polychlorinated biphenyls (PCBs) were detected in fish and crayfish tissue during Phase 1. The fish tissue guidelines used for this evaluation are provided in Appendix G-WQ2 of the PDEA.

None of the individual chlordane compounds exceeded the guidance values. However, the sum of the individual chlordane compounds (i.e., total chlordane) exceeded the maximum tissue residue level (MTRL) at each site where any chlordane compounds were detected.

Chlorpyrifos was detected only in fish from the Lower Pacific Heights Pond, and did not exceed any criteria. Dieldrin levels exceeded the MTRL in channel catfish in Lake Oroville, the North Fork Arm, and near the Spillway. Dieldrin levels exceeded the MTRL in carp collected from North Thermalito Forebay swim area, and from South Thermalito Afterbay, and bullhead sampled from Mile Long Pond also exceeded the MTRL.

While hexachlorobenzene was detected in catfish, Sacramento sucker, Sacramento pikeminnow, and carp sampled, it was not found in samples of bass or crayfish. No criteria were exceeded for hexachlorobenzene.

Some polynuclear aromatic hydrocarbons (PAHs) were detected in fish tissue composites obtained from the Feather River Fish Hatchery. Hatchery composite PAHs with associated USEPA screening value criteria, including benzo(a)pyrene, were below reporting limits. However, the DFG laboratory reporting limits were over three times higher than the screening value for benzo(a)pyrene. Therefore, no clear conclusions can be drawn for benzo(a)pyrene.

PCBs were detected in all fish and crayfish species from all water bodies that were sampled. Aroclors were detected in at least some fish in all water bodies (except Mile Long Pond) and in crayfish in the Feather River downstream from the SR 70 bridge. (Aroclor is a trade name under which Monsanto marketed a product line of insulating fluids beginning in the 1930s and continuing for several decades.) The elevated data level (EDL) for Aroclor 1254 was exceeded in Sacramento sucker collected from the Diversion Pool, pikeminnow and carp from North Thermalito Forebay swim area, carp from South Thermalito Afterbay, crayfish from the Feather River downstream of the SR 70 bridge, and channel catfish from the Lower Pacific Heights Pond. The EDL for Aroclor 1260 was exceeded in channel catfish from both South Fork Arm collection sites and the lower Middle Fork Arm of Lake Oroville, pikeminnow and carp from the North Thermalito Forebay swim area, and carp from the South Thermalito Afterbay.

Bass tissue samples contained PCBs at much lower levels than found in other fish species. However, spotted bass collected from both South Fork arms of Lake Oroville and largemouth bass collected from the Feather River both upstream and downstream from Thermalito Afterbay Outlet to the Feather River, contained total PCBs (as the sum of Aroclors) that exceeded the MTRL and screening values of the USEPA and OEHHA. Spotted bass from the lower Middle Fork Arm of Lake Oroville contained total PCBs that

exceeded the MTRL and were at the same concentration as the USEPA screening value. Total PCBs (as the sum of Aroclors) exceeded the MTRL and USEPA and OEHHA screening values in channel catfish from all sites where samples of this species was collected, which included all the Lake Oroville sampling sites and Lower Pacific Heights Pond. In addition, channel catfish sampled from the lower Middle Fork Arm of Lake Oroville exceeded the USFWS contaminant hazard recommendation for wildlife (USFWS 1986), while those sampled from both South Fork Arm collection sites also exceeded the EDL and USFWS contaminant hazard recommendation for wildlife. Both pikeminnow and carp collected from North Thermalito Forebay swim area exceeded the MTRL, EDL, USEPA, and OEHHA screening values and USFWS contaminant hazard recommendation for wildlife. Carp collected from both North Fork arms of Lake Oroville, South Thermalito Afterbay, and Potters Pond, as well as Sacramento sucker collected from the Diversion Pool and crayfish collected downstream of the SR 70 bridge exceeded the MTRL, USEPA, and OEHHA screening values for total PCBs as the sum of Aroclors. In addition, the EDL and USFWS contaminant hazard recommendations for wildlife were exceeded in carp collected from South Thermalito Afterbay.

Some of the detected PCBs found in post-spawn, adult Chinook salmon, and steelhead tissue composites were found to contain PCB levels, expressed as the sum of Aroclors, exceeding the MTRL for carcinogens in inland surface waters and the USEPA action level. Additionally, the larger size class steelhead composite also exceeded the OEHHA screening value. The coho composites collected from the Feather River Fish Hatchery and from Lake Oroville were found to have very low PCB levels that did not exceed any criteria or guideline. The hatchery coho composites were analyzed for pesticides in addition to PCBs. The coho composite collected from the Hatchery Annex rearing facility exceeded the MTRL for the pesticide dieldrin.

Although hatchery-raised fingerling Chinook salmon and steelhead were not analyzed for PCBs, hatchery-raised coho salmon of smolt size were analyzed. Based on PCB levels measured in these fish, as well as adult coho collected from the lake, it is clear that coho accumulate PCBs at an increased rate after removal from the Feather River Fish Hatchery for stocking into Lake Oroville, though still at levels below criteria. The PCB levels detected in adult coho collected from Lake Oroville serve as an indicator of bio-available PCB uptake in salmonids in Project waters, as the coho spend their entire life history in Feather River water. Conversely, PCB levels in the adult anadromous Chinook salmon and steelhead are much higher, indicating that uptake of these contaminants most likely occurred during their extended migrations through the Delta and Pacific Ocean.

Composite tissue samples of carp were found to contain the highest concentration of PCBs of all fish species sampled during Phase 2. Carp composites with the highest levels detected, were collected from the South Fork Arm of Lake Oroville, South Thermalito Afterbay, and Robinson Pond. Carp from these locations exceeded human health criteria, including the MTRL, EDL, OEHHA, and USEPA screening values, and wildlife protection criteria for total Aroclors. The Robinson Pond samples also exceeded wildlife protection criteria for total PCB congeners. PCB levels in individual channel and

white catfish sampled from Lake Oroville stations also exceeded human health criteria, but were below wildlife protection criteria.

Pikeminnow composite tissue samples were found to contain PCB levels exceeding human health criteria for total Aroclors from the North Fork Feather River near Poe Powerhouse, the Feather River near Gridley, and the South Fork Feather River upstream of Ponderosa Reservoir. The South Fork Feather River fish also exceeded the wildlife criteria for total PCB congeners. One composite sample of largemouth bass from Robinson Pond, as well as one composite of rainbow trout collected from the South Fork Feather River upstream of Ponderosa Reservoir, contained total Aroclors exceeding human health criteria. PCB uptake is most pronounced in minnows (carp, pikeminnow, and hardhead), followed by catfish. The only black bass composite to exceed criteria came from Robinson Pond, but this may be due to the larger size class of these bass sampled when compared to the other bass composites analyzed for this phase of the study. However, heavy industrial uses in this area may also contribute to PCB levels in fish; sediment PCB levels sampled nearby in the Feather River were at detectable levels.

Sediments collected during Phase 1, analyzed for organochlorine and organophosphorus pesticides during Phase 2, showed results below detection limits. Analyses for 52 different PCB congeners yielded detectable levels for only 8 congeners at 1 sampling station (Feather River upstream of Thermalito Afterbay Outlet). While fish samples contained PCB levels exceeding various criteria, sediments from Project waterbodies do not appear to be a major source of this contamination. The sediments with detectable levels of eight PCB congeners were collected from the downstream extent of the LFC, which has industrial activity adjacent to several miles of the river upstream of the sampling location.

The SP-W7 report indicates that methoprene and malathion and their breakdown byproducts were below detection levels. These pesticides are typically applied for mosquito control in the OWA. However, DWR was not informed that the Butte County Mosquito Abatement District used different pesticides during the year of monitoring.

Existing Conditions

The use of pesticides at the Oroville Facilities is minor. The Butte County Mosquito Abatement District applies pesticides for the control of mosquitoes to OWA ponds. Additionally, herbicides are applied for routine and ongoing maintenance of recreational and other facilities within the FERC Project boundary. However, application methods should be in accordance with Butte County Agriculture Commissioner Bulletins and pesticide label rates. Some pesticides were detected in fish tissue samples.

Petroleum Byproducts and Fuel Additives

Project-related boating and stormwater runoff from recreation use areas could contribute to infrequent and isolated detections of petroleum byproducts and fuel additives. The following subsections describe the relationship between these

parameters and beneficial uses, and summarize the results of related relicensing studies.

Relationship to Beneficial Uses

The beneficial uses identified in the Basin Plan that petroleum products can potentially affect are municipal and domestic water supply, warm freshwater habitat, cold freshwater habitat, and wildlife habitat. The California drinking-water standards are not applicable to ambient concentrations in source water supplies because the standards specifically apply to water after it has been treated.

Results of Relicensing Studies

The SP-W1 report (DWR 2004b) indicates that petroleum products were largely undetected in water samples. Similar results are reported in the SP-W7 report (DWR 2004c) for water samples collected in storm drains and the lower Feather River.

Existing Conditions

Project activities and facilities likely provide no direct source of detectable levels of petroleum byproducts and fuel additives.

Nutrients

Project-related recreation use and operation of the Feather River Fish Hatchery may contribute to increased nutrient loading in the project area. The following subsections describe the relationship between these nutrients and beneficial uses, and summarize the results of related relicensing studies.

Relationship to Beneficial Uses

The beneficial uses identified in the Basin Plan that nutrients can potentially affect are warm freshwater habitat and cold freshwater habitat.

Results of Relicensing Studies

The SP-W1 report (DWR 2004b) provides information on nitrogen and phosphorus concentrations in the project area, the SP-W3 report (DWR 2004e) provides information on nutrients near recreational facilities, and the SP-W7 report (DWR 2004c) provides information on nutrients in stormwater runoff. Results of all three studies were compared to the Central Valley RWQCB Basin Plan water quality objectives and criteria. Nutrient concentrations throughout the project area were consistently below most Basin Plan objectives for protection of beneficial uses.

The SP-W1 report also provides results of three focused investigations:

- Monitoring of periphyton (attached algae) density and dominant taxa to assess nutrient conditions;

- Nutrient additions from decomposition of spent salmon carcasses; and
- Nutrients from the Sewerage Commission Oroville Region (SCOR) treated sewage discharge downstream of Thermalito Afterbay Outlet. The SCOR facility is not operated by DWR.

Phosphorus and nitrate plus nitrite concentrations did not exceed Basin Plan criteria or objectives. Levels of total phosphorus in water samples from the tributaries upstream of Lake Oroville were frequently below 3 micrograms per liter (µg/L), and levels of total nitrogen (ammonia plus nitrate plus nitrite) were sometimes below 15 µg/L (see the SP-W1 report [DWR 2004b]). Water samples collected from the upper watershed frequently exceeded the USEPA-recommended criteria for phosphorus, and nitrate plus nitrite, which suggests that these streams often have an overabundant supply of nutrients.

Water samples were collected during the salmon spawning season to evaluate effects of decomposing salmon carcasses on water quality. Low levels of nutrients were detected in most of these samples. The study found no clear evidence of an effect of salmon carcasses on nutrient levels in the lower Feather River.

The periphyton (algae) monitoring program included stations in the tributaries upstream of Lake Oroville and in the lower Feather River. Water samples collected from the water column and from within gravel substrates at stations immediately upstream and downstream of the SCOR outlet showed no consistent differences in nutrient concentrations. However, the periphyton community at the station downstream of the SCOR outlet had characteristics indicative of a higher nutrient status than the communities at other stations. Green algae, which are considered indicative of higher nutrient levels than diatoms, were dominant in a sample downstream of the SCOR outlet collected in June.

On June 27, 2005, DWR staff investigated an algal bloom reported on the Middle Fork Arm of Lake Oroville. The water level at the Merrimac station was fairly low and the amount of attached algae in the water at the site appeared to be very high. Staff boated up the Middle Fork Arm and reported seeing algae against the shore near Nutmeg Creek, and farther upstream (the 90-degree bend at the north end of the arm) the entire waterway was covered with algae.

The algae were identified as *Anabaena flos-aquae*, blue-green algae that are actually a type of bacteria called cyanobacteria that grow in water and are photosynthetic. Blooms occur when algae that are normally present begin to reproduce rapidly, typically a result of warm water and slow-moving, nutrient-rich waters. Blue-green algae produce toxins that can affect human health.

DWR staff had previously sampled water at the Merrimac station in May 2005. The amounts of many chemical constituents in the Merrimac water sample were very high compared to previous data. For example, at this station in 3 years of sampling, the total iron levels had never exceeded 1,805 µg/L. The May 2005 sample contained 13,627

µg/L of iron. The highest total aluminum measured at FRMF-M was December 2004 at 1,472 µg/L and dissolved aluminum at 835 µg/L; in May 2005, total aluminum was 11,214 µg/L and dissolved aluminum was 2,230 µg/L. Manganese once measured 60.8 µg/L (total) in December 2002 and 15.1 µg/L (dissolved) in February 2004; in May 2005, manganese was measured at 696 µg/L (total) and 22.8 µg/L (dissolved). Phosphorus is usually reported at very low to non-detectable levels at this station, once reaching a maximum of 0.044 mg/L in December 2003. In May 2005, total phosphorus was measured at 0.6 mg/L, a significant increase. It is unclear what factors led to the bloom, but the relatively high level of phosphorus is presumed to be involved.

Existing Conditions

Nutrient concentrations throughout the project area were consistently below most Basin Plan objectives for protection of beneficial uses; the Oroville Facilities do not contribute to an adverse effect on beneficial uses resulting from nutrients. Nutrient levels are likely related to recreational activities and operation of the Feather River Fish Hatchery. Lake Oroville and the Thermalito Complex impoundments result in increased levels of recreation, which could potentially increase nutrient inputs; however, phosphorus and nitrate plus nitrite concentrations did not exceed Basin Plan criteria or objectives. Hence, the effects of these sources on nutrient concentrations in the future are likely to be minimal.

Pathogens (Bacteria)

Water samples from several locations in the project area where concentrated water contact recreational use occurs in conjunction with concentrated waterfowl use contain high bacterial counts on a seasonal basis when recreational activity and wildlife are present in the highest numbers. The following subsections describe the relationship between pathogens and beneficial uses, and summarize the results of related relicensing studies.

Relationship to Beneficial Uses

The beneficial uses identified in the Basin Plan that pathogens can potentially affect are water contact recreation and municipal and domestic water supply. The Basin Plan's numerical water quality objectives for fecal coliform bacteria concentrations in natural water bodies are designed to reduce human exposure to pathogens. The California Department of Health Services (DHS) also provides draft guidance for freshwater beaches (DHS 2006). The California drinking-water standards are not applicable to ambient concentrations in source water supplies because the standards specifically apply to water after it has been treated.

Results of Relicensing Studies

The SP-W1 report (DWR 2004b) provides information regarding indicator bacteria in the project area, the SP-W3 report (DWR 2004e) provides information about areas near recreational facilities, and the SP-W7 report (DWR 2004c) provides information on stormwater runoff.

The monthly monitoring study results generally indicate very low bacterial concentrations in the upper watershed tributaries to Lake Oroville and open-water sites within Lake Oroville. Elevated bacterial concentrations were detected periodically at many recreation sites within Lake Oroville and the Thermalito Complex based on weekly samples. The DHS-recommended level of bacteria contamination to trigger beach posting or closure was exceeded at least once at each recreation area monitored in 2003. Based on visual observations of large amounts of waterfowl present near recreation areas, it is apparent that the recreation facilities are also attractive to migratory waterfowl that also directly discharge fecal wastes to water or nearby drainage ways.

Existing Conditions

Occasionally there are elevated bacteria concentrations at certain areas within the Oroville Facilities. Recreation activities such as swimming and wading have the greatest potential for discharges of fecal wastes and exposure to human pathogens. Recreation facilities also attract wildlife (waterfowl and shorebirds) that also directly discharge fecal wastes to water. Bacterial contamination levels were elevated during seasonal peak periods of recreational activity and during non-recreation periods when many waterfowl are present, which indicates that bacteria is coming from both sources.

Aquatic Toxicity Tests

Aquatic toxicity was detected in some water samples collected in the project area; however, the data indicate that the Oroville Facilities are not likely a major contributor to these effects. The following subsections describe the relationship between toxicity and beneficial uses and summarize the results of related relicensing studies.

Relationship to Beneficial Uses

Toxicity tests are designed primarily to identify potential impairment for designated beneficial uses that pertain to aquatic organisms, such as warm freshwater habitat, cold freshwater habitat, and spawning, reproduction, and/or early development (warm and cold). The Basin Plan objective is narrative and states that “all waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses … in aquatic life” (Central Valley RWQCB 2006).

Results of Relicensing Studies

The SP-W1 report (DWR 2004b) provides aquatic toxicity information that was compiled using USEPA’s standardized tests for freshwater acute and chronic toxicity with fathead minnow (*Pimephales promelas*) and zooplankton (*Ceriodaphnia dubia*). Water samples from nine upper watershed tributary sites were collected bimonthly during the summer, following the first flush in the fall, following winter dormant spraying in February, and again during the high-runoff period in April or May. Water samples from eight lower Feather River monitoring sites (from the Fish Barrier Dam to Honcut Creek) were analyzed monthly. Water samples from three OWA ponds were also analyzed. Toxicity

identification evaluation (TIE) procedures were used for samples from sites with confirmed toxicity to evaluate whether particulate matter, metals, and/or polar organic compounds were associated with the toxicity.

SP-W7 also evaluated the toxicity of stormwater from the following locations: several City of Oroville drains; the Feather River Fish Hatchery settling ponds; and the Feather River at Oroville, downstream of the Feather River Fish Hatchery, and at SR 162.

In the upper-watershed tributaries, positive reproductive toxicity to *Ceriodaphnia* was present at all 9 regularly sampled sites; the frequency of toxicity per site ranged from 20 to 83 percent of the sampling dates. Survival toxicity to *Ceriodaphnia* was generally absent. Survival toxicity to fathead minnows in filtered samples occurred in all but 1 of the upper watershed sites, with frequency of toxicity per site ranging from 0 to 20 percent of sampling dates.

At the lower Feather River sites, reproductive toxicity to *Ceriodaphnia* was present on 21–58 percent of the sampling dates, which is similar to the range of frequencies at the upper-tributary sites. However, survival toxicity to *Ceriodaphnia* was detected more frequently at the lower Feather River sites than at the upper-watershed sites, ranging from 4 to 33 percent of the sampling dates. The Feather River Fish Hatchery settling pond and the Feather River downstream of the hatchery had the two highest reproductive-toxicity and survival toxicity rates. *Ceriodaphnia* reproductive toxicity was also present in the majority of storm event samples, and survival was reduced at several sites during one storm event.

Survival toxicity to fathead minnows was present at all 8 regularly sampled sites in the lower Feather River; the frequency in filtered samples ranged from about 4 to 18 percent of sampling dates. The sites with the highest fathead minnow toxicities were the city of Oroville, the Feather River Fish Hatchery settling pond, the Feather River downstream of the hatchery, and Thermalito Afterbay Outlet. Fathead minnow toxicity was generally absent in the storm event samples.

Detections of toxicities in the OWA ponds were relatively infrequent or absent both for *Ceriodaphnia* and for fathead minnows.

The TIE evaluation for several August 2003 sample sites confirmed that toxicity could be reduced when particulate matter, metals, and/or polar organic compounds were removed from the samples. However, the evaluation could not determine cause-and-effect relationships for specific contaminants or sample locations.

Existing Conditions

The Oroville Facilities are not a significant source of contaminants in the project area. The presence of aquatic toxicity in tests with *Ceriodaphnia* and fathead minnows in sites in the upper watershed and the lower Feather River indicates the presence of toxic constituents. The Project has no direct influence on water quality of the upper watershed sites and has no known direct discharges of toxic contaminants; hence, the Oroville Facilities likely have few effects on aquatic toxicity in the project area.

4.2.2.3 Water Quality Trends

Other than the change in water temperatures in the Feather River at Oroville (see Figure 4.2-12), review of historical water quality data did not reveal any upward or downward trends for the various water quality parameters. There are no reasonably foreseeable actions upstream of Oroville that would result in future changes in water quality other than water temperature.

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4.3 GROUNDWATER

4.3.1 Groundwater Quantity

Operation of the Oroville Facilities under Existing Conditions results in elevated groundwater levels near Thermalito Forebay and Thermalito Afterbay. Under Existing Conditions, groundwater levels have stabilized and there are no identified adverse effects associated with such elevated levels.

4.3.1.1 Groundwater Hydrology

Oroville Dam and Lake Oroville are underlain by relatively impermeable igneous and metamorphic bedrock that largely eliminates interaction between groundwater and Lake Oroville. However, Thermalito Forebay and Thermalito Afterbay are located on more permeable volcaniclastic and consolidated alluvial sediments where reservoir water and local groundwater interact. Thermalito Afterbay was constructed on an older, dissected upland consisting of coarse gravels cemented in a sandy clay matrix. The upland area is adjacent to the edge of the groundwater basin to the west, where younger alluvial materials overlap the older sediments. The younger sediments consist of alluvial fan, stream, and basin deposits. Existing lithology data from well driller reports indicate that there are at least two aquifers in the area, a confined zone and an unconfined zone, and there may be localized areas of semi-confined zones. Aquifer zones are not uniform in thickness, and there is not much uniformity in the depth at which different aquifer materials are encountered in area wells.

Groundwater flows in a south-southwest direction in the vicinity of Thermalito Forebay and Thermalito Afterbay. Localized seepage occurs from these reservoirs, and pumps have been installed to return the water to the reservoirs. Information developed as part of Study Plan W-5, *Project Effects on Groundwater*, indicates that the Oroville Facilities may have increased groundwater levels through recharge in the vicinity of Thermalito Forebay. Two wells potentially affected by Thermalito Forebay were monitored for water levels from 1959 to 1982. The monitoring results indicated that groundwater elevations increased by about 10 feet after project completion in 1969.

4.3.2 Groundwater Quality

Operations of the Oroville Facilities under Existing Conditions do not result in changes to groundwater quality. Under Existing Conditions, groundwater quality is stabilized and there are no identified adverse effects associated with such groundwater quality in the project area.

4.3.2.1 Relationship to Beneficial Uses

The Basin Plan (Central Valley RWQCB 2004) designates beneficial uses and water quality objectives for groundwater. The Basin Plan considers all groundwater in the Central Valley region suitable or potentially suitable, unless otherwise designated, for municipal and domestic, agricultural, industrial service, and industrial process supplies. Therefore, the water quality objectives for groundwater differ somewhat from those for surface waters. The Basin Plan lists the objectives, standards, and criteria used to evaluate project groundwater compliance with respect to the relevant water quality parameters. The Basin Plan objectives may be found in Section 4.2.2, Surface Water Quality. The California drinking-water standards do not apply to ambient concentrations in source water supplies because the standards specifically apply to water after it has been treated.

4.3.2.2 Results of Relicensing Studies

The results of Study Plan W-5, *Project Effects on Groundwater*, provide information on the water quality of groundwater around the Thermalito Forebay and Thermalito Afterbay Complex. Water quality was measured by sampling groundwater from 18 wells in the vicinity of these reservoirs (2 sampled wells were upgradient from the Thermalito Complex). Each well was sampled once in the late spring or early summer and once in the fall of 2003. Temperature, pH, and specific conductance were measured. The groundwater samples were analyzed for general mineral composition, aluminum, and mercury.

The groundwater quality results were compared to each other and to the surface-water quality results collected from two sites in Thermalito Afterbay and two sites in Thermalito Forebay. Two of the groundwater wells were located upgradient from the Thermalito Complex. The mineral content of the groundwater samples downgradient from the Thermalito Complex was consistently higher than that of the surface-water samples or upgradient wells. Specific conductance and total dissolved solids were consistently higher in the groundwater samples than in the surface-water samples. The metal content in groundwater was consistently lower than that in surface water (Table G-WQ2.5.3-1 in Appendix G-WQ2 of the PDEA).

4.3.2.3 Existing Conditions

The results of the groundwater survey indicate that the Oroville Facilities are not affecting local groundwater quality conditions. Mineral content was consistently much higher in the groundwater samples downgradient from the Thermalito Complex than in upgradient wells or surface-water samples. At the same time, concentrations of aluminum and mercury metal concentrations were generally similar or lower than upgradient wells and surface waters.

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4.4 AQUATIC RESOURCES

Operation of the Oroville Facilities influences environmental conditions within the lower Feather River, as well as within Lake Oroville and its upstream tributaries, the Diversion Pool, Thermalito Forebay, Thermalito Afterbay, the Feather River Fish Hatchery, the Fish Barrier Pool, and the Oroville Wildlife Area (OWA) ponds.

Evaluating potential effects on aquatic resources within the project study area requires an understanding of fish species' life histories and life stage–specific environmental requirements. General information is provided in Section 4.4.2, Fish Species Overview, regarding the species of primary management concern that occur within the Oroville Facilities project study area, as well as other species of local or regional importance. To reduce redundancy, discussions regarding some species with similar life histories, habitat requirements, and/or management strategies and objectives have been combined. Species-specific information for warmwater and coldwater species is provided separately in Section 4.4.2. More detailed information regarding fish species is provided in Appendix G-AQUA1, Affected Environment, of the PDEA for the Oroville Facilities, which summarizes the results of the aquatics study plan reports.

This section describes the affected environment related to fisheries and aquatic ecosystems in all water bodies that may be influenced by implementation of the alternatives. This includes the upper Feather River tributaries, Lake Oroville, the Diversion Pool, Thermalito Forebay, Thermalito Afterbay, the Fish Barrier Pool, the Feather River Fish Hatchery, OWA ponds, and the lower Feather River.

Fish species of primary management concern include:

- State and/or federally listed species within the project study area (spring-run Chinook salmon, green sturgeon, and Central Valley steelhead);
- Species that are recreationally or commercially important (fall-run Chinook salmon, American shad, coho salmon, striped bass, and four species of black bass);
- Candidate species for listing under the California Endangered Species Act (CESA) or federal Endangered Species Act (FESA); and
- State species of special concern (Sacramento splittail, river lamprey, and hardhead).

Special emphasis is placed on these fish species to facilitate compliance with applicable laws, particularly CESA and/or FESA, and to be consistent with State and federal restoration/recovery plans and federal biological opinions. This focus is consistent with:

- The CALFED Bay-Delta Program's (CALFED's) 2000 *Ecosystem Restoration Program Plan* (ERPP) and *Multi-Species Conservation Strategy* (MSCS);
- The programmatic determinations for the CALFED program, which include DFG's Natural Community Conservation Planning Act approval and the programmatic biological opinions (BOs) issued by NMFS and USFWS;

- The USFWS 2001 *Final Restoration Plan for the Anadromous Fish Restoration Program* (AFRP), which identifies specific actions to protect anadromous salmonids;
- The DFG 1996 *Steelhead Restoration and Management Plan for California*, which identifies specific actions to protect steelhead (DFG 1996); and
- DFG's *Restoring Central Valley Streams, A Plan for Action* (1993), which identifies specific actions to protect salmonids.

Improvement of habitat conditions for these species of primary management concern will likely protect or enhance conditions for other fish resources, including native resident species.

The overall fish species composition within the project study area is summarized in Table 4.4-1. Table 4.4-1 identifies those species that are considered species of primary management concern related to the Oroville Facilities and indicates whether each species is native or introduced, identifies the general geographic distribution of the species by water body, and summarizes both the regulatory and abundance/ management status of each species within the project study area.

Major issues related to fisheries identified during the scoping process included:

- Effects of project operations on aquatic resources, including populations and habitats of: (1) warmwater fish; (2) coldwater/anadromous fish; (3) special-status species; and (4) macroinvertebrates and other aquatic organisms;
- With respect to anadromous fish, project effects on populations, habitat quantity and quality, fish passage, and recruitment to ocean populations;
- Effects of fisheries management plans and activities on a balanced coldwater and warmwater fishery;
- Compliance of project operations with SWP Feather River flow constraints and adequacy of constraints to protect anadromous fish and other aquatic species; and
- The cumulative effect of existing and future project effects on regional fisheries, fish passage, and habitat quality and quantity within project-affected areas.

4.4.1 Regional Overview and Management Status

An overview of the Oroville Facilities and associated water bodies as they relate to aquatic resources is provided in Section 4.4.1.1, Facilities, Waterbodies, and Related Fisheries Resources. Applicable laws, ordinances, regulations, and standards related to fisheries resources are provided in Section 4.4.1.2.

4.4.1.1 Facilities, Waterbodies, and Related Fisheries Resources

Detailed physical descriptions of the Oroville Facilities and their operations are provided in Section 3.2, Oroville Facilities and Operations.

Table 4.4-1. List of fish species within the study area.

Common Name	Scientific Name	Regulatory Status [1]	Primary Mgmt. Concern Species [2]	CA Native or Introduced	Location Within Study Area [3]	Abundance/Mgmt Status [4]
Pacific lamprey	*Lampetra tridentata*	FSC	No	Native	LFR	Watch List
River lamprey	*Lampetra ayresi*	CSC, FSC	Yes	Native	LFR	Watch List
Green sturgeon	*Acipenser medirostris*	CSC; FT [5]	Yes	Native	LFR	Special concern
White sturgeon	*Acipenser transmontanus*	---	No	Native	LO, LFR	Stable or increasing
American shad	*Alosa sapidissima*	---	Yes	Introduced	LFR	Widespread and stable
Threadfin shad	*Dorosoma petenense*	---	No	Introduced	LO, TA, LFR	Widespread and expanding
Common carp	*Cyprinus carpio*	---	No	Introduced	UT, LO, TF, DP, TA, LFR, OWA	Widespread and expanding
Golden shiner	*Notemigonus crysoleucas*	---	No	Introduced	LO, DP, TF, TA, OWA	Widespread and expanding
Hardhead	*Mylopharodon conocephalus*	CSC	Yes	Native	LO, TF, DP, TA, LFR	Watch List
Hitch	*Lavinia exilicauda*	---	No	Native	TA, LFR	Watch List
Sacramento pikeminnow	*Ptychocheilus grandis*	---	No	Native	UT, LO, TF, DP, TA, LFR	Stable or increasing
Sacramento splittail	*Pogonichthys macrolepidotus*	CSC; [6] FSC	Yes	Native	LFR	Special Concern
Sacramento blackfish	*Orthodon microlepidotus*	---	No	Native	OWA	Stable or increasing
Goldfish	*Carassius auratus*	---	No	Introduced	LO	Widespread and stable
Sacramento sucker	*Catastomus occidentalis*	---	No	Native	UT, LO, TF, DP, TA, LFR, OWA	Stable or increasing
Black bullhead	*Ameiurus melas*	---	No	Introduced	LFR	Widespread and stable
Brown bullhead	*Ameiurus nebulosus*	---	No	Introduced	LFR, OWA	Widespread and stable
White catfish	*Ameiurus catus*	---	No	Introduced	LO, LFR, OWA	Widespread and stable

Table 4.4-1. List of fish species within the study area.

Common Name	Scientific Name	Regulatory Status [1]	Primary Mgmt. Concern Species [2]	CA Native or Introduced	Location Within Study Area [3]	Abundance/Mgmt Status [4]
Channel catfish	*Ictalurus punctatus*	---	No	Introduced	LO, LFR, OWA	Widespread and stable
Wakasagi	*Hypomesus nipponensis*	---	No	Introduced	LO, TF, DP, TA, LFR	Widespread and expanding
Fall-run Chinook salmon	*Oncorhynchus tshawytscha*	CSC, FSC [7]	Yes	Native	FRFH, LFR	Watch List
Spring-run Chinook salmon	*Oncorhynchus tshawytscha*	ST; FT	Yes	Native	FRFH, LFR	Threatened or Endangered
Coho salmon	*Oncorhynchus kisutch*	CSC; SE, FT [8]	No	Native	LO	Threatened or Endangered
Central Valley steelhead	*Oncorhynchus mykiss*	FT	Yes	Native	FRFH, LFR	Threatened or Endangered
Rainbow trout	*Oncorhynchus mykiss*	---	Yes	Native	UT, LO, TF, DP, TA, LFR	Widespread and stable
Brown trout	*Salmo trutta*	---	Yes	Introduced	UT, LO, LFR	Widespread and stable
Brook trout	*Salvelinus fontinalis*	---	Yes	Introduced	TF, DP, TA, LFR	Widespread and stable
Lake trout	*Salvelinus namaycush*	---	No	Introduced	LO	Localized
Western mosquitofish	*Gambusia affinis*	---	No	Introduced	OWA	Widespread and expanding
Threespine stickleback	*Gasterosteus aculeatus*	---	No	Native	LO	Stable or increasing
Prickly sculpin	*Cottus asper*	---	No	Native	UT, LO, TF, DP, TA, LFR, OWA	Stable or increasing
Riffle sculpin	*Cottus gulosus*	---	No	Native	UT, LO, TA, LFR, OWA	Watch List
Striped bass	*Morone saxatilis*	---	Yes	Introduced	LFR	Widespread and stable
Bluegill	*Lepomis macrochirus*	---	No	Introduced	LO, TF, DP, TA, LFR, OWA	Widespread and stable

Table 4.4-1. List of fish species within the study area.

Common Name	Scientific Name	Regulatory Status [1]	Primary Mgmt. Concern Species [2]	CA Native or Introduced	Location Within Study Area [3]	Abundance/Mgmt Status [4]
Green sunfish	*Lepomis cyanellus*	---	No	Introduced	LO, LFR, OWA	Widespread and stable or expanding
Redear sunfish	*Lepomis microlophus*	---	No	Introduced	LO, LFR, OWA	Widespread and stable
Warmouth	*Lepomis gulosus*	---	No	Introduced	LO, OWA	Localized
Black crappie	*Pomoxis nigromaculatus*	---	No	Introduced	LO, DP, TA, OWA, LFR	Widespread and stable
White crappie	*Pomoxis annularis*	---	No	Introduced	LO, TA, OWA, LFR	Widespread and stable
Largemouth bass	*Micropterus salmoides*	---	Yes	Introduced	LO, TF, DP, TA, LFR, OWA	Widespread and stable
Smallmouth bass	*Micropterus dolomieu*	---	Yes	Introduced	LO, DP, TA, LFR	Widespread and stable
Redeye bass	*Micropterus coosae*	---	Yes	Introduced	LO, LFR	Localized
Spotted bass	*Micropterus punctulatus*	---	Yes	Introduced	LO, TA, LFR	Widespread and expanding
Tule perch	*Hysterocarpus traski*	---	No	Native	DP, TF, TA, LFR	Stable or increasing

Table 4.4-1. List of fish species within the study area.

Common Name	Scientific Name	Regulatory Status [1]	Primary Mgmt. Concern Species [2]	CA Native or Introduced	Location Within Study Area [3]	Abundance/Mgmt Status [4]

[1] *FT = listed as Threatened under FESA; ST = listed as Threatened under CESA; FE = federal Endangered; SE = State Endangered; FC = candidate for listing under FESA; CC = candidate for listing under CESA; FSC = federal species of concern; CSC = California species of special concern.*

[2] *Species of primary management concern evaluated in this analysis include those that are recreationally or commercially important, State- and/or federally listed species within the project study area under FESA or CESA, candidate species for listing under FESA or CESA, and California species of special concern.*

[3] *Frequently or infrequently observed in the following: UT = upstream tributaries; LO = Lake Oroville; DP = Diversion Pool; TF = Thermalito Forebay; TA = Thermalito Afterbay; FBP = Fish Barrier Pool; FRFH = Feather River Fish Hatchery; OWA = Oroville Wildlife Area ponds; LFR = Lower Feather River.*

[4] *As defined in Moyle 2002.*

[5] *After reviewing the petition for listing green sturgeon, on January 29, 2003, NMFS determined that such listing was not warranted, although it was still considered a candidate species. On April 15, 2004, NMFS announced that the Northern and Southern Distinct Population Segments of Green Sturgeon would change in listing status from a candidate species to a species of concern (69 Federal Register [FR] 19977). However, litigation challenging NMFS' determination that green sturgeon do not warrant listing as an Endangered or Threatened species under FESA asserted that the agency was arbitrary and capricious in failing to examine whether habitat loss constituted a significant portion of the species' range. The court partially agreed with the Plaintiff's motion, and remanded the determination back to NMFS for further analysis and decision as to whether green sturgeon are endangered or threatened in a significant portion of its range. Hence, according to NMFS' April 15, 2004 interpretation of FESA provisions, green sturgeon were considered a candidate species as well as a species of concern, until this matter could be resolved. On April 7, 2006, a final rule was issued and adopted, and the southern distinct population segment was listed as Threatened. The final rule became effective June 6, 2006 (71 FR 17757 [2006]).*

[6] *USFWS removed Sacramento splittail from the list of Threatened species on September 22, 2003, and did not identify it as a candidate for listing under FESA. Sacramento splittail is identified as a California species of special concern and, informally, as a federal species of concern.*

[7] *Although late fall–run Chinook salmon does not occur within the project study area, the Central Valley fall-run/late fall–run Chinook salmon is identified as one Evolutionarily Significant Unit (ESU). In 1999, the Central Valley ESU underwent a status review after NMFS received a petition for listing. Pursuant to that review, NMFS found that the species did not warrant listing as Threatened or Endangered under FESA, but sufficient concerns remained to justify addition to the candidate species list. On April 15, 2004, NMFS published a notice in the Federal Register acknowledging establishment of a species of concern list, addition of species to the species of concern list, and revision of the candidate species list. In this notice, NMFS announced the Central Valley fall-run and late fall–run Chinook salmon ESU change in status from a candidate species to a species of concern. Therefore, according to NMFS' April 15, 2004 interpretation of FESA provisions, the Central Valley ESU now qualifies as a species of concern, rather than a candidate species (69 FR 19977).*

[8] *Populations south of San Francisco are listed by the State as endangered. Special-status species designations pertain only to coho salmon within their native habitats. Coho salmon occur within the project study area as a result of stocking programs and are managed for their recreational importance only.*

Sources: Initial Information Package (DWR 2001); Moyle 2002

Upstream Tributaries

There are four major upstream tributaries to Lake Oroville: the North Fork Feather River, the West Branch of the North Fork Feather River, the Middle Fork Feather River, and the South Fork Feather River (see Figure 4.4-1). The Middle Fork Feather River is designated as a National Wild and Scenic River and a Heritage Trout Water by DFG (DFG Website 2003).

The coldwater fish species present in the upstream tributaries above Lake Oroville and below the first impassable fish barrier include rainbow trout and brown trout. The warmwater fish species in the upstream tributaries include bluegill, brown bullhead, carp, largemouth bass, redeye bass, roach, smallmouth bass, spotted bass, Sacramento pikeminnow, Sacramento sucker, and sculpin.

Project operations associated with the Oroville Facilities do not control flows and/or temperatures within the upstream tributaries. However, operations of the Oroville Facilities do potentially influence other aquatic resources in the upper Feather River tributaries up to the first impassable fish barriers (see Figure 4.4-1). The upstream tributaries' first impassable fish barriers were identified as the falls below Big Kimshew Creek (provisional impassable barrier) for the West Branch of the North Fork Feather River, Poe Dam on the North Fork Feather River, Curtain Falls for the Middle Fork Feather River, and Ponderosa Dam for the South Fork Feather River (additional information on upstream tributary migration barriers is included in Section G-AQUA1.3.1.1 in Appendix G-AQUA1 of the PDEA). There are several types of potential operational effects on fisheries resources in the upstream tributaries up to the first impassable fish barriers, including fish interactions, nutrient transfer, and sediment deposition in the tributary arms of Lake Oroville.

Fish within Lake Oroville can potentially interact with the upstream tributary fisheries through predation, competition for available food and habitat, disease transmission, and genetic introgression (additional information on potential fisheries interactions is included in Section G-AQUA1.5.1 in Appendix G-AQUA1 of the PDEA). Lake Oroville reservoir operations influence the accessibility of the upstream tributaries to fish species within Lake Oroville through the stage elevation of the reservoir. When Lake Oroville stage elevations are near full pool, Big Bend Dam becomes passable to fish; when reservoir stage elevations are reduced, sediment wedges in the tributary arms of the reservoir may be exposed and may inhibit or prohibit fish movement from the reservoir into the upstream tributaries. Increases or decreases in reservoir stage elevations also increase or decrease the distance from the reservoir to fish habitat in the upstream tributaries above the reservoir high-pool mark, which also may influence the amount and frequency of fish interactions between the reservoir fishery and the upstream tributary fishery.

The Oroville Facilities, including Oroville Dam, Thermalito Diversion Dam, and the Fish Barrier Dam, currently block the upstream movement of anadromous fish to that portion of historical spawning areas in the upstream tributaries of the Feather River below the

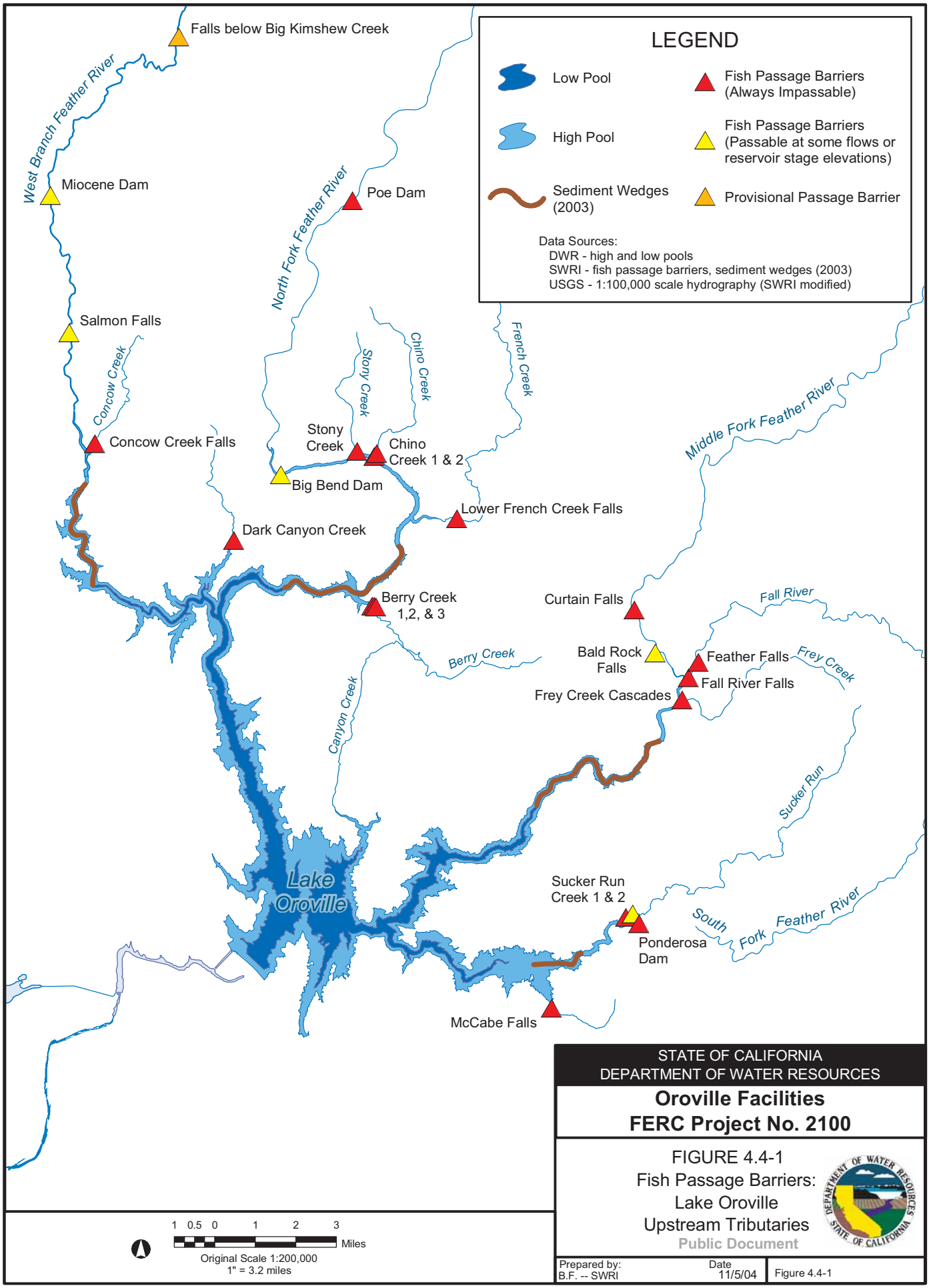

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FIGURE 4.4-1
Fish Passage Barriers:
Lake Oroville
Upstream Tributaries

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next impassable barrier (hydroelectric dams and facilities upstream that pre-date this project). Blockage of anadromous fish from upstream tributaries deprives these areas of fish-derived nutrients that could otherwise contribute to the productivity of both the aquatic and terrestrial ecosystems in and adjacent to the upstream tributaries. (Additional information on nutrient transfer is included in Section G-AQUA1.6 in Appendix G-AQUA1 of the PDEA.)

Lake Oroville

Lake Oroville is a warm, monomictic reservoir that thermally stratifies in the spring, destratifies in the fall, and remains destratified throughout the winter. Due to this stratification, Lake Oroville has been said to contain a “two-story” fishery, supporting both coldwater and warmwater fisheries that are thermally segregated for most of the year. The coldwater fish use the deeper, cooler, well-oxygenated hypolimnion, whereas the warmwater fish are found in the warmer, shallower, epilimnetic, and littoral zones. Once Lake Oroville destratifies in the fall, the two fishery components mix in their habitat utilization.

Lake Oroville’s coldwater fishery is primarily composed of coho salmon, although rainbow trout, brown trout, and lake trout are periodically caught. The coldwater fishery for coho salmon is sustained by hatchery stocking. Lake Oroville’s coldwater fishery is not self-sustaining, possibly due to insufficient spawning and rearing habitat in the reservoir and accessible tributaries, and natural and artificial barriers to migration into the upstream tributaries, where sufficient spawning and rearing habitat has historically existed (DWR 2001). A “put-and-grow” hatchery program is currently in use, where coho salmon are raised at the Feather River Fish Hatchery and stocked in the reservoir as juveniles, with the intent that these fish will grow in the reservoir before being caught by anglers (DWR 2001). Approximately 170,000 yearling sized coho salmon are stocked each fall. These fish are coded wire tagged and released following a final disease certification from DFG. Lake Oroville’s warmwater and coldwater fish species are listed in Table 4.4-1 (additional information on Lake Oroville fish species composition is included in Section G-AQUA1.3.2.1 in Appendix G-AQUA1 of the PDEA).

The Lake Oroville warmwater fishery is a regionally important self-sustaining warmwater recreational fishery. The black bass fishery is significant both in terms of angler effort and economic effect on the area (additional information on black bass is included in Section G-AQUA1.3.2.3 in Appendix G-AQUA1 of the PDEA). Spotted bass are the most abundant bass species in Lake Oroville, followed by largemouth, redeye, and smallmouth bass. Catfish are the next most popular warmwater sport fish at Lake Oroville, with both channel and white catfish present. White and black crappie are also found in Lake Oroville, though populations fluctuate widely from year to year. Bluegill and green sunfish are the two primary sunfish species in Lake Oroville, though redear sunfish and warmouth are also present in very low numbers. Although common carp are considered by many to be a nuisance species, they are also abundant in Lake Oroville (DWR 2001). The primary forage fish in Lake Oroville are wakasagi and threadfin shad. Threadfin shad were intentionally introduced in 1967 to provide forage

for game fish, whereas the wakasagi migrated down from an upstream reservoir in the mid-1970s (DWR 2001).

Although the Lake Oroville warmwater fishery is self-sustaining, in the past, DWR has implemented programs for aquatic habitat improvements. For example, DWR implemented a habitat improvement program in 1995 that was completed in the spring of 2000 (DWR 2001). Components of the program included installing Christmas tree brush shelters, Manzanita brush shelters, and the planting of Button Brush and willow trees in riparian zones (DWR 1999). There have also been some experimental structures placed in the lake to improve channel catfish habitat. These structures utilize rocks or existing woody debris found along the shore of the lake. Most of these structures are approximately 30 inches long, 20 inches wide, and 10 inches deep (DWR 1997). Additional warmwater fish habitat enhancement projects have been conducted on an annual basis since 2000, utilizing these same techniques.

Water surface elevation fluctuations in Lake Oroville occur on a seasonal basis, resulting from seasonal variations in upstream tributary inflows into the reservoir, as well as seasonal variations in Oroville Facilities reservoir releases. Reservoir stage elevation reductions as well as the rate of reductions can reduce the amount of littoral fish habitat, invertebrate recruitment as a fisheries food base, coldwater pool volume, quantity of coldwater fishery habitat, and bass nest survival from dewatering (see Section 4.2.1, Surface Water Quantity, for more information on reservoir drawdown characteristics, and Section G-AQUA1.3.2.3 in Appendix G-AQUA1 of the PDEA for additional information on bass nest dewatering).

Oroville Facilities releases from selected water depth ranges from the reservoir affect the downstream water temperatures of the Thermalito Complex and the lower Feather River. Oroville Facilities water temperature releases directly affect the quantity, quality, and distribution of fish habitat in the Thermalito Complex and the lower Feather River (additional information on facility effects on fish habitat within the Thermalito Complex is included in Section G-AQUA1.3.3.2 in Appendix G-AQUA1 of the PDEA). The quantity and water temperature range selected for release from the reservoir also affect the coldwater pool volume and the quantity and quality of the coldwater fisheries habitat available in the reservoir (additional information regarding effects on coldwater pool volumes is included in Section 4.2.2, Surface Water Quality).

The elevations of the sediment wedges in the tributary arms of the reservoir (see Figure 4.4-1) are influenced by Oroville Facilities operations (additional information on upstream tributary sediment wedges is included in Section G-AQUA1.3.1.1 in Appendix G-AQUA1 of the PDEA). As sediment loads are suspended in the upstream tributary flows, a portion of the sediment load is deposited at the interface of the tributary and the reservoir (see Section 4.1, Geology, Soils, and Paleontological Resources, for additional information on sediment wedges). The stage elevation of the reservoir during these sediment deposition events determines the elevation of the resulting sediment wedge formation, which in turn determines the frequency and duration of sediment wedge exposure from reservoir operations as potential fish passage barriers. As sediment wedges are exposed by reductions in reservoir surface elevations, the

sediment is remobilized and redeposited at a lower stage elevation of the reservoir. The remobilization of the sediment can also potentially affect reservoir water quality suitability for aquatic life (additional information on water quality effects is included in Section 5.2.2, Surface Water Quality).

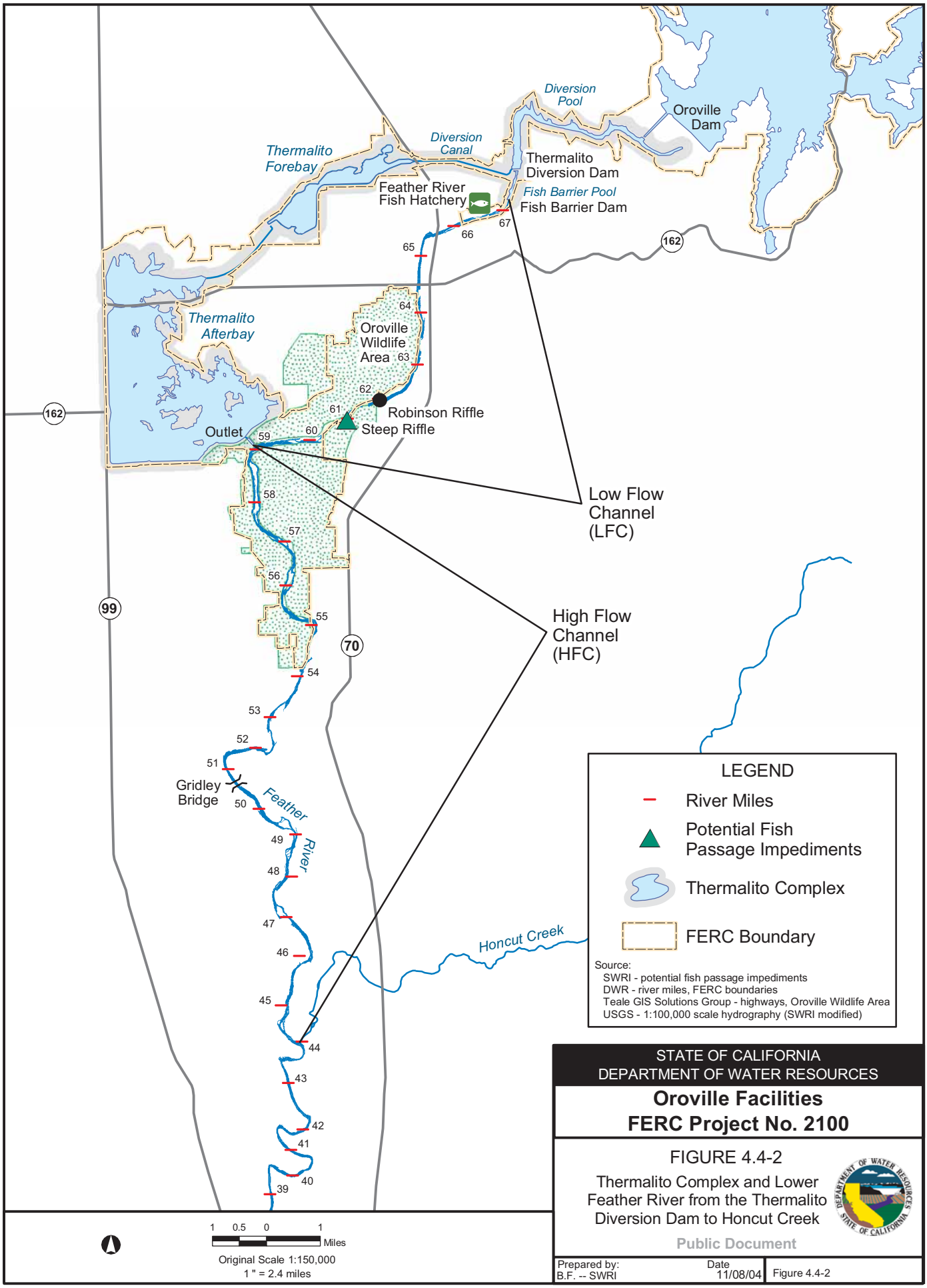
Lake Oroville traps upstream tributary contributions of gravel and sediment to the lower Feather River. Oroville Dam stops all of the gravel and most of the sand from being transported into the lower Feather River; generally, only fine sediment is discharged to the river below the dam (see Section 5.1, Geology, Soils, and Paleontological Resources, for additional information on reservoir effects on gravel and sediment transport). The gravel and sediment captured in the reservoir affect the fluvial geomorphologic functions of the lower Feather River and its contribution to the quality, quantity, and distribution of fish habitat in the lower Feather River (more information regarding Feather River fish habitat is included in Section G-AQUA1.8.1.4 in Appendix G-AQUA1 of the PDEA). The reservoir also traps large woody debris (LWD) contributions from the upstream tributaries and blocks the transport of these resources from contributing to the development and maintenance of fish habitat quality and diversity in the lower Feather River.

Diversion Pool

The Diversion Pool is located between Oroville Dam and Thermalito Diversion Dam (see Figure 4.4-2). The Diversion Pool is supplied with cold water from Lake Oroville's hypolimnion to meet water temperature requirements at the Feather River Fish Hatchery per the 1983 DWR Operating Agreement with DFG and at Robinson Riffle in the Low Flow Channel (LFC) of the lower Feather River per the 2004 NMFS Biological Opinion (see Section 4.2.2, Surface Water Quality, for additional information on water temperature requirements). The water intake for the Feather River Fish Hatchery is in the Diversion Pool at the Diversion Dam. Water temperatures in the Diversion Pool seldom exceed the high 50s (degrees Fahrenheit [°F]). Therefore, the Diversion Pool habitat is primarily suited for coldwater fish species; salmonids such as rainbow trout, brook trout, brown trout, and Chinook salmon have been sampled in the past (DWR 2001; DWR 2002). Although the Diversion Pool is not currently stocked, a lack of barriers between the Diversion Pool and Thermalito Forebay allows fish stocked in Thermalito Forebay to migrate freely into the Diversion Pool (DWR 2001; DWR 2002). Project peaking and pump-back operations, especially during the summer, potentially can increase water temperatures in the Diversion Pool, but the hatchery water temperature requirements limit the water temperature effects to ranges below salmonid water temperature requirements.

Thermalito Forebay

The Thermalito Forebay is an open, cold, shallow reservoir with a high surface area-to-volume ratio with few water surface elevation fluctuations (DWR 2001; DWR 2002) (see Figure 4.4-2). Thermalito Forebay remains cold throughout the year because it is supplied with water from the Diversion Pool, although pump-back operations from Thermalito Afterbay can increase water temperatures in the forebay somewhat (more


Diversion Pool
Oroville Dam
Diversion Canal
Thermalito Forebay
Thermalito Diversion Dam
Feather River Fish Hatchery
Fish Barrier Pool
Fish Barrier Dam
67
66
65
162
64
Thermalito Afterbay
Oroville Wildlife Area
63
62
Robinson Riffle
61
Steep Riffle
162
Outlet
59
60
58
57
56
99
55
70
54
53
52
51
Gridley Bridge
50
Feather River
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39
Honcut Creek
Low Flow Channel (LFC)
High Flow Channel (HFC)
LEGEND
River Miles
Potential Fish Passage Impediments
Thermalito Complex
FERC Boundary
Source:
SWRI - potential fish passage impediments
DWR - river miles, FERC boundaries
Teale GIS Solutions Group - highways, Oroville Wildlife Area
USGS - 1:100,000 scale hydrography (SWRI modified)
1 0.5 0 1
Miles
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1 " = 2.4 miles
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FIGURE 4.4-2
Thermalito Complex and Lower Feather River from the Thermalito Diversion Dam to Honcut Creek
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Date
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Figure 4.4-2

information regarding the influences of project operations on Thermalito Forebay is included in Section G-AQUA1.3.3.2 in Appendix G-AQUA1 of the PDEA). Because of the cool water temperatures, Thermalito Forebay provides habitat primarily for coldwater fish (DWR 2001; DWR 2002), although warmwater fish species in Lake Oroville are believed to exist in the forebay in low numbers as well (DWR 2001). DFG manages Thermalito Forebay as a put-and-take trout fishery, where rainbow trout of approximately 0.5 pound are stocked (DWR 2001; DWR 2002). The Thermalito Forebay is the second most popular reservoir sport fishery of the Oroville Facilities (DWR 2001; DWR 2002).

Thermalito Afterbay

Thermalito Afterbay constitutes the most hydrologically complex regime of all of the Oroville Facilities reservoirs (DWR 2001) (see Section 4.2.1, Surface Water Quantity, for more information on Thermalito Afterbay fluctuation characteristics). Thermalito Afterbay is a large, shallow, open reservoir with frequent water level fluctuations and a high surface-to-volume ratio (see Figure 4.4-2). Water temperatures can vary widely around the afterbay in the summer, with water in the low 60s near the tailrace channel that feeds the afterbay, and water in the mid 80s in the backwater areas that do not readily circulate (DWR 2001). Changes in flow rates, direction, and water surface elevations resulting from project operations affect water temperatures and the quality, quantity, and distribution of fish habitat in Thermalito Afterbay (additional information regarding Thermalito Afterbay habitat availability is included in Section G-AQUA1.3.4.2 in Appendix G-AQUA1 of the PDEA). Thermalito Afterbay provides habitat for both coldwater and warmwater fish.

In addition to a popular largemouth bass fishery, other warmwater species including smallmouth bass, spotted bass, various species of sunfish, bluegill, white crappie, black crappie, catfish, and common carp occur in Thermalito Afterbay (DWR 2001). Tule perch also has recently been confirmed in the Afterbay (pers. comm., See 2003). Although salmonids are not currently stocked, rainbow trout have been observed in Thermalito Afterbay. Most of the Lake Oroville sport fish species probably occur in the afterbay to some degree (DWR 2001).

Water surface elevations in Thermalito Afterbay change on a weekly and daily frequency, depending on power generation and pump-back operations. The shallow nature of Thermalito Afterbay results in obvious fluctuation effects with only a few feet of water surface elevation changes (DWR 2001). Mudflats can be exposed and a significant amount of the littoral zone can be dewatered, which affects the quantity of habitat available to fish species. Reductions in Thermalito Afterbay water surface elevations can dewater bass nests and potentially affect the sustainability of the centrarchid populations (further discussion of bass nest dewatering is included in Section G-AQUA1.3.2.3 in Appendix G-AQUA1 of the PDEA).

Oroville Facilities operations affect the water temperatures and their distribution in Thermalito Afterbay, which affects coldwater and warmwater fish habitat quantity, quality, and distribution in the afterbay as well as the water temperatures at the

agricultural diversions and the Thermalito Afterbay Outlet (see Section 5.2.2, Surface Water Quality, for additional information on water temperature effects in Thermalito Afterbay). Project operations that affect Thermalito Afterbay water temperatures include Oroville Dam release water temperatures and those operational variables that determine the effective residence time of water in the afterbay. Oroville Facilities operations that determine the effective residence time of water in the afterbay include the volume of inflows compared to the total releases from the afterbay (at both the Thermalito Afterbay Outlet and the agricultural diversions), afterbay stage elevations, and the amount of peaking and pump-back.

Fish Barrier Pool

The Fish Barrier Pool is located between the Thermalito Diversion Dam and the Fish Barrier Dam (see Figure 4.4-2). The Fish Barrier Dam diverts fish into a fish ladder that leads to the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the LFC of the Feather River between the dam and the Thermalito Afterbay Outlet, and provides attraction flow for the hatchery. Because of the relatively constant discharge of approximately 600 cubic feet per second (cfs) into the Fish Barrier Pool from the Thermalito Diversion Dam Power Plant, the Fish Barrier Pool remains at a stable pool elevation, except during periods of spill releases when flood flows are routed through the Fish Barrier Pool.

Feather River Fish Hatchery

The Feather River Fish Hatchery facilities include the Fish Barrier Dam below Oroville Dam, the fish ladder, holding tanks, hatchery buildings, and raceways (DWR 2002) (see Figure 4.4-2). DWR constructed the Feather River Fish Hatchery in 1967 to compensate for salmonid spawning habitat lost with construction of Oroville Dam. The facility is operated by DFG and maintained by DWR, and can accommodate 15,000–20,000 adult fish annually. The hatchery is one of five major Central Valley hatcheries producing and releasing fall-run Chinook salmon, one of three producing and releasing steelhead, and the only hatchery producing and releasing spring-run Chinook salmon (DWR 2002).

The hatchery complex uses water that is diverted from the Diversion Pool, which receives cold, hypolimnetic water (which rarely exceeds the mid to high 50s [°F]) from Lake Oroville. Water temperatures for the hatchery water intake are monitored for operational compliance with the hatchery water temperature requirements per the 1983 Oroville Operating Agreement between DWR and DFG.

Feather River Fish Hatchery practices of releasing hatchery production in San Pablo Bay have been suggested as contributing to the increase in straying rates of fish returning to non-natal tributaries for spawning. Hatchery operations may affect water quality conditions, such as temperature, dissolved oxygen, and pH, which in turn potentially may affect the rate or severity of fish disease occurrences both in the hatchery and in the lower Feather River (DWR 2002). Fish species, holding densities,

and the presence and amount of pathogens in the environment also may be related to the frequency or severity of occurrence and spread of fish diseases.

Hatchery practices also may potentially affect the genetic integrity of distinct runs of Chinook salmon, with the potential to commingle spring and fall Chinook salmon runs in the hatchery. Since 2004, DWR has been tagging adult spring-run Chinook salmon that enter the fish ladder starting as early as mid-May, after which the ladder is closed on June 30 or earlier if the permit limit is met and no more fish are tagged. The number of tagged fish varies from year to year. In 2006 there were 10,179 tagged (including reward tags) and an additional 7,197 were marked with a caudal fin-clip. The tagging/marking occurs every year between May 15 and June 30. This tagging/marking operation allows the Feather River Fish Hatchery staff to know which salmon are spring-run when it is time to spawn fish in the fall. Hatchery staff open the ladder for spawning in mid-September, and because the fish with tags are known to be the ones that came in during May and June, only these fish are spawned as “spring run.” Hatchery-produced fish also have the potential to adversely affect naturally spawning salmonid runs in the Feather River and other Central Valley streams through competition with wild spawned salmonids for food and habitat, potential transmission of diseases, predation, and through genetic introgression.

Oroville Wildlife Area Ponds

The OWA contains over 75 warmwater ponds and sloughs, along with vast complexes of emergent marsh and flooded cottonwood, willow, and sycamore trees, totaling approximately 11,980 acres (see Figure 4.4-2). The OWA pond water levels are replenished, in part, by the Feather River, which seeps through the porous levees and substrates, or floods into the OWA during high-flow events. Because the stage of the Feather River is controlled by Oroville Facilities operations, fish and their habitat in the OWA may potentially be affected by Oroville Facilities releases. After the floods on the Feather River in 1997, DWR repaired a levee and left in place a culvert that was used during the repairs. Subsequently, beavers have constructed dams, backing up the water through the culvert, which has resulted in inundation of areas in the OWA. The inundated area increased the amount of potential fish and wildlife habitat in the OWA, but species of invasive aquatic plants are growing to densities that reduce the quality of or eliminate potential fish habitat (additional information on OWA ponds is included in Section G-AQUA1.3.5.1 in Appendix G-AQUA1 of the PDEA).

Largemouth bass, channel catfish, white catfish, bluegill, green sunfish, and carp are all highly abundant in the OWA ponds, along with populations of black and white crappie (further discussion of OWA fish species composition and management is included in Section G-AQUA1.3.5.1 in Appendix G-AQUA1 of the PDEA). The fish are replenished through natural reproduction in the ponds and from the Feather River, which floods into the OWA during Oroville Facilities high-flow release events.

Lower Feather River

The lower Feather River extends from the Fish Barrier Dam (River Mile [RM] 67) to the confluence with the Sacramento River (RM 0). The LFC extends from the Fish Barrier Dam to the Thermalito Afterbay Outlet (RM 59) and the High Flow Channel (HFC) from the Thermalito Afterbay Outlet to the confluence with Honcut Creek (RM 44) (see Figure 4.4-2). The reaches of the lower Feather River are identified by the confluences with Honcut Creek to Yuba River (RM 27.5), Yuba River to Bear River (RM 12.5), and Bear River to the confluence with the Sacramento River (see Figure 4.4-3).

The lower Feather River supports a variety of anadromous and resident fish species. Fish species of primary management concern present in the lower Feather River include spring-run Chinook salmon, fall-run Chinook salmon, Central Valley steelhead, rainbow trout, brown trout, brook trout, green sturgeon, striped bass, river lamprey, American shad, hardhead, Sacramento splittail, largemouth bass, smallmouth bass, redeye bass, and spotted bass (more information on Feather River fish species is included in Section G-AQUA1.4.2 in Appendix G-AQUA1 of the PDEA).

Chinook salmon are the most numerous fish species in the lower Feather River; 30,000–170,000 Chinook salmon spawn in the lower Feather River annually. Approximately two-thirds of the natural Chinook salmon spawning occurs between the Fish Barrier Dam and the Thermalito Afterbay Outlet (RM 67–59), and one-third of the spawning occurs between the Thermalito Afterbay Outlet and Honcut Creek (RM 59–44). Chinook spawning typically occurs from September through December. Most juvenile Chinook salmon emigrate from the lower Feather River within a few days of emergence, and 95 percent of the juvenile Chinook have typically emigrated from the Oroville Facilities project area by the end of May. Adult Chinook salmon exhibiting the typical life history of the spring-run are found holding at the Thermalito Afterbay Outlet and the Fish Barrier Dam as early as April.

Most of the natural steelhead spawning in the Feather River occurs in the LFC, particularly in the upper reaches near Hatchery Ditch, a side channel located between RM 66 and RM 67 (additional information on steelhead spawning is included in Section G-AQUA1.8.2.2 in Appendix G-AQUA1 of the PDEA). Limited steelhead spawning also occurs below the Thermalito Afterbay Outlet. Soon after emerging from gravel, a moderate percentage of the fry appear to emigrate. The remainder of the population rears in the river for at least 6 months to 1 year. Studies have confirmed that juvenile rearing and probably adult spawning are associated with secondary channels within the LFC. The smaller substrate size and greater amount of cover (compared to the main river channel) likely make these side channels more suitable for juvenile steelhead rearing. Currently, this type of habitat comprises less than 1 percent of the available habitat in the LFC (DWR 2001).

The occasional capture of larval green sturgeon in outmigrant traps suggests that green sturgeon spawn in the Feather River (Moyle 2002); however, NMFS (NMFS 2002) reports that evidence of green sturgeon spawning in the Feather River is unsubstantiated. Significant efforts including scuba and snorkel surveys, hook and line

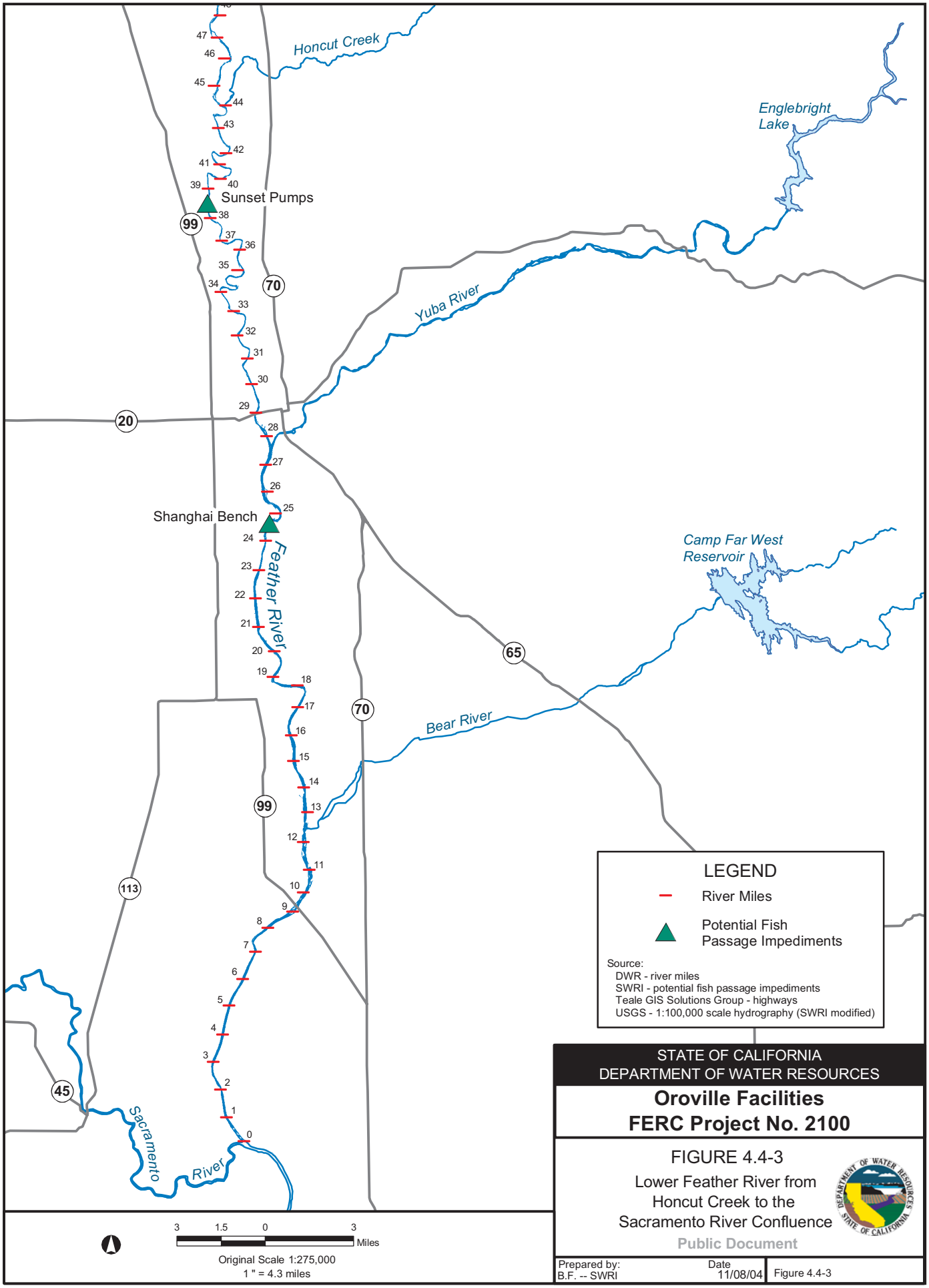

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FIGURE 4.4-3
Lower Feather River from Honcut Creek to the Sacramento River Confluence

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sampling, and larval traps during preparation of the Oroville Facilities studies were all unsuccessful in documenting the presence of green sturgeon in the lower Feather River. Sturgeon passage may be impeded at Shanghai Bench and Sunset Pumps on the lower Feather River at lower flow ranges, and sturgeon are reported as not typically entering the mouth of the Feather River at flows lower than approximately 5,000 cfs (more information regarding sturgeon passage impediments is included in Section G-AQUA1.4.3.1 in Appendix G-AQUA1 of the PDEA).

Sacramento splittail intermittently use the lower Feather River from February through May for spawning, egg incubation, and initial rearing. Splittail utilize shallow flooded vegetation for spawning and are infrequently observed in the lower Feather River from the confluence with the Sacramento River up to Honcut Creek. The majority of spawning activity in the lower Feather River is thought to occur below the Yuba River confluence, and occurs in greatest abundance in the Sutter Bypass during high-flow events (more information on splittail habitat use is included in Section G-AQUA1.4.3.3 in Appendix G-AQUA1 of the PDEA).

Oroville Facilities releases are regulated and subject to regulatory flow criteria. Under an agreement with DFG, flows in the LFC are regulated at 600 cfs, except during flood events when flows have reached as high as 150,000 cfs (DWR 1983). The instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. In Critical years, however, the minimum flow can be reduced to 1,200 cfs from October to February, and to 1,000 cfs in March. Flows in the HFC are maintained at or below 2,500 cfs from October 15 through November 30 to prevent Chinook salmon redd dewatering.

The magnitude of Oroville Facilities releases can affect the quality, quantity, and distribution of fish habitat in the lower Feather River in several ways, including changes in water stage elevations, inundated area, water depth, water velocities, water quality, and water temperatures. Oroville Facilities releases determine the flows in the upstream reaches of the lower Feather River and contribute proportionately to total flows below the confluences with Honcut Creek, Yuba River, Bear River, and locations of other flow accretions or depletions. High Oroville Facilities releases contribute to the inundation of floodplain habitat utilized for salmonid juvenile rearing and emigration and splittail spawning, contribute to attraction flows for immigrating fish, and facilitate fish passage at potential fish passage impediments in the lower Feather River (more information regarding flow-related effects on fishes is included in Sections G-AQUA1.8.3.4, G-AQUA1.8.4.2, G-AQUA1.4.3.3, and G-AQUA1.3.1.1 in Appendix G-AQUA1 of the PDEA). The timing and magnitude of releases from the Oroville Facilities can affect the quantity, quality, and distribution of salmonid spawning and rearing habitat in the LFC and HFC and may affect predation rates on juvenile salmonids. Project structures associated with the release facilities may influence predation of juvenile salmonids by producing turbulence, eddies, and other in-river conditions that can be advantageous for predatory species (more information on predation of juvenile salmonids is included in Section G-AQUA1.11.4.1 in Appendix G-AQUA1 of the PDEA).

The frequency and magnitude of high-flow events drive many fluvial geomorphic processes that contribute to the development and maintenance of fish habitat quality, quantity, and distribution. Some of the fluvial geomorphic processes that affect fish habitat characteristic quality, quantity, and distribution include channel shaping, river meander, bank cutting, gravel and sediment recruitment, transport, and deposition, and LWD recruitment and retention (see Section 4.1, Geology, Soils, and Paleontological Resources, for additional information on fluvial geomorphic processes). Oroville Facilities releases moderate the flow regime in the lower Feather River. The relatively static flow regime in the LFC, with the exception of high volume releases associated with high-flow events, reduces fluvial geomorphic processes in this reach of the river and results in channel stabilization and reduces gravel and LWD recruitment, which reduces the diversity of instream habitat and affects fish and wildlife habitat quality.

Fluctuations in Oroville Facilities releases occur under flood management operations, scheduled operation-maintenance activities, storm events, or emergency shutdowns. The timing, location, and magnitude of flow fluctuations may result in redd dewatering or scouring and juvenile stranding, and may affect the timing of juvenile salmonid emigration (more information regarding flow fluctuation effects on salmonids is included in Sections G-AQUA1.8.2.6 and G-AQUA1.8.4.2 in Appendix G-AQUA1 of the PDEA).

Changes in flows and the resulting changes in water velocity may affect the distribution of suitable habitat for some fish species. In the case of extremely high flows, such as those occurring during a high-flow event, the resulting water velocities may make some areas of the lower Feather River unsuitable for some fish species for the duration of the high-flow event. High water velocities that occur during the higher ranges of Oroville Facilities releases can scour salmonid redds and mobilize substrate, which could potentially affect fish habitat substrate suitability, quality, and distribution.

Increases or decreases in flow releases from the Oroville Facilities result in increases or decreases in water depths in the lower Feather River. Increases in Oroville Facilities releases, such as those occurring during a high-flow event, could result in an increase in the amount of potentially suitable fish habitat for those fish species having minimum water depth requirements. Similarly, reductions in releases could potentially reduce the amount of potentially suitable fish habitat for those fish species with minimum water depth requirements. The greatest proportion of deep water and the greatest water depth diversity occur in the upstream-most reach of the lower Feather River, between the Fish Barrier Dam and the Thermalito Afterbay Outlet. Downstream of the Thermalito Afterbay Outlet, the river tends to become progressively shallower and less diverse in its depth distribution.

Oroville Facilities releases affect water temperatures in the upper portions of the lower Feather River. Oroville Facilities releases are currently managed to primarily benefit coldwater fisheries (DWR 2002). Water temperatures tend to be coldest in the uppermost portions of the lower Feather River near the Fish Barrier Dam and warm progressively moving downstream during the spring, summer, and fall. The LFC water temperatures have been managed to comply with the 2002 and 2004 supplemental NMFS BOs on the interim operations of the CVP and SWP on federally listed

Threatened Central Valley spring-run Chinook salmon and Central Valley steelhead (NMFS 2002). These BOs stipulated that from June 1 through September 30, DWR shall, to the extent possible and consistent with SWP requirements, control water temperatures to a daily average water temperature of less than or equal to 65°F at Robinson Riffle (see Figure 4.4-2). In October 2004, NMFS issued a BO on the effects of the long-term CVP and SWP Operations Criteria and Plan (OCAP), which superseded all previous BOs regarding the CVP and SWP OCAP (NMFS 2004). Water temperature objectives prescribed in the October 2004 OCAP BO at RM 61.6 near Robinson Riffle remained 65°F from June 1 through September 30 to protect over-summering steelhead.

Water temperatures in the lower Feather River below the Thermalito Afterbay Outlet in the spring, summer, and fall can be increased by releases from Thermalito Afterbay. The amount of water temperature increase in the lower Feather River below the Thermalito Afterbay Outlet is affected by ambient air temperatures, the proportion of flows released from the afterbay in comparison to flows in the LFC, and by the duration of reside time of water in the afterbay (see Section 4.2.2, Surface Water Quality, for additional information on Thermalito Afterbay and lower Feather River water temperatures).

The water temperature regime associated with the baseline operations of the Oroville Facilities may expose pre-spawning adult salmonids to elevated water temperatures that can adversely affect production (e.g., increased pre-spawning mortality, decreased fertilization, increased egg retention). Existing operations may also expose pre-spawning adult Chinook salmon to elevated water temperatures during the holding time period, which may adversely affect reproductive success. Water temperatures also can directly affect the spawning and incubation periods of salmonids, as well as the distribution of salmonid spawning and rates of egg and alevin survival (more information on water temperature effects on egg and alevin survival is included in Section G-AQUA1.8.2.5 in Appendix G-AQUA1 of the PDEA). Rearing juveniles exposed to high water temperatures may experience acute direct mortality or sublethal chronic thermal stress, which can be evidenced through indicators such as disease outbreaks, reduction in growth and food conversion efficiency, and hyperactivity or disorientation. (Additional information on water temperature effects on juvenile salmonids is included in Sections G-AQUA1.8.3.2 and G-AQUA1.8.3.3 in Appendix G-AQUA1 of the PDEA.) Elevated water temperatures also may affect the abundance and emigration pattern of Feather River juvenile salmonids. Warm water temperatures have the potential to create habitat conditions that are advantageous for some predatory fish species, which in turn may affect the juvenile rearing and emigration success of salmonids in the lower Feather River. (Additional information regarding predation of juvenile salmonids is included in Section G-AQUA1.11.3 in Appendix G-AQUA1 for of the PDEA.)

In the fall of 2005, DWR conducted an experimental release of cold water into the LFC by pulling stop logs in the Lake Oroville intake structure. The purpose of the experiment was to determine if there were any effects on spawning behavior and spawning success of spring-run and fall-run Chinook salmon. Analysis and results of this experimental

release have yet to be published. This additional release of cold water into the LFC does not reflect normal operations.

The Oroville Facilities physically block the upstream basin contributions of gravel, sediment, and LWD from the lower Feather River, and the upstream passage of anadromous salmonids to historical spawning areas.

Oroville Dam, Thermalito Diversion Dam, and the Fish Barrier Dam block gravel contribution from the upstream Feather River to the lower Feather River (see Section 4.1, Geology, Soils, and Paleontological Resources, for additional information on gravel recruitment and lower Feather River substrate conditions). High-flow releases from the Oroville Facilities mobilize smaller substrate particle sizes. The smaller substrate sizes are not replaced by upstream gravel, therefore resulting in a gradual relative coarsening of the particle size distribution of the substrate in the upper portions of the lower Feather River. Coarsening and armoring of the substrate size can affect fish spawning habitat suitability, quality, and distribution for salmonids and other fish species spawning in gravel substrates (more information regarding spawning substrate suitability is included in Section G-AQUA1.8.2.1 in Appendix G-AQUA1 of the PDEA). In general, the reach of river with the highest proportion of coarse substrate components is the upstream-most portion of the lower Feather River below the Fish Barrier Dam and above the Thermalito Afterbay Outlet.

More than 97 percent of the sediment from the upstream watershed is trapped in the upstream reservoirs, resulting in sediment starvation downstream (see Section 4.1, Geology, Soils, and Paleontological Resources, for additional information on sediment recruitment). Only very fine sediment is discharged from Lake Oroville to the river below. Depletion of the sediment load in the lower Feather River results in reduced formation of sediment benches, which affects riparian vegetation colonization and succession. The riparian vegetation provides overhanging cover for rearing fish, riparian shade, invertebrate contributions to the fish food base, and future LWD site contributions. Soft sediment substrates also contribute to the function of capture and retention of LWD.

The Oroville Facilities block the upstream contribution of LWD (see Section 4.1, Geology, Soils, and Paleontological Resources, for additional information on LWD recruitment and fluvial geomorphic functions). LWD creates zones of differential scour and deposit, creating gravel bars for use as spawning habitat by anadromous salmonids (Lassettre and Harris 2001). Logs, root wads, and undercut banks provide juvenile salmonid rearing cover from predators, velocity refuges, and increased concentrations of drifting food organisms. Debris-formed pools also provide adult salmonid holding habitat. LWD is an important functional component in the development and maintenance of habitat diversity and contributes to instream cover complexity (DWR 2002). The lowest proportion of instream cover complexity occurs in the upstream-most reach of the lower Feather River, from the Fish Barrier Dam to the Thermalito Afterbay Outlet. Downstream of the Thermalito Afterbay Outlet, the river increases in instream cover complexity. The farther downstream in the Feather River, the more the opportunity for lower Feather River LWD contribution to accumulate from the riparian

vegetation of the river, as well as from potential LWD contributions from lower Feather River tributaries.

The Oroville Facilities currently block the upstream migration of anadromous salmonids into historical spawning habitat in upstream tributaries. This blockage of upstream migration results in an overall reduction of total salmonid spawning habitat and a lack of access to historical upstream habitat, which may affect natural selection processes and eventually the genetic characteristics of the fish species. It also deprives these upstream tributary reaches up to the next impassable upstream barrier of the energy and nutrients that would otherwise be transferred there by the anadromous salmonid carcasses (more information regarding nutrient transfer is included in Section G-AQUA1.6 in Appendix G-AQUA1 of the PDEA).

Restricted access to historic spawning grounds causes spring-run Chinook salmon to spawn in the same lowland reaches that fall-run Chinook salmon utilize as spawning habitat. The overlap in spawning sites, combined with a slight overlap in spawning timing (Moyle 2002) with temporally adjacent runs, may be responsible for in-breeding between spring-run and fall-run Chinook salmon in the lower Feather River (Hedgecock et al. 2001). At present, the genetic distinctness of Feather River spring-run Chinook is still officially undetermined, although additional analysis has been conducted to determine the genetic distinction of spring-run and fall-run Chinook salmon (additional discussion is included in Section G-AQUA1.7 in Appendix G-AQUA1 of the PDEA).

The Fish Barrier Dam blocks upstream migration of anadromous salmonids and concentrates the intensity of habitat utilization to unnaturally high levels in the LFC. This increased concentration of intensity causes increased competition for spawning habitat and contributes to increased adult pre-spawning mortality levels and redd superimposition rates, which contributes to egg and alevin mortality (additional information on salmonid life stages and associated mortality estimates is included in Sections G-AQUA1.8.2.4, G-AQUA1.8.2.5, and G-AQUA1.8.2.6 in Appendix G-AQUA1 of the PDEA). Redd superimposition occurs when spawning Chinook salmon dig redds on top of existing redds dug by other Chinook salmon. The rate of superimposition is a function of spawning densities and typically occurs in systems where spawning habitat is limited (Fukushima et al. 1998). Redd superimposition may disproportionately affect early spawners, and therefore potentially affect Chinook salmon exhibiting spring-run life history characteristics.

As discussed in Section 4.2.2, six of the relicensing studies specifically address metals contamination in the project area. As part of these studies, water quality samples were collected at 17 locations within the lower Feather River. Samples exceeding aquatic life water quality criteria occurred for four constituents: total aluminum, iron, copper, and lead. In the reach of the Feather River extending from the Fish Barrier Dam downstream to the Thermalito Afterbay Outlet, 19 percent of the water quality samples exceeded aquatic life water quality criteria. Samples taken from the reach of the Feather River extending from the Thermalito Afterbay Outlet downstream to the confluence with the Sacramento River were variable, but all were higher than the upstream reach and 3 exceeded aquatic life water quality criteria 100 percent of the

time. Copper exceeded aquatic life water quality criteria in 5 of 276 samples; two of these occurrences were in the reach of the Feather River extending from the Fish Barrier Dam downstream to the Thermalito Afterbay Outlet. Iron only exceeded aquatic life water quality criteria at three sampling locations; all locations were downstream of the lower Feather River confluence with Honcut Creek. Lead exceeded aquatic life water criteria only once at several stations, but three or four times at the two most downstream stations on the Feather River.

4.4.2 Fish Species Overview

Detailed information regarding the life history and habitat requirements of each of the following fish species is provided in Section G-AQUA1.4 of Appendix G-AQUA1 of the PDEA for the Oroville Facilities, which summarizes the results of the aquatics study plan reports.

4.4.2.1 Warmwater Fish Species

Black Bass

Black bass species within the project area include spotted bass (*Micropterus punctulatus*), largemouth bass (*M. salmoides*), smallmouth bass (*M. dolomieu*), and redeye bass (*M. coosae*). None of these species of black bass are native to California; however, all are considered important recreational game fish.

Black bass spawn in the spring from March through June, with peak spawning activity in early May. All species prefer similar spawning habitat and are nest builders. Nest building begins at water temperatures around 54 degrees °F (12.2 degrees Celsius [°C]) and spawning continues until water temperatures exceed 75.2°F (24°C) (Aasen and Henry 1981; Baylis et al. 1993; Davis and Lock 1997; Graham and Orth 1986; Miller and Storck 1984; Wang 1986). Black bass spawning occurs in water 1–4 feet (ft) (0.3–1.2 meters [m]) deep near shore and has been observed as deep as 20 ft (6.1 m) in clear water (Davis and Lock 1997). In California, with changing reservoir levels, spawning has been observed at water depths up to 13.1–16.4 ft (4–5 m) (Moyle 2002).

Black bass species are found throughout the affected environment including tributaries upstream of Lake Oroville (DWR Unpublished Work), Lake Oroville (DWR 2003b), Thermalito Forebay (DWR 2003b), Thermalito Afterbay, and the lower Feather River from the mouth of the Thermalito Afterbay Outlet to the confluence with the Sacramento River (DWR 2003a). Black bass species are seldom observed in the LFC, probably due to colder water temperatures (DWR 2003a).

Catfish

Two species of catfish are found in the project area: channel catfish (*Ictalurus punctatus*) and white catfish (*I. catus*). Neither species is native to California; however, both are popular game fish. Adult channel catfish tend to be slightly larger than white catfish (13.8–17.7 inches vs. 11.8–15.7 inches [35–45 centimeters (cm) vs. 30–40 cm]) and, when in a river environment, are typically found in faster moving water, although

both species do well in large reservoirs (Moyle 2002). Both species of catfish are frequently observed in Lake Oroville (DWR 2003b).

In California, channel catfish generally spawn from April through June, while white catfish spawn slightly later during June through July (Moyle 2002). Spawning channel catfish require water temperatures ranging from 69.8 to 84.2°F (21–29°C), with 78.8 to 82.4°F (26–28°C) being the optimum water temperature range (Moyle 2002). Channel catfish typically construct nests in cave-like structures, and one reason for unsuccessful introductions has been suggested to be a lack of spawning habitat (Moyle 2002). Cavelike structures have been constructed in Lake Oroville to promote the channel catfish fishery (DWR 1997). In large impoundments, nests generally occur among rubble and boulders along protected shorelines at depths of 6.6–13.2 ft (2–4 m) (McMahon and Terrell 1982). White catfish construct nests in shallow depressions in sand or gravel near cover or utilize cave sites similar to channel catfish (Moyle 2002).

Crappie

Two species of crappie currently inhabit the project area: white crappie (*Pomoxis annularis*) and black crappie (*P. nigromaculatus*). Neither species is native to California; however, both are popular game fish. Sexually mature crappie are generally 4–8 inches (10–20 cm) in length and seem to prefer water temperatures ranging from 80.6 to 84.2°F (27–29°C) (Moyle 2002). Black crappie are more frequently observed in Lake Oroville, although both species are present (Moyle 2002).

Both species of crappie spawn in late spring and early summer, with white crappie tending to spawn a little earlier, although there is substantial overlap. Crappie spawn in water temperatures ranging from 62.6 to 68°F (17–20°C), at a depth of 3.3–23 ft (1–7 m) (Moyle 2002). Males of both species construct nests utilizing vegetation in shallow depressions in mud or gravel substrate (Moyle 2002).

Forage Fish

Two species of forage fish are found within the project area: threadfin shad (*Dorosoma petenense*) and wakasagi (*Hypomesis nipponensis*). Neither species is native to California, and both were introduced with the express purpose of serving as forage fish for game species in California lakes and reservoirs. Wakasagi were introduced to Lake Almanor in 1972 to serve as forage for salmonids (Moyle 2002). They have migrated downstream and are now found in Lake Oroville (Aasen et al. 1998; DWR 2003b) and are frequently observed in both Lake Oroville and Thermalito Forebay (DWR 2003b). Wakasagi spawn in the spring in small tributaries where eggs adhere to rocks or submerged vegetation (Aasen et al. 1998). Wakasagi normally spawn after their first year (Aasen et al. 1998), with a few surviving to spawn again in their second year. California wakasagi can tolerate a wide range of water temperatures, for both growth and reproduction (Moyle 2002).

Threadfin shad were first introduced in 1951 (Moyle 2002). Threadfin shad are broadcast spawners with fertilized eggs adhering to submerged logs or vegetation. In

California, threadfin shad spawning takes place during April through August and peaks in June and July when water temperatures exceed 68°F (20°C) (Moyle 2002; DWR 2003b; Wang 1986). Although originally introduced as a forage fish, the success of this program has been limited, and some authors suggest that the fish may actually compete for food resources with juvenile game fish (Moyle 2002). Threadfin shad have been infrequently observed in Lake Oroville (DWR 2003b).

Minnows

Four species of minnow are commonly found in the project area: Sacramento pikeminnow (*Ptychocheilus grandis*), hardhead (*Mylopharodon conocephalus*), hitch (*Lavinia exilicauda*), and Sacramento splittail (*Pogonichthys macrolepidotus*). All four species are native to the Sacramento River drainage (Moyle 2002).

Sacramento pikeminnow is ranked as the third most common species of native fish in the lower Feather River (Seesholtz et al. 2003). Pikeminnow are resident year-round and, therefore, all life stages are present. Spawning generally takes place from April through June (Moyle 2002), and the preferred water temperatures for spawning are in the range of 59 to 68°F (15–20°C). In reservoirs, pikeminnow have been observed spawning in very shallow water (a few inches in depth), as well as in water as deep as the thermocline (Patten and Rodman 1969). Pikeminnow are known predators of juvenile salmonids.

Hardhead was designated as a State species of special concern by DFG in 1995 and is listed as a Class 3 Watch List species, meaning that it occupies much of its native range, but was formerly more widespread or abundant within that range (Moyle 2002). Hardhead are fairly common in the Sacramento River and lower mainstems of the American and Feather Rivers. Hardhead are resident year round; therefore, all lifestages are present in the Feather River. Hardhead are frequently observed in the Feather River from the Fish Barrier Dam downstream to the confluence with the Sacramento River (Moyle 2002). Juvenile recruitment suggests that hardhead spawn from April through June in Central Valley streams, but the spawning may extend into August in the foothill streams of the Sacramento–San Joaquin drainage. Hardhead reportedly spawn in water temperature ranges from 55 to 75°F (12.8–23.9°F) (Moyle 2002; Wang 1986).

Hitch are a Class 3 Watch List species as designated by DFG (Moyle 2002). Females normally spawn between March and June (Wang 1986) and are broadcast spawners, selecting habitat and conditions similar to hardhead (Moyle 2002). Hitch are frequently observed in the Feather River from the Thermalito Afterbay Outlet to the confluence with the Sacramento River (USFWS 1999).

Sacramento splittail were designated as a Threatened species under FESA by USFWS on February 8, 1999 (64 *Federal Register* [FR] 5963 [1999]). Sacramento splittail were listed as Threatened throughout their entire range, which includes the Feather River (64 FR 5963 [1999]). On September 22, 2003, USFWS issued a Notice of Remanded Determination for the Sacramento Splittail (Seesholtz et al. 2003). This removed the

Sacramento splittail from the Endangered Species List; however, Sacramento splittail is still considered a species of special concern by DFG.

Other than incidental observations of Sacramento splittail in the Feather River (Seesholtz et al. 2003; USFWS 1995a), there have been no directed studies of abundance in this area. Because Sacramento splittail have been observed in the Feather River, it is assumed that some spawning takes place. Sacramento splittail spawning can occur anytime between late February and early July, but peak spawning occurs in March and April (Moyle 2002). Sacramento splittail spawn primarily in inundated floodplains (Moyle 2002; Wang 1986). The literature indicates that adult Sacramento splittail migrate into inundated areas during February (Moyle 2002), and that peak Sacramento splittail spawning occurs from March through April (Moyle 2002). Spawning reportedly is followed by 3–7 days of egg incubation (Moyle 2002), and the larvae remain in the vegetation for another 7–10 days, feeding on zooplankton. Approximately 10–14 days after Sacramento splittail eggs are fertilized, they reportedly develop into free-swimming larvae (Sommer et al. 1997). Juvenile rearing continues until juvenile Sacramento splittail have transformed into benthic-feeding juveniles. After floodplain waters begin to recede, juveniles leave the floodplain and begin to migrate downstream to brackish waters. Juvenile Sacramento splittail begin appearing at Sacramento–San Joaquin Delta (Delta) salvage pumps in April and peak during late April and May, suggesting that most juvenile out-migration from the Feather River has occurred by the end of May (Daniels and Moyle 1983; Sommer Unpublished Work).

Sacramento splittail spawning generally occurs in water with a depth of 3.0–6.6 ft (0.9–2.0 m) over submerged vegetation (Moyle 2002; Wang 1986). This same habitat is used for initial juvenile rearing. Sacramento splittail have a wide thermal tolerance during this time period, and water temperatures may range from 48 to 75°F (Moyle 2002; Sommer et al. 1997; Wang 1986).

Sacramento Sucker

The Sacramento sucker (*Catostomus occidentalis*) is common in the project area and is native to California (Wang 1986). The Sacramento sucker is described as one of the few native fish species that have thrived despite massive changes to historic habitat (Moyle 2002). Spawning occurs between late February and early June, with peak spawning during March and April (Moyle 2002). Sacramento suckers prefer water temperatures for spawning between 53.6 and 64.4°F (12–18°C), with water depths of 11.8 inches (30 cm) or more (Moyle 2002). The Sacramento sucker is infrequently observed in Lake Oroville and frequently observed in Thermalito Forebay (DWR 2003b). It is also common in the lower Feather River (Seesholtz et. al 2003).

Striped Bass

Striped bass (*Morone saxatilis*) is an introduced game fish that frequents the project area in April through June for spawning (Moyle 2002; Bell 1991; Hassler 1988; Hill et al. 1989). Striped bass have also been reported in Thermalito Forebay (DWR 2003b), which may indicate a small landlocked breeding population. The striped bass fishery is

one of the most valuable sport fisheries in California, both in terms of the recreation it provides and economic wealth it generates (Skinner 1962).

Female striped bass reach sexual maturity at age 4 to 6, while males reach sexual maturity at age 2 to 3 (Moyle 2002). The maximum age of striped bass is estimated at over 30 years; however, fish older than 10 years are uncommon (Moyle 2002). In California, striped bass have reportedly attained lengths of up to 49.2 inches (125 cm) and weights up to 90.4 pounds (41 kilograms [kg]) (Moyle 2002).

Striped bass are broadcast spawners, with peak spawning activity occurring from April through June (Wang 1986). Striped bass spawn in mainstem rivers and have shown little preference for substrate (Wang 1986). Based on various studies, the water temperature range in which spawning occurs is reported to be approximately between 59 and 68°F (20°C) (Moyle 2002; Bell 1991; Hassler 1988; Hill et al. 1989).

Sunfish

Three species of sunfish, bluegill (*Lepomis macrochirus*), green sunfish (*L. cyanellus*), and redear sunfish (*L. microlophus*), are common in the project area. None of these species is native to California, although all are popular recreational gamefish (Moyle 2002; Wang 1986).

All three sunfish species exhibit a similar life history, have a similar lifespan, and attain similar sizes; therefore, the traits of bluegill are discussed herein. Spawning normally occurs as water temperatures exceed 68°F (20°C) (Wang 1986). In California, spawning occurs throughout the summer, with peak spawning in June and July (Wang 1986). All three species generally inhabit small warm streams, ponds, and lake edges (Moyle 2002). All of the sunfishes are frequently observed in Lake Oroville, and a small population of bluegill may exist in Thermalito Forebay (DWR 2003b). Bluegill, green sunfish, and redear sunfish are also common in the OWA ponds (DWR 2003b) and in the lower Feather River (Seesholtz et. al 2003).

Tule Perch

The tule perch (*Hysterocarpus traski*) is native to California, including the Sacramento River system (Moyle 2002). As a species, the tule perch population is stable or increasing while the Sacramento River population of tule perch retains a Watch List status (Moyle 2002).

Tule perch prefer lotic water habitats with temperatures less than 71.6°F (22°C) and are reportedly not found in temperatures greater than 77°F (25°C) (Moyle 2002). Beds of surfacing aquatic plants, deep pools, and banks with complex cover, such as overhanging bushes, fallen trees, undercutting, and riprap, provide the preferred environment for tule perch (Moyle 2002). Tule perch are livebearers with females producing 25–60 young (Moyle 2002). Mating generally occurs in late summer, with females storing sperm from multiple males (Wang 1986). Actual fertilization takes place in January and birth occurs in May (Wang 1986). Young are released among tule

marshes and other types of vegetation (Wang 1986). A few tule perch have been observed in Thermalito Forebay (DWR 2003b) and they are common in the lower Feather River (Seesholtz et. al 2003).

4.4.2.2 Coldwater Fish Species

American Shad

The American shad (*Alosa sapidissima*) is an introduced species (Moyle 2002) that provides high recreational and economic value (Froese and D. Pauly Website 2002). American shad are present in the Feather River from May through mid-December, during the adult immigration, spawning, and emigration periods of their life cycle (Moyle 2002). American shad are an anadromous species, and the population in California is considered widespread and stable (Moyle 2002).

The Sacramento River supports large runs of American shad in late May and early June during their upstream spawning migration (Moyle 2002). American shad are broadcast spawners and normally spawn over sand or gravel substrate in main river channels (Moyle 2002). In the Sacramento River, American shad prefer water temperatures ranging from 62.6 to 75.2°F (17–24°C) for spawning (Moyle 2002) but elsewhere have been reported to spawn in water temperatures between 46 and 79°F (7.8–26.1°C) (Painter et al. 1979; Wang 1986). Emigration of juveniles from the spawning area takes place from July through December, generally peaking in August and September (Painter et al. 1979). Juveniles may spend up to 1 year in freshwater (Moyle 2002).

Chinook Salmon

Chinook salmon (*Oncorhynchus tshawytscha*) are native to California waters, including the Feather River. Chinook salmon have a varied life history. Within the Sacramento River system, three different Evolutionarily Significant Units (ESUs) of the species are recognized based on the time of year that upstream migrations begin. Spring-run Chinook salmon normally begin migration during March and continue through the beginning of September, holding in coldwater pools until ready to spawn. Fall-run Chinook salmon begin upstream migration in the summer and last until December. Although not located within the project area, a small winter-run population of Chinook salmon also exists within the Sacramento River system, with upstream migration beginning in December (Moyle 2002; DWR 1982; Sommer et al. 2001).

On September 19, 1999, the Central Valley spring-run Chinook salmon ESU was listed as Threatened under FESA by NMFS (NMFS 1999). The Central Valley spring-run Chinook salmon ESU includes all naturally spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries, including the naturally spawned spring-run Chinook salmon in the lower Feather River (NMFS 1999). The Feather River Fish Hatchery-spawned population of spring-run Chinook are also considered part of the ESU ((70 FR 37160) 2005). Additional discussion regarding spring-run Chinook salmon is provided in Section 4.4.2.4, Listed Fish Species.

In the same September 19, 1999 ruling, NMFS determined that naturally spawned Central Valley fall-run Chinook salmon were not warranted for listing under FESA (NMFS 1999), but were designated as a candidate for listing (NMFS 1999). On April 15, 2004, NMFS announced the Central Valley fall-run Chinook salmon change in status from a candidate species to a species of concern. The Central Valley fall-run Chinook salmon ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin River basins and their tributaries, which includes naturally spawned fall-run Chinook salmon in the lower Feather River (NMFS 1999).

The timing of adult Chinook salmon spawning activity is strongly influenced by water temperature. When daily average water temperatures decrease to approximately 60°F (15.5°C), female Chinook salmon begin to construct nests (redds) into which their eggs (simultaneously fertilized by the male) are eventually released. Fertilized eggs are subsequently buried with streambed gravel. Spawning activity in the Feather River occurs from late August through December and generally peaks in mid to late November (Myers et al. 1998).

The intragravel residence period of incubating eggs and alevins (yolk-sac fry) is highly dependent upon water temperature. The intragravel egg and fry incubation life stage for Chinook salmon generally extends from about mid-October through March. Egg incubation survival rates are dependent on water temperature and intragravel water movement. Incubation temperatures of approximately 62 to 64°F (16.7–17.8°C) reportedly appear to be the physiological limit for embryo development resulting in 80 to 100 percent mortality prior to emergence (NMFS 1993). Egg incubation survival is highest at water temperatures at or below 56°F (13.3°C) (NMFS 1993; Vogel and Marine 1991).

Within the project area, fall-run Chinook salmon fry emergence generally occurs from late December through March. In the Sacramento River basin, fall-run Chinook salmon juvenile emigration occurs from January through July (Snider et al. 1997b; Vogel and Marine 1991). Emigration surveys conducted by DFG have shown no evidence that peak emigration of Chinook salmon is related to the onset of peak spring flows in the lower American River (Snider et al. 1997a). Temperatures required during emigration are believed to be about the same as those required for successful rearing. Water temperatures reported to be optimal for rearing of Chinook salmon fry and juveniles are between 45 and 65°F (7.2–18.3°C) (Raleigh et al. 1986b; Rich 1987). Raleigh et al. (Raleigh et al. 1986a) reviewed the available literature on Chinook salmon thermal requirements and suggested a suitable rearing temperature upper limit of 75°F (23.8°C) and a range of approximately 53.6 to 64.4°F (12–18°C). Juvenile fall-run Chinook salmon normally rear for 1–7 months in freshwater before migrating to the ocean (Moyle 2002). Chinook salmon from the Feather River normally spend 3–5 years in the ocean (Moyle 2002). Returning fall-run Chinook salmon average 35.4 inches (90 cm) in length (Moyle 2002).

Coho Salmon

Coho salmon (*O. kisutch*) are native to California waters and while no wild populations currently exist in the Feather River, they are stocked in Lake Oroville (DWR 2001). The Central California Coast ESU for coho salmon was listed as Threatened under FESA on December 2, 1996. Coho salmon also is designated as a State species of special concern, and populations south of San Francisco are listed by the State as endangered. These special-status species designations pertain only to coho salmon within their native habitats. Coho salmon occur within the project area as a result of stocking programs and are managed for their recreational importance only. Coho salmon supports valuable commercial and sport fisheries in the Pacific Southwest Region. According to the Pacific Fishery Management Council (PFMC), the sport fishery accounted for 58 percent of the total catch of coho salmon along the California coast in 1985 (Moyle 2002).

California coho salmon within their native habitat generally have a 3-year life cycle, with about half spent in freshwater and half spent in saltwater (Moyle 2002). Coho salmon die after spawning, with peak spawning migrations in California occurring from late December through January followed by immediate spawning (Weitkamp et al. 1995). Coho salmon spawn in riffles at water temperatures of 42.8 to 53.6°F (6–12°C) (Moyle 2002). Juveniles remain in freshwater for 12–15 months, then migrate to the ocean where they remain for 16–18 months before returning to spawn (Moyle 2002). Coho salmon have been introduced to the Great Lakes, and small reproducing populations have been observed in tributaries of Lake Superior (DWR 2003a); therefore, under certain conditions, the saltwater life cycle phase of coho salmon may not be a requirement for successful reproduction.

On August 19 and November 21, 2003, NMFS submitted comments to DWR regarding the Lake Oroville coho salmon stocking program. NMFS expressed concerns that the stocking of coho salmon in Lake Oroville may negatively affect threatened native populations of coastal coho salmon if stocked coho escape the reservoir and stray into a coastal coho stream. NMFS requested that DWR assess the risk of this occurring prior to the continuance of the coho stocking program (DWR 2004).

In 2004, DWR responded with a risk assessment that concluded:

- A low number of Lake Oroville stocked coho would successfully escape from the reservoir to the Pacific Ocean;
- High mortality in the ocean would further reduce the number of Lake Oroville stocked coho that would be available for return to freshwater;
- The probability that these fish would stray is low, and the probability that this straying would occur into a coastal coho stream is even lower; and
- Hatchery fish have inferior spawning performance when compared with wild fish.

Therefore, due to the reduction in probability that occurs each step of the way, DWR does not believe that stocking coho salmon in Lake Oroville poses a risk to coastal coho salmon populations (DWR 2004).

Coho salmon have been stocked in Lake Oroville since 2002. The current stocking goal is to plant approximately 170,000 juvenile coho per year. This goal was met in 2002 and 2003; however, in 2004 an outbreak of Bacterial Kidney Disease at the facility providing coho prevented any fish from being stocked in Lake Oroville in 2004. In 2005 approximately 59,000 yearling coho were stocked in Lake Oroville. During the fall of 2006, DWR stocked a total of 251,146 coho salmon in Lake Oroville. A total of 1,299 of these fish were 2-year-old adult coho salmon (approximately 20 inches long) and 249,847 were yearlings (approximately 8 inches long); these fish received a disease certification from DFG prior to stocking. At the request of NMFS, all of the yearlings were marked with a coded wire tag and an adipose fin clip (pers. comm., See 2007).

Lamprey

Two species of lamprey, river lamprey (*Lampetra ayresi*) and Pacific lamprey (*L. tridentata*), are found within the project area. Pacific lamprey are more frequently observed in the Feather River than river lamprey (DWR 2003a). Both species are native to California waters and are on the Watch List (Moyle 2002); however, river lamprey is designated as a State species of special concern by DFG. Both species spend 3–4 years in freshwater as ammocoetes (larval form of lamprey) before the metamorphosis to the adult form takes place, at which time they migrate to the ocean (Moyle 2002; Beamish 1980).

River lamprey congregate upstream of saltwater for 4 months as young adults, rapidly grow to 9.8–12.2 inches (25–31 cm), and enter the ocean in late spring (Moyle 2002). After approximately 3 months in the ocean, river lamprey return to freshwater to spawn in the fall (Moyle 2002). River lamprey hold in freshwater for up to 8 months until spawning from April through June (Beamish 1980). Lamprey construct gravel nests, and river lamprey are reported to spawn at water temperatures of 55.4 to 56.3°F (13–13.5°C) (Wang 1986).

Juvenile Pacific lamprey migrate to the ocean in the fall where they spend approximately 3.5 years in saltwater (Beamish 1980). Pacific lamprey enter freshwater in April through June. By September, upstream migration is complete, and adults over-winter and spawn in the spring of the following year (Bayer et al. 2001; Beamish 1980; Close et al. 2002). Crude nests are constructed in gravelly areas, and the water temperature range for Pacific lamprey spawning is 53.6 to 64.4°F (12–18°C) (Moyle 2002).

Steelhead/Rainbow Trout

Steelhead and rainbow trout are the same species (*O. mykiss*), with steelhead being the anadromous form. Steelhead are native to California waters. On March 19, 1998, naturally spawned Central Valley steelhead was listed as Threatened under FESA by

NMFS (53 FR 13347 [1998]). The Central Valley steelhead ESU includes all naturally spawned populations of steelhead (and their progeny) in the Sacramento and San Joaquin Rivers and their tributaries residing below naturally formed and artificial impassable barriers (e.g., waterfalls and dams), which includes the naturally spawned steelhead in the Feather River (53 FR 13347 [1998]). NMFS concluded that there are two artificial propagation programs considered to be part of the Central Valley ESU, i.e., the Coleman National Fish Hatchery on Battle Creek and the Feather River Fish Hatchery. Additional discussion regarding Central Valley steelhead is provided in Section 4.4.2.4, Listed Fish Species.

Rainbow trout are the most popular and widely distributed gamefish in California (Moyle 2002) and are currently stocked in Thermalito Forebay (DWR 2001). Naturally spawning populations of rainbow trout currently exist in the tributaries above Lake Oroville (Moyle 2002).

Most wild rainbow trout spawn in the spring between February and June (Moyle 2002). Rainbow trout normally spawn by constructing redds (nests) in coarse gravel substrate, 0.5–5.1 inches in diameter, in the tail of a pool or riffle (Moyle 2002). The number of eggs per female normally depends on the size of the fish at spawning but ranges from 200 to 12,000 eggs (Moyle 2002). Most spawning is observed when water temperatures are between 46 and 52°F (7.8–11.1°C) in water flowing at 0.2–3.6 ft per second (ft/sec) (Moyle 2002). Water temperatures above approximately 63°F (17.2°C) are reportedly lethal to developing rainbow trout embryos (Moyle 2002). Eggs normally hatch in 3–4 weeks, with alevins remaining in the gravel for another 2–3 weeks (Moyle 2002).

For the first year of life, juvenile rainbow trout normally inhabit cool, fast-flowing streams and rivers where riffles predominate over pools and there is cover from riparian vegetation and undercut banks (Moyle 2002). Older rainbow trout tend to move into deeper runs or pools (Moyle 2002). Rainbow trout are reportedly found where daytime water temperatures range from 32°F (0°C) in the winter to 80.6°F (27°F) in the summer, although 73.4°F (23°C) is reportedly lethal for unacclimated fish (Moyle 2002).

Rainbow trout are also stocked in Thermalito Forebay as part of a put-and-take fishery. These fish are generally stocked as 0.5 lb fish with the assumption that they will be caught by anglers. Rainbow trout stocked in the Thermalito Forebay are particularly sensitive to ceratomyxosis and die within about 3 months. Ceratomyxosis is caused by *Ceratomyxa Shasta*, an endemic myxozoan parasite that is lethal to many strains of rainbow trout. Salmonid populations that are native to rivers where *C. Shasta* naturally occurs (e.g., Feather River) appear to have developed varying degrees of resistance to infection (Noga 1996). The stocking of disease susceptible rainbow trout in Thermalito Forebay helps to ensure that those stocked rainbow trout that escape the fishery and migrate into the lower Feather River do not interact with the wild or stocked steelhead native to the Feather River watershed.

Sturgeon

Two species of sturgeon, white sturgeon (*Acipenser transmontanus*) and green sturgeon (*A. medirostris*), are found within the project area. White sturgeon are more commonly observed in the Feather River than green sturgeon (DWR 2003a), although both species are native to California waters. Green sturgeon are currently listed as Threatened under FESA and are discussed more thoroughly in Section 4.4.2.4, Listed Fish Species.

White sturgeon are known to spawn in the Feather River (Moyle 2002). The presence of larval green sturgeon in salmon outmigrant traps indicates that the Feather River may support a spawning green sturgeon population (NMFS 2002). However, NMFS (NMFS 2002) reports that evidence of green sturgeon spawning in the Feather River is unsubstantiated; substantial efforts (including scuba and snorkel surveys, hook-and-line sampling, and larval traps) during preparation of the Oroville Facilities Relicensing studies were all unsuccessful in documenting their presence in the lower Feather River. Both species begin an upstream spawning migration between February and June, with spawning occurring between April and June (Moyle 2002; Beamesderfer and Webb 2002). A few white sturgeon have been observed in Lake Oroville (DWR 2003b).

White sturgeon are broadcast spawners (Moyle 2002). Suitable water temperatures for white sturgeon spawning in California are 46.4 to 66.2°F (8–19°C); peak spawning occurs at water temperatures of approximately 57.2°F (14°C) (Moyle 2002). Juveniles remain in freshwater for 1–4 years before migrating to the ocean (Moyle 2002).

Trout

Brown trout (*Salmo trutta*), brook trout (*Salvelinus fontinalis*), and lake trout (*S. namaycush*) are found within the project area. None of these species are native to California waters, and all were introduced to provide a recreational sport fishery. All three species have been stocked in either Lake Oroville or Thermalito Forebay (DWR 2001). Brook trout and lake trout are not true trout but actually members of the char family.

Currently, only rainbow trout are stocked by DFG in the Thermalito Forebay. Lake trout were stocked in Lake Oroville during 1984 and 1985, and a few lake trout are still observed in Lake Oroville (DWR 2003b), suggesting the possibility of a small breeding population. Brown trout were stocked in Lake Oroville as recently as 2000 (DWR 2001).

Adult trout are largely bottom-oriented pool dwellers in streams and rivers (Moyle 2002). Overhanging and submerged vegetation, undercut banks, and instream objects such as debris piles, logs, and large rocks provide escape cover for adults and juveniles (Raleigh et al. 1986b). The water temperature tolerance range for trout is 32 to 80.6°F (0–27°C), although the preferred water temperatures for trout are reportedly 53.6 to 68°F (12–20°C) (Raleigh et al. 1986b).

All three species spawn in the fall or winter. In California, brook trout spawn from September through January, brown trout from November through December, and lake trout from September through November (Moyle 2002). Brook trout normally spawn in small tributaries but have been observed spawning on the gravel bottom shallows of some lakes (Moyle 2002). Brown trout spawn in small tributaries (Raleigh et al. 1986b). Lake trout are one of the few salmonids that do not construct redds; instead, they broadcast spawn in deep cold water of lakes (Moyle 2002).

4.4.2.3 Existing Conditions

Existing effects associated with the Oroville Facilities are discussed in detail in Section 4.4.1.1, Facilities, Waterbodies, and Related Fisheries Resources. In general, existing effects are associated with blocking sediment, gravel, and LWD contributions from the upstream tributaries to the lower Feather River, as well as blocking fish passage from the lower Feather River to the upstream tributaries. In addition to this physical blockage, the Oroville Facilities will continue to alter the flow regime and water temperatures in the lower Feather River, which affects fish habitat quality, quantity, and distribution, as well as the geomorphic processes that affect fish habitat complexity and diversity. More specifically, existing project effects include:

- Blockage of the upstream migration of anadromous salmonids to historic spawning grounds in tributaries of the Feather River upstream of Oroville Dam to the next upstream impassable barrier, resulting in redd superimposition and genetic introgression between fall-run and spring-run Chinook salmon populations, high spawning densities in the lower Feather River, and high juvenile rearing densities in the lower Feather River;
- Continued supplementation of Chinook salmon population levels due to Feather River Fish Hatchery production;
- Continued supplementation of steelhead population levels due to Feather River Fish Hatchery production;
- Blockage of gravel, sediment, and LWD contributions from the upstream tributaries to the lower Feather River by Oroville Dam, preventing these resources from contributing to the development and maintenance of fish habitat quality and diversity in the lower Feather River;
- Dewatering of bass nests during spawning season, although the effect is not great enough to change the self-sustaining nature of the bass fishery. Continued benefits to Lake Oroville warmwater fisheries with ongoing implementation of the Habitat Enhancement Program;
- Reduced habitat complexity and diversity in the lower Feather River due to regulated flows;
- Potential for disease transmission associated with the Feather River Fish Hatchery and Lake Oroville stocking programs;
- Increased rates of straying of adult Chinook salmon from the Feather River Fish Hatchery practices;

- High rates of pre-spawning mortality associated with a combination of stress related to water temperature, disease, spawning density, and recreational angling; and
- Fluctuations in Oroville Facilities releases resulting in redd dewatering and juvenile stranding.

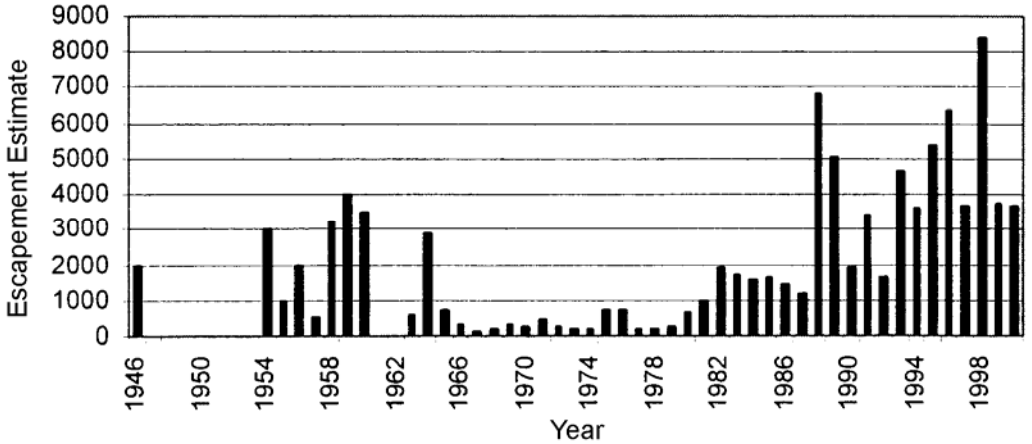
4.4.2.4 Listed Fish Species

A general discussion of fisheries and aquatic resources within the study area is provided in Section 4.4.1.1, Facilities, Waterbodies, and Related Fisheries Resources. Warmwater and coldwater fish species also are discussed in Sections 4.4.2.1 and 4.4.2.2, respectively. The following discussion specifically addresses those fish species within the study area that are federally and State listed, which includes spring-run Chinook salmon, Central Valley steelhead, and green sturgeon.

Of particular interest and importance is the distribution of Chinook salmon and steelhead spawning and rearing habitat in relation to the Oroville Facilities. Before construction of the major dams in the Central Valley, an estimated 6,000 miles of spawning and rearing habitat was accessible to Chinook salmon and steelhead. Currently, an estimated 95 percent of this habitat is blocked by dams or other obstructions (DWR 2002). The Oroville Facilities have the potential to directly affect spawning and rearing habitat for these species, as well as other species identified by State and/or federal resource agencies as species of special concern because of their declining numbers or limited distribution.

DWR constructed the Feather River Fish Hatchery in 1967 to compensate for salmonid spawning habitat lost with construction of Oroville Dam. Each year, approximately 9,000–18,000 salmon and 2,000 steelhead are artificially spawned at the hatchery. Salmon and steelhead raised at the hatchery are transported for release in the Feather and Sacramento rivers, in Lake Oroville and other California reservoirs, and in San Pablo Bay north of San Francisco Bay (DWR 2002).

Prior to construction of the Oroville Facilities, the Feather River spring-run Chinook salmon population was similar in magnitude to the size of the present hatchery run (Figure 4.4-4). Spring-run Chinook salmon ascended the very highest streams and headwaters of the Feather River watershed prior to the construction of hydroelectric power dams and diversions (DWR 2001). Before Oroville Dam (1946–1963), available population estimates ranged from 500 to 4,000 fish and averaged 2,200 per year (DFG 1998 in DWR and USBR 2001). However, Feather River spring-run Chinook salmon had probably been significantly affected by hydroelectric power facilities in the upper watershed well before completion of Oroville Dam. For instance, DFG found substantial overlap in the spawning distributions of fall-run and spring-run Chinook salmon upstream of the Oroville Dam site (DFG 1998 in DWR and USBR 2001).



Source: DWR and USBR 2001

Figure 4.4-4. Estimated adult spring-run Chinook salmon population abundance in Feather River, California.

As in several of the other spring-run streams, returns of spring-run Chinook salmon to the Feather River Fish Hatchery suggest that the population has been increasing slightly in the recent past (DWR 2001). This population trend could be caused by a large number of potentially contributing factors, some occurring within the project area and others unrelated to project operations (e.g., ocean cycle survival, decadal cycles), and are assessed further in the cumulative effects analysis provided in Section 6.2.

In September 2001, the U.S. District Court in Eugene, Oregon, in *Alsea Valley Alliance v. Evans* (161 F. Supp. 2d 1154, D. Oreg. 2001; *Alsea* decision) ruled that the ESA does not allow NMFS to list a subset of an ESU and that NMFS had improperly excluded stocks from the listing after it had decided that certain hatchery stocks were part of an ESU. Although the Court's ruling affected only the Oregon Coast coho salmon, it called into question nearly all of NMFS Pacific salmonid listing determinations. In its June 14, 2004, proposed listing determinations for 27 ESUs of West Coast salmonids, NMFS states that "for the proposed listing determinations … to be compliant with the Court's ruling in the *Alsea* case, all populations or stocks (natural, hatchery, resident, etc.) included in an ESU must be listed if it is determined that the ESU is threatened or endangered under the ESA."

<u>Central Valley Spring-run Chinook Salmon</u>

On September 19, 1999, the Central Valley spring-run Chinook salmon ESU was listed as Threatened under FESA by NMFS (NMFS 1999). The Central Valley spring-run Chinook salmon ESU includes all naturally spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries, which includes the naturally spawned spring-run Chinook salmon in the lower Feather River. In June 2005, NMFS published a final listing determination for Central Valley spring-run Chinook salmon that identifies the Feather River's nominal spring run as part of the Central Valley spring-run Chinook salmon ESU and is thus listed as Threatened. Spring-run Chinook salmon

produced at the Feather River Fish Hatchery are included in the ESU (70 FR 37160 [2005]).

On December 10, 2004, NMFS issued a proposed rule designating critical habitat for seven ESUs of Pacific salmon and steelhead in California. The final designation for critical habitat was published on September 2, 2005, and became effective on January 2, 2006. The critical habitat includes approximately 1,272 miles of occupied stream habitat and 427 square miles of estuarine habitat. A key area included in the newly designated critical habitat includes the lower Feather River (70 FR 52488 [2005]). The Central Valley spring-run Chinook salmon ESU also is listed as Threatened under CESA. A discussion of Chinook salmon in general is provided in Section 4.4.2.2, Coldwater Fish Species.

Adult spring-run Chinook salmon immigration into the Delta and lower Sacramento River occurs from mid-February through July, and peaks during April-May (Moyle 2002). Suitable water temperatures for adult upstream migration reportedly range between 51 and 67°F (10.5–19.4°C) (Bell 1991). Other authors suggest that varying degrees of adverse effects could potentially occur to migrating adult Chinook salmon at water temperatures of 60, 64, and 68°F (15.6, 17.8, and 20°C) (USEPA 2003a; USEPA 2003b; NMFS 1997; ODEQ 1995; USFWS 1995b). In addition to suitable water temperatures, adequate flows are required to provide migrating adults with olfactory and other cues needed to locate their spawning reaches (NMFS 1997).

The primary characteristic distinguishing spring-run Chinook salmon from the other runs of Chinook salmon is that adult spring-run Chinook salmon hold in areas downstream of spawning grounds during the summer months until their eggs fully develop and become ready for spawning. Maximum water temperatures for adult Chinook salmon holding while eggs are maturing are reported to be approximately 59 to 60°F (15–15.6°C) (NMFS 1997). However, variation among studies suggests that holding adult Chinook salmon exposed to water temperatures above 60, 64, and 68°F (15.6, 17.8, and 20°C) have varying degrees of effects on individuals (USEPA 2003a; USEPA 2003b; NMFS 1997; ODEQ 1995; USFWS 1995b). Spring-run Chinook salmon spawn in the upper Sacramento River upstream of Red Bluff Diversion Dam, the lower Yuba River, and the lower Feather River. Spawning has been reported to primarily occur during September and October, peaking in mid-September (Moyle 2002). Available literature suggests that water temperatures above 56, 58, 60, and 62°F (13.3, 14.4, 15.6, and 16.7°C) each have varying effects on spawning adult Chinook salmon and incubating embryos (Combs and Burrows 1957; Dauble and Watson 1997; Groves and Chandler 1999; Johnson and Brice 1953; NMFS 1993; NMFS 1997; NMFS 2002; USFWS 1995b). Although some portion of an annual year-class may emigrate as post-emergent fry (individuals less than 45 millimeters [mm] in length), most are believed to rear in the upper Sacramento River and tributaries during the winter and spring and emigrate as juveniles (individuals greater than 45 mm in length, but not having undergone smoltification) or smolts (silvery colored fingerlings having undergone the smoltification process in preparation for ocean entry). Juvenile spring-run Chinook salmon normally rear for 3–15 months before migrating to the ocean (Vogel and Marine 1991). The timing of juvenile emigration from the spawning and rearing grounds varies among the

tributaries of origin, and can occur during the period extending from October through April (Vogel and Marine 1991). In the Feather River, data on juvenile spring-run emigration timing and abundance have been collected sporadically since 1955 and suggest that November and December may be key months for spring-run emigration (Painter et al. 1977). Spring-run Chinook salmon from the Feather River normally spend 3 years in the ocean (Moyle 2002). Detailed discussion of the effects of exposure to elevated water temperatures on various life stages of spring-run Chinook salmon is provided in Section G-AQUA1.8 of Appendix G-AQUA1 of the PDEA.

Central Valley Steelhead

On March 19, 1998, naturally spawned Central Valley steelhead was listed as Threatened under FESA by NMFS (53 FR 13347 [1998]). When originally listed, the Central Valley steelhead ESU included all naturally spawned populations of steelhead (and their progeny) in the Sacramento and San Joaquin Rivers and their tributaries residing below naturally formed and artificial impassable barriers (e.g., waterfalls and dams), which includes the naturally spawned steelhead in the Feather River (53 FR 13347 [1998]). The listing was further clarified in January 2006, redefining the protected fish as Central Valley steelhead (71 FR 834 [2006]). On June 14, 2004, NMFS proposed that Central Valley steelhead remain listed as Threatened under FESA. In their proposed rule (113 FR 33102 [2004]), NMFS concluded that there are two artificial propagation programs considered to be part of the Central Valley steelhead ESU (i.e., the Coleman National Fish Hatchery on Battle Creek and the Feather River Fish Hatchery), although both programs are intended to support recreational fisheries for steelhead rather than to supplement naturally spawning populations. In addition, NMFS proposed that resident steelhead occurring with anadromous populations below impassable barriers also be included in the ESU. The Feather River Fish Hatchery largely sustains steelhead runs in the Feather River (McEwan 2001).

On December 10, 2004, NMFS issued a proposed rule designating critical habitat for seven ESUs of Pacific salmon and steelhead in California. The lower Feather River below Oroville Dam is identified as critical habitat for Central Valley steelhead.

Steelhead are known to live up to 9 years in the Central Valley (Moyle 2002). Adult steelhead immigration into Central Valley streams typically begins in December and continues into March. Steelhead may reenter fresh water anytime between July and May, but immigration generally peaks during January and February (Moyle 2002). Optimal immigration temperatures have been reported to range from 46 to 52°F (7.8–11.1°C) (NMFS 2000). However, other authors suggest that varying biological effects could occur to adult steelhead after exposure to water temperatures above 52, 56, and 70°F (11.1, 13.3, and 21.1°C) during immigration and holding (Leitritz and Lewis 1980; McCullough et al. 2001; NMFS 2000; USBR 1997a). Spawning occurs between January and March (McEwan 2001). Optimal spawning temperatures have been reported to range from 39 to 52°F (3.8–11.1°C) (NMFS 2000). However, other authors suggest that varying biological effects could occur to adult steelhead after exposure to water temperatures above 52, 54, 57, and 60°F (11.1, 12.2, 13.8, 15.6°C) during steelhead spawning and embryo incubation (Busby et al. 1996; USEPA 2001;

Humpesch 1985; Kwain 1975; McCullough et al. 2001; NMFS 2000; NMFS 2002; USBR 1997b; Redding and Schreck 1979; Rombough 1988; Timoshina 1972; USFWS 1995b) Unlike Chinook salmon, many steelhead do not die after spawning. Those that survive return to the ocean and may spawn again in future years. Most steelhead in California spawn twice (Busby et al. 1996).

Optimal egg incubation temperatures have been reported to range from 48 to 52°F (8.8–11.1°C) (NMFS 2000). However, other authors suggest that varying biological effects could occur to adult steelhead after exposure to water temperatures above 52, 54, 57, and 60°F (11.1, 12.2, 13.8, and 15.6°C) during steelhead spawning and embryo incubation (Busby et al. 1996; USEPA 2001; Humpesch 1985; Kwain 1975; McCullough et al. 2001; NMFS 2000; NMFS 2002; USBR 1997b; Redding and Schreck 1979; Rombough 1988; Timoshina 1972; USFWS 1995b) Preferred water temperatures for fry and juvenile steelhead rearing are reported to range from 45 to 65°F (7.2–18.3°C) (NMFS 2000) Each degree increase between 65°F (18.3°C) and the upper lethal limit of 75°F (23.9°C) reportedly becomes increasingly less suitable and thermally more stressful for the fish (Bovee 1978). Juveniles spend 1–2 years in freshwater before migrating to the ocean. The primary period of steelhead emigration occurs from March through June (Castleberry et al. 1991). Most steelhead in the Central Valley return to spawn after 1 year in the ocean while a smaller number may spend 2 years (Busby et al. 1996). Detailed discussions of the effects of exposure to elevated water temperatures on various life stages of steelhead are provided in Section G-AQUA1.8 in Appendix G-AQUA1 of the PDEA.

Green Sturgeon

On April 15, 2004, NMFS announced that the Northern and Southern Distinct Population Segments of Green Sturgeon would change in listing status from a candidate species to a species of concern (69 FR 19977). However, litigation challenging the NMFS determination that green sturgeon do not warrant listing as an Endangered or Threatened species under FESA asserted that the agency was arbitrary and capricious in failing to examine whether habitat loss constituted a significant portion of the species' range. The court partially agreed with the Plaintiff's motion, and remanded the determination back to NMFS for further analysis and decision as to whether green sturgeon are endangered or threatened in a significant portion of its range. Hence, according to NMFS April 15, 2004, interpretations of FESA provisions, green sturgeon were considered a candidate species as well as a species of concern, until this matter could be resolved. On April 7, 2006, a final rule was issued and adopted, and the southern distinct population segment was listed as Threatened. The final rule became effective June 6, 2006 (71 FR 17757 [2006]). Green sturgeon also are designated as a species of special concern in California (Moyle et al. 1995).

Green sturgeon may reach an age of 20 years before spawning and then spawn every 4 to 11 years (DFG Website 2002). Green sturgeon spawning migrations occur between February and July (DFG Website 2002), with peak spawning activity between April and June (Beamesderfer and Webb 2002). Green sturgeon also are broadcast spawners (Beamesderfer and Webb 2002). Green sturgeon can spawn in water temperatures

ranging from 46.4 to 68°F (8–20°C) (Moyle 2002; Beamesderfer and Webb 2002; DFG Website 2002). Juveniles remain in freshwater for up to 4 years before beginning a seaward migration (Beamesderfer and Webb 2002; DWR 2001).

4.5 TERRESTRIAL RESOURCES

The Oroville Facilities are located within the Sacramento Valley and Sierra Nevada Foothills subregions of the California Floristic Province (Hickman 1993). Broad vegetation patterns in this area correspond with changes in elevation from the valley floor to the upper elevations of the Sierra Nevada. The vegetation ranges from valley grasslands to foothill woodlands (characterized by blue-oak/foothill pine woodlands with varying amounts of chaparral), to mixed conifer forests in the higher elevations. These patterns vary and are influenced not only by elevation but also by precipitation, temperature, soils, aspect, slope, and disturbance history (SNEP 1996). This area is characterized by hot, dry summers and moderately cold, wet winters. Temperatures range from below zero to more than 100 degrees Fahrenheit (°F). Approximately 95 percent of the annual precipitation occurs during the winter. Precipitation ranges from less than 33 inches per year at Oroville to 5–10 feet per year at the upper elevations of the watershed.

4.5.1 Wildlife

4.5.1.1 Wildlife Resources

Overview

This section of the DEIR describes the affected environment as it relates to wildlife resources. It includes descriptions of wildlife habitats, richness of wildlife species, non-native species, commercially or recreationally important wildlife species in the project area, and current wildlife management activities. Special-status wildlife species that may occur in the project area are addressed in Section 4.5.1.2 of this DEIR.

Wildlife and wildlife habitats in the project area are greatly influenced by the proximity of the Oroville Facilities to the Sierra Nevada, the habitats generally found in the Sacramento Valley, the abundance of surface water associated with the Oroville Facilities and the Feather River, and adjacent land uses. The diversity of wildlife habitats within and adjacent to the project area also reflects variability in slope, aspect, precipitation, elevation, hydrology, land use, and localized edaphic (soil-related) conditions. Habitats in the project area support a variety of wildlife species, including numerous recreationally and commercially important species as well as special-status species.

Several land management agencies—USFS, BLM, DPR, DFG, and DWR—manage wildlife habitats in the project area. Lands in the project area are managed under the following federal, State, and local land resource management plans:

- *Proposed Amended Recreation Plan for Lake Oroville State Recreation Area* (DWR 2003a);
- *Plumas National Forest Land and Resource Management Plan* (USFS 1988) as amended by the *Sierra Nevada Forest Management Plan* (USFS 2001), including

provisions of the Herger-Feinstein Quincy Library Group Forest Recovery Act of 1998;

- *Proposed Redding Resource Management Plan* (BLM 1993);
- *Resource Management Plan and General Development, Lake Oroville State Recreation Area* (DPR 1973);
- *Oroville Wildlife Area Management Plan* (DFG 1978);
- *Management Plan for the Thermalito Afterbay Unit of the Oroville Wildlife Area* (DFG no date); and
- *Land Management Plan for the Protection of the Potential Habitats of Special Status Species of Fairy and Tadpole Shrimp* (DWR 2004a).

Project lands are also managed under five Bald Eagle Nest Territory Management plans.

In addition to CEQA, under which this document has been prepared, the principal statutes that form the basis for land management activities as they relate to wildlife resource management are:

- Federal Power Act of 1920, as amended;
- Endangered Species Act of 1973 (FESA), as amended;
- Fish and Wildlife Coordination Act;
- Migratory Bird Treaty Act of 1972;
- Bald Eagle Protection Act of 1940, as amended;
- NEPA; and
- California Endangered Species Act (CESA).

All of these statutes were considered in development and implementation of the Oroville Facilities relicensing studies. The BLM and USFS guidelines for management of sensitive species, and various DFG code sections, including Section 3500, were also considered. Descriptions of the acts are provided in Section 5.5.1.1 in Chapter 5.0, Environmental Consequences.

Detailed field investigations were completed in the project area in 2002, 2003, and 2004. These investigations focused on addressing management issues identified during scoping. Field investigations included surveys of wildlife habitats and species, special-status wildlife species, non-native species, and recreationally/commercially important species. Results of the investigations are reported in the reports for the following relicensing study plans:

- Study Plan T-1 (SP-T1), Effects of Project Operations and Features on Wildlife and Wildlife Habitat (DWR 2004b);
- SP-T2, Project Effects on Special Status Wildlife Species (DWR 2004c);
- SP-T4, Biodiversity, Vegetation Communities and Wildlife Habitat Mapping (DWR 2003b);
- SP-T6, Interim Interagency Wildlife Management Coordination and Wildlife Management Plan Development (DWR 2004d);
- SP-T8, Project Effects on Non-Native Wildlife (DWR 2003c);
- SP-T9, Recreation and Wildlife (DWR 2004e); and
- SP-T11, Effects of Fuel Load Management and Fire Prevention on Wildlife and Plant Communities (DWR 2003d).

The studies were conducted in the same study area described for botanical resources (Section 4.5.2). Detailed descriptions of the study area, methods, and results are contained in the individual relicensing study plan reports.

Wildlife Habitats

The California Wildlife Habitat Relationships [CWHR] classification system was used to determine the wildlife habitat types that occur within the project area. As listed in Table 4.5-1 and described in the SP-T4 report, 24 habitat types occur within the project area. The distribution of these habitats is shown in Figures 4.5-1 and 4.5-1a through 4.5-1e. The principal wildlife habitat types are:

- Lacustrine (open water);
- Montane hardwood;
- Blue oak/foothill pine;
- Valley/foothill riparian;
- Montane hardwood/conifer;
- Annual grassland;
- Barren;
- Freshwater emergent wetland;
- Urban; and
- Blue oak woodland.