Oroville Facilities Relicensing
Environmental Work Group
Draft Geomorphology Study Plan 1

SP-G1 Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam

Introduction

The effects of dams on upriver geomorphic processes are extensive. These processes include physical attributes and functions such as channel shape, channel stability, sediment transport and deposition, and bedload recruitment. This is caused by the lake, which changes the local base level. As the lake level changes from day to day and from year to year, the upstream channel responds with channel aggradation or~~and~~ degradation. This creates a highly dynamic channel section immediately upstream of the reservoir~~,~~ that can affect riparian vegetation, fish, aquatic invertebrates, and other resources.

Fluctuating~~The altered~~ base level also affects substrate scour or deposition, mobilization of sediment, turbidity levels in the lake and its drawdown zone.~~.~~ ~~During winter storms w~~When lake levels are high, sediment deposits in the upper reaches of the lake. Sediment is subsequently eroded in the spring and summer when lake levels are lower, causing large amounts of sediment to move. In addition, wave action can erode shorelines during winter storms when lake levels are high. High turbidity and sediment movement affects the reservoir's benthic invertebrates, riparian vegetation, and fish. The sediment deposits sometimes create fish spawning migration barriers, particularly in small tributaries entering the lake.

Objective

To determine ongoing project operation effects (primarily seasonal water level changes) on reservoir sedimentation, landsliding, shoreline erosion, channel geomorphology, and sediment transport in the Feather River in and above Lake Oroville. This information will be provided to other studies to be included in their evaluations of the Oroville Facilities ongoing effects on riparian resources, water quality, fish and wildlife. Components of sediment mass balance studies include:

1. Determine sediment conditions and sediment transport requirements.
2. Evaluate sediment sources (including tributaries) and conditions.
3. Map major sediment deposits.
4. Evaluate upstream channel stability.
5. Compare unimpaired and Project-affected sediment regimes.
7. Quantify and characterize sediment volume and grain size variation in Lake Oroville.

Need for Study\ Relationship to Relicensing:

Relicensing participants have identified the altered sediment routing and reservoir drawdown caused by the Oroville Facilities as -potential project effects on the river above the lake. The following Project-related structures and operations can adversely impact sediment transport regimes: diversions, reservoirs, channels with flow augmentation, tailraces, roads, sluicing/sediment removal practices, rock drops, surge chamber discharge, spillways/forebay overflow, and instream structures. These structures can result in the storage of sediments or the discharge of greater quantities of sediment than would occur under natural conditions.

The geomorphic investigation will quantify changes that have~~s~~ occurred in the 30+ years since the dam was built ~~to the upper stream system and the area of the lake~~ by comparing pre- and post project data. This information will help address continuing effects to native plant and animal habitats and riparian resources from hydrologic, channel, and sediment routing changes. These data, together with other study results, will provide boundary conditions for identifying and assessing potential management actions.

Study Area:

The study area includes the reservoir, the fluctuation zone, and ~~its~~ the tributaries that are influenced by the drawdown of the lake. The effect of the drawdown can extend to the next salmonid migration barrier upstream of the lake, such as the Big Bend Dam on the North Fork Feather. On the Middle Fork, the study area will extend about 3 or 4 miles upstream from the lake. The specifics of the upstream extent and numbers of tributaries will be based on initial survey results of the reservoir shoreline exposed during low water conditions.

Methodology and Analysis:

The study methodology consists of five individual tasks.

TASK 1: Obtain and Review Existing Resource Data.

DWR will compile previous work using the State Resources Agency Library and extensive in-house publications. Hydrologic and cross-section data will be compiled. A set of base maps and photos will be obtained for plotting the data.

A set of these maps is in the DWR map library. These maps will be used to quantify pre- and postproject conditions.

Available photography will be compiled for use in charting changes in stream ~~geo~~morphology, vegetation, land use, and other data. The most recent photography will be ortho-corrected and used as a base for a Geographic

Information System. If recent photography is not available, it will be obtained with new flights.

Previous information dealing with the Feather River above Oroville Dam will be collected. This includes reports on sediment, landslides, watershed attributes, stream ~~geo~~morphology and others. Historic gauging station data from gages directly upstream of the lake will be compiled.

Sub-tasks and products under Task 1 include the following:

- Consult with county, State, and federal agencies, including DFG, CDMG, USFWS, NMF, USGS, USACE, and USBR. Consult with companies and private individuals having knowledge of the geology and geomorphic processes in project area.
- Perform initial survey of reservoir shoreline noting the location of sediment deposits, deltas, and bars at or above the water line and relationship to tributary streams.
- Review previous work will include compiling data sets, assessing the adequacy of the data, and identifying data gaps.
- Prepare a general description of the physiographic setting, including maps of precipitation, geology, soils, topography, vegetation, and other watershed characteristics upstream of the dam. Most of this information is available and can be modified from existing DWR and USFS reports.
- Compile information on large-scale geomorphic processes and disturbances within the watershed. These include large flood events, volcanic eruptions, landsliding, and glacial activity. It will also include human-induced events, such as deforestation, hydraulic mining, urbanization, dam building, diversions, and others. These events influence reservoir life, sedimentation, turbidity, storage, and fish.
- Prepare maps and tables showing the sediment sources in the watershed and the relative amounts produced by the North, Middle, and South forks.
- Classify upstream reaches within the sphere of influence of the lake, using the Rosgen stream classification system. The reaches will be classified using Rosgen's Level I stream typing, then further classified using the Level II or higher classification based on channel form and substrate ~~and form~~. The results of the stream classification and data collection will be presented on the river atlas and GIS system.
- Access historic information related to woody debris input to reservoir

TASK 2: Map the Channel Resources in the Tributaries above Oroville Dam.

DWR will measure the geomorphic channel characteristics of the West Branch, North Fork, Middle Fork, South Fork and other tributaries, identified during the

initial survey as being influenced by reservoir-induced backwater effects, shoreline erosion, and landsliding. Study methodology, computer model selection, and other parameters will be selected depending on Task 1 findings. Geomorphic parameters include channel width, depth, cross-section, hydraulic radius, roughness, large woody debris, gravel bars, islands, and others. Cross-sections will be surveyed at impacted areas identified as having~~with~~ a deleterious buildup of sediment or excessive erosion. The spacing and level of detail will be selected based on the magnitude of the impacted area. Some cross-sections will be surveyed, but intermediate ones may be developed using sonar and GPS during high lake levels. The end-points will be permanently marked using steel pipe set in concrete monuments. Each cross-section will have a photo point, and additional photo points will be established in critical areas.

Pools, riffles, and runs will be mapped. Representative areas at the riffles will be analyzed using bulk gravel sampling and surface sampling techniques to determine the surface and substrate quality of trout spawning gravel. Gradation curves for each riffle will be prepared. These data are particularly important in evaluating project effects on fish and the riparian community.

Sub-tasks and products under Task 2 include the following:

- Prepare an aerial photo atlas using recent, rectified aerial photos. These will be used as a base layer for the GIS system.
- Establish baselines, locate benchmarks and existing cross-sections, and set monuments. Survey monuments using GPS.
- Survey channel cross-sections using a tagline strung between the endpoints. Vertical measurements will be taken every ten feet and at topographic break points. The river portion will be surveyed using a small boat. The roughness coefficient and bed material size will be estimated for each cross-section.
- Conduct Wolman gravel sampling at each cross-section and tabulate data to compare with acceptable limits for spawning gravel.
- Describe the features of tributary inputs,
- Evaluate the presence/absence of active and/or remnant deltas at confluences with main stem and reservoir.
- Describe the sediment characteristics of tributary inputs: lithology, grain sizes, stratigraphy of deposits.
- Map and characterize sediment sources and deposits.
- Describe the type of sediment (size class based on visual observation for areas between cross-sections).
- Identify the category of sediment source (e.g., moraine, residual bedrock weathering/colluvium, mass wasting—landslides, rockslides, or other specific sources such as roads, burns, timber harvest sites).
- Estimate the approximate thickness of sediment accumulations.

For the reservoir, the following will be described in the field: 1) location and estimated volume of visible sediment deposits; and, 2) effects of wave erosion on

turbidity. In addition, Project operations data regarding reservoir sediment and history will be collected and reviewed.

For each major reservoir arm, a bathymetric survey will be conducted using a digital echosounder and GPS combination. Information collected from these surveys will be entered into GIS for map production and area calculations at different elevations. Reservoir substrates will be characterized at low lake elevations and by grab samples in deeper locations. These and additional reservoir habitat data described below, also will be added to the GIS. Shoreline steepness will be measured from reservoir morphometry and bathymetry.

TASK 3: Re-survey Reservoir Cross-Sections and Determine Sediment in Storage

This task will consist of two parts. The first part consists of monitoring sediment in Lake Oroville to determine the amount of sediment the dam stops from going downstream. Cross-sections were surveyed prior to dam construction in the early 1960's, in 1973, and again in 1994. A large storm in January 1997 brought a large slug of new sediment into the lake. The lake would be re-surveyed as part of this project to determine the total amount of sediment deposited to date.

The second part of Task 3 would consist of determining sediment sources derived from the lake. These include reservoir shoreline erosion and landslides. Shoreline erosion would be measured by comparing soil profiles and other evidence above and below the high water level. ~~A landslide map would show the areas of instability and to measure the amount of sediment from this source.~~ Areas of instability would be identified from aerial map survey and delineated on a landslide map. The map would be used to make an estimate of sediment volume contributed by landslides. Some of the landslides would be instrumented with slope indicators or motion sensors to determine rates of movement.

Subtasks and products under Task 3 include the following:

- Compile and digitize cross-sections surveyed in the mid-1960s, 1973, and 1994.
- Re-survey cross-sections to determine change since 1994, and use these data to determine long-term sedimentation rates.
- Map shoreline erosion and estimate sediment amount derived from this source. In some areas, bank erosion will be measured in detail using erosion pins and cross-section surveys. This information will be provided to other studies to include in their evaluation of on-going project effects on lake turbidity, sediment, recreation, cultural resource, and vegetation.
- Map landslides in affected stream reaches above the dam and within the reservoir. Install motion sensors, survey monuments, and slope indicators to determine rates of landslide movement. Estimate sediment derived from this source.

TASK 4: Cross-section Monitoring

Cross-sections will be monitored during the length of the study to measure changes in geomorphic characteristics and to chart sediment degradation, aggradation, and movement within the reservoir area. A few will be selected based on the hydraulics of the stream flow, magnitude of impacted area, and sediment characteristics to measure hydraulic and sediment transport conditions at a variety of discharges when the lake is low. The monitoring will consist of setting a tag line between the cross-section monuments; measuring the depth and stream velocity; measuring bedload transport using a Helley-Smith bedload sampler; measuring temperature; measuring the wetted hydraulic radius; and other stream parameters as necessary. This will assist in evaluating geomorphic changes affecting habitat in this important interface between river and lake.

Subtasks and products under Task 4 include the following:

- Collect existing survey, topographic, and photographic data. Survey cross-section using a tagline strung between the endpoints. Vertical measurements will be taken every ten feet and at topographic break points. The river portion will be surveyed using a small boat. The roughness coefficient and bed material size will be estimated for each cross-section.
- Conduct monitoring activities at representative low, medium, and high flows to cover the full spectrum of streamflow and sediment transport. This should be done during low reservoir levels when most of the river is actively flowing.
- Measure temperature, depth, velocity, turbidity, bedload movement, and suspended sediment across the cross-section using standard U.S. Geological Survey methodology.
- Prepare graphs, tables, and charts showing streamflow, temperature, turbidity, sediment discharge, bedload and suspended sediment size distribution.

TASK 5: Determine Changes in River Geomorphic and Hydraulic Parameters.

This will be done by comparing historic data with recent data. Available past cross-sectional data will be compared to those surveyed in Task 3 to determine upstream changes in channel shape, form, and function caused by the dam. Changes in depth, width, hydraulic radius, roughness, gradient, pool-riffle-run ratio, and other hydraulic parameters will be determined.

A conceptual sediment budget will be developed for the streams and reservoirs upstream of Oroville Dam based upon the results of Tasks 1 and 2. The budget will identify locations, types, and relative magnitudes of sediment sources, and describe the location, volume, and trapping status of sediment traps (reservoirs

and other impoundments). The budget will help identify areas subject to Project related effects in the next steps, compared to the natural conditions that would be expected in the absence of the Project.

- Determine ongoing impacts caused by Oroville Dam by comparing pre- and post dam sediment transport, gravel bars, riffles, channel width, gradient and other geomorphic characteristics using maps, photographs, and surveys. Prepare figures, graphs, and charts showing the changes.
- Collect available streamflow data from adjacent upstream gaging stations. The U.S. Geological Survey Water Resources Data website provides these data.

Reservoir bathymetry mapped as part of this study (Task 3) will be compared to previous bathymetry, when available, and pre-reservoir topography. In addition to volume comparison, reservoir profiles will be evaluated to locate areas of sediment deposition, if any. Where possible, the type and character of these sediment deposits will be assessed visually when the reservoirs are drawn down during the late fall and early winter months.

Schedule

The initial survey of the reservoir area will be conducted during December-January 2001-02. Cross-section surveys will be conducted from March through August of 2002. Gravel sampling and geomorphic mapping will be accomplished during the same period. Monitoring will occur during late 2002- early 2003. Follow-up surveys will be completed in Fall 2003 if needed. An atlas, maps, surveys, and the GIS will be produced concurrently during the studies and should be completed by the summer of 2004. The final report would be completed by December 2004.

Results and Products:

The study will be used to identify the hydraulic, geomorphic, and sediment transport changes that have occurred in the tributaries and the lake above Oroville Dam. The effect of the changes on fish, flooding, riparian vegetation, and invertebrates will be assessed in other studies. Results of the study will help identify rehabilitation needs.

TASK 6: Prepare a Draft Report.

The draft report will allow for comments, corrections, and additional data in preparation of the final report.

TASK 7: Prepare a Final Report.

The final report will include the main report with an introduction, previous work, procedures, description of work done, results, summary, conclusions, and recommendations. A river and lake atlas will also be prepared with recent photography, ortho- corrected, at a scale of 1 inch = 500 feet. Locations of riffles, pools, runs, cross-sections, monuments, sample areas, photo points, and other data will be shown. A Geographic Information System using Arcview will also be prepared with the same data. This will allow the data to be presented in both atlas and electronic form. The GIS will also allow additional information to be added and presented at a later date.

STUDY PLAN COORDINATION

COORDINATION WITH OTHER RESOURCE AREAS/STUDIES

It is anticipated that this study will require coordination with those individuals responsible for collecting water quality, temperature, fishery, habitat, cultural resource, recreation, and project operation data, and performing biological surveys, and fishery studies. Contact with CDFG and USGS also are expected.

Implementation of this study plan will require coordination with other Oroville relicensing studies, as follows: historic air photos, riparian habitat mapping and occurrence data (SP-T4);Effects in the Fluctuation Zone (SP-T3);Contaminent Accumulation (SP- W-2), Effects on Reservoir Fish Habitat (SP-F3), historical and alternative operations data will be obtained (SP-EO2); and description of recreation use (SP-RS03). This study will also require coordination with the GIS program

Issues Addressed by this Study Plan are described in Geology Issue Statement 4 which included the following issues:

GE19 Gravel recruitment impacts of the dam – both up and down stream;
GE22 Effect of accumulated sediment on lake bathymetry of Lake Oroville;
W6 Effect of existing and future project facilities and operations on sediment deposition and potential impoundment of metals and toxins, including the potential presence and uptake of methyl mercury through the food chain. Lake Oroville, fed by tributaries that have a history of gold mining activity, has potential for accumulation of elemental mercury in its basin sediments;

Other issues addressed by this Study Plan are included in Geology Issue Statement 1 which included the following issues:

GE10 Has the project resulted in sediment starvation (e.g., reduced gravel recruitment) to the lower river, and if so, by how much;

GE19 Gravel recruitment impacts of the dam – both up and down stream;

GE24 Direct, indirect, and cumulative impacts of project facilities and operations on sediment movement and deposition, river geometry, and channel characteristics. This includes impacts on stream competence, capacity, bank stability and extent, duration, and repetition of high flow events;

GE25 Natural geomorphological processes historically occurred within the Feather River watershed and are the result of geologic and hydrologic processes such as weathering, erosion, runoff patterns, material transport and deposition. Project features and operations have altered these natural geomorphic processes. Alteration of these geomorphic processes has affected the riverine habitat and species that depend on it. The FWS is concerned that project operations may have taken us beyond some critical thresholds for ecosystem sustainability. We are concerned that maintenance of a satisfactory abiotic template (e.g., substrate used for invertebrate production and fish spawning) is not occurring). The FWS wants assurance that new license conditions will allow for minimum thresholds of geomorphic processes to take place thus ensuring sufficient natural sediment movement and a satisfactory abiotic habitat template are in place;

F1 Effects of existing and future project operations (including power generation, water storage, ramping rates, and releases, pump-back, water levels, and water level fluctuations) during all water year types on the behavior (e.g., migration timing, microhabitat selection, vulnerability to predators), reproduction, survival and habitat of warm- and cold-water fish and other aquatic resources (e.g., macroinvertebrates), which include in project waters and tributaries within the project boundaries (Lake Oroville, Diversion Pool, Fish Barrier Pool, Forebay, Afterbay, Oroville Wildlife Area), and in project affected waters;

F3 Project effects on resident fish species (e.g., trout and other salmonids and warm-water fish) habitat quantity and quality (including instream flow, sediment, woody debris, water temperature, etc.,) and habitat for other aquatic species;

F6 Effects of existing and future project operations on sediment deposition, erosion, and recruitment through the system (including downstream sediment supply) and associated changes in water quality on the quantity and quality of aquatic habitats within project affected waters;

FE9 Use Instream Flow Incremental Methodology (IFIM) or a comparable methodology to determine streamflow needs to ensure that trout habitat quality and quantity are not reduced within project area and/or project affected areas;

FE11 Inventory streams, streamside areas, and other wetlands in deteriorating condition and restore on a priority basis within project area and/or project affected areas;

FE14 Provide for fish passage and maintain natural channel character at stream crossings within project area and/or project affected areas;

FE38 Preserve natural riparian flood control abilities. Remove only those log jams or major debris accumulations that have a high potential of causing channel damage, block fish passage, or could be transported downstream by high flows and cause loss of property;

FE83 Macroinvertebrates as an indicator of water quality;

T3 Effects of existing and future project operations on floodplains and project water fluctuation zones, including soil stability, wildlife habitat and natural flood control functions, revegetation of native plant communities, and restoration opportunities (e.g., red willow planting);

Oroville Facilities Relicensing
Environmental Work Group
Draft Geomorphic Study Plan 2

SP-G2 Effects of Project Operations on Geomorphic Processes Downstream of Oroville Dam

Introduction

The Feather River drains the western slope of the Sierra Nevada Geologic Province. Upstream of Oroville dam, t~~T~~he watershed contains steep, forested slopes for the most part~~ upstream of Oroville Dam~~. Some of the headwaters lie within the Basin and Range Geologic Province, containing both steep mountains and large intermountain valleys. The climate is Mediterranean, with mostly dry summers and wet winters. Annual p~~P~~recipitation ranges from 30 inches near the dam to over 75 inches higher in the watershed.

Oroville Dam was completed in 1969. Since then, the dam has affected the movement of water, sediment, and woody debris down the Feather and Sacramento rivers.

Oroville Dam and its operation have extensive downstream effects on river geomorphic processes. Most of the changes are caused by the primary function of the dam to store winter high flows and release them for irrigation and water supply during the summer. The result includes changes in yearly, monthly, and daily stream flow distribution, bankfull discharge, flow exceedance, peak flows, and other geomorphic parameters.

The reservoir also captures up to 97 percent of the clay, silt, sand, and gravel transported by the river from the watershed. ~~The c~~Changes in sediment transport and discharge ~~result in~~ alter~~ation of~~ physical attributes and functions such as channel shape, channel stability, sediment transport and deposition, bedload recruitment, and woody debris recruitment. Channel capacity may also change, affecting flood frequency. ~~The effect of river process changes on the biological resources may also be extensive and includes~~Altered river processes may affect biological resources as well. These affected resources include coarsening of spawning gravel on riffles, changes in riparian vegetation habitat complexity and diversity, and aquatic macro-invertebrate production. ~~s, f~~Flooding, land use, recreation, and aesthetic resources are also affected by altered river processes~~, and others~~.

The downstream effects of Oroville Dam are complicated by extensive stream and watershed alterations caused by other factors such as hydraulic mining, gravel mining, gold dredging, timber harvesting, and urbanization.

Another concern is the effect of the altered hydrology on substrate scour or deposition, mobilization of sediment, and turbidity levels, both in the low flow reach and downstream of the Afterbay. Reduction in the sediment load and streamflow in the Feather River below Oroville may also affect the Sacramento River downstream of its confluence with the Feather River.

Objective

The objective is to determine the effects of altered downstream hydrology and sediment retention in Lake Oroville on channel ~~geo~~morphology and sediment transport below Lake Oroville. Study results will be used to develop and implement a comprehensive sediment management plan that considers restoration of river form and function in the Feather River. The study results will also be used by other studies to help assess the project's ongoing effects on downstream water quality, aquatic and riparian resources.

A naturally functioning alluvial channel in equilibrium is capable of transporting the water and sediment delivered to it without significantly changing its geometry, streambed composition, or gradient through time. The flow conditions that promote this stability can be described as geomorphically-significant flows. These flows do the majority of the sediment transport and are considered most responsible for channel form. A natural flow regime typically includes flow ranges responsible for in-channel clearing and overbank flows to support riparian vegetation, along with channel-forming flows.

This study will determine the effect of flows on the ~~geo~~morphology of Project affected streams and impoundments downstream of Oroville Dam. Specifically, the study will address the following components:

1. Determine sediment conditions and sediment transport requirements.
2. Evaluate sediment sources (including tributaries) and conditions.
3. Map major sediment deposits.
4. Evaluate stream channel stability.
5. Compare unimpaired and Project-affected sediment regimes.
6. Evaluate timing, magnitude, and duration of unimpaired and Project-affected flows in relation to geomorphic effects.
7. Determine the effect of the Project on fluvial geomorphologic features.

Need for Study\ Relationship to Relicensing

The altered sediment routing and hydrology caused by the Oroville Facilities have affected river ~~geo~~morphology. There is a need to understand these relationships and determine corrective actions that might be undertaken to protect, restore, and enhance downstream resources.

The geomorphic investigation will quantify changes that have occurred to the stream system in the 30+ years since the dam was built by comparing pre- and post-project data. This information will be used to identify continuing project effects to downstream geomorphological processes. It will also be used by other studies to help assess the project's effects on native plant, fish, animal, and ~~the~~ riparian resources caused by hydrologic, channel, and sediment routing changes. These data, together with other study results, will provide boundary conditions for assessing potential management actions.

The Oroville Project-related structures and operations also alter flow regimes, which can impact the occurrence of geomorphically significant flows. Potential adverse effects include loss of undercut banks, increased instream fine sediment, braiding, loss of channel capacity, reduced sediment transport capability, gravel displacement, unnatural channel scour, armoring, and impairment of the ability of the stream to maintain functional riparian and instream habitat. Project-related structures and operations can also impair the stream's ability to transport the sediment delivered to it from source areas.

Study Area

The study area includes the Feather River below Oroville Dam. Depending on the results, it is possible that the study area may be expanded farther downstream.

Methodology and Analysis

The study methodology consists of 10 individual tasks.

TASK 1: Obtain and Review Existing Resource Data.

DWR will compile previous work using the State Resources Agency Library and extensive in-house publications. Hydrologic and cross-section data will be compiled. A set of base maps will be obtained for plotting the data.

A set of these maps is in the DWR map library. The maps show the low flow reach in great detail. An aerial photo atlas published by DWR also shows spawning riffle and cross-section locations. These will be useful for quantifying pre- and post-project conditions.

Available photography will be compiled. The historic photography is a valuable resource for charting changes in stream ~~geo~~morphology, vegetation, land use, and other data. The most recent photography will be ortho-corrected and used as a base for a Geographic Information System.

Sub-tasks and products under Task 1 include the following:

- Review previous work will include compiling data sets, assessing the adequacy of the data, and identifying data gaps.

- Prepare a general description of the physiographic setting, including maps and descriptions of precipitation, geology, soils, topography, vegetation, and other watershed characteristics.
- Compile and summarize information on large-scale geomorphic processes and disturbances within the watershed. These include large flood events, volcanic eruptions, landsliding, and glacial activity. Information~~t~~ will also include human-induced events, such as deforestation, hydraulic mining, urbanization, dam building, diversions, and others.
- Identify the major sediment sources in the watershed and amount of sediment produced by the North, Middle, and South forks.
- Classify downstream reaches, using the Rosgen stream classification system. The reaches will be classified using Rosgen's Level I stream typing, then further classified using the Level II or higher classification based on channel form and substrate ~~and form~~. The location of bank protection structures, levees, 100-year floodplain and other river data will also be collected. The results of the stream classification and data collection will be presented on the river atlas and GIS system.

TASK 2: Map the Aerial Extent of Spawning Gravel Deposits.

In coordination with fishery biologists, DWR will measure the actual spawning area in square feet of the riffles throughout the spawning reach. The measured spawning area is incorporated into the assessment. Representative areas at the head of riffles will be analyzed using bulk gravel sampling and surface sampling techniques to determine the surface and substrate quality of salmon spawning gravel. Gradation curves for each riffle will be prepared and compared to similar investigations done in 1980, 1982, and 1997. Trend lines showing the changes in gravel size distribution will be prepared.

Subtasks and products under Task 2 include the following:

- Prepare an aerial photo atlas using recent, rectified aerial photos. These will be used as a base layer for the GIS system.
- Identify, classify, and measure the velocity, width, depth, and length of spawning riffles.
- Plot redd counts and locations (information to be obtained from fisheries study results).
- Sample and sieve gravel from the upstream end of salmon spawning riffles.

- Conduct Wolman surface grid sampling at each sieve site. Compare and develop mathematical relation between the two sampling methods.
- Prepare tables, charts, and figures showing riffle spawning area, gravel size distribution, and spawning gravel quality. Map the spawning riffles on the atlas and the GIS.

TASK 3: Survey Cross-Sections and Establish Photo Points.

This part consists of surveying cross-sections in the river below the dam. Cross-sections have been surveyed in the low flow reach in the past. As many of these as possible will be re-established, and additional cross-sections surveyed to provide sufficient spacing for the study needs. Cross-sections will also be established below the Thermalito outfall, for some distance downstream and with spacing dependent on need. The end-points will be permanently marked using steel pipe set in concrete monuments and surveyed using GPS. Each cross-section will have a photo point, and additional photo points will be established in critical areas.

Field characteristics of sediment, floodplain, and riparian condition will provide the basis for transect selection for detailed study. The study sites may include: sensitive sites with potential Project-related impacts, representative sites for the range of identified stream types, stream gage locations, and reference reaches.

Subtasks and products under Task 3 includes the following:

- Establish baselines, locate benchmarks and existing cross-sections, and set monuments. Survey monuments using GPS.
- Survey cross-section using a tagline strung between the endpoints. Vertical measurements will be taken every ten feet and at topographic break points. The river portion will be surveyed using a small boat. The roughness coefficient and bed material size will be estimated for each cross-section.
- Conduct gravel sampling at each cross-section and tabulate data.

TASK 4: Monitor Cross-sections ~~Monitoring~~ and Conduct Sediment Transport Sampling

Cross-sections will be monitored. A representative number will be selected to measure hydraulic and sediment transport conditions at a variety of discharges. These data will be used to calibrate the sediment transport and geomorphic models used in another part of the study. The monitoring will consist of setting a tag line between the cross-section monuments; measuring the depth and stream velocity; measuring bedload transport using a Helley-Smith bedload sampler; measuring temperature; measuring the ~~wetted~~ hydraulic radius; and other stream parameters as necessary.

Subtasks and products under Task 4 include the following:

- Select representative number of cross-sections for monitoring.
- Conduct monitoring activities at representative low, medium, and high flows to cover the full spectrum of streamflow and sediment transport.
- Measure temperature, depth, velocity, turbidity, bedload movement, and suspended sediment across the cross-section using standard U.S. Geological Survey methodology.
- Prepare graphs, tables, and charts showing streamflow, temperature, turbidity, sediment discharge, bedload and suspended sediment size distribution.

The assessment of channel characteristics and sediment regime observations will include:

- presence of vegetation encroachment in the low-flow channel,
- observed emergent and/or woody vegetation in low-flow, or bottom width, channel,
- geomorphic function of woody debris,
- role in formation of habitat units,
- role in bed or bank definition and stability,
- verification of inventory data from the prior Level 1 survey,
- evaluation of bank stability,
- identify bank stability characteristics by channel type, instability mechanism, bank height and length,
- alteration of channel morphology,
- field evidence of change in alignment (lateral movement, avulsion),
- observations of vertical instability (aggradation, degradation),
- observations of changes in channel dimensions (width, depth),
- excessive deposition of fine sediment,
- presence of instream bars, observation of bar size and material,
- type of depositional features associated with each channel type,
- descriptions of the features of tributary inputs,
- presence/absence of active and/or remnant deltas at confluences with main stem,
- sediment characteristics of tributary inputs: lithology, grain sizes, stratigraphy of deposits,
- length (along observed channel corridor) and estimated sediment volume,
- type of sediment (size class based on visual observation),
- approximate thickness of accumulations,
- indicators of scour and erosion,
- comparison with reference reaches,
- project-related sediment starving,
- project-related structural controls,
- dependence on channel type, and
- functionality of riparian habitat.

TASK 5: Determ~~ining~~ Changes in River Geomorphic and Hydraulic Parameters since Construction of Lake Oroville.

In this step, hydrologic analysis will be used to provide an indication of the Project's affect on geomorphically-significant flows. Flood-frequency analysis, using hydrologic data presented in the Initial Information Package, will be applied to the Feather River to determine these flows. For alluvial systems, Andrews and Nankervis (1995) describe sediment transport and channel maintenance flows range between 0.8 and 1.6 times the bankfull discharge in gravel-bed rivers. For gravel-bed streams in the Rocky Mountain region, this study recommended that the channel maintenance flow be provided for an average of 15 days per year. This benchmark will be applied as an initial evaluation for river reaches with alluvial (sand or gravel beds) channels. This study will also attempt to quantify riparian and valley-forming flows using the concepts as defined in Hill et al. (1991), as appropriate. Flood-frequency analysis will be used in conjunction with field indicators to determine bankfull flow. Methods in Hill et al. (1991) will be used to guide the assessment of the magnitude, timing, frequency, duration, and rate of change of out-of-channel flows.

~~The f~~Flow duration curves developed in ~~the Hydrology Study~~SP-E2 and 3 will then be used to determine the timing and duration of geomorphically-significant flows (indicated by the flood frequency analysis) in the Project streams. The magnitude, timing, duration, frequency, and rate of change of flows will be described where gaging data is available. The data will be displayed graphically, and as exceedence tables. Comparison will be made between regulated and unregulated flows. These data, taken together with the determination of geomorphically-significant flows, will describe the effect of Project operations on the occurrence of these flows.

This will be done by comparing historic data with recent data. Available past cross-sectional data will be compared to those surveyed in Task 3 to determine changes in channel shape, form, and function caused by the dam. Changes in depth, width, hydraulic radius, roughness, gradient, pool-riffle-run ratio, and other hydraulic parameters will be determined.

Changes in stream flow will be studied by comparing pre- and post dam hydrology. Pre- and post dam flood frequency, flow duration, and mean monthly flow graphs will be prepared to show the changes. The "Indicators of Hydrologic Alteration" (IHA) model will be run on the data.

Aerial photos and old survey maps will be used to establish the location of historic river channels. These will be used to establish the extents of the meander belt (if any). Geologic maps will be used with aerial photo interpretation to identify structural controls on river erosion and plan form ~~compiled to determine the geologic units, and geologic controls on river erosion and meandering~~.

Subtasks and products under Task 5 include the following:

- Conduct IHA analyses to compare current and historic flow conditions. Describe and compare patterns of total annual precipitation and runoff. Delineate changes in base flows. Prepare graphs, tables, charts showing pre- and post dam changes in flood frequency, ramping rates, flow duration, mean monthly discharge, and others.
- Collect existing survey, topographic, and photographic data. Plot channel locations for the years available on the atlas and the GIS. Delineate changes in channel location, islands, multiple channel areas, levees, and riprap. Determine ongoing impacts of the dam by comparing pre- and post dam bank erosion and channel migration rates, island and multiple channel formation rates, gravel bars, riffles, channel width, gradient, and other geomorphic characteristics. Prepare figures, graphs, and charts showing the changes.
- Use Rosgen's Level I and Level II or higher stream classification systems to determine pre- and post dam changes.

TASK 6: Establish Bank Erosion Monitoring Sites

In areas where bank erosion is occurring, monitoring sites will be set up to determine erosion rates and the nature of the material eroded (to determine contribution to the sediment load and spawning gravel recruitment). The eroding bank endpoints will be marked using steel pipe set in concrete monuments. Banks will be surveyed a minimum of twice yearly, once in the spring to determine amount of winter erosion, and once in the late fall to determine low flow erosion. The global positioning system technique will be used to determine bank location to the nearest 3 feet.
For all identified transects, detailed field measurements will include surveying the channel profile into the floodplain and abandoned floodplain (if present), identification of bankfull elevation, water surface slope, and the wetted perimeter at the time of measurement. Substrate material will also be documented (Wolman pebble count and laboratory grain size analysis), and bank slope would be recorded for alluvial sections. An assessment of out-of-channel flow requirements for riparian vegetation/floodplain landforms will be completed at approved transect locations. In addition, measurement of channel dimensions, indicators of sediment accumulation (V* or other sediment accumulation indicator), quantitative analysis of flows required to initiate motion (Shields criterion), and quantitative comparison of sediment supply and transport capacity (expressed in tons/day or equivalent) will be analyzed at each site.

Subtasks and products under Task 6 include the following:

- Identify bank erosion sites using air photos, survey maps, and field inspection. Banks with noticeable erosion and banks that have eroded in the past (as identified by comparing the air photos and survey maps) will be

catalogued. Ortho-rectify recent aerial photo to use as a base map for plotting bank erosion.

- Plot successive bank lines available from existing topographic and photographic data.
- Set survey benchmarks. Survey bank lines using GPS. Re-survey twice yearly during study to establish bank erosion rates.
- Prepare figures showing bank erosion sites. Compare pre- and post dam bank erosion rates using figures and tables. Insert data into ArcView GIS.

TASK 7: Channel Hydraulic and Sediment Transport Modeling

We will review~~survey~~ the available models and select the model most appropriate for the conditions occurring in the study reach. The selected model will be used to estimate sediment transport parameters and compare existing and potential future channel form and sediment transport function. Model outputs will include changes in channel scour and fill, bedload, roughness, cross-section, gradient, and sediment transport. Hydraulic conditions such as bottom shear stress, velocity, and wetted hydraulic radius will also be model outputs. Several bedload transport equations will be used, in order to identify the one most compatible with the Feather River. A bedload transport curve will be developed from model output data. This will allow the use of "design" flows to move gravel in the system. The curve can also be used to predict when additional gravel needs to be added to the system.

One of the main uses of the model is to determine at which flows the gravel bed begins to mobilize. This is critical in determining flow conditions that degrade spawning riffles. It is also important in designing spawning gravel rehabilitation measures. The model is a useful tool for predicting future changes caused by various hydraulic scenarios.

Model outputs will be calibrated with data from Task 4 and with painted and radio-tagged rocks. These rocks will be placed in the river in a number of selected places, and monitored through the winter season to determine at what flows the rocks begin to move. Rocks will be color-coded according to location. Radio-tagged rocks are first drilled using a rock bit, then a small radio transmitter or transponder is inserted, and sealed using epoxy. A radio receiver or oscilloscope will be used periodically to monitor movement after significant flow events have occurred.
The magnitude, timing, duration, rate of change and frequency of flows will be described with hydrographs and exceedance tables. The time-scales will be those allowed by the existing data, daily, monthly, hourly, or in 15-minute increments. A series of tables will also be generated from the streamflow gaging data including: monthly flow statistics tables summarizing mean monthly flow and monthly exceedance flows; tables summarizing average monthly flow; tables summarizing mean daily flow for each year of the period of record; duration curves depicting the median flow for each station.

Subtasks and products under Task 7 include the following:

- Select most appropriate model from the numerous available.
- Collect data and insert into model.
- Calibrate model using sediment and hydraulic monitoring data collected under Task 4.
- Run model to determine future changes. Conduct hydraulic simulations to determine initial gravel bed motion, sediment transport rates, channel changes (aggradation or degradation), slope change, bed armoring, etc.
- Document major assumptions used in the modeling.

TASK 8: ~~Develop~~ Provide input to an Adaptive Management Program

The results of the monitoring program will be used in conjunction with biological data to develop an adaptive management program to be reccommended as part of the settlement agreement. Such biologic monitoring as macroinvertebrate density, number of spawning redds, fry emergence success, riparian vegetation density, and others will be used to determine specific sediment management objectives. The adaptive management program will propose to rehabilitate the dynamic fluvial processes, maintain transport of coarse sediment, and increase the complexity and diversity of habitat. Habitat elements that should be managed for include:

- Variable channel width, depth, and velocities.
- Increase in wetted spawning area, islands, and multiple channel areas.
- Restoring an active interplay between the floodplain and the channel, possibly using setback levees.
- Increase in bank erosion, bedload movement, channel migration, and meandering.
- Restoring as much as is possible the pre-dam pool:riffle:run ratios.

Schedule:

Gravel movement experiments will be conducted in the Fall and Winter of 2001-2. Cross-section surveys will be conducted from March through August of 2002. Gravel sampling and salmon spawning riffle mapping will be accomplished during the same period. Monitoring will occur during the winter of Fall 2002- Winter 2003. Follow-up surveys will be completed in Fall 2003 if needed. Modeling will be done in the Fall of 2003. The Atlas, maps, surveys, and the GIS will be produced concurrently during the studies and should be completed by the Fall of 2003. The draft report should be done by the Fall of 2003 and the final report would be completed by Summer 2004.

Results and Products:

The study will be used to identify the hydraulic, geomorphic, and sediment transport changes that have occurred. The effect of these changes on salmon spawning riffles, flooding, riparian vegetation, riparian habitat, and river habitat will be assessed. Changes in sediment transport will be evaluated for various proposed flow regimes. Based on the results of the study, we will identify needs for rehabilitation activities. As appropriate, we will identify strategies to mitigate the changes that have occurred. Potential measures to be considered could include the following:

- Restore and maintain a balanced sediment budget by placing coarse sediment (gravel) on existing salmon spawning riffles. This would provide gravel deposits of the right size distribution for salmon spawning.
- Inject gravel periodically below the dam to maintain the restored gravel deposits. The injection rate may be predicted using a sediment routing model. Provide flow releases designed to move the injected gravel to riffle areas.
- Place fine sediment in bank and over-bank areas scoured by the river to re-establish lost soil. These areas would then be stabilized and planted with riparian vegetation.
- Periodically release channel-forming flows to sculpt channel features.

TASK 9: Submit a Draft Report.

The draft report will allow for comments, corrections, and additional data in preparation of the final report.

TASK 10: Prepare a Final Report.

The final report will include the main report with an introduction, previous work, procedures, description of work done, results, summary, conclusions, and recommendations. A river atlas will also be prepared with recent photography, ortho- corrected, at a scale of 1 inch = 500 feet. Locations of riffles, pools, runs, spawning areas, cross-sections, monuments, sample areas, photo points, and other data will be shown. A Geographic Information System using ArcView will also be prepared with the same data. This will allow the data to be presented in both atlas and electronic form. The GIS will also allow additional information to be added and presented at a later date.

STUDY PLAN COORDINATION

COORDINATION WITH OTHER RESOURCE AREAS/STUDIES

It is anticipated that this study will require coordination with those individuals responsible for collecting water quality, temperature, fishery, habitat, cultural

resource, recreation, and project operation data, and performing biological surveys, and fishery studies. Contact with CDFG and USGS also are expected.

Implementation of this study plan will require coordination with other Oroville relicensing studies, as follows: historic air photos, riparian habitat mapping and occurrence data (SP-T4);Effects on Riparian Resources (SP-T5), Effects on Anadramous Fish (SP-F10). Historical and alternative operations data will be obtained from (SP-E2), and the Flood Study (SP-E3). This study will also require coordination with the GIS program

Issues Addressed by this Study Plan are described in Geology Issue Statement 1 which included the following issues:

-GE3 Alterations in stream hydrology affect the natural fluvial geomorphologic processes of a riverine system. How has the change in magnitude, frequency and timing of peak flows and rates of flow change on the Feather River affected riparian vegetation recruitment in the low-flow reach and immediately downstream of the Afterbay, under wet and dry year criteria;

GE4 Under existing conditions, are bankfull flows frequent enough to maintain channel morphology, sediment transport, habitat diversity and adequate gravels for salmonid spawning and rearing in the low-flow section and in the river downstream of Thermalito Afterbay;

GE5 Under existing conditions, are the moderate winter floods and bankfull flows adequately recruiting the amount of large woody debris needed to maintain adequate salmonid rearing habitat in the low-flow section and in the river downstream of Thermalito Afterbay;

GE6 How will the future demand for project water change the timing and duration of moderate winter floods and bankfull flows in the low-flow section and in the river downstream of Thermalito Afterbay;

GE7 Are the present streamflows defined under the SWP Feather River Flow Constraints adequate for maintaining natural fluvial river functions in the low-flow section and in the river downstream of Thermalito Afterbay (i.e., diversity of habitats: pool to riffle ratios, pool depth, stream bank angle, stream bank stability, stream bank vegetative cover, bedload deposition pattern, and stream bank vegetation root depth versus stream bank height above bankfull height);

GE9 Channel morphology and changes from operation – armoring spawning habitat and lateral erosion of banks;

GE10 Has the project resulted in sediment starvation (e.g., reduced gravel recruitment) to the lower river, and if so, by how much;

GE12 River flows through low-flow sections (historically 1,600 cfs, now 600 cfs) have changed – what is the effect on channel morphology, physical processes and biological habitat;

GE19 Gravel recruitment impacts of the dam – both up and down stream;

GE23 Releases that reflect nature cycles benefit biological cycles – how have changes in seasonal release patterns affected fish, invertebrates, and their habitat;

GE24 Direct, indirect, and cumulative impacts of project facilities and operations on sediment movement and deposition, river geometry, and channel characteristics. This includes impacts on stream competence, capacity, bank stability and extend, duration, and repetition of high flow events;

GE25 Natural geomorphological processes historically occurred within the Feather River watershed and are the result of geologic and hydrologic processes such as weathering, erosion, runoff patterns, material transport and deposition. Project features and operations have altered these natural geomorphic processes. Alteration of these geomorphic processes has affected the riverine habitat and species that depend on it. The FWS is concerned that project operations may have taken us beyond some critical thresholds for ecosystem sustainability. We are concerned that maintenance of a satisfactory abiotic template (e.g., substrate used for invertebrate production and fish spawning) is not occurring). The FWS wants assurance that new license conditions will allow for minimum thresholds of geomorphic processes to take place thus ensuring sufficient natural sediment movement and a satisfactory abiotic habitat template are in place;

F1 Effects of existing and future project operations (including power generation, water storage, ramping rates, and releases, pump-back, water levels, and water level fluctuations) during all water year types on the behavior (e.g., migration timing, microhabitat selection, vulnerability to predators), reproduction, survival and habitat of warm- and cold-water fish and other aquatic resources (e.g., macroinvertebrates), which include in project waters and tributaries within the project boundaries (Lake Oroville, Diversion Pool, Fish Barrier Pool, Forebay, Afterbay, Oroville Wildlife Area), and in project affected waters;

F6 Effects of existing and future project operations on sediment deposition, erosion, and recruitment through the system (including downstream sediment supply) and associated changes in water quality on the quantity and quality of aquatic habitats within project affected waters;

F10 Effect of existing and future project facilities and operations on anadromous fish habitat and populations (e.g., instream flows, water temperature, ramping rates, riparian habitat, large woody debris, predation, spawning gravels, stranding and desiccation, macroinvertebrate prey base, upstream and downstream passage, rearing conditions);

F11 Compliance of project operations with SWP Feather River Flow Constraints and adequacy of constraints to protect anadromous fish and other aquatic species in the low-flow section and in the river downstream of the Afterbay;

F13 Project effects on fish species listed for protection under the California and/or federal Endangered Species Acts (ESA), species of special concern, candidate species, proposed, and likely listed threatened and/or endangered fish species, and the habitat needed to support them;

FE9 Use Instream Flow Incremental Methodology (IFIM) or a comparable methodology to determine streamflow needs to ensure that trout habitat quality and quantity are not reduced within project area and/or project affected areas;

FE11 Inventory streams, streamside areas, and other wetlands in deteriorating condition and restore on a priority basis within project area and/or project affected areas;

FE14 Provide for fish passage and maintain natural channel character at stream crossings within project area and/or project affected areas;

FE33 Are the present streamflows defined under the State Water Projects Feather River Flow Constraints being met and are they adequately protecting steelhead and fall, late-fall, and spring-run Chinook salmon in the low-flow section and in the river downstream of Thermalito Afterbay for migrating, holding, spawning, and rearing of steelhead and fall, late-fall, and spring-run Chinook salmon;

FE36 Under existing conditions, does the diversity and abundance of benthic macroinvertebrates in the low-flow section and in the river downstream of Thermalito Afterbay suggest a healthy stream channel;

FE37 Under existing conditions, are there adequate amounts of suitable gravel for salmonid spawning in the low-flow section and in the river downstream of Thermalito Afterbay;

FE38 Preserve natural riparian flood control abilities. Remove only those log jams or major debris accumulations that have a high potential of causing channel damage, block fish passage, or could be transported downstream by high flows and cause loss of property;

FE39 Insure that stream alterations restore the original flow capacity while preserving the existing channel alignment;

FE83 Macroinvertebrates as an indicator of water quality;

FE86 Adequacy of current ramping rate to protect anadromous salmonids and conserve their habitats and forage. This includes providing a range of schedule of flows necessary to optimize habitat, stable flows during spawning and incubation of in gravel forms, flows necessary to ensure redd replacement in viable areas, and flows necessary for channel forming processes, riparian habitat protection and maintenance of forage

communities. This also includes impacts of flood control or other project structures or operations that act to displace individuals or their forage or destabilizes, scours, or degrades habitat;

TE58 Effects of changes in the magnitude, frequency and timing of peak flows in the Feather River on riparian vegetation recruitment in the low flow reach and immediately downstream of the Afterbay;

T3 Effects of existing and future project operations on floodplains and project water fluctuation zones, including soil stability, wildlife habitat and natural flood control functions, revegetation of native plant communities, and restoration opportunities (e.g., red willow planting);

T5 Project effects on riparian resources and protection and management of riparian habitat and wetlands (including vernal pools and brood ponds).

Other issues addressed by this Study Plan are included in Geology Issue Statement 5 which included the following issue:

GE2 Project features and operations alter the hydrology of the system, creating the possibility for scour zones within both natural and designed channels. What effects do discharge and ramping rates have on substrate scour and the mobilization of sediments into the water column downstream?

Oroville Facilities Relicensing
Environmental Work Group
Draft Study Plan

SPW1. Project Effects on Water Quality Designated Beneficial Uses for Surface Waters

Introduction

The Environmental Work Group identified as an issue the effects of existing and future project operations on the physical, chemical, and biological components of water quality in the Feather River, affected tributaries, and downstream waters. The project was considered to have potential for direct and indirect water quality effects on aquatic ecosystem health, recreational opportunity, and domestic and agricultural water supply. Concern was expressed ~~for~~about the potential effects of~~from~~ the project on compliance with water quality objectives identified in the Regional Water Quality Control Board's Water Quality Control Plan (Basin Plan), and effects on designated beneficial uses of the water. The beneficial uses for the reservoir and Feather River as defined in the Basin Plan include municipal and domestic supply, agriculture irrigation, electrical power production, contact and non-contact recreation, canoeing and rafting recreation, warm and cold freshwater habitat, warm and cold fish migration and spawning, and wildlife habitat.

Some physical, chemical, and biological data have been collected from the North, Middle, and South forks of the Feather River near their confluences with Lake Oroville, from the reservoir itself, and downstream from Oroville Dam in the Feather River, Thermalito Power Canal, and Thermalito Afterbay. However, these data are not, nor were expected to be, sufficient to determine ~~project~~ compliance of project waters with all Basin Plan objectives, goals, and criteria for protection of the designated beneficial uses. Some of the existing data also indicate potential areas of concern for adverse water quality conditions. Additional physical, chemical, and biological data are needed to demonstrate project compliance with Basin Plan objectives.

Relicensing of the Oroville Facilities by the Federal Energy Regulatory Commission requires certification from the State Water Resources Control Board that the project complies with Section 401 of the Federal Clean Water Act. The water quality certification signifies compliance with water quality standards and other appropriate requirements for any discharge or discharges to waters of the United States resulting from an activity that requires a federal license or permit. Information required by the SWRCB for certification includes evidence of compliance with appropriate requirements of the Basin Plan.

Objective

The objective of the study is to evaluate the physical, chemical, and biological integrity of water quality in Lake Oroville, its tributaries, the Feather River, Diversion

Pool, Thermalito Power Canal, Forebay and Afterbay, and other project-affected surface waters. Information obtained from the study will be used to determine whether project-affected waters meet Basin Plan objectives and are protective of beneficial uses designated in the Basin Plan.

Relationship to Relicensing/Need for Study

Construction of Oroville Dam, impoundment of water to form Lake Oroville, and associated facilities of the project have affected the physical, chemical, and biological characteristics of water in the Feather River. These changes in water quality characteristics may affect beneficial uses of the water.

Prior to issuance of a new license for the project, FERC will require a water quality certification by the SWRCB or a waiver of such certification. The certification requires a determination by the SWRCB that the project complies with appropriate requirements of the CVRWQCB Basin Plan, which includes water quality objectives for protection of designated beneficial uses. The CVRWQCB has established surface water quality objectives for ~~bacteria, biostimulatory substances, chemical constituents, color, dissolved oxygen, floating material, oil and grease, pH, pesticides, radioactivity, salinity, sediment, settleable material, suspended material, tastes and odors, temperature, toxicity, and turbidity~~ a variety of water quality constituents, for which both numerical and narrative standards have been developed. ~~Groundwater quality objectives, which have been established for bacteria, chemical constituents, radioactivity, tastes and odors, and toxicity, will be addressed in Study Plan SPW5.~~ Demonstration of compliance with water quality standards and other appropriate requirements is needed in the application for water quality certification. The water quality certification is needed to file with the application for license renewal with the Federal Energy Regulatory Commission

~~Information obtained from the study will be used to determine whether project-affected waters meet Basin Plan objectives and are protective of beneficial uses designated in the Basin Plan. Demonstration of compliance with water quality standards and other appropriate requirements is needed in the application for water quality certification. The water quality certification is needed to file with the application for license renewal with the Federal Energy Regulatory Commission~~.

Study Area

The study area is generally within the FERC project boundary, but also includes the Feather River downstream to the confluence with the Sacramento River for project-related effects. Specific water bodies included in the study plan are the North, Middle, and South forks of the Feather River and the West Branch and Concow Creek just above their confluences with the reservoir, Lake Oroville, Feather River downstream from Oroville Dam to the confluence with the Sacramento River, Thermalito Diversion Pool, Forebay, and Afterbay, and Oroville Wildlife Area ponds.

Methodology and Analysis

Task 1. Project Effects on Surface Water

Monitoring will be conducted at sites within and adjacent to the study area to assess physical, chemical, and biological water quality characteristics in major inflows, discharges, impounded waters, and ponds, and to assess effects of various land use activities within the Feather River watershed project area (Figures SPW1-1 and 2, Table SPW1-1). Adjacent areas included in the monitoring program are primarily the tributaries entering Lake Oroville. Monitoring of these tributaries at their confluences with the reservoir will establish a baseline for determining any changes in water quality induced by the project. Additional monitoring stations may be added if~~as~~ data indicate the need to determine sources and effects of any detected adverse habitat or water quality conditions. Physical, chemical, and biological components of water quality will be assessed in study area waters (Table SPW1-2).

Water Temperature — Water temperatures in the study area will be assessed since this parameter controls the rate of chemical and biological processes, and is important in determining suitability of project waters for survival and reproduction of aquatic organisms, including anadromous fish. These data will also be necessary for development of a temperature model in other study plans.

Continuously recording loggers (Onset Optic Stowaway) will be used to record temperatures at 15-minute intervals at river or discharge (e.g., hatchery) monitoring locations. Additional loggers will be placed along the river or tributaries as needed to document thermal conditions affecting salmonids (such as in spawning, rearing, or migration areas) or other aquatic life, to identify sources of thermal change or stress, and provide information for calibration of temperature models. Redundant recorders will be placed at sites subject to vandalism to help ensure no loss of data. Temperature loggers will be serviced and data downloaded to lap top computers at intervals not exceeding monthly.

Water temperatures will be measured at least monthly in impounded waters (Lake Oroville and Thermalito Diversion Pool, Forebay, and Afterbay) and ponds (Oroville Wildlife Area). Temperature profiles will be measured at intervals from the surface to the bottom of these water bodies using a thermistor. Cross section measurements will also be conducted at the Forebay and Afterbay to determine variation in temperatures from shallower to deeper areas and in the various arms of these water bodies.

Temperature profiles will also be measured in deeper pools in holding and spawning areas in the Feather River downstream from the dam for determination of effects of higher flows on stratification. This information will also be used to evaluate the importance of pools in providing adequate temperatures to salmonids when riffle or run temperatures may be less than optimal.

This study will provide much of the temperature data needed for verification of the temperature model being developed by the Engineering and Operations Workgroup ~~Group~~. The temperature model will be used to address several temperature related issues of the Environmental Workgroup (Issue Sheets W9, W10, W11, W12, W13, and W14)~~,~~ that are addressed in Study Plan SPW6. Output from the temperature model will also provide information for a greater range of operations than those that may be able to be monitored under this study.

Field Parameters — Basic water quality parameters, including dissolved oxygen, conductivity, pH, and turbidity, will be measured with properly calibrated field instrumentation at each visit to every monitoring station. Stream samples or measurements will be collected about one foot below the surface in flowing, well mixed riffle or run areas. Stream depth at the sampling site will also be measured. Dissolved oxygen will be measured in streams by titration (azide modification of the iodometric method). Dissolved oxygen in lakes will be measured at intervals from the surface to the bottom using meters and membrane electrode probes calibrated at the surface using the iodometric method. Conductivity and pH will be measured with meters and probes in samples collected at intervals from the surface to the bottom with a van Dorn water bottle. Turbidity will be measured with a nephelometer from samples collected using the van Dorn water bottle.

At some stations, the basic water quality field parameters may also be recorded with data loggers. Data loggers may also be installed where data indicate potential water quality degradation or where water quality parameters could be expected to experience wide diurnal variations. Logging instrumentation will be calibrated no less frequently than monthly, or more often if data indicate significant instrument drift.

Inorganic Chemistry — Water inorganic chemistry will be assessed since these parameters influence beneficial uses of water and may become elevated due to contamination, which often results in deleterious effects to aquatic life and other beneficial uses. Limnological processes in project water bodies may alter the chemical state of some parameters, and include potential release of soluble metals from bottom sediments and methylation of mercury due to warmer water and organic content in the Thermalito Afterbay. Water samples will be collected monthly for chemical analyses at the monitoring stations. Additional samples will be collected to target specific storm events.

Inorganic chemical analytes will include minerals (calcium, sodium, potassium, magnesium, sulfate, chloride, boron, and alkalinity), nutrients (nitrate plus nitrite, ammonia, dissolved orthophosphate, and total phosphorus), and metals (aluminum arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, and zinc). For all metals except mercury, samples will be collected for both total recoverable and dissolved metals analyses. Mercury analyses will include both total recoverable and total methyl fractions. Total and suspended solids~~,~~ and hardness will also be analyzed from samples collected at each site. Analyses may also be

conducted at other locations to determine sources of analytes found at the primary monitoring stations that may degrade the beneficial uses of the water.

Samples for chemical analyses from streams will be collected by wadding into the channel and dipping sample containers to a depth of approximately one- foot into the well-mixed channel flow. Mineral and nutrient samples will be collected into clean polyethylene containers. Samples for trace metals analyses at water quality criteria levels will be collected into polyethylene or glass bottles according to U.S. EPA Method 1669 (USEPA 1996). Samples for mineral, nutrient, and metal analyses from lakes and ponds will be collected from the surface by dipping an inverted container to approximately 0.5 meters below the surface. Water samples ~~from near the bottom~~ at greater depths will be collected with a van Dorn water bottle for minerals and nutrients and teflon bomb or Kemmerer style bottles for trace metals.

Water samples for oil and grease analyses will be collected from the surface at each station into clean glass bottles and preserved with hydrochloric acid.

Chemical analyses of minerals, nutrients, metals and oil and grease will be performed at the DWR Bryte Chemical Laboratory in West Sacramento using U.S. EPA approved techniques, equipment, and methods (Table SPW1-3).

Pesticides — A variety of pesticides may be used within the watershed which may affect the aquatic resources in the Feather River watershed. Silviculture and agriculture pesticide uses are well regulated, but some application practices still contribute to pesticide contamination in streams and lakes. A significant source of pesticides in many areas has been identified as urbanized areas. Urban use of readily available household pesticides is unregulated and significantly more pesticides may be applied by homeowners than is applied for similar products by the regulated community.

Water samples will be collected from the monitoring stations in the fall after rains produce the first significant runoff and again during February or March. Samples will be analyzed at the Bryte Chemical Laboratory for chlorinated organic pesticides, organic phosphorus pesticides, chlorinated phenoxy acid herbicides, volatile organic pesticides, carbamate pesticides, and glyphosate.

Pathogens — Fecal coliform bacteria in aquatic ecosystems are indicative of fecal contamination. Though these bacteria generally do not themselves pose adverse risks, their presence indicates the possible presence of far more serious microorganisms which may impact human health and nutrient loading that may adversely affect the aquatic environment.

Bacteria levels will be screened monthly at the monitoring stations using membrane filter procedures for both fecal and total coliform bacteria. Analyses may be conducted at additional sites to identify sources of fecal contamination indicated by the presence of these bacteria. In addition, a few selective intensively used recreation areas, such as the North Forebay Recreation Area, will be monitored during major

holidays (Independence and Labor days) according to requirements in the Basin Plan (i.e., not less than five samples for any 30-day period).

Phytoplankton and Zooplankton — Phytoplankton form the basis of the food web in lakes and reservoirs. Phytoplankton respond to nutrient enrichment by increasing in numbers of organisms as well as type of organism dominance. Zooplankton subsequently graze on phytoplankton, and may exhibit changes in populations due to nutrient enrichment or contamination.

Both phytoplankton and zooplankton will be sampled from impounded project waters. Phytoplankton samples will be collected with a van Dorn water bottle at three-meter increments from the surface to 30 feet below the surface (the approximate depth of the thermocline during stratification) in Lake Oroville, and to the bottom in the other impounded waters. Zooplankton will be sampled with a plankton net towed from -30 feet in depth to the surface in Lake Oroville, and from the bottom in the other impounded waters. Samples will be collected during each monthly visit to the monitoring stations. Analyses of phytoplankton will include identification, enumeration, and chlorophyll determination. Zooplankton will be identified, enumerated, and measured volumetrically.

Periphyton — Periphyton are attached algae in streams that contribute to the basis of the food web along with organic input (e.g., leaves) from terrestrial sources. As with phytoplankton, periphyton also respond to nutrient enrichment by changes in types and abundance of species.

Periphyton will be sampled from riffle substrates in streams. A cylindrical sampler will be used to enclose the periphyton, which will then be brushed from the substrate and aspirated into collection jars. Ten samples from each site will be composited. Analyses of the periphyton will include species identification and counts, and chlorophyll determination.

Aquatic Macroinvertebrates — Aquatic macroinvertebrates form the basis of the aquatic food web and are excellent indicators of long-term water quality conditions since specific communities develop in response to specific stream conditions and perturbations. Various methods have been devised to sample aquatic macroinvertebrates. The U.S. EPA recently developed a “rapid bioassessment method” that provides basic information on types of species present. This method was meant to be a quick survey tool for determining relative abundance of species in a sample, but does not provide population estimates, is skewed toward the most abundant species, and is not statistically valid. Since potential project impacts could not only affect the types of species present but also population numbers, a traditional approach will be used to assess both types of organisms present and their abundance. This method relies on analyzing all organisms from a sample, and has been used historically for samples from the Feather River and many other areas throughout northern California including the Sacramento Valley.

Decreasing reservoir levels during the summer results in exposure of former stream channels that may become habitat for fish and other aquatic organisms. Two to three riffle areas in each of these types of habitats in the major tributaries to Lake Oroville will be sampled in September of 2002 to determine the benthic community structure. Organisms will be collected using a kick screen and metal frame delineating a three square foot sampling area. Three transects will be established across each monitoring site. Three samples will be collected along each transect and combined into one sample, resulting in three samples per monitoring site. All organisms will be removed from samples, identified to the lowest practical taxon (generally genus), and enumerated. The areas will again be sampled during the spring when the riffles are inundated to evaluate changes in aquatic macroinvertebrate composition. Spring samples will be collected with an Ekman dredge.

Habitat conditions downstream from major dams generally result in significant changes to macroinvertebrate community structure and function due to altered temperature, flow, food, and substrate regimes. In addition, relatively sudden flow changes (e.g., ramping) could result in stranding macroinvertebrates and contribute to catastrophic drift. Concentrated salmon spawning in the low flow section of the river also undoubtedly contributes to macroinvertebrate habitat disruption and organism drift.

Aquatic macroinvertebrates will be assessed at the monitoring stations in the Feather River downstream from the Fish Barrier Dam during September of 2002 to determine effects from Oroville Dam on community structure and function. Organisms will be collected from riffle substrate areas using a kick screen and metal frame delineating a three square foot sampling area. Three closely spaced riffles or one extensive riffle will be sampled at each monitoring station. Three transects will be established across each monitoring site. Three samples will be collected along each transect and combined into one sample, resulting in three samples per monitoring station. All organisms will be removed from samples, identified to the lowest practical taxon (generally genus), and enumerated at the DWR Aquatic Macroinvertebrate Laboratory in Red Bluff.

As indicated in Study Plan SPF10, stream flow fluctuations (e.g., ramping) due to other than normal hydrologic events occur only downstream from the Afterbay Outlet. Several sites identified in Study Plan SPF10 where dewatering may occur due to ramping will be sampled in this study for macroinvertebrate riffle community composition and drift. The affected riffle areas will be assessed for community composition using the previously described method and a series of drift nets will be placed upstream and downstream from the riffle areas prior to and following ramping flow reductions to evaluate effects on stranding and drift of aquatic macroinvertebrates.

Effects from concentrated salmon spawning in the low flow section on macroinvertebrates will be assessed by collecting bottom and drift samples from several riffles. Samples will be collected immediately ~~preceding~~proceeding and during significant salmon spawning activity.

Aquatic macroinvertebrates have substrate, depth, and velocity preferences. Ramping of stream flows from project operations affects depth and velocity, while occasional high flows have altered substrate composition in the Feather River, and therefore may have affected the benthic community. Substrate size, flow, and depth preferences will be reviewed in the literature. Substrate, flow, and depth information from Study Plans SPG2 and SPF10 and information from available literature will be used to evaluate project effects on aquatic macroinvertebrate habitat.

Aquatic macroinvertebrates will be sampled in four ponds in the Oroville Wildlife Area using an Ekman dredge. Ten dredged samples will be collected from areas within a pond and composited.

Stream Sediments — Sedimentation is a major impairment in many streams. Fine sediments in gravels adversely affect salmonid reproduction and survival of aquatic macroinvertebrates and other organisms that are important as food for fish. Stream gravels from riffle areas will be analyzed for laboratory determination of particle size distribution in Study Plan SPG2, Task 2.

Aquatic Toxicity — The direct measurement of toxicity to aquatic organisms of stream water may be indicative of the ability of the stream to support aquatic life. The Basin Plan has an objective that "all waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses … in aquatic life." The Basin Plan stipulates that "compliance with this objective shall be determined by … biotoxicity tests." Water column toxicity assessment will be used to identify direct impacts to fish and zooplankton from toxic substances that may be either dissolved or suspended in the water column.

Water column toxicity testing will use *Ceriodaphnia* and the fathead minnow. Toxicity tests will measure survival and growth for the minnow, and reproduction and survival of Ceriodaphnia over a seven-day test period. Water samples will be analyzed during the high temperature months of July and September, following the first flush in the fall, following winter dormant spraying in February, and again during the high runoff period in April or May in tributaries to Lake Oroville. Samples will be analyzed monthly for toxicity analyses from the monitoring sites downstream from the Fish Barrier Dam to Honcut Creek. If significant toxicity is detected at these sites, additional analyses will be conducted at sites further downstream to determine the extent of project effects. Several Oroville Wildlife Area ponds will be sampled in the spring and again in mid-summer. Toxicity tests will be conducted at the Pacific EcoRisk Laboratory or U.C. Davis Toxicology Laboratory. The causative agent for significant toxicity in samples will be identified through toxicity identification evaluation procedures.

Specific Effects Analyses — Some aspects of the project may have water quality effects related to specific parameters or that require additional monitoring for specific parameters. As these potential effects are identified, appropriate monitoring programs will be developed to evaluate their significance.

An issue that has been raised is the effect of carcasses from over 100,000 salmon that spawn each year in the low flow section of the Feather River. Following spawning, the salmon die and begin decomposition. The decomposition process provides food for scavenger macroinvertebrates, bacteria, and other animals. Decomposition releases nutrients that may be used by periphyton and higher plants, but also may decrease oxygen levels in the water. Additional nutrients are discharged to the Feather River a quarter mile downstream from the Afterbay Outlet by the Sewerage Commission Oroville Region, which treats sewage from the Oroville area. Additional nutrient and periphyton monitoring will be conducted at two week intervals at the monitoring sites within the project ~~bounday~~boundary downstream from the Fish Barrier Dam to determine effects from ~~hatchery~~ decomposing salmon carcasses and SCOR discharges. Dissolved oxygen levels, as well as temperature, conductivity and pH, in the water and within the gravels will be recorded at 15-minute intervals at several of these sites.

Task 2. Project Effects on Water Quality Objectives

Data for this analysis will be obtained from Task 1. The data will be evaluated for compliance to applicable criteria and objectives for protection of beneficial uses. The CVRWQCB has established numerical objectives for parameters which can be measured quantitatively (such as mg/L of a chemical contaminant) and narrative objectives for parameters that are not readily quantifiable (such as color). Both numerical and narrative objectives are applicable in determining impacts to beneficial uses. The criteria and objectives used for evaluating the data include:

- numerical and narrative objectives identified in the CVRWQCB Basin Plan~~;~~
- criteria of the U.S. EPA California Toxics Rule~~,~~
- criteria of the National Toxics Rule~~, and~~
- criteria of the Nutrient Guidance Documents~~;~~
- maximum contaminant levels for protection of drinking water from the U.S. EPA Title 40, Code of Federal Regulations, Parts 141 (primary MCLs) and 143 (secondary MCLs)~~ and~~
- criteria of Title 22 of the California Administrative Code, California Domestic Water Quality and Monitoring Regulations~~;~~
- agriculture water quality goals in the Water Quality for Agriculture, Irrigation and Drainage Paper No. 29 of the Food and Agriculture Organization of the United Nations~~;~~
- bacterial limits in the Draft Guidance for Fresh Water Beaches of the California Department of Health Services; and
- contaminant action levels established by the California Office of Environmental Health Hazard Assessment.

Task 3. Project Effects on Designated Beneficial Uses

Information for this analysis will be obtained from Task 2. Compliance with numerical and narrative water quality objectives will be evaluated in conjunction with agency representatives and the Environmental Workgroup Task Force to determine project effects to designated beneficial uses. Designated beneficial uses potentially

affected by parameters that do not meet water quality objectives will be identified in this study. A summary table will be prepared showing designated beneficial uses, water quality criteria or objectives, and range of values obtained from the study. In addition, a report will be prepared discussing results, compliance issues, and potential mitigation.

Results

Results from this study will be presented in a detailed report that evaluates effects of the project to water quality. Data obtained from this study will be compared to applicable numerical and narrative water quality objectives and criteria established for the protection of beneficial uses. Data obtained from the study will be presented in tables and graphs depicting concentrations of the various parameters and associated criteria. The graphs will illustrate variations in parameter concentrations throughout the period of collection. Parameters that exceed criteria will also be compared in graphs to concentrations of associated parameters, such as metal concentration association with turbidity levels, to help understand potential causes of elevated parameters.

Compliance with water quality objectives will be used to evaluate effects on designated beneficial uses for Lake Oroville and the Feather River downstream from the Fish Barrier Dam as defined in the Basin Plan. The beneficial uses include municipal and domestic supply, agriculture, electrical power production, contact and non-contact recreation, warm-water and cold-water fish spawning, rearing and migration, warm and cold freshwater habitat, and wildlife habitat. Designated beneficial uses potentially affected by parameters that do not meet water quality objectives will be identified. Water quality data within the project area will be compared with that for waters entering the project as well as downstream from the project to determine whether the project has any affect on water quality objectives.
The data from this study will also be used to evaluate effects to water quality of any proposed operational alternatives.~~of the CVRWQB Basin Plan; numerical criteria of the U.S. EPA and California Department of Health Services drinking water maximum contaminant levels, U.S. EPA California Toxics Rule criteria for freshwater aquatic life for dissolved metals, U.S. EPA National Toxics Rule criteria for freshwater aquatic life for total recoverable metals, and U.S. EPA National Ambient Water Quality Criteria for freshwater aquatic life protection; and agricultural goals for water quality from the Food and Agriculture Organization of the United Nations; and the U.S. EPA Information Collection Rule for protozoan pathogens.(make consistent with changes to Task 3)~~

Aquatic macroinvertebrate data will be analyzed using various metrics, such as the diversity and equitability indices, to determine the health of this component of the aquatic ecosystem. The data will also be used to evaluate the effects of the dam on downstream community structure and function due to altered temperature, flow, and food regimes, effects of relatively sudden flow changes (ramping) on stranding macroinvertebrates and contributing to catastrophic drift, and effects of concentrated salmon spawning in the low flow section. Benthic macroinvertebrate community species composition and structure will be compared upstream and downstream from potential impacts to access effects. Comparisons will include tables and graphs

comparing various metrics used to analyze community structure. Literature information on substrate size, flow, and depth preferences will be reviewed and an assessment made for effects in the Feather River using habitat information from Study Plans SPG2 and SPF10.~~...~~

Toxicity test results will be used to identify parameters that may be adversely affecting aquatic life. The data will be presented in tables and graphs showing levels of toxicity during the monitoring period. The toxicity information will be correlated with chemical data to evaluate cause and effect relationships.

~~Compliance with water quality objectives will be used to evaluate effects on designated beneficial uses for Lake Oroville and the Feather River downstream from the Fish Barrier Dam as defined in the Basin Plan. The beneficial uses include municipal and domestic supply, agriculture, electrical power production, contact and non-contact recreation, warm-water and cold-water fish spawning, rearing and migration, warm and cold freshwater habitat, and wildlife habitat. Designated beneficial uses potentially affected by parameters that do not meet water quality objectives will be identified. Water quality data within the project area will be compared with that for waters entering the project as well as downstream from the project to determine whether the project has any affect on water quality objectives.~~
~~Mitigation measures will be investigated for parameters that do not meet Basin Plan objectives, and recommendations developed for implementation. The data from this study will also be used to evaluate effects to water quality of any proposed operational alternatives.~~

Information derived from this study will be used by the~~-~~ SWRCB to determine conditions in the water quality certification to comply with Section 401 of the Federal Clean Water Act.

Coordination with Other Resource Areas/Studies

This study plan provides the information for evaluation of Issue Sheets W1 (Project Effects on Designated Beneficial Uses), W2 (Project Effects on Water Quality Objectives), and W3 (Project Effects on Feather River and Tributaries), and will provide information for determination of project compliance with water quality standards and other appropriate requirements in the application for water quality certification. This study plan will also provide most of the data needed in Study Plan SPW4 for evaluation of effects of the hatchery to water quality, and will be coordinated with water quality studies in Study Plan SPW3 for evaluation of recreation facilities and activities on water quality. Temperature data from this study will provide much of the information needed for development and calibration of a temperature model for Study Plan SPW6, and will provide temperature and macroinvertebrates (as fish food) information for fisheries evaluations in Study Plan SPF10. This study will rely on sediment information collected in Study Plan SPG2. Study Plan SPW5 will provide information for determination of project effects to groundwater.

Schedule

Monitoring for Task 1 of the study will begin in ~~February~~ early 2002 and continue for two years. Subsequently, data will be analyzed for completion of Tasks 2 and 3. Additional monitoring may be warranted for parameters that exceed goals and criteria, or if years in which monitoring was conducted prove to be exceptional water years (dry or wet) and not yield information about other water year types. Information developed will be presented quarterly to the Environmental Workgroup and Task Force for review to evaluate the adequacy and progress of the study. A progress report will be prepared ~~by March of~~ in early 2003, and a draft final report discussing results of the two-year study will be prepared by June of 2004.

Issues

W1. Effects of existing and future project operations and facilities on all designated beneficial uses of the water. The beneficial uses for the Feather River watershed as defined in the Basin Plan include municipal and domestic supply, agriculture, electrical power production, contact and non-contact recreation, warm-water and cold-water fish spawning, rearing and migration, freshwater habitat, and wildlife habitat. Issues Addressed: WE1, WE10, WE19, WE24, WE25, WE30, WE31, WE32, WE36, WE37, WE40, WE46, WE47, WE48, WE50, WE54, F1, FE36, FE83, FE89, FE96, FE97

W2. Effects of existing and future project operations on compliance with water quality objectives identified in the Regional Water Quality Control Board (RWQCB) Basin Plan. Specific compliance issues include bacteria, chemical constituents, dissolved oxygen, pH, oil and grease, pesticides, sediment, temperature, toxicity, and turbidity. Issues Addressed: WE2, WE4, WE10, WE25, WE30, WE31, WE32, WE36, WE40, WE48, WE50, WE53, WE54, F1

W3. Effects existing and future project operations on the physical, chemical and biological components of water quality of the Feather River, affected tributaries and downstream waters. The project has the potential for direct and indirect effects on aquatic ecosystem health, on recreational opportunity, and on domestic and agricultural water supply. Issues Addressed: WE3, WE10, WE24, WE25, WE30, WE31, WE32, WE33, WE40, WE46, WE48, WE50, WE53, F1, T1, F6, FE36, FE64, FE83

F1. Effects of existing and future project operations (including power generation, water storage, ramping rates, and releases, pump-back, water levels, and water level fluctuations) during all water year types on the behavior (e.g., migration timing, microhabitat selection, vulnerability to predators), reproduction, survival and habitat of warm- and cold-water fish and other aquatic resources (e.g., macroinvertebrates), which include in project waters and tributaries within the project boundaries (Lake Oroville, Diversion Pool, Fish Barrier Pool, Forebay, Afterbay, Oroville Wildlife Area), and in project affected waters. Issues Addressed: FE83, FE86, FE90, FE95, FE96, GE23, G1

F10. Effect of existing and future project facilities and operations on anadromous fish habitat and populations (e.g., instream flows, water temperature, ramping rates, riparian habitat, large woody debris, predation, spawning gravels, stranding and desiccation, macroinvertebrate prey base, upstream and downstream passage, rearing conditions). Issues Addressed: FE36, FE54, FE86

F11. Compliance of project operations with SWP Feather River Flow Constraints and adequacy of constraints to protect anadromous fish and other aquatic species in the low-flow section and in the river downstream of the Afterbay. Issues Addressed: FE54, G1

G1. Effects of existing and future project operations on natural geomorphic processes. These include physical attributes and functions (e.g., channel morphology, channel stability, sediment transport and deposition, spawning gravel and large woody debris recruitment, habitat diversity) and subsequent effects on biological resources (e.g., aquatic macroinvertebrates, riparian vegetation) in the low-flow section and in the Feather River downstream of Thermalito Afterbay under wet and dry year criteria. Issues Addressed: GE23

Table SPW1-1. Monitoring Site Number System for Maps

1. West Branch
2. Concow Creek
3. North Fork
4. French Creek
5. Middle Fork
6. Fall River
7. South Fork
8. Ponderosa Reservoir
9. Sucker Run
10. North Fork Arm Lake Oroville
11. Middle Fork Arm Lake Oroville
12. South Fork Arm Lake Oroville
13. Lake Oroville Main Body
14. Lake Oroville nr. Dam
15. Diversion Pool ab. Kelly Ridge PH
16. Kelly Ridge PH Discharge
17. Diversion Pool bl. Kelly Ridge PH
18. Diversion Pool nr. Diversion Dam
19. Feather River ab.Hatchery
20. Hatchery Wastewater Pond
21. Feather River bl. Hatchery
22. Feather River bl. Hwy 162
23. Feat~~e~~her River at Robinson Riffle
24. Feather River ab. Afterbay Outlet
25. Feather River bl. Afterbay Outlet
26. Feather River bl. SCOR Outfall
27. Afterbay Outlet to Feather River
28. Afterbay Outlet to Sutter Buttes Canal
29. Thermalito Afterbay (south)
30. Thermalito Afterbay (north)
31. Afterbay Outlet to Western Canal
32. Thermalito Forebay (south)
33. Thermalito Forebay (north)
34. Feather River ab. Honcut Creek
35. Honcut Creek
36. Feather River nr. Live Oak
37. Feather River ab. Yuba River
38. Yuba River at Marysville
39. Feather River at Shanghai Bend
40. Bear River
41. Feather River nr. Verona
42. Sacramento River ab. Feather River

Figure SPW1-1. Monitoring Sites in the Project area

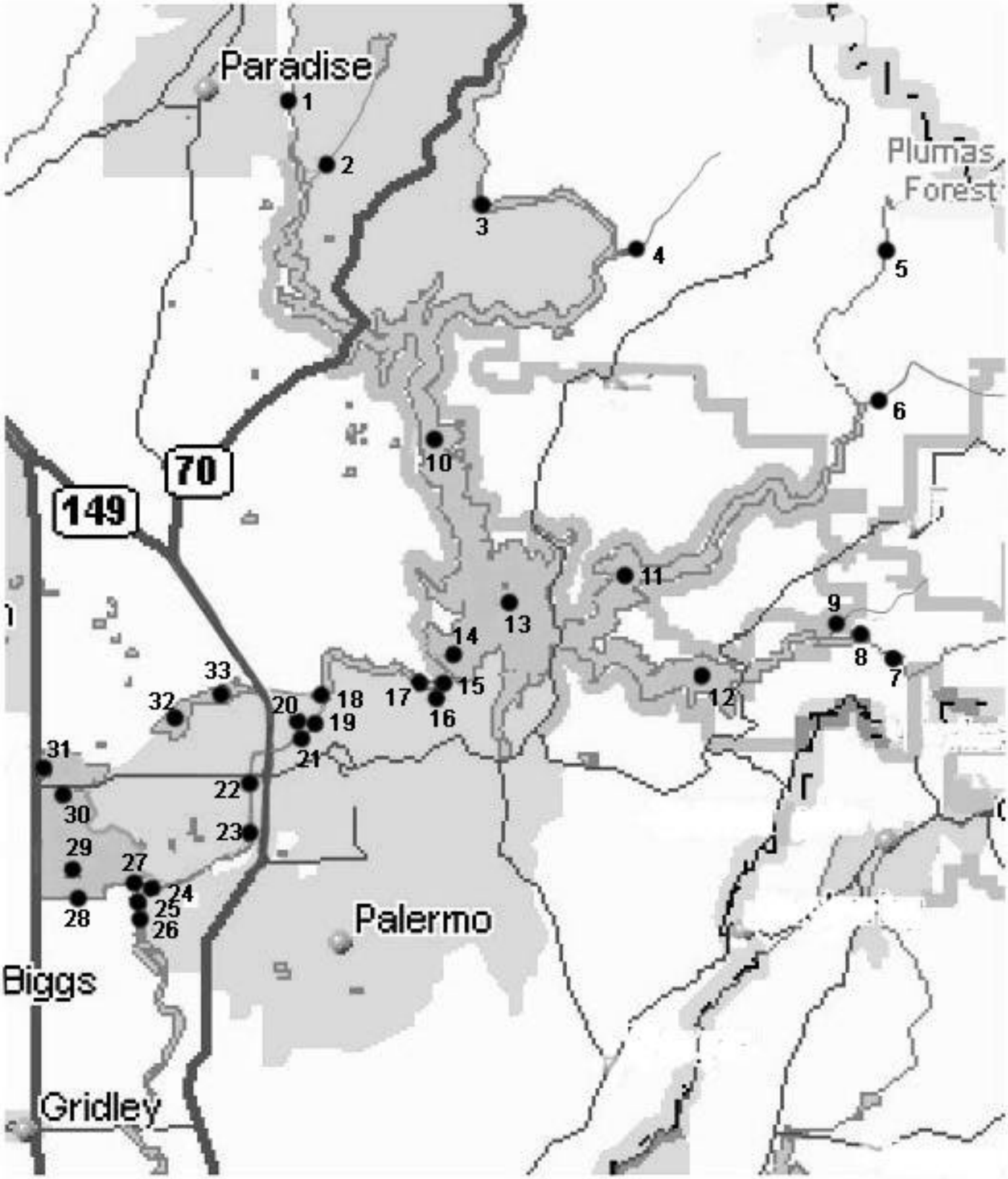

Figure SPW1-2. Monitoring Sites in the Lower Feather River

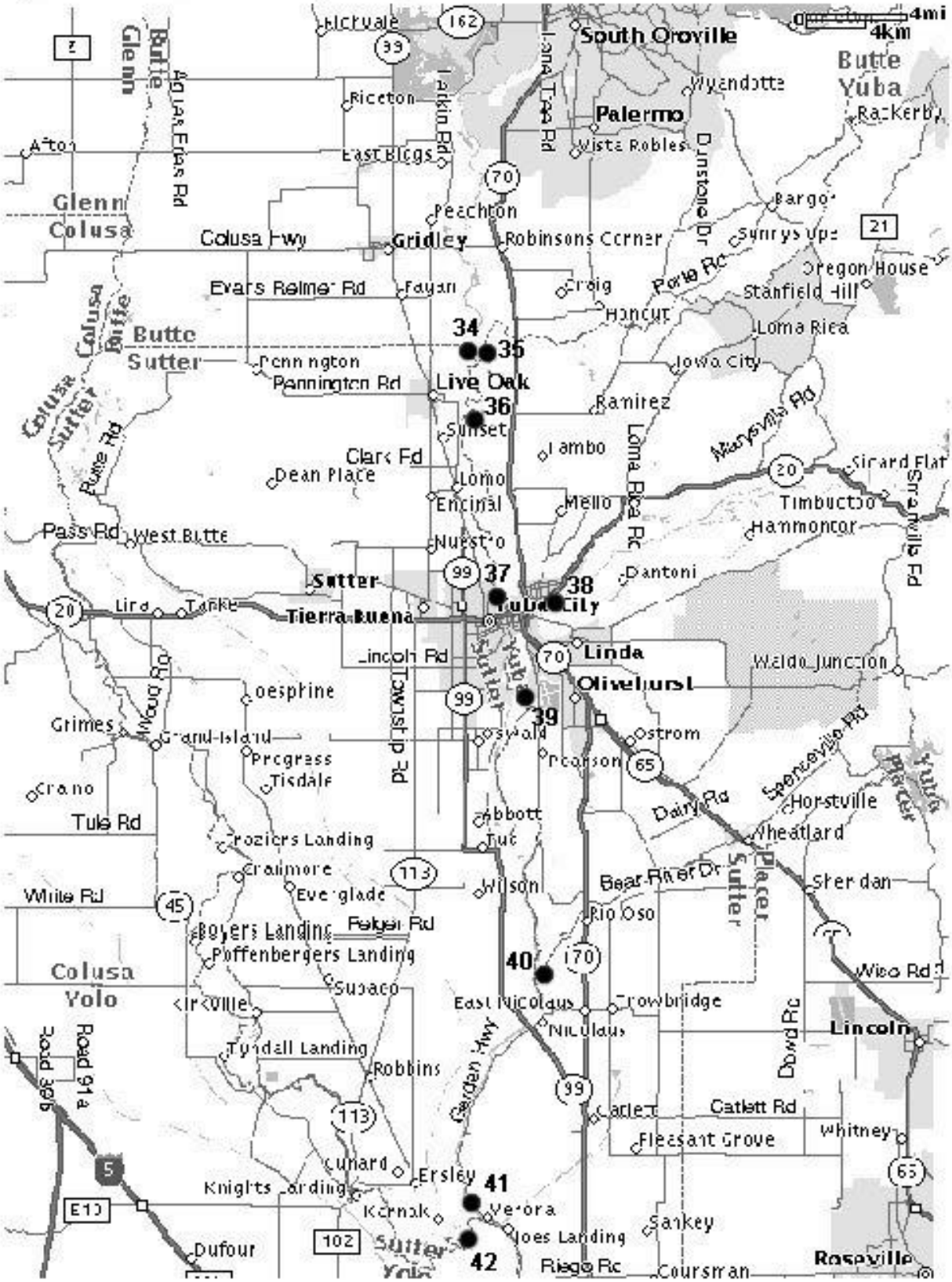

Table SPW1-2. Water quality monitoring schedule for the Oroville Relicensing Project

Station	Temperature (a)	Field Parameters (b)	Inorganic Chemistry (c)	Pesticides (d,f)	Pathogens (Coliform bacteria)	Phytoplankton & zooplankton	Periphyton	Macro-Invertebrates	Aquatic Toxicity
West Branch	R	m (e)	m	F & W	m		m	l	o
Concow Creek	R	m	m	F & W	m		m	l	o
North Fork	R	m	m	F & W	m		m	l	o
French Creek	R								
Middle Fork	R	m	m	F & W	m		m	l	o
Fall River	R	m	m	F & W	m		m	l	o
South Fork	R	m	m	F & W	m		m	l	o
Sucker Run	R	m	m	F & W	m		m	l	o
Ponderosa Dam	P	m	m	F & W (i)	m	m			
Lake Oroville									
North Fork Arm	P	m	m (r)	F & W (i)	m	m			
Middle Fork Arm	P	m	m (r)	F & W (i)	m	m			
South Fork Arm	P	m	m (r)	F & W (i)	m	m			
Main Body	P	m	m (r)	F & W (i)	m	m			
Dam	P	m	m (s)	F & W (i)	m	m			
Diversion Pool	P	m	m	F & W (i)	m	m			
ab Kelly Ridge Power House	P	m	m	F & W (i)	m	m			
bl Kelly Ridge Power House	P	m	m	F & W (i)	m	m			
Kelly Ridge Power House	R								
Thermalito Forebay	P	m	m	F & W (i)	m	m			
Thermalito Afterbay	P	m	m	F & W (i)	m	m			
Outlet to Feather River	R	m	m	F & W (i)	m				m
Outlet to Western Canal	R	m	m	F & W (i)	m				
Outlet to Sutter Buttes Canal	R	m	m	F & W (i)	m				
Oroville Wildlife Area ponds	P	m	m	F & W (i)	m	m		l	p
Feather River									
ab Hatchery	R	m (g)	m (h)	F & W (j)	m		k	l	m
Hatchery wastewater pond	R	m	m (h)	j	m				
bl Hatchery	R	m (g)	m (h)	F & W (j)	m		k	l, n	m
nr Hwy 162 bridge	R	m	m (h)		m		k	l, n	
Robinson Riffle	R	m	m (h)		m		k	l, n	
ab Afterbay Outlet	R	m (g)	m (h)	F & W	m		k	l	m
bl Afterbay Outlet	R	m (g)	m (h)	F & W	m		k	l	m
bl SCOR Outfall (q)	R	m (g)	m (h)	F & W	m		k	l	m
ab Honcut Creek	R	m (g)	m (h)	F & W	m		k	l	m
Honcut Creek	R	m	m	F & W	m		m	l	
nr Live Oak	R	m	m	F & W	m		m	l	
ab Yuba River	R	m	m	F & W	m		m	l	
Yuba River	R	m	m	F & W	m		m	l	
at Shanghai Bend	R	m	m	F & W	m		m	l	
Bear River	R	m	m	F & W	m		m	l	
nr Verona	R	m	m	F & W	m		m	l	
Sacramento R ab FR	R	m	m	F & W	m		m	l	

Table SPW1-2. Water quality monitoring schedule for the Oroville Relicensing Project, continued

a. R = recorder, P = profile
b. Includes dissolved oxygen, conductivity, pH, turbidity
c. minerals (calcium, sodium, potassium, magnesium, sulfate, chloride, boron, and alkalinity), nutrients (nitrate plus nitrite, total and dissolved ammonia, dissolved orthophosphate, and total phosphorus), total and dissolved metals (aluminum arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, selenium, and zinc), total recoverable and methyl mercury, total and suspended solids, and hardness
d. includes chlorinated organic pesticides, organic phosphorus pesticides, chlorinated phenoxy acid herbicides, volatile organic pesticides, carbamate pesticides, and glyphosate.
e. m = monthly measurement or sample collection
f. F = fall (after significant runoff), W = winter (after dormant spray season)
g. data logger to record dissolved oxygen, temperature, conductivity, and pH
h. nutrients (and field parameters) at two week intervals
i. surface samples
j. iodine, potassium permanganate, and formaldhyde
k. periphyton sampled at two week intervals
l. benthic macroinvertebrate samples collected in September 2002
n. drift samples
o. seasonal analysis of toxicity (July, September, first flush, February, April/May
p. spring and summer toxicity analyses
q. Sewerage Commission Oroville Region discharge 1/4 mile downstream from Afterbay Outlet
r. surface and bottom samples
s. Surface, intake structure withdrawal elevation, and bottom

Table SPW1-3. Analytical methods and detection levels

Method	Analyte	Units	Reporting Limit
Minerals			
EPA 200 7 (D)	Dissolved Calcium	mg/L	1
EPA 200.7 (D)	Dissolved Sodium	mg/L	1
EPA 200.7 (D)	Dissolved Potassium	mg/L	0.5
EPA200.7 (D)	Dissolved Magnesium	mg/L	1
EPA 300.0 (28d hold)	Dissolved Sulfate	mg/L	1
EPA 300.0 28d Hold	Dissolved Chloride	mg/L	1
EPA 200.7 (D)	Dissolved Boron	mg/L	0.1
Std Method 2320 B	Alkalinity	mg CaCO3/L	0.1
Nutrients			
Std Method 4500-NO3-F Modified	Dissolved Nitrite + Nitrate	mg/L as N	0.05
EPA 350.1	Dissolved Ammonia	mg/L as N	0.02
Std Method 4500-NH3	Total Ammonia	mg/L as N	0.02
EPA 365.1	Dissolved Ortho-phosphate	mg/L as P	0.01
EPA 365.4	Total Phosphorus	mg/L	0.01
Metals			
EPA 1631	Total Mercury	µg/L	0.0002
EPA 1631	Total Methyl Mercury	µg/L	0.005
EPA 1632	Total and Dissolved Arsenic	µg/L	0.004
Std Method 3500-Fe D	Total and Dissolved Iron	µg/L	2.2
EPA 1638	Total and Dissolved Aluminum	µg/L	0.4
EPA 1638	Total and Dissolved Cadmium	µg/L	0.003
EPA 1638	Total and Dissolved Chromium	µg/L	0.03
EPA 1638	Total and Dissolved Copper	µg/L	0.01
EPA 1638	Total and Dissolved Lead	µg/L	0.005
EPA 1638	Total and Dissolved Manganese	µg/L	0.02
EPA 1638	Total and Dissolved Nickel	µg/L	0.01
EPA 1638	Total and Dissolved Selenium	µg/L	0.1
EPA 1638	Total and Dissolved Zinc	µg/L	0.03
Miscellaneous			
EPA 160.2	Total Suspended Solids	mg/L	1
Std Method 2540 C	Total Dissolved Solids	mg/L	1
Std Method 2340 B	Hardness	mg/L as CaCO3	1
EPA 1644	Oil and Grease	mg/L	
Std Method 2550 B 1, 2	Temperature	degree Celcius	0.1
Std Method 4500-O C	Dissolved oxygen	mg/L	0.1
Std Method 4500-H+ B	pH	pH units	0.1
Std Method 2510 B	Conductivity	umhos/cm	0.1
EPA 445.0	Chlorophyll	µg/L	
EPA 600-4-91-002	Toxicity		
Pathogens			
Std Method 9222 B	Total Coliform bacteria	colonies/100 mL	0
Std Method 9222 D	Fecal Coliform bacteria	colonies/100 mL	0

Table SPW1-3. Analytical methods and detection levels, continued

Method	Analyte	Units	Reporting Limit
Pesticides			
Chlorinated Organic Pesticides			
EPA 508	Alachlor	µg/L	0.05
EPA 508	Aldrin	µg/L	0.01
EPA 508	Atrazine	µg/L	0.02
EPA 508	BHC-alpha	µg/L	0.01
EPA 508	BHC-beta	µg/L	0.01
EPA 508	BHC-delta	µg/L	0.01
EPA 508	BHC-gamma (Lindane)	µg/L	0.01
EPA 508	Captan	µg/L	0.02
EPA 508	Chlordane	µg/L	0.05
EPA 508	Chlorothalonil	µg/L	0.01
EPA 508	Chlorpropham	µg/L	0.02
EPA 508	Chlorpyrifos	µg/L	0.01
EPA 508	Cyanazine	µg/L	0.3
EPA 508	Dacthal (DCPA)	µg/L	0.01
EPA 508	Dichloran	µg/L	0.01
EPA 508	Dicofol	µg/L	0.05
EPA 508	Dieldrin	µg/L	0.01
EPA 508	Diuron	µg/L	0.25
EPA 508	Endosulfan sulfate	µg/L	0.02
EPA 508	Endosulfan-I	µg/L	0.01
EPA 508	Endosulfan-II	µg/L	0.01
EPA 508	Endrin	µg/L	0.01
EPA 508	Endrin aldehyde	µg/L	0.01
EPA 508	Heptachlor	µg/L	0.01
EPA 508	Heptachlor epoxide	µg/L	0.01
EPA 508	Methoxychlor	µg/L	0.05
EPA 508	Metolachlor	µg/L	0.2
EPA 508	Oxyfluorfen	µg/L	0.2
EPA 508	p,p'-DDD	µg/L	0.01
EPA 508	p,p'-DDE	µg/L	0.01
EPA 508	p,p'-DDT	µg/L	0.05
EPA 508	PCB-1016	µg/L	0.1
EPA 508	PCB-1221	µg/L	0.1
EPA 508	PCB-1232	µg/L	0.1
EPA 508	PCB-1242	µg/L	0.1
EPA 508	PCB-1248	µg/L	0.1
EPA 508	PCB-1254	µg/L	0.1
EPA 508	PCB-1260	µg/L	0.1
EPA 508	Pentachloronitrobenzene (PCNB)	µg/L	0.01
EPA 508	Ronnel	µg/L	0.3
EPA 508	Simazine	µg/L	0.02
EPA 508	Thiobencarb	µg/L	0.02
EPA 508	Toxaphene	µg/L	0.4
EPA 508	Trifluralin	µg/L	0.05

Table SPW1-3. Analytical methods and detection levels, continued

Method	Analyte	Units	Reporting Limit
Organic Phosphorus Pesticides			
EPA 508	Azinphos methyl (Guthion)	µg/L	0.05
EPA 508	Benfluralin	µg/L	0.01
EPA 508	Bromacil	µg/L	1
EPA 508	Carbophenothion (Trithion)	µg/L	0.02
EPA 508	Chlorpyrifos	µg/L	0.01
EPA 508	Cyanazine	µg/L	0.3
EPA 508	Demeton (Demeton O + Demeton S)	µg/L	0.02
EPA 508	Diazinon	µg/L	0.01
EPA 508	Dimethoate	µg/L	0.01
EPA 508	Disulfoton	µg/L	0.01
EPA 508	Ethion	µg/L	0.01
EPA 508	Malathion	µg/L	0.01
EPA 508	Methidathion	µg/L	0.02
EPA 508	Mevinphos	µg/L	0.01
EPA 508	Naled	µg/L	0.02
EPA 508	Napropamide	µg/L	5
EPA 508	Norflurazon	µg/L	5
EPA 508	Parathion (Ethyl)	µg/L	0.01
EPA 508	Parathion, Methyl	µg/L	0.01
EPA 508	Pendimethalin	µg/L	5
EPA 508	Phorate	µg/L	0.01
EPA 508	Phosalone	µg/L	0.02
EPA 508	Phosmet	µg/L	0.02
EPA 508	Profenofos	µg/L	0.01
EPA 508	Prometryn	µg/L	0.05
EPA 508	Propetamphos	µg/L	0.1
EPA 508	Ronnel	µg/L	0.01
EPA 508	s,s,s-Tributyl Phosphorotrithioate (DEF)	µg/L	0.01
EPA 508	Trifluralin	µg/L	0.01
Volatile Organics (Purgeable)			
EPA 502.2	1,1,1,2-Tetrachloroethane	µg/L	0.5
EPA 502.2	1,1,1-Trichloroethane	µg/L	0.5
EPA 502.2	1,1,2,2-Tetrachloroethane	µg/L	0.5
EPA 502.2	1,1,2-Trichloroethane	µg/L	0.5
EPA 502.2	1,1-Dichloroethane	µg/L	0.5
EPA 502.2	1,1-Dichloroethene	µg/L	0.5
EPA 502.2	1,1-Dichloropropene	µg/L	0.5
EPA 502.2	1,2,3-Trichlorobenzene	µg/L	0.5
EPA 502.2	1,2,3-Trichloropropane	µg/L	0.5
EPA 502.2	1,2,4-Trichlorobenzene	µg/L	0.5
EPA 502.2	1,2,4-Trimethylbenzene	µg/L	0.5
EPA 502.2	1,2-Dibromo-3-chloropropane (DBCP)	µg/L	0.5
EPA 502.2	1,2-Dibromoethane	µg/L	0.5
EPA 502.2	1,2-Dichlorobenzene	µg/L	0.5
EPA 502.2	1,2-Dichloroethane	µg/L	0.5

Table SPW1-3. Analytical methods and detection levels, continued

Method	Analyte	Units	Reporting Limit
Volatile Organics (Purgeable), continued			
EPA 502.2	1,2-Dichloropropane	µg/L	0.5
EPA 502.2	1,3,5-Trimethylbenzene	µg/L	0.5
EPA 502.2	1,3-Dichlorobenzene	µg/L	0.5
EPA 502.2	1,3-Dichloropropane	µg/L	0.5
EPA 502.2	1,4-Dichlorobenzene	µg/L	0.5
EPA 502.2	2,2-Dichloropropane	µg/L	0.5
EPA 502.2	2-Chlorotoluene	µg/L	0.5
EPA 502.2	4-Chlorotoluene	µg/L	0.5
EPA 502.2	4-Isopropyltoluene	µg/L	0.5
EPA 502.2	Benzene	µg/L	0.5
EPA 502.2	Bromobenzene	µg/L	0.5
EPA 502.2	Bromochloromethane	µg/L	0.5
EPA 502.2	Bromodichloromethane	µg/L	0.5
EPA 502.2	Bromoform	µg/L	0.5
EPA 502.2	Bromomethane	µg/L	0.5
EPA 502.2	Carbon tetrachloride	µg/L	0.5
EPA 502.2	Chlorobenzene	µg/L	0.5
EPA 502.2	Chloroethane	µg/L	0.5
EPA 502.2	Chloroform	µg/L	0.5
EPA 502.2	Chloromethane	µg/L	0.5
EPA 502.2	cis-1,2-Dichloroethene	µg/L	0.5
EPA 502.2	cis-1,3-Dichloropropene	µg/L	0.5
EPA 502.2	Dibromochloromethane	µg/L	0.5
EPA 502.2	Dibromomethane	µg/L	0.5
EPA 502.2	Dichlorodifluoromethane	µg/L	0.5
EPA 502.2	Ethyl benzene	µg/L	0.5
EPA 502.2	Fluorobenzene	µg/L	0.5
EPA 502.2	Hexachlorobutadiene	µg/L	0.5
EPA 502.2	Isopropylbenzene	µg/L	0.5
EPA 502.2	m + p Xylene	µg/L	0.5
EPA 8260	Methyl tert-butyl ether (MTBE)	µg/L	0.5
EPA 502.2	Methylene chloride	µg/L	0.5
EPA 502.2	n-Butylbenzene	µg/L	0.5
EPA 502.2	n-Propylbenzene	µg/L	0.5
EPA 502.2	Naphthalene	µg/L	0.5
EPA 502.2	o-Xylene	µg/L	0.5
EPA 502.2	sec-Butylbenzene	µg/L	0.5
EPA 502.2	Styrene	µg/L	0.5
EPA 502.2	tert-Butylbenzene	µg/L	0.5
EPA 502.2	Tetrachloroethene	µg/L	0.5
EPA 502.2	Toluene	µg/L	0.5
EPA 502.2	trans-1,2-Dichloroethene	µg/L	0.5
EPA 502.2	trans-1,3-Dichloropropene	µg/L	0.5
EPA 502.2	Trichloroethene	µg/L	0.5
EPA 502.2	Trichlorofluoromethane	µg/L	0.5
EPA 502.2	Vinyl chloride	µg/L	0.5

Table SPW1-3. Analytical methods and detection levels, continued

Method	Analyte	Units	Reporting Limit
Chlorinated Phenoxy Acid Herbicides			
EPA 515.1	2,4,5-T	µg/L	0.1
EPA 515.1	2,4,5-TP (Silvex)	µg/L	0.1
EPA 515.1	2,4-D	µg/L	0.1
EPA 515.1	2,4-DB	µg/L	0.1
EPA 515.1	2,4-Dichlorophenylacetic acid (DCAA)	µg/L	0.1
EPA 515.1	Dacthal (DCPA)	µg/L	0.1
EPA 515.1	Dicamba	µg/L	0.1
EPA 515.1	Dichlorprop	µg/L	0.1
EPA 515.1	Dinoseb (DNPB)	µg/L	0.1
EPA 515.1	MCPA	µg/L	0.1
EPA 515.1	MCPP	µg/L	0.1
EPA 515.1	Pentachlorophenol (PCP)	µg/L	0.1
EPA 515.1	Picloram	µg/L	0.1
EPA 515.1	Triclopyr	µg/L	0.1
Glyphosate			
EPA 547	Aminomethylphosphonic Acid (AMPA)	µg/L	100
EPA 547	Glyphosate	µg/L	100
Carbamate Pesticides			
EPA 531.1	3-Hydroxycarbofuran	µg/L	2
EPA 531.1	Aldicarb	µg/L	2
EPA 531.1	Aldicarb sulfone	µg/L	2
EPA 531.1	Aldicarb sulfoxide	µg/L	2
EPA 531.1	Carbaryl	µg/L	2
EPA 531.1	Carbofuran	µg/L	2
EPA 531.1	Formetanate hydrochloride	µg/L	100
EPA 531.1	Methiocarb	µg/L	4
EPA 531.1	Methomyl	µg/L	2
EPA 531.1	Oxamyl	µg/L	2

Oroville Facilities Relicensing
Environmental Work Group
Draft Study Plan

SPW2. Contaminant Accumulation in Sediments and Aquatic Food Chain

Introduction

The Environmental Work Group has identified sediment accumulation behind Oroville Dam as a potentially significant issue. Sediments trapped behind the dam are potentially laden with metals and organic contaminants, which may bioaccumulate in the food web. Sediments carried into Lake Oroville initially deposit into the upper tributary arms. Decreasing reservoir levels, periodic discharge surges from upstream hydropower generation, and increased tributary discharges from fall rains rework these deposits and carry them further into the reservoir.

Contamination of fish from mercury and other metals and organic contaminants is a significant concern in many areas of California, including the Feather River watershed. Lake Oroville tributaries in the upper Feather River watershed experienced significant gold mining activity during the Gold Rush era, and continue to experience significant recreational gold mining activity. Numerous large mercury mines were developed in the Coast Range to supply mercury as an amalgam for gold extraction in the Feather River and other areas. Mercury lost to the tributaries during gold mining operations is slowly being transported downstream with sediments. Though the Gold Rush era has long since passed, significant quantities of mercury still remain in the streams tributary to and in Lake Oroville.

Potentially occurring anoxic conditions beneath the sediment-water interface at the reservoir bottom create ideal conditions for biologically mediated liberation of methyl mercury by sulfate-reducing bacteria. The redistribution of methyl mercury in the water column during lake mixing in the fall and winter may affect the rate of~~allow~~ bioaccumulation into the food web, including plankton, fish, and piscivorous birds and other animals, including humans

In addition, other industrial activities in the upper Feather River watershed have contributed metal and organic contaminants, including polychlorinated biphenyls (PCB's), which also have an affinity for sediments and bioaccumulate in the food web. Resuspended sediments and recycled metals and organic contaminants in Lake Oroville can be transported downstream to other project waters, including the Diversion Pool, Thermalito Afterbay and Forebay, Oroville Wildlife Area ponds, and the Feather River, where uptake and bioaccumulation in aquatic organisms can occur.

Objective

The objectives of the study are to evaluate: 1) the levels of metals and organic contaminants in sediments impounded within project waters; 2) potential effects of

contaminated sediments on the food web in the project area, and 3) effects of project features, operations, and maintenance on sediment contamination and bioaccumulation in aquatic organisms.

Relationship to Relicensing/Need for Study

Sediments in Feather River tributaries are known to carry metal and organic contaminants. Prior to construction of Oroville Dam, sediments carried by the tributaries and the main stem of the Feather River in the reservoir footprint were transported downstream. Subsequent to completion of the dam, sediments carried by the tributaries settle into the upper arms of Lake Oroville, but are reworked by stream flows as reservoir levels drop throughout the summer and are redeposited further into the reservoir area. Thermal stratification in the reservoir during the summer can affect the rate at which~~allow~~ metals and organic contaminants ~~to~~ leach from the sediments into the water column, where they become available for uptake by aquatic life or release downstream. In addition, sediment dwelling organisms (e.g., crayfish, insects) ingest the sediments and can absorb contaminants. Contaminants in lower trophic levels are bioaccumulated in higher trophic level organisms, and may reach levels that are deleterious to other organisms (including listed species and humans) that ingest them. Impoundment of the reservoir created conditions in which sediments laden with contaminants are trapped and can bioaccumulate in the food web. Water with bioavailable forms of metals and organic contaminants that is released from the reservoir may contribute to bioaccumulation in downstream organisms. Bioaccumulation may not have been significant downstream of the dam prior to its construction because the metals and organic contaminants were bound to the sediment particles, and thus not readily available for uptake, and transported out of the system with higher flows.

The Department of Water Resources and State Water Resources Control Board have conducted limited sampling for metals in some fish from the reservoir and Feather River downstream from the dam. Analyses of the few fish from Lake Oroville and the Feather River have detected mercury at concentrations that exceed current U.S. Environmental Protection Agency and California Office of Environmental Health Hazard Assessment criteria. These data are not sufficient to determine the magnitude and extent of mercury contamination in fish and other organisms, nor the source. Additional analyses of fish tissue for mercury and other metals and organic contaminants is necessary to determine project effects and compliance with Basin Plan objectives.

Demonstration of compliance with basin plan objectives is necessary for the SWRCB to issue a water quality certification. The water quality certification is needed to file with the application for license renewal with the Federal Energy Regulatory Commission. Information derived from this study will be used to demonstrate compliance with water quality standards and other appropriate requirements in the application for water quality certification. Information from the study is also needed to address concerns related to endangered species that feed on potentially contaminated aquatic organisms in the project area.

Study Area

The study area is generally within the FERC project boundary, but also includes lands adjacent to the project boundary where piscivorous species may occur. The vulnerability of piscivorous species to bioaccumulated contaminants will be evaluated in the terrestrial studies if fish eaten as prey are found to contain high levels of contaminants. The assessment of piscivorous susceptibility will be evaluated through a literature review of effects from the specific contaminants identified in this study as occurring in significant concentrations in prey species. ~~If those studies show bioaccumulated contaminant effects on piscivorous terrestrial species, additional studies would be conducted to determine the levels of contaminants specifically in those aquatic prey species taken by piscivorous terrestrial species.~~

Specific water bodies included in this study plan are the North, Middle, and South forks of the Feather River and the West Branch and Concow Creek just above their confluences with the reservoir, Lake Oroville, Diversion Pool, Thermalito Forebay and Afterbay, Feather River from Oroville Dam to just downstream from the Afterbay Outlet, and Oroville Wildlife Area ponds.

Methodology and Analysis

This study will be conducted in phases. The first phase will emphasize analysis of metals and organic contaminants in fish and crayfish in the project area. If the first phase detects metals or organic contaminants at levels greater than criteria for protection of human health or fish and crayfish predators, the second phase will be initiated. The second phase, if necessary, will evaluate metals and organic contaminants in sediments, fish, and crayfish in tributaries to the reservoir to provide background data needed to evaluate the role of the reservoir in bioaccumulation. The second phase would also evaluate metals and organic contaminants in sediments in the project area and the extent of project related impacts to fish, crayfish, and sediments downstream from the project area.

Phase 1. Project Area Metals and Organic Contaminant Assessment — Water bodies sampled for Phase 1 of the study will include Oroville Reservoir, Diversion Pool, Thermalito Forebay and Afterbay, low flow section of the Feather River, Feather River immediately downstream from the Afterbay Outlet, and Oroville Wildlife Area ponds.

Phase 1 Sample Collection — Specific fish species sampled is dependent on the types resident in the water body sampled. Newly planted fish (i.e., less than one year residency) will be avoided. Two size classes of at least two species will be targeted from each sampling site. Following the protocol of the California Office of Environmental Health Hazard Assessment, composites of at least five fish for each size class will be collected. Each size class will be composed of fish with no greater than 20 percent weight difference between the largest and smallest fish. Fish will be collected beginning in the late spring with gill nets, hook and line, or seining. Fish will be weighed

and measured, wrapped in aluminum foil, and immediately frozen for transport to the laboratory.

Crayfish, if present, will be collected from the same sites from which fish are collected. Larger (older) crayfish will be targeted. At least ten crayfish of similar size from each site will be composited. Crayfish will be collected by hand, nets, or baited traps. Crayfish will be wrapped in aluminum foil and frozen for transport to the laboratory.

Lake Oroville —A comprehensive survey of fish and crayfish contamination in Lake Oroville requires multiple sampling sites in each arm and the main body of the reservoir. Fish and crayfish, if present, will be collected from sampling sites in the upper and mid reaches in each of the North, Middle, and South fork arms and from both the east and west sides of the main body of the reservoir.

Targeted fish species will include largemouth or smallmouth bass and channel catfish from the reservoir arms, and largemouth bass, channel catfish, and chinook or coho salmon from the main body of the reservoir.

Diversion Pool — The Diversion Pool will be sampled near the Diversion Dam. Fish targeted for collection from the Diversion Pool will include largemouth or smallmouth bass, and chinook or coho salmon. Crayfish will be collected from the same site.

Thermalito Forebay, Thermalito Afterbay, and Oroville Wildlife Area — One monitoring site will be established in the south Thermalito Forebay. The Thermalito Afterbay will be sampled in both the northern and southern regions. Specific sampling sites in the Thermalito Afterbay will be determined in consultation with State and federal agency staff due to the complex water currents and potential for methylation of mercury in this water body. Two representative ponds will be sampled in the Oroville Wildlife Area both upstream and downstream from the Afterbay Outlet. If analyses of samples indicate significant variation in contaminant levels in these water bodies, additional samples may be necessary. Warmwater fish species targeted in these water bodies will include largemouth or smallmouth bass and channel catfish. Crayfish will be collected from the same areas as the fish.

Lower Feather River — The Feather River downstream from Oroville Dam will be sampled at one site in the low flow section between the fish hatchery and Afterbay Outlet and at another site downstream from the outlet within the project boundary. Targeted fish species will include smallmouth bass, channel catfish, and pikeminnow. Crayfish will be collected from riffle or pool areas.

Phase 1 Sample Analysis — Analytical procedures will follow those used in the Toxic Substances Monitoring Program conducted by the State Water Resources Control Board and Department of Fish and Game. Metals, pesticides, polychlorinated

biphenyls, and polynuclear aromatic hydrocarbons are analyzed for this program (Table 1). PCB congeners analyzed will be those determined to pose significant ecological risks in a U.S. Environmental Protection Agency sponsored study (USEPA 1998).

Methylmercury is assumed to be the form of mercury available for bioaccumulation in the food web. Most mercury in fish tissues is in the methylmercury fraction. Total mercury, however, is typically analyzed and is assumed to represent the methylmercury content of tissues. Fish muscle (filet) tissue is analyzed for the metals arsenic, cadmium, nickel, mercury, and selenium, while fish liver is analyzed for copper, zinc, chromium, lead, and zinc. All organic chemicals in fish are analyzed from filets. Whole body analyses of metals and organic chemicals are performed from very small fish and crayfish. Crayfish are shelled at the laboratory prior to analysis. All fish and crayfish analyses will be performed at the Department of Fish and Game Water Pollution Control Laboratory in Rancho Cordova or the West Coast Analytical Services laboratory in Santa Fe Springs, California.

Tissue concentrations of metals and organic chemicals are measured on a wet weight basis. In addition to wet weight measures, organic chemicals are also expressed on a lipid weight basis since chlorinated hydrocarbons partition into lipid-rich tissues of aquatic organisms. Season, water temperature, health of the organism, stress on the organism, and type of species can affect the lipid levels of samples, and cause variability in results. Therefore, lipid weight values may represent a more realistic measure of environmental availability of chlorinated hydrocarbons than wet weight values. Wet weight measures, however, are preferred because all standards for human health and predator protection are based on wet weight measures. Also, wet weight measures better reflect the exposure of predators or humans to the actual concentration in freshly caught fish.

Phase 2. Metals and Organic Contaminant Assessment Pathways — If analyses in Phase 1 demonstrate significant contamination of fish or crayfish (i.e., criteria exceeded), a second phase will evaluate sediment, fish, and crayfish contamination in the tributaries to the reservoir to determine background (i.e., upstream) contributions to bioaccumulation and organic contamination. In addition, sediment, fish, and crayfish would be sampled downstream from the project area in the Feather River to evaluate the extent of possible project effects on downstream contamination. Parameters analyzed would include both metals and organic contaminants that were found to be significant in Phase 1. Sediments and possibly additional fish (such as threadfin shad or wakasagi) will also be sampled for metals and organic contaminants in the project area water bodies sampled in Phase 1 where contamination was found to be significant

Phase 2 Sample Collection — Fish and crayfish species sample collection will use the same procedures and protocols as in Phase 1.

Bottom sediments will be obtained with a core sampler during the spring to early summer prior to the development of anoxic conditions in the hypolimnion. Anoxic conditions allow some contaminants to recycle from sediments to the overlying water.

The top ~~two centimeters~~ six inches of sediments in the dredge will be collected with teflon spoons into containers provided by the laboratory. Ten core samples at each site will be composited into a single sample.

Feather River Tributaries — Fish, crayfish, and sediments in the North, Middle, and South forks of the Feather River and the West Branch, ~~and~~ Concow Creek, and Fall River will be sampled just above their confluences with the reservoir. Targeted fish species will include rainbow trout, smallmouth bass, and pikeminnow. Sediments will be collected from riffle deposits or the bottom of pools. If deposited sediments are found to contain significant loads of metals or organic contaminants, sediments in the bedload will be sampled for contaminants during the fall, winter, and spring to determine temporal variability in contamination and concentrations in sediments being transported into Lake Oroville.

Lake Oroville — Sediments will be collected from the same sites from which fish and crayfish were sampled in Phase 1. Additional sites for sediment samples may be necessary in the main body of the reservoir due to the areal extent and potential for different loading from each arm of the reservoir. The need to collect additional samples will be determined by the variability found in the initial samples.

Prey fish species (threadfin shad and wagasaki) in the reservoir may be sampled if high contaminant loads are found in fish that prey on them in Phase 1. If necessary, these species will be collected with gill nets or seines.

Diversion Pool — Sediments will be collected from the Diversion Pool at the same site selected for fish and crayfish sampling in Phase 1.

Thermalito Forebay, Thermalito Afterbay, and Oroville Wildlife Area — Sediments will be sampled in these water bodies in the same areas from which fish and crayfish were sampled.

Lower Feather River — Sediments will be collected from riffle deposits or from the bottom of pools in the previously sampled sites in the low flow section of the river and downstream from the Afterbay Outlet in the project area. Additional sites may be necessary to sample downstream from the Afterbay Outlet as far downstream as the mouth of~~in~~ the Feather River if significant contamination is found in fish, crayfish, or sediments to determine the extent of effect to contamination from the project. The necessity for sampling downstream from the project area will be determined after results from Phase 1 are reviewed in consultation with State and federal agency staffs.

Phase 2 Sample Analysis — Analytes, laboratories, and procedures for fish and crayfish analyses -will be the same as in Phase 1 Sediments will be analyzed for metals, organic chemicals, percentage organic carbon, and acid volatile sulfides at the Cal-test Laboratory in Napa.

Results

Information from this study will be used to evaluate the effects of the project and project operations on contamination in sediments and bioaccumulation of contaminants in fish and crayfish. Information developed will be presented quarterly to the Environmental Workgroup and Task Force for review to evaluate the adequacy and progress of the study.

Data obtained from this study will be compared to numerical criteria of the U.S. EPA and California Office of Environmental Health Hazard Assessment for human health concern, and National Academy of Sciences predator protection criteria. Additional criteria used for evaluation of the data will include maximum tissue residue levels developed by the SWRCB, action levels of the U.S. Food and Drug Administration, median international standards for trace elements of the Food and Agriculture Organization of the United Nations, and elevated data levels of the SWRCB. Data will be presented in tables and graphs showing the relationship between concentrations of any contaminants found and the various criteria.

Compliance with criteria will be used to evaluate compliance with Basin Plan objectives, which is necessary for the SWRCB to issue a water quality certification. The water quality certification must be submitted to the Federal Energy Regulatory Commission with the application for a new license for the project.

A draft report documenting findings will be prepared after completion of Phase 1, and a final report with results and recommendations will be prepared at the completion of Phase 2, if necessary.

Coordination with Other Resource Areas/Studies

This study will provide information for evaluation of Issue Sheet W6 (effect of existing and future project facilities and operations on sediment deposition and potential impoundment of metals and toxins, including the potential presence and uptake of methylmercury through the food chain) and will be coordinated with Study Plan SPG1 (Geology Issue G4 - project effect on sediment accumulation upstream of the dam). Information derived from SPG1 will be used to determine the magnitude of potentially contaminated sediment influx into the reservoir.

Schedule

The study will begin in the spring of 2002. Collection of samples necessary for analyses of the significance of metals and organic contamination in fish and crayfish in project waters (Phase 1) should be completed by early summer of 2002. If necessary, additional samples to determine effects from tributary contributions, sediment loads, and downstream effects would occur the following year. Additional samples may be necessary in subsequent years if sampling attempts fail to collect the requisite samples or if particularly contaminated samples are encountered. A draft report discussing

sampling, analytical results, project implications, and recommendations will be completed at the end of each study year.

Issues

W6. Effect of existing and future project facilities and operations on sediment deposition and potential impoundment of metals and toxins, including the potential presence and uptake of methylmercury through the food chain. Lake Oroville, fed by tributaries that have a history of gold mining activity, has potential for accumulation of elemental mercury in its basin sediments. Issues Addressed: WE7, WE13, WE41, G4, F6

Figure SPW2-1. Phase 1 and 2 Contaminant Monitoring Sites

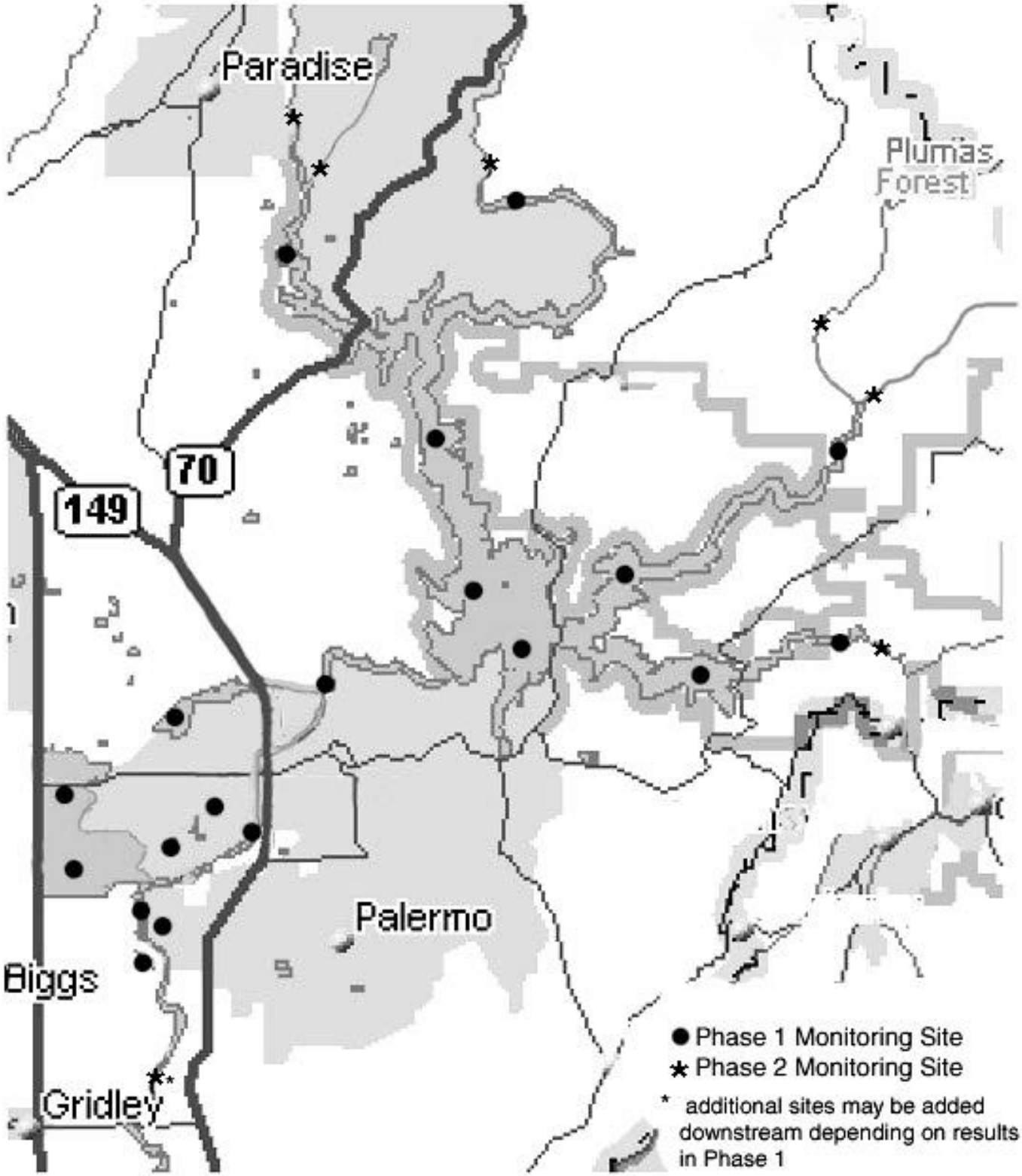

Table SPW2-1. Metals and organic contaminants for analyses

Organochlorine Pesticides by EPA Method 8081A

Analyte	Reporting Limit ppb (ng/g)	Analyte	Reporting Limit ppb (ng/g)
aldrin	1	dieldrin	1
alpha-BHC	1	endosulfan I	2
beta-BHC	2	endosulfan II	2
gamma-BHC	1	endosulfan sulfate	2
delta-BHC	1	endrin	2
alpha-chlordane	1	endrin aldehyde	2
gamma-chlordane	1	endrin ketone	2
alpha-chlordene	1	heptachlor	1
gamma-chlordene	1	heptachlor epoxide	1
chlorpyrifos	2	Kelthane (dicofol)	2
chlorthal (dacthal)	2	methoxychlor	10
2,4'-DDD	2	mirex	2
2,4'-DDE	2	nonachlor, cis	2
2,4'-DDT	2	nonachlor, trans	2
4,4'-DCBP	2	oxadiazon	2
4,4'-DDD	2	oxychlordane	2
4,4'-DDE	2	tetradifon (tedion)	2
4,4'-DDT	2	toxaphene	100
4,4'-DDMU	2		

Polynuclear Aromatic Hydrocarbons by EPA Method 8270C/SIM

Analyte	Reporting Limit ppb (ng/g)	Analyte	Reporting Limit ppb (ng/g)
acenaphthene	10	fluoranthene	10
acenaphthylene	10	fluorene	10
anthracene	10	indeno(1,2,3-cd)pyrene	10
benzo(a)anthracene	10	3-methylcholanthrene	10
benzo(b, j&k)fluoranthene	10	1-methylnaphthalene	10
benzo(g,h,i)perylene	10	2-methylnaphthalene	10
benzo(a)pyrene	10	1-methylphenanthrene	70
benzo(e)pyrene	10	naphthalene	10
biphenyl	10	perylene	10
chrysene	10	phenanthrene	10
dibenzo(a,h)anthracene	10	pyrene	10
2,6-dimethylnaphthalene	10	2,3,5-trimethylnaphthalene	10

Table SPW2-1. Metals and organic contaminants for analyses, continued

Polychlorinated Biphenyls (PCB) Congeners by GC/ECD w/congener standards

Congener	Reporting Limit ppb (ng/g)	Congener	Reporting Limit ppb (ng/g)
8	0.6	128	0.6
15	0.6	132	0.6
18	0.6	137	0.6
27	0.6	138	0.6
28	0.6	149	0.6
29	0.6	151	0.6
31	0.6	153	0.6
44	0.6	156	0.6
49	0.6	157	0.6
52	0.6	158	0.6
66	0.6	167	0.6
70	0.6	169	0.6
74	0.6	170	0.6
77	0.6	174	0.6
81	0.6	177	0.6
87	0.6	180	0.6
95	0.6	183	0.6
97	0.6	187	0.6
99	0.6	189	0.6
101	0.6	194	0.6
105	0.6	195	0.6
110	0.6	200	0.6
114	0.6	201	0.6
118	0.6	203	0.6
123	0.6	206	0.6
126	0.6	209	0.6

Table SPW2-1. Metals and organic contaminants for analyses, continued

Organophosphorus Pesticides by EPA Method 8141A

Analyte	Reporting Limit ppb (ng/g)	Analyte	Reporting Limit ppb (ng/g)
chlorpyrifos	2	parathion, ethyl	2
diazinon	20	parathion, methyl	4

Metals by EPA Method 6020 (ICPMS)

Analyte	Reporting Limit ppm (ug/g)	Analyte	Reporting Limit ppm (ug/g)
arsenic*	0.02	mercury	0.01
cadmium	0.005	nickel	0.01
chromium	0.1	selenium*	0.02
copper	0.006	silver	0.005
lead	0.007	zinc	0.06

* analysis with methanol addition

Miscellaneous Sediment Analyses

Percent organic carbon	EPA Method 9060
Acid volatile sulfides	EPA ABS/SEM procedures, Dec. 2, 1991
Nonyl phenols	GC-MS/DFG

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SPW3. Recreational Facilities and Operations Effects on Water Quality

Introduction

Existing and future operation of the Oroville Project recreational facilities, operations, and activities may have effects on the physical, chemical and biological integrity of water quality. The Environmental Workgroup identified issues related to the recreational facilities and operations of the project. Issues identified included potential for introduction of nutrients, bacterial contamination at swim areas such as the North Forebay, sewage spills into Lake Oroville, fuel spills as a result of fluctuating lake levels, and contamination from boat maintenance and cleaning products.

Numerous recreational and related activities occur within the project boundary. Various bike, horse, and hiking trails, boat launching and maintenance facilities, camping areas, concessions, waste handling facilities, and swim areas have been developed in association with the project. The proximity of recreational facilities and their associated activities to the shoreline and banks of project waters offers potential for shoreline erosion and introduction of nutrients and bacterial contaminants. Recreational activities may also introduce contaminants into project waters, such as MTBE, oils and greases from watercraft operation and maintenance, petroleum hydrocarbons from fuel spills and floating gas tanks, and nutrients and bacteria from floating septic systems, restrooms, watercraft gray water tanks, and pump out facilities.

Objective

The objective of the study is to evaluate the potential effects of recreational facilities, operations, and activities on the physical, chemical, and biological integrity of project waters. ~~Integrity of project waters refers to the state of being unimpaired.~~ Effects from project facilities and operations to the integrity of project waters, as well as general water quality conditions, are evaluated in SPW1. This study will evaluate localized effects to water quality from specific recreational facilities and activities. ~~Information from this study plan will be used to demonstrate compliance with water quality standards and other appropriate requirements in the application for water quality certification.~~

Relationship to Relicensing/Need for Study

~~Existing and future operation of the Oroville Project recreational facilities, operations, and activities may have effects on the physical, chemical and biological components of water quality. The proximity of recreational facilities and their associated activities to the shoreline and banks of project waters offers potential for shoreline erosion and introduction of nutrients and bacterial contaminants.~~

~~Recreational activities may also introduce contaminants into project waters, such as MTBE, oils, and greases from watercraft operation and maintenance, petroleum hydrocarbons from fuel spills and floating gas tanks, and nutrients and bacteria from floating septic systems, restrooms, watercraft gray water tanks, and pump out facilities.~~

Demonstration of compliance with water quality standards and other appropriate requirements are necessary in the application for water quality certification. Some physical, chemical, and biological data have been collected from the North, Middle, and South forks of the Feather River near their confluences with Lake Oroville, from the reservoir itself, and downstream from Oroville Dam in the Feather River, Thermalito Power Canal, and Thermalito Afterbay. However, these data are not, nor were expected to be, sufficient to determine compliance with all Basin Plan Standards and appropriate goals and criteria protective of the designated beneficial uses. Therefore, additional water quality data are necessary for the application for water quality certification.

Information obtained from the study will be used to determine effects from recreational facilities, operations, and activities on the physical, chemical, and biological components of water quality, and the need for mitigation for impacts to water quality. This analysis is required for water quality certification by the SWRCB. The water quality certification is needed to file with the application for license renewal with the Federal Energy Regulatory Commission.

Study Area

The study area is generally within the FERC project boundary, but also includes adjacent lands and waterways for effects to project waters, and downstream for project effects in the Feather River. Specific water bodies included in the study area are the North, Middle, and South forks of the Feather River, ~~the~~ West Branch and Concow Creek just above their confluences with the reservoir, Lake Oroville, Feather River downstream from Oroville Dam within the project boundary, Diversion Pool, Thermalito Forebay~~, Thermalito~~ and Afterbay, and Oroville Wildlife Area ponds.

Methodology and Analysis

This study will evaluate both current and potential future recreational facilities and operations. Some future recreational facilities and operations are known, but others will not be known until near the end of the study. Data obtained from the study will be compared to water quality goals and criteria for protection of beneficial uses.

Task 1. Effects of Current Recreation Facilities and Operations

The first phase of the study will focus on~~-~~ evaluating the potential for recreation facilities, operations, and activities to affect water quality, and monitoring to determine contamination. Information from recreation study plans will be obtained, as necessary,

to evaluate the potential and sources of potential contamination from recreation facilities, operations, and activities.

Sub-Task 1a. Evaluation of Potential for Contamination — The current Lake Oroville State Recreation Areas map ~~(Figure 1)~~ will be reviewed for completeness and updated to insure that all recreational facilities and activities are identified.

The potential types of contamination associated with each type of recreational facility and activity (Table SPW3-1) will be assessed. Field surveys will be conducted to determine potential sources of contamination from recreation facilities and activities. Operators of recreation facilities will be interviewed, recreation facilities visited, and recreational activities reviewed to determine potential for contamination to project waters. Seasonal useage will also be evaluated to determine temporal potential for contamination. The interviews and field visits will identify potential sources of contamination, potential contaminants, source pathways, and operations and management that may contribute to contamination.

Table SPW3-1. Recreational facilities, operations, and activities

Bike trail	Fish cleaning station
Boating	Hiking
Boat/car top access	Hunting
Boat house	Marina
Boating/no power	Nature study
Boat launch	OHV-ATV
Boat-in camping	Picnicking
Campfire center	Restrooms
Campground	Floating restrooms
Camping/group	Swimming
Concessions	Trailhead/with parking
Dump station	Vista point
Enroute camping	Visitor center
Equestrian trail	Wheelchair access
Equestrian camp	

Sub-Task 1b. Monitoring for Potential Contamination — Specific monitoring will be determined for each type of recreational facility and activity with potential to contaminate project waters (Table 1). Monitoring will be implemented to target specific recreational facilities and activities with potential to introduce contaminants into project waters, such as marina operations, boat launch and maintenance facilitiies, developed and primitive campgrounds, floating campsites, beach areas (e.g., North Forebay Recreation Area, Bedrock Recreation Area), swimming areas, floating restrooms, houseboats and pumpout facilities, fishing facilities (e.g., fish cleaning stations, heavy fishing areas such as the Afterbay Outlet), hiking and bicycle trails, horse camp and

horse riding trails, and picnic areas. The contribution of contaminants from wildlife will also be investigated where appropriate, such as waterfowl contribution to bacterial levels at swim areas. Specific monitoring activities will be developed and implemented following determination of the potential for recreation facilities, operations, and activities to affect water quality. The monitoring program will be presented to the Environmental Work Group Task Force for review prior to implementation.

Monitoring for evaluation of effects to water quality from recreational facilities and activities would be dependent upon the type of recreational facility or activity and the period of impact. Parameters monitored may include erosion, turbidity, sedimentation, microbiological indicator organisms (i.e., coliform and enterococcus bacteria), periphyton (attached algae), petroleum byproducts (e.g., hydrocarbons, MTBE, oil and grease), metals, minerals, nutrients, and pesticides. Weekly and event-based (e.g., holiday weekends, recreation or fishing tournaments) water quality data collection would occur during the recreation season or event. Monthly or other appropriately timed (e.g., spills) monitoring would occur to determine effects from activities that occur throughout the year.

Task 2. Effects of Future Recreation Facilities and Operations

The Recreation Workgroup will be evaluating project related recreational facilities and operations, and investigating the need for any changes to the current facilities or operations and the need for additional facilities. As these groups develop proposals or recommendations for changes to existing facilities and operations or development of new facilities, the proposals will be evaluated for potential water quality effects. For example, a proposed increase in boat facilities may lead to increased boat usage on the reservoir, and hence increased contamination from petroleum products. Recommendations based on the analysis will be made to the appropriate group for any necessary modifications to minimize potential adverse effects to water quality.

Results

Information derived from this study will be used to determine whether recreational facilities, operations, and activities adversely affect the physical, chemical, and biological integrity of project waters. Information gathered through interviews and monitoring will be presented in tabular form identifying potential sources of contamination, potential contaminants, source pathways, operations and management that may contribute to contamination, and effectiveness of facility or operations in preventing contamination. Water quality monitoring ~~D~~data obtained from this study will be compared to numerical and narrative water quality objectives of the CVRWQB Basin Plan; numerical criteria of the U.S. EPA and California Department of Health Services drinking water maximum contaminant levels, U.S. EPA California Toxics Rule criteria for freshwater aquatic life for dissolved metals, U.S. EPA National Toxics Rule criteria for freshwater aquatic life for total recoverable metals, and U.S. EPA National Ambient Water Quality Criteria for freshwater aquatic life protection; and agricultural goals for water quality from the Food and Agriculture Organization of the United Nations. The

data will be presented in tables and graphs comparing monitoring data for the various types and locations of recreational activity with the various criteria.

Compliance with water quality objectives and criteria will be used to evaluate effects of recreation facilities and activities on designated beneficial uses as defined in the Basin Plan, which include municipal and domestic supply, agriculture, electrical power production, contact and non-contact recreation, warm-water and cold-water fish spawning, rearing and migration, freshwater habitat, and wildlife habitat. Mitigation measures will be investigated for parameters that do not meet Basin Plan objectives.~~, and recommendations developed for implementation.~~

~~Data will be presented in tables and graphs showing the type and location of recreational activity and associated contamination that was detected.~~ Information derived from this study will be used by the SWRCB to determine ~~whether to issue~~ conditions in the~~a~~ water quality certification to comply with Section 401 of the Federal Clean Water Act.

Coordination with Other Resource Areas/Studies

This study will provide some of the information necessary for determination of project compliance with water quality standards and other appropriate requirements in the application for water quality certification.

This study will collect and share data with Study Plan SPW1 (Issue Sheet W1, W2, and W3) and SPW7(Issue Sheet W7). The study will coordinate with the Recreation Workgroup and their study plans in identifying potential current and proposed recreational facilities and activities that may contaminate project waters, and methods to reduce or eliminate potential contamination.

Schedule

Task 1 of the study will begin in ~~February~~early 2002. The monitoring plan developed in Sub-Task 1a will be presented to the Environmental Workgroup Task Force for review and concurrence in the spring of 2002. Monitoring of potential sources of contamination will then commence and continue for at least two years. Information obtained by the study will be presented to the Environmental Workgroup and Task Force at quarterly intervals for review to evaluate the adequacy and progress of the study. Task 2 will provide additional analyses to evaluate effects from proposed recreation facilities and operations, and will continue until all proposed recreation facilities and operations have been identified and evaluated. A draft report will be prepared at the completion of each task,~~.~~ and a final report will be prepared at the end of the study.

Issues

W4. Effects of existing and future project operations and facilities and its associated recreational facilities, activities and uses on water quality. Proximity of project features and recreational facilities to shoreline and banks of water bodies offers potential for introduction of nutrients and bacterial contaminants to these waters. Issues Addressed: WE5, WE35, WE43, WE44, WE45, FE8, FE16, FE20, FE79

W5. Effects of existing and future water-based recreation on water quality of project waters. Concerns include MTBE, oils and greases, fuel spills, floating gas tanks, floating septic systems, floating restrooms, houseboat gray water tanks (e.g., nutrients) and pump out facilities. Issues Addressed: WE6, WE35, WE38, WE39, WE42, WE43, WE44, WE45

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SPW5. Project Effects on Groundwater

Introduction

Relicensing participants raised a concern about the effects of project reservoir and Feather River water quality and levels in the project area on groundwater quality and quantity, including hyporheic zone interactions. The "hyporheic zone" comprises the interstices or spaces in the mixture of coarse sand, gravel, and other rocks beneath and beside a river or stream. The spaces are permeated by flowing water in contact with that in the stream, and are inhabited by a variety of insects and other aquatic organisms, including fish fry.

Recharge to groundwater in the Sacramento Valley occurs from percolation along the margins of the valley. Construction of the Oroville Facilities flooded a portion of the potential foothill recharge area. Creation of Lake Oroville likely has had little effect on groundwater, since the reservoir is underlain by hard rock that does not transmit water in any appreciable quantity. However, the Thermalito Forebay and Afterbay exert significant hydraulic head that increases recharge downgradient from these water bodies. The hydraulic head from these reservoirs could contribute to higher groundwater levels in the affected area, though the extent of this impact has not been quantified. Recharge to groundwater from the Thermalito Forebay and Afterbay may also differ in quality than that occurring naturally from rainfall percolation. ~~In addition, hydraulic head from these reservoirs contributes to higher groundwater levels in the affected area, though the extent of this impact has not been quantified.~~

Existing and future operation of the Oroville Facilities may have effects on the physical, chemical, and biological components of groundwater quality in the project area. Some physical, chemical, and biological data have been collected from groundwater in the project area. However, these data are not, nor were they expected to be, sufficient to determine compliance with Basin Plan criteria, goals, and objectives for groundwater. Additional physical, chemical, and biological data are needed to demonstrate project compliance with Basin Plan objectives for groundwater.

Objective

The objectives of the study are to evaluate the effects of project features and operations of the Thermalito Forebay and Afterbay and the Feather River in the project area on groundwater quality and levels, and the effects of subsurface movement on the hyporheic zone and its connectivity with ponds in the Oroville Wildlife Area.

Relationship to Relicensing/Need for Study

Construction of Oroville Dam, impoundment of water to form Lake Oroville, and associated facilities of the project have affected the physical, chemical, and biological characteristics of water in the Feather River. Since the Feather River provides recharge to local groundwater, these changes in water quality characteristics in the river may subsequently affect groundwater characteristics. In addition, recharge to groundwater from the Thermalito Forebay and Afterbay may affect groundwater quality as well as levels. Ponds in the Oroville Wildlife Area are likely hydraulically connected to the Feather River, and thus may also be affected by the water quality characteristics of the Feather River.

Though the project may potentially affect biological characteristics of groundwater, aquatic macroinvertebrates as a component of the biological characteristics of groundwater are not included for study since sufficient information about these organisms is being obtained from riffle areas of the Feather River in Study Plan SPW1. However, if information from this study suggests that there may be adverse effects to the biological hyporheic element, then studies will be developed in collaboration with the Environmental Workgroup and Task Force to examine those effects.

Prior to issuance of a new license for the project, the Federal Energy Regulatory Commission will require a water quality certification by the State Water Resources Control Board (SWRCB). The certification requires a determination by the SWRCB that the project complies with appropriate requirements of the Central Valley Regional Water Quality Control Board (CVRWQCB) Basin Plan, which includes water quality objectives for protection of designated beneficial uses. The CVRWQCB has established groundwater quality objectives for bacteria, chemical constituents, radioactivity, tastes and odors, and toxicity.

Information obtained from the study will be used to determine project effects to the physical, chemical, and biological components of groundwater, demonstrate compliance with water quality standards and other appropriate requirements in the application for water quality certification, and identify the need for project modification or mitigation for impacts to groundwater quality or levels from project operations. Water quality analysis is required for determination of conditions in the water quality certification by the SWRCB. The Federal Energy Regulatory Commission (FERC) requires a water quality certification or a waiver of the water quality certification before it can issue a new license.

Study Area

The study area is generally within the FERC project boundary, but also includes adjacent areas for project-related effects. The specific area of study is the groundwater generally downgradient from the Thermalito Forebay and Afterbay and the Feather River, and ponds within the Oroville Wildlife Area. Measurement of the effects of the~~se~~ project ~~to~~on groundwater~~water bodies~~ will require monitoring groundwater quality and levels in areas adjacent to the project, including farmland adjacent to the Afterbay.

Methodology and Analysis

Surface water quality information from~~-~~ the Thermalito Forebay and Afterbay ~~Forebay,~~ and~~-~~ Feather River downstream from the dam collected in Study Plan SPW1 will be compared with groundwater quality downgradient from~~ from~~ these areas and in surrounding areas to assess effects from the project. Groundwater levels will be monitored to determine effects from the project to area groundwater levels and pond levels in the Oroville Wildlife Area.

Task 1. Inventory Existing Wells and Groundwater Data

Relevant ~~D~~data from the existing groundwater level and quality monitoring program of the Northern District of DWR will be collated. Well locations from the monitoring program will be plotted on GIS maps. The monitoring data will be reviewed to determine whether suitable data are being collected for use in this study, and the need to collect additional monitoring information for both groundwater levels and quality.

Task 2. Groundwater Monitoring

If data from the existing monitoring program are not sufficient to determine effects from the project to groundwater, then other ~~S~~suitable existing wells will be identified for monitoring.~~ in the area that may be influenced by recharge from the project as well as in areas likely not to be influenced~~ Wells logs maintained by DWR will be reviewed to identify potential groundwater monitoring wells. Well logs will be obtained for both shallow and deeper wells. The well logs will be reviewed to assure that wells selected for monitoring are perforated within the desired groundwater zone. If insufficient suitable existing wells are found, monitoring wells will be constructed to obtain information on groundwater quality and levels. Wells in areas both influenced and likely not to be influenced by recharge from the project will be monitored ~~-~~so as to be able to determine the degree of effect in affected areas.~~ Well logs will be obtained for both shallow and deeper wells. The well logs will be reviewed to assure that wells selected for monitoring are perforated within the desired groundwater zone.~~ All irrigation and domestic wells~~-~~ for sampling from the area will be surveyed for elevation and will be plotted on ~~a~~GIS maps. Wells will be selected for monitoring that will characterize the horizontal and vertical quality and levels of groundwater in the area.~~. If insufficient suitable existing wells are found, monitoring wells will be constructed to obtain information on groundwater quality and levels.~~

Groundwater levels will be measured during the spring and again in the fall. Levels will be measured following a period when the wells have not been used. Any data on groundwater levels being monitored by others will also be compiled.

Groundwater quality information will be collected during the summer. Depth to water in ~~E~~each selected well will be measured, and the well purged prior to collection of water quality samples. Purging will involve running the well pump with periodic

measurements of conductivity, temperature, and pH. When these parameters have been stable between at least three successive measurements taken at least five minutes apart, water samples for chemical analyses will be obtained. Parameters analyzed will include minerals (calcium, magnesium, sodium, potassium, alkalinity, sulfate, chloride, boron), nutrients (nitrate plus nitrite, ammonia, ortho-phosphate, and total phosphorus), metals (aluminum arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, and zinc), pesticides (chlorinated organic pesticides, organic phosphorus pesticides, chlorinated phenoxy acid herbicides, volatile organic pesticides, carbamate pesticides, and glyphosate), MTBE, hardness, total dissolved solids, conductivity, pH, temperature, and total and fecal coliform bacteria.

Water temperature will be measured using a calibrated thermometer or thermistor. Conductivity and pH will be measured with calibrated meters and probes. Mineral and nutrient samples will be collected into clean polyethylene containers. Samples for trace metals analyses at water quality criteria levels will be collected into polyethylene or glass bottles according to U.S. EPA Method 1669. Chemical analyses of minerals, nutrients, metals, pesticides, and total dissolved solids will be performed at the DWR Bryte Chemical Laboratory in West Sacramento using U.S. EPA approved techniques, equipment, and methods (Table SPW5-1). Total and fecal coliform will be analyzed at the DWR laboratory in Red Bluff.

Task 3. Hyporheic Monitoring

The hyporheic zone will be characterized using stage recorders and analyses of water samples. Stage recorders will be installed along the river and selected Oroville Wildlife Area ponds to ~~monitor how~~evaluate the effects of river-level changes ~~affects~~on pond levels. Water samples collected for chemical analyses from the ponds will be compared to river water ~~quality data~~ chemical analyses collected in Study Plan SPW1 to ~~determine~~evaluate the relationship between river water quality and that in ~~source water for~~ the ponds. Additional shallow monitoring wells may be constructed ~~near~~between the river and ponds to aid in river stage-pond level and source water determinations. If physical and chemical data indicate concern for groundwater contamination, then effects on benthic macroinvertebrates in the hyporheic zone may need to be analyzed in a subsequent phase of the study.

Results

Data obtained from this study will be compared to applicable numerical and narrative water quality objectives and goals. Surface water quality data from Study Plan SPW1 will be compared to groundwater quality data from this study to evaluate the degree of connectivity between~~of~~ surface and groundwater, and effects to groundwater quality in relation to natural groundwater quality. Water quality data will be presented in tables and graphs showing relationships between surface water and groundwater and applicable criteria. Groundwater elevation data will be evaluated to determine the influence of project water bodies on recharge to groundwater, and ~~any~~potential adverse

effects from ~~potential~~ project recharge.~~ ~~.Groundwater level data will be presented on contour maps.

Water quality data from the ponds and river will also be presented in tables and graphs to illustrate their relationship. Water levels in the river and ponds will be presented in graphs to illustrate their hydraulic connectivity, water quality relationship, and time (lag) relationship for changes in elevation.

Compliance with groundwater quality objectives will be used to evaluate project effects on designated beneficial uses for groundwater in the project area as defined in the Basin Plan. Information developed from this study will be presented to the SWRCB for review and determination of conditions to be included in the water quality certification to comply with Section 401 of the Federal Clean Water Act. The certification requires a determination by the SWRCB that the project complies with appropriate requirements of the CVRWQCB Basin Plan. The water quality certification is needed to file with the application for license renewal with the Federal Energy Regulatory Commission. ~~Mitigation measures will be investigated for parameters affected by the project that do not meet Basin Plan Standards, and recommendations developed for implementation.~~

Coordination with Other Resource Areas/Studies

This study will provide information for determination of project compliance with water quality standards and other appropriate requirements in the application for water quality certification.

This study will be coordinated with Study Plan SPW1 (Issue Sheets W1, W2, and W3), and use water quality data for the Feather River from that study for comparison with groundwater quality data. The study will also be coordinated with Study Plan SPW2 (Issue Sheet W6) for determination of hyporheic effects on contaminant accumulation in aquatic organisms in the Oroville Wildlife Area ponds. Water quality information from the ponds developed by this study will be used in the terrestrial and fisheries studies to evaluate any effects to terrestrial and fish species.

Schedule

The study will begin in ~~February~~early 2002. The initial stages of the study will focus on obtaining ~~previous~~existing information from groundwater monitoring in the area, and identifying suitable wells for monitoring. Groundwater monitoring for the study would begin during the~~-~~ spring of 2002 and continue for two monitoring seasons. Groundwater level monitoring would occur during the spring and fall, while water quality monitoring would be conducted during the summer. Subsequently, additional water quality monitoring may be warranted for parameters that exceed goals~~-~~ or criteria. Information developed in this study will be presented quarterly to the Environmental Workgroup and Task Force for review to evaluate the adequacy and progress of the study, and to provide information needed by the other environmental work groups. ~~-~~A

progress report will be prepared following completion of analysis of data from the first season of monitoring. A draft final report discussing results, implications for the project, and recommendations will be prepared at the end of the second season of monitoring.

Issues

W17. Effects of reservoirs and Feather River downstream of Oroville Dam on groundwater quality and quantity (e.g. hyporheic zone interaction). Issue Addressed: WE55

Table SPW5-1. Analytical methods and detection levels

Method	Analyte	Units	Reporting Limit
Minerals			
EPA 200 7 (D)	Dissolved Calcium	mg/L	1
EPA 200.7 (D)	Dissolved Sodium	mg/L	1
EPA 200.7 (D)	Dissolved Potassium	mg/L	0.5
EPA200.7 (D)	Dissolved Magnesium	mg/L	1
EPA 300.0 (28d hold)	Dissolved Sulfate	mg/L	1
EPA 300.0 28d Hold	Dissolved Chloride	mg/L	1
EPA 200.7 (D)	Dissolved Boron	mg/L	0.1
Std Method 2320 B	Alkalinity	mg CaCO3/L	0.1
Nutrients			
Std Method 4500-NO3-F I	Dissolved Nitrite + Nitrate	mg/L as N	0.05
EPA 350.1	Dissolved Ammonia	mg/L as N	0.02
Std Method 4500-NH3	Total Ammonia	mg/L as N	0.02
EPA 365.1	Dissolved Ortho-phosphate	mg/L as P	0.01
EPA 365.4	Total Phosphorus	mg/L	0.01
Metals			
EPA 1631	Total Mercury	ug/L	0.0002
EPA 1631	Total Methyl Mercury	ug/L	0.005
EPA 1632	Total and Dissolved Arsenic	ug/L	0.004
Std Method 3500-Fe D	Total and Dissolved Iron	ug/L	2.2
EPA 1638	Total and Dissolved Aluminum	ug/L	0.4
EPA 1638	Total and Dissolved Cadmium	ug/L	0.003
EPA 1638	Total and Dissolved Chromium	ug/L	0.03
EPA 1638	Total and Dissolved Copper	ug/L	0.01
EPA 1638	Total and Dissolved Lead	ug/L	0.005
EPA 1638	Total and Dissolved Manganese	ug/L	0.02
EPA 1638	Total and Dissolved Nickel	ug/L	0.01
EPA 1638	Total and Dissolved Selenium	ug/L	0.1
EPA 1638	Total and Dissolved Zinc	ug/L	0.03
Miscellaneous			
Std Method 2540 C	Total Dissolved Solids	mg/L	1
Std Method 2340 B	Hardness	mg/L as CaCO3	1
Std Method 2550 B 1	Temperature	degree Celcius	0.1
Std Method 4500-O C	Dissolved oxygen	mg/L	0.1
Std Methods 4500-H+ B	pH	pH units	0.1
Std Method 2510 B	Conductivity	umhos/cm	0.1
Pathogens			
Std Method 9222 B	Total Coliform bacteria	colonies/100 mL	0
Std Method 9222 D	Fecal Coliform bacteria	colonies/100 mL	0

Table SPW5-1. Analytical methods and detection levels, continued

Method	Analyte	Units	Reporting Limit
Pesticides			
Chlorinated Organic Pesticides			
EPA 508	Alachlor	µg/L	0.05
EPA 508	Aldrin	µg/L	0.01
EPA 508	Atrazine	µg/L	0.02
EPA 508	BHC-alpha	µg/L	0.01
EPA 508	BHC-beta	µg/L	0.01
EPA 508	BHC-delta	µg/L	0.01
EPA 508	BHC-gamma (Lindane)	µg/L	0.01
EPA 508	Captan	µg/L	0.02
EPA 508	Chlordane	µg/L	0.05
EPA 508	Chlorothalonil	µg/L	0.01
EPA 508	Chlorpropham	µg/L	0.02
EPA 508	Chlorpyrifos	µg/L	0.01
EPA 508	Cyanazine	µg/L	0.3
EPA 508	Dacthal (DCPA)	µg/L	0.01
EPA 508	Dichloran	µg/L	0.01
EPA 508	Dicofol	µg/L	0.05
EPA 508	Dieldrin	µg/L	0.01
EPA 508	Diuron	µg/L	0.25
EPA 508	Endosulfan sulfate	µg/L	0.02
EPA 508	Endosulfan-I	µg/L	0.01
EPA 508	Endosulfan-II	µg/L	0.01
EPA 508	Endrin	µg/L	0.01
EPA 508	Endrin aldehyde	µg/L	0.01
EPA 508	Heptachlor	µg/L	0.01
EPA 508	Heptachlor epoxide	µg/L	0.01
EPA 508	Methoxychlor	µg/L	0.05
EPA 508	Metolachlor	µg/L	0.2
EPA 508	Oxyfluorfen	µg/L	0.2
EPA 508	p,p'-DDD	µg/L	0.01
EPA 508	p,p'-DDE	µg/L	0.01
EPA 508	p,p'-DDT	µg/L	0.05
EPA 508	PCB-1016	µg/L	0.1
EPA 508	PCB-1221	µg/L	0.1
EPA 508	PCB-1232	µg/L	0.1
EPA 508	PCB-1242	µg/L	0.1
EPA 508	PCB-1248	µg/L	0.1
EPA 508	PCB-1254	µg/L	0.1
EPA 508	PCB-1260	µg/L	0.1
EPA 508	Pentachloronitrobenzene (PCNB)	µg/L	0.01
EPA 508	Ronnel	µg/L	0.3
EPA 508	Simazine	µg/L	0.02
EPA 508	Thiobencarb	µg/L	0.02
EPA 508	Toxaphene	µg/L	0.4
EPA 508	Trifluralin	µg/L	0.05

Table SPW5-1. Analytical methods and detection levels, continued

Method	Analyte	Units	Reporting Limit
Organic Phosphorus Pesticides			
EPA 508	Azinphos methyl (Guthion)	µg/L	0.05
EPA 508	Benfluralin	µg/L	0.01
EPA 508	Bromacil	µg/L	1
EPA 508	Carbophenothion (Trithion)	µg/L	0.02
EPA 508	Chlorpyrifos	µg/L	0.01
EPA 508	Cyanazine	µg/L	0.3
EPA 508	Demeton (Demeton O + Demeton	µg/L	0.02
EPA 508	Diazinon	µg/L	0.01
EPA 508	Dimethoate	µg/L	0.01
EPA 508	Disulfoton	µg/L	0.01
EPA 508	Ethion	µg/L	0.01
EPA 508	Malathion	µg/L	0.01
EPA 508	Methidathion	µg/L	0.02
EPA 508	Mevinphos	µg/L	0.01
EPA 508	Naled	µg/L	0.02
EPA 508	Napropamide	µg/L	5
EPA 508	Norflurazon	µg/L	5
EPA 508	Parathion (Ethyl)	µg/L	0.01
EPA 508	Parathion, Methyl	µg/L	0.01
EPA 508	Pendimethalin	µg/L	5
EPA 508	Phorate	µg/L	0.01
EPA 508	Phosalone	µg/L	0.02
EPA 508	Phosmet	µg/L	0.02
EPA 508	Profenofos	µg/L	0.01
EPA 508	Prometryn	µg/L	0.05
EPA 508	Propetamphos	µg/L	0.1
EPA 508	Ronnel	µg/L	0.01
EPA 508	s,s,s-Tributyl Phosphorotrithioate	µg/L	0.01
EPA 508	Trifluralin	µg/L	0.01
Volatile Organics (Purgeable)			
EPA 502.2	1,1,1,2-Tetrachloroethane	µg/L	0.5
EPA 502.2	1,1,1-Trichloroethane	µg/L	0.5
EPA 502.2	1,1,2,2-Tetrachloroethane	µg/L	0.5
EPA 502.2	1,1,2-Trichloroethane	µg/L	0.5
EPA 502.2	1,1-Dichloroethane	µg/L	0.5
EPA 502.2	1,1-Dichloroethene	µg/L	0.5
EPA 502.2	1,1-Dichloropropene	µg/L	0.5
EPA 502.2	1,2,3-Trichlorobenzene	µg/L	0.5
EPA 502.2	1,2,3-Trichloropropane	µg/L	0.5
EPA 502.2	1,2,4-Trichlorobenzene	µg/L	0.5
EPA 502.2	1,2,4-Trimethylbenzene	µg/L	0.5
EPA 502.2	1,2-Dibromo-3-chloropropane (DB	µg/L	0.5
EPA 502.2	1,2-Dibromoethane	µg/L	0.5
EPA 502.2	1,2-Dichlorobenzene	µg/L	0.5
EPA 502.2	1,2-Dichloroethane	µg/L	0.5

Table SPW5-1. Analytical methods and detection levels, continued

Method	Analyte	Units	Reporting Limit
Volatile Organics (Purgeable), continued			
EPA 502.2	1,2-Dichloropropane	µg/L	0.5
EPA 502.2	1,3,5-Trimethylbenzene	µg/L	0.5
EPA 502.2	1,3-Dichlorobenzene	µg/L	0.5
EPA 502.2	1,3-Dichloropropane	µg/L	0.5
EPA 502.2	1,4-Dichlorobenzene	µg/L	0.5
EPA 502.2	2,2-Dichloropropane	µg/L	0.5
EPA 502.2	2-Chlorotoluene	µg/L	0.5
EPA 502.2	4-Chlorotoluene	µg/L	0.5
EPA 502.2	4-Isopropyltoluene	µg/L	0.5
EPA 502.2	Benzene	µg/L	0.5
EPA 502.2	Bromobenzene	µg/L	0.5
EPA 502.2	Bromochloromethane	µg/L	0.5
EPA 502.2	Bromodichloromethane	µg/L	0.5
EPA 502.2	Bromoform	µg/L	0.5
EPA 502.2	Bromomethane	µg/L	0.5
EPA 502.2	Carbon tetrachloride	µg/L	0.5
EPA 502.2	Chlorobenzene	µg/L	0.5
EPA 502.2	Chloroethane	µg/L	0.5
EPA 502.2	Chloroform	µg/L	0.5
EPA 502.2	Chloromethane	µg/L	0.5
EPA 502.2	cis-1,2-Dichloroethene	µg/L	0.5
EPA 502.2	cis-1,3-Dichloropropene	µg/L	0.5
EPA 502.2	Dibromochloromethane	µg/L	0.5
EPA 502.2	Dibromomethane	µg/L	0.5
EPA 502.2	Dichlorodifluoromethane	µg/L	0.5
EPA 502.2	Ethyl benzene	µg/L	0.5
EPA 502.2	Fluorobenzene	µg/L	0.5
EPA 502.2	Hexachlorobutadiene	µg/L	0.5
EPA 502.2	Isopropylbenzene	µg/L	0.5
EPA 502.2	m + p Xylene	µg/L	0.5
EPA 8260	Methyl tert-butyl ether (MTBE)	µg/L	0.5
EPA 502.2	Methylene chloride	µg/L	0.5
EPA 502.2	n-Butylbenzene	µg/L	0.5
EPA 502.2	n-Propylbenzene	µg/L	0.5
EPA 502.2	Naphthalene	µg/L	0.5
EPA 502.2	o-Xylene	µg/L	0.5
EPA 502.2	sec-Butylbenzene	µg/L	0.5
EPA 502.2	Styrene	µg/L	0.5
EPA 502.2	tert-Butylbenzene	µg/L	0.5
EPA 502.2	Tetrachloroethene	µg/L	0.5
EPA 502.2	Toluene	µg/L	0.5
EPA 502.2	trans-1,2-Dichloroethene	µg/L	0.5
EPA 502.2	trans-1,3-Dichloropropene	µg/L	0.5
EPA 502.2	Trichloroethene	µg/L	0.5
EPA 502.2	Trichlorofluoromethane	µg/L	0.5
EPA 502.2	Vinyl chloride	µg/L	0.5

Table SPW5-1. Analytical methods and detection levels, continued

Method	Analyte	Units	Reporting Limit
Chlorinated Phenoxy Acid Herbicides			
EPA 515.1	2,4,5-T	µg/L	0.1
EPA 515.1	2,4,5-TP (Silvex)	µg/L	0.1
EPA 515.1	2,4-D	µg/L	0.1
EPA 515.1	2,4-DB	µg/L	0.1
EPA 515.1	2,4-Dichlorophenylacetic acid (DC	µg/L	0.1
EPA 515.1	Dacthal (DCPA)	µg/L	0.1
EPA 515.1	Dicamba	µg/L	0.1
EPA 515.1	Dichlorprop	µg/L	0.1
EPA 515.1	Dinoseb (DNPB)	µg/L	0.1
EPA 515.1	MCPA	µg/L	0.1
EPA 515.1	MCPP	µg/L	0.1
EPA 515.1	Pentachlorophenol (PCP)	µg/L	0.1
EPA 515.1	Picloram	µg/L	0.1
EPA 515.1	Triclopyr	µg/L	0.1
Glyphosate			
EPA 547	Aminomethylphosphonic Acid (AM	µg/L	100
EPA 547	Glyphosate	µg/L	100
Carbamate Pesticides			
EPA 531.1	3-Hydroxycarbofuran	µg/L	2
EPA 531.1	Aldicarb	µg/L	2
EPA 531.1	Aldicarb sulfone	µg/L	2
EPA 531.1	Aldicarb sulfoxide	µg/L	2
EPA 531.1	Carbaryl	µg/L	2
EPA 531.1	Carbofuran	µg/L	2
EPA 531.1	Formetanate hydrochloride	µg/L	100
EPA 531.1	Methiocarb	µg/L	4
EPA 531.1	Methomyl	µg/L	2
EPA 531.1	Oxamyl	µg/L	2
Pyrethrins	will be analyzed if a suitable method becomes available		

Oroville Facilities Relicensing
Environmental Work Group
Draft Study Plan

SP-W6. Project Effects on Temperature Regime

Introduction

Existing and future operation of the Oroville Facilities may have effects on the temperature goals and objectives for the Feather River. Issues raised at public meetings include: effects of existing and future project facilities and operations on thermal stratification and other thermal processes on project waters, including availability of cold water for release in various water year types under current and future operational demands (W9); effects of existing and future water releases and operations on water temperatures in the Diversion Pool, Forebay, Afterbay, Oroville Wildlife Area, low-flow section of the river and downstream areas; at the hatchery; for agriculture; and the quality and availability of habitat for salmonids and other aquatic resources (W10); existing and future project compliance with temperature requirements of the SWP Feather River Flow Constraints and effectiveness of constraints for a) protection of salmonids in the low-flow and high-flow sections of the Feather River, b) hatchery operation, and c) agricultural operations (W11); effects of existing and future project facilities and operations on access to the cold water pool during below normal water years and multiple below normal water years under existing and future operational demands, and effectiveness of the Temperature Control Device in providing access (W12); effects of existing and future hatchery operations on water quality and water temperatures in the Feather River and Afterbay (W13); and effects of existing and future pump-back operations on water quality and water temperatures in Lake Oroville, Diversion Pool, Thermalito Forebay, Thermalito Afterbay, and Oroville Wildlife Area, habitat suitability, and outmigration for salmonids (W14).

Some temperature data have been collected from the North, Middle, and South forks of the Feather River near their confluences with Lake Oroville, from the reservoir itself, and downstream from Oroville Dam in the Feather River, Thermalito Power Canal, and Thermalito Afterbay. However, these data are not sufficient to determine compliance with all Basin Plan objectives, goals, and criteria for the designated beneficial uses. Additional temperature data and analyses are needed to demonstrate project compliance with Basin Plan objectives, commitments, and other requirements.

Objectives

The objectives of the study are to evaluate effects of project facilities and operations on the temperature regime of project waters and waters affected by the project, and the ability of the project to meet the temperature requirements for protection of beneficial uses, including agriculture, fish, and other aquatic resources.

Relationship to Relicensing/Need for Study

Construction of Oroville Dam resulted in an altered thermal regime of waters within the project boundary and downstream in the Feather River, which can have significant effects on the ecosystem. Temperatures downstream from large reservoirs are generally cooler than normal during the summer but warmer than normal during the winter. These temperature changes can have significant effects on beneficial uses of water released downstream. Cooler water diverted from the Thermalito Afterbay and directly from the Feather River for agriculture during the spring and summer may delay seed germination or crop growth. Water temperatures for various life stages of fish may not be suitable or conflict with temperature requirements of other beneficial uses. Aquatic insect communities that serve as food for fish may be reduced due to cooler summer temperatures that slow growth, which subsequently may cause emergence to the terrestrial life cycle to be delayed to a period when air temperatures are no longer suitable for survival. Large shallow water bodies such as the Thermalito Forebay and Afterbay may affect water quality by providing water temperatures that facilitate conversion of sediment-bound metals (e.g., mercury) to bioavailable forms (e.g., methylmercury), which can have significant effects on the aquatic food chain, wildlife, and humans.

Prior to issuance of a new license for the project, the Federal Energy Regulatory Commission will require a water quality certification by the State Water Resources Control Board. The certification requires a determination by the SWRCB that the project complies with appropriate requirements of the CVRWQCB Basin Plan, which includes water quality objectives for protection of designated beneficial uses. The CVRWQCB has established surface water quality objectives for temperature. In addition, DWR has agreements with the Department of Fish and Game for temperature objectives for the Feather River Fish Hatchery and with several water districts for temperature objectives for irrigation. The National Marine Fisheries Service has also identified temporary temperature goals in the Feather River downstream from Oroville Dam for salmonids that are listed under the federal Endangered Species Act.

Information obtained from the study will be used to determine the ability of the project to meet water temperature requirements, and the need for project modification or mitigation for impacts to water temperature from project operations. This analysis is required for water quality certification by the SWRCB. The water quality certification is needed to file with the application for license renewal with the Federal Energy Regulatory Commission.

Study Area

The study area is generally within the FERC project boundary, but also includes the Feather River downstream to the confluence with the Sacramento River. Specific water bodies included in the study plan are the North, Middle, and South Forks and West Branch of the Feather River, Concow Creek, Lake Oroville, Feather River downstream from Oroville Dam to the confluence with the Sacramento River, Thermalito Diversion Pool, Forebay, and Afterbay, and Oroville Wildlife Area ponds.

Methodology and Analysis

Task 1. Thermal regime of project waters (Issue Sheet W9)

Determination of existing project effects on thermal processes in project waters will involve empirical analysis of temperature data, while evaluation of future project effects will require development and calibration of a temperature model to simulate conditions. Where historic and current temperature data are not sufficient to evaluate project effects under various hydrologic conditions, the temperature model will be used to simulate temperature conditions for analysis. Output from the temperature model will provide information for a greater range of operations than may be able to be empirically analyzed.

Sub-Task 1a. Existing project effects on thermal regime of project waters

Some existing temperature data have been collected from the tributaries to the reservoir, Lake Oroville, Feather River downstream from Oroville Dam, and Thermalito Afterbay Outlet to the Feather River and Western Canal. These data will be compiled into a computer database for access and evaluation.

Additional temperature data will be collected at the existing monitoring sites as well as additional sites to provide information needed for analyses of project effects on the thermal regime of project waters. Continuously recording loggers (Onset Optic Stowaway) will be used to record temperatures at 15--minute intervals at river or discharge (e.g., hatchery, Thermalito Afterbay Outlet) monitoring locations (Table 1, Figure 1). Redundant recorders will be placed on opposite banks at sites most subject to vandalism to reduce potential loss of data. Temperature loggers will be serviced and data downloaded to lap top computers at intervals not exceeding monthly, but more frequently at sites where recorder loss is prevalent.

Temperature profiles will be measured with a thermistor at half-meter intervals in deeper pools in holding and spawning areas in the Feather River downstream from the dam for determination of effects of flow on thermal stratification. Temperature profiles will be measured from a variety of flow patterns during the summer and fall.

Water temperatures will be measured at monthly intervals during the winter and biweekly from spring to fall in impounded waters (Lake Oroville, Thermalito Diversion Pool, Forebay, and Afterbay, and Fish Barrier Pool) and ponds in the Oroville Wildlife Area. Temperature profiles will be measured in Lake Oroville and with a thermistor at meter intervals when temperature differences are observed between successive depth measurements, and at three to five meter intervals when temperatures are uniform between depths. Temperature profiles will be measured at half to one-meter intervals in the other water bodies from the surface to the bottom using a thermistor. Cross section measurements will also be conducted at the Forebay and Afterbay to determine variation in temperatures in shallower and deeper areas, arms, and bays.

Existing and newly collected data will be evaluated to determine thermal processes in Lake Oroville, Thermalito Diversion Pool, Forebay, and Afterbay, Fish Barrier Pool, Oroville Wildlife Area ponds, and the Feather River. Temperature data and the depth-capacity curve for the reservoir will be used to evaluate the extent of the cold water pool under existing project operations. Temperature data from the river will be used to evaluate existing effects from the hatchery and Thermalito Afterbay Outlet.

Sub-Task 1b. Future project effects on thermal regime of project waters

The Engineering and Operations Workgroup has prepared a study plan that will develop the necessary tools to simulate the physical attributes of Oroville Facilities operations in support of studies involving changes or impacts to flow, water temperature, sediment transport, and power generation. The study plan will result in development of a model to simulate expected temperature conditions from potential future project operations.

Model calibration and verification will be dependent on use of existing data and additional temperature data collected under Sub-Task 1a of this study. In addition, model development will require stage/discharge relationships at key locations along the river. Presently, stage/discharge is determined near the project boundary along the Feather River only near Gridley. Discharge relationships may have to be developed for other sites along the Feather River for model development and calibration. Installation of equipment and development of rating tables at sites where additional discharge data are necessary for model development and calibration will be coordinated with the Engineering and Operations Workgroup.

The temperature model will be used to evaluate effects from potential future project operations on the cold water pool in Lake Oroville, and daily water temperatures in the Thermalito Diversion Pool, Forebay, and Afterbay, and Fish Barrier Pool. The model will also be used to simulate hourly temperatures at designated control points in the project area of the Feather River due to potential future project operations.

Task 2. Project effects on water temperatures downstream from Oroville Dam (Issue Sheet W10)

Effects of existing and future project operations, including water releases, on temperatures in the Thermalito Diversion Pool, Forebay, and Afterbay, Fish Barrier Pool, Oroville Wildlife Area ponds, and Feather River downstream to the Thermalito Afterbay Outlet will be assessed in Task 1. Effects of existing and future project operations on water temperatures downstream from the project boundary will be assessed in this task. This assessment will include water temperatures in the Feather River downstream from the Thermalito Afterbay Outlet, agricultural canals fed by the Thermalito Afterbay, and downstream agricultural diversions from the Feather River.

Sub-Task 2a. Existing project effects on thermal regime downstream from project boundary

Temperature data will be collected at existing and additional monitoring sites downstream from the Afterbay Outlet (Figure 2) to provide information needed for analyses of existing project effects on the thermal regime in the Feather River and agricultural diversions. Continuously recording loggers (Onset Optic Stowaway) will be used to record temperatures at 15-minute intervals at the monitoring locations. Redundant recorders will be placed on opposite banks at critical sites to reduce potential loss of data. Temperature loggers will be serviced and data downloaded to lap top computers at intervals not exceeding monthly, but more frequently at sites where recorder loss is prevalent. Temperature data from the river and diversions will be used to evaluate existing effects due to project releases from the dam and the Thermalito Afterbay.

Sub-Task 2b. Future project effects on thermal regime downstream from project boundary

The temperature model developed in Task 1 will be expanded to include simulation of temperature conditions due to potential future project operations in the Feather River downstream from the Afterbay Outlet and in agricultural diversions from the Afterbay and river. Model calibration and verification will be dependent on temperature data collected under Sub-Task 2a. Model development will require stage/discharge relationships at key locations along the river and diversion canals. Presently, stage/discharge is determined along the Feather River only near Gridley, while stage only is measured near Live Oak, Yuba City, Boyd's Landing (downstream from Yuba City), and Nicolaus. Tributary stage/discharge measurements are also available from the Yuba River near Marysville and Bear River near Wheatland. Discharge relationships may have to be developed for the stage only gages or other sites along the Feather River for model development and calibration. Installation of equipment and development of rating tables at sites where additional discharge data are necessary for model development and calibration will be coordinated with the Engineering and Operations Workgroup.

The temperature model will be used to simulate hourly temperatures due to potential future project operations at designated control points in the Feather River and agricultural diversions.

Task 3. Project effects on temperature compliance (Issue Sheet W11)

Various agreements have established temperature requirements downstream from Oroville Dam. An agreement with the Department of Fish and Game specifies water temperatures at the Feather River Hatchery for raising chinook salmon and steelhead, and between the Thermalito Afterbay Outlet and Verona to provide suitable temperatures during the fall for fall-run chinook salmon and from May through August for shad and striped bass. The National Marine Fisheries Service issued a Biological

Opinion in 2001 that included a~~requires the project to meet~~ temporary temperature objective~~s~~ that will avoid or minimize Oroville's adverse effect to spring-run chinook salmon and steelhead between March 2001 and February 2002. This temporary objective was~~, and~~ to maintain water temperatures in the low flow channel from June 1 through September 30, 2001 to a daily average temperature of no more than 65 °F to protect over-summering steelhead. A new Biological Opinion is expected in March 2002 that will likely also include temperature objectives from June through September of 2002 and 2003. DWR and NMFS also expect to develop a long-term Biological Opinion that would likely include temperature objectives after March, 2004. An additional agreement with several irrigation districts concerns suitable water temperatures for maintaining agricultural production with water diverted from the Thermalito Afterbay and Feather River. In addition, the Central Valley Regional Water Quality Control Board's Basin Plan has designated beneficial uses for the Feather River from the Fish Barrier Dam to the Sacramento River as cold freshwater habitat, salmon and steelhead migration, and salmon and steelhead spawning.

Sub-Task 3a. Existing project effects on temperature compliance

Effects of existing project operations on fisheries and agriculture temperature compliance will be evaluated with data obtained in Tasks 1 and 2. Data obtained from these tasks will be compared to the temperature requirements in the various agreements, Biological Opinions, and Basin Plan to determine project compliance.

Sub-Task 3b. Future project effects on temperature compliance

The temperature model developed in Task 1 will be used to simulate temperature conditions due to potential future project operations in the Feather River. This simulation will be used to determine compliance of future project operations with the temperature agreements, Biological Opinions, and Basin Plan.

Task 4. Access to cold water pool (Issue Sheet W12)

Water temperatures in the Feather River downstream from Oroville Dam are regulated by a temperature control intake structure. This structure consists of a series of shutters that are removed to withdraw water down to a specific depth in the reservoir. As the reservoir level decreases, additional shutters are opened to maintain downstream temperatures. Drought years reduce the cold water pool available for downstream release. The intake structure controls the lake level from which water is withdrawn to supply water to the hatchery and low-flow channel for temperature maintenance. Since all controlled water releases from the reservoir pass through the intake structure, water released for downstream water supply and power generation is obtained from the same depths as that for temperature maintenance at the hatchery and low flow channel, which further reduces the cold water pool.

Sub-Task 4a. Existing project effects on cold water pool

Current data collection activities include monthly temperature profiles in the reservoir near the intake structure, daily reservoir water levels, daily reservoir releases, and several sites in the Feather River downstream from the dam to the Sacramento River. Temperature data from thermistors positioned on the intake structure every 18 to 19 feet from the 612 to 819 foot elevation are recorded once per month. The frequency of temperature recording from the thermistors will be increased to daily.

Additional monthly temperature profiles will be obtained in other areas of the reservoir (Figure 3) using the methods specified in Sub-Task 1a to determine whether intake structure withdrawals produce local or wider ranging effects to water column temperatures. The depicted profile locations in Figure 3 may be modified or additional locations added depending on results of the initial temperature measurements. Water column effects from intake structure operations will be determined by comparing temperature profile~~s~~ graphs near the intake structure with those obtained further away. Temperature profiles will also be obtained at the profile monitoring locations preceding and following pump-back operations to determine effects to water column temperatures.

Previous reservoir temperature data, additional reservoir temperature data collected during this study, reservoir water level data, reservoir releases data, and downstream temperature data will be evaluated to determine the effects of the project on the cold water pool and the effectiveness of the project to meet temperature requirements during various water year types.

Sub-Task 4b. Future project effects on cold water pool

Water temperature data collected in Sub-Task 4a will be used to calibrate a temperature model for the reservoir. The reservoir temperature model will be used to evaluate effects from potential future project operations on the cold water pool in Lake Oroville and temperature of water released from the reservoir. The river temperature model developed in Task 1 will be used to simulate hourly temperatures at designated control points in the Feather River resulting from reservoir release temperatures. The river temperature simulations will be used to determine the ability of the project to comply with the various temperature requirements.

Task 5. Hatchery effects on water quality (Issue Sheet W13)

The depth at which water is released from the reservoir to provide suitable temperatures at the fish hatchery also controls the temperature of the water in the low flow section of the Feather River and water diverted to the Thermalito Afterbay for release to agricultural users. Similarly, the quality of water released to the low flow channel and the Afterbay is controlled by the quality of water at the depth of release from the reservoir to maintain hatchery temperatures. In addition, chemicals used at the hatchery and fish waste products are diverted to holding ponds that percolate into the ground which then may leach to the adjacent Feather River. Water quality effects to the Feather River from the hatchery are analyzed in Study Plan SPW4, while effects

from reservoir withdrawal elevations are analyzed in Study Plan SPW1. Hatchery effects on temperatures are analyzed in this study plan.

Sub-Task 5a. Existing hatchery effects on water quality

This study plan evaluates the existing effects to beneficial uses of water released from Oroville Dam to maintain water temperatures at the hatchery, and effects to water temperatures in the Feather River from hatchery discharges.

Evaluation of the existing effects to beneficial uses of water released for maintenance of temperatures at the hatchery will use data collected in Tasks 1 and 2. The data will be compared to temperature agreements for fisheries and agriculture, Basin Plan Standards, and ~~the~~ Biological Opinions.

The fish hatchery does not directly discharge to the Feather River. However, water leaching to the Feather River from percolation in the wastewater holding ponds could affect water temperatures in the river. Evaluation of the effects of hatchery discharges through percolation of wastewater on temperatures in the Feather River will use data collected in Task 1. Additional temperature data along the Feather River adjacent to the hatchery will be collected with a thermistor to help determine locations of hatchery water leaching to the river. Upstream and downstream water temperatures will be compared to determine effects from the hatchery. Any changes in temperature due to hatchery discharges will be compared with the temperature objectives for fisheries and agriculture, Basin Plan Standards, and Biological Opinions to determine their significance.

Sub-Task 5b. Future hatchery effects on water quality

Hatchery operations are presently undergoing review. Results of this review will be evaluated to determine any changes in hatchery operations that may affect water temperatures. The temperature model developed in Task 1 will be used to simulate the effects of any future altered hatchery operation on water temperatures in the Feather River. Model simulation results will be used to determine effects to beneficial uses as described in the Basin Plan, temperature agreements, and ~~requirements of the~~ Biological Opinions.

Task 6. Effects of pump-back operations (Issue Sheet W14)

Water can be pumped back from the Thermalito Afterbay, Forebay, and Diversion Pool for reuse in power generation. Water from the Diversion Pool is discharged into the reservoir through the temperature control intake structure. Potentially warmer water from the Diversion Pool can disrupt the reservoir temperature profile near the intake structure. In addition, potentially warmer water pumped back into the Diversion Pool can be released to the low flow section of the Feather River that may affect hatchery operations and fisheries in the river.

Sub-Task 6a. Existing effects of pump-back operations

Water temperature data for evaluation of existing effects of pump-back operations in the reservoir and river will be obtained from Tasks 1 and 4. In addition, water profile temperatures will be measured in the Thermalito Diversion Pool, Power Canal, Forebay, and Afterbay immediately preceding and following pump-back operations to determine the effects on the temperature regime in these impoundments. A range of pump-back operations (e.g., volume of water pumped, duration of pumping) and temperature conditions (e.g., early summer, mid-summer, late summer) will be monitored to determine pump-back and temperature conditions that produce critical effects. The data will be compared with the various temperature agreements, Basin Plan Standards, and Biological Opinions to evaluate effects from pump-back operations on beneficial uses.

Effects from pump-back operations on water temperatures at the hatchery will be evaluated using temperature and pump-back records from historic operations, as well as data obtained during this study. Water temperatures at the hatchery will be compared prior to and following pump-back operations to determine whether any changes in temperatures occurred. These records will be compared for a range of pump-back operations and temperature conditions. These comparisons will be presented in graphical format.

Sub-Task 6b. Future effects of pump-back operations

The temperature model developed in Task 1 will be used to simulate temperatures in Lake Oroville, Thermalito Diversion Pool, Forebay, Afterbay, and the fish hatchery to determine the effects of any future altered project operations. The results of the model simulation will be used to determine compliance with various temperature agreements, Basin Plan Standards, and Biological Opinions.

Results

Results from this study will be used to evaluate effects of the project on water temperatures both within and downstream from project boundaries. Data obtained from the study will also be used to determine the ability of the project to meet temperature requirements for protection of beneficial uses, including agriculture, fish, and other aquatic resources.

Results from this study will be presented in a detailed report that evaluates existing and future effects of the project to water temperatures. Historical and current temperature data will be presented in graphs depicting the thermal regime in different water year types, for which data are available, for project waters and the Feather River downstream from the project. Graphs will depict thermal stratification in Lake Oroville, Thermalito Diversion Pool, Forebay, and Afterbay, and Oroville Wildlife Area ponds. Effects of the intake structure and pump-back operations on water column stratification in Lake Oroville will also be depicted in graphs for different periods and levels of

withdrawal and pumping. Graphs depicting conditions in the Feather River downstream from Oroville Dam will illustrate daily maximum, minimum, and mean daily temperature variations (based on 15-minute data collected to compute hourly values) over the course of the year at key locations, such as the hatchery or agricultural diversion points. Graphs will also depict how temperatures in the Feather River change from the upper to lower reaches.

Output from the temperature model will be in the form of curves or graphs (e.g., exceedance curves, temperature vs. time of year at key locations, temperature vs. river mile, etc.) that can be used to evaluate future project effects. Additional model output will be coordinated with the Environmental Workgroup, Task Force, and regulatory agencies to provide information in the format these groups may require for analysis of effects. This analysis will be dependent on any decisions that necessitate changes in project operations, and may not be available until completion of other studies or negotiations.

Compliance with the various temperature agreements, Basin Plan Standards, and Biological Opinions will be used to evaluate both existing and future effects of the project to water temperatures. Information derived from this study will be used by the SWRCB to determine conditions in the water quality certification to comply with Section 401 of the Federal Clean Water Act.

Coordination with Other Resource Areas/Studies

This study plan provides the information for evaluation of Issue Sheets W9 (thermal regime of project waters), W10 (project effects on water temperatures downstream from Oroville Dam), W11 (project effects on temperature compliance), W12 (access to cold water pool), W13 (hatchery effects on water quality), and W14 (effects of pump-back operations). This study plan coordinates with data collection activities of Study Plan W1 (project effects on water quality designated beneficial uses) and W4 (hatchery effects on water quality). This study plan provides temperature data to the Engineering and Operations Study Plan 1 for temperature model calibration and verification, and will rely on the temperature model developed in that study plan to provide temperature simulations for evaluation of future effects of the project. In addition, the study plan provides data for evaluation of effects of water temperature to habitat suitability and fisheries in Fisheries Study Plans SPF10 (Appendices A and C), and SPF15.

Schedule

Data collection activities will begin in ~~February~~early 2002 and continue for at least two years. Concurrently, the temperature models will be developed by the Engineering and Operations Workgroup. A progress report will be prepared by March of 2003, and a draft final report discussing results of the two-year study will be prepared by June of 2004. Interim output products will be identified through coordination with other work groups to meet their data needs.

Issues

W9. Effects of existing and future project facilities and operations on thermal stratification and other thermal processes on project waters, including availability of cold water for release in various water year types under current and future operational demands. Issues Addressed: WE16, WE19, WE25, WE32, G4, F1, F3, FE89

W10. Effects of existing and future water releases and operations on water temperatures in the Diversion Pool, Forebay, Afterbay, Oroville Wildlife Area, low-flow section of the river and downstream areas; at the hatchery; for agriculture; and the quality and availability of habitat for salmonids and other aquatic resources. Issues Addressed: WE17, WE19, WE25, WE28, WE29, WE32, WE40, WE46, WE54, F1, F10, F11, FE3, FE8, FE41, FE46, FE49, FE52, FE56, FE81, FE85, FE89, FE90, FE95, FE96, FE99

W 11. Existing and future project compliance with temperature requirements of the SWP Feather River Flow Constraints and effectiveness of constraints for a) protection of salmonids in the low-flow and high-flow sections of the Feather River; b) hatchery operation; and c) agricultural operations. Issues Addressed: WE18, WE20, WE21, WE25, WE46, WE54, F11, FE33, FE41, FE46, FE49, FE56, FE89, FE90

W12. Effects of existing and future project facilities and operations on access to the cold-water pool during below normal (BN) water years and multiple BN water years under existing and future operational demands, and effectiveness of the Temperature Control Device in providing access. Issues Addressed: WE19, WE22, WE23, F1, FE3, FE85, FE89, FE90, FE95, FE96

W13. Effects of existing and future hatchery operations on water quality and water temperatures in the Feather River and Afterbay. Issues Addressed: WE26, WE33, F1, F9, FE88, FE89, FE90, FE95, FE96, FE99

W 14. Effects of existing and future pump-back operations on water quality and water temperatures (in Lake Oroville, Diversion Pool, Forebay, Afterbay, and Oroville Wildlife Area), habitat suitability, and outmigration for salmonids. Issues Addressed: WE25, WE27, WE54, F1, FE3, FE85, FE89, FE90, FE95, FE96

Table SPW6-1. Temperature Measurement Sites in Project and Downstream Waters

	Location	Measurement Method	Rationale
1	West Branch nr gage	Recorder	a,b
2	West Branch at Oroville Reservoir	Recorder	a,b,c
3	Concow Cr at Jordan Hill Road	Recorder	a,b
4	Concow Creek at Oroville Reservoir	Recorder	a,b,c
5	North Fork nr Poe Dam	Recorder	a,b
6	North Fork at Oroville Reservoir	Recorder	a,b,c
7	French Creek	Recorder	a,b,c,d
8	Middle Fork at Milsap Bar Road	Recorder	a,b
9	Middle Fork at Oroville Reservoir	Recorder	a,b,c
10	Fall River	Recorder	c
11	South Fork	Recorder	c
12	Ponderosa Reservoir	Profile	c
13	Sucker Run	Recorder	a,b,c,d
14	North Fork Arm Lake Oroville	Profile	b,e
15	Middle Fork Arm Lake Oroville	Profile	b,e
16	South Fork Arm Lake Oroville	Profile	b,e
17	Lake Oroville Main Body	Profile	b,e
18	Lake Oroville nr. Dam	Profile	b,e
19	Lake Oroville Intake Structure	Sensors/SCADA	e,f
20	Hyatt tailrace	Sensor/SCADA	e
21	Diversion Pool ab. Kelly Ridge PH	Profile	e
22	Kelly Ridge PH Discharge	Recorder	e
23	Diversion Pool bl. Kelly Ridge PH	Profile	e
24	Diversion Pool nr. Diversion Dam	Profile	e
25	Diversion Dam Power Plant	Sensor/SCADA	e
26	Thermalito Power Canal at Diversion Pool	Sensor/SCADA	e
27	Thermalito Power Canal at Hwy 70	Sensor/SCADA	e
28	Thermalito Forebay (north)	Profile	e,g
29	Thermalito Forebay (south)	Profile	e,g
30	Thermalito Pumping-Generating Plant	Sensor/SCADA	e
31	Thermalito Afterbay (north)	Profile	e,g
32	Thermalito Afterbay (south)	Profile	e,g
33	Afterbay Outlet to Western Canal	Sensor/SCADA	e,h
34	Afterbay Outlet to Sutter Buttes Canal	Sensor/SCADA	e,h
35	Afterbay Outlet to PGE	Sensor/SCADA	e,h
36	Afterbay Outlet to Feather River	Sensor/SCADA	d,e,g,h,k
37	Oroville Wildlife Area Ponds	Profile	b
38	USGS Gage ab. Fish Barrier Dam	Recorder	b,e
39	Fish Barrier Dam	Sensor/SCADA	e,I,j

Table SPW6-1. Temperature Measurement Sites, continued

	Location	Measurement Method	Rationale
40	Feather River ab. Hatchery	Recorder	d,e,I
41	Feather River Fish Hatchery	Sensor/SCADA	e,j
42	Hatchery Wastewater Pond	Recorder	k
43	Hatchery ditch	Recorder	k
44	Feather River bl. Hatchery	Recorder	d,e,I,k
45	Feather River at Auditorium Riffle	Recorder	d,e,I,h
46	Feather River bl. Hwy 162	Recorder	d,e,I,h
47	Feathehr River at Robinson Riffle	Recorder	d,e,I,h
48	Feather River at Eye Riffle	Recorder	d,e,I,h
49	Feather River ab. Afterbay Outlet	Recorder	d,e,I,h
50	Feather River bl. Afterbay Outlet	Recorder	d,e,h,k,L
51	Feather River bl. SCOR Outfall	Recorder	k
52	Feather River nr. Mile Long Pond	Recorder	d,e,h,L
53	Feather River nr. Gridley	Recorder	d,e,h,L
54	Feather River ab. Honcut Creek	Recorder	d,e,h,L
55	Honcut Creek	Recorder	e,k
56	Feather River nr. Live Oak	Recorder	d,e,h,L
57	Feather River ab. Yuba River	Recorder	d,e,h,L
58	Yuba River at Marysville	Recorder	e,k
59	Feather River at Shanghai Bend	Recorder	d,e,h,L
60	Feather River at Star Bend	Recorder	d,e,h,L
61	Bear River	Recorder	e,k
62	Feather River nr. Nicolaus	Recorder	d,e,h,L
63	Feather River nr. Verona	Recorder	d,e,h,L

a. Fisheries acces, passage
b. Habitat quality, evaluation
c. Inflow effects to reservoir temperatures
d. Endangered species concern
e. Temperature model calibration
f. Effects to stratification
g. Temperature effects to water quality (e.g., Hg methylation)
h. Effects to agricultural beneficial uses
I. Biological Opinion temperature compliance
j. Fish hatchery temperature agreement
k. Discharge effects to river temperature
L. Basin Plan standards compliance

Figure SPW6-1. Temperature monitoring locations for Project waters

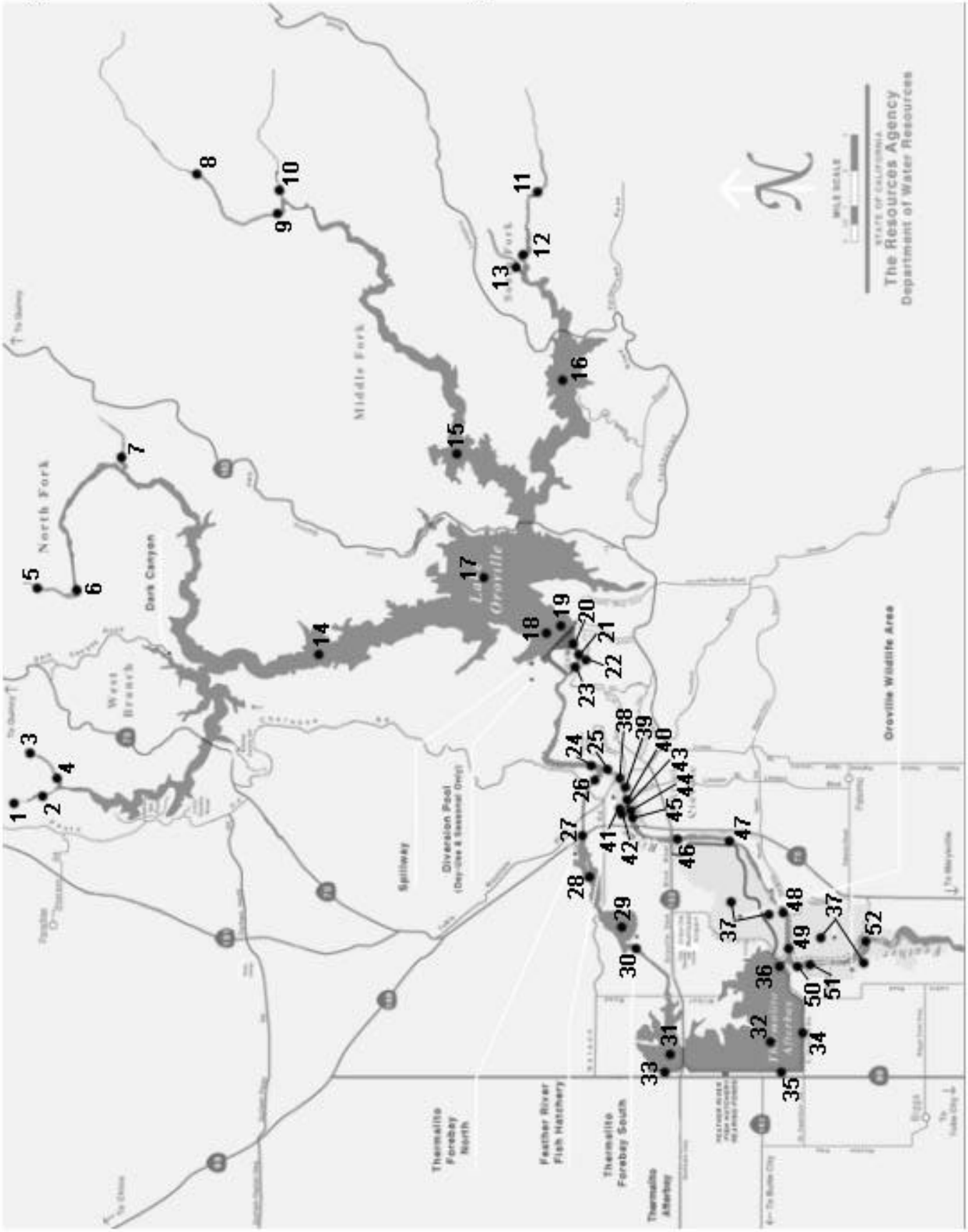


Figure SPW6-2. Temperature monitoring locations in the lower Feather River

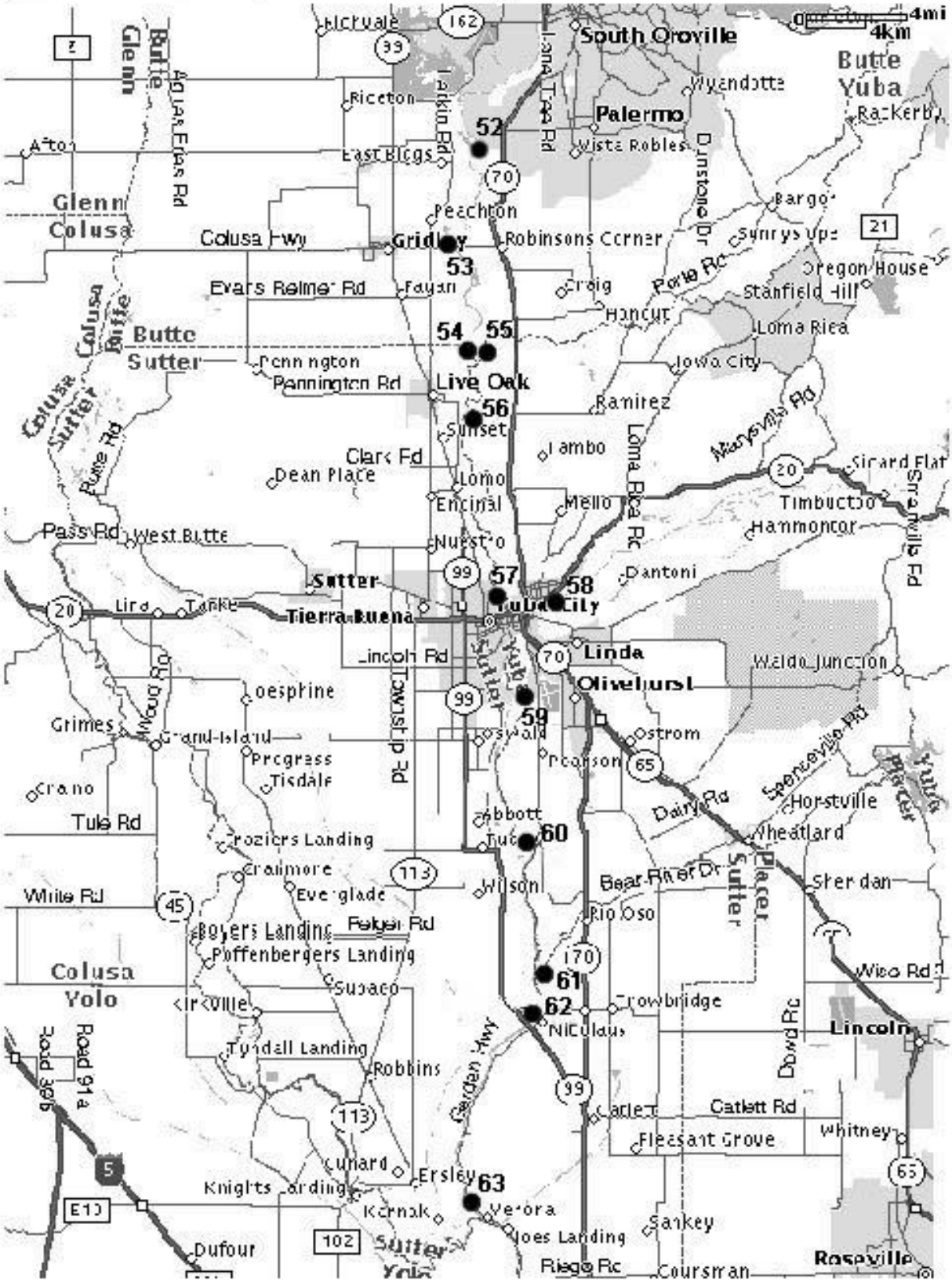
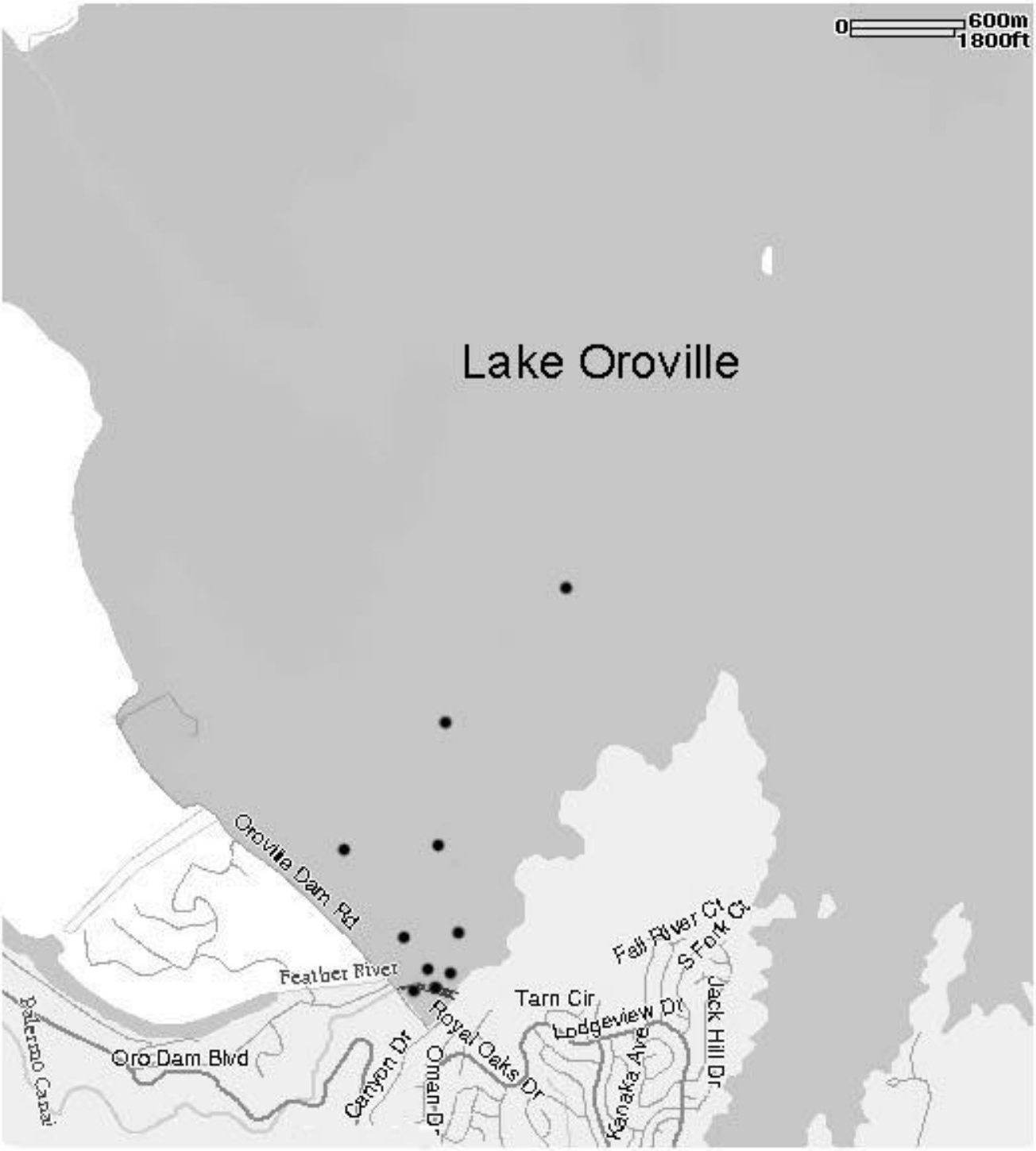


Figure SPW6-3. Illustrative temperature monitoring sites (•) near the Temperature Control Intake Structure



Environmental Work Group
Draft Study Plan

SPW7. Land and Watershed Management

Introduction

Land and watershed management activities within and adjacent to the project area have the potential to affect water quality and other aquatic and terrestrial resources. The Environmental Workgroup raised several issues related to land and watershed management effects on aquatic and terrestrial resources, including:

- protection of riparian areas and water quality by limiting disturbance in streamside management zones
- use of Best Management Practices during land use and management activities to avoid water quality degradation
- rehabilitation of deteriorating watersheds to reduce channel erosion, sedimentation, and sediment yield
- plan and manage on a watershed scale in cooperation with other agencies and private landowners
- effects of land use and management activities on terrestrial plant and animal communities and habitats.

The Feather River watershed is very large (about 3,600 square miles upstream from Oroville Dam), but only a small percentage is within the project boundary (about 41 square miles upstream from Oroville Dam). Therefore, land and watershed management activities that potentially affect aquatic and terrestrial resources in the watershed predominantly occur on non-project controlled lands, which limits the ability of the project to manage these activities. Land and management activities occurring in the upper watershed may affect downstream resources, including those present within the project boundary.

Most of the land within the watershed upstream from Oroville Dam is owned by the federal government, and is predominantly managed by the U.S. Forest Service with smaller holdings managed by the Bureau of Land Management and some dispersed lands in private ownership. Some of the lands in private ownership along the tributaries to Lake Oroville have been developed with hydroelectric generation facilities, especially along the North Fork by the Pacific Gas and Electric Company. A small portion of the land within the project boundary upstream from Oroville Dam is managed by the USFS and BLM, but most of the land is owned by the State. The Department of Parks and Recreation manages the water surface area of Lake Oroville and shoreline areas typically from the waterline to about the 1,100-foot elevation. The Department of Fish and Game manages the Oroville Wildlife Area downstream from the dam. No private lands are included in the project boundary, but adjacent residential developments on private property fall under the management jurisdiction of Butte County.

Lands within the watershed upstream from the dam are managed under several land and resource management plans, including the Plumas National Forest Land and Resource Management Plan, BLM's Redding Resource Management Plan and Record of Decision, and Butte County General Plan. Downstream from the dam, the City of Oroville manages land under the General Plan. Within the project boundary upstream from the dam, land is managed under DWR's Recreation Plan for Lake Oroville State Recreation Area, the USFS LRMP, BLM's RRMP, and DPR's Resource Management Plan and General Development Plan, Lake Oroville State Recreation Area, while downstream areas are managed under DFG's Oroville Wildlife Management Area Management Plan.

The myriad of ownership and land management plans and activities in conjunction with the relatively small portion of the watershed actually under control of DWR results in little ability of DWR to effectively manage land within the watershed. Nonetheless, DWR can work with adjacent property owners on land use and management activities, as well as those within the project boundary, that affect resources on project lands.

Objective

The objective of the study is to evaluate existing and future project-related land and watershed activities that have the potential to affect water quality. Effects to other aquatic and terrestrial resources from land and watershed activities are evaluated in other study plans.

Relationship to Relicensing/Need for Study

DWR must prepare a report on land management activities so that the Federal Energy Regulatory Commission can determine project conformance and compatibility with local and regional land uses and land plans. Projects must be consistent with management plans that have been identified by FERC. These can include federal, State, regional, and local plans. The report will contain information on project activities that may affect various resources, such as water quality, that are contained in the management plans.

In addition, relicensing of the Oroville Facilities by FERC requires certification from the State Water Resources Control Board that the project complies with Section 401 of the Federal Clean Water Act. The water quality certification signifies compliance with water quality standards and other appropriate requirements for any discharge or discharges to waters of the United States resulting from an activity that requires a federal license or permit. Information required by the SWRCB for certification includes evidence of compliance with appropriate requirements of the Central Valley Water Quality Control Board's Basin Plan. Effects from project related land use and management activities on water quality must be evaluated to demonstrate compliance with water quality standards and other appropriate requirements for the application for water quality certification.

Study Area

The study area includes lands within the FERC project boundary and adjacent lands for effects to resources within the project boundary.

Methodology and Analysis

This study will evaluate both current and potential future effects to water quality from land uses and management within and adjacent to the project boundary. Future land uses and management are not known, but will be evaluated as these become proposed or known later in the study. Much of the information for this study will be obtained from other study plans or workgroups.

Land uses and management effects to other aquatic and terrestrial resources, such as fish or riparian habitat, are evaluated in other study plans.

Task 1. Effects from Existing Land Uses and Management

The first phase of the study will rely on information derived from Land Use Study Plans 1 and 2. Land Use Study Plan 1 will describe existing land uses in and near the project, while Land Use Study Plan 2 will determine the management objectives of the entities which manage land adjacent to project land.

Information from Land Use Study Plans 1 and 2 will be used to evaluate the potential for water quality effects from the identified land uses and management activities. Factors evaluated will include physical, chemical, and biological land uses and management activities. Physical land use and management activities may include construction of fuel breaks for fire management, hiking or horse riding trails, logging, and road location and construction practices. Chemical land use and management activities might include spraying for control of undesirable plant species or vector pests, and fertilization of crops. Biological land use and management activities may include establishment of critical wildlife areas and buffer zones, grazing, and planting or stocking of desirable plant or animal species. Parameters that may be monitored to determine effects from the various land use and management activities may include turbidity, erosion, nutrients, minerals, metals, pesticides, bacteria, and dissolved oxygen, among others. The specific monitoring and assessment that may be needed to evaluate the effects to water quality from land uses and management activities will be developed in consultation with the Environmental Workgroup and Task Force. However, it is anticipated that much of the information that is needed for this evaluation will be provided by water quality monitoring data from SPW1. Some additional monitoring may be required under this study plan for sources or parameters not already being monitored under SPW1.

Task 2. Effects from Future Land Uses and Management

The second phase of the study will be undertaken as proposed changes to land use and management activities become formulated. This phase will use the information about potential land use and management activities to evaluate their effects on water quality.

Results

Information derived from this study will be used to evaluate effects to water quality from existing and future land and watershed use and management activities adjacent to and within the project boundary. Effects to other aquatic and terrestrial resources from land and watershed activities are evaluated in other study plans. Output will be in the form of tables and graphs ~~depicting~~ illustrating effects or potential effects associated with each land use and management activity. ~~Recommendations~~ Options will be ~~made~~ presented to the Land Use Workgroup concerning methods to mitigate ~~identified~~ future land uses and management activities that could adversely affect water quality, including protection of riparian areas, creation of streamside management zone, use of Best Management Practices, rehabilitation of deteriorating watersheds, and increased cooperation with other agencies and private landowners.

Coordination with Other Resource Areas/Studies

This study relies on information from Land Use Study Plans 1 and 2 for a description of existing land uses and management objectives within and adjacent to the project boundary. Other studies will evaluate land uses and management effects to other aquatic and terrestrial resources, such as fish or riparian habitat. These studies include SPG1 (geomorphic resources), SPF1 (non-fish aquatic resources), SPF10 (anadromous fish), and terrestrial Study Plans SPT1 through 4 and 9 and 10. Information developed in this study plan will also be used in SPW1 to evaluate water quality and sources of impairment in project waters.

Schedule

Task 1 of the study will begin in ~~February~~early 2002, while Task 2 is dependent on determination of potential future land uses and management activities. A draft report will be prepared at the completion of each task, with a final report prepared at the end of the study.

Issues

W7. Effect of existing and future project-related land management and watershed management activities (including waste disposal and pesticide use) on water quality, slope stability, erosion, sedimentation, channel stability, riparian habitat, fish habitat, and other beneficial uses). Issues Addressed: WE8, WE11, WE12, WE13, WE14, WE15, WE34, WE41, WE46, T1, T3, T5, T10, GE1, GE15, GE16, GE17, GE18, FE11, FE39

California Department of Water Resources
Oroville Facilities
Draft Study Proposal

SP-T1 Effects of Project Features and Operation on Wildlife and Wildlife Habitat

Introduction

Current and future Department of Water Resources management and operation of the Oroville facilities may impact wildlife and their habitats. Project operation and management can affect wildlife species and their habitats in a positive or negative manner. Identification and quantification of these impacts can provide project managers and stakeholders with the information necessary to make sound management decisions. This information will be used to:

- Identify management options or project modifications which minimize project related impacts
- Identify opportunities for habitat enhancement
- Identify species trade-offs associated with management and operation of the facilities

The scope of this issue includes all of the other wildlife issues identified during the scoping process. Analyses will rely extensively on information collected under other terrestrial resource studies.

Objective

The objective of the study is to identify current and future project effects on wildlife and wildlife habitat, including band-tailed pigeon, black bear, waterfowl, black-tailed deer, special emphasis species, harvest species, and species biodiversity.

Relationship to Relicensing/Need for Study

Identification and quantification of project effects on wildlife and wildlife habitat has been recognized as an issue by relicensing stakeholders including stakeholders with mandatory conditioning authority and is a FERC requirement. Evaluation of project effects on wildlife resources is also required for CEQA/NEPA compliance. Limited data currently exists related to project effects on wildlife resources and no previous evaluation of overall project effects on wildlife resources has been conducted. The information collected will be used to identify opportunities to minimize or mitigate project-related impacts to wildlife resources.

Study Area

The study area is generally within the FERC project boundary, but also includes the Feather River downstream to the confluence with the Sacramento River. The study area includes those described for SP-T3 through SP-T11. For ESA analysis, the study area is defined in SP-T2.

Methodology and Analysis

The effects of project features and operation on wildlife and wildlife habitat is an overarching issue inclusive of all the other identified wildlife issues including current and future project effects on:~~,~~

- State and federal special status species
- Flood plains and water level fluctuation zones
- Wildlife habitat, wildlife populations, and species biodiversity
- Riparian, wetland, and upland~~,~~ habitats
- Interagency wildlife management, coordination, and planning
- Noxious weeds and undesirable non-native wildlife
- Recreation related impact assessment
- Land management impact assessment
- Cumulative effects analysis

The information/results from the other wildlife related studies will provide the basic information used for analyses of effects of project features and operation on wildlife and wildlife habitat.

Task 1). Obtain wildlife habitat/plant community mapping (SP-T4), obtain wildlife biodiversity/habitat analyses (SP-T4), and obtain analyses of current and future project effects on state and federal special status species (SP-T2)

Task 2). Identify areas where project operations may occur and influence wildlife species.

~~Task 2). Obtain wildlife biodiversity/habitat analyses (SP-T4)~~

~~Task 3). Obtain analyses of current and future project effects on state and federal special status species (SP-T2)~~
Task 3~~4~~). Complete analyses of current and future project effects on wildlife and wildlife habitat related to operations and maintenance (SP-T3, SP-T5, SP-T8, and SP-T10). Task 5). Complete analyses of current and future project related effects on wildlife and wildlife habitat related to recreation use and recreation facilities (SP-T9). Assessment of ~~T~~these effects may include both direct and indirect habitat loss as well as estimates of impacts on the populations of selected wildlife species including waterfowl~~.~~

Task 4~~6~~) Complete analyses of current and future project effects on wildlife and wildlife habitat related to land management within the project area (SP-T6, SP-T7, and SP-T11). These impacts may include vegetation and fuels management, grazing, gravel harvest,

Task 5~~7~~). Using the information collected and results obtained from Tasks 1 through 6, summarize the current and future project effects on wildlife and wildlife habitat. Identify area wide and site specific impacts~~ as well as opportunities to minimize these adverse effects~~. ~~(add impacts and potential mechanisms for impacts~~ These effects may include water level fluctuations, altered river hydrology, and maintenance activities.

Task 6~~8~~). Based on the impact analysis, identify a range of measures to improve, preserve, or replace habitat for wildlife. These measures will provide conceptual information on the benefits of each measure as well as, general location, approximate timing, and relative scale for implementation. These conceptual measures will be further developed after appropriate review and approval.

~~(Move Task 8 and 9 into results to indicate how this information will be used)~~
~~Task 8). Negotiate protection, mitigation, and enhancement measures and settlement agreements with stakeholders~~

~~Task 9). Incorporate the results of Tasks 7 and 8 into Project area Wildlife Management Plan for submission to FERC.~~

Results

Results of the study will be presented as a summary report to stakeholders. This report will provide the basis for development of PM&E measures and settlement agreements related to wildlife and wildlife habitat. The results of these negotiations and agreements will be incorporated into a wildlife management plan for submittal to FERC as part as the license application. The report will identify potential project effects to wildlife species including band-tailed pigeon, black bear, waterfowl, black-tailed deer, special emphasis species, CDFG harvest species, and species biodiversity. The report will also identify potential effects on wildlife habitat including deer winter range, riparian, wetland, and lacustrine (~~L~~lakes).

Coordination with Other Resource Areas/Studies

This study requires information related to current and future project operations, maintenance, recreation use and development, and land use. Coordination with these other work groups will be required for timely completion of this study. The results of this study also require completion of other terrestrial resource studies

including those related to issues SP-T2, SP-T3, SP-T4, SP-T5, SP-T6, SP-T7, SP-T8, SP-T9, SP-T10, and SP-T11.

Schedule

The schedule is highly dependant upon the schedule of the recreation, land use, and operations work groups in providing information for analyses of future operations, recreation use and facilities, and land use. ~~(fix task numbers to track with changes made above)~~ Preliminary schedule is to complete ~~Task 1 by April 2002,~~ Task 2 by August 2002, Tasks 1, 3 and 4 by August 2004, Tasks 5 and 6 by January 2004, Task 7 by October 2004, Task 8 by November 2004, and Task 9 by December 2004. Interim reports will be available during July 2003 and July 2004.

Issues

Issue Statement T1
Effects of project features, existing and future operations (including power generation, water storage and release, ramping rates, pump-back, water levels and water level fluctuations) and maintenance of wildlife and wildlife habitat. Specific concerns include deer winter range, band tailed pigeon wintering habitat, designated emphasis and harvest species, wintering and nesting waterfowl, and wildlife use of project and project-affected waters.

Issues Identified During Scoping
2 Maintain winter habitat for band-tailed pigeons
3 Maintain or enhance deer winter range
17 Maintain habitat to support viable populations of all native and desired nonnative vertebrate species
18 Improve and protect habitat for designated emphasis and harvest species
19 Provide diversity of plant and animal communities and tree species by assuring the continuous and viable presence of all seral stages of all native plant communities on the forest
20 Provide a diversity of vegetation types and habitat to support viable populations of all fish, wildlife and plant species
39 Manage flows and/or reservoir storage to maintain or enhance riparian plant communities and habitat for all life stages of fish. Cooperate with local, State, and other Federal water management agencies. Protect riparian areas while providing developed facilities
41 North forebay – preservation of existing wildlife
44 Preserve wildlife habitat in the diversion pool area
46 Improve terrestrial habitat with introduction of salmon (bears)
47 Continue inventory of plant and animal species in the project area.
48 Protect riparian habitat in project area
50 Effects of fluctuating water levels in afterbay on wildlife
51 Restoration of areas used as stockpile sites during dam construction

59 Operate water levels in Thermalito Afterbay to prevent adverse impacts to Pacific Flyway waterfowl, especially during nesting in spring and early summer; continue to coordinate with DFG

60 Evaluate effects of proposed increases in recreational activity in Thermalito Afterbay on waterfowl and other wildlife

63 Protection and sustained conservation of terrestrial wildlife and flora in the project-affected area; comprehensive and well-crafted planning

California Department of Water Resources
Oroville Facilities
Draft Study Plan~~roposal~~

SP-T2 Project Effects on Special Status Species

1.0 Introduction

The following study plan~~roposal~~ addresses ~~-~~stakeholder concerns for special status plants and animals associated with the recreation and power generation facilities at Oroville and project releases to the Feather River downstream to the Sacramento River. This investigation will provide 1) information for ESA consultation with the US Fish and Wildlife Service (USF&WS) and California Department of Fish and Game (CDFG); 2) information for Federal agencies review~~ing~~ of the project under Section 4(e) of the Federal Power Act; and 3) a description of existing conditions ~~for~~ and potential project effects on special status species as required by CEQA and NEPA. The following is an overview of the special status species considered in this investigation.

Numerous special status species may occur within the immediate project vicinity. These species include plants and animals classified as threatened or endangered under the State or Federal Endangered Species acts, U.S. Forest Service sensitive species, U. S. Bureau of Land Management sensitive species, State and Federal species of concern, Federal migratory non-game birds of management concern, ~~State protected,~~ and State fully protected species.

Several State and/or federally "listed" species are known to occur within the ~~vicinity of the Oroville Facilities~~ the Project boundary including southern bald eagle, American peregrine falcon, greater sandhill crane, and valley elderberry longhorn beetle. Other "listed" species are known to occur in the project vicinity including bank swallow, western yellow-billed cuckoo, Swainson's hawk, red-legged frog, giant garter snake, vernal pool fairy shrimp, Butte County meadowfoam, hairy Orcutt grass, slender Orcutt grass, Greene's tuctoria, and Hoover's spurge. Potentially suitable habitat may exist within the study area for these species as well as vernal pool tadpole shrimp and Conservancy fairy shrimp.

The following information provides backgound information on the status, distribution, and habitat requirements for listed species within the Study area. This information was used to guide the study approach for each species.

Bank swallow

The State of California listed the bank swallow as a threatened species during March 1989. Bank swallows historically bred in suitable habitat throughout lowland California (Grinnell and Miller 1944). The bank swallow's range in

California has decreased significantly with only four known populations south of San Francisco Bay. Approximately 70 percent of the statewide population currently occur~~s~~ along the Sacramento and Feather rivers (CDFG 1992). Bank swallows occur in riverine habitat and require a sandy or silty vertical bluff or riverbank for nesting (Zeiner et al. 1990). Floods or very high flows are required to create and maintain the eroded banks favored by this migratory, colonial species. The principal threat to bank swallows are bank protection projects (Remsen 1978).

During a 1987 survey of the Feather River, 18 bank swallow colonies were identified with a total of over 6,500 burrows (Laymon et al. 1988). ~~Two~~ No colonies are known to occur within the ~~study area~~ Project boundary (CDFG 2001). However, project-related flood control activities serve to limit the natural flow variability in the Feather River and associated bank erosion~~. Suitable nesting habitat is generally absent within the leveed study area.~~

Greater sandhill crane

Both the lesser and greater subspecies of sandhill crane winter in the Central Valley of California. The greater sandhill crane subspecies is classified as a State threatened species. This species is not federally listed but is considered a sensitive species by Region 5 of the U.S. Forest Service.

The greater sandhill crane breeds in North-eastern California and South-central Oregon and winters in California's Central Valley (Littlefield 1982). The California wintering population was estimated at 3,400 to 6,000 individuals in 1988 (CDFG 1992). The California breeding population is believed to be less than 300 pairs. In addition to greater sandhill cranes, approximately 25,000 lesser sandhill cranes migrate to and winter in California's Central Valley (CDFG 1992).

Wintering crane habitat consists of an open expanse of shallow water for communal roosting, rice or corn fields for foraging, and irrigated pasture for loafing (CDFG 1992). No nesting sandhill cranes occur within the study area. Wintering sandhill cranes (unknown sub-species) are frequently observed in the rice/corn growing area west of the Thermalito Afterbay and infrequently in flight over the study area. Wintering sandhill cranes are not known to use habitats within the project boundary.

American peregrine falcon

The American peregrine falcon was federally listed as an endangered species in 1970 and subsequently listed as endangered by the State of California as well. The USF&WS recently delisted peregrine falcons but they remain State listed. The breeding population of peregrine falcons in California has increased from two known active nest locations in 1970 to over 120 nesting pairs in 1999.

Within California, this uncommon breeding resident is found from the southern coast range north to the Oregon border and throughout the Cascade and Sierra Nevada mountain ranges (Zeiner et, al 1990). Peregrine falcons nest on a variety of substrates throughout their range including river cut banks, hollows in large old trees, old raptor nests, bridges, skyscrapers, and cliffs. However, cliffs are the most common nest sites. Suitable cliffs are generally extremely high, frequently overlook water, and permit an expansive view of the surrounding countryside (Hickey 1942). Wintering peregrine falcons forage over most of California (excluding desert regions). Several peregrine falcon nest territories are present in Butte County including two recently active sites within the study area.

Swainson's hawk

Swainson's hawks were historically found throughout most of lowland California (Grinnell and Miller 1944). Current distribution is limited to northeast California (primarily Modoc, Siskiyou and Lassen Counties) and the Central Valley. This species decline is believed to be related to agricultural and urban land conversions (Estep 1989). Recent telemetry data indicate that Swainson's hawks nesting in the Central Valley migrate to agricultural areas in Mexico and Central America during the winter.

Swainson's hawks use a variety of agricultural crops for foraging including alfalfa, fallow fields, beet, tomato, irrigated pasture, riceland (non-flooded), and cereal grains.

No Swainson's hawk nest territories are known to occur within the FERC Project Boundary (CDFG 2001). However, several nesting pairs are known from the Butte Creek area near the communities of Durham and Nelson and along the lower Feather River. Suitable foraging habitat in the immediate vicinity of project facilities is generally lacking. Potentially suitable nesting habitat is present at several locations along the Feather River below the Thermalito outfall.

Western yellow-billed cuckoo

The western yellow-billed cuckoo was listed as a State threatened species in 1971. This species status was reclassified to endangered in 1987. This species is currently a federal candidate for listing. Historic records indicate that this species was widespread and locally common in California. Today its distribution is limited to several small isolated areas of the State. The two largest remaining populations in the State are located near the Colorado and Sacramento rivers. The 1977 statewide population was estimated at between 122 and 163 pairs (Gaines and Laymon 1984). A subsequent statewide survey in 1988 estimated that only 31 to 33 pairs remained (Laymon and Halterman 1989). Loss of riparian habitat accounts for most of the population decline (Laymon 1980).

Suitable cuckoo nesting habitat is described as deciduous riparian thickets or forests with dense low understory near slow moving waterways (Ziener et al

1990). These thickets or woodlands are generally at least 25 acres in size and 300 feet in width (Gaines 1974).

At least two historic cuckoo nest territories are known from the lower Feather River near the confluence with the Sacramento River. Several potentially suitable patches of nesting habitat of adequate size are present ~~in the study area~~ within the portion of the Oroville Wildlife Area bordering the Feather River.

Vernal pool invertebrates

Three invertebrate species Conservancy fairy shrimp, vernal pool tadpole shrimp, and vernal pool fairy shrimp were federally listed during September 1994. Conservancy fairy shrimp and vernal pool tadpole shrimp are listed as endangered while the vernal pool fairy shrimp is classified as threatened. This group of species is endemic to seasonal wetlands and vernal pools throughout the Central Valley, Coast Range, Transverse Ranges, and coastal plain near Santa Rosa.

These species are totally dependent upon vernal pools and other seasonal wetlands and are not known to occur in rivers, marine habitats or permanent water-bodies. The season and duration of pool inundation, as well as, water chemistry of the pools strongly influences these species. Several reasons for the population decline have been identified including habitat loss (alteration, degradation), urbanization, agricultural practices, recreational impacts, and contaminants.

Potentially suitable vernal pool habitat is present within the study area. Approximately two hundred vernal pools of various sizes have been identified within the portion of the Oroville Wildlife Area surrounding the Thermalito Afterbay, Thermalito Forebay, and Power Canal. However, the presence and or distribution of these species within the study area are currently unknown. Vernal pool fairy shrimp have been reported immediately west of the Thermalito Afterbay near the intersection of State Highway 99 and Richvale Road (CDFG 2001). The proposed study will not include protocol level surveys of vernal pool habitats to detect the presence of fairy and tadpole shrimp. Rather, DWR proposes to manage the block of land containing vernal pools under the assumption that these listed invertebrates are present. DWR will evaluate land management practices within the area containing pools to identify potential impacts and avoidance measures. Current land management practices that will be evaluated include firebreaks, trails, roads, levees, pesticide use, wetland developments, grading, and recreational uses.

Valley elderberry longhorn beetle

The valley elderberry longhorn beetle (VELB) was listed as a federal threatened species during August 1980. The known distribution of this species has greatly increased through additional survey efforts since the time of it's initial listing.

USF&WS now identifies the species range as throughout the Central Valley and up to 3,000 feet on the eastern edge of the valley and to the Coast Range watershed divide along the western side of the valley (USF&WS 1984).

The beetle is primarily restricted to riparian habitat and adjacent uplands. The VELB is dependent upon its host plant the elderberry (*Sambucus* sp.) throughout its life cycle. The VELB spends most of its two-year life cycle boring within the stem in a larval stage. The beetles emerge from the stem March through June as adults to lay eggs completing the life cycle (Barr 1991).

Elderberry bushes containing VELB emergence holes have been identified at several locations within the ~~study area, including~~ the Oroville Wildlife Area (OWA).~~, the lower Feather River, and adjacent to recreation and generation facilities.~~

California red-legged frog

The California red-legged frog was listed as a federal threatened species during June 1996. This species is considered a species of special concern by the State. The California red-legged frog has been extirpated from approximately 70 percent of its former range.

The California red-legged frogs are present from sea level up to approximately 5,000 feet elevation with most known populations below 3,500 feet. This species uses a variety of aquatic habitats for reproduction including streams, deep pools, backwaters, ponds, marshes, sag ponds, dune ponds, and lagoons (USF&WS 2000). Breeding adults are generally associated with deep (greater than two feet) slow moving water bordered by dense low riparian or emergent vegetation (USF&WS 2000). Upland areas near breeding locations can also be used extensively during the summer (USF&WS 2000). Several reasons for the population decline have been identified including habitat loss (alteration, degradation, and fragmentation), urbanization, agricultural practices, water management activities, mining, livestock practices, recreational impacts, timber harvest practices, exploitation (as food), disease, introduced species (bullfrog, mosquitofish, largemouth bass), drought and contaminants (USF&WS 2000).

California red-legged frogs are not currently known to exist within the project boundary. However, the largest remaining population within the Sierra Nevada mountain range is located within a few miles of the project boundary within the North Fork Feather River drainage. Portions of this watershed are designated as core recovery areas in the Draft Red-Legged Frog Recovery Plan (USF&WS 2000).

Giant garter snake

The giant garter snake was listed as a threatened species under the federal Endangered Species Act during October 1993. It has also been listed as threatened under the California Endangered Species Act since 1971.

The giant garter snake is endemic to the wetlands of the Central Valley of California. The historic range is believed to include valley floor wetlands from the vicinity of Butte County south to near Bakersfield. Historically, giant garter snakes were found in natural wetlands associated with flood basins.

Thirteen sub-populations of giant garter snake have been identified. Population information is generally lacking. The northern extent of the current range of this species is described as Sacramento and Contra Costa Counties (Fox 1951), to near Gridley (Hansen and Brode 1980), to the vicinity of Chico (Rossman and Stewart 1987). In addition to natural wetlands, giant garter snakes are now found in agricultural wetlands (rice), managed wetlands (duck clubs and State and federal refuges) agricultural drains, ponds, and other artificial waterways.

The Giant Garter Snake Recovery Plan (Miller and Hornaday 1999) describes the essential habitat components for this aquatic reptile as 1) adequate water during the snakes active season (early spring through mid-fall) to support dense populations of prey; 2) presence of emergent herbaceous cover (cattails and tules) for escape cover and foraging habitat; 3) grassy upland habitat adjacent to waterways for basking; and 4) higher elevation upland habitat for flood flow refuge. This species is absent from larger rivers, riparian woodlands, and wetlands with sand, rock, or gravel substrates (Miller and Hornaday 1999). Within the southern Sacramento Valley this species has been identified in areas ranging from 10 to 40 feet elevation (Hansen 1988).

Giant garter snakes have not been identified within the project boundary. However, this species has been reported in the Cherokee Canal near Richvale (approximately 2 miles west of the Thermalito Afterbay). Rice fields and associated irrigation/drainage canals are present at the western project boundary along State Highway 99. Potentially suitable habitat is present within the study area. Five waterfowl brood ponds have been constructed in and around the Thermalito Afterbay by the Licensee. These ponds are not subject to the water level fluctuations experienced in the Thermalito Afterbay and as a result support extensive emergent wetland habitat. All the components of essential giant garter snake habitat are found in and around these habitat improvement projects.

Southern bald eagle

Southern bald eagles were listed as an endangered species by USF&WS in March 1967. After a federal status review they were down-listed to threatened in 1995. They are currently proposed for federal delisting (Federal Register July 6,1999). This species is currently State listed as endangered.

Bald eagles historically nested throughout California near seacoasts, major rivers, and lakes. Over 160 pairs currently nest in California (up from 28 pair in 1978) while hundreds of additional bald eagles migrate into California during the winter.

Nesting habitat is described as old-growth trees and snags in remote mixed stands near water (Zeiner et.al 1990). In a 1979 survey of 95 bald eagle nest sites in northern California, 87 percent were located in dominant or co-dominant ponderosa pine or sugar pine (Lehman 1979). Associated stands were generally open (less than 40 percent canopy cover), and within one mile of a water body. Approximately 1/3 of the nest sites were within 0.1 miles of a water body and 85 percent of the nests had an unobstructed view of the water body. Seventy percent of the nests were associated with reservoirs.

At least three bald eagle nest territories are present within the project vicinity (Jurek 1990). Plumas National Forest, California Department of Parks and Recreation and Pacific Gas and Electric Company manage the lands occupied by these territories and monitor nest occupancy and success. The Poe territory on the North Fork Feather River has been active since at least 1970 and remains one of the most productive nest territories in the State with at least 39 young produced. Nest activity at the Spring Hollow nest territory was first identified in 1989 when two young were produced. Successful reproduction was observed in 1990 and 1991. No further activity was observed at this territory until the territory was occupied in 1997. The Fall River nest territory was identified in 1991. However, use of the territory has been sporadic. No successful reproduction was observed until 1997 when two young were produced. In 1997, the Licensee (in cooperation with US Fish and Wildlife Service and the Plumas National Forest) constructed and installed a floating log boom to restrict recreational access near the Fall River nest site. Subsequently, California Department of Parks and Recreation personnel have re-installed and maintained the barrier. California Department of Parks and Recreation has also provided enforcement for the recreational closure. The study area also receives moderate wintering bald eagle use. Moderate, sporadic winter bald eagle use of the Lake Oroville, Feather River below Lake Oroville, and the Thermalito Forebay/Afterbay complex have been observed.

Butte County meadowfoam

Butte County meadowfoam (*Limnanthes floccosa* ssp. *californica*) is an annual herb in the false mermaid family (Limnanthaceae). It is both a federally and State listed endangered species. This species appears in l~~L~~ate March to early May in ephemeral drainages, vernal pool depressions in ephemeral drainages, and occasionally around the edges of isolated vernal pools. It is restricted to a narrow 25-mile strip along the eastern margin of the Sacramento Valley in Butte County.

Sixteen of the eighteen remaining populations of Butte County meadowfoam occur on private land and are subject to urban development, agricultural land conversion, and highway widening or realignment (Fed. Register, March 26, 1997). Two populations are known from approximately five miles north of the Thermalito Afterbay. Suitable habitat for this species exists within the study area.

Hairy Orcutt grass

Hairy Orcutt grass (*Orcuttia pilosa*) is an annual herb in the grass family (Poaceae). It is listed as a federally endangered and California endangered species. It occurs in drying vernal pools along the eastern margin of the Central Valley from May to August.

Of the original 34 known populations of hairy Orcutt grass, eleven are thought to have been extirpated due to agricultural land conversion, urbanization, and intensive cattle grazing (Fed Register, March 26, 1997). A population is known within five miles of the project boundary and suitable habitat for the hairy Orcutt grass exists within the boundaries.

Slender Orcutt grass

Slender Orcutt grass (*Orcuttia tenuis*) is an annual herb in the grass family (Poaceae). It is listed as a federally threatened and California endangered species. It occurs in drying vernal pools in Northern California from May to August.

There are 39 known populations of the slender Orcutt grass. Although new populations discovered recently have extended its range, the overall trend is one of decline due to habitat alteration and loss (Federal Register, March 26, 1997). Suitable habitat for this species exists within the Project boundary.

Greene's tuctoria

Greene's tuctoria (*Tuctoria greenei*) is an annual herb in the grass family (Poaceae). It is listed as a federally endangered species and a California rare species. It occurs in drying ephemeral wetlands or vernal pools along the eastern margin of the California Central Valley from May to July.

Thirty-eight populations have been documented from Fresno to Shasta Counties. However, nineteen of these populations are thought to have been extirpated from Fresno, Madera, Stanislaus, Tulare, and San Joaquin Counties. The remaining populations occur in Butte, Glenn, Merced, Shasta, and Tehama Counties. All populations are on private lands except for one population at the Sacramento National Wildlife Refuge. One population occurs just west of Hwy 99 within ¼ mile and another within five miles of the project boundary. Suitable habitat for this species exists within the project boundary.

Hoover's spurge

Hoover's spurge (*Chamaesyce hooveri*) is a federally listed threatened species. This annual herb in the spurge family (Euphorbiaceae) is found in relatively large vernal pools on the eastern margin of the Central Valley from late June to September.

There are twenty-five known populations of Hoover's spurge from Tulare, Merced, Stanislaus, Glenn, Butte, and Tehama Counties. All are on private lands except for four populations in Glenn County on the Sacramento National Wildlife Refuge. Loss of vernal pool habitat to irrigated agriculture is the biggest threat to this species. The nearest population occurs approximately five miles north of the project boundary. Suitable habitat exists within the study area for this species.

Hartweg's golden sunburst

Hartweg's golden sunburst (*Pseudobahia bahifolia*) is an annual herb in the sunflower family (Asteraceae). It is found on clay soils in annual grassland and open woodland from March to May.

There are fifteen remaining populations identified in the CNDDB in Madera, Fresno, and Stanislaus Counties. Hartweg's golden sunburst is known from the floodplain of the lower Feather River. A historic population of Hartweg's golden sunburst was documented on the bank near the junction of the Yuba and Feather rivers. This type locality from the banks near the Feather River has been extirpated. There is little probability of finding this plant within the study area.

2.0 Objectives

- Provide information on special status species occurrence and distribution within the study area
- Evaluate~~Provide information on~~ potential project effects to special status species for use in consultation processes with State and Federal wildlife management agencies
- Identify opportunities for habitat protection and enhancement for special status species

3.0 Relationship to Relicensing/Need for Study

The federal Endangered Species Act (FESA) requires evaluation and consultation to avoid take of listed species or adverse modification of their habitats. The California Endangered Species Act (CESA) also requires assessment of the proposed project's impact on listed species. Both CEQA and NEPA require assessment of a project's impacts on State and federally listed

species and their habitats. In addition CEQA requires an evaluation of species that have not been listed under the FESA or CESA, but meet the definition of threatened and endangered as listed in the CESA. CEQA requires evaluation of project impacts on State and federal species of concern. Both federal land management agencies have an obligation to insure that project operations do not adversely affect sensitive species on federal lands.

With the exception of southern bald eagle and American peregrine falcon, relatively little is known about the occurrence or distribution of State and federally listed species within the project vicinity. These studies are needed to provide sufficient information for these consultations and CEQA-NEPA documentation.

4.0 Study Area

The study area for this investigation includes the FERC Project Boundary and the lower Feather River downstream to the Sacramento River. The scope of study for each species will focus on areas of suitable habitat within the study area that may be affected by project activities. The study area will extend beyond the FERC boundary for evaluation of disturbances related to the analysis of project-related impacts. The survey area for each special status species will be developed as follows.

Scope of surveys for state and federally listed species will be determined on a species by species basis in consultation with the CDFG and USF&WS.

Scope of surveys for federal land management agency sensitive species will include federal lands within the study area, adjacent federal lands outside the study area, and State lands within the study area adjacent to federal lands.

Study scope related to Federal and State species of concern will be restricted to the FERC boundary and downstream along the Feather River floodplain to the confluence with the Sacramento River. Information related to project impacts on these species would be collected along with other survey efforts.

5.0 Methods and Analysis

Animals

The diversity of habitat types associated with the FERC project boundary and lower Feather River provide potentially suitable conditions for 12 species listed under FESA or CESA. These habitats could support an additional 56 species of special concern to federal and State agencies. These special status species are listed in Table 1 below.

Table 1. Special Status Wildlife Species With The Potential to Occur In The Immediate Project Vicinity

Species	Status	Species	Status
American bittern	MN	western yellow-billed cuckoo	SE, MN
American peregrine falcon	SE, MN, FP	white-faced ibis	CS, MN
American white pelican	CS	yellow-breasted chat	CS, MN
bank swallow	ST	California red-legged frog	FT, CS, P
Barrow's goldeneye	CS	foothill yellow-legged frog	CS, FC, FS, P
Bell's sage sparrow	CS, MN	western spadefoot toad	CS, FC, BS, P
black swift	CS, MN	California horned lizard	CS, FC, BS, P
black tern	CS, MN	giant garter snake	FT, ST, P
black-crowned night heron	BS	northwestern pond turtle	CS, FC, FS, P
black-shouldered kite	MN, FP	-western mastiff bat	CS, FC, BS
Brewer's sparrow	MN	fringed myotis bat	FC, BS
California gull	CS	long-eared myotis bat	CS, FC,
California horned lark	CS	long-legged myotis bat	FC, BS
common loon	CS, MN	Marysville kangaroo rat	CS, FC, BS
Cooper's hawk	CS	Occult little brown bat	CS, FC, BS
double-crested cormorant	CS	pPale big-eared bat	CS, FC, FS. B$
ferruginous hawk	CS, MN, BS	pallid bat	CS, FS, BS
golden eagle	CS, FP	San Joaquin pocket mouse	CS, FC, BS
grasshopper sparrow	MN	small-footed myotis bat	FC, BS
greater sandhill crane	ST, FP	spotted bat	CS, FC, BS
Lawrence's goldfinch	MN	Towndsend's western big-eared bat	CS, FC, FS, BS
loggerhead shrike	CS, MN	Yuma myotis bat	FC, BS
long-billed curlew	CS, MN	amphibious caddisfly	FC
long-eared owl	CS	Conservancy fairy shrimp	FE
merlin	CS	longhorn fairy shrimp	FE
northern harrier	CS	Sacramento anthicid beetle	FC
osprey	CS	Sacramento valley tiger beetle	FC
prairie falcon	CS	valley elderberry longhorn beetle	FT
purple marten	CS	vernal pool fairy shrimp	FT
sharp-shinned hawk	CS	vernal pool tadpole shrimp	FE
short-eared owl	CS, MN	**KEY**	
southern bald eagle	SE, FT, FP	SE=State Endangered	
Swainson's hawk	ST	ST=State Threatened	
tricolored blackbird	CS, MN, BS	FE=Federal Endangered	
Vaux's swift	CS, MN	FT=Federal Threatened	
western burrowing owl	CS, MN, BS	P=California Protected	
western least bittern	CS, MN	FS=Forest Service Sensitive	
yellow warbler	CS	BS=Bureau of Land Management Sensitive	
Status per CDFG California Natural Diversity Database-July 2001		CF=California Fully Protected Species	
		CS=California Species of Special Concern	
		FC=Federal Species of Concern	
		MN=Migratory Nongame Birds of Management Concern	

Tasks

The following is a description of the study methods that will be used to determine the status of occurrence and project effects on special status animals within the study area.

Task 1 Bank swallow

No bank swallow colonies have been identified within the project boundary. However, numerous colonies occur along the lower Feather River. ~~Within the study area, two nesting colonies of bank swallows have been reported along the lower Feather River. Additional colonies of bank swallows may occur along the lower Feather River.~~ These nesting colonies may be disturbed by DWR levee maintenance projects and changes in project operations that alter bank formation processes. The following investigations would be conducted to evaluate project effects on bank swallows.

Scope of survey. DWR proposes to conduct annual summer (June) surveys of the bank swallow colonies along the Feather River from the fish barrier dam to the confluence with the Sacramento River. These boat-based surveys will evaluate the location, quantity, and quality of habitat and develop a population estimate based on the number of burrows in occupied colonies.

Evaluation for project effects. Project-related effects on bank swallow nesting colonies will be based on onsite identification of potential disturbances, review of proposed DWR maintenance activities and an assessment of potential project water operations that may alter bank forming processes. Bank formation will be assessed based on hydrological modeling and additional information collected under SP-G2. This analysis will focus on the timing, magnitude, and frequency project releases and erosion events within the Feather River below the Thermalito outfall. Bank protection activities will be assessed for potential alteration of bank forming processes and direct effects due the nest removal and nesting disturbance. ~~Impact analysis will compare current and historic population levels.~~

Task 2 Greater sandhill crane

The greater sandhill crane over-winters within the general vicinity of the project facilities. There are no known winter roosting sites within the study area, cranes may forage sporadically in the study area. The following study would 1) determine greater sandhill crane use of the study area for roosting and foraging; and 2) evaluate the potential for habitat disturbance to these sites due to human intrusion, maintenance activities, or water operations.

Scope of survey. DWR proposes to conduct annual surveys (during 2002 and 2003) of greater sandhill crane use of suitable habitat within the study area during the period from mid-September through the first week in October. This

survey period serves to eliminate lesser sandhill cranes (unlisted subspecies) that arrive later in the year. Field observations will note numbers of cranes, habitat use and crane behavior. Observations of cranes ~~and~~ in relation to project associated facilities and activities will be mapped in the field.

Evaluation for project effects. Evaluation of project effects on greater sandhill crane will evaluate alterations of crane occurrence and habitat use due to maintenance and recreational disturbance, vegetative management practices and water level fluctuations in the Thermalito Afterbay. Habitat use for greater sandhill cranes will be based on field observations in areas of suitable habitat and CDFG aerial waterfowl survey data (which includes the Thermalito Afterbay). The potential for project disturbances to roosting or foraging cranes will be assessed, based on the proximity of nearby project facilities, likelihood for project-related recreation activities, and a review of project-related maintenance activities within one half mile of the observation. Data analysis will involve evaluation of habitat use including timing, location, quality, and potential for project ~~activities~~effects.

Task 3 American peregrine falcon

American peregrine falcons are known to occur within the study area on a year-round basis. The project facilities provide suitable foraging habitat for falcons that nest within the project vicinity as well as wintering birds. Project activities have the potential to cause ~~significant~~ disruption ~~to~~ of nesting birds due to project maintenance activities or recreational activities. The following survey is proposed to 1) identify all nesting sites within the study area; and 2) evaluate all project activities within one half mile of nest sites for the potential to reduce nesting success.

Scope of survey. Several peregrine falcon nest territories are present in Butte County including two recently active sites within the study area. DWR proposes to monitor habitat use, reproduction, and project-related impacts at the two known nest locations. Further, DWR will evaluate and survey the limited amount of potentially suitable unoccupied habitat (cliffs and bridges) within the study area. These surveys will be conducted twice a year, once early in the spring breeding season and again in late spring or early summer when chicks would be present. Annual surveys will be completed during both 2002 and 2003. Boat, vehicle, and foot surveys of potential nesting habitat will be required.

Evaluation for project effects. Data analyses will include evaluation of reproductive success, existing population levels, habitat location and use, potential project effects and potential management options. Evaluation of potential project effects will include bridge maintenance and access, toxins, recreational use of cliffs (rock climbing) and vegetative management.

Task 4 Swainson's hawk

Within the study area, potentially suitable nesting habitat is present at several locations along the Feather River below the Thermalito ~~o~~Outfall. Swainson's hawks are known to nest along the lower Feather River, and are expected to forage in croplands adjoining the river. Project-related disturbances to Swainson's hawk nest sites during the nesting season could result in nest abandonment and impaired nesting success. Project releases could alter the recruitment of riparian trees for Swainson's hawk nesting. The following study would 1) collect site specific data on Swainson's hawk nesting along the lower Feather River, 2) evaluate these nesting territories for project-related disturbances; and 3) assess the effects of project water operations on the recruitment of riparian vegetation in the lower Feather River for potential future nest sites.

Scope of survey. DWR proposes to conduct breeding season surveys of suitable nesting habitat within the study area using the Draft Swainson's Hawk Recovery Team protocol (CDFG 1992). This protocol requires three surveys of potentially suitable habitat during the course of the breeding season. Both boat and vehicle surveys will be employed. During field investigations, nest sites will be identified in the field and mapped. Field observations will note the status of each nest, alternate nest sites, and potential project-related activities within one half mile of the nest.

Evaluation for project effects. Data analyses will include evaluation of existing population, habitat location and use, potential project effects, and potential management options. Evaluation of project effects will include hydrology effects on the maintenance and development of mature riparian/valley oak habitat (SP-T3-5), DWR levee maintenance practices, and pesticide use.

Task 5 Western yellow-billed cuckoo

At least two historic cuckoo nest territories are known from the lower Feather River near the confluence with the Sacramento River. Several potentially suitable patches of nesting habitat of adequate size are present in the study area within the Oroville Wildlife Area bordering the Feather River. DWR proposes to conduct annual breeding season surveys (during 2002 and 2003) of potential nesting habitat at these sites and downstream along the Feather River floodplain to the confluence with the Sacramento River. These surveys would involve broadcasting pre-recorded cuckoo calls and soliciting responses during the spring breeding season. These surveys would involve both boat and vehicular access. Data analyses will include evaluation of existing population, habitat location and use, potential project effects, and potential management options. Evaluation of project effects will include hydrology effects on the maintenance and development of mature riparian habitat (SP-T3), and vegetative management practices.

Task 6 Valley elderberry longhorn beetle

Elderberry shrubs are known to occur throughout the project study area. At some locations, emergence holes for VELB have been identified. Potentially ~~S~~suitable habitat for VELB ~~can~~ could be removed during maintenance activities within the FERC project boundary; or altered by project water operations along the lower Feather River. DWR proposes to identify all areas of suitable habitat for VELB, and conduct USF&WS protocol level surveys in areas where suitable habitat could be reduced or modified by project operations or maintenance. The following describes the study approach for each of these areas.

Scope of survey. Surveys will be conducted within the study area to 1) develop protection measures within the OWA; 2) determine if project operations affect elderberry occurrences on the lower Feather River; and 3) evaluate the effects of facilities maintenance within the FERC project boundary.

Oroville Wildlife Area. Elderberry bushes are one of the most common shrub species within the portion of the Oroville Wildlife Area bordering the Feather River. Thousands (possibly tens of thousands) of elderberry stems greater than one inch in diameter are present in this area. The licensee proposes to continue to manage these areas for wildlife habitat without the addition of new facilities or ground disturbing activities that would remove these plants. DWR proposes to map these locations and develop VELB habitat protections measures for the OWA that will avoid or mitigate for operations and maintenance activities with the potential to impact VELB. These elderberry stands will also be assessed for intentional flood detention within the Oroville Wildlife Area, gravel mining, DWR levee maintenance, and herbicide/pesticide use.

Lower Feather River. DWR proposes to conduct field surveys and map elderberry locations along the lower Feather River to the confluence with the Yuba River. During these field surveys, the elevation of the elderberry occurrences will be taken relative to the river to allow for an assessment of potential impacts due to project water operations. Evaluation of project impacts on VELB and its habitat will also include analysis of DWR levee maintenance practices.

Recreation and Generation Facilities. DWR proposes to survey within 150 feet of all recreation and generation facilities in keeping with the USF&WS protocol during 2003. DWR will survey proposed sites for recreation improvement using USF&WS protocol during 2004.

Evaluation for project effects. The potential for loss of suitable VELB habitat will be assessed based on the results of field surveys and 1) maintenance practices within the OWA; 2) historic and alterative water releases from the project within the lower Feather River; and 3) maintenance practices at all of the project facilities (generation and operation). The final assessment will include the results of field investigations, and a description of activities that could or would remove suitable habitat for VELB.

Task 8 California Red-legged Frog

There are no known occurrences of California red-legged frog within the study area. Suitable habitat for California red-legged frog includes ponds, slow-moving streams, and wetland areas. These habitat types may occur throughout the study area. Suitable habitat for red-legged frog may be affected by ground disturbing activities, vegetation removal, introduction of predators, pesticides, and hydrologic changes. The proposed study would survey areas of suitable habitat and evaluate these sites for potential adverse affects related to the project.

Scope of survey. Delineation of potentially suitable habitat will be conducted by DWR (based on hydrology, topography and site characteristics) in consultation with USF&WS. DWR proposes to conduct annual surveys of potentially suitable red-legged frog habitat within and adjacent to the study area using the USF&WS survey protocol. All occurrences of red-legged frogs will be mapped, field assessed for potential impacts, and data will be collected on population and habitat conditions. Data on presence predatory species will also be noted.

Evaluation for project effects. Red-legged frog occurrences will be evaluated for project-related effects based on proximity to project facilities and project-related activities (maintenance, recreation, etc). Data analyses will include an evaluation of the existing population, habitat location and use, project effects, and potential management options. Evaluation of project effects will include effects on habitat alteration, introduced competitors/predators, ~~Oroville Reservoir as a barrier to dispersal,~~ vegetative management practices, and recreational impacts.

Task 9 Giant garter snake

While giant garter snakes are not known to occur within the study area, suitable habitat for this species has been identified ~~near~~ in agricultural areas west of the Afterbay. Giant garter snakes at this location could be affected by changes in water management, introduction of predators, vegetation removal, recreational disturbance, and pesticide application.

Scope of survey. Delineation of potentially suitable habitat will be conducted in consultation with USF&WS and CDFG. DWR proposes to conduct annual surveys (during 2002 and 2003) of potentially suitable habitat within the study area using USF&WS survey protocol. If giant garter snakes are located during field surveys, data will be collected on the location of the snakes, habitat use, and population.

Evaluation for project effects. If giant garter snakes are located at the Afterbay complex, the potential for project effects will be assessed using CDFG mitigation guidelines for the giant garter snake. Data analyses will include evaluation of

existing population, habitat location and use, project effects, and potential management options. Evaluation of project effects will include analyses of water level fluctuations within the Thermalito Afterbay and brood ponds, DWR levee maintenance practices, flood detention within the OWA, pesticide use, vegetative management, and recreation use.

Task 10 Southern bald eagle

Lake Oroville supports several bald eagle nesting territories and a wintering population of bald eagles. Project-related disturbances at nest sites and roosting sites should be avoided. The project could also alter habitat through vegetative/ fuels management practices and reservoir level flucuations. The following study would 1) collect data on the occurrence bald eagle nesting and roosting sites within the study area; and 2) evaluate the likelihood for project-related disturbances within one half mile ~~the during nesting season~~of occupied nests or ~~wintering season~~ or roost sites. 3) collect data on habitat alterations related to vegetative/fuels management and reservoir operations.

Scope of survey. DWR proposes to conduct annual breeding surveys (during 2002 and 2003) of currently know and potentially suitable nesting habitat as well as area-wide wintering surveys. Potentially suitable nesting habitat will be delineated in consultation with both USF&WS and CDFG. Nest surveys will be conducted from a boat and will involve glassing all potentially suitable nest trees to detect new or previously undetected nests, following adult birds, monitoring reproduction, identification of foraging areas, and a field assessment of potential for project related effects. At least three surveys will be conducted during the breeding season to monitor reproductive success at occupied nests. Wintering habitat surveys will be conducted on a single date in January using multiple observers to cover suitable wintering habitat within the study area on that date.

Evaluation for project effects. Data analyses will include evaluation of the existing population, reproductive success, habitat location and use, project effects, and potential management options. Evaluation of project effects will include recreational disturbance of nesting and wintering eagles, vegetative and fuels management, and reservoir level effects on nesting eagles.

Task 11 Federal Land Management Agency Sensitive Species

Both the Bureau of Land Management and Plumas National Forest manage federal lands within the project boundary. These lands have the potential to support federal sensitive species including tricolored blackbird, western burrowing owl, foothill yellow-legged frog, western spadefoot, western pond turtle, fringed myotis, long-eared myotis, long-legged myotis, pallid bat, small-footed myotis, Townsend's big-eared bat, Pacific big-eared bat, and Yuma myotis. Relatively little information exists on the occurrence or distribution of these species on federal lands within the study area.

Scope of surveys. Surveys will be conducted on federal lands within the FERC project boundary, adjacent federal lands outside the project boundary, and State lands within the project boundary adjacent to federal lands. to assess habitat conditions for federal sensitive species. During field investigations, vegetation structure and composition will be noted, as well as, disturbance factors that may preclude habitat use by federally sensitive species. The locations of sensitive species observed during the habitat assessment will be mapped.

Evaluation for project effects. DWR proposes to assess habitat conditions for federal sensitive species on federal lands. This investigation will include field assessments of wildlife habitat and an evaluation of habitat conditions using the California Wildlife Habitat Relations system. The information collected under these surveys will be used to evaluate potential project effects on federal land management agency's sensitive species. Evaluation of potential project effects on these species will include analyses of Lake Oroville water level fluctuations, vegetation and fuels management practices, recreational use, and maintenance practices.

Task 12 State and Federal Species of Concern

Numerous species classified as California Species of Special Concern, federal species of concern, State fully protected species, or federal migratory non-game birds of management concern are known to occur in the project vicinity (Table 1).

Scope of surveys. Field surveys will be conducted to assess habitat conditions for species of State and federal concern. Field assessment sites will be selected from representative habitat units identified from vegetation mapping (SP-T4). During field investigations, vegetation structure and composition will be noted, as well as, disturbance factors that may preclude habitat use by state and federally sensitive species. The locations of species of concern observed during the habitat assessment will be mapped.

Evaluation for project effects. Habitat for species of concern will be assessed by review of vegetation mapping, onsite field evaluation, and habitat modeling with CWHR. Information on the occurrence and distribution of these species will be collected during surveys or study efforts of SP-T2, SP-T3, SP-T4, SP-T8, SP-T9, and SP-T10. A brief evaluation of potential project effects will be developed for each species for inclusion in the CEQA-NEPA documents.

Plants

There are no known occurrences of federal or State listed endangered, threatened, or rare plant species within the Project boundary. However, a preliminary review of exiting literature indicates that the study area may support six species that are listed under FESA or CESA, and an additional 36 species of concern. These species of concern include former USFWS Category 2

candidate species and species of concern to the U.S. Forest Service, Bureau of Land Management and/or the California Native Plant Society. Table 2 identifies all listed plant species and species of concern that occur or have potential for occurring within the Project boundary.

In addition, the surrounding area may potentially support seven additional species listed by the California Native Plant Society as List 4 species or by the U.S. Forest Service as Special Interest species (Table 3). These plants are considered to be limited in distribution and may warrant a higher listing in the future.

Six plant species of concern are known to occur within the project boundaries. They include Mosquin's clarkia, Ahart's dwarf rush, fox sedge, four-angled spikerush, Butte County calycadenia, and Brandegee's clarkia. These species are not listed or currently proposed for listing but their rarity warrants further investigation and they may be listed in the future.

Table 2 Special status plant species with potential for occurring within the Oroville Facilities study area

Scientific name Common name	Status USFWS[1]	 State[2]	 CNPS[3]	Habitat (elevation)	Flowering period
Federally or State listed					
Chamaesyce hooveri Hoover's spurge	FT		1B	Vernal pools (<250m)	Jul
Limnanthes floccosa ssp *californica* Butte County meadow foam	FE	SE	1B	Valley & foothill grassland (mesic), Vernal pools (<100m)	Mar-May
Orcuttia pilosa Hairy Orcutt grass	FE	SE	1B	Vernal pools (<200m)	May-Aug
Orcuttia tenuis Slender Orcutt grass	FT	SE	1B	Vernal pools (<200m)	May-Aug
Tuctoria greenei Greene's tuctoria	FE	SR	1B	Vernal pools (<200m)	May-Jul
Pseudobahia bahifolia Hartweg's golden sunburst	FE	SE	1B	Annual grassland and open woodland in clay soils (150m)	Mar-May
Species of Concern					
Agrostis hendersonii Henderson's bent grass	SC		3	Valley & foothill grassland (mesic), Vernal pools (<300m)	Apr-May
Allium jepsonii Jepson's onion	SC		1B	Cismontane woodland, Lower montane coniferous forest/serpentinite or volcanic (300-600m)	May-Jun
Astragalus tener var *ferrisiae* Ferris's milk-vetch	SC		1B	Meadows (vernally mesic), Valley & foothill grassland (subalkaline flats) (<60m)	Apr-May
Atriplex cordulata Heartscale	SC		1B	Chenopod scrub, Valley & foothill grassland (sandy)/saline or alkaline (<200m)	May-Oct
Atriplex depressa Brittlescale			1B	Chenopod scrub, Valley & foothill/ alkaline or clay, Playas (<200m)	May-Oct
Atriplex minuscula Lesser saltscale			1B	Chenopod scrub, Valley & foothill grassland/alkaline, Playas (<200m)	May-Oct
Balsamorhiza macrolepis var. *macrolepis* Big-scale balsamroot			1B	Cismontane woodland, Valley & foothill grassland /sometimes serpentinite (<1400m)	Mar-Jun
Calycadenia oppositifolia Butte County calycadenia			1B	Chaparral, Cismontane woodland, Valley & foothill grassland/volcanic or serpentinite (<900m)	Apr-Jun
Calystegia atriplicifolia ssp *buttensis* Butte County morning glory	SC		1B	Lower montane coniferous forest (600-1200m)	May-Jun
Carex vulpinoidea Fox sedge			2	Marshes & swamps, Riparian woodland (<1200m)	Jun
Clarkia biloba ssp *brandegeae* Brandegee's clarkia			1B	(<500m)	

Clarkia gracilis ssp *albicaulis* White-stemmed clarkia		1B	Chaparral, Cismontane woodland/ sometimes serpentinite (+/-500m)	May-Jul
Clarkia mosquinii ssp *mosquinii* Mosquin's clarkia	SC	1B	Cismontane woodland (+/-500m)	May-Jul
Clarkia mosquinii ssp *xerophila* Enterprise clarkia	SC	1B	Cismontane woodland, Lower montane coniferous forest (185m)	May-Jul
Cypripedium fasciculatum Clustered lady's slipper	SC		Lower montane coniferous forest, North coast coniferous forest/usually serpentinite seeps and stream beds (100-1700m)	Mar-Jul
Delphinium recurvatum Recurved larkspur	SC	1B	Chenopod scrub, Cismontane woodland, Valley & foothill grassland/alkaline (30-600m)	Mar-May
Eleocharis quadrangulata Four-angled spikerush		2	Marshes & swamps (freshwater) (<500m)	Jul-Sep
Fritillaria eastwoodiae Butte County Fritillary	SC	3	Chaparral, Cismontane woodland, Lower montane coniferous forest (openings)/sometimes serpentine (500-1500m)	Mar-May
Fritillaria pluriflora Adobe lily	SC	1B	Chaparral, Cismontane woodland, Valley & foothill grassland/often adobe (<500m)	Feb-Apr
Hibiscus lasiocarpus Rose-mallow		2	Marshes & swamps (freshwater) (<40m)	Aug-Sep
Juncus leiospermus var *ahartii* Ahart's dwarf rush	SC	1B	Vernal pools (50-100m)	Mar-May
Juncus leiospermus var *leiospermus* Red Bluff dwarf rush		1B	Chaparral, Cismontane woodland, Valley & foothill grassland, Vernal pools/vernally mesic ((280-500m)	Mar-May
Lewisia cantelovii Cantelow's lewisia		1B	Broadleafed upland forest, Chaparral, Cismontane woodland, Lower montane coniferous forest/mesic, granitic, sometimes serpentinite seeps (400-1300m)	May-Jun
Lupinus dalesiae Quincy lupine		1B	Lower montane coniferous forest, Upper montane coniferous forest/often in disturbed areas (1000-2500m)	May-Jul
Monardella douglasii ssp *venosa* Veiny monardella	SC	1B	Valley & foothill grassland (heavy clay) (<400m)	May
Myosurus minimus ssp. *apus* Mousetail	SC		Vernal pools (alkaline) (<1500m)	Mar-Jun
Paronychia ahartii Ahart's paronychia	SC	1B	Cismontane woodland, Valley & foothill grassland, Vernal pools (<500m)	Apr-Jun
Penstemon personatus Closed-throated beardtongue	SC	1B	Lower montane coniferous forest, Upper montane coniferous forest/metavolcanic (1500-1800m)	Jul-Sep
Rhyncopora california California beaked-rush		1B	Marshes, bog, and seeps (<1000m)	May-July
Sagittaria sanfordii Sanford's arrowhead	SC	1B	Marshes & swamps (assorted shallow freshwater) (<300m)	May-Aug
Sanicula tracyi Tracy's sanicle	SC	4	Cismontane woodland, Lower montane coniferous forest, Upper montane coniferous forest/openings (100-1000m)	Apr-Jul
Sedum albomarginatum Feather River stonecrop		1B	Chaparral, Lower montane coniferous forest (serpentinite) (300-900m)	Jun
Senecia eurycephalus var *lewisrosei* Cut-leaved ragwort		1B	Chaparral, Cismontane woodland, Lower montane coniferous forest/serpentinite	Apr-Jul
Sidalcea robusta Butte County checkerbloom	SC	1B	Chaparral, Cismontane woodland, (100-1600m)	Apr-Jun
Silene occidentalis ssp *longistipitata* Butte County catchfly	SC		Chaparral, Lower montane coniferous forest (1000-2000m)	Jul-Aug
Trifolium jokerstii Butte County golden clover		1B		

[1] United States Fish and Wildlife Service: FE - federal endangered, FT - federal threatened, SC - federal species of concern (not a formal listing)
[2] CDFG: SE - State endangered, SR - State rare
[3] California Native Plant Society: List 1B - plants rare, threatened, or endangered in California and elsewhere; List 2 - plants rare, threatened, or endangered in California but more common elsewhere; List 3 - plants about which more information is needed; List 4 - plants of limited distribution

Table 3 Low priority special status plant species with potential for occurring within the Oroville Facilities Study area

Scientific name Common name	Status CNPS[1]	Habitat (elevation)	Flowering Period
Allium sanbornii var. *sanbornii* Sanborn's onion	4	Chaparral, Cismontane woodland, Lower montane coniferous forest/serpentinite or volcanic(300-1400m)	Apr-Jul
Bulbostylis capillaris Hair-like bulbostylis	4	(>1000m)	
Clarkia mildrediae Mildred's clarkia	4	Lower montane coniferous forest (500-1600m)	Jun-Jul
Erigeron petrophilus var *sierrensis* Northern Sierra daisy	4	Cismontane wilderness, Lower montane coniferous forest, Upper montane coniferous forest/sometimes serpentinite (300-1900m)	Jun-Sep
Lilium humboldtii ssp. *humboldtii* Humboldt lily	4	Chaparral, Lower coniferous forest/ openings (600-1100m)	Jun-Jul
Stellaria obtuse Obtuse starwort	4	Upper montane coniferous forest, (mesic) (1600-2000m)	Jul
Viola tomentosa Wooly violet	4	Lower montane coniferous forest, Subalpine coniferous forest, Upper montane coniferous forest/gravelly (1500-2000m)	May-Aug

[1]California Native Plant Society: List 4 - plants of limited distribution

Tasks

The following tasks will be used to identify populations of special status plants and evaluate these occurrences for potential project-related impacts.

Task 1 Collect existing information

Collect existing information on special-status plant species that have potential for occurring in or near the study area. This data will be compiled from 1) CDFG Natural Diversity Database records (CNDDB); 2) Letter dated 12/10/99, USFWS to Chief, DWR Northern District regarding request for federally endangered and threatened species list for relicensing studies; 3) California Native Plant Society Inventory, 6th Ed.; 4) Plumas National Forest Sensitive Plant and Special Interest Species; 5) CDFG's Special Plants List, January 2001; and 6) other State and/or County biological survey records.

Conduct a literature survey to collect additional distribution and ecology information. In addition, survey botanists will familiarize themselves with individual species morphology and ecology by visiting local herbaria and extant populations prior to field searches. Vegetation and soils maps (from SP-T4 and SP-G1/2) will be used to help predict special status plant habitats within the study area.

Task 2 Field surveys

Surveys will conducted according to guidelines put out by the CDFG. Surveys will be floristic in nature and will be conducted to coincide with the flowering period of the target species. Some areas may need to be visited more than once

if multiple species have potential for occurring in the area. Survey intensities will depend on whether project impacts are likely to occur as well as habitat conditions and expected likelihood of rare plant occurrences.

All species will be identified by qualified botanists, either in the field or later at the CSU Chico Herbarium. If a special status plant population is located, detailed site and population information will be recorded, a CNDDB field survey form will be completed, the location mapped, and population photographed. Voucher specimens of non-listed species will be deposited with the CSU Chico Herbarium.

Task 3 Evaluation for project effects.

Analyze potential and on-going Project effects from Project facilities, operations, maintenance, and recreation facilities on special-status plant species. The qualitative phase of this assessment will be based on 1) habitat conditions noted in the field (observation of disturbance factors, threats, and adjacent land uses); and 2) a review of the operations and maintenance practices associated with the generation and recreational facilities supplies by the Recreation and Operations and Engineering Work Groups. The quantitative phase of this assessment will be based on any proposed recreation facilities enhancements that are developed by the Recreation Work Group.

6.0 Results

Study results will be summarized in a written report. Results will be prepared to form the basis of a Biological Assessment for the project or inclusion in the EIR/EA~~IS~~. An interim report will be prepared based on preliminary data that identifies critical environmental areas by June 2002. These critical environmental area designations will include areas containing vernal pools, elderberry bushes, bald eagle and peregrine falcon nest territories, and other areas where additional development or habitat disturbance should be avoided. This information will be provided to other work groups as a planning tool.

7.0 Coordination With Other Resource Areas/Studies

This study will require information from other Oroville relicensing studies. SP-EO2 will provide information related to reservoir and afterbay fluctuation models, river hydrology models, projected changes related to future operation, maintenance plans (including pesticide use and levee management practices), and operation of flood detention/relief structures. SP-LU1, SP-LU5, and SP-LU2 will provide information related to current and future land use/mananagement practices or plans including those associated with grazing, fuels, and vegetative management. Information required from the Technical Services Work Group include Geographic Information System layers related to ownership, land use, slope, aspect, elevation, project boundary, project facilities and features, roads, watershed boundaries, and precipitation isobars. SP-RS01 and SP-RS02 will

provide information related to type, intensity, and season of current recreational uses. Additional information to be provided SP-RS17 includes future recreational development and recreation related maintenance activities.

This study will also require information from environmental studies, including SP-T2, SP-T3, SP-T4, SP-T8, SP-T9, and SP-T10. Information related to projected river erosion rates and bank protection (SP-G2), water temperature (SP-W1), and tributary fisheries (SP-F?).

This study will provide both interim and final reports designating critical environmental areas to the ~~other~~ relicensing work groups.

8.0 Schedule

Animals

Tasks 1,4 and 5 completed by August 2003. Tasks 2,6,9, and 11 completed by December 2003. Tasks 3 and 10 completed by February 2004. Interim report is due June 2002. Final report is due March 2004.

Plants

Task 1 and 2 will be completed by August 2003 and Task 3 by February 2004. An interim report will be completed in September 2002. Final report is due March 2004.

Issues

Issue Statement: Project effects on federal and State listed, species of concern, candidate, proposed, and likely threatened, endangered, sensitive, and special interest plant and animal species and the habitat needed to support them. Concerns include, but are not limited to, amphibians, bald eagle foraging habitat, wintering roosts, and nest territories.

TE4 Provide suitable bald eagle foraging habitat along the North Fork upstream from Lake Oroville;
TE7 From January through August limit activities within active Bald Eagle nesting territories;
TE8 Between November 1 and March 31 limit activities within winter Bald Eagle roost habitat;
TE11 Encourage species recovery;
TE12 Develop plans for each Bald Eagle nesting territory; perform habitat improvement projects to enhance bald eagle nesting, roosting or foraging habitat;

TE13 Have adequate surveys been completed to determine what State or federally listed species (plant and animal) are potentially being impacted by project operations;

TE15 Inventory and monitor State and federal protected and sensitive plant and wildlife species;

TE16 Provide habitat leading to viable populations of endangered species;

TE17 Maintain habitat to support viable populations of all native and desired nonnative vertebrate species;

TE19 Provide diversity of plant and animal communities and tree species by assuring the continuous and viable presence of all seral stages of all native plant communities on the forest;

TE20 Provide a diversity of vegetation types and habitat to support viable populations of all fish, wildlife, and plant species;

TE21 Maintain and enhance the suitability of currently occupied nest territories, and provide sufficient potential nesting, foraging and winter habitat to meet recovery goals of the Pacific States Bald Eagle Recovery Plan;

TE22 At a minimum, provide habitat sufficient to maintain existing Bald Eagle populations;

TE25 Maintain viable populations of sensitive plant species. Protect sensitive and special interest plant species, as needed, to maintain viability;

TE38 Evaluate and mitigate bank swallow habitat impacts (threatened);

TE45 ESA compliance, want to hear about conflicts with folks and other species (bald eagles);

TE46 Improve terrestrial habitat with introduction of salmon (bears);

TE53 Biological Evaluation of species of concern from BLM and USFS (Plumas and Lassen NF) perspective Surveys should include Region 5 Sensitive plant and animal species as well as Plumas National Forest Special Interest plant species;

TE56 Adequacy of survey information to document the presence of state or federally listed plant or animal species that are potentially impacted by project operation;

TE57 Effects of reservoir surface elevation fluctuations on wildlife habitat;

TE59 Operate water levels in Thermalito Afterbay to prevent adverse impacts to Pacific Flyway waterfowl, especially during nesting in spring and early summer; continue to coordinate with DFG;

TE60 Evaluate effects of proposed increases in recreational activity in Thermalito Afterbay on waterfowl and other wildlife;

TE62 Protection and sustained conservation of terrestrial wildlife and flora in the project-affected area; comprehensive and well-crafted planning;

F13 Project effects on fish species listed for protection under the California and/or federal Endangered Species Acts (ESA), species of special concern, candidate species, proposed, and likely listed threatened and/or endangered fish species, and the habitat needed to support them.

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Oroville Facilities Relicensing
Environmental Work Group
~~Preliminary~~ Draft Study Plan~~roposal~~

SP-T3/T5. Riparian Resources, Wetlands, and associated floodplains

Introduction~~:~~

~~The following study plan addresses stakeholder concerns for wetland and riparian vegetation associated with the project facilities. The study includes four elements that focus on plant communities associated 1) with water operations along the Feather River; 2) with Lake Oroville; 3) with project operations between the Main Dam and the Afterbay Outlet; as well as, 4) with isolated wetlands located throughout the project study area. The following is a brief overview of the wetland and riparian communities within the study area.~~

In California, riparian ecosystems refer to those plant communities adjacent to and influenced by the surface and subsurface hydrologic regimes of aquatic systems. They support vegetation distinct from the upland habitats and are characterized by a mixture of plant species. Riparian systems provide a number of important functions to both the aquatic and terrestrial ecosystems associated with them. These include stream bank stabilization, flow moderation and flood control, sediment control, organic matter necessary to support aquatic communities, water quality improvement by filtration, temperature moderation by shading, stream structural diversity (large-woody debris), and wildlife habitat. The biological productivity of a stream is directly related to the health and proper functioning of the riparian system.

Wetlands are areas that are covered periodically or permanently with somewhat shallow water and support vegetation adapted to saturated soils. They include low-lying areas adjacent to lakes, streams, or channels that will periodically flood from both rainfall events and high water levels in the main water body. These include both natural and constructed wetlands such as marshes, lagoons, and the brood ponds around the Thermalito Afterbay. Isolated wetlands include ponds, impoundments created by dredger tailings, and vernal pools. Vernal pools occur in low-lying areas that are usually underlain by a substrate that limits drainage. These are filled by a combination of rainfall, overland runoff, and subsurface ~~groundwater~~flows. These pools may remain inundated for a week to several months before they dry down. These types of wetlands tend to have a high number of native plant species and associated wildlife and in California provide critical habitat for a number of special status plant and animal species.

Riparian and wetland habitats are important vegetation communities for wildlife. The diversity and density of species associated with these ecosystems is disproportionately high in comparison to other plant communities. The influence of riparian and wetland ecosystems on wildlife is not limited to animal species

that are restricted to the riparian or wetland zone. Population densities of species in adjacent upland habitats are directly related to the presence and health of the riparian or wetland areas.

Historically, these systems were flanked by extensive floodplains that supported riparian forests and associated wetlands. Extensive modification of these systems from land-use practices, levees, and flood control functions of dams has~~d~~ ~~drastically~~ altered and decreased functioning floodplains, and riparian and wetland systems in California.

Objectives

The objectives of this study ~~is~~ are to: 1) assess the effects of project-water operations on wetland and riparian habitats in the downstream reach of the Feather River, within the ~~diversion pool to the Afterbay outlet~~Project boundary below Oroville Dam, and around the perimeter of Lake Oroville and its tributaries within the project boundary and, 2) assess the effects of project operations on isolated wetland habitats within the project boundary.

Relationship to Study/Need for Study~~:~~

The results of this study will be used to provide 1) a description of the existing conditions for wetland and riparian vegetation and 2) an assessment of potential project-related effects to be included in the Preliminary Draft Environmental Assessment. These elements are required under CEQA and NEPA. This information is also required for license review under the Federal Power Act.

Study Area

The study area will include all areas within the Oroville Project boundary and downstream Feather River floodplain to the confluence with the Sacramento River.

Methods

The following methods will be used to investigate and evaluate the potential project effects on riparian and wetland vegetation associated with the project. These investigations will focus on three specific areas of concern associated with the project water operations, as well as, isolated wetlands that may be affected by water operations and other factors. These investigations are described below: including 1) an evaluation of riparian conditions along the lower Feather River~~LFR~~; 2) wetland communities associated with the water operations between ~~the Main~~Oroville Dam and the Afterbay outlet; 3) shoreline vegetation associated with the shoreline of Lake Oroville and tributaries within the project boundary, and 4) isolated wetlands throughout the study area.

Task 1: Evaluation of riparian conditions in the Lower Feather River

The ~~L~~lower Feather River ~~(LFR)~~ extends approximately 67 miles from the Main Dam to the Sacramento River, and is joined by the Yuba and Bear Rivers. The Feather River is a major tributary of the Sacramento River providing 25 percent of the instream flows. Riparian communities have been greatly reduced from the lower Feather River ~~LFR~~ due to levee construction and agricultural development. Levees separate the river from the riparian habitats that occur within the historic floodplain. The following study plan would address concerns for the project water releases on the remaining riparian communities along the lower Feather River~~LFR~~.

Fremont cottonwood, black willow, shining willow, and sandbar willow are the primary riparian succession species along the lower Feather River~~LFR~~, on gravels, sand bars, and riverbanks. A preliminary review of the existing riparian conditions along the Feather River indicate that mature stands of riparian vegetation are common along some reaches of the river, however, riparian vegetation is absent in other reaches. Project releases could impair recruitment for cottonwood and willow by altering the hydrology for cobble, gravel, and sandbar recruitment sites within the leveed floodplain of the lower Feather River~~LFR~~. The objective of this task is to identify and understand the local factors affecting the distribution, abundance and composition of riparian vegetation within the study area. Implementation of the following tasks would evaluate riparian recruitment along the lower Feather River~~LFR~~.

Task 1.1 **Lower Feather River** ~~LFR~~ Data Review

Collection and review of site-specific data from existing sources will allow for an understanding of the existing riparian and wetland conditions and an evaluation of the effects of project releases on riparian and wetland communities along the lower Feather River~~LFR~~. ~~The objective of this task is to identify and understand the local factors affecting the distribution, abundance and composition of riparian vegetation within the study area.~~ The following data would be reviewed from existing sources to describe and evaluate riparian conditions along the Feather River: historic air photos, riparian habitat mapping and occurrence data (SP-T4), historical hydrologic data (SP-EO2), channel typing by reach (Rosgen Level 2), and channel transects at key locations (SP-G2). Background information will also be collected on restoration and planning efforts along the Feather River, by contacting local planning departments and reclamation districts, Army Corps of Engineers, and Flood Management Div~~e~~ir~~r~~sion of DWR.

Task 1.2 **Lower Feather River** ~~LFR~~ Onsite Data Collection

Field investigations will be conducted to determine the status of riparian recruitment and collect data that will allow for evaluation of project releases at sites where impaired recruitment is identified.

Channel typing and air photo review will be used to identify river reaches for field investigations. These investigations will sample each reach type, and focus on areas of potential impaired recruitment. Sampling will also include reaches above and below the junction of the Bear and Yuba ~~R~~rivers. Indicators of impaired recruitment include stressed or dead vegetation, absence of seedling or sap~~p~~lings, colonization of riparian zones by upland species, and altered riparian cover. Indicators of impaired recruitment will be mapped, photo-documented, and data will be collected on the nature and extent of the impaired recruitment, as well as, substrates, and field indicators of hydrology.

Representative river cross-section data will be collected from sites that are identified with impaired recruitment. This will allow for further evaluation of potential adverse effects due to hydrologic alteration. At these sites, channel cross sections will be used to establish the stage-discharge relationship between recruitment sites and instream flows.

Task 1.3 Project Evaluation of Riparian Conditions

River deposits of sand, gravel, and cobbles provide recruitment sites for Fremont cottonwood, black willow, shining willow, and sandbar willow. A literature review will be conducted to identify specific criteria for successful recruitment at these sites along the Feather River, including grain-size distribution on substrate, including the timing of seeding establishment, rate of seeding establishment, and required hydrologic conditions for seeding establishment.

Project releases and potential alternatives for re-operation will be evaluated using the specific criteria for the natural establishment of riparian species and the stage-discharge relationship for each recruitment site. This evaluation will include an analysis of the frequency and duration of flooding on the recruitment of riparian vegetation.~~Three water year types will be used to review project releases at these sites. Water year types will include wet, normal, and critical dry years.~~

Where this evaluation identifies adverse effects on riparian recruitment, measures will be recommended to enhance, promote, or restore riparian habitat. Recommendations will be evaluated for conflicts with local and regional planning efforts. These measures will be developed pursuant to 18CFR4.51(f)(3)(v) ~~18CFR4.541(f)(3?)(iv?)~~, including 1) a description of the measure; 2) implementation schedule; 3) cost estimate and funding sources; 4) construction drawings (if needed); and 5) appropriate maps.

Task 2: Evaluate effects of project operations on wetland and riparian habitats in the project area below the dam

Project facilities below the dam that support wetland and riparian habitats include the Thermalito Forebay, Thermalito Afterbay, and the Oroville Wildlife Area (collectively, the Thermalito Complex). These areas provide high-value nesting habitat for waterfowl along the Pacific Flyway. Project operations can influence the quality and quantity of nesting habitat and nesting success. In the following tasks, data will be collected and evaluated to understand the relationship between project releases in the Thermalito Complex, with vegetation and local topography. The following tasks will investigate the current and alternative water operations in the Thermalito Complex and potential effects on wetland habitat for nesting waterfowl.

Task 2.1 Data Collection

The abundance and distribution of wetland vegetation within the Thermalito Complex is based on water surface elevations that fluctuate with project operations. Water surface elevations are controlled by water releases from the project and local topography (natural contours as well as berms, dikes, and checks). ~~Data will be collected to understand the relationship between project releases in Thermalito Complex, with vegetation and local topography.~~ Historical and alternative operations data will be obtained from SP-EO2. Vegetation information will be obtained from SP-T4. Topographic information will be obtained from project maps and SP-G1. This data will be compiled in a GIS database.

Task 2.2 Development of Hydrologic Criteria

Specific criteria for water level elevations within the Thermalito Complex has been provided by the California Waterfowl Association to maintain vegetation conditions surrounding and brood pond water levels. These criteria include a range of water levels that reach 133 feet on a regular interval during the waterfowl-nesting season (between Marc~~s~~h 15 and July 15). These criteria will be field checked by measuring the elevation profiles of water control features including flap gates and natural topography. If needed the stage-discharge relationship will be measured at selected locations in the Thermalito Complex.

Task 2.3 Project Evaluation

The effects of current and alternative water operations will be quantified based on water-level criteria by integrating historic data and model output with a GIS overlay of vegetation and topographic contours. This evaluation will determine the optimal conditions for maintenance of wetland vegetation and conditions for nesting waterfowl, including timing, inundation mapping, flood frequency, and duration of flooding.~~.~~

Task 3: Evaluate the project operations on riparian and wetland shoreline vegetation at Lake Oroville

The objective of this task is to evaluate and understand the effects of project water operations on riparian and wetland vegetation at the shoreline of Lake Oroville. This task will identify the current shoreline vegetation; distinguish the factors and mechanisms that influence existing distribution and occurrence of shoreline vegetation; evaluate current and alternative water operations that may affect wetland and riparian shoreline vegetation; and identify areas suitable for potential establishment of riparian and wetland vegetation at the reservoir shoreline. The following tasks will collect and compile data on substrate and vegetation into GIS to allow for riparian and wetland community correlation analysis.

Task 3.1 Identify and compile onsite resources and background data.

DWR will review existing sources of information and collect data from other Oroville relicensing studies to 1) provide a description of the existing wetland and riparian shoreline vegetation; and 2) allow for evaluation of project operations. This task will utilize the following data from other studies: 1) vegetation mapping of the reservoir (SP-T4); 2) hydrologic data on reservoir (SP- EO2); and 3) quantitative data on topography, soil types, and geomorphology (SP-G2). ~~Substrate and vegetation mapping information will be complied into GIS, allowing for riparian and wetland community correlation analysis.~~ Hydrological data will be assessed to determine frequency and periodicity of inundation. Existing literature will be reviewed to identify specific establishment criteria for dominant native plant species occurring at the shoreline.

Task 3.2 Assess onsite field conditions.

Riparian and wetland shoreline communities identified in Task 3.1 will be assessed in the field at low water conditions to 1) identify the species composition; 2) observe distribution patterns of the existing vegetation at the shoreline; 3) analyze community structure with respect to history; 4) assess plant recruitment and establishment; 5) collect data on elevation, slope, and topography; and 6) identify wetland functions.

Task 3.3 Evaluate current and alternative reservoir operations

Current and future project operations will be evaluated by comparing hydrologic modeling and vegetation mapping with field evaluations and species-specific establishment criteria.

Using data from Task 3.1 and 3.2, the reservoir evaluation will 1) determine the effects of water operations on the distribution of wetland and riparian shoreline vegetation; 2) identify the constraints for recruitment and establishment of vegetation at the reservoir shoreline; 3) identify areas suitable for potential establishment of riparian and wetland vegetation at the reservoir shoreline and

critical conditions needed for vegetation establishment; and 4) describe the potential alteration of wetland functions due to potential development of shoreline vegetation.

Task 4: Evaluate the effect of project operations on isolated wetland habitats within the project area

Isolated wetland features occur throughout the project lands. These include ponds, impoundments created by dredger tailings, and vernal pools. These wetlands can be affected by maintenance associated with recreation and generation facilities.

Task 4.1 Obtain and collect data on isolated wetlands

The following data will be obtained from other Oroville Relicensing studies: 1) mapping of isolated wetlands and species composition (SP-T4); 2) groundwater hydrology (SP-EO2); and 3) soil type and topography (SP-G2). This information will be integrated into GIS, allowing for watershed delineation for each isolated wetland. When isolated wetlands occur within 500 feet of each other, one watershed boundary will be determined for the unit. Information on the historical threats to isolated wetlands will be collected from the California Natural Diversity Data Base.

Task 4.2 Field assessment~~.~~

Wetland functions associated with isolated wetlands will be assessed in the field. Field inspections will be conducted when soil conditions are moist, to allow for detection of trampling, off-road vehicle use, and other types of effects on the watershed of each isolated wetland. Herbicide use and adjacent land uses will be noted during field inspection.

Task 4.3 Evaluation of isolated wetlands

A qualitative assessment of isolated wetlands will be prepared, including an assessment of wetland functions and values. This assessment will include the current state of isolated wetlands, historical and current disturbances, and proposed guidelines for future development of recreational facilities at or near wetland areas. This assessment will focus on areas of significant disturbance.

Results/Products

This investigation will provide qualitative and quantitative information on wetland and riparian habitats due to project water operations at Lake Oroville, in the Thermalito Complex, and in the ~~L~~lower Feather River. The results of this investigation will be summarized into a report on wetland and riparian vegetation with appropriate GIS maps for use with other studies on vegetation and wildlife.

The report will include suitable information for development of a Biological Assessment and the CEQA/-NEPA document.

Study Plan Coordination/Implementation

Implementation of this study plan will require coordination with other Oroville relicensing studies, as follows: historic air photos, riparian habitat mapping and occurrence data (SP-T4); channel typing of the ~~LFR~~lower Feather River, and channel transects at key locations (SP-G1 and SP-G2); historical and alternative operations data will be obtained (SP-EO2); quantitative data on topography, soil types, and geomorphology (SP-G2); and description of recreation use and recreation facility maintenance (SP-RS03 and SP-RS05). This study will also require coordination with the GIS program. Results from this study will be used for the evaluation of wildlife habitat in SP-T1 SP-T2, and SP-T10.

References

(To be completed)

Issue Statements

T3 Effects of existing and future project operations on floodplains and project water fluctuation zones, including soil stability, wildlife habitat and natural flood control functions, revegetation of native plant communities, and restoration opportunities (e.g. red willow planting).

T5 Project effects on riparian resources and protection and management of riparian habitat and wetlands (including vernal pools and brood ponds).

Issues Addressed

TE6 Re-vegetatate disturbed areas within floodplains to stabilize soil, bene~~g~~fit fish and wildlife, and restore the natural flood control qualities

TE9 Water releases from Oroville Dam and downstream impacts (vegetation and properties)

TE23 Minimize adverse impacts to riparian resources through appropriate mitigation

TE24 Facilitate hydroelectric development that provides protection of riparian resources

TE29 Interaction of lake with wildlife species (birds, amphibians, etc.) - how is lake used

TE34 Favor riparian dependent resources and limit disturbance in all riparian areas including riparian and aquatic ecosystems, wetlands, stream banks, and floodplains

TE35 Favor riparian resources over other resources, except cultural resources, in cases of conflict

TE37 Assure adequate protection of riparian area for Wildlife and fish resources

TE39 Manage flows and/or reservoir storage to maintain or enhance riparian plant communities and habitat for all life stages of fish. Cooperate with local, State, and other Federal water management agencies. Protect riparian areas while providing developed facilities

TE40 Native plant landscaping (potential sites: Feather River Fish Hatchery, State Parks Headquarters, DWR Field Office, Spillway Launch Facility - future) and restoration of native plant communities

TE52 Evaluate quality of vernal pools in the project boundary and project operations on health/quality of pools

TE57 Effects of reservoir surface elevation fluctuations on wildlife habitat

TE61 Project effects on downstream riparian habitat and the reservoir shoreline including on-going effects of reservoir operations and recreational uses; effective stabilization, restoration and enhancement measures

~~(To be completed)~~

Study Plan Implementation Schedule:

This program will task place on a concurrent schedule as follows: Tasks 1.1; 2.1; and 3.1 will be completed by June 2002. Field investigations identified in Tasks 1.2; 2.2; and 3.2 will take place between May 2002 and November 2002. A progress report on field investigations will be provided in January 2003. Evaluation of wetland and riparian conditions can take place with completion of the project operations model. Wetland and riparian evaluations are expected to take place between November 2002 and June 2003. An interim report will be provided for assessment of wildlife in August 2003 (for SP-T1, SP-T2, and SP-T10) and a final report will be prepared in December 2003.

Oroville Facilities Relicensing
Environmental Work Group
Preliminary Study Proposal

SP-T4. Biodiversity

Introduction

Vegetation cover and land use data maps are a necessary tool for planning resource studies and determining management options. They can help to identify areas that provide important habitat for threatened, endangered, or special status plant and animal species as well as help to determine which areas are vulnerable to habitat loss, degradation, or fragmentation due to project-related operations. They are also necessary for planning and conducting restoration projects especially following natural disasters such as a fire or a flood.

The only existing data source for the Oroville project area is the California GAP (Geographic Approach to Planning for Biological Diversity) Analysis Project, a cooperative effort between the U.S. Fish and Wildlife Service and the University of California at Santa Barbara. These data maps were produced using small-scale photography of 1:100,000 to describe general land cover. It is not adequate to provide sufficient resolution necessary for planning studies or assessing project effects required under the FERC license. Riparian vegetation along the Feather River downstream of the Fish Hatchery was mapped by CSU Chico's Geographic Information Center in 1996 and 1997. The 1:12,000 aerial photography used to map the riparian vegetation was taken in 1995, 1996, and 1997. The majority of the aerials used for mapping the Feather River riparian vegetation were taken prior to the 1997 floods and do not adequately depict the current conditions along the river. In addition, a field reconnaissance of the Feather River in the Fall of 2001 identified discrepancies and/or changes in a number of the vegetation polygons.

Vegetation maps will be produced using aerial photo interpretation together with ground-based surveys to produce a Geographic Information System (GIS) database of land cover with species specific information. These vegetation cover classes can be converted to wildlife habitat classes used by the California Wildlife Habitat Relations (CWHR) System to help predict wildlife use and develop management options.

Objectives

The objectives of this study are to 1) complete plant community and wildlife habitat mapping for evaluating project related effects on biological resources~~;~~ and 2) provide ecological data on the existing conditions and project related effects on vegetation and wildlife resources associated with the project pursuant to the CEQA, NEPA, and FERC regulatory framework.

Relationship to Study/Need for Study

A vegetation cover map will be included in the license application to describe the botanical resources of the Project affected area. These vegetation cover and wildlife habitat maps will be used to plan other studies related to botanical and wildlife resources and to assess a number of other issues of concern including 1) extent and acreages of plant communities and wildlife habitat (SP T1): 2) endangered or threatened species habitat (SP T2); 3) riparian and wetlands habitat (SP T3/5); 4) development of a wildlife management plan (SP T6); 5) recreation and wildlife (SP T9); 6) upland plant communities~~habitats~~, revegetation and restoration (SP T10); and 7) -f~~F~~uels and fire prevention (SP T11). These mapping efforts will be coordinated with the mapping studies in SP T7 (noxious weeds).

This information will provide the relicensing participants~~Environmental Work Group~~ with information on the botanical and wildlife habitat associated with the project area. It will help to address operation effects such as water fluctuation levels,~~;~~ recreation,~~;~~ and maintenance and construction activities on plant communities and wildlife habitat types. The existing data source is not adequate or at a resolution necessary for planning studies or assessing project effects.

Study Area

The study area will include all areas within 0.5 miles of the Oroville Facilities Project boundary and downstream Feather River floodplain to the confluence with the Sacramento River. This study area includes the geographic area of concern for potential direct and indirect impacts at project facilities on biological resources due to project maintenance and operations. The lower Feather River will be assessed for potential indirect effects due to operations for flood management and water releases.

Methods

Task 1: Aerial photography preparation

Aerial photography was flown for the Department in 1996 and 1999 at a scale of 1:12,000. These photos have been scanned at 600 dpi and will be orthorectified, mosaicked, and clipped into workable file sizes using ER Mapper software. The base grid used will be UTM Zone 10, NAD 83. Aerial photography for the Feather River downstream of the project area is currently being flown at a 1:7,200 scale.

Task 2: Develop preliminary list of vegetation types expected to occur within the study area

In order to define a vegetation classification system to be used for the study area, a preliminary classification system for mapping vegetation in the Oroville Project area is presented in Table 1. This draft classification system was developed by botanical staff familiar within the project area, in combination with a literature search, California Natural Diversity Database ecology files, and a review of existing vegetation classification and maps of the project area. They are based on the vegetation types used by the Holland vegetation classification (Holland 1986) and those described *in A Manual of California Vegetation* (Sawyer and Keeler-Wolf 1995). This list will be modified or refined as necessary in conjunction with preliminary sampling visits.

Table 1. Preliminary vegetation cover/land use types expected to occur within the Oroville Facilities Project Area.

UPLAND VEGETATION	**Forest/Woodlands**
	Mixed conifer forest
	Ponderosa pine forest
	Black oak forest
	Canyon live oak forest
	Mixed oak woodland (dense, open phases)
	Valley oak woodland
	Valley oak savanna
	Foothill pine-mixed oak woodland
	Foothill pine-mixed chaparral
	Foothill pine savanna
	Shrublands
	Mixed chaparral
	Whiteleaf manzanita chaparral
	Grassland/Herbaceous
	California annual grassland
RIPARIAN/WETLAND VEGETATION	**Forest/Woodland**
	Mixed riparian
	Black willow riparian
	Fremont cottonwood riparian
	Valley oak riparian
	Shrublands
	Mixed riparian scrub
	Willow scrub
	Blackberry scrub
	Herbaceous
	Freshwater marsh
	Vernal pool
	Disturbed
	Gravel tailings
	Gravel/Sandbar
	Disturbed riparian

	Open Water
	Lake
	River
DISTURBED/OTHER	Urban/disturbed
	Irrigated cropland
	Orchard
	Rock outcrop – non-serpentine
	Serpentine outcrop

Aerial photos will be used to subjectively locate vegetation patterns related to species composition, landforms, moisture regimes, canopy closures, etc. Sampling locations will be mapped with a GPS recorder. These sample locations will help refine the vegetation classification used for the study area. Field data will include information on species composition, percent cover, and canopy height.

Task 3: Vegetation mapping, accuracy assessment, and riparian vegetation data

Vegetation patterns will be digitized from the orthorectified aerial photos using Arcview software. Digitizing will typically be performed at a scale of 1:2,400; however, for finer detail a larger scale of up to 1:600 may be used to determine smaller sites. The minimum mapping unit for upland vegetation types will be one acre. Other unique cover types such as riparian and wetland habitats may be mapped as small as 0.1 acre. The resulting polygons will be labeled with a cover type attribute.

An accuracy assessment of the aerial photo interpretation will be conducted by field visits. A percentage of polygons of each vegetation type will have site visits. Each site will be mapped with a Global Positioning System (GPS). Site data will be recorded on data sheets.

Additional data on the riparian vegetation composition and structure will be collected for SP-T3/5 (riparian and wetland habitats analysis). Parameters will include canopy cover, species composition, and structure.

Task 4: Culturally important plant species

Obtain list of culturally important plant species to local Native Americans that have potential for occurring in the project area from the Cultural Resources Work Group. This list should also include high priority species with appropriate minimum mapping units for each species. Low priority species will not be mapped but presence per area or vegetation type will be included in the plant

species inventory. Significant populations will be mapped using a GPS and transferred to a data layer in the GIS database.

Task 5: Plant species inventory

During field surveys, ~~all~~ terrestrial and aquatic plant species encountered will be identified (if possible). An inventory of ~~all~~ plant species that occur within the FERC Project boundary will be compiled. A separate inventory will be compiled from the downstream Feather River studies.

Task 6: California Wildlife Habitat Relationships

The classification system used by the CWHR System was developed to predict wildlife habitat relationships. It provides a crosswalk used by CWHR to those used in other vegetation classification systems such as those described above. The habitats used by CWHR are grouped according to vegetative dominance or unique characteristics to which wildlife is thought to respond (Mayer and Laudenslayer, 1988). The vegetation cover/land use maps produced under Task 3 will be converted to the wildlife habitat classification system. These cover types will be further classified through aerial photo interpretation according to percent canopy closure for tree- and shrub-dominated and herbaceous habitats. Site visits will field check the canopy closure data. Field measurements will be taken to describe the habitat's structural condition such as size classes and forest structure. A preliminary list of California wildlife habitats for the project area is presented in Table 2.

Table 2. Preliminary list of California Wildlife Habitats within the Oroville Facilities Project Area

Riverine
Lacustrine
Annual grassland
Valley/foothill riparian
Cropland
Orchard/vineyard
Urban/residential
Emergent wetland
Mixed chaparral
Blue oak/foothill pine
Sierran mixed conifer/Montane hardwood
Ponderosa pine

Task 7: Vegetation cover/habitat type acreages and location maps

The GIS and data produced under Tasks 2, 3, 4,and 6 will be used to generate cover type acreage tables and habitat/vegetation cover type location maps. Large-scale maps will be produced of smaller features such as wetlands, riparian habitat, and culturally important plant species. A table of species diversity related to the density and size classes within each habitat type will be generated.

Task 8: California Wildlife Habitat Relations analysis

CWHR predictions will be used to determine the species diversity represented by each size and density class of each habitat type. This analysis will serve to identify high diversity habitat types, or high diversity size or density classes within habitat types for protection, maintenance, or enhancement.

Task 9: Analysis of Project effects

~~Evaluate t~~The~~-~~ potential and on-going Project effects on wildlife and native plant communities will be evaluated, incorporating information on current and future project-related impact areas obtained from the Recreation Work Group (SP-R5, SP-R9, SP-R10, and SP-R17); Land Use Work Group (SP-LU1 and SP-LU5); and Engineering and Operations Work Group (SP ~~-~~-E2 and SP-E4~~??~~). ~~GIS~~A Geographic Information System will be used to develop a quantitative assessment of habitat loss due to the construction of new facilities based on proposed recreational improvements. The evaluation will also include a qualitative assessment of maintenance activities related disturbance to wildlife and plant communities based on field assessment, mapping review, and appraisal of maintenance activities.

Results/Products

Following completion of this investigation, a summary reported will be prepared~~,~~ including 1) a description of the plant and wildlife communities (with area extent in acres); 2) maps illustrating the distribution of plant communities and wildlife habitat; 3) designation of high value areas of habitats for wildlife; 4) designation of areas which are vulnerable to habitat loss, degradation, or fragmentation due to ~~from~~ project operations; 5) identification of areas or habitats of high wildlife and plant species diversity for protection or enhancement purposes; 6) documentation on the presence of and map significant populations of plant species important to local Native Americans; 7) list of wildlife species potentially occurring within the project area; 8) ~~produce~~ an inventory of ~~all~~ terrestrial and aquatic plant species that occur within the Project boundary and lower Feather River; and 9) an analysis of potential and on-going project effects to wildlife and native plant communities.

The GIS mapping from this effort will include ~~-~~both vegetation cover and wildlife habitat ~~will be produced in this study~~ along with a table of acreages for each

cover type. A data layer in the GIS will be produced of culturally important plant species populations.

Study Plan Coordination/Implementation

The first five tasks of this study will not be coordinated with other work groups except Task 5 which will require a list of plants from the Cultural Resources Work Group. ~~Its products~~ The products produced in Tasks 7 and 8 will provide information/data for planning other studies. Task 9~~7~~ will require information from the Recreation Work Group (SP-R5, SP-R9, SP-R10, and SP-R17), Land Use Work Group (SP-LU1 and SP-LU2), Cultural Resources Work Group and Engineering and Operations Work Group. ~~DWR leads will be our contacts with the appropriate work groups.~~

References - To be completed

~~**(To be completed)**~~

Study Plan Implementation Schedule: Task 1 and a portion of Task 2 have been completed. Tasks 2, 3, 6, & 7~~&4~~ should be completed by ~~April~~ May 2002. Task ~~5~~4 and 5~~6~~ by ~~June 2002~~August 2003. Task ~~7~~ 8 will be completed by September 2002 and Task 9 by September 2003.

Issue Statement

Existing and future project effects on biodiversity (including plant species, seral stages, vegetation types and communities and wildlife) and ecosystem health and stability

Issues Addressed

TE4 Map plant and wildlife habitat communities

TE17 Maintain habitat to support viable populations of all native and desired nonnative vertebrate species

TE18 Improve and protect habitat for designated emphasis and harvest species

TE19 Provide diversity of plant and animal communities and tree species by assuring the continuous and viable presence of all seral stages of all native plant communities on the forest

TE20 Provide a diversity of vegetation types and habitat to support viable populations of all fish, wildlife, and plant species

TE25 Maintain viable populations of sensitive plant species. Protect sensitive and special interest plant species, as needed, to maintain viability

TE39 Manage flows and/or reservoir storage to maintain or enhance riparian plant communities and habitat for all life stages of fish. Cooperate with local, State, and other Federal water management agencies. Protect riparian areas while providing developed facilities

TE40 Native plant landscaping (potential sites: Feather River Fish Hatchery, State Parks Headquarters, DWR Field Office, Spillway Launch Facility - future) and restoration of native plant communities

TE47 Continue inventory of plant and animal species in the project area

TE62 Protection and sustained conservation of terrestrial wildlife and flora in the project-affected area; comprehensive and well-crafted planning

~~**(To be completed)**~~

Oroville Facilities Relicensing
Environmental Work Group
Draft Study Proposal

SP-T6 Interagency Wildlife Management Coordination and Wildlife Management Plan Development

Introduction

Several land management agencies actively manage wildlife resources within the project boundary including Plumas National Forest, Bureau of Land Management, California Department of Fish and Game, California Department of Parks and Recreation, and California Department of Water Resources. Each of these land management agencies has differing missions, policies, management direction, funding levels and priorities related to management of wildlife resources. Stakeholders have suggested that opportunities exist to improve interagency coordination, management, and planning related to wildlife resources.

Objectives

1) Identify opportunities to enhance interagency coordination, management, and planning related to wildlife resources within the project area.
2) Develop a coordinated interagency terrestrial resource management plan for the project area.
3) Create a forum to discuss terrestrial resource relicensing studies and facilitate resolution of potentially conflicting land use and wildlife management issues over the term of the license (adaptive management)

Relationship to Relicensing/Need for Study

There is concern that wildlife management of project lands may currently be undertaken in a piecemeal fashion by each individual land management agency. Previous interagency wildlife management decisions may not have always proceeded in a coordinated manner, forcing regulatory agency intervention. This study will ~~provide~~ identify opportunities to improve interagency coordination and communication on land use and wildlife management issues over the term of the license~~. The information developed in this study is not required for CEQA or NEPA.~~ . The study is important to the development of a wildlife management plan ~~which~~ that is required by FERC.

Study Area

Within the FERC ~~project~~ Project boundary and other areas that affect wildlife use of Project lands.

Methods and Analysis

Task 1). ~~C~~Collect and analyze each land management agencies' current mission, goals, objectives, management direction, policies and plans as they relate to wildlife management within the ~~project~~ study area.

Task 2). Identify common elements in land management agencies' plans and policies as well as inconsistencies between agencies.

Task 3). At the task force level, discuss and resolve identified management inconsistencies. Evaluate the adequacy of current levels of wildlife management and fish and wildlife related law enforcement funding. ~~Evaluate current and potential hunting and fishing opportunities within the project area.~~

Task 4). At the task force level, identify methods for improving interagency communication and coordination on wildlife issues. Explore funding needs and sources for wildlife management and law enforcement.

Task 5). At the task force level develop criteria for development of a coordinated ~~interagency wildlife~~ Wildlife ~~resource management~~ Management ~~plan~~ Plan for the project area.

Task 6). Complete all relicensing studies related to wildlife resources.

Task 7). Develop a Preliminary ~~Interagency~~ Wildlife Management ~~plan~~ Plan using the information and agreements developed under tasks 1-6 as well as results from other relicensing studies.

Task 8). Revise draft plan to include public and agency~~'s~~ concerns and comments and results from settlement negotiations.

Task 9). Submit to FERC a ~~final interagency wildlife~~ Wildlife ~~management~~ Management ~~plan~~Plan.

Results

The product of this study will be a~~n interagency~~ wildlife management plan for the lands within the project area that is consistent to the extent possible with wildlife management plans relevant to the ~~project boundary~~study area. This plan will identify how interagency coordination will occur in the future, guidelines for wildlife management, opportunities for interagency habitat improvements, evaluation of current wildlife management and law enforcement funding, ~~evaluation of current and future fishing and hunting opportunities,~~ relicensing ~~PM&E~~protection, mitigation, and enhancement measures, and coordinated monitoring efforts.

Coordination with Other Resource Areas/Studies

This study will be conducted concurrently with other terrestrial resource studies. Products from this study are highly dependent on the participation of all land management agencies in a special task force. The results of other terrestrial resource studies will be incorporated into the final product. Evaluation of current and future fishing and hunting opportunities will be handled in the Recreation and Socioeconomics Work Group.

Schedule

Tasks 1 and 2 completed by June 2002. Tasks 3, 4, and 5 completed by September 2002. Task 6 completed by July 2004. Task 7 completed by October 2004. Task 8 and 9 completed by December 2004.

Issues Addressed

Issue Statement-Interagency management coordination; adequacy of management plans and activities and funding for wildlife management

26 Are additional funds needed to augment the existing budget of the Oroville Wildlife Area? Presently available Fish and Game funds are being dedicated to managing people and not wildlife habitat.

32 DWR and DFG to work cooperatively to preserve hunting and fishing opportunities in the afterbay and borrow areas, and Lake Oroville. (transfer to Rec Group)

49 Responsible management by resource agencies.

50 Effects of fluctuating water levels in afterbay on wildlife. This issue addressed elsewhere.

54 Evaluation of funding adequacy for Oroville Wildlife Area.

55 Evaluation of funding adequacy for law enforcement.

56 Adequacy of survey information to document the presence of state or federally listed plant or animal species that are potentially impacted by project operation. This issue addressed elsewhere.

Oroville Facilities Relicensing
Environmental Work Group
Draft Study Plan

SP-T7 Project effects on noxious terrestrial and aquatic plant species

Introduction

Non-native, invasive plant species can have a significant impact on both human and environmental resources. Areas where vegetation and soils have been disturbed are much more susceptible to invasion by noxious weeds than natural environments. Aggressive noxious weeds crowd out native vegetation, alter the natural environment, and eliminate habitat for native wildlife species, as well as impacting agricultural water-use efficiency and recreational land values.

In Butte County, the Weed Management Area (BWMA), under direction of the County Agricultural Commissioner's Office, is coordinating efforts to control aggressive weed expansion, increase public awareness, and establish a database of weed locations throughout the county. The Department of Water Resources is working with the BWMA in its efforts to prevent the spread of and to control noxious weeds. Purple loosestrife, an aggressive weed along waterways in and near the project area, has been mapped by the California Department of Food and Agriculture in cooperation with the Butte County Agricultural Office and other State offices.

Relicensing participants have identified the land management practices, the associated clearing of land within the project boundary and the altered hydrology downstream of the Oroville Facilities as potential effects of the project on noxious weeds.

Objectives

The objectives of this study are to 1) ~~to~~ provide sufficient information allowing State agencies to comply with State noxious weed legislation; 2) ~~to~~ provide sufficient information that will allow Federal agencies to comply with federal noxious weed legislation; 3~~4~~) allow for habitat analysis of species listed under the Endangered Species Acts; and 4~~3~~) address the concerns of stakeholders relating to the infestation and spread of noxious weeds associated with project operation and maintenance activities.

Relationship to Relicensing

Relicensing participants have identified the land management practices, the associated clearing of land within the project boundary, and the altered hydrology downstream of the Oroville Facilities as potential effects of the project on noxious weeds. Non-native plant species can adversely impact native plant species and communities (including State and federally listed species) through competition. The federal Endangered Species Act requires an evaluation of project-related impacts to federally listed species through competition and habitat degradation. This includes land disturbances and other project operations that favor non-native species over listed species and projection operations that influence the dispersal of noxious weed species into downstream waters.

The maps produced from this study will provide information on the distribution and extent of noxious weed locations within the project area. This information will help address continuing effects to native plant and animal habitats and riparian resources from water fluctuations, recreation, and other project-related activities. This data, together with other study results, will provide baseline conditions for assessing potential management actions.

These mapping efforts will be coordinated with mapping studies in SP T4 (vegetation and wildlife habitat) and in conjunction with other plant species inventories produced in SP T1 and SP T2. This information will provide relicensing participants~~the Environmental Work Group~~ with information on the distribution of noxious weeds in areas affected by project operations as well as their life history and dispersal mechanisms relative to project-related land management practices.

Study Area

The study area will include all areas within 0.5 miles of the Oroville Facilities Project boundary, downstream irrigation canals, and downstream Feather River levees to the confluence with the Yuba River. Surveys may be expanded if survey data and information gathered indicate project-related effects influence the dispersal and establishment of noxious weeds further downstream.

Methodology

Task 1: Develop list of high priority noxious plant species expected to occur within the study area and literature search

High priority plant pest species lists will be developed from the California Department of Food and Agriculture, California Exotic Plant Pest Council, the U.S. Department of Agriculture, and the Plumas National Forest lists. A preliminary list is presented in Table 1. This list includes all species that have potential for occurring in the project-affected area~~. It will be modified to include only those species of greatest concern.~~ Literature surveys will be conducted and

information will be gathered on the biology and ecology of noxious weed species, as well as information on dispersal mechanisms in relation to project operations.

Table 1. Preliminary list of noxious weed species that have potential for occurring in the Oroville Facilities Project area.

Scientific Name Common Name	CDFA List[1]	CalEPPC List[2]	Habitat (elevation)
Ailanthus altissima Tree of heaven	A	A-2	Disturbed urban areas, waste places, riparian areas, grasslands (<1250m)
Arundo donax Giant reed	A	A-1	Moist places, seeps, ditchbanks (<500m)
Brassica nigra Black mustard		B	Fields, disturbed areas (<1500m)
Bromus madritensis ssp. rubens Red brome		A-2	Open, disturbed places (<2200m)
Cardaria chalepensis Lens-podded hoarycress	B	B	Disturbed, gen saline soils, fields (<1500m)
Cardaria pubescens Whitetop	B		Saline soils, fields, ditchbanks (<2000m)
Carduus pycnocephalus Italian thistle	C	B	Roadsides, pastures, waste areas (<1000m)
Centaurea maculosa Spotted knapweed	A	Red Alert	Disturbed areas (<2000m)
Centaurea solstitialis Yellow starthistle	C	A-1	Pastures, roadsides, disturbed grassland or woodland (<1300m)
Cirsium arvense Canada thistle	B	B	Disturbed places (<1800m)
Convolvulus arvensis Field bindweed	C		Orchards, gardens (gen <1500m)
Cortaderia selloana Pampas grass		A-1	Disturbed sites (<300m)
Cynodon dactylon Bermuda grass	C		Disturbed sites (<900m)
Cytisus scoparius Scotch broom	C	A-1	Disturbed places (<1000m)
Ficus carica Edible fig		A-2	Disturbed, moist areas (<800m)
Foeniculum vulgare Wild fennel		A-1	Roadsides, waste places (<350m)
Genista monspessulana French broom	C	A-1	Disturbed places in foothills (<550m)
Hypericum perforatum Klamathweed	C	B	Pastures, abandoned fields, disturbed places (<1500m)
Lepidium latifolium Broad-leaved peppergrass	B	A-1	Saline soil, roadsides (<1900m)
Linaria genistifolia ssp. *dalmatica* Dalmation toadflax	A		Disturbed places, pastures, fields; (gen <1000m)

Lythrum salicaria Purple loosestrife	B	Red Alert	Marshes, ponds, streambanks, ditches (<1000m)
Myriophyllum aquaticum Parrot's feather	B	B	Ponds, ditches, streams, lakes, (<500m)
Rubus discolor Himalayan blackberry		A-2	Disturbed moist areas (<1600m)
Salsola paulsenii Tumbleweed	C		Disturbed places (700-1800m)
Solanum elaeagnifolium Hoary horsenettle	B		Dry, disturbed places fields (<1200m)
Sorghum halepense Johnson grass	C		Disturbed areas, ditchbanks, roadsides (<800m)
Taeniatherum caput-medusae Medusa-head	C	A-2	Grassy slopes and flats
Tamarix parviflora, T. ramosissima Tamarisk, salt cedar		A-2	Washes, streambanks, ditches (<800m)
Tribulus terrestris Puncturevine	C		Roadsides, railways, vacant lots, dry, disturbed areas (<100m)
Vinca major Periwinkle		BC	Sheltered places, especially along streams (2-200m)

[1]California Department of Food & Agriculture List of Noxious Weeds: List A - Most invasive wildland pest plants - eradication, containment or other holding action at the state-county level; List B - Includes species less widespread and more difficult to contain - eradication, containment, control or other holding action at the discretion of the Commissioner: List C - Weeds that are so widespread that the agency does not endorse state or county-funded eradication except in nurseries.

[2]California Exotic Pest Plant Council List of Exotic Pest Plants of Greatest Ecological Concern: List A-1 - Most invasive wildland pest plants, widespread; List A-2 - Most invasive wildland pest plants, regional; List B: Wildland pest plants of lesser invasiveness; List Red Alert: Species with potential to spread explosively, infestation currently restricted.

Task 2: Species surveys and data collection

Surveys will be conducted concurrently with floristic and special status plant species surveys. All weed species and non-native plant species will be noted in the floristic surveys. However, only high priority species will be mapped. This will include CDFA List A and B, Cal EPPC List A1/2 and Red Alert species, and other species of concern to local irrigation districts and State or Federal agencies All species on the USFS noxious weed lists will be surveyed ~~for~~ on National Forest Lands. Voucher specimens for these species will be collected and deposited with the Feather River Ranger District. All other voucher specimens will be deposited with CSU Chico Herbarium. Surveys will be conducted during the appropriate time of year for proper identification of each species.

Data will be collected by hand mapping on 1:24,000 USGS topographic maps and/or by using a Trimble GeoExplorer Global Positioning System (GPS) Unit. According to weed mapping standards, data will be collected as points, lines

(such as along a road or river corridor) or as area features. Point infestations include area classes of

1) <0.1 acre
2) 0.1 to 1 acre
3) 1 to 5 acres

Line infestations will be represented by a line with a representative width to determine acreage. Polygons will be used for infestations that are more than 5 acres in size. The following cover classes (percent coverage) will be used to describe the density of the infestations.

T = (Trace; rare): less than 1% cover
L = (Low; occasional plants): between 1 and 5% cover
M = (Moderate; scattered plants): between 5 and 25% cover
H = (High; fairly dense): between 25 and 100 % cover

Task 3: Weed mapping and coverage tables

The information collected will be entered into a Geographic Information System (GIS) using Arcview software. Maps of noxious weed species distribution and acreages of each coverage will be produced.

Task 4: Evaluation and management strategies

These data, together with species information, will be evaluated relative to dispersal mechanisms, project-related land management practices and project operations. Should noxious weeds be identified as a concern downstream of the Oroville Facilities, the effects of altered hydrology as a primary dispersal mechanism via the discharge from the project will be assessed. Management strategies for controlling noxious weed species dispersal in cooperation with other county and State efforts will be identified and analyzed. This evaluation will include an analysis of economic benefits due to noxious weed populations, as well as, adverse effects on native vegetation.

Results/Products

The results of this investigation will be summarized in a report and will include the following: 1) identification of the high priority noxious weed species considered high priority species that have potential ~~to~~for occurring in or adjacent to the project area and project-affected downstream waters that may be affected by project operations; 2) an inventory and map of high priority noxious plant species in the study area; 3) information on the life history and dispersal mechanisms of the target species; 4) an evaluation of the project-related land management practices and project operations in relation to dispersal of noxious weed species; 5) management strategies for controlling noxious weed species on project lands and for controlling their dispersal onto adjacent lands and

downstream waters such as irrigation releases; and 6) information on the economic use of noxious weed species within and near the project boundaries.

A GIS map and an acreage table of noxious weed locations will be produced in this study. A summary report will include the location data, information on the life history and dispersal mechanisms of the target species, and an evaluation of land management practices and project operations such as altered hydrology, recreational impacts, and operation and maintenance activities on the dispersal of these species. Management strategies will be addressed for controlling the further spread of and to control noxious weed populations within the project boundary, on adjacent lands, and downstream waters.

Study Plan Coordination/Implementation

Information will be needed from the Recreation Work Group (SP-R5, SP-R9, SP-R10, and SP-T17), Engineering and Operations Work Group (SP-E2 and SP-E4~~??~~), and Land Use Work Group (SP-LU1 and SP-LU2) for the evaluation of project-related operations on the potential for project-related distribution and dispersal of noxious weeds.

Study Plan Implementation Schedule

Surveys will be conducted from March through August of 2002 in conjunction with SP T1, SP T2, SP T3/5, SP T4, and SP T10 studies. Follow-up surveys will be completed in 2003 if needed. Maps will be produced concurrently during the studies and should be completed by the summer of 2003. Task 4, the evaluation and summary report, should be completed by September 2003.

References – To be completed

~~(To be completed)~~

Issue Statement

Effects of the project on the introduction, distribution and management of noxious terrestrial and aquatic weeds

Issues Addressed

TE30a Inventory and map alien plant and animal species

TE30b There is an interest in determining locations of noxious weeds within and adjacent to the project area and determining control and eradication measures as needed. Inventory plants located on National Forest system lands within and adjacent to project facilities as well as the perimeter of Lake Oroville. Survey for

California Department of Food and Agriculture Category A, B and C noxious weeds.
TE31 Remove non-native plant species around lake, river, forebay and afterbay areas especially star thistle, ailanthus, and other invasive plant species

TE40 Native plant landscaping (potential sites: Feather River Fish Hatchery, State Parks Headquarters, DWR Field Office, Spillway Launch Facility – future) and restoration of native plant communities

TE42 Include aquatic species of non-native plants

TE47 Continue inventory of plant and animal species in the project area

TE51 Restoration of areas used as stockpile sites during dam construction

~~(To be completed)~~

~~Study Plan Implementation Schedule~~

~~Surveys will be conducted from March through August of 2002 in conjunction with SP T1, SP T2, SP T3/5, SP T4, and SP T10 studies. Follow-up surveys will be completed in 2003 if needed. Maps will be produced concurrently during the studies and should be completed by the summer of 2003. Task 4, the evaluation and summary report, should be completed by September 2003.~~

Oroville Facilities Relicensing
Environmental Work Group
Draft Study Plan

SP-T8 Project Effects on Undesirable Non-native Wildlife

Introduction

The California Wildlife Habitat Relationships Program identifies at least 14 non-native vertebrate wildlife species as having potential to occur within the project area, including, including six birds, seven mammals, and one amphibian~~s~~ (Table 1).

Table 1. List of non-native vertebrate wildlife species potentially found within the project area.

Common Name	Scientific Name	Status
Bullfrog	*Rana catesbeiana*	DFG Harvest
House sparrow	*Passer domesticus*	
Bobwhite quail	*Colinus virginianus*	DFG Harvest
Ring-necked pheasant	*Phasianus colchicus*	DFG Harvest
Wild turkey	*Meleagris gallopavo*	DFG Harvest
Rock dove	*Columba livia*	
European starling	*Sturnus vulgaris*	
Virginia opossum	*Didelphis virginiana*	DFG Harvest
Black rat	*Rattus rattus*	
Norway rat	*Rattus norvegicus*	
House mouse	*Mus musculus*	
Muskrat	*Ondatra zibethicus*	DFG Harvest
Red fox	*Vulpes vulpes*	
Feral pig	*Sus scrofa*	DFG Harvest

Several of these species were introduced by the California Department of Fish and Game as harvest species or are currently managed as harvest species (Table 1). All of these harvest species compete with, displace, or prey upon native wildlife to a certain extent. However, due to their management status these species are not perceived as undesirable by the local public user groups or the California Department of Fish and Game. Therefore, these species will not be included in the analyses of the project effects on undesirable non-native wildlife.

Study efforts will focus the remaining seven non-native vertebrate wildlife species including house sparrow, rock dove, European starling, black rat, Norway rat, house mouse, and red fox.

House sparrows were first introduced from Europe into the eastern United States around 1850 and rapidly spread across the country arriving in California at San Francisco in the early 1870s (Ziener et. al 1990). Preferred habitats include urban and croplands (primarily grain crops). This species occurs throughout the project area near human habitation or livestock with highest densities frequently near outdoor restaurants, stables, and other human developments. House sparrows are aggressive nesters and frequently displace native avian species by evicting nesting adults or destroying nests. This species primarily impacts secondary cavity nesting species including swallows, western bluebird, house wren, and house finch.

Rock doves or domestic pigeons were also introduced from Europe. This species was probably introduced into the United States prior to 1800 as a food source. Preferred habitats includes perennial and annual grasslands as well as croplands, pasture, and urban. Rock doves nest within sheltered locations in variety of human-related structures including bridges and buildings (Harrison 1978). This species may compete with native species for food resources including waste grains, seeds, and human food scraps. Rock doves are preyed upon by several native species including peregrine falcon and several species of carnivorous furbearers.

European starlings were introduced into the United States from Europe and are currently an abundant species within the project area and nearby agricultural habitats. Preferred habitats include urban, cropland, pasture, and orchard/vineyard. They feed on insects, grains, garbage, fruits, nuts and seeds. This species can form large wintering flocks capable of inflicting damage to crops. Starlings (like house sparrows) are aggressive competitors for cavity nest sites. They will use almost any cavity greater than 1.5 inches diameter in buildings, nest boxes or trees (Bent 1950). They successfully displace wrens, nuthatches, swallows, titmouse, bluebirds, kestrels, acorn woodpeckers and wood ducks (Small 1974, Kessel 1957, Troetschler 1976, and Grabill 1977).

Black rats were introduced from Europe in the early 1800s and are relatively common in urban areas in California's Central Valley. In Northern California this arboreal species also occurs in riparian habitat, and Himalayaberry thickets (Ingles 1965, Dutson 1973). The introduced Norway rat and muskrat are this species closest competitor. Black rats carry a variety of diseases, which can effect humans including bubonic plague, rabies, typhus, tularemia, and trichinosis (Zeiner et. al 1990).

Norway rats were introduced from Europe and occur within the valley portions of the project area. Norway rats occur in both urban, agricultural, and native plant communities including wetlands and riparian habitats. Highest densities occur in dumps and grain croplands. Norway rats are omnivorous and prey upon native birds, eggs, and small mammals in addition to fruits, seeds, and garbage. Hawks, owls, foxes, weasels and snakes prey upon Norway rats. Like black rats,

this species carries a variety of diseases including salmonellosis, tularemia, leptospiral jaundice, Haverhill fever, and typhus fever (Godin 1977).

House mice were also introduced from Europe and are common in the project area near human habitation. This species is less common in native plant communities but does occur in grassland, forest, and shrub habitats near urban habitats. Native harvest mice and microtus (voles) dominate this introduced species. Most carnivorous furbearers as well as hawks, owl, voles, snakes and rats prey on house mice. Like the other introduced rodents, which have evolved in close association with humans, this species can carry and transmit viral and bacterial diseases to humans.

Two subspecies of red fox occur in California. Native red foxes are restricted to higher elevation with most sightings ranging from 3,900 feet to 11,900 feet elevation (Schempf and White 1977). The introduced subspecies generally occurs at elevation less than 3,000 feet elevation (Schempf and White 1977). Original introduction of the non-native subspecies was probably related to hound hunting or fur farming. Red foxes within the project area are the non-native subspecies and use annual grasslands, perennial grasslands, emergent wetland and cropland habitats. They feed primarily on small mammals but are believed to be an increasingly important predator of nesting waterfowl, shorebirds, and upland game birds as its range and density continue to expand within California's Central Valley (Zeiner et. al 1990). Non-native red fox appears to coexist with native canids including coyote, gray fox, and kit fox.

Objectives

Identify potential changes in project operations, land use, features, and management practices which could serve to reduce the potential impact of these seven undesirable non-native wildlife species on native species and their habitats.

Relationship to Relicensing/Need for Study

Relicensing participants have identified project effects including land management, project facilities, and operation on undesirable non-native wildlife as a relicensing issue. Non-native wildlife species can adversely impact native wildlife (including State and federal special status species) through competition, predation, and disease. Further, several of the undesirable non-native species have evolved in close association with humans and carry or transmit disease to humans. NEPA requires assessment of public health impacts. Many of the currently developed recreation facilities contain features or activities which are attractive to these non-native undesirable species.

Study Area

Within the project boundary and downstream within the Feather River floodplain to the Yuba River as well as areas outside the project area as appropriate. Most of the undesirable non-native species identified in the Introduction have relatively small home ranges and prefer urban or agricultural habitats.

Methodology

For the purpose of this evaluation DWR will assume that all seven undesirable non-native wildlife species are present in the project area and that some level of project related effects may occur.

Task 1). Literature review - Review scientific literature related to species biology, habitat requirements, and life history requirements of the seven selected undesirable non-native wildlife species.

Task 2). Using the information reviewed and collected under Task 1, conduct a desktop evaluation which identifies general management guidelines within the study area which serve to limit the occurrence of these seven selected undesirable non-native wildlife species. Identify potential management practices that could be incorporated into the Wildlife Management Plan if it is determined that a problem with these undesirable non-native wildlife species exists or could exist during the term of a new license.

~~Task 3). Incorporate management recommendations identified under Task 2 into Wildlife Management Plan (SP-T6) for submittal to FERC.~~

Results

Study results in the form of general management guidelines will be identified so that they can be incorporated into the Wildlife Management Plan ~~for submittal to FERC~~.

Coordination with Other Resource Areas/Studies

This study will be conducted concurrently with other terrestrial resource studies. Results from this study may be incorporated into other terrestrial resource studies including SP-T2 (Special Status Species) and SP-T7 (Noxious Plants). Study results will be incorporated into Wildlife Management Plan (SP-T6) for submittal to FERC.

Schedule

Task 1 literature review completed by August 2002. Task 2 desktop analyses completed by April 2003.

References

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Issues Addressed:

Issue Statement-Effects of existing and future operations of project on the introduction, distribution and management of undesirable non-native wildlife species.

California Department of Water Resources
Oroville Facilities
Preliminary Study Plan

SP-T9 Recreation and Wildlife

Introduction

The project area is one of the major recreation areas in Northern California with an estimated one-half million-visitor days use per year. Recreational use in many forms occurs throughout the year with peak use occurring between May and September. These recreational uses include camping, boating, fishing, hunting, bird watching/nature study, horseback riding, hiking, biking, swimming, sailing, and picnicking. Recreational developments impact wildlife and plant communities through direct loss due to habitat conversion (roads, boat ramps, campgrounds, trails, swimming beaches, parking lots, utilities, sewage systems, hatcheries, buildings, storage areas, fuel breaks, marinas, and other developments). Recreation use can indirectly impact wildlife density and distribution through disturbance/displacement of resident and migratory wildlife. Other potential direct and indirect impacts to wildlife and plant communities are associated with recreation related maintenance activities, soil erosion, chemical contamination, gravel removal, fencing, herbicide and pesticide use.

Objectives

1) Identify current and future recreation-related direct and indirect impacts to wildlife and plant communities.
2) Identify opportunities to reduce or eliminate recreation-related impacts to wildlife and plant communities.

Relationship to Relicensing /Need for the Study

Both direct and indirect impacts to wildlife and the plant communities that support them may occur as a result of the high level of recreational use in the project area. Levels of recreational development and use are likely to increase in the future, resulting in localized and area-wide impacts to wildlife and their habitats. However, opportunities exist to reduce both current and future recreational impacts through project siting, project design, area closures, seasonal closures, habitat improvements, modification of maintenance practices, restrictions on certain types of recreational use, public education, and other practices. The results of this study are required for both CEQA and NEPA compliance. Further identification of potential recreational impacts to State and federal special status species is required for compliance with the Endangered Species Acts. Results of this study may lead to protection, mitigation, and enhancement measures incorporated into the license.

Study Area

Within the FERC project boundary and other areas potentially affected by Project recreation facilities and use. Data collection on wildlife and habitat use may take place outside the FERC boundary when evidence indicates that recreational disturbances extend beyond the FERC boundary. These disturbance can be due to noise, intrusion, dust or erosion. When surveys extend beyond the FERC boundary, the rational and justification for additional data collection will be provided within the survey report. The survey report will also include the nature of impact, including a qualitative description of the effect as well as the specific affected. ~~(capture criteria to make that judgement in methodology). (check with Steve Nachtman re: responsibility for trails that extend outside Project boundary)~~

Methods and Analysis

Task 1). Obtain wildlife habitat/plant community map in GIS format (produced under SP-T4). Wildlife habitat designation will follow CWHR methodology

Task 2). Add location information derived from ESA surveys (produced under SP-T2) to wildlife habitat/plant community map.

Task 3). Identify current and potential future recreational developments and associated maintenance practices. (provided by Rec SP-R10)

Task 4). Using GIS, map existing recreation developments and associated maintenance practices identified in Task 3 (available in Autocad format). Mapping of maintenance practices will be developed from the O&M maintenance plan which identifies the frequency, timing, and location of maintenance activities (provided in SP-R5).

Task 5). Collect and evaluate recreation use levels by season, location, and use type (provided by Rec SP-R7 and SP-R13~~)~~

Task 6). Conduct seasonal field evaluations of potential wildlife recreational conflicts. Direct habitat loss/conversion will be estimated for each facility including roads, parking lots, and boat ramps. Indirect habitat loss/displacement will be evaluated at each location using a number of criteria including species-specific sensitivity to human intrusion, noise, cover requirements, reproductive, forage and water needs. Identification and evaluation of recreational impacts to special status species will be conducted under SP-T2.

Task 7). ~~Develop~~ Identify site-~~-~~specific ~~recommendations~~ alternative actions to reduce or eliminate current and future wildlife/recreation use conflicts (provided in SP-R12, SP-R15, and SP-R16).

Task 8). Provide study results in written report.

Results

Study product consists of a report that identifies recreation/wildlife conflicts and alternative ~~with recommendations for~~ area-wide and site-specific avoidance or remediation actions. The information provided in the report will be the basis for development of protection, mitigation, and enhancement measures and may lead to settlement agreements. This report will include a set of tables that identify the potential recreation wildlife conflicts, and estimate both direct and indirect habitat losses at each location.

Coordination with Other Resource Areas/Studies

Study requires products from studies related to SP-T2, SP-T4, planned recreation use surveys, operations and maintenance practices, and identification of any future recreational developments for successful implementation.

Study Schedule

Task 1 completed by April 2002. Task 2 completed by June 2004. Task 3 current developments completed by April 2002, future developments as identified. Task 4 current developments completed by April 2002, future developments as identified. Task 5 (unknown completion date). Task 6 current developments completed by August 2003, future developments completed as identified. Task 7 and 8 completed by June 2004. Preliminary report will be available June 2003.

Issues Addressed

Issue Statement-Effects of project-related recreation facilities, activities (including authorized and unauthorized access and use) and management on nesting and wintering Pacific Flyway waterfowl, other wildlife and plant communities.

60 Evaluate effects of proposed increases in recreational activity in Thermalito Afterbay on waterfowl and other wildlife

63 Protection and sustained conservation of terrestrial wildlife and flora in the project-affected area; comprehensive and well-crafted planning

California Department of Water Resources
Oroville Facilities
Draft Study ~~Proposal~~Plan

SP-T10 Effects of project features, operations and maintenance on upland ~~habitat~~ plant communities~~s~~

Introduction

Current and future operations of the Oroville Facilities may impact upland plant communities, including rare or unique community types. These impacts can be from any project-related activity that alters, degrades, destroys, or enhances habitat features necessary to support that plant community type. Changes in land use, maintenance and operation activities, or recreational use of an area could potentially affect plant communities within and near the Project area.

A qualitative assessment and analysis of project-related impacts on the plant communities can provide program managers and stakeholders the information necessary to ~~1)~~ identify those management options or project modifications which minimize project-related impacts. ~~And (move 2 to results section) 2) identify opportunities for enhancement by restoration or revegetation of native plant communities.~~

Objectives

The objective~~s~~ of this study is~~are~~ to ~~1)~~ identify direct and indirect impacts of project features (facilities, operations, maintenance, and recreation) on upland vegetation communities including rare or unique plant communities.~~; (move to results) and 2) identify opportunities for restoration and/or revegetation within the Project area.~~

Relationship to Relicensing/Need for Study

Relicensing participants have identified project-related facilities, operations, maintenance, and recreation facilities and associated activities as having a potential effect on upland plant communities. An evaluation of project effects on botanical resources is also required for CEQA/NEPA compliance and will be included in the FERC license application.

The information collected will be used to identify opportunities to minimize or mitigate project-related impacts to plant communities and to identify potential areas for enhancement through revegetation and restoration of a site

Study Area

The study area will include all areas within the FERC project boundary and other areas potentially affected by project recreation facilities and use. An analysis of downstream Feather River riparian habitats will be analyzed under SP-T3/5. For ESA analysis and their associated plant communities, the study area is defined in SP-T2.

Methods

Task 1: Data collection and review

Collect and review information affecting plant communities in the ~~project~~ study area. Data to be collected include vegetation communities mapping and analysis (SP-T4); noxious weed locations and dispersal and management options (SP-T7); state and federal special status species analysis (SP-T2); riparian and wetland issues (SP-T3/5); fuels management (SP-T11); and soil types and topography information (SP-G1/G2). Obtain and review current and future Project-related facilities data from the Recreation Work Group (SP-R5, SP-R9, SP-R10, SP-R17~~—~~); ~~Engineering and Operations Work Group (SP-)~~; and the Land Use Work Group (SP-LU1 and SP-LU2~~—~~). Review current literature on the natural community types found within the study area and factors affecting their distribution.

Task 2: Analysis of project-related effects on plant communities

Evaluate upland plant community status within the ~~project~~ study area. This assessment of lands within and near the project area will include an analysis of the current vegetation patterns, unique or rare habitats, habitats that support special status species, and the factors affecting their distribution, composition, and condition. It will assess the effect of noxious weed populations and the planting of non-native plant species for wildlife forage on native plant communities. ~~It will describe c~~Current and future project related effects on these vegetation communities, including recreation, maintenance and operations, land use changes, and fuels management and identify opportunities to minimize the adverse impacts will be addressed.

Task 3: Identify areas for revegetation and/or restoration

Identify opportunities to enhance or restore native plant communities within the ~~Project~~ study area by using information obtained in Tasks 1 and 2 above. This will include an evaluation of conditions necessary for the maintenance of healthy plant communities and opportunities to enhance upland habitats, special status species habitat and rare or unique habitats found within or near the project area.

Results/Products

A summary report will be produced which will identify current and future potential projects effects to native plant communities within and near the project area. This qualitative assessment will include current vegetation patterns, project-related effects, enhancement opportunities, and proposed guidelines for future development of facilities or land use that will minimize impacts to local native plant communities.

Study Plan Coordination/Implementation

Information will be needed from other terrestrial resource studies including SP-T2 (special-status species), SP-T4 (Biodiversity); SP- T3/5 (Riparian and wetland issues); SP-T7 (noxious weeds); fuels management (SP-T11); and SP-G1/G2 (soils and topography). Information on current and future project-related land-use activities will be needed from the Recreation Work Group (SP-R5, SP-R9, SP-R10, and SP-R17), ~~Engineering and Operation Work Group (SP-??),~~ and Land Use Work Group (SP-LU1 and SP-LU2) for the evaluation of project-related effects on natural plant communities.

Study Plan Implementation Schedule

This schedule is dependent on the completion of work by other terrestrial studies and by the Recreation, Land Use, and Engineering and Operations Work Groups. The analysis in Task 2 and opportunities for enhancement under Task 3 should be completed by September 2003.

References - To be completed

Issue Statement

Effects of existing and future project features, operations and maintenance on upland habitat, including revegetation and restoration efforts

Issues

TE40 Native plant landscaping (potential sites: Feather River Fish Hatchery, State Parks Headquarters, DWR Field Office, Spillway Launch Facility - future) and restoration of native plant communities

TE62 Protection and sustained conservation of terrestrial wildlife and flora in the project-affected area; comprehens~~e~~ive and well-crafted planning

G3

W7

~~Study Plan Implementation Schedule~~

~~This schedule is dependent on the completion of work by other terrestrial studies and by the Recreation, Land Use, and Engineering and Operations Work Groups. The analysis in Task 2 and opportunities for enhancement under Task 3 should be completed by September 2003.~~

California Department of Water Resources
Oroville Facilities
Draft Study Proposal

SP-T11 Fire Prevention/Fuel Load Control

Introduction

Relicensing stakeholders have expressed concern that historic land management and fire prevention activities within the FERC project ~~area~~ boundary have resulted in increased fuel loading which has lead to an increased risk of destructive wildfire. Relatively little information is available from the project area related to current fuel loads or wildfire risk. The purpose of this study is to provide information to the Land Use Work Group whiche is evaluating this issue. Specific information to be collected under this study includes the effects of fire prevention and fuels management practices on native plant and animal communities within the project area.

Objectives

Study goal is to provide information to the Land Use Work Group that will allow evaluation of land use practices and options within the project ~~area~~boundary. One project objective is to provide information related to effects of historic fire prevention strategies ~~on the development and maintenance of~~ on existing plant communities and wildlife resources within the project ~~area~~boundary. The second objective is to provide information which will allow assessment of potential fuels management activities impacts (both positive and negative) on native plant communities and wildlife resources.

Relationship To Relicensing Project/ Need For The Study

The information collected under this study plan is not directly related to hydropower generation. Rather, the information collected will be used to evaluate potential options and risks related to land management practices within the project boundary. The data collected will be used to evaluate potential changes in land management within the project area. The potential changes in land management practices could be developed into PM&E measures. This information is needed by the Land Use Work Group to evaluate and compare the risks, benefits, costs, and liabilities of changing land use practices within the project area.

The California Environmental Quality Act requires evaluation of potential project impacts related to safety including increased risk of wildfire. The fuels management problem is an issue throughout the western United States and an abundance of scientific literature exists related to the ecological effects of both fire prevention and fuels management. Much of this information was collected

within California and directly relates to the plant communities and wildlife resources present within the project area. This study does not propose to collect additional information. Rather, the proposed study will collect existing ecological information which be used as the basis for evaluation.

Study Area

The study scope will include ~~all~~ terrestrial plant communities and wildlife habitats present within the project boundary. Neither DWR nor FERC have any regulatory authority to alter land use practices on lands outside the project area. However, most of the plant communities and wildlife habitats which occur within the project ~~area~~ boundary are also found all along the western slope of the Sierra Nevada mountain range. Therefore, the information collected as part of this study will be applicable to wide areas outside the project ~~area~~ boundary and may be used in a cumulative impacts assessment.

Methods

The general approach to this study will be a literature review followed by computer modeling, and resulting in a written evaluation comparing the effects of current and potential fuels management. Our hypothesis is that historic fire prevention practices have served to reduce fire related disturbance which has led to changes in plant community composition and structure. These changes can a~~e~~ffect the occurrence, density, and distribution of wildlife species.

Detailed Methodology and Analysis Procedures

Task 1 Data Collection-Perform literature review and gather data. The primary sources of information includes the annual proceedings of the Tall Timbers Fire Ecology Conference, discussion with Pacific Southwest Range and Experiment Station fire ecologists, fire ecology literature reviews, and other scientific literature.

Task 2 Habitat Mapping-Obtain mapping of plant communities/wildlife habitats under SP-T4.

Task 3 Ecological Effects of Fire Prevention-Using the information collected in Tasks 1 and 2, develop predictions of the potential ecological effects of historic/current fire prevention practices on each of the major plant communities present within the project area. These predictions may include changes in plant succession, density, distribution, size classes, plant species composition, stand structure, understory development, ground cover as well as changes in other physical and biological characteristics.

Task 4 CWHR Analyses of Fire Prevention-Using the California Wildlife/Habitat Relationships Database (CWHR), input the plant community changes identified

and modeled in Task 3. CWHR will predict which wildlife species may benefit from the predicted habitat changes as well as those species which could be adversely impacted.

Task 5 Ecological Effects of Fuels Management Options-Using the information collected in Task 1 and 2, develop predictions of the potential impact of fuels reductions activities on each major plant community. These predictions may include changes in plant succession, stand density, species and community distribution, size classes, plant species composition, stand structure, understory development, shrub density and ground cover as well as changes in other physical and biological characteristics.

Task 6 CWHR Analyses of Fuels Management Options-Using the California Wildlife/Habitat Relationships Database~~)~~ input the plant community changes identified and modeled in Task 5. CWHR model output will predict which wildlife species benefit from the predicted habitat changes as well as those species which could be adversely impacted.

Task 7 Summarize and Report-Summarize findings from Tasks 3 through 5 in a written summary report to be submitted to the Land Use Work Group. This report will include the ecological basis for predicted changes in plant community composition and structure, the individual plant community models, the CWHR model outputs, and a brief statement of findings.

Results

Study results will be summarized in a written report to the Land Use and Environmental Work Groups. This report will include the ecological basis for predicted changes in plant community composition and structure, the CWHR model outputs, and a brief statement of findings. These data will allow the Land Use Work Group to identify the plant community and wildlife effects of the current fire prevention/control strategy as well as the potential environmental effects of possible alternative fuels management strategies. These plant community effects may include changes in species composition, canopy closure, snag densities, tree understory, stand density, and shrub occurrence.

Coordination with Other Resource Areas/Studies

Study results are one component of Study Plan LM-2. Study requires information from SP-T4.

Schedule

Task 1 completed by September 2002. Task 2 completed by April 2002. Tasks 3 through 6 completed by December 2002. Task 7 completed by February 2003.

Issues Addressed

Issue Statement T11- Effects of fire prevention/fuel load control on natural communities

Issues
T33-fuel load on state lands: potential impact to habitat (wildlife and human)
T64-effects of existing and future fire prevention/fuel load control on natural communities.

DWR OROVILLE FACILITIES RELICENSING PROJECT
(FERC Project No. 2100)

ENVIRONMENTAL WORK GROUP
DRAFT STUDY PLAN

F2. EFFECTS OF PROJECT OPERATIONS ON FISH DISEASES

1.0 INTRODUCTION

As mitigation for the loss of salmonid habitat due to construction of the Oroville Facilities, DWR constructed the Feather River Hatchery (FRH). Millions of spring-run and fall-run chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) have been released from FRH, providing significant contribution to the commercial and recreational harvest, both in the ocean and inland fisheries.

Several endemic salmonid pathogens ~~or diseases~~ occur in the Feather River Basin, including *Ceratomyxa shasta*, *Flavobacterium columnaris*, infectious hematopoietic necrosis virus (IHN), ~~bacterial kidney disease (BKD)~~*Renibacterium salmoninarum* (bacterial kidney disease [BKD]) and ~~cold-water disease~~ *Flavobacterium psychrophilium* (cold water disease). While these pathogens ~~are~~ occur naturally ~~occurring~~, the Oroville Facilities, as well as other dams, water withdrawals, agriculture and silviculture, ~~practices and development~~ may have produced environmental conditions favorable to many pathogens. ~~The general decline in numbers of endemic salmonids has resulted in a decrease in the genetic pool and diversity, decreasing their inherited resistance to some of these diseases with which they have co-evolved.~~ Impediments to migration may have altered the timing and increased the duration of exposure ~~for~~ of anadromous salmonids to certain pathogens. In addition to introducing exotic fish species, fish management practices, such as hatchery production and out-of-basin transplants, have inadvertently introduced foreign diseases, such as whirling disease, or highly virulent strains of diseases that originated in the hatcheries, into river basins.

Of the fish diseases occurring in the Feather River Basin, those that are main contributors to fish mortality (e.g., IHN, BKD, *Ceratomyxa shasta*) are of highest concern for fisheries management in the region. Although other diseases associated with parasite copepods (e.g., gill maggots, *Salmincola californiensis*; anchor worms, *Learnaea spp.*) and other ectoparasites (e.g., *Epistylis spp.*, *Costia spp.*, *Gyrodactylus spp.*) may occur in Feather River fish, they do not necessarily lead to fish death nor threaten fish populations in terms of increased mortality. Thus, they may be considered less important for the management of the Feather River fisheries. Hereinafter, the use of the adjective "significant" will be restricted to those diseases or vectors that are important for the management of the Feather River fisheries because of their contribution to Feather River fish mortality.

Currently, the two most significant fish diseases in the Oroville Project area are IHN and ceratomyxosis, approximately 30 percent of the hatchery production in 2000 was lost to these diseases. The infectious hematopoietic necrosis virus (IHN) is a significant disease for chinook

salmon, steelhead, rainbow trout, and even brown trout populations. IHN infectivity is increased when water temperatures fall below 60ºF. Since 2000, IHN issues have caused the stocking of chinook and brown trout in Lake Oroville to be halted until further notice in order to protect the water supply to the Feather River Hatchery. A plan to use coho salmon (*Oncorhynchus kisutch)* to stock Lake Oroville is currently under evaluation; although IHN has also been found in coho salmon populations, this species appears more resistant than other salmonids.

Ceratomyxosis is caused by *Ceratomyxa shasta*, an endemic myxosporean parasite that is lethal to many strains of rainbow trout~~,~~ and is prevalent in Lake Oroville. Ceratomyxosis was first observed in 1948 in fall spawning rainbow trout from the Crystal Lake Hatchery in Shasta County, California. The poor success of California Department of Fish and Game (CDFG) efforts at stocking rainbow trout in Lake Oroville in the 1970s and 80s may have been related~~,~~ to, among other things, the prevalence of the infective stage of *C. shasta* in the lake. This parasite has a complex life cycle, which includes a common freshwater polychaete worm as an alternate host. Salmonids that are native to rivers where *C. shasta* naturally occurs have developed varying degrees of resistance to the disease through natural selection. Likewise, ~~fish~~ salmonid populations that have not evolved with the parasite are highly susceptible to the disease. Resistance to the disease is heritable; offspring of a resistant parent and a susceptible parent have been found to have intermediate resistance to the disease. The progression of ceratomyxosis is influenced by water temperature. Mortality increases as water temperature increases above 50ºF, though it has been documented in some drainages to be infective even at lower temperatures.

Another potentially significant disease for Oroville project waters is cold-water disease (*Flavobacterium psychrophilium*). The incidence of both diseases is more serious in colder waters. *F. psychrophilium* is a Gram-negative bacterium known to affect wild and hatchery populations of *O. kisutch*, *O. tshawytscha*, *O. nerka*, *O. mykiss*, *O. masou*, *Salmo trutta*, *S. clarkii*, and *Salvelinus namaycush*. This bacterium can cause mortality of up to 50 percent among young salmonids. Cold-water disease infection generally occurs at temperatures below 53ºF. The classic form of the disease involves the infection and necrosis of the caudal peduncle, followed by septicemia and death.

BKD is a typically chronic disease caused by the Gram-positive bacterium *Renibacterium salmoninarum*. BKD is economically significant to salmonid husbandry, especially with regard to Pacific salmon (*Oncorhynchus* spp.), because of its widespread distribution both in freshwater and saline environments, its chronic nature, which does not allow the disease to be diagnosed before late clinical or debilitating manifestations, its vertical transmission through sexual products, and the inefficacy of the main therapeutic compounds used in treating infected fish.

Whirling disease, a European disease introduced into North America in the late 1950s, is caused by the metazoan parasite, *Myxobolus cerebralis*. To date, whirling disease has caused severe damage primarily to wild rainbow trout populations, but it impacts other salmonids as well. *M. cerebralis* was first detected in California in 1966, and is now found in many Central Valley drainages, including the Feather River. This parasite has a similar life cycle to *C. shasta*. A very common oligochaete worm serves as the alternate host. Native North American salmonids have developed no known resistance to the disease. Brown trout, which originate in Europe, have

developed a resistance and may carry the parasite without succumbing to the disease, shedding spores and contaminating streams.

~~Recently, a strain of IHN that is highly virulent to steelhead has been documented in Lake Oroville. IHN has also been found in chinook salmon populations. Concerns have been raised over the effects of pump-back operations and the project's effects on water temperature for the establishment and transmission of IHN as well as other salmonid diseases~~.

Lake Oroville also supports a warmwater fishery. There is little information on the warmwater diseases present and their impacts ~~to~~ on the fishery. However, many warmwater diseases could be of potential significance for Oroville Facilities waters, especially when water temperature increases above 50°F. These potentially significant warmwater diseases include the bacterial gill disease (*Flavobacterium branchophillum*), the enteric redmouth disease (*Yersinia ruckeri*), and columnaris disease *F. columnaris*.

The present study plan is envisioned as a two-phase study, consisting of a literature review and desktop study (Phase 1) and field surveys (Phase 2). Phase 1 will review all available information on fish diseases that are significant to Feather River Basin fish, and it will evaluate their potential impacts on project reservoirs and on hatchery production and operations, as well as their potential for spreading downstream the Feather River. Phase 2 will develop and implement field studies required to enhance the knowledge gained through the execution of Phase 1.

2.0 OBJECTIVES

The overall objective of the study is to evaluate the effects of ongoing and future project operations (pump-back operations, hatchery production, water temperature, etc.) on the establishment, transmission, extent and control of IHN, BKD, and other significant coldwater and warmwater fish diseases within ~~Lake Oroville~~ the project reservoirs, the Low Flow Channel and the lower Feather River. Significant diseases are (as defined earlier) those diseases that can cause serious losses to Feather River basin fish populations though increased direct, or indirect, mortality. ~~(Consider moving rest of paragraph to approach section)The study will be divided into two phases. The objective of Phase 1 is to evaluate how project operations, including hatchery production, might affect the establishment, extent and control of diseases and document outbreaks. In the second phase of the analysis, specific field studies may be developed, as appropriate, based on the type and extent of data needs identified during Phase 1.~~

3.0 RELATIONSHIP OF THE STUDY PLAN TO RELICENSING PROJECT PROCESS/ NEED FOR THE STUDY

The purpose of the study is to obtain and review existing information and to evaluate the project's effects on the establishment, transmission and control of fish diseases in project affected waters of the Feather River watershed. This information will be used to evaluate direct, indirect and cumulative effects of the Oroville Facilities required to comply with the Federal Energy Regulatory Commission's (FERC) environmental review process under the National Environmental Policy Act (NEPA) and Endangered Species Act (ESA) consultation information

requirements. ~~(May want to articulate the boxes from the conceptual framework to establish clear link to relicensing here)~~

Fish diseases are related to a variety of factors, including fish species, densities, the presence and amounts of pathogens in the environment, and water quality conditions, such as temperature, dissolved oxygen, and pH ~~and salinity~~. The project operations have the potential to affect all of these factors in the FERC project waters, Feather River Hatchery, and the Feather River downstream of the Oroville Facilities.

4.0 SCOPE – STUDY AREA

For purposes of identifying disease presence and prevalence, the study area will encompass the entire Feather River basin. Project-affected waters within the FERC boundary, tributaries upstream to the current upper migratory limit, and the Feather River downstream to ~~the confluence with the Yuba River will be the focus for evaluating the potential influence project operations have on the establishment and transmission of the diseases found in the basin. The Yuba River was selected as the downstream limit of the study because any fish disease effects in the lower Feather River attributable to the Oroville Facilities would be manifested in this portion of the Feather River. (Make sure that justification for limit of scope is defensible)~~ the Sacramento Delta and Bay areas. This southern limit was selected based on the normal Feather River Hatchery practice of planting or releasing juvenile salmonids at various sites within the Sacramento Delta and Bay areas (e.g., Benicia, Fort Baker, Tiburon).

5.0 GENERAL APPROACH

The first phase (Phase 1) of the study will entail a literature review (Task 1) to determine the presence and prevalence of endemic and introduced fish diseases in the Feather River Basin. This review ~~analysis~~ will identify the documented disease outbreaks in these waters, the life history characteristics of the causative agents, mechanism of disease transmission, disease outbreak timing and duration, and control methods. A history of impediments to fish passage and fish transplants in and upstream of the project and their origin (i.e., rearing facility) will be included to provide a comprehensive disease summary. Data collection and review will be coordinated with other fisheries study plans (see section 7.0, Study Plan Coordination).

In Task 2, data will be gathered on project operations, including Feather River Hatchery practices, and their influence on water temperatures, ~~and~~ other relevant water quality parameters and parameters significant to the spread and control of fish diseases. These efforts will be coordinated with the project operations modeling, ~~and~~ water quality and hatchery-effects study plans. This information will be combined with the analysis from the first task to evaluate how project operations, including hatchery production and release practices, might affect the establishment, extent and control of diseases and documented outbreaks. Results will be organized to address: (1) the impact of reservoir diseases, (2) reservoir-hatchery interactions, and (3) the impact of reservoir and hatchery diseases on Feather River fish downstream of the Fish Barrier Dam. Throughout the process, data gaps will be identified. Recommendations for

minimizing potential project impacts on the establishment and transmission of fish diseases will be provided.

The Phase 2 analysis will entail specific field studies, if necessary, based on the data needs identified during Phase 1. Refinement of the studies will occur through consultation with agency personnel to identify and prioritize fish management goals, as well as other data collection efforts that could potentially be combined with disease investigations. A final report will be prepared as the final task.

METHODOLOGY AND ANALYSIS

The two phases of the study plan have been divided into four tasks, as described below.

(1) Perform Literature Review and Gather Data of Disease Presence;

(2) Evaluate Project's Impacts on Fish Diseases from Literature Review;

(3) Field Studies if determined necessary by Work Group; and

(4) Final Report.

Descriptions for the identified tasks and corresponding subtasks are provided below.

Phase1

Task 1 – Perform Literature Review and Gather Data of Disease Presence

Task 1 will gather and review existing information on diseases diagnosed in the Feather River Basin. Endemic and non-endemic pathogens present in the watershed, including the FRH, and their historic and current distribution will be identified. To evaluate hatchery contributions, past and present DWR and CDFG fisheries management activities, including transplanting data and the origin of the stocks transplanted, will be reviewed. For each significant disease identified, the life history characteristics of the causative agent, mechanism for disease transmission, disease outbreak timing and duration, preferred habitats and control methods emphasizing problematic diseases such as IHN will be documented. For the pathogens determined to be present, this task identify any alternate hosts, their life history and habitat preferences. We will catalogue historical and current fish species present in the study area, their basin-wide distribution and habitat preferences. We will identify presence and distribution of alternate host species required for the transmission of certain diseases and summarize historical and current fish passage and fish transplants in and upstream of the project, as well as their origin (i.e., rearing facility). Specific references will include, but will not be limited to, the following:

- CDFG Health Lab Reports;
- Feather River Hatchery Annual Reports;
- Coleman National Fish Hatchery Annual Reports;
- Crystal Lake Hatchery Annual Reports;

- Annual reports of other hatcheries in the Sacramento-San Joaquin Basin, that normally receive juveniles or eggs from FRH; and
- Interim data from IHN studies currently conducted by CDFG and the University of California.

Fish health specialists from DWR, CDFG, and the California-Nevada Fish Health Center will be consulted. A report of the existing conditions of diseases in the basin will be produced. Results from the review will be organized by disease name, date and site of detection, and measures of incidence and control of the outbreaks. Data gaps will be identified.

Task 2 – Evaluate Project's Impacts on Fish Diseases from Literature Review

The objective of the second task is to review existing information on the environmental conditions of project-affected waters with the potential to influence disease transmission and prevalence, and evaluate how project operations, including hatchery operations (i.e. disinfection methods, fish drugs/chemical treatments, river discharge, planting practices) and production, ~~and planting practice,~~ and pump-back operations, might affect the establishment, extent and control of diseases and documented outbreaks. Environmental data including water temperature profiles, dissolved oxygen, pH, turbidity, and contaminant concentrations for each of the water bodies within and surrounding the project area including Lake Oroville, Thermalito Diversion Pool, Thermalito Forebay, Thermalito Afterbay, and the lower Feather River will be reviewed with a primary emphasis on water temperature. The effects of water temperature on the rates of disease progression and meantime to death are well documented for many salmonid pathogens. In addition to water temperature, the project has impacted other environmental parameters, including river flows, sedimentation, and fish habitat that in turn may alter the prevalence of certain pathogens and the distribution of fish.

Much of this information will be gathered as part of studies SP-F3 and SP-F10, which evaluate the effects of the project on habitat quantity and quality for resident and anadromous fish, respectively. Pump-back operations data at Thermalito and Hyatt power plants and data from several ongoing studies will be incorporated including:

- DWR temperature monitoring data for the lower Feather River, Thermalito Afterbay and Feather River Hatchery at various water releases and operations;
- Spatial and temporal distribution of steelhead and chinook salmon rearing in the lower Feather River;
- Screw trap data recording chinook salmon emigration;
- Effects of water temperature on juvenile steelhead rearing; and
- DWR and CDFG fish habitat enhancement projects.

A preliminary evaluation of the effects of the current operations of each project facility on diseases potentially occurring and their impact to the fisheries resource will be produced. Project and hatchery operations data and timing of disease outbreaks will be analyzed. IHN evaluations conducted by CDFG and the University of California will be incorporated. Hatchery

management practices with respect to fish health, and the efficacy of the ultraviolet sterilization system will be ~~evaluated~~ analyzed together with FRH release practices to evaluate the likelihood of transmitting disease from FRH infected fish to other wild or hatchery uncontaminated fish. This evaluation will require the review of reports such as Scott Foote's USFWS report on likelihood of transmission of disease through release of chinook salmon from Coleman National Fish Hatchery, and some simulation techniques and cohort analysis to estimate the contribution of FRH production to Central Valley salmonid populations. This particular activity will require coordination with study plan SP-F9 *Effects of Feather River Hatchery on Naturally Spawning Salmonids.* Data gaps will be identified throughout the review and evaluation process. ~~(Does this need to include evaluation of potential saltwater diseases processes potentially impacted by hatchery operations?)~~

For the sake of clarity, the review and evaluations encompassed in Task 2 will be organized as three sub-tasks:

Subtask 2.1 – Project's Impacts on Reservoir Fish Diseases

Subtask 2.2 – Impacts of Feather River Hatchery Fish Diseases and Operations on Reservoir Fish

Subtask 2.3 – Impacts of Reservoir and Hatchery Fish Diseases, and Project Operations on Downstream Feather River Fish Populations

Phase 2

Task 1~~3~~ – Develop and Implement Field Studies

If data or information gaps are identified in Phase 1 Tasks 1 and 2, a Phase 2 study plan~~s~~ will be developed detailing specific criteria and appropriate methodologies for implementation. ~~To comprehensively evaluate the potential project impacts and any differences between project waterbodies, the species presence and prevalence of both fish and pathogens will need to be determined.~~ The studies will be refined through consultation with participants and agency personnel to identify and prioritize fish management goals, as well as other data collection efforts that could potentially be combined with disease investigations.

Every attempt will be made to coordinate fish sampling with other ongoing studies such as:

- Steelhead snorkel surveys
- Steelhead and salmon beach seine surveys
- Rotary screw trap
- Creel surveys
- Chinook egg survival studies

Task 4 – Final Report

The objective of Task 4 is to summarize the information gathered during the first three tasks of the study and develop recommendations for minimizing or eliminating any adverse project related effects on fish diseases within project affected waters.

6.0 RESULTS, PRODUCTS/DELIVERABLES AND SCHEDULE

Results of the Phase 1 study will be used to evaluate potential project impacts and develop measures that minimize potential impacts to fish as well as provide recommendations on relevant opportunities to protect, mitigate, or enhance fish resources in the project area. A report will be prepared with each task or subtask of the study as a chapter in a larger report summarizing the project's effects on disease establishment and transmission in the basin.

The first chapter will: (a) identify the presence and prevalence of significant fish diseases in the basin, both endemic and hatchery contributions; (b) summarize life histories of the causative agents and mechanisms for transmission; and (c) provide a history of fish disease management in the study area and how fishery management has affected fish diseases. A map depicting the distribution of diseases in the basin will be included. A table will be produced summarizing the main characteristics of the diseases present.

The second chapter will provide an analysis of the project operations that may affect fish diseases and describe how project operations affect the establishment, extent, and control of the fish disease in the study area.

The final chapter will summarize the information gathered from the literature review and provide recommendations for minimizing or eliminating adverse project-related effects on the establishment and transmission of fish diseases in the Feather River basin. Each chapter will be prepared as a draft and final product and will be distributed for review. If significant ~~Salient~~ data gaps are ~~will be~~ identified throughout thi~~s~~e process, this will ~~to~~ provide the~~a~~ basis for the Phase 2 study.

If a Phase 2 field study is necessary, the study methodology, schedule, and report products will be developed through consultation with participants and agency personnel. ~~Prior to completion of Chapter 3, draft and final study plans will be developed if needed. The final study plans will be the foundation for the methods section of Chapter 3 that also will include a presentation of the study results and implications. A fourth chapter will be included in the final report which summarizes the information gathered from the literature review and any field studies and provides recommendations for minimizing or eliminating adverse project-related effects on the establishment and transmission of fish diseases in the Feather River basin. Each chapter will be prepared as a draft and final product and will be distributed for review.~~

SCHEDULE

It is anticipated that the Phase 1 Report will be completed by February 2003. A schedule for the Phase 2 study plan would be provided once a decision is made regarding the need and extent of the Phase 2 activities.

7.0 STUDY PLAN COORDINATION

COORDINATION WITH OTHER RESOURCE AREAS/STUDIES

A comprehensive evaluation of the potential effects of project operations on diseases will require coordination with other relicensing studies. To minimize the cost of field collection and impacts to fish populations, fish sampling will be coordinated with any relicensing, DWR, CDFG, USFWS, NMFS, or other groups (UC Davis) sampling fish in the study area. Sampling activities will be coordinated during the development of detailed study plans (Task 3).

Information gathered during the following studies is relevant to the fish disease study and will be required to assess the history and status of diseases and habitat conditions in the basin:

SP-F3.1 – Evaluation of Project Effects on Resident Fish and Their Habitat Within Lake Oroville, the Thermalito Complex, and Upstream Areas Within the Project Boundaries

The characterization of fish, life stages and habitat, as well as the analysis results regarding project effects on resident fish habitat quantity and quality, will be utilized in SP-F2.

SP-F4 – Evaluation of Project Effects on Fish Passage Upstream of Lake Oroville

Study plan SP-F4 and SP-F15 will provide information related to existing fish passage and project effects. Additionally, SP-F15 will provide an evaluation of habitat upstream of Oroville Dam and constraints with regard to disease transmission.

~~*SP-F10 – Project Impacts on Anadromous Fish and their Habitat*~~
~~The characterization of fish, life stages and habitat, as well as the analysis results regarding project effects on anadromous fish habitat quantity and quality, will be utilized in SP-F2.~~

~~*SP-F4 – Passage of Resident Fish Upstream of Lake Oroville*~~
~~SP-F4, SP-F15, and SP-F20 will provide information related to existing fish passage and project effects. Additionally, SP-F15 will provide an evaluation of habitat upstream of Oroville Dam and constraints with regard to disease transmission.~~

SP-F5 – Effects of Fisheries Management Plans on a Balanced Fishery

Study plan SP-F5 will provide information on existing and proposed management plans that will be evaluated to determine how fisheries management activities may affect the establishment, extent and control of diseases and documented outbreaks.

SP-F9 – Evaluation of the ~~Effects of the~~ Feather River Hatchery Effects on Naturally Spawning Salmonids

Study plan SP-F9 will provide basic information on FRH operations, release sites, and cohort analysis estimates of the contribution of FRH production to Central Valley salmonid populations.

SP-F10 – Evaluation of Project Effects on Anadromous Salmonids and Their Habitat

The characterization of fish, life stages and habitat, as well as the analysis results regarding project effects on anadromous fish habitat quantity and quality, will be utilized in SP-F2.

SP-W1 – Project Effects on Water Quality Designated Beneficial Uses

Study plan SP-W1 will provide water temperature and water quality information that will be integrated in the evaluations of SP-F2 *Task 2*.

SP-W6 – Project Effects on Temperature Regime

Study plans SP-W6 will provide water temperature and water quality information that will be integrated in the evaluations of SP-F2 *Task 2*.

Engineer and Operations Working Group Study Plans

- *Model Development Study Plan,* and
- *Statewide Operations Model Development.*

These plans will produce estimates of long-term annual and monthly flows and temperatures along the Feather River under different operation strategies that will be used by SP-F2 *Task 2* to evaluate the impact of reservoir and FRH diseases on downstream Feather River fish populations.

The following studies will likely utilize the disease analysis conducted during this study (SP-F2):

SP-F5 – Effects of Fisheries Management Plans on a Balanced Fishery

Study plan SP-F2 will provide suggestions for minimizing project-related effects on the establishment and transmission of fish disease for consideration in making recommendations to the long-term fisheries management planning for a balanced fishery.

SP-F8 – ~~Analysis of Impacts to Fish and Wildlife in Project Tributaries Caused by Introduction of Salmon or Salmon Carcasses~~Transfer of Energy and Nutrients by Anadromous Fish Migration

Study plan SP-F8 will consider information provided in SP-F2 in its review of project effects on changes in biomass and nutrient dispersal due to loss of fish carcasses upstream of Oroville Dam.

SP-F15 – Evaluation of the Feasibility of Providing Passage for Anadromous Salmonids Past Oroville Dam

Study plan SP-F15 will provide an evaluation of habitat upstream of Oroville Dam and constraints with regard to disease transmission.
(Add hatchery study and water quality studies relevant to information needs)

ISSUES, CONCERNS, COMMENTS TRACKING AND/OR COMPLIANCE REQUIREMENTS

Issues Addressed by *Effects of Project Operations on Fish Diseases* Study Plan.

Issue	Description
FE4	Have biologists describe the extent of viral infection in Lake Oroville;
FE5	Would a fish screen(s) on the pump-back operation prevent Infectious Hemapoeitic Necrosis (IHN) and other diseases specific to Salmonid species from spreading and becoming permanently established in Lake Oroville? IHN, if permanently established in Lake Oroville would affect survival of hatchery and river spawned Salmonid species;
FE48	Evaluate potential of fish diseases spread from Lake Oroville to Feather River and back as result of pump-back operation; and
FE49	Incidence of fish disease in response to temperature changes below dam.

DWR OROVILLE FACILITIES RELICENSING PROJECT
(FERC Project No. 2100)

ENVIRONMENTAL WORK GROUP
DRAFT STUDY PLAN

SP-F3.1. EVALUATION OF PROJECT EFFECTS ON RESIDENT FISH AND THEIR HABITAT WITHIN LAKE OROVILLE, THE THERMALITO COMPLEX AND UPSTREAM ~~TO~~ AREAS WITHIN PROJECT BOUNDARIES

1.0 INTRODUCTION

The Oroville Facilities, completed in 1968, provide for multiple project purposes including water supply, power generation, flood protection, recreation, and fish and wildlife enhancement. Flood control and power generation operations of Oroville Facilities necessitate changes in lake water surface elevation. Lake water surface elevation fluctuations may hinder colonization of rooted aquatic vegetation in the lake's littoral zone, limiting the establishment of terrestrial vegetation within the fluctuation zone (DWR 2001). Terrestrial vegetation provides spawning and nursery habitat, offers protection from predation, and results in increased food availability for warmwater fisheries (DWR 2001; DWR and USBR 2000). Depletion of such cover may contribute to reduced numbers of centrarchid game fish (DWR 2001). Additionally, reductions in lake water surface elevation associated with reductions in storage could reduce the reservoir's coldwater pool volume, thereby reducing the quantity of habitat available to coldwater fish species (PWCA and USBR 2001).

Lake Oroville ~~is a warm reservoir that~~ thermally stratifies in the spring, destratifies in the fall, and remains destratified throughout the winter. Lake Oroville supports a two-story fishery, which means that it supports both coldwater and warmwater fish species 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. When Lake Oroville destratifies, the two fishery components mix in their habitat utilization.

~~For the purpose of this study, "resident fish" are all fish species found in Lake Oroville and its upstream tributaries, either those fish belonging to the coldwater fisheries or the warmwater fisheries. This study plan does not address anadromous salmonids.~~

The Lake Oroville coldwater fishery is a managed fishery composed of four salmonid species including fall-run chinook salmon (*Oncorhynchus tshawytscha*), brown trout (*Salmo trutta*), rainbow trout (*O. mykiss*) and lake trout (*Salvelinus namaycush*). The California Department of Fish and Game (CDFG) manages the fishery with the primary objectives of producing trophy salmonids and providing a quality fishery characterized by high salmonid catch rates (DWR 2000). The coldwater fishery is sustained by

hatchery stocking from the Feather River Fish hatchery because natural recruitment to the Lake Oroville coldwater fishery is very low, possibly due to insufficient spawning and rearing habitat in the reservoir and accessible tributaries, and natural and artificial barriers to migration into the tributaries with sufficient spawning and rearing habitat (DWR 2001).

The Lake Oroville warmwater sport fishery is a self-sustained fishery dominated by fish of the Centrarchidae (sunfish) family, including ~~comprised of~~ four species of black bass (*Micropterus punctulatus*, *M. salmoides*, *M. dolomieui* and *M. coosae*), ~~two species of catfish (*Ictalurus punctatus* and *I. catus*),~~ two species of sunfish (*Lepomis cyanellus* and *L. macrochirus*) and two species of crappie (*Pomoxis nigromaculatus* and *P. annularis*). Two species of catfish (*Ictalurus punctatus* and *I.* ~~*C*~~*catus*) also contribute to the sport fishery.

In addition to game species, Lake Oroville provides habitat for many other fish species, including native fish such as Sacramento pikeminnow (*Ptychocheilus grandis*), hardhead (*Mylopharodon conocephalus*), *and* Sacramento sucker (*Catostomus occidentalis*), and introduced fish such as Carp (*Cyprinus carpio*), wakasagi (*Hypomesis nipponensis*), and threadfin shad (*Dorosoma petenense*). The evaluation of potential project effects on warmwater fisheries will focus on the bass species that dominate the sport fishery.

~~The Lake Oroville coldwater fishery is a managed fishery composed of four salmonid species: fall-run chinook salmon (*Oncorhynchus tshawytscha*), brown trout (*Salmo trutta*), rainbow trout (*O. mykiss*) and lake trout (*Salvelinus namaycush*). The California Department of Fish and Game (CDFG) manages the fishery with the primary objectives of producing trophy salmonids and providing a quality fishery characterized by high salmonid catch rates (DWR 2000). The coldwater fishery is sustained by hatchery stocking because natural recruitment to the Lake Oroville coldwater fishery is very low, apparently due to insufficient spawning and rearing habitat in the reservoir and accessible tributaries, and natural and artificial barriers to migration into the tributaries with sufficient spawning and rearing habitat (DWR 2001).~~

~~Besides the game species, Lake Oroville provides habitat for many other fish species, including native fish (e.g., Sacramento pikeminnow, *Ptychocheilus grandis*; hardhead, *Mylopharodon conocephalus*; Sacramento sucker, *Catostomus occidentalis*) and introduced fish (e.g., Carp, *Cyprinus carpio*; wakasagi, *Hypomesis nipponensis*; threadfin shad, *Dorosoma petenense*), that occupy different trophic levels in the Lake Oroville fish community. For many of these species, no consistent records on their abundance or distribution exist.~~

~~Water is released from Oroville Dam into the Thermalito Diversion Pool through a multilevel outlet to provide appropriate water temperatures for the operation of the Feather River Hatchery and to protect downstream fisheries. Water is diverted at the Thermalito Diversion Dam into the Thermalito Power Canal, located approximately four miles downstream from Oroville Dam. From the canal, water is directed to the~~

~~Thermalito Forebay, through the Thermolito Pumping-Generating Plant, and then to the Thermalito Afterbay through the Tail Channel. The Thermalito Afterbay is connected to the lower Feather River through the River Outlet (**Figure 1**). For this study plan, these various project facilities are referred to as the "Thermalito Complex".~~

The Thermalito Complex (including the Thermalito Diversion Pool, the Thermalito Forebay, the Thermalito Afterbay, and the Fish Barrier Pool) and its tributary streams probably support fish assemblages of warmwater and coldwater sportfish, and other native and introduced non-game fish species, similar to those present in Lake Oroville. The four salmonid species found in the coldwater fishery of Lake Oroville (fall-run chinook salmon, brown trout, rainbow trout and lake trout) also are found in the pools of the Thermalito Complex. In fact, CDFG manages the Thermalito Forebay as a put-and-take trout fishery, where rainbow and brook trout (*Salvelinus fontinalis*) of over 0.5 pounds are stocked biweekly. The Forebay is the second most popular reservoir sport fishery of the Oroville Facilities. Although no fish have been stocked in the Fish Barrier Pool, Thermalito Diversion Pool or Thermalito Afterbay, the same coldwater sportfish stocked in the Thermalito Forebay also are caught in these pools.

The species that constitute the Lake Oroville warmwater fishery also are found in the waters of the Thermalito Complex. For instance, warmwater fish such as largemouth bass, bluegill, and green sunfish have been observed in low numbers in backwater areas of the Thermalito Diversion Pool, and a popular largemouth bass fishery currently exists in the Thermalito Afterbay (DWR 2001).

For the purpose of this study, “resident fish” are fish species found in the study area, either those fish belonging to the coldwater fisheries or the warmwater fisheries. This study plan does not evaluate project effects on anadromous salmonids.

~~This study was designed as a desktop study to obtain additional general information on Lake Oroville resident fish species and their habitat characteristics from other studies. The study will provide an evaluation of current project effects on the quantity and quality of resident fish habitat based upon review of available information on the distribution, life history and habitat requirements of Lake Oroville resident fish species and a review and evaluation of the physical and hydraulic characteristics of Lake Oroville and its tributaries within the FERC boundary~~.

2.0 OBJECTIVES

The study plan objective is to evaluate potential project effects on resident coldwater and warmwater fish habitat within the study area, and resultant impacts on fish populations.

~~- Identify and describe the resident fish habitat in Lake Oroville and its tributaries within the FERC boundary; and~~

- Evaluate the effects of the Oroville Facilities on the quantity and quality of resident fish habitat within the FERC boundary.

3.0 RELATIONSHIP OF THE STUDY PLAN TO RELICENSING PROJECT PROCESS/ NEED FOR THE STUDY

This study is needed because project operations influence flow rates, water surface elevations, habitat availability, water temperature and other factors contributing to the success of resident warmwater and coldwater populations. Because Lake Oroville's warmwater sportfish species (black bass, crappie, and catfish) use the warm upper layer of the reservoir and nearshore littoral habitats throughout most of the year (DWR 2001), seasonal changes in reservoir storage, water surface elevation, and the rate of change in water surface elevation can directly affect the reservoir's warmwater fish resources. Reduced water surface elevations can reduce the availability of nearshore littoral habitats used by warmwater fish for spawning and rearing, therefore reducing spawning and rearing success and subsequent year-class strength. In addition, decreases in reservoir water surface elevation during the primary period for warmwater fish nest-building and spawning may result in reduced initial year-class strength through fish nest abandonment (and subsequent egg and larval mortality due to suffocation and predation) and exposure to dessication.

Additionally, during the period when Lake Oroville is thermally stratified (generally April through November), coldwater fish primarily reside in the coolest portions (i.e., the metalimnion and hypolimnion) of the reservoir. Potential project effects include reduced reservoir storage during this period which, in turn, could reduce the reservoir's coldwater pool volume and thereby reduce the quantity of habitat available to coldwater fish species. Therefore it is necessary to assess potential storage-related impacts to coldwater fish habitat availability in the study area in order to assess potential project impacts.

Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the FERC Application for License for major hydropower projects, including a discussion of the fish, wildlife and botanical resources in the vicinity of the project. The discussion needs to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operations of the project. The results of this study plan will be used to identify resident fish species and describe their existing habitat in Lake Oroville and its tributaries within the FERC boundary. This information will then be used to determine current project effects on the quantity and quality of resident fish habitat. The study results will be used in the assessment of impacts associated with anticipated future operations of the project, according to proposed terms and conditions identified as part of the relicensing process. This information ultimatelyIn addition to fulfilling these requirements, information developed in this study plan also may be used in determining appropriate protection, mitigation and enhancement (PM&E) measures or other management actions for the project.

4.0 SCOPE – STUDY AREA

The proposed study area includes Lake Oroville, its upstream tributaries, and the Thermalito Complex. ~~Lake Oroville, the West Branch Feather River and the North, South and Middle Forks of the Feather River to the limits of the FERC boundary. These~~ This includes areas within the fluctuation zone of Lake Oroville, and reaches above the high water mark still within the FERC boundary. The proposed study area also includes the Thermalito Complex and its tributaries and those sections above the high water mark yet still within the FERC boundary.

Historically, the drainage area above the gauging station at Oroville, known as the upper Feather River watershed, provided habitat for anadromous and resident fish species. Part of the upper Feather River watershed is included within the FERC boundary, and fish habitat may be influenced by operation of the Oroville Facilities.

The portion of the study area upstream of Lake Oroville will be the same as that of SP-G1, *Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam*. Specifically, the proposed study area for tributaries to Lake Oroville extends to stream channel obstructions that would limit upstream migration of salmon and steelhead. The principal obstructions are generally known and may include Big Bend Dam and Poe Dam on the North Fork Feather River, Ponderosa Diversion Dam on the South Fork Feather River, and Curtain Falls on the Middle Fork Feather River. Big Bend Dam had a fish ladder, but the efficiency of the ladder is not known (Taylor 2001). Maps, agency reports, newspaper articles, and information obtained from other study plans will be reviewed to definitively establish study area boundaries on streams that are tributary to Lake Oroville, in coordination with study plan SP-G1.

~~Historically, the drainage area above the gauging station at Oroville, known as the Upper Feather River Watershed, provided habitat for anadromous and resident fish species. Part of this Upper Feather River Watershed is included within the FERC boundary, and its fish habitat may be influenced by the operations of the Oroville Facilities.~~

5.0 GENERAL APPROACH

This study is designed as a desktop study to assemble and summarize general information regarding resident fish species and their habitat requirements, and to evaluate potential project effects on fish habitat, and resultant impacts on fish populations, within the study area. ~~This study, which is a reconnaissance-level or desktop study based on available information including study reports, scientific papers, past surveys and other miscellaneous information such as documents related to other relicensing efforts, results from simulation models, maps and/or newspaper articles, is~~

~~needed to provide an evaluation of the impact of project operations on resident fish habitat quantity and quality~~

This study plan is structured as a five-task study. *Tasks 1* and *2* involve literature and data reviews to gather information on resident fish in the study area and their life history, distribution and habitat preference. *Tasks 3* and *4* include characterization of the study area in terms of resident fish habitats categorized into two basic types: (1) lotic habitat (flowing streams or channels within the study area); and (2) lentic habitat (lake-like bodies of water). These classifications will be based on the review and assessment of past and current survey information in the study area, and information obtained from other study plans. *Task 5* will integrate the information gathered in the previous tasks to evaluate potential project effects on resident fish and their habitat.

The study plan is organized into the following five tasks:

(1) ~~Determine~~ Document the distribution of resident fish species in ~~Lake Oroville and its tributaries within the FERC boundary~~Lake Oroville, its upstream tributaries, and the Thermalito Complex;~~;~~

(2) Review life history and habitat requirements of resident fish species known to occur in ~~Lake Oroville and its tributaries within the FERC boundary~~Lake Oroville, its upstream tributaries, and the Thermalito Complex~~;~~

(3) Evaluate resident fish habitat conditions ~~of Lake Oroville tributaries within the FERC boundary~~in the primarily lotic environments within the study area;

(4) Evaluate resident fish habitat conditions of the primarily lentic environments within the study area (Lake Oroville, Thermalito Diversion Pool, Fish Barrier Pool, Thermalito Forebay, and Thermalito Afterbay); and

(5) Assess ~~the~~ potential project ~~likely~~ effects ~~of the Oroville Facilities~~ on ~~the quantity and quality of~~ resident fish and their habitat.

In order to achieve the final objective of assessing potential project effects on resident fish and their habitat, information from many sources must be integrated and summarized. Literature review may include, but is not limited to, the following existing sources:

- DWR Lake Oroville Annual Reports of Fish Stocking and Fish Habitat Enhancements to FERC, 1994-1999 - Lake Oroville fishery management information, resident fish stocking data, resident fish species data, and fish habitat enhancement projects.
- DWR Lake Oroville 90-Day Fishery Reports to FERC, 1995-1999 - Lake Oroville fishery management information, resident fish species data, resident fish stocking data, fish habitat enhancement projects, and water temperature profiles.
- DWR Lake Oroville Fisheries Habitat Enhancement Plan, 1995 - Lake Oroville fish habitat and habitat enhancement information.

- DWR Lake Oroville Fishery Management Plan Progress Report, October 1993 - Lake Oroville fishery and tributary information.
- DWR Amended Recreation Plan for Lake Oroville State Recreation Area, 1993 - Lake Oroville fishery information.
- DWR project operations data, including surface elevations of project reservoirs and inflow/outflow data.
- PG&E FERC relicensing proceedings and studies of North Fork Feather River projects - Including draft Poe Project License Application. Information on tributary (North Fork Feather River) fish.
- DFG: An Evaluation of Fish Populations and Fisheries in the Post-Oroville Project Feather River, 1977.
- DFG: Inland Fisheries Division - Information Leaflet No. 42, Warm Water Reservoir Fish Habitat Improvement Guide.
- DFG Annual Reports on Fish Habitat Enhancement.
- DFG Strategic Plan for Trout Management.
- 1993-1994 DWR Lake Oroville Siltation Study.
- Historic literature related to fish habitat within the FERC project waters.

These sources also may be used, in part, to fulfill the objective of study plan SP-F3.2, *Evaluation of Project Effects on Resident Fish and their Habitat in the Feather River Downstream of the Fish Barrier Dam*

~~Tasks 1 and 2 involve literature and data reviews to gather information on Lake Oroville resident fish and their life history, distribution and habitat preference. Tasks 3 and 4 include characterization of the study area in terms of resident fish habitats categorized into two basic types: (1) riverine or lotic habitat (streams within the study area); and (2) lentic or lacustrine habitat (essentially, Lake Oroville). These classifications will be based on the review and assessment of past and current survey information in the study area. Task 5 uses the information gathered in the previous tasks to evaluate the effects of operation of the Oroville Facilities on Lake Oroville resident fish habitat.~~

METHODOLOGY AND ANALYSIS

Task 1 – ~~Determine~~ Document the Distribution of Resident Fish Species in ~~Lake Oroville and its Tributaries within the FERC Boundary~~Lake Oroville, its Upstream Tributaries, and the Thermalito Complex

This task consists of a general review of existing information sources previously listed as well as additional reports by federal and state agencies, scientific papers, salmonid stocking and creel census reports, and other ~~miscellaneous~~ sources such as regional newspapers and fishing tournament logs to ~~identify~~ document species composition, distribution and relative abundance of resident fish in ~~the~~ Lake Oroville, its upstream

tributaries, and the Thermalito Complex~~ study area~~. Although it is recognized that all fish in the study area fulfill an ecological role, this task and subsequent tasks will focus on the cold and waterwater sportfish species of primary management concern. ~~-~~ Contingent on the information available, the literature review will cover the following topics:

- Temporal and geographic distribution of resident fish;
- Habitat utilization of resident fish; and
- ~~Dates and sites of stocking or introduction of individual species~~;
- Characterization of the relative abundance of resident fish including, as available, seasonal and geographic variations in relative abundance. ~~ as "abundant," "common" or "rare~~

~~Habitat requirements of resident fish by life-cycle stage (habitat types, preferred water temperatures, flow levels).~~

Task 2 –~~ Review Life History and Habitat Requirements of Lake Oroville Resident Fish~~Review Life History and Habitat Requirements of Resident Fish Species ~~k~~Known to ~~o~~Occur in Lake Oroville, its Upstream Tributaries, and the Thermalito Complex

Information ~~on~~ detailing the specific life history periodicities (e.g., adult spawning, juvenile rearing, and adult and juvenile migration), ~~and~~ general habitat requirements (warmwater or coldwater, bottom or pelagic, lentic or lotic dwellers), specific habitat requirements (e.g., water depth, water velocity, substrate composition) and community interactions (predators, prey, competitors) of resident fish is necessary to effectively evaluate ~~the~~ potential project effects on resident fish and their habitat. ~~ the quantity and quality of existing habitat.~~ Information related to habitat selection and suitability, conditions for fish stocking in reservoirs, and ~~for the~~ dispersion of stocked salmonids and resident fish to reservoir tributaries will be compiled and collected, as available. Information ~~on~~ regarding the habitat requirements, ~~and~~ life history characteristics, and community interactions of the resident fish identified and catalogued in *Task 1* will be obtained from available general scientific literature, data and reports from studies conducted by federal and state agencies, and interviews with private parties in the Central Valley, particularly local sportfishing guides and recreational fishing clubs. The lifestage ~~cycle~~ characteristics and habitat requirements for adult and juvenile resident salmonids will be developed under this task using, to the extent applicable, information developed in SP-F10, *Evaluation of Project Effects on Anadromous Salmonids and Their Habitat.* ~~Information pertaining to the life history characteristics and habitat requirements of resident fish that prey on juvenile salmonids will be obtained from SP-F21, *Project Effects on Predators of Feather River Anadromous Salmonids*.~~

Contingent on the information available, the following topics will be addressed in the review:

- Habitat requirements of resident fish by species and life~~-cycle~~ stage (habitat types, preferred water temperatures, water depth, water velocity, substrate, etc. ~~flow levels~~);
- Adult migration characteristics (timing, and prevalent water temperature and flow conditions);
- Spawning characteristics (habitat availability, timing, and factors affecting timing and success such as substrate conditions and water temperatures);
- Early development (factors affecting incubation and survival during incubation);
- Juvenile rearing (water temperature, substrate characteristics, refuges, shade, cover, food availability);
- Juvenile movements (timing, prevalent flow, water temperature and other abiotic conditions, predation, stranding);
- Behavioral and/or physiological changes in stocked or introduced individuals of the species; and
- Resident fish diet.

The objectives of this task are to~~include~~:

(1) Provide species-specific life history descriptions~~ (spawning, juvenile rearing and migration times, life-span, growth, mortality)~~ and habitat requirements for ~~all~~ resident fish in Lake Oroville, its upstream tributaries, and the Thermalito Complex~~and upstream to project boundaries~~;

(2) Characterize~~-~~ the fish community (predators, prey, competitors) of Lake Oroville, its upstream tributaries, and the Thermalito Complex~~ and upstream to project boundaries~~; and

(3) Classify resident fish species and/or their life stages in guilds according to their habitat requirements (warmwater or coldwater, bottom or pelagic, lentic or lotic dwellers).

Task 3 – Evaluate Resident Fish Habitat Conditions ~~of Lake Oroville~~in the Primarily Lotic (Riverine) Environments Within the Study Area

This task involves the review and summarization of habitat information of ~~tributaries to Lake Oroville~~the primarily lotic (riverine) environments within the study area.~~ within the FERC boundary, including the stream segments within the fluctuation zone of Lake Oroville, and those sections above the high water mark yet still within the FERC boundary~~. The review will use available cartographic information (e.g., aerial photographs and topographic maps)~~ to identify all 3rd order or larger tributaries,~~ and information obtained from SP-G1, *Effects of Project Operations on Geomorphic*

Processes Upstream of Oroville Dam. will be used to describe the habitat in smaller tributaries. The inventory of potential and available habitat for adult and juvenile resident salmonids upstream of Lake Oroville will be developed under this task. As specified in SP-G1, upstream reaches within the sphere of influence of the lake will be classified using the Rosgen stream classification system. The reaches will be classified using Rosgen's Level I stream typing, then further classified using the Level II classification based on channel substrate and form. As specified in SP-G1, geomorphic parameters will be assessed including channel width, depth, cross-section, hydraulic radius, roughness, large woody debris, gravel bars, islands, and others. Pools, riffles, and runs will be mapped. Representative areas at the riffles will be analyzed using bulk gravel sampling and surface sampling techniques to determine the surface and substrate quality of trout spawning gravel. Gradation curves for each riffle will be prepared. Water quality parameters such as dissolved oxygen, conductivity, pH, and turbidity will be obtained from existing reports, and from SP-W1, *Project Effects on Designated Beneficial Uses,* and SP-W3, *Project and Recreational Operations and Facilities Effects to Water Quality*. Water Ttemperature information will be obtained from existing surveys and from SP-W6, *Project Effects on Temperature Regime*. Micro and macro-cover characteristics such as substrate, woody debris, and aquatic vegetation will be generally described using existing information and information from SP-T7, *Project Effects on Noxious and Aquatic Plant Species,* and SP-G1, *Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam*.

The following activities will be included:

- Identification and mapping of the streams and creeks that constitute the watershed of the West Branch Feather River and the North, Middle and South Fork Feather Rivers (using 7.5 minute quadrangle U.S. Geological Survey (USGS) topographic maps);
- Review of available historic and recent aerial photographs and topographic maps of the streams and creeks of the watershed of the West Branch Feather River and the North, Middle and South Fork Feather Rivers to identify potential salmonid spawning grounds and juvenile rearing habitat (i.e., backwaters, side channels, riffles, pools);
- Review of existing water quality, sediment and riparian vegetation information for the upper watershed (to be obtained in coordination with other environmental study plans);
- Review of data and reports from upper watershed surveys performed by federal and state agencies, newspaper accounts, as well asand interviews with private parties, to locate or assess spawning and juvenile rearing habitat for salmonids; and
- Review of data and reports from upper watershed surveys performed by federal and state agencies, newspaper accounts, as well asand interviews with private parties, to identify and evaluate the distribution of fish and other fauna that may constitute potential prey, predators or competitors for resident salmonids.

Task 4 – Evaluat~~ion of~~e Resident Fish Habitat Conditions of ~~Lake Oroville~~the Primarily Lentic or Lacustrine Environments within the Study Area (Lake Oroville, Thermalito Diversion Pool, Fish Barrier Pool, Thermalito Forebay, and Thermalito Afterbay)

This task will consist of a review and summarization of available data and reports on physical, hydrological, ~~biological~~ and operational characteristics of the primarily lentic or lacustrine environments within the study area (Lake Oroville, Thermalito Diversion Pool, Fish Barrier Pool, Thermalito Forebay, and Thermalito Afterbay)~~Lake Oroville~~. Key parameters that can affect the quantity and quality of ~~Lake Oroville ichthyofauna~~fish include ~~Lake Oroville~~ water surface levels and water temperature stratification, dissolved oxygen, pH, turbidity and nutrient ~~and mineral~~ content~~s~~. ~~Some of the information reviewed in this task will proceed from concurrent study plans.~~ Water quality parameters such as dissolved oxygen, conductivity, pH, and turbidity will be obtained from existing reports, and from SP-W1, *Project Effects on Designated Beneficial Uses*, and ~~—~~SP-W3, *Project and Recreational Operations and Facilities Effects to Water Quality*. Water ~~T~~temperature information will be obtained from existing surveys and from SP-W6, *Project Effects on Temperature Regime*. Micro and macro-cover characteristics such as substrate, woody debris, and aquatic vegetation will be generally described using existing information and information from SP-T7, *Project Effects on Noxious and Aquatic Plant Species*, and SP-G1, *Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam*. Descriptions of non-fish aquatic resources (e.g., macroinvertebrates~~) and primary production)~~ will be obtained from existing information and from SP-F1, *Evaluation of Project Effects on Non-Fish Aquatic Resources (e.g., macroinvertebrates).* ~~The performance of~~ ~~T~~this task also will require ~~coordination with the~~ integration of Engineering and Operation Group output regarding ~~for~~ water temperature, ~~and~~ flow rate, rate of flow rate change, reservoir water surface elevation and fluctuation. ~~model outputs.~~

Elements of this review will include:

- ~~Lake topography~~Morphometry of the Thermalito Diversion Pool, Fish Barrier Pool, Thermalito Forebay and Afterbay, and Lake Oroville, ~~in~~ with particular attention given to the confluence with the West Branch Feather River and the North, Middle and South Fork Feather ~~R~~rivers;
- Annual cycle of Lake Oroville, Thermalito Diversion Pool, Fish Barrier Pool, and Thermalito Forebay and Afterbay water levels, describing monthly and inter-annual variation;
- Water temperature profiles throughout the year for:

  1. Lake Oroville. Specifically, differences between the central part of the lake and the area of confluence with the West Branch Feather River and the North, Middle and South Fork Feather ~~R~~rivers will be indicated; and

2. Thermalito Complex lentic water bodies. Water temperature horizontal distribution and vertical profiles throughout the year including, if possible, differentiating between the central part of the pools, the inlet and outlet areas, and the backwater areas and isolated coves with reduced water circulation. These last areas are particularly important in the case of the Thermalito Afterbay.

- -Changes in dissolved oxygen, pH, turbidity, and nutrient and mineral contents throughout the year in Lake Oroville, Thermalito Diversion Pool, Fish Barrier Pool, and Thermalito Forebay and Afterbay;
- Catalogue Description of invertebrate species present in Lake Oroville, detailing the timing and location (water layer) of their lifecycle stages in Lake Oroville, Thermalito Diversion Pool, Fish Barrier Pool, and Thermalito Forebay and Afterbay; and
- Catalogue Description of Lake Oroville, Thermalito Diversion Pool, Fish Barrier Pool, and Thermalito Forebay and Afterbay aquatic vegetation;

Changes in Lake Oroville primary production;

Catalogue of fish species present in Lake Oroville, detailing the timing and location (water layer) of their different lifecycle stages; and

Identification of most common ecological relationships among fish and invertebrate species, detailing, when possible, inter-annual changes.

Task 5 – Assessment of Potential Project Likely Effects of the Oroville Facilities on the Quantity and Quality of Resident Fish and Their Habitat

In this task, the information gathered in *Tasks 1* through *4* will be evaluated used to evaluate the likely potential project effects on the quantity and quality of resident fish and their habitat. This task will provide a conceptual model of the potential project effects of the operations of the Oroville Facilities on the availability and quality of habitat for the various resident fish in Lake Oroville and tributariesthe study area. The model will identify the mainpossible stressors (changes ine.g., unsuitable water temperature, inadequate flow levels, deteriorating water quality, lack of availability of refuge against predators, and insufficient availability and/or quality of spawning, feeding and rearing habitat grounds), the type (negative or positive) the affected fish species or fish guild, and intensity potential project-related effect, and the affected fish species or fish guild. effects.

To assess potential elevation-related impacts to the warmwater fish in the study area, the following two-phased approach will be used. First, a relationship between reservoir water surface elevation and acres of nearshore littoral habitat containing submerged structure (submerged macrophytes and/or inundated terrestrial vegetation) will be developed using data gathered in *Tasks 1* through *4*. Using this relationship, the mean number of acres of littoral habitat will be estimated for each month of the primary spawning and rearing

period (April through July). Second, the magnitude of change (feet) in reservoir water surface elevation occurring each month of the primary spawning period for nest-building fish (April through September) will be determined. A recent study by CDFG, which examined the relationship between reservoir elevation fluctuation rates and nesting success for black bass, suggests that a reduction rate of 0.15, 0.18, and 0.39 meter per day (m/day) or greater would result in 100 percent nest mortality (or zero percent nest survival) for largemouth bass, smallmouth bass, and spotted bass, respectively (Lee et al. 1998). However, CDFG reservoir biologists suggest that, on the average, a nest survival rate of at least 20 percent is necessary to maintain the long-term population levels of high-fecundity, warmwater fish (D. Lee, pers. comm. 1998). Using nest survival curves developed by CDFG (Lee et al. 1998), reservoir fluctuation criteria will be developed that would provide a minimum nest survival rate of approximately 20 percent for largemouth bass, the bass species found by CDFG to be most sensitive to reservoir elevation fluctuations, based upon reservoir storage - elevation relationships for Lake Oroville.

In the case of coldwater fisheries, availability of cold water is an important factor contributing to self-sustaining coldwater fish populations. It is therefore necessary to assess potential storage-related impacts to coldwater fish habitat availability in the lentic portions of the study area. During the period when Lake Oroville is thermally stratified (April through November), coldwater fish within the reservoir reside primarily within the reservoir's metalimnion and hypolimnion where water temperatures remain suitable. Reduced reservoir storage during this period could reduce the reservoir's coldwater pool volume, thereby reducing the quantity of habitat available to coldwater fish species during these months. Reservoir coldwater pool size generally decreases as reservoir storage decreases, although not always in direct proportion because of the influence of reservoir basin morphometry. Therefore, to assess potential storage-related impacts to coldwater fish habitat availability in Lake Oroville, end-of-month storage will be modeled for each year of the period of record for each month of the April through November period. Potential project effects on coldwater fish in lotic portions of the study area will be assessed using a habitat-evaluation based approach. Habitat characterization information will be provided by *Task 3*, including maps of pools, riffles, and runs in the study area. In addition, habitat-specific hydraulic information (i.e., water depth and velocity) will be obtained from SP-G1, *Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam*. As specified in SP-G1, monitoring will be conducted at representative low, medium, and high flows to cover the full spectrum of stream flows. For resident salmonids in lotic portions of study area, existing information regarding spawning and rearing habitat preference or suitability criteria will be obtained from published literature. Habitat characteristics, including hydraulic information, will be compared to habitat suitability criteria to evaluate potential project effects on habitat suitability and availability in lotic portions of the study area. Potential comparative methodologies include an IFIM-type of comparative framework or an IHA-type approach.
~~If the information gathered in Tasks 1 through 4 is sufficient to reliably quantify some of these effects, response and explanatory variables will be identified and related through simple mathematical expressions or models to assess the statistical significance of the project-related effects. Under those circumstances, the response variables will be some~~

~~expression of habitat characteristics (e.g., area of watered spawning or rearing grounds, area of inundated littoral vegetation, number of pools and creeks occupied by the resident fish species) or utilization (e.g., fish abundance), and the explanatory variables will be some measure of the stressor such as water temperatures, water level or flows.~~

6.0 RESULTS, PRODUCTS/DELIVERABLES AND SCHEDULE

RESULTS

Results will be organized following the task headings. Each task will include a narrative of the relevant findings as well as tables, figures and maps summarizing the key points. ~~After the results of the five individuals tasks are presented, t~~The ~~relationships among the findings~~results of the ~~five~~ first four sections will be ~~identified~~ integrated to evaluate potential project effects on resident fish habitat and resultant impacts on fish populations. ~~to provide general answers to the main questions of the study. The primary issues of the study and the likely ways to link the study findings of the five individual tasks to address them are listed below.~~

- ~~Identification of the resident fish habitat in Lake Oroville (*Tasks 1*, *2* and *- 4*);~~
- ~~Identification of the resident fish habitat in Lake Oroville tributary streams and creeks (*Tasks 1*, *2* and *3*);~~
- ~~Evaluation of project effects on the quantity and quality of the fish habitat in Lake Oroville and tributaries (*Tasks 1 - 5*);~~

The anticipated maps, graphical representation of reviewed data (e.g., charts, and graphs) and summary figures and tables include:

- Figures summarizing lifecycle periodicity for identified ~~Lake Oroville~~study area resident fish species;
- Tables summarizing main habitat suitability characteristics for spawning, juvenile rearing and migrations of identified primary ~~Lake Oroville~~study area resident fish species;
- ~~Tables or figures summarizing interspecific relationships within the Lake Oroville fish community,~~
- Maps showing seasonal distributions of identified primary resident fish in ~~Lake Oroville and tributaries~~the study area;
- Tables summarizing key topographic, hydrologic and operational characteristics of ~~Lake Oroville and its tributaries~~the study area;
- Topographic maps of ~~Lake Oroville and its tributaries~~the study area, showing contours of the water level during periods of minimum and maximum flow, and sites ~~of~~ potentially influencing~~e on~~ resident fish;

- Topographic maps of ~~Lake Oroville and its tributaries~~the study area, showing monthly average water-temperature contours (isoclines), and sites ~~of~~ potentially influencing~~e on~~ resident fish;
- Species-specific summary tables showing habitat characteristics likely to be affected by ~~the~~ project operations~~ of the Oroville Facilities~~; and
- Figure(s) depicting the conceptual model developed to evaluate the potential ~~effects of the~~ project effects ~~operations of the Oroville Facilities~~ on resident fish ~~the availability and quality of~~ habitat ~~for~~ and the fish population in ~~various resident fish in Lake Oroville and tributaries~~the study area.

PRODUCTS/DELIVERABLES

The study plan summary report will include:

- Executive Summary
- Table of Contents
- List of Tables
- List of Figures
- Introduction
- Narratives of relevant findings by task
- Discussion addressing most relevant questions (see above) and indicating any complications/data concerns
- Conclusions related to study plan goals and objectives

~~Recommendations~~

- References
- Appendices

SCHEDULE

The results of the tasks performed under the study plan will be presented in a summary report. It is anticipated that the final report will be completed by December 2003.

Any regulatory reporting requirements, and the report distribution procedure and list, will be indicated at least four months before the completion of the final report. By that time, the agency review and approval requirements will be determined. Some of the tables and maps that may constitute part of the report attachments or appendices were indicated in previous paragraphs.

7.0 STUDY PLAN COORDINATION

COORDINATION WITH OTHER RESOURCE AREAS/STUDIES

~~It is anticipated that t~~This study will require coordination with those individuals responsible for collecting temperature and project operation data, ~~and~~ performing

biological surveys, and conducting hydraulic and channel morphology studies. Contact with CDFG and USGS also is~~are~~ expected.

Given the nature of the tasks of this study, contacts with work groups directing and conducting other studies relevant to the Oroville Facilities FERC Relicensing Project also are expected. A preliminary list of study plans that will be related to the development of the present study includes:

SP-F1 –Effects on Non-Fish Aquatic Resources (e.g. macroinvertebrates)

The scope of this study plan is currently under development and information needs will be incorporated as the study becomes available.

SP-F2 – Effects of Project Operations on Fish Diseases

This study will provide information to SP-F2 regarding resident fish identification, lifestages, migration, movement, habitat, water quality, temperature, and temporal and geographic distribution in the study area. ~~This study plan (~~SP-F3.1~~)~~ will rely on information and study results generated by SP-F2~~. It is anticipated that information will~~, including~~e~~ temporal and geographical distribution of resident fish diseases in ~~Lake Oroville and the Upper Feather River Watershed~~the study area, based on a review of data and reports from state and federal agencies.~~ In particular, on review of the records of hatcheries in the area and reports on the results of regional efforts at stocking and planting of salmonids in Lake Oroville and in reservoirs, ponds and streams of the Upper Feather River Watershed.~~ Results from the review will be organized by disease name, date and site of detection and measures of incidence and control of the outbreaks.

Additionally, the characterization of diseases in Lake Oroville and the Upper Feather River Watershed will be obtained from SP-F2. Based on the availability of scientific and technical literature information, the information listed below will be considered with the aim of producing synoptic descriptions of the diseases prevalent in the region.

- Characterization of the disease agent (including lifecycle of the pathogen and stages of the disease).
- Listing of all known hosts (including non-salmonids) and classification of hosts according to degree of specificity.
- Means of transmission.
- Methods for identification and diagnosis.
- Available methods for prevention and cure.

SP-F3.2 – Evaluation of Project Effects on Resident Fish and Their Habitat in the Feather River Downstream of the Fish Barrier Dam

Study Plan SP-F3.2 will provide and obtain information on resident fish life stages and interactions; fish habitats; migration, movement, and rearing; and distribution in the Feather River downstream of the Fish Barrier Dam. Information also will be provided to SP-F3.3 regarding temperature, flow, and water quality in the Feather River (as summarized from geomorphology, terrestrial, water quality, and engineering/modeling).

SP-F4 – Passage of Resident Fish Upstream of Lake Oroville

Study plan SP-F4 will receive information regarding upstream habitat from SP-F3.1.

SP-F5 – Effects of Fisheries management Plans on a Balanced Fishery

This study plan will provide information to SP-F5 for an evaluation of those fisheries management plans that encompass the Thermalito Complex. This will include information on fish species present, habitat quantity and quality, and potential PM&E measures.

~~*SP-F17 – Recreational Fishery Survey of FERC Project Waters*~~

~~This recreation study plan that contains the recreational fisheries characteristics proposed in SP-F17 will be obtained and incorporated as relevant to habitat and habitat impacts.~~

SP-F21 – Project Effects on Predators of Feather River Anadromous Salmonids

~~This study will provide identification of fish species and fish interactions.~~
Study Plan SP-F21 will provide information on the life history characteristics and habitat requirements of resident fish, that are predators of anadromous salmonids.

SP-G1 – Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam

SP-G1 will provide SP-F3.1 with geomorphic information regarding tributaries upstream of Lake Oroville including channel width, depth, cross-section, hydraulic radius, roughness, large woody debris, gravel bars, and islands. Additionally SP-G1 will provide maps of pools, riffles, and runs. Representative areas at the riffles will be analyzed using bulk gravel sampling and surface sampling techniques to determine the surface and substrate quality of trout spawning gravel. Gradation curves for each riffle will be prepared. SP-G1 will also provide Rosgen stream classifications for upstream reaches influencing Lake Oroville.

~~*SP-W6 – Project Effects on Temperature Regime*~~

SP-W1 – Project Effects on Designated Beneficial Uses

Water quality parameters such as dissolved oxygen, conductivity, pH, and turbidity will be obtained from existing reports, and from SP-W1 and SP-W3.

SP-W3 – Project and Recreational Operations and Facilities Effects to Water Quality

Water quality parameters such as dissolved oxygen, conductivity, pH, and turbidity will be obtained from existing reports, and from SP-W1 and SP-W3.

SP-W6 – Project Effects on Temperature Regime

Temperature information will be obtained from existing surveys and from SP-W6. Water temperature and flow model outputs will be required from the DWR Engineering/Ops Group. Coordination with the DWR group in charge of the Study Plan SP-W6 will be required prior to the start of water temperature monitoring. New temperature monitoring stations will have to be added to the proposed stations to assure adequate coverage of the Thermalito Diversion Pool, Fish Barrier Pool, Thermalito Forebay and, in particular, the Thermalito Afterbay, where the backwater areas and isolated coves with reduced water circulation will be monitored.

SP-T7 – Project Effects on Noxious and Aquatic Plant Species

Micro and macro-cover characteristics such as substrate, woody debris, and aquatic vegetation will be generally described using existing information and from SP-T7. The performance of this task also will require coordination with the DWR GIS Group and the Engineering and Operations Group.

Engineering and Operations Work Group Studies and Models

Results from hydrologic and water temperature modeling completed for the project will be incorporated into the descriptions and evaluations of study area characteristics. Anticipated specific information to be obtained would include daily and monthly flow fluctuations in the lower Feather River, and daily and monthly mean water temperatures in the lower Feather River.

Maps Produced by DWR GIS Group

~~*Engineering and Operations Workgroup Studies and Models*~~

ISSUES, CONCERNS, COMMENTS TRACKING AND/OR COMPLIANCE REQUIREMENTS

Stakeholder Issue Statements Addressed by the Study Plan *Evaluation of Project Effects on Resident Fish Habitat in Lake Oroville and its Tributaries within the FERC Boundary*.

Issue	Description
FE1	Are the project related Lake Oroville water level fluctuations presently affecting the reproduction and survival of warm-water sportfish?
FE3	Is the present minimum pool adequate for protecting The Lake Oroville cold-water sport fishery;
FE2	How will the project related Lake Oroville water level fluctuations affect the reproduction and survival of warm-water sportfish under future operational demands?
FE8	Lake Oroville releases made for power generation may cause dramatic fluctuations in lake level. What are the potential impacts of fluctuation zone and surface elevation change on recreation opportunities and on fish and wildlife habitat?
FE12	Protect and improve wild trout habitat.
FE13	Require proponents to coordinate with Plumas National Forest (PNF) in analysis of instream flow need for all potentially affected riparian dependent species.
FE23	Hire a full-time independent biologist for Lake Oroville in addition to DWR biologist.
FE52	Facility operations and impact on bass fishery and spawning activities at Afterbay (protect and enhance bass fishery).
FE57	Provide habitat leading to viable populations of endangered species. Maintain habitat to support viable populations of all native and desired nonnative vertebrate species.
FE58	Improve and protect habitat for designated emphasis and harvest species. Identify and evaluate potential conflicts among project effects and management actions for protected and sensitive species.
FE59	Protect and improve habitat for trout.
FE64	Effect of project on available upstream fishery habitat (Incorporate all project facilities).
FE66	Expand land-lock fishery to include all salmon not just chinook.

Issue	Description
FE81	Currently some of the species of fish commonly found in Lake Oroville are also found in the Poe reach of the North Fork Feather River. Maximum water temperatures in the Poe reach often exceed 20 C (68 F), making management of the Poe reach as a coldwater fishery difficult. There is an interest in determining the interaction of the Lake Oroville fishery with the Poe reach fishery, and identifying measures that can be taken to maintain the Poe reach as a coldwater fishery.
FE83	Macroinvertebrates as an indicator of water quality.
FE84	Evaluate indicators of hydrological alteration (IHA analysis).

Source: NEPA Scoping Document 1 and CEQA Notice of Preparation, DWR 2001.

8.0 REFERENCES

A complete list of references used in the completion of the study will be part of the summary report. The references cited in the present plan are listed below.

DWR. 2000. 1999 Lake Oroville Annual Report of Fish Stocking and Fish Habitat Improve-ments, February 2000.

DWR. 2001. Initial Information Package, Relicensing of the Oroville Facilities, January 2001.

DWR and USBR. 2000. Effects of the Central Valley Project and State Water Project on Steelhead and Spring-run Chinook Salmon, November 2000.

PCWA and USBR. 2001. PCWA American River Pump Station Project. Draft of Environmental Impact Statement/ Environmental Impact Report, August 2001.

DWR OROVILLE FACILITIES RELICENSING PROJECT
(FERC Project No. 2100)

ENVIRONMENTAL WORK GROUP
DRAFT STUDY PLAN

SP-F3.2~~3~~. EVALUATION OF PROJECT EFFECTS ON ~~NON-SALMONID~~RESIDENT FISH AND THEIR HABITAT IN THE FEATHER RIVER DOWNSTREAM OF THE FISH BARRIER DAM

1.0 INTRODUCTION

~~The Feather River Fish Barrier Dam, located upstream of the Feather River Hatchery and approximately five miles below Oroville Dam, was identified as the first impassable salmonid migration barrier on the Feather River (Yoshiyama et al. 1996; DWR and USBR 2000). The Feather River reach extending from the Feather River Fish Barrier Dam and the Thermalito Afterbay River Outlet is known as the Feather River Low Flow Channel.~~ Operations of the Oroville Facilities can result in varying flow rates in the Feather River. Flow fluctuations and changes in river stage may hinder colonization of rooted aquatic vegetation in the riparian zone, limiting the establishment of terrestrial vegetation within the fluctuation zone (DWR 2001). Terrestrial vegetation provides spawning and nursery habitat for warmwater fisheries, and offers protection from predation and results in increased food availability for warmwater and coldwater fisheries (DWR 2001; DWR and USBR 2000). Therefore, depletion of such cover may contribute to reduced numbers of game fish (DWR 2001). Additionally, variations in flow may affect water temperature, spawning habitat availability, egg incubation success, and juvenile survival, all of which are factors in determining coldwater fisheries success in the Feather River (DWR 2001).

The lower Feather River supports a variety of ~~anadromous and non-salmonid~~ fish species. The two most important fish species in terms of sport fishing are ~~the~~ chinook salmon (*Oncorhynchus tshawytscha*) and steelhead ~~trout~~ (*O. mykiss*), although striped bass (*Morone saxatilis*) and American shad (*Alosa sapidissima*) are also common targets for anglers. Additionally, the Feather River warmwater sport fishery is dominated by fish of the *Centrarchidae* (sunfish) family including four species of black bass (*Micropterus punctulatu, M. salmoides, M. dolomieui, and M. coosae),* three species of sunfish (*Lepomis macrochirus, L. cyanellus, and L. microlophus),* and two species of crappie (*Pomoxis nigromaculatus* and *P. annularis)* (DWR 2001). In addition to the game species mentioned above, ~~several other native and exotic fish species reside in the Feather River~~the Feather River and its tributary streams also provide habitat for many other fish species, including native fish (e.g., Sacramento pikeminnow (*Ptychocheilus grandis),* hardhead (*Mylopharodon conocephalus),* Sacramento sucker (*Catostomus occidentalis),* splittail (*Pogonichthys macrolepidotus),* river lamprey (*Lamptera ayresi*)), and introduced fish (e.g., carp (*Cyprinus carpio),* wakasagi (*Hypomesis nipponensis),* and threadfin shad (*Dorosoma petenense*)). ~~The evaluation~~

~~of potential project effects on warmwater species will focus on the sport fish (centrarchids) mentioned above.. Many of these species can also be found as part of the assemblages of warmwater and coldwater fish species supported by the waters of Oroville Lake and the Thermalito Complex~~.

This study will also include the OWA, which contains over 75 warmwater ponds and sloughs, along with vast complexes of emergent marsh and flooded cottonwood, willow, and sycamore trees. It provides habitat for largemouth bass, bluegill, green sunfish, carp, black and white crappie, and two species of catfish (*Ictalurus pnctatus*, and *I. Catus*). The OWA also includes the Thermalito Afterbay Outlet, the most popular spot for steelhead and salmon fishing in Butte County.

~~For the purpose of this study, "non-salmonid fish" are all fish species found in the lower Feather River and its tributary waters that are not anadromous salmonids. The Feather River and its tributary streams probably support fish assemblages of warmwater and coldwater sportfish, and other native and introduced non-game fish species, similar to the fish assemblages present at Lake Oroville and the Thermalito Complex.~~

~~Some species that constitute the Lake Oroville and Thermalito warmwater fishery, such as spotted bass, *Micropterus punctulatus*; largemouth bass, *M. salmoides*; smallmouth bass, *M. dolomieui*; redeye bass, *M. coosae*; bluegill, *Lepomis macrochirus*; green sunfish, *Lepomis cyanellus*; redear sunfish, *L. microlophus*; black crappie, *Pomoxis nigromaculatus* and white crappie, *P. annularis*, also are found in the waters of the Feather River (DWR 2001). Other game species such as striped bass (*Morone saxatilis*) and American shad (*Alosa sapidissima*) are also known to be present in the Feather River. During some pre-project years the fishery for the non-native striped bass did well in the Feather River although with considerable year-to-year variation (Painter et al. 1977). However, the current post-project status of the fishery on the Feather River has not been well documented. Although the current status of the American shad fishery on the Feather River is not well known, Painter et al.'s (1977) study suggested how the Oroville Project would have affected the spring temperature regiment of the Feather River and, consequently, American shad spawning.~~

~~Besides the game species, the Feather River and its tributary streams also provides habitat for many other fish species, including native fish (e.g., Sacramento pikeminnow, *Ptychocheilus grandis*; hardhead, *Mylopharodon conocephalus*; Sacramento sucker, *Catostomus occidentalis*; splittail, *Pogonichthys macrolepidotus*; river lamprey, *Lamptera ayresi*) and introduced fish (e.g., carp, *Cyprinus carpio*; wakasagi, *Hypomesis nipponensis*; threadfin shad, *Dorosoma petenense*), that occupy different trophic levels within the fish community. For many of these species, no consistent records on their abundance or distribution exist.~~

For the purpose of this study, "resident fish" are fish species found in the study area, either those fish belonging to the coldwater fisheries or the warmwater fisheries. The evaluation of potential project effects on warmwater species will focus on sportfish (centrarchid) mentioned above. The evaluation also will include striped bass, American

shad, splittail, river lamprey and green and white sturgeon. This study plan does not evaluate project effects on anadromous salmonids. Potential project effects on anadromous salmonids will be addressed in SP-F10, *Evaluation of Project Effects on Anadromous Salmonids and Their Habitat.*

~~This study was designed as a desktop study to Feather River in the study area ious reports and communications. assemble information on Feather River resident fish species and their habitat characteristics, and to provide an evaluation of current project effects on the quantity and quality of resident fish habitat. This study plan includes reviews of available information on the distribution, life history and habitat requirements of Feather River resident fish species, and a review and evaluation of the physical and hydraulic characteristics of the Feather River and the streams that are tributary to the Feather River between the Fish Barrier Dam and the confluence with the Yuba River, as well as the ponds, sloughs, and wetlands of the Oroville Wildlife Area, to provide an evaluation of current project effects on the quantity and quality of resident fish habitat.~~

2.0 OBJECTIVES

The study plan objective is to evaluate potential project effects on resident coldwater and warmwater fish habitat within the study area, and resultant impacts on fish populations.

~~The study plan objectives are to:~~

- ~~Identify the non-salmonid fish and habitat in the Feather River downstream of the Fish Barrier Dam; and~~
- ~~Evaluate the effects of the Oroville Facilities on the quantity and quality of the fish habitat in the Feather River downstream of the Fish Barrier Dam.~~

3.0 RELATIONSHIP OF THE STUDY PLAN TO RELICENSING ~~PROJECT PROCESS~~/ NEED FOR THE STUDY

This study is needed because project operations influence flow rates, river stage, habitat availability, water temperature and other factors contributing to the success of resident warmwater and coldwater populations within the study area. Reduced river stage can reduce the availability of inundated riparian vegetation used by warmwater fish for spawning and rearing, therefore reducing spawning and rearing success and subsequent year-class strength. In addition, decreases in flow and river stage during the primary period for warmwater fish nest-building and spawning may result in reduced initial year-class strength through fish nest abandonment (and subsequent egg and larval mortality due to suffocation and predation) and exposure to dessication (PCWA and USBR 2001). Additionally, project operations potentially impact coldwater salmonids. Potential project effects may include limiting the extent of Feather River anadromous salmonid distribution, altered distribution of Feather River resident species, decreased availability and quality of resident fish habitat, and changes in the magnitude,

frequency and timing of flow and water temperatures in the Feather River. Therefore, this study is necessary to evaluate potential project impacts on resident fish and their habitats in the lower Feather River below the Fish Barrier Dam, in the Feather River tributaries and in the ponds, sloughs, and wetlands of the Oroville Wildlife Area.

Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the FERC Application for License for major hydropower projects, including a discussion of the fish, wildlife and botanical resources in the vicinity of the project. The discussion needs to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operation of the project. ~~The results of this study plan will be used to identify Feather River resident fish species within the study area and describe their existing habitat. This information will then be used to determine potential of the current project effects on the quantity and quality of resident fish habitat. The study results will help to infer potential effects of any changes in project operations that may result from proposed terms and conditions identified as part of the relicensing process, and may ultimately~~In addition to fulfilling these requirements, information developed in this study plan also may be used in determining appropriate protection, mitigation and enhancement (PM&E) measures.

~~within the study area (PCWA and USBR 2001) inundated riparian habitatvegetationperiod for nest-building warmwater fish nest "dewatering (PCWA and USBR 2001).~~

~~(move to approach) This study, which is a desktop study on available information including concurrent study reports, scientific papers, past surveys and other miscellaneous information such as documents related to other relicensing efforts, results from simulation models, maps and/or newspaper articles, is needed to provide an evaluation of the impact of project operations on Feather River resident fish habitat quantity and quality. Besides limiting the extent of Feather River anadromous salmonid distribution, construction and operation of the Oroville Facilities may affect the distribution of Feather River resident species, and the availability and quality of their habitat. Project operations affect the magnitude, frequency and timing of flow and water temperatures in the Feather River. Therefore, this study is necessary to evaluate project impacts on resident fish and their habitats in the lower Feather River below the Fish Barrier Dam, in the Feather River tributaries and in the ponds, sloughs, and wetlands of the Oroville Wildlife Area.~~

~~This desktop study will complement the assessments of project-related effects on the populations of anadromous salmonids and resident fish upstream and downstream of Lake Oroville. These other assessments and the present study will be important for the evaluation of direct, indirect and cumulative effects of the Oroville Facilities that are relevant to the Oroville Facilities relicensing environmental review and Endangered Species Act (ESA) consultation processes.~~

4.0 SCOPE – STUDY AREA

~~The proposed study area~~ The proposed study area includes the Feather River downstream of the Fish Barrier Dam and tributary waters within the FERC boundary. The study area includes the Low Flow Channel~~-~~, which is the reach of the Feather River extending from the Fish Barrier Dam to the Thermolito Afterbay River Outlet, and the lower Feather River extending from the Thermolito Afterbay River Outlet downstream ~~up~~ to its confluence with the Yuba River. ~~The vast array of small (< 5 acre) ponds, sloughs, and wetlands of the Oroville Wildlife Area, and Feather River tributary streams and creeks within the FERC boundary or under the potential effect of Oroville flow releases or spills, will also be included in the study.~~ The confluence with the Yuba River is the southern boundary for the study due to its flow contribution. Below the confluence with the Yuba River, Feather River water temperatures, flows and fish habitats would be affected not only by Oroville project operations but also by the operations of the projects upstream on the Yuba River (e.g., Narrows I and II power plants and Englebright Dam). The vast array of small (< 5 acre) ponds, sloughs, and wetlands of the Oroville Wildlife Area, and Feather River tributary streams and creeks within the FERC boundary or under the potential effect of Oroville flow releases or spills, will also be included in the study.

5.0 GENERAL APPROACH

~~This desktop study will consist of a review, comparison and assessment of available information on the impact of Oroville Facilities on the community of Feather River non-salmonid fish and their habitat.~~ This study is designed as a desktop study to assemble and summarize general information regarding resident fish species and their habitat requirements, and to evaluate potential effects on fish habitat, and resultant impacts on fish populations, within the study area. ~~It will provide an assessment of the effects of the operation of the Oroville Facilities on the quantity and quality of the Feather River non-salmonid fish habitat.~~ The study plan is structured as a five-task study ~~(see tasks below)~~. ~~The first two tasks will consist of~~ *Tasks 1* and *2* involve literature and data reviews to gather information on ~~Feather River non-salmonid~~resident fish in the study area and their life history, distribution and habitat preference. ~~The third and fourth tasks will~~*Tasks 3* and *4* include characteriz~~e~~ation of the study area in terms of their resident fish habitats~~. They also identify~~ categorized into two basic types ~~of habitats~~: (1) r

~~-~~ Riverine or lotic habitat (~~the Feather River and all the streams that are tributaries to the Feather River between the Fish Barrier Dam and the confluence with the Yuba River~~flowing streams of channels within the study area); and (2) lacustrine or lentic habitat (lake-like bodies of water

~~Ponds, sloughs, and wetlands of the Oroville Wildlife Area~~).

~~These tasks (three and four)~~ These classifications will ~~consist of~~ be based on the review~~ing~~ and assessment~~ing~~ of past and current survey ~~efforts~~ information in the study

area, and information obtained from other study plans. ~~The fifth task will~~ *Task 5* will integrate ~~evaluate~~ the information gathered in the previous tasks to evaluate ~~the~~ potential project effects ~~of operation of the Oroville Facilities~~ on ~~Feather River non-salmonid~~resident fish and their habitat.

~~The tasks are~~The sudy plan is organized into the following five tasks:

(1) Document the d~~D~~istribution of resident fish species in the Feather River downstream of the Fish Barrier Dam to the Yuba River confluence, ~~and i~~ its tributary waters, and the ponds, sloughs and wetlands of the Oroville Wildlife Area;

(2) Review ~~of~~ life history and habitat requirements of resident fish species known to occur in the Feather River downstream of the Fish Barrier Dam to the Yuba River confluence, its tributary waters, and the ponds, sloughs and wetlands of the Oroville Wildlife Area; ~~Feather River non-salmonid fish;~~

(3) Evaluate resident fish ~~H~~habitat ~~evaluation~~ conditions of the ~~of~~ ponds, sloughs, and wetlands of the Oroville Wildlife Area and ~~other~~ Feather River tributaries;

(4) Evaluate resident fish habitat conditions of the Feather River ~~habitat evaluation~~ from the Fish Barrier Dam to the Yuba River confluence; and

(5) Assess~~ment~~ ~~of~~ potential project ~~likely~~ effects ~~of the Oroville Facilities~~ on ~~the quantity and quality of non-salmonid~~resident fish and their ~~fish~~ habitat ~~in the Feather River downstream of the Fish Barrier Dam~~.

In order to achieve the final objective of assessing potential project effects on resident fish and their habitat, information from many sources must be integrated and summarized. Literature review may include, but is not limited to, the following existing sources:

~~Feather River Below Oroville Dam~~

- DWR-ESO records or operation (December - June) of rotary screw traps, fyke traps, and seining -Abundance and emigration timing of juvenile salmon and steelhead since 1996. ~~Data comes from DWR-ESO operation of rotary screw traps, fyke traps, and seining. Traps typically operated from December through June.~~
- DFG surveys conducted (using various methods) every Fall since 1954 -Annual population estimates for fall and spring run salmon returning to spawn.~~.~~ ~~Surveys conducted by DFG (using various methods) every Fall since 1954.~~
- DWR-ESO study begun in Spring of 1999 -Distribution and habitat use of juvenile salmon and steelhead which~~. DWR-ESO study began in Spring of 1999~~, utilizes snorkeling observations~~. Surveys are conducted from~~ (March - August) on the Feather River between the Fish Barrier Dam and Gridley Bridge.~~.~~

~~Survival and contribution rate of "wild" and hatchery produced salmon:~~

- DWR-ESO and DFG records of have been implanting coded wire tags in juvenile hatchery salmon since 1975. DWR-ESO began tagging "wild" juvenile salmon in 1998. The tags are recovered through ocean and inland harvest recovery programs coordinated by DFG and new analysis of tag recoveries underway through contract with SFSU Romberg Tiburon Center and USFWS.
    - Tags are recovered through ocean and inland harvest recovery programs coordinated by DFG
    - New analysis of tag recoveries underway through contract with SFSU Romberg Tiburon Center and USFWS
    - Habitat surveys, habitat maps and gravel surveys:
- DWR-ESO steelhead and salmon habitat use studies in 1999 and 2000 -Depth, current velocity, substrate, in-stream cover, over-head cover are recorded. as part of DWR-ESO steelhead and salmon habitat use studies in 1999 and 2000
- DWR-ESO mapping studies in 1999, and with 1992 IFIM studies - Riffles, pools, glides and backwater habitats have been delineated on aerial photographs from the Fish Barrier Dam to the Gridley Bridge. This mapping was conducted by DWR-ESO as part of lower river fish studies in 1999, and with 1992 IFIM studies
- DWR Northern District published Feather River gravel condition reports in 1982 and 1996.
- Historic stream flows in the low flow channel and below Thermalito Afterbay outlet..

Temperature data from the low flow channel and below Thermalito Afterbay outlet:

- DWR-ESO Hourly temperatures recordingsed at 20 sites between the Thermalito Diversion Dam and Live Oak by DWR-ESO.- bBegan in 1997 but records are incomplete until 1999.
- USGS recorded temperatures records at gage downstream from Oroville Dam, 1958 to 1992; continuous temperatures since 1995 by DWR.
- OFD has recorded mean daily water temperatures recordeds at the Feather River Hatchery since initiation of hatchery operations and Robinson Riffle since July 31, 2000.
- USGS has published records of maximum and minimum daily water temperatures at the Thermalito Afterbay Outlet from October 1968 through September of 1992. Since 1992, only mean daily water temperature data is available from OFD.
- River temperature model developed by UC Davis under contract with DWR-ESO in 2000.
- DWR-ESO instream flow study from 1992. Thirty-two transects selected between the Fish Barrier Dam and Honcut Creek. Salmon, steelhead and American shad were the target species..

- UC Davis study in 1999 under contract with DWR-ESO - Laboratory study on steelhead growth and thermal biology.~~. Study conducted by UC Davis in 1999 under contract with DWR-ESO.~~
- Macro-invertebrate food base available for rearing salmon and steelhead. Study began in Fall 2000 and will continue for two years. Funded by DWR-ESO through contract with Chico State University.~~.~~
- DWR-ESO study begun in Fall 2000 regarding ~~S~~stranding and redd dewatering ~~study by DWR-ESO began in Fall 2000~~. Study will identify potential stranding areas between the Fish Barrier Dam and Honcut Creek, and attempt to quantify salmonid losses.

~~Various DFG studies, management plans and activities, such as:~~

~~o~~• DFG: An Evaluation of Fish Populations and Fisheries in the Post-Oroville Project Feather River, 1977.

~~o~~• DFG: Strategic Plan for Trout Management.

~~o~~• DFG: Feather River Hatchery Production Goals and Constraints (Operational Plans).

- Current DFG/NMFS assessment of hatchery impacts.~~.~~
- DWR/DFG water temperature criteria for the Feather River Hatchery.~~.~~
- National Marine Fisheries Service temperature criteria for the Feather River at Robinson Riffle (low flow channel) in the 2001 biological opinion.~~.~~
- Other historic literature related to fish habitat within the FERC project waters and the Feather River downstream to Yuba River.~~.~~
- Information from reports, fish surveys and creel census performed by CDFG or other agencies (e.g., Painter et al. 1977).

~~Geomorphic information listed in G1 such as:~~

- 1982 DWR Feather River Spawning Gravel Baseline Study.

~~o~~• 1967 USGS report, "Sediment Transport in the Feather River, Lake Oroville to Yuba City, California.

- NMFS Habitat Conservation Plan with CDFG on striped bass stocking program.~~.~~
- Results from the current Oroville Facilities FERC Relicensing study plans.

These sources also may be used, in part, to fulfill the objective of study plan SP-F3.1, *Evaluation of Project Effects on Resident Fish and Their Habitat Within Lake Oroville, the Thermalito Complex and Upstream Areas Within Project Boundaries*.

METHODOLOGY AND ANALYSIS

Task 1 – Document the Distribution of ~~non-salmonid~~Resident Fish Species in the Feather River Downstream of the Fish Barrier Dam *to the Yuba River Confluence, its Tributary Waters, and the Ponds, Sloughs and Wetlands of the Oroville Wildlife Area~~**and its Tributary Waters**~~*

This task consists of a general review of existing information sources previously listed as well as additional reports or studies by federal and state agencies, scientific papers, salmonid stocking and creel census reports, and other miscellaneous sources such as regional newspapers and fishing tournament logs to ~~identify~~ document species composition, distribution, and relative abundance of ~~non-salmonid~~resident fish in the ~~Feather River between the Fish Barrier Dam and the Yuba River~~study area. Although it is recognized that all fish in the study area fulfill an ecological role, this task and subsequent tasks will focus on fish species of primary management concern – namely, the coldwater and warmwater sport fish previously identified. ~~The objective of this task is to provide a complete inventory of Feather River non-salmonid fish, and details on their abundance and temporal and geographic distribution. To achieve this objective the review will rely on the following existing information:~~

~~- Information on abundance and emigration timing of non-salmonid species coming from DWR-ESO operation of rotary screw traps, fyke traps and seining started in 1996;~~

~~- Information on distribution and habitat use of non-salmonid species, from the DWR-ESO study began in Spring of 1999 that utilizes snorkeling observations;~~

~~- Information from reports, fish surveys and creel census performed by CDFG or other agencies (e.g., Painter et al. 1977); and~~

~~- Results from the current Oroville Facilities FERC Relicensing study plans.~~

Contingent on the information available, this review will include the following topics:

- Temporal and geographic distribution of ~~non-salmonid~~resident fish;
- Habitat utilization of resident fish; and

~~- Dates and sites of stocking or introduction of the species;~~

- Characterization of the relative abundance of ~~non-salmonid~~resident fish ~~as "abundant", "common" or "rare";~~ including, as available, seasonal and geographic variations in relative abundance.

~~- Estimates of abundance and residence time;~~

Task 2 – Review ~~of~~ Life History and Habitat Requirements of *Resident Fish Species known to occur in the Feather River Downstream of the Fish Barrier Dam to the Yuba River Confluence, itsTributary Waters, and the Ponds, Sloughs and Wetlands of the Oroville Wildlife Area****~~Feather River~~*** ~~NON-SALMONID~~ ***~~Fish~~***

Information ~~on~~ detailing the specific life history periodicities (e.g., adult spawning, juvenile rearing, and adult and juvenile migration), ~~and~~ general habitat requirements (warmwater or coldwater, bottom or pelagic, lentic or lotic dwellers), specific habitat requirements (e.g., water depth, water velocity, substrate composition), and community interactions (predators, prey, competitors) of ~~non-salmonid~~resident fish ~~species will be~~is necessary to effectively evaluate ~~the~~ potential project effects on ~~the quantity and quality of existing~~resident fish and their habitat. Information ~~on~~ regarding the habitat requirements, ~~and~~ life history characteristics, and community interactions of the ~~non-salmonid~~ resident fish identified and catalogued in *Task 1* will be obtained from available general scientific literature, data and reports from studies conducted by federal and state agencies, and interviews with private parties in the Central Valley, particularly local sportfishing guides and recreational fishing clubs. The lifestage characteristics and habitat requirements for adult and juvenile resident salmonids will be developed under this task using, to the extent applicable, information developed in SP-F10, *Evaluation of Project Effects on Anadromous Salmonids and Their Habitat.*

Contingent on the information available, the following topics will be included in the review:

- Habitat requirements of ~~non-salmonid~~resident fish by species and life~~-cycle~~ stage (habitat types, preferred water temperatures, ~~flow levels~~water depth, water velocity, substrate, etc.);
- Adult migrations characteristics (timing, and prevalent water temperature and flow conditions);
- Spawning characteristics (habitat availability, timing, and factors affecting timing and success such as substrate conditions and water temperatures);
- Early development (factors affecting incubation and eclosion, survival during incubation);
- Juvenile rearing (water temperature, substrate characteristics, refuges, shade, cover, food availability);
- Juvenile movements (timing, prevalent flow, water temperature and other abiotic conditions, predation, stranding);
- Behavioral and/or physiological changes in stocked or introduced individuals of the species; and
- ~~non-salmonid~~Resident fish diet~~, and~~.

~~Habitat requirements of non-salmonid fish by lifecycle stage (habitat types, preferred water temperatures, flow levels).~~

The objectives of this task are to:

1. Provide species-specific life history descriptions ~~(spawning, juvenile rearing and migration times, life-span, growth, mortality)~~ and habitat requirements for ~~all Feather River non-salmonid~~resident fish~~;~~ in the Feather River downstream of the Fish Barrier Dam to the Yuba River confluence, its tributary waters, and the ponds, sloughs and wetlands of the Oroville Wildlife Area
2. Characterize the fish community (predators, prey, competitors) for all resident fish in the Feather River downstream of the Fish Barrier Dam to the Yuba River confluence, its tributary waters, and the ponds, sloughs and wetlands of the Oroville Wildlife Area; and~~of the Feather River between the Fish Barrier Dam and the Yuba River; and~~
3. Classify resident fish species and/or their life stages in guilds according to their habitat requirements (warmwater or coldwater, bottom or pelagic, lentic or lotic dwellers).

Task 3 – Evaluate Resident Fish Habitat Conditions ~~Habitat Evaluation~~ of the Ponds, Sloughs, and Wetlands of the Oroville Wildlife Area and ~~Other~~ Feather River Tributaries

This task ~~consists of~~involves the ~~a~~ review and summarization of habitat information of the ponds, sloughs, and wetlands of the Oroville Wildlife Area and Feather River tributaries~~on water bodies that are tributary to the Feather River between the Fish Barrier Dam and the Yuba River~~. It includes streams and creeks within the FERC boundary or under the potential effect of Oroville flow releases or spills, and the Oroville Wildlife Area (OWA). The review will use available cartographic information (e.g., aerial photographs and topographic maps) and information obtained from SP-G2, *Effects of Project Operations on Geomorphic Processes Downstream of Oroville Dam.* The inventory of potential and available habitat for adult and juvenile resident fish in the Feather River downstream of the Fish Barrier Dam will be developed under this task. As specified in SP-G2, downstream reaches within the sphere of influence of the project will be classified using the Rosgen stream classification system. The reaches will be classified using Rosgen's Level I stream typing, then further classified using the Level II classification based on channel substrate and form. Geomorphic parameters will be assessed including cross-section monitoring, hydraulic radius, roughness, large woody debris, gravel bars, islands, and others. Pools, riffles, and runs will be mapped. Representative areas at the riffles will be analyzed using bulk gravel sampling and surface sampling techniques to determine the surface and substrate quality of trout spawning gravel. Gradation curves for each riffle will be prepared. Water quality parameters such as dissolved oxygen, conductivity, pH, and turbidity will be obtained from existing reports, and from SP-W1, *Project Effects on Designated Beneficial Uses,* and SP-W3, *Project and Recreational Operations and Facilities Effects to Water Quality*. Water temperature information will be obtained from existing surveys and from SP-W6, *Project Effects on Temperature Regime*. Micro and macro-cover characteristics such as substrate, woody debris, and aquatic vegetation will be generally described using

existing information and information from SP-T7, *Project Effects on Noxious and Aquatic Plant Species,* and SP-G2, *Effects of Project Operations on Geomorphic Processes Downstream of Oroville Dam*. ~~The OWA contains over 75 warmwater ponds and sloughs, along with vast complexes of emergent marsh and flooded cottonwood, willow, and sycamore trees. It provides habitat for largemouth bass, channel catfish, white catfish, bluegill, green sunfish, carp, and black and white crappie. The OWA also includes the Thermalito Afterbay Outlet, the most popular spot for steelhead and salmon fishing in Butte County.~~

~~The following activities will be included:~~

- ~~Identification and mapping of the streams, creeks and other water bodies tributary to the Feather River between the Fish Barrier Dam and the Yuba River (using 7.5 minute quadrangle U.S. Geological Survey (USGS) topographic maps);~~
- ~~Review of available historic and recent aerial photographs and topographic maps of the streams, creeks and other water bodies tributary to Feather River between the Fish Barrier Dam and the Yuba River to identify potential spawning grounds and juvenile rearing habitat (i.e., backwaters, side channels, riffles, pools); and~~
- ~~Review of existing temperature, flow, water quality, sediment and riparian vegetation information for the streams, creeks and other water bodies that are tributaries to the Feather River between the Fish Barrier Dam and the Yuba River.~~

Task 4 – Evaluate Resident Fish ~~Feather River~~ Habitat ~~Evaluation~~ Conditions of the Feather River from the Fish Barrier Dam to the Yuba River Confluence

~~Oroville~~ Project operations may affect the availability and quality of resident fish habitat by affecting flows and water temperatures in the Low Flow Channel and lower Feather River. The knowledge of the changes in water levels and water temperature ~~stratification~~, as well as changes in dissolved oxygen, pH, turbidity and nutrient and mineral contents throughout the year, are important for~~to~~ evaluating~~e~~ the potential project effects on ~~the quantity and quality of~~ Feather River resident fish and their habitat. Such data will be obtained from existing reports, and additional information may be obtained from SP-W1, *Project Effects on Designated Beneficial Uses,* and SP-W3, *Project and Recreational Operations and Facilities Effects to Water Quality*.

This task will consist of a review of available data and reports on physical, hydrological, and ~~biological~~ operational characteristics of the Feather River Low Flow Channel and Lower Feather River ~~collected by DWR or other parties~~. Key parameters that can affect the quantity and quality of ichthyofauna include in water levels, water temperature, dissolved oxygen, pH, turbidity and nutrient content. Water quality parameters such as dissolved oxygen, conductivity, pH, and turbidity will be obtained from existing reports, and from SP-W1, *Project Effects on Designated Beneficial Uses,* and SP-W3, *Project and Recreational Operations and Facilities Effects to Water Quality*. Water temperature information will be obtained from existing surveys and from SP-W6, *Project Effects on*

Temperature Regime. Micro and macro-cover characteristics such as substrate, woody debris, and aquatic vegetation will be generally described using existing information and information from SP-T7, *Project Effects on Noxious and Aquatic Plant Species,* and SP-G2, *Effects of Project Operations on Geomorphic Processes Downstream of Oroville Dam*. Descriptions of non-fish aquatic resources (e.g., macroinvertebrates) will be obtained from existing information and from SP-F1, *Evaluation of Project Effects on Non-Fish Aquatic Resources (e.g., macroinvertebrates).* This task also will require integration of Engineering and Operation Group output regarding water temperature, flow rate, rate of flow rate change, and river stage fluctuation. ~~Most of the information describing geographic and topographic characteristics (e.g., main channel, mid-channel bars and islands, side channels and backwaters) will be obtained from available cartographic information (e.g., aerial photographs and topographic maps) and from information collected by the other Oroville Facilities FERC Relicensing study plans, such as descriptions of non-fish aquatic resources (e.g., macroinvertebrates and primary production).~~

Elements of this review will include:

- Morphometry~~Topography~~ of the Feather River Low Flow Channel and Lower Feather River (e.g., main channel, mid-channel bars and islands, side channels and backwaters);
- Annual cycle of the Feather River Low Flow Channel and Lower Feather River water levels, describing monthly and inter-annual variation;
- Water temperature horizontal distribution on the Feather River Low Flow Channel and Lower Feather River;
- Changes in dissolved oxygen, pH, turbidity, and nutrient and mineral contents throughout the year in the Feather River Low Flow Channel and Lower Feather River;
- ~~Catalogue~~ Description of invertebrate species present in the Feather River Low Flow Channel and Lower Feather River;
- ~~Catalogue~~ Description of the aquatic vegetation ~~at~~ in the Feather River Low Flow Channel and Lower Feather River; and

~~(Can you do this with a desktop analysis? How will it be used?).~~

Task 5 – Assess~~ment of Likely~~ Potential Project Effects ~~of the Oroville Facilities~~ on ~~the Quantity and Quality of Non-salmonid~~Resident Fish ~~and~~ and Their Habitat ~~in the Feather River Downstream of the Fish Barrier Dam~~

In this task, the information gathered in *Tasks 1* through *4* will be used to evaluate the ~~likely~~ potential project effects on ~~the quantity and quality of~~ resident fish and their habitat. This task will provide a conceptual framework of the potential project effects ~~of the operations of the Oroville Facilities~~ on the availability and quality of habitat for the various ~~Feather River~~ resident fish in the ~~Feather River below the Fish Barrier Dam~~study area. The conceptual framework will identify the main stressors (~~changes~~

~~in~~unsuitable water temperature, inadequate flow levels, deteriorating water quality, lack of availability of refuge against predators, and insufficient availability and/or quality of spawning, feeding and rearing ~~grounds~~habitat), the ~~type (negative or positive)~~affected fish species or fish guild, and ~~intensity~~ the ~~of the~~ potential project-related effects~~, and the affected fish species or fish guild~~.

In the lower Feather River, altered river flows could affect the availability of potential splittail spawning habitat by reducing the amount of inundated riparian vegetation during spawning season. In order to determine the relationship between potential splittail spawning habitat availability and flow, an index area must be designated. The index area will be a small, representative reach of the lower Feather River, and it will be chosen in consultation with USFWS. To assess flow-related impacts to potential splittail spawning habitat availability during each month of the February through May period, for each year of the period of record, the amount of riparian habitat inundated in acres (dependent variable) will be regressed against flow in cfs (independent variable). Study plans SP-T3/5, *Riparian Resources, Wetlands, and Associated Floodplains*, and SP-T4, *Biodiversity*, will furnish inventories and evaluations of riparian vegetation and conditions in the lower Feather River as well as substrate and vegetation mapping. SP-W9, *Project Effects on Natural Protective Processes*, will provide an assessment of species composition, dominant species, vegetation density, demographics, and ground cover in riparian areas of the study area. The Engineering and Operations Work Group will furnish flow-related information, including stage-discharge relationships. Required fish habitat and flow data will be obtained in *Tasks 1* through *4*. Information provided by SP-F16, *Evaluation of Project Effects on Instream Flows and Fish Habitat (PHABSIM)*, which assists in habitat characterization also provide information regarding resident fish habitat and flow.

The simple linear regression analysis detailed above will identify~~ied~~ the relationship between flow and the total acreage of inundated riparian vegetation within the index area. This relationship will be defined by the equation:

$$y = (m)(x) + b$$

Where: y = habitat = the total amount of riparian vegetation inundated within the study area (acres);
x = flow within the study area (cfs);
m = slope of the line; and
b = y intercept

The x-intercept of the linear regression line will occur at the flow rate at which zero acres of riparian habitat are inundated within the study area. Data from the above-mentioned sources will indicate how much vegetation should be inundated to provide suitable potential habitat for splittail, and the regression equation can then be used to calculate the minimum flow required to achieve the desired acreage of inundation. Additionally, this analysis can be used to determine the increase (in acres) of inundated riparian vegetation per increase in flow (in cfs) within an applicable range. Habitat suitability criteria can be adopted and applied to other resident fish of primary management concern in the lower

Feather River, and a similar approach may be used to evaluate potential project impacts on resident fish and their habitat. ~~If the information gathered in Tasks 1 through 4 is sufficient to reliably quantify some of these effects, response and explanatory variables will be identified and related through simple mathematical expressions or models to assess the statistical significance of the project-related effects. Under those circumstances, the response variables will be some expression of habitat characteristics (e.g., area of watered spawning or rearing grounds, area of inundated riparian vegetation, number of pools and creeks occupied by the resident fish species) or utilization (e.g., fish abundance), and the explanatory variables will be some measure of the stressor such as water temperatures, water level or flows. Information provided by SP-F16, *PHABSIM*, will be used to evaluate and quantify the relationship between Feather River resident fish habitat and flow.~~

6.0 RESULTS, PRODUCTS/DELIVERABLES, AND SCHEDULE

RESULTS

Results will be organized following the task headings. Each task will include a narrative of the relevant findings as well as tables, figures and maps summarizing the key points. ~~After the results of the five individuals tasks are presented,~~ T~~t~~he ~~relationships among the findings~~results of the ~~five~~ four sections will be ~~identified~~ integrated to ~~provide general answers to the main questions of the study~~evaluate potential project effects on resident fish habitat and resultant impacts on fish populations. ~~The primary issues of the study and the likely ways to link the study findings of the five individual tasks to address them are listed below.~~

- ~~Assessment of main differences between the Feather River fish assemblage and the assemblage of resident fish in Lake Oroville and the Thermalito Complex (*Tasks 1*, *2* and results from SP-F3.1 *Evaluation of Project Effects on Resident Fish and Habitat Within Lake Oroville Upstream to Project Boundaries*, and SP-F3.2 *Evaluation of Project Effects on Resident Fish Habitat within the Thermalito Complex*);~~
- ~~Identification and evaluation of the resident fish habitat in the Feather River Low Flow Channel and the Oroville Wildlife Area (*Tasks 1-4*);~~
- ~~Identification and evaluation of the resident fish habitat in the Lower Feather River and tributary streams (*Tasks 1-4*);~~
- ~~Evaluate project effects on the quantity and quality of Feather River resident fish habitat (*Tasks 1-5*);~~

The anticipated maps, graphical representation of reviewed data (e.g., charts, and graphs) and summary figures and tables include:

- Figures summarizing lifecycle periodicity for identified ~~Feather River~~study area resident fish species;
- Tables summarizing main habitat suitability characteristics for spawning, juvenile rearing and migrations of identified ~~Feather River~~study area resident fish species;
- ~~Tables or figures summarizing interspecific relationships within the Feather River fish community, delineating differences within the Lake Oroville and Thermalito Complex fish communities;~~
- Maps showing seasonal distributions of identified primary ~~Feather River~~study area resident fish species;
- Tables summarizing key topographic, hydrologic and operational characteristics of the Feather River Low Flow Channel, the Oroville Wildlife Area, Lower Feather River and tributary waters;
- Topographic maps of the ~~Feather River Low Flow Channel, the Oroville Wildlife Area, Lower Feather River and its tributary waters~~study area, showing contours of the water level during periods of minimum and maximum flow, and sites ~~of~~ potentially influenc~~e~~ing ~~on~~ resident fish;
- Topographic maps of the ~~Feather River Low Flow Channel, the Oroville Wildlife Area, Lower Feather River~~study area, showing monthly average water-temperature contours (isoclines), and sites ~~of~~ potentially influencing~~e~~ ~~on~~ resident fish;
- Species-specific summary tables showing ~~Feather River~~ resident fish habitat characteristics likely to be affected by ~~the~~ project operations ~~of the Oroville Facilities~~; and
- Figures depicting the conceptual framework developed to evaluate the potential project effects ~~of the operations of the Oroville Facilities~~ on the ~~availability and quality of~~ resident fish habitat and the fish population. ~~for the various Feather River resident fish.~~

~~(Consider adding output that gets at project effects)~~

PRODUCTS/DELIVERABLES

The study plan summary report will include:

- Executive Summary
- Table of Contents
- List of Tables
- List of Figures
- Introduction
- Narratives of relevant findings by task
- Discussion addressing most relevant questions (see above) and indicating any complications/data concerns
- Conclusions related to study plan goals and objectives

~~Recommendations ?~~
- References
- Appendices

SCHEDULE

The results of the tasks performed under the study plan will be presented in a summary report. It is anticipated that this report will be completed by December 2003.

7.0 STUDY PLAN COORDINATION

COORDINATION WITH OTHER RESOURCE AREAS/STUDIES

It is anticipated that this study will require coordination with those individuals responsible for collecting temperature, flow and project operation data, ~~and~~ performing biological surveys, and conducting hydraulic and channel morphology studies. In particular, coordination with the DWR work group currently responsible of the study plan SP-W6, ~~"~~*Project Effects on Temperature Regime*,~~"~~ will be required prior to the start of water temperature monitoring. Also, coordination with the DWR group collecting the information for the IFIM/PHABSIM model (study plan SP-F16, ~~"~~*Evaluation of Project Effects on Instream Flows and Fish Habitat (PHABSIM~~ Study Plan"~~*), is required. Contact with CDFG and USGS also are expected.

Given the nature of the tasks of this study, contacts with work groups directing and conducting other studies relevant to the Oroville Facilities FERC Relicensing Project also are expected. A preliminary list of study plans that will be related to the development of the present study includes:

SP-F2 – Effects of Project Operations on Fish Diseases

This study will provide information to SP-F2 regarding resident fish identification, lifestages, migration, movement, habitat, water quality, temperature, and temporal and geographic distribution in the ~~Feather River~~study area.

Additionally, the characterization of diseases in ~~Lake Oroville and the Feather River~~the study area will be obtained from SP-F2. Based on the availability of scientific and technical literature information, the information listed below will be considered with the aim of producing synoptic descriptions of the diseases prevalent in the region.

- Characterization of the disease agent (including lifecycle of the pathogen and stages of the disease);
- Listing of all known hosts (including non-salmonids) and classification of hosts according to degree of specificity;
- Means of transmission;

- Methods for identification and diagnosis; and
- Available methods for prevention and cure.

SP-F3.1 – Evaluation of Project Effects on Resident Fish and their Habitat Within Lake Oroville, the Thermalito Complex, and Upstream Areas Within ~~to~~ Project Boundaries

Study Plan SP-F3.1 will ~~obtain and~~ provide descriptions on resident fish life stages and interactions; fish habitats; migration, movement, and rearing; and distribution ~~of lifecycle characteristics and habitat requirements for resident fish~~in Lake Oroville, the Thermalito Complex, and upstream areas within project boundaries.~~.~~

~~*SP-F3.2 – Evaluation of Project Effects on Resident Fish Habitat Within the Thermalito Complex*~~

~~Study Plan SP-F3.2 will provide and obtain information on resident fish lifestages, distribution, and interactions; fish habitats; migration, movement, and rearing; and distribution. Information also will be provided regarding temperature, flow, and water quality (as summarized from geomorphology, terrestrial, water quality, and engineering/modeling.~~

SP-F10 – Evaluation of Project Effects ~~Project Impacts~~ on Anadromous Fish and their Habitat

Information developed in SP-F10, *Evaluation of Project Effects on Anadromous Salmonids and Their Habitat,* including lifestage characteristics and habitat requirements for adult and juvenile anadromous salmonids, may be applicable to similar characterization of adult and juvenile resident salmonids and their habitat in SP-F3.2.

SP-F16 – Evaluation of Project Effects on Instream Flows and Fish Habitat (PHABSIM) ~~Study Plan~~

Providing that enough information on Feather River resident fish habitat preference is collected and exchanged with the DWR IFIM/PHABSIM group, the IFIM/PHABSIM model will be run to evaluate and quantify the relationship between Feather River resident fish habitat and flow. Model results, expressed in terms of Weighted Usable Area (WUA), will be included in this task because changes in WUA generally represent changes in the availability of aquatic habitat, provided other factors such as water temperature and food supply are adequate.

~~*SP-F20 – Evaluation of the Project Effects on the Upstream Migration of the Adult Anadromous Salmonids in the Feather River Below Oroville Dam*~~

SP-F21 – Project Effects on Predators of Feather River Anadromous Salmonids

Information pertaining life history characteristics and habitat requirements of resident fish that prey on juvenile salmonids will be obtained from the study plan SP-F21.

SP-W1 – Project Effects on Designated Beneficial Uses

Water quality parameters such as dissolved oxygen, conductivity, pH, and turbidity will be obtained from existing reports, and from SP-W1 and SP-W3.

SP-W3 – Project and Recreational Operations and Facilities Effects to Water Quality

Water quality parameters such as dissolved oxygen, conductivity, pH, and turbidity will be obtained from existing reports, and from SP-W1 and SP-W3.

SP-W6 – Project Effects on Temperature Regime

Temperature information will be obtained from existing surveys and from SP-W6. Water temperature and flow model outputs will be required from the DWR Engineering/Ops Group. Coordination with the DWR group in charge of the Study Plan SP-W6 will be required prior to the start of water temperature monitoring.

SP-W9 - *Project Effects on Natural Protective Processes*

SP-W9 will provide an assessment of species composition, dominant species, vegetation density, demographics, and ground cover in riparian areas which will be incorporated into *Task 5* of SP-F3.2.

SP-T3/5, *Riparian Resources, Wetlands, and Associated Floodplains*,

Inventories and evaluations of riparian vegetation and conditions in the Flower Feather River as well as substrate and vegetation mapping will be provided in consort with SP-T3/5.

SP-T4 – *Biodiversity*

Inventories and evaluations of riparian vegetation and conditions in the Flower Feather River as well as substrate and vegetation mapping will be provided in consort with SP-T3/5.

SP-T7 – Project Effects on Noxious and Aquatic Plant Species

Micro and macro-cover characteristics such as substrate, woody debris, and aquatic vegetation will be generally described using existing information and from SP-T7.

SP-G2 – Effects of Project Operations on Geomorphic Processes Downstream of Oroville Dam

The inventory of potential and available habitat for adult and juvenile resident fish in the Feather River downstream of the Fish Barrier Dam will be developed under this task.

Downstream reaches within the sphere of influence of the project will be classified using the Rosgen stream classification system. The reaches will be classified using Rosgen's Level I stream typing, then further classified using the Level II classification based on channel substrate and form. Geomorphic parameters will be assessed including cross-section monitoring, hydraulic radius, roughness, large woody debris, gravel bars, islands, and others. Pools, riffles, and runs will be mapped. Representative areas at the riffles will be analyzed using bulk gravel sampling and surface sampling techniques to determine the surface and substrate quality of trout spawning gravel. Gradation curves for each riffle will be prepared. Information from SP-G2 will be utilized in Task 3 of SP-F3.2.~~Information obtained from SP-G2 will be used to describe the habitat of smaller tributaries.~~

~~SP-W? the one related to pond water level elevations~~
Engineering and Operations Workgroup Studies and Models.

Results from hydrologic and water temperature modeling completed for the project ~~The~~ will be incorporated into descriptions and evaluations of study area characteristics ~~will incorporate the results from hydrologic and water temperature modeling completed for the project~~. Anticipated specific information to be obtained would include ~~:~~daily and monthly flow fluctuations in the lower Feather River, and daily and monthly mean water temperatures in the lower Feather River.

~~- Daily and monthly flow fluctuations in the lower Feather River; and~~

~~- Daily and monthly mean water temperatures in the lower Feather River~~

Water temperature and flow model outputs will be required from the DWRO Engineering and Operations Group.

ISSUES, CONCERNS, COMMENTS TRACKING AND/OR COMPLIANCE REQUIREMENTS

Stakeholder Issue Statements Addressed by the Study Plan *Evaluation of Project Effects on Resident Fish Habitat in the Feather River Downstream of the Fish Barrier Dam*.

Issue	Description
F1	Effects of existing and future project operations (including power generation, water storage and releases, ramping rates, pump-back, water levels, and water level fluctuations) during all water year types on the behavior (e.g., migration timing, microhabitat selection, vulnerability to predators), reproduction, survival and habitat of warm- and cold-water fish and other aquatic resources (e.g., macroinvertebrates) in project waters, which include tributaries within the project boundaries (lake Oroville, Diversion Pool, Fish Barrier Pool, Forebay, Afterbay, Oroville Wildlife Area), and in project affected waters.

Issue	Description
F3	Project effects on resident fish species (e.g., trout and other salmonids and warm-water fish) habitat quantity and quality (including instream flow, sediment, woody debris, water temperature, etc) and habitat for other aquatic species.
F5	Effects of existing and proposed fisheries management plan(s) and activities on a balanced cold- and warm-water fishery (including stocking levels, hatchery management and production relative to in-river populations, habitat enhancement projects, predator and undesirable species control and preservation of future introductions (e.g., Northern pike, striped bass, etc), disease, tree stakes and tire removal, and harvest).
F6	Effects of existing and future project operations on sediment deposition, erosion, and recruitment through the system (including downstream sediment supply) and associated changes in water quality on the quantity and quality of aquatic habitats within project affected waters.
F7	Project effects on interactions, including predation and competition, among lake and tributary fish populations (e.g., land-locked chinook salmon, trout, bass, and other land-locked species) that affect species abundance, growth, reproduction and survival.
F16	Effects of existing and future project facilities and operations on the abundance of predators, their seasonal and geographic distribution, the impact of predation mortality on population dynamics of salmonids and other species, and alternatives for predator control and management (including prevention of introductions).
FE9	Use Instream Flow Incremental Methodology (IFIM) or a comparable methodology to determine stream-flow needs to ensure that trout habitat quality and quantity are not reduced within project area and/or project affected areas.
FE12	Protect and improve wild trout habitat.
FE15	Develop and maintain a balanced fishery.
FE36	Under existing conditions, does the diversity and abundance of benthic macroinvertebrates in the low-flow section and in the river downstream of Thermalito Afterbay suggest a healthy stream channel.
FE57	Provide habitat leading to viable populations of endangered species. Maintain habitat to support viable populations of all native and desired nonnative vertebrate species.
FE58	Improve and protect habitat for designated emphasis and harvest species. Identify and evaluate potential conflicts among project effects and management actions for protected and sensitive species.
FE59	Protect and improve habitat for trout.
FE66	Expand land-lock fishery to include all salmon not just chinook.
FE75	Project structures or operations that either have in the past, or continue to introduce predators, create suitable habitat for predators, harbor predators, or are conducive to the predation of salmonids.
FE83	Macroinvertebrates as an indicator of water quality.

Issue	Description
FE84	Evaluate indicators of hydrological alteration (IHA analysis).
FE86	Adequacy of current ramping rate to protect anadromous salmonids and conserve their habitats and forage. This includes providing a range of schedule of flows necessary to optimize habitat, stable flows during spawning and incubation of in gravel forms, flows necessary to ensure redd replacement in viable areas, and flows necessary for channel forming processes, riparian habitat protection and maintenance of forage communities. This also includes impacts of flood control or other project structures or operations that act to displace individuals or their forage or destabilizes, scours, or degrades habitat.
FE95	The lower Feather River provides habitat to support a variety of anadromous fish species including chinook salmon, steelhead, striped bass, American shad and sturgeon. Potential changes in license conditions could adversely impact habitat supporting these species. Habitat investigations should evaluate the existing quality and quantity of habitat and determine alternative improvements for the various life history needs of anadromous species including flow, water temperature, instream and riparian cover, substrate and spatial area.
FE96	The lower Feather River provides habitat to support a variety of resident native and resident introduced species including coldwater species such as rainbow, brook, and brown trout, and warm water species such as bass, catfish, bluegill, green sunfish, carp and others. Potential changes in license conditions could adversely impact habitat supporting these species or upset habitat conditions such that less desirable species are favored. Habitat investigations should evaluate the existing quality and quantity of habitat and determine alternative improvements for the various life history needs of these resident native and non-native species including flow, water temperature, instream and riparian cover, substrate and spatial area.
FE97	The habitat for fishes in the lower Feather River is affected by the flow releases from the project. Seasonal timing, volume, and rate of release all have an affect on fish habitat conditions. Potential changes in license conditions for flow releases could adversely affect habitat conditions for one or more fish species. Fishery investigations should examine the adequacy of flows for maintaining all life history needs for anadromous and resident species. There should be evaluation of potential for flow improvements in the low-flow section. Fishery investigations should be sufficient to determine how best to meet the combined needs of the various anadromous and resident fish species.

Source: NEPA Scoping Document 1 and CEQA Notice of Preparation, DWR 2001.

8.0 REFERENCES

A complete list of references used in the completion of the study will be part of the summary report. The references cited in the present plan are listed below.

DWR. 2000. 1999 Lake Oroville Annual Report of Fish Stocking and Fish Habitat Improve-ments, February 2000.

DWR. 2001. Initial Information Package, Relicensing of the Oroville Facilities, January 2001.

DWR and USBR. 2000. Biological Assessment: Effects of the Central Valley Project and State Water Project on Steelhead and Spring-run Chinook Salmon, November 2000.

Painter, R. E., L. H. Wixom, and S. N. Taylor. 1977. An evaluation of fish populations and fisheries in the post-Oroville project Feather River. Sacramento, California, Department of Fish and Game, Anadromous Fisheries Branch.

PCWA and USBR. 2001. PCWA American River Pump Station Project. Draft of Environmental Impact Statement/ Environmental Impact Report, August 2001.

Yoshiyama, R. M., E. R. Gerstrung, F. W. Fisher, and P. B. Moyle. 1996. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California in Sierra Nevada Ecosystem Project. Final Report to Congress, vol. III: Assessments, Commissioned Reports and Background Information. (University of California, Davis, Centers for Water and Wildland Resources, 1996.)

DWR OROVILLE FACILITIES RELICENSING PROJECT
(FERC Project No. 2100)

ENVIRONMENTAL WORK GROUP
DRAFT STUDY PLAN

SP-F4. EVALUATION OF PROJECT EFFECTS ON FISH PASSAGE UPSTREAM OF LAKE OROVILLE

1.0 INTRODUCTION

Four main tributaries flow into Lake Oroville: the West Branch Feather River, the North Fork Feather River, the Middle Fork Feather River, and the South Fork Feather River. Historically, the drainage area above the gauging station at Oroville, known as the upper Feather River ~~Watershed~~watershed, provided habitat for anadromous and resident salmonids. Salmonid habitat in the upper Feather River ~~Watershed~~watershed has been lost by the construction of dams and water diversions, and other human activities (Yoshiyama et al. 1998). However, the degree to which the limits of the distribution of salmonids in the Feather River and its main tributaries were altered by the construction of dams, reservoirs and water diversions prior to the construction of Oroville Dam (1961-68) has not been well documented.

Lake Oroville supports a two-story fishery, which means that it supports both coldwater and warmwater fish species 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. When Lake Oroville destratifies, the two fishery components mix in their habitat utilization.

~~The Lake Oroville warmwater fishery is a self-sustained fishery comprised of four species of black bass (*Micropterus punctulatus*, *M. salmoides*, *M. dolomieui* and *M. coosae*), two species of catfish (*Ictalurus punctatus* and *I. catus*), two species of sunfish (*Lepomis cyanellus* and *L. macrochirus*) and two species of crappie (*Pomoxis nigromaculatus* and *P. annularis*).~~

This study focuses on t~~T~~he Lake Oroville coldwater fishery which is a managed fishery and is currently composed of four salmonid species (referred to in this study as "resident salmonids") ~~including~~: fall-run chinook salmon (*Oncorhynchus tshawytscha*), brown trout (*Salmo trutta*), rainbow trout (*O. mykiss*) and lake trout (*Salvelinus namaycush*). Currently, ~~–~~the California Department of Fish and Game (DFG) is considering changing the salmonid program at Lake Oroville to an inland coho salmon (*Ocorynchus kisutch*) fishery. The Lake Oroville salmonids are the lake residents of primary management concern that are potentially capable of exhibiting migratory behavior. The California Department of Fish and Game (CDFG) manages the fishery with the primary objectives of producing trophy salmonids and providing a quality fishery characterized by high salmonid catch rates (DWR 2000). The coldwater fishery is

sustained by hatchery stocking because natural recruitment to the Lake Oroville coldwater fishery is low, apparently due to insufficient spawning and rearing habitat in the reservoir and accessible tributaries, and natural and artificial barriers to migration into the tributaries with sufficient spawning and rearing habitat (DWR 2001).

From 1991 through 2000, f~~F~~all-run chinook salmon ~~is~~ -were the primary coldwater fish species ~~now~~ stocked in Lake Oroville. They were ~~are~~ part of the CDFG Inland Chinook Program, where surplus fall-run chinook salmon eggs ~~are~~ were taken and raised under quarantine conditions at the Feather River Hatchery, and stocked in Lake Oroville either as fingerlings or yearlings. Brown trout were ~~are~~ the only other salmonid ~~currently~~ stocked in Lake Oroville during this period. Since the mid-1980s, rainbow and lake trout have not been stocked in the lake. However, they are still periodically ~~-~~caught in the coldwater sport fishery, prompting the hypothesis of a downstream migration from streams and lakes in the upper Feather River ~~Watershed~~watershed where they are present ~~stocked every year~~.

~~For the purpose of this study, "resident fish" are the four salmonid species that comprise the coldwater fishery of Lake Oroville (i.e., fall-run chinook salmon and brown, rainbow and lake trout). These four species are lake residents of primary management concern that are potentially capable of exhibiting migratory behavior.~~

This study plan is proposed in two phases. Phase 1, which is directly addressed by this study plan, consists of a desktop review and assessment of available information on Lake Oroville and the upper Feather River ~~Watershed~~watershed to ~~produce a desktop study of~~ evaluate how project operations may be affecting resident salmonid ~~fish~~ passage, and of the current conditions of potential salmonid habitat upstream of Lake Oroville. ~~This assessment will include characterization of habitat in a manner which is applicable to consideration for both resident and anadromous salmonids. (Note, passage of anadromous salmonids past Oroville Dam is addressed by study plan SP-F15)~~.

If the Phase 1 desktop study determines that the~~re are adverse~~ project effects ~~on~~ resident ~~fish~~ salmonid passage and that there are remaining upstream habitats potentially suitable for resident salmonid spawning and rearing, then a Phase 2 study plan will be prepared. The Phase 2 study plan will be implemented to perform field studies required to identify and assess the feasibility of protection, mitigation and/or enhancement (PM&E) measures.

2.0 OBJECTIVES

The overall objective of this study plan is to evaluate ongoing and future project effects (e.g. inundation, water level fluctuations) on the ability of Lake Oroville resident salmonids to migrate into upper Feather River watershed tributaries.

~~The Phase 1 study plan objectives are to:~~

- ~~Evaluate the quantity and quality of existing upstream habitat conditions for resident fish and anadromous salmonid (fall-run and spring-run chinook salmon and steelhead) spawning, rearing, and juvenile emigration (applying information from SP-F3.1 and SP-F10);~~
- ~~Evaluate the potential sources of mortality (e.g., predation, competition, exposure to desiccation) for resident fish and anadromous salmonids upstream of Lake Oroville;~~
- ~~Identify potential barriers, both natural and artificial, to migration of resident fish and anadromous salmonids upstream from Lake Oroville;~~
- ~~Evaluate the potential for spreading non-endemic pathogens carried by resident fish and anadromous salmonids moving to and from the upper watershed (applying information from SP-F2); and~~
- ~~Identify project operation effects (e.g., water surface level fluctuations) on the passage of resident fish and anadromous salmonids to and from habitats upstream of Lake Oroville.~~

3.0 RELATIONSHIP OF THE STUDY PLAN TO THE RELICENSING PROJECT PROCESS/NEED FOR THE STUDY

Lake Oroville can fluctuate more than 100 feet during the course of a normal year due to flow and temperature requirements in the lower Feather River, power requirements, and minimum flood control space. These water level fluctuations resulting from project operations may affect the passage of fish to and from habitat upstream of Lake Oroville.

Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the application to Federal Energy Regulatory Commission (FERC) for licensing of major hydropower projects, including discussions of the fish, wildlife and botanical resources in the project study area. The discussion needs to identify the impacts of the project on those resources, and describe any anticipated continuing impacts related to future project operations.

Although some information and data have been collected by California Department of Water Resources (DWR), most of this information is confined to Lake Oroville and spanned the last six years (e.g., DWR Lake Oroville Annual Reports of Fish Stocking and Fish Habitat Enhancements to FERC, DWR temperature data). There is still a clear need to catalogue and evaluate data and information from sources other than DWR, particularly for habitats located upstream of Lake Oroville. Some of the information needs relevant to the Oroville relicensing process and Endangered Species Act~~ESA~~ consultation information requirements that will help achieve the objectives of this study include:

- Historic and current limits to the distribution of Lake Oroville resident salmonids upstream of Lake Oroville;
- Life history characteristics of Lake Oroville resident and stocked fish related to migration;
- Habitat evaluation of the main tributaries to Lake Oroville;
- Inventory of ~~man-made~~ natural and artificial barriers (i.e., dams and water diversions) upstream of Lake Oroville and assessment of their effects on Lake Oroville salmonids; and
- Inventory of endemic and non-endemic fish diseases that can be spread by the passage of salmonids to and from Lake Oroville.

4.0 SCOPE – STUDY AREA

The proposed study area was designed to contain the water bodies within the FERC boundaries whose surface water elevation may be affected by Oroville facilities operations, and which potentially impacts resident salmonid passage to upper Feather River tributaries. The proposed study area includes Lake Oroville and its upstream tributaries. This includes areas within the fluctuation zone of Lake Oroville , and any reaches above the high water mark still within the FERC boundary. Historically, the drainage area above the gauging station at Oroville, known as the upper Feather River watershed, provided habitat for salmonid species. Part of the upper Feather River watershed is included within the FERC boundary, and the quality and quantity of fish habitat may be influenced by the operations of the Oroville Facilities.

The portion of the study area upstream of Lake Oroville will be the same as that of SP-G1, *Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam*. Specifically, the proposed study area for tributaries to Lake Oroville extends to stream channel obstructions that limit upstream migration of salmon and steelhead. The principal obstructions are generally known and may include Big Bend Dam on the North Fork of the Feather River, Miocene Dam on the West Branch Feather River, Ponderosa Diversion Dam on the South Fork of the Feather River, and Curtain Falls on the Middle Fork of the Feather River. Big Bend dam had a fish ladder, but the efficiency of the ladder is not known (Taylor 2001). Reports and newspaper articles will be review to estimate salmon and steelhead passage over this dam. Maps and agency reports will be consulted to determine the probable upstream limits of migration on streams that are tributary to Lake Oroville. Most if not all, of the information necessary to complete this task will be obtained from Study Plan SP-G1, *Effects of Project Operation on Geomorphic Process Upstream of Oroville Dam*.

~~The proposed study area extends from Lake Oroville above Oroville Damto the current upper migratory limits on the West Branch Feather River and the North, Middle and South Forks of the Feather River.~~

5.0 GENERAL APPROACH

The evaluation of ~~fish~~ resident salmonid passage upstream of Oroville Dam is proposed in two phases. Phase 1, which is directly addressed by this study plan, consists of a review ~~and assessment~~ of available information on Lake Oroville and the upper Feather River ~~Watershed~~watershed and an assessment of the project operations effect on the passage of resident salmonid to and from available fish habitat upstream of Lake Oroville.

The four tasks identified for the Phase 1 study plan are:

(1) Identification of Life-Stage Periodicity and Habitat Requirements Relevant to Passage of Resident Salmonids

(2) Identification of Lake Oroville and Upper Feather River Tributary Habitat Characteristics Relevant to Passage of Resident Salmonids

(3) Identification of Habitat Suitability Criteria for Passage of Resident Salmonids

(4) Assessment of Resident Salmonid Passage to and from Upper Feather River Tributaries

The evaluation of resident salmonid habitat in Lake Oroville and upper Feather River tributaries will be performed in Study Plan SP-F3.1, *Evaluation of Project Effects on Resident Fish and Their Habitat Within Lake Oroville, the Thermalito Complex and Upstream Areas Within Project Boundaries*. Thus, Phase 1 of this study plan will review and incorporate information reported in Study Plan SP-F3.1, as it directly relates to the objective of the study, evaluation of resident salmonid passage into upstream tributaries. In addition other study plans such as Engineering and Operations study plans and SP-G1, *Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam*, will be reviewed. This study also will review reports, scientific papers, past surveys performed in the study area and other miscellaneous documents such as photographs, maps and/or newspaper articles.

If the desktop study of Phase 1 determines that there are remaining upstream habitats potentially utilizable by resident salmonid spawning and rearing, and utilization of this habitat is limited by resident salmonid passage, Phase 2 of the plan will be implemented. Phase 2 will assess the feasibility of protection, mitigation and enhancement measures, and it will identify, design and perform all field studies required to apply these measures.

~~This study includes completion of a reconnaissance-level assessment based on available information including reports, scientific papers, past surveys performed in the study area and other miscellaneous documents such as photographs, maps and/or newspaper articles. The study will not only inventory, but also will evaluate the available information so that it can be used to assess potential effects of the project operations on the passage of resident fish to and from available fish habitat upstream of Lake Oroville.~~

~~If the desktop study of Phase 1 determines that there are remaining upstream habitats potentially utilizable by resident salmonid spawning and rearing, Phase 2 of the plan will be implemented. Phase 2 will assess the feasibility of PM&E measures, and it will identify, design and perform all field studies required to apply these measures.~~

~~The five tasks identified for the Phase 1 study plan are:~~

~~(1)Identify historic (pre-1961) and current distribution of resident and anadromous salmonids in habitats upstream of Lake Oroville;~~

~~(2)Determine life history and habitat requirements of Lake Oroville resident fish (salmonids);~~

~~(3)Evaluate resident, and potential anadromous salmonid habitat conditions within main tributaries to Lake Oroville (applying information from SP-F3.1 and SP-F10);~~

~~(4)Evaluate habitat conditions of Lake Oroville; and~~

~~(5)Review inventory of endemic and non-endemic salmonid pathogens in Lake Oroville, Feather River main tributaries, and reservoirs upstream of Lake Oroville obtained from SP-F2, *Effects of Project Operations on Fish Diseases*.~~

Methodology and Analysis

Task 1 - Identification of Life-Stage Periodicity and Habitat Requirements Relevant to Passage of Resident Salmonids

This task will describe the life-stage periodicity and habitat requirements for the resident salmonid species. This description will largely come from evaluations by other FERC Oroville Relicensing study plans, primarily SP-F3.1, *Evaluation of Project Effects on Resident Fish and Their Habitat Within Lake Oroville, the Thermalito Complex and Upstream Areas Within Project Boundaries* and SP-F10, *Project Effects on Anadromous Fish and Their Habitat*.

Relevant information obtained from the identified study plans, pertaining to resident salmonid migration to and from the upper Feather River tributaries, will include a description of and an evaluation of the life history and habitat requirements of Lake Oroville resident salmonids. This will include descriptions of the life-stage activities and potential factors affecting these activities, such as:

- Spawning migration (timing, and prevalent water temperature and flow conditions);
- Adult holding habitat (habitat availability, water temperature, holding pool or stream characteristics);
- Spawning (habitat availability, timing, and factors affecting timing and success such as substrate conditions and water temperatures);

- Early development (factors affecting incubation and eclosion, survival during incubation);
- Juvenile rearing (water temperature, substrate characteristics, refuges, shade, cover, food availability);
- Juvenile out-migration and movements (timing, prevalent flow, water temperature and other abiotic conditions, predation, stranding);
- Habitat conditions for successful stocking;
- Habitat suitability for dispersion of stocked individuals; and
- Behavioral and/or physiological changes in stocked individuals of the species.

Task 2 - Identification of Lake Oroville and Upper Feather River Tributary Habitat Characteristics Relevant to Passage of Resident Salmonids

Any successful introduction of resident salmonids from Lake Oroville to the upper tributaries of the Feather River depends on providing reliable passage for adult and juvenile fish through natural and artificial barriers that may exist within the watershed, as much as it will depend on the existence of adequate habitats for adults and juvenile fish in the upper Feather River watershed. Most of the pristine salmonid habitats in the upper Feather River tributaries that existed historically have been considerably altered by mining, farming, logging and railroad construction activities. Moreover, the construction of dams and water diversion projects potentially has resulted in further loss of those originally pristine upper watershed habitats.

This task will describe the habitat characteristics of Lake Oroville and the upper Feather River watershed for the resident salmonid species. This description will largely come from evaluations performed by other FERC Oroville Relicensing study plans, primarily SP-F3.1, *Evaluation of Project Effects on Resident Fish and Their Habitat Within Lake Oroville, the Thermalito Complex and Upstream Areas Within Project Boundaries* and SP-F10, *Project Effects on Anadromous Fish and their Habitat*.

This study plan will obtain information from SP-F3.1 pertaining to evaluation of resident salmonid habitat conditions within main tributaries to Lake Oroville. This includes identification and mapping of the streams and creeks, review of available historic and recent aerial photographs and topographic maps of the streams and creeks to identify potential salmonid spawning grounds and juvenile rearing habitat (i.e., backwaters, side channels, riffles, pools), review of existing water quality, sediment and riparian vegetation information for the upper watershed, location and assessment of spawning and juvenile rearing habitat for salmonids, and evaluation of the distribution of fish and other fauna that may constitute potential prey, predators or competitors for resident salmonids. In addition, SP-F3.1 will provide identification and mapping of the dams and water-diversions, review of available aerial photographs and topographic maps showing details of the dams and water-diversions, and review of existing information describing physical and operational characteristics of the dams and water-diversions located in the upper Feather River watershed, upstream of Lake Oroville.

Also, this study plan will obtain information from SP-F3.1 pertaining to evaluation of habitat conditions of Lake Oroville. The knowledge of the changes in Lake Oroville water levels and water temperature stratification, as well as changes in dissolved oxygen, pH, turbidity and nutrient and mineral contents throughout the year, are important to determine when the lake may act as a potential barrier to adult and juvenile target salmonids attempting passage to and from the upper Feather River watershed. Moreover, Lake Oroville has particular ichthyo- and invertebrate- faunas, with different species or species lifecycle stages competing with each other and occupying predator or prey levels at different times of the year. The characteristics of Lake Oroville aquatic fauna also may deter or benefit the passage of the target salmonids to and from the upper Feather River watershed.

In addition, other study plans such as engineering and operations study plans and SP-G1, *Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam*, will be reviewed and incorporated. For example, these study plans will provide data on water level fluctuations, flow and temperature, specifically timing of fluctuations and flows, water level elevation changes, and distribution of water temperatures within the lake and tributaries (i.e., stratification of lake, extent of stratification impact into tributaries)

For the purpose of expanding information gathered from FERC Oroville Relicensing study plans on resident salmonid life history and habitat characteristics, to focus on resident salmonid passage, this task will review additional information including reports, scientific papers, past surveys performed in the study area, stocking reports, local sportfishing guides and clubs, and other miscellaneous documents such as photographs, maps and/or newspaper articles. Currently identified existing information potentially supporting this task includes:

- DWR Lake Oroville Annual Reports of Fish Stocking and Fish Habitat Enhancements to FERC, 1994-1999.
- DWR Lake Oroville 90-Day Fishery Reports to FERC, 1995-1999.
- DWR Lake Oroville Fisheries Habitat Enhancement Plan, 1995.
- DWR Lake Oroville Fishery Management Plan Progress Report, October 1993.
- Pacific Gas and Electric Company FERC relicensing proceedings and studies of North Fork Feather River projects -– including draft Poe Project License Application. Information on North Fork Feather River habitat and fish.
- USGS stream gage data for the North, Middle, and South Forks Feather River and West Branch Feather River.
- DWR temperature data collected at Lake Oroville, the North, South, and Middle Forks Feather River.
- DWR project operations data, including surface elevations of project reservoirs and inflow/outflow data.

Task 3 - Identification of Habitat Suitability Criteria for Passage of Resident Salmonids

The purpose of this task is to develop the habitat suitability criteria for passage to and from upper Feather River tributaries of the Lake Oroville resident salmonids. This information will be obtained through literature reviews of existing information, as well as information developed in other FERC Oroville study plans, such as SP-F10, *Project Effects on Anadromous Fish and their Habitat*. This information will be reviewed for its applicability to Lake Oroville and upper Feather River tributary resident salmonids and their habitat, and as relevant incorporated in this study.

It is anticipated that passage suitability criteria will incorporate characteristics such as water depth, velocity and channel width, water temperature, sedimentation (silt deposits or deltas at tributary mouths). These habitat characteristics may potentially influence the migratory responses of resident salmonids through biological impacts such as thermal shock, physical blockage of migration, and exposure to predators. In addition, because these characteristics have the potential to change throughout the year as a result of project operations, passage suitability criteria will need to be developed for the different life-stages of the resident salmonids.

The literature review of passage habitat criteria may include Thompson (1972), CDFG, the Potter Valley Project Fishery Review Group and VTN studies. Thompson established some guidelines for minimum passage (10 percent of longest continuous usable width) and passage depth (0.8 meters (m) for chinook salmon and 0.6 m for steelhead) that could be used to evaluate passage. CDFG also has developed passage criteria based on a minimum depth of 0.8 feet, which must cover continuously 10 percent of the transect, and a total of 25 percent of the cross-sectional width (YCWA 2000). The Potter Valley Project Fishery Review Group (comprised of NMFS, CDFG, USFWS and PG&E) agreed upon a critical riffle passage "standard" of a water depth of 0.6 feet for a width of four continuous feet in the Eel River, California.

Task 4 - Assessment of Resident Salmonid Passage to and from Upper Feather River Tributaries

Task 4 will apply the habitat suitability criteria identified in Task 3 to the information on life stage periodicity and habitat requirements from Task 1 and the habitat characterization of Task 2 to evaluate the likelihood for passage of adult resident salmonids from Lake Oroville to the upper Feather River watershed tributaries and of juvenile resident salmonids from the tributaries to the lake. For instance, Task 4 will evaluate whether of the times when adult salmonids are physically ready to move upstream of Lake Oroville, the water surface elevation and water temperature of Lake Oroville, and water velocity, water temperatures, chemical characteristics (e.g., sediment buildup along or at the mouth) and physical obstructions in the Oroville tributaries permits upstream passage.

~~Descriptions of the five identified tasks and corresponding subtasks are provided below.~~

~~Task 1 – Identify Historic (pre-1961) and Current Distribution of Resident and Anadromous Salmonids in Habitats Upstream of Lake Oroville~~

~~A review of reports by federal and state agencies, scientific papers, salmonid stocking reports and other miscellaneous sources such as regional newspapers will be used to delineate the historic and current distribution of target salmonids in the study area. In turn, the contrast of the historic and current distributions will geographically focus the search for possible project-related effects on the passage of the target salmonid species. The results of this task also will set a geographic boundary for any effort to reduce project-related effects on salmonid passage upstream from Lake Oroville.~~

~~Task 2 – Determine Life History and Habitat Requirements of Lake Oroville Resident Fish (Salmonids)~~

~~Information on the specific life history and habitat requirements of Feather River salmonids will be necessary to effectively evaluate the quantity and quality of existing upstream habitat conditions and potential sources of mortality for wild and stocked salmonid spawning, rearing, and juvenile and adult migrations. Information related to habitat selection and suitability, conditions for the stocking of salmonids in reservoirs, and for the dispersion of stocked salmonids to reservoir tributaries will be compiled and collected, as available. Information on the habitat requirements of chinook salmon and other salmonids will be obtained from available general scientific literature, and data and reports from studies conducted by federal and state agencies and private parties, particularly local sportfishing guides and clubs. These efforts will be coordinated with the information to be obtained, reviewed and compiled by other fisheries studies, including, but not limited to SP-F10, *Project Effects on Anadromous Fish and their Habitat*, and SP-F3, *Evaluation of Project Effects on Resident Fish Habitat*.~~

~~The following topics will be included in the review:~~

- ~~Spawning migration (timing, and prevalent water temperature and flow conditions);~~
- ~~Adult holding habitat (habitat availability, water temperature, holding pool or stream characteristics);~~
- ~~Spawning (habitat availability, timing, and factors affecting timing and success such as substrate conditions and water temperatures);~~
- ~~Early development (factors affecting incubation and eclosion, survival during incubation);~~
- ~~Juvenile rearing (water temperature, substrate characteristics, refuges, shade, cover, food availability);~~
- ~~Juvenile out-migration and movements (timing, prevalent flow, water temperature and other abiotic conditions, predation, stranding);~~

- Habitat conditions for successful stocking;
- Habitat suitabilities for dispersion of stocked individuals; and
- Behavioral and/or physiological changes in stocked individuals of the species.

Each species-specific review will be undertaken as a separate subtask, as listed below. These efforts will address the topics identified above taking into consideration the characteristics innate to each target species.

Subtask 2.1 – Life History and Habitat Suitability Characteristics of Stocked Fall-Run Chinook Salmon
Subtask 2.2 – Life History and Habitat Suitability Characteristics of Resident Brown Trout
Subtask 2.3 – Life History and Habitat Suitability Characteristics of Resident Rainbow Trout
Subtask 2.4 – Life History and Habitat Suitability Characteristics of Resident Lake Trout

Task 3 – Evaluate Resident and Anadromous Salmonid Habitat Conditions Within Main Tributaries to Lake Oroville

Any successful introduction of stocked salmonids from Lake Oroville to the upper tributaries of the Feather River depends on providing reliable passage for adult and juvenile fish through man-made barriers that may exist within the watershed encompassing the West Branch Feather River, and the North, Middle and South Forks of the Feather River, as much as it will depend on the existence of adequate habitats for adults and juvenile fish in the upper Feather River Watershed. Most of the pristine salmonid habitats in the upper Feather River tributaries that existed historically have been considerably altered by mining, farming, logging and railroad construction activities. Moreover, the construction of dams and water diversion projects has resulted in further loss of those originally pristine upper watershed habitats.

Subtask 3.1 – Inventory of Potential and Available Habitat for Adult and Juvenile Salmonids Upstream of Lake Oroville

Much of the information necessary to accomplish this subtask will be provided by SP-F3.1, *Evaluation of Project Effects on Resident Fish Habitat within Lake Oroville and Upstream to Project Boundaries.* Specific application of this information in this subtask includes:

- Identification and mapping of the streams and creeks that constitute the watershed of the West Branch Feather River and the North, Middle and South Fork Feather Rivers (using 7.5 minute quadrangle U.S. Geological Survey (USGS) topographic maps);
- Review of available historic and recent aerial photographs and topographic maps of the streams and creeks of the watershed of the West Branch Feather River and the North, Middle and South Fork Feather Rivers to identify potential

salmonid spawning grounds and juvenile rearing habitat (i.e., backwaters, side channels, riffles, pools);

- Review of existing water quality, sediment and riparian vegetation information for the upper watershed (to be obtained in coordination with other environmental study plans);
- Review of data and reports from upper watershed surveys performed by federal and state agencies, as well as private parties, to locate or assess spawning and juvenile rearing habitat for salmonids; and
- Review of data and reports from upper watershed surveys performed by federal and state agencies, as well as private parties, to identify and evaluate the distribution of fish and other fauna that may constitute potential prey, predators or competitors for resident salmonids.

Subtask 3.2 – Inventory of Present Physical Barriers to the Passage of Adult and Juvenile Salmonids to and from Upstream Tributaries of Lake Oroville

The following activities will be included in this subtask:

- Identification and mapping of the dams and water-diversions located in the watershed of the West Branch Feather River, the North Fork Feather River, the Middle Fork Feather River and the South Fork Feather River (using 7.5 minute quad USGS hydrological maps);
- Review of available aerial photographs and topographic maps showing details of the dams and water-diversions located in the Upper Feather River Watershed, upstream of Lake Oroville; and
- Review of existing information describing physical and operational characteristics of the dams and water-diversions located in the Upper Feather River Watershed, upstream of Lake Oroville.

Task 4 – Evaluate Resident and Anadromous Salmonids Habitat Conditions of Lake Oroville

The knowledge of the changes in Lake Oroville water levels and water temperature stratification, as well as changes in dissolved oxygen, pH, turbidity and nutrient and mineral contents throughout the year, are important to determine when the lake may act as a potential barrier to adult and juvenile target salmonids attempting passage to and from the upper Feather River Watershed. Moreover, Lake Oroville has particular ichthyo- and invertebrate- faunas, with different species or species lifecycle stages competing with each other and occupying predator or prey levels at different times of the year. The characteristics of Lake Oroville aquatic fauna also may deter or benefit the passage of the target salmonids to and from the upper Feather River Watershed. Accordingly, this task has been subdivided into the two subtasks identified below.

~~The following two subtasks will rely heavily on the information developed in SP-F3.1, *Evaluation of Project Effects on Resident Fish Habitat Within Lake Oroville Upstream to Project Boundaries*. Elements of each subtask specify the information anticipated to be required for this study, SP-F4.~~

~~*Subtask 4.1 – Abiotic Characterization of Lake Oroville*~~

~~This subtask will consist of a review of data and reports on physical, hydrological and operational characteristics of Lake Oroville collected by DWR or other parties. Elements of this review will include:~~

- ~~Lake topography, in particular at the confluence with the West Branch Feather River and the North, Middle and South Fork Feather Rivers;~~
- ~~Annual cycle of Lake Oroville water levels, describing monthly and inter-annual variation;~~
- ~~Water temperature profiles throughout the year (if possible, differences between the central part of the lake and the area of confluence with the West Branch Feather River and the North, Middle and South Fork Feather Rivers will be indicated); and~~
- ~~Changes in dissolved oxygen, pH, turbidity, and nutrient and mineral contents throughout the year.~~

~~*Subtask 4.2 – Biotic Characterization of Lake Oroville*~~

~~This subtask will consist of a review of data and reports, by DWR or other parties, on the ichthyo- and invertebrate faunas of Lake Oroville. Particular attention will be paid to possible trophic relationships and competition among Lake Oroville hydrofauna components described in the scientific literature. It is expected that this review will provide at least the following results:~~

- ~~Catalogue of fish species present in Lake Oroville, detailing the timing and location (water layer) of their different lifecycle stages;~~
- ~~Catalogue of invertebrate species present in Lake Oroville, detailing the timing and location (water layer) of their lifecycle stages; and~~
- ~~Identification of most common ecological relationships among fish and invertebrate species, detailing, when possible, interannual changes.~~

~~***Task 5 – Review Inventory of Endemic and Non-endemic Salmonid Pathogens in Lake Oroville, Feather River Main Tributaries and Reservoirs Upstream of Lake Oroville Obtained from SP-F2, Effects of Project Operations on Fish Diseases***~~

~~Knowledge of the distribution of salmonid pathogens in Lake Oroville and its upper watershed is important in the assessment of present habitat conditions for the passage~~

~~of salmonids upstream of Lake Oroville. Salmonid pathogens present in the upper watershed may constitute an effective biological barrier to the passage of salmonid from Lake Oroville. Moreover, future actions to enhance salmonids passage from and to the lake, whether successful, could cause the accidental transmission to Lake Oroville of pathogens that are endemic to the upper watershed. Moreover, parasites that are prevalent in the lake, such as *Ceratomyxa shasta*, could be transmitted to waters of the upper watershed.~~

~~The catalog of all endemic and non-endemic salmonid diseases to Lake Oroville and the Upper Feather River Watershed, developed under SP-F2 through review of all available, pertinent information found in data, scientific and technical literature, and reports by DWR and other state and federal agencies will be used in this study as it relates to fish passage issues.~~

6.0 RESULTS, PRODUCTS/DELIVERABLES AND SCHEDULE

RESULTS

Results will be organized following the task ~~and subtasks~~ headings indicated above. Each task will include a narrative of the relevant findings as well as tables, figures and maps summarizing the main findings, as appropriate. After the results of the individual tasks are presented, the relationships among the findings of the sections will be connected to obtain general answers to the main questions of the study. The main issues of the study and the likely ways to link the study findings ~~of the five individual tasks to address them~~ are:

- Quantity and quality of existing upstream habitats for salmonid spawning, rearing and migration ~~(*Tasks 1 - 3*)~~;
- Project-related effects on the passage of adult and juvenile salmonids to and from upstream habitats ~~(*Tasks 1 - 4*)~~;
- Physical barriers to salmonid passage upstream of Lake Oroville ~~(*Task 1* and *Subtask 3.1*)~~; and
- ~~Potential transmission of diseases by enhancement or facilitation of passage for salmonids (*Tasks 3 - 5*); and~~
- Likely effects of facilitating or enhancing the passage of salmonids to and from the upper Feather River ~~Watershed~~watershed on the Lake Oroville ecosystem ~~(*Tasks 2*, *4* and *5*)~~.

The maps, graphical representation of reviewed data (e.g., charts, and graphs) and summary figures and tables that are anticipated ~~by individual tasks~~ are identified below:~~.~~

~~Task 1, Identify Historic (pre-1961) and Current Distribution of Resident and Anadromous Salmonids in Habitats Upstream of Lake Oroville includes:~~

- Maps showing the distribution of Feather River salmonids before 1961 and after 1968;

- ~~Maps showing the distribution of fall-run chinook salmon before 1961 and after 1968;~~
- ~~Maps showing the distribution of rainbow trout before 1961 and after 1968;~~
- ~~Maps showing the distribution of brown trout before 1961 and after 1968;~~
- ~~Maps showing the distribution of lake trout before 1961 and after 1968;~~
- ~~Maps showing the distribution of spring-run chinook salmon before 1961 and after 1968; and~~
- ~~Maps showing the distribution of steelhead before 1961 and after 1968.~~

~~Task 2, Determine Life History and Habitat Requirements of Lake Oroville Resident Fish (Salmonids) includes:~~

- Figure summarizing salmonid ~~fall-run chinook salmon~~ lifecycle periodicity for the Feather River Basin;
- ~~Figure summarizing rainbow trout lifecycle periodicity for the Feather River Basin;~~
- ~~Figure summarizing brown trout lifecycle periodicity for the Feather River Basin;~~
- ~~Figure summarizing lake trout lifecycle periodicity for the Feather River Basin;~~
- Tables summarizing habitat suitability characteristics of Feather River and Lake Oroville salmonids ~~fall-run chinook salmon~~ for spawning, juvenile rearing and adult and juvenile migrations;
- ~~Tables summarizing habitat suitability characteristics of rainbow trout for spawning, juvenile rearing and adult and juvenile migrations;~~
- ~~Tables summarizing habitat suitability characteristics of brown trout for spawning, juvenile rearing and adult and juvenile migrations;~~
- ~~Tables summarizing habitat suitability characteristics of lake trout for spawning, juvenile rearing and adult and juvenile migrations; and~~
- Tables identifying main differences between stocked and anadromous individuals of the species.

~~Task 3, Evaluate Resident and Anadromous Salmonid Habitat Conditions Within Main Tributaries to Lake Oroville, includes:~~

- Table summarizing species-specific criteria used to classify upper watershed habitats for spawning, incubation and rearing salmonids;

- Summary tables listing streams and creeks in the upper Feather River ~~Watershed~~watershed that are accessible to Lake Oroville migratory salmonids and associated habitat suitability characteristics for spawning, incubation and rearing of salmonids;
- Species-specific maps showing the distribution of remaining suitable habitats in the upper Feather River ~~Watershed~~watershed accessible to Lake Oroville migratory salmonids;
- Summary table listing the name, location, main physical and operational characteristics of dams of the upper watershed, indicating whether they constitute a barrier to the passage of salmonids; and
- Map showing the location of dams on the tributaries to Lake Oroville that block the passage of salmonids from the lake.
- Map showing the location of natural barriers on the tributaries to Lake Oroville that block passage of salmonids from the lake

~~Task 4, Evaluate Resident and Anadromous Salmonid Habitat Conditions of Lake Oroville, includes:~~

- Map showing topography of Lake Oroville upper boundaries, indicating potential sites for ~~trout~~ salmonid spawning;
- Figure showing annual cycle of Lake Oroville water levels;
- Figure showing annual evolution of Lake Oroville temperature profiles; and
- Figure or diagram showing the relationships (i.e., predation and competition) among the most common fish and invertebrates of Lake Oroville (includes coordination with SP-F21).

~~Task 5, Review Inventory of Endemic and Non-endemic Salmonid Pathogens in Lake Oroville, Feather River Main Tributaries and Reservoirs Upstream of Lake Oroville Obtained from SP-F2, Effects of Project Operations on Fish Diseases, includes:~~

- ~~Map showing current distribution of salmonid diseases endemic to Lake Oroville and the upper Feather River Watershed; and~~
- ~~Table summarizing main characteristics of diseases endemic to Lake Oroville and the upper Feather River Watershed.~~

PRODUCTS/DELIVERABLES

The results of the tasks performed under the study plan will be presented in a summary report. If, after agency review of the report, it is determined that there are project-related effects on ~~resident fish~~resident salmonid passage, and that there are remaining upstream habitats potentially utilizable for resident salmonids, a Phase 2 study plan will be developed and implemented.

Regulatory reporting requirements, as well as the report distribution procedure and list, will be indicated at least four months before the completion of the final report. By that time, agency review and approval requirements will be determined. The study plan summary report will include:

- Executive Summary
- Table of Contents
- List of Tables
- List of Figures
- Introduction
- Narratives of relevant findings by task
- Discussion addressing most relevant questions (see above), indicating any complications/data concerns
- Conclusions related to study plan goals and objectives
- ~~Recommendations~~
- References
- Appendices

SCHEDULE

It is anticipated that the Phase 1 Summary Report will be completed by ~~May~~ October 2002. A schedule for the Phase 2 study plan would be provided once a decision is made regarding the need for Phase 2 activities.

7.0 STUDY PLAN COORDINATION

COORDINATION WITH OTHER RESOURCE AREAS/STUDIES

It is anticipated that this study will require information from other resource study plans being prepared for the Oroville Facilities FERC Relicensing Project including water quality (water temperature), engineering and operations (project operations and hydrologic and water temperature modeling results), geomorphology (river channel characterization), as well as other fisheries studies.

SP-F1 –Evaluation of Project Effects on Non-Fish Aquatic Resources (e.g., macroinvertebrates)

~~Subtask 4.2 of the~~This study plan (SP-F4) will rely on information and study results generated by SP-F1.

~~*SP-F2 – Effects of Project Operations on Fish Disease*~~

~~Task 5 of this study plan (SP-F4) will rely on information and study results generated by SP-F2. It is anticipated that information will include temporal and geographical distribution of salmonid diseases in Lake Oroville and the upper Feather River~~

~~Watershed, based on a review of data and reports from state and federal agencies. In particular, on review of the records of hatcheries in the area and reports on the results of regional efforts at stocking and planting of salmonids in Lake Oroville and in reservoirs, ponds and streams of the upper Feather River Watershed. Results from the review will be organized by disease name, date and site of detection and measures of incidence and control of the outbreaks.~~

~~Additionally, the characterization of salmonid diseases in Lake Oroville and the upper Feather River Watershed will be obtained from SP-F2. Based on the availability of scientific and technical literature information, the information listed below will be considered with the aim of producing synoptic descriptions of the diseases prevalent in the region.~~

- ~~Characterization of the disease agent (including lifecycle of the pathogen and stages of the disease).~~
- ~~Listing of all known hosts (including non-salmonids) and classification of hosts according to degree of specificity.~~
- ~~Means of transmission.~~
- ~~Methods for identification and diagnosis.~~
- ~~Available methods for prevention and cure.~~

SP-F3.1 – Evaluation of Project Effects on Resident Fish and Their Habitat Within Lake Oroville, the Thermalito Complex and Upstream Areas Within Project Boundaries ~~Evaluation of Project Effects on Resident and Anadromous Salmonid Habitat within Lake Oroville and Upstream to Project Boundaries~~

Habitat information and the assessment of project-related effects provided by SP-F3.1 will be ~~used in~~ required for this study plan~~, Tasks 1 through 4~~. This includes

- Identification and mapping of the streams and creeks that constitute the watershed of the West Branch Feather River and the North, Middle and South Fork Feather Rivers (using 7.5 minute quadrangle U.S. Geological Survey (USGS) topographic maps);
- Review of available historic and recent aerial photographs and topographic maps of the streams and creeks of the watershed of the West Branch Feather River and the North, Middle and South Fork Feather Rivers to identify potential salmonid spawning grounds and juvenile rearing habitat (i.e., backwaters, side channels, riffles, pools);
- Review of existing water quality, sediment and riparian vegetation information for the upper watershed (to be obtained in coordination with other environmental study plans);
- Review of data and reports from upper watershed surveys performed by federal and state agencies, as well as private parties, to locate or assess spawning and juvenile rearing habitat for salmonids; and

- Review of data and reports from upper watershed surveys performed by federal and state agencies, as well as private parties, to identify and evaluate the distribution of fish and other fauna that may constitute potential prey, predators or competitors for resident salmonids.
- Spawning migration (timing, and prevalent water temperature and flow conditions);
- Adult holding habitat (habitat availability, water temperature, holding pool or stream characteristics);
- Spawning (habitat availability, timing, and factors affecting timing and success such as substrate conditions and water temperatures);
- Early development (factors affecting incubation and eclosion, survival during incubation);
- Juvenile rearing (water temperature, substrate characteristics, refuges, shade, cover, food availability);
- Juvenile out-migration and movements (timing, prevalent flow, water temperature and other abiotic conditions, predation, stranding);
- Habitat conditions for successful stocking;
- Habitat suitability for dispersion of stocked individuals; and
- Behavioral and/or physiological changes in stocked individuals of the species.
- Lake topography, in particular at the confluence with the West Branch Feather River and the North, Middle and South Fork Feather Rivers;
- Annual cycle of Lake Oroville water levels, describing monthly and inter-annual variation;
- Water temperature profiles throughout the year (if possible, differences between the central part of the lake and the area of confluence with the West Branch Feather River and the North, Middle and South Fork Feather Rivers will be indicated); and
- Changes in dissolved oxygen, pH, turbidity, and nutrient and mineral contents throughout the year.
- Catalogue of fish species present in Lake Oroville, detailing the timing and location (water layer) of their different lifecycle stages;
- Catalogue of invertebrate species present in Lake Oroville, detailing the timing and location (water layer) of their lifecycle stages; and
- Identification of most common ecological relationships among fish and invertebrate species, detailing, when possible, interannual changes.

SP-F10 – Project Impacts on Anadromous Fish and their Habitat

The Feather River anadromous salmonid life history and habitat requirements information compiled for the SP-F10 study plan will be used to supplement information

obtained from SP-F3.1 for ~~to be compiled under~~ Task ~~2~~ 1 of this study plan (SP-F4). In addition, habitat suitability criteria information from SP-F10 will be reviewed for its applicability to Lake Oroville and upper Feather River tributary resident salmonids and their habitat, and as relevant incorporated in this study.

SP-F21 – Project Effects on Predati~~ors~~on of Feather River Anadromous Salmonids

The description of available information regarding the extent of predation on juvenile salmonids and the physical environment of Lake Oroville and its upstream tributaries associated with predation will be considered in the completion of this study plan. Specific considerations include those related to the following topics:

- Juvenile rearing (refuges, shade, cover).
- Juvenile out-migration and movements (predation).
- Distribution of fish and other fauna that may constitute potential prey, predators or competitors for resident salmonids.

Other Environmental Work Group Study Plans

Coordination among environmental work group study plan authors has been initiated to determine appropriate links and abilities to share information, thereby minimizing duplication of efforts and reducing overall costs of study plan implementation. For example, completion of SP-F4 may include use of aerial photographs that may be produced under either geomorphology or terrestrial study plan efforts. Results from the Recreation Survey (SP-RS#) will be considered in Task ~~1~~ 2 to identify current distribution of resident salmonids in Lake Oroville and upstream tributaries.

Completion of SP-F4 tasks will utilize information from the Geomorphic Processes study plan~~s (~~ SP-G1, *Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam*~~SP-G1 and SP-G2)~~. Relevant information includes:

- Adult holding habitat (holding pool or stream characteristics).
- Spawning (factors affecting timing and success such as substrate conditions).
- Juvenile rearing (substrate characteristics).
- Review of existing water quality, sediment and riparian vegetation information for the upper watershed (to be obtained in coordination with other environmental study plans).

Engineering and Operations Work Group Study Plans

These study plans will provide data on water level fluctuations, flow and temperature, specifically timing of fluctuations and flows, water level elevation changes, and distribution of water temperatures within the lake and tributaries (i.e., stratification of lake, extent of stratification impact into tributaries) Results from hydrologic and

temperature modeling studies prepared by the Engineering and Operations Work Group will be used to address the following topics:

- Spawning migration (prevalent water temperature and flow conditions during spawning season);
- Adult holding habitat (water temperature);
- Spawning (water temperatures);
- Early development (factors affecting incubation and eclosion, survival during incubation, water temperature and flows);
- Juvenile rearing (water temperature); and
- Juvenile out-migration and movements (prevalent flow and water temperature).

ISSUES, CONCERNS, COMMENTS TRACKING AND/OR COMPLIANCE REQUIREMENTS

Issues ~~Statements~~ Addressed by the *Evaluation of Project Effects on Fish Passage Upstream of Lake Oroville* Study Plan.

Issue	~~Issue Statement~~ Description
FE10	Provide for fish passage on any drainage or stream where spawning activity occurs.
FE14	Provide for fish passage and maintain natural channel character at stream crossings within project area and/or project-affected areas.
FE21	Remove or replace fish ladder at North Fork Feather River Big Bend Dam so that coldwater fish (salmon and trout) are able to spawn in natural waters.
FE59	Protect and improve habitat for trout.
FE64	Effect of project on available upstream fishery habitat (incorporate all project facilities).
FE67	All tributaries to project waters evaluated for spawning potential including upstream of Big Bend diversions.
FE78	Quality and extent of habitat above currently impassable barriers to migration.

Issue	~~Issue Statement~~ Description
FE80	Big Bend Dam is located on the North Fork Feather near the maximum elevation of Lake Oroville. The dam has been partially breached, but appears to act as an impediment to upstream and downstream migration of fish and aquatic depending species during portions of the year. There is an interest in determining the impact of Big Bend Dam on migration of fish and aquatic dependent species from Lake Oroville to the North Fork Feather River and back.
FE85	Impact of project facilities and operations on fish passage includes structures, flows, and/or water quality conditions that impede or block passage within and from current and/or historic habitat and operations that impact passage or have the potential to enhance passage. Passage includes movement of spawning or holding adults, emigrating smolts, and juveniles searching for areas where to feed, avoid predators, or shelter.

Source: NEPA Scoping Document 1 and CEQA Notice of Preparation, DWR 2001

8.0 REFERENCES

A complete list of references used in the completion of the study will be part of the summary report. The references cited in the present study plan are listed below.

DWR 2000. 1999 Lake Oroville Annual Report of Fish Stocking and Fish Habitat Improvements, February 2000.

DWR 2001. Initial Information Package, Relicensing of the Oroville Facilities, January 2001.

DWR and USBR 2000. Biological Assessment: Effects of the Central Valley Project and State Water Project on Steelhead and Spring-run Chinook Salmon, November 2000.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California. North American Journal of Fisheries Management 18: 487-521.

DWR OROVILLE FACILITIES RELICENSING PROJECT
(FERC Project No. 2100)

ENVIRONMENTAL WORK GROUP
DRAFT STUDY PLAN

F5. PROJECT EFFECT OF FERC PROJECT FISHERIES MANAGEMENT PLANS ON A BALANCED FISHERY OF RESIDENT AND ANADROMOUS FISH AND THEIR HABITAT

1.0 INTRODUCTION

Widespread listings of anadromous salmonids under the Endangered Species Act (ESA) have caused state and federal agencies to re-evaluate fish management programs in the Sacramento River basin. Some of these management programs developed prior to recent ESA-listings may contain management principles or guidelines that conflict with the ongoing recovery efforts for depressed stocks. Evaluating the Federal Energy and Regulatory Commission's (FERC) license-related fish management plans of the Project for consistency with recent Sacramento Basin restoration initiatives is an important first step for providing balanced warm and coldwater fisheries in and below Lake Oroville.

The lower Feather River is within the area designated as critical habitat for several ESA-listed salmonids (Table 1). Recent ESA-listings, in addition to other federal and state actions, have led to a variety of fisheries management activities within the Feather River basin. This study will evaluate whether these activities associated with the FERC license will achieve a "balanced" fishery at Oroville facilities. The "balanced" management approach addresses the needs of both warm and coldwater recreational fisheries within Project waters, in particular Lake Oroville, as well as balance with salmonid fisheries below the lake.

The "two-story" fishery at Lake Oroville is unique in the Sacramento River basin. Coldwater fish (e.g., salmonids) use the deeper, cooler hypolimnion while warmwater species prefer the epilimnetic and littoral zones (California Department of Water Resources 2001). When the lake destratifies in the fall, warm and cold water fishes overlap in their habitat use (California Department of Water Resources 2001). Fish species also are found within other waters associated with the project, including the Thermolito Diversion Pool, Fish Barrier Pool, Thermalito Forebay, Thermolito Afterbay, the Oroville Wildlife Area, and the tributaries of these waters within the FERC project boundary.

The California Department of Fish and Game (CDFG) has been involved with fishery management activities in the Feather River watershed for over 100 years. In the 1960s, the CDFG narrowed its focus and initiated fishery management activities within the FERC project boundary. These activities in the basin included fisheries studies, species introductions, fish stocking programs, habitat enhancement projects, and operation of the Feather River Fish Hatchery. While habitat restoration efforts and fish stocking from the Feather River Fish Hatchery have increased natural fish production and provided increased angling opportunities in Lake Oroville, management actions such as the introduction of exotic species and disease

propagation through stocking (Study Plan-2) may have adversely affected fishery resources in project waters. Downstream of the Oroville facilities, runs of natural anadromous salmonids and other resident species are affected by water releases from the dam, diversion pools associated with the Project, and the Project's effects on water quality in the Feather River (California Department of Water Resources 2001). Potential impacts to natural fish populations below the lake also may occur from downstream passage of hatchery chinook stocked in Lake Oroville.

In 1993, the California Department of Water Resources (DWR) became involved with fisheries management activities as a result of an order from FERC. The FERC order required that DWR implement measures to benefit the coldwater and warmwater fisheries of Lake Oroville and to develop a long-term management plan with a "balanced" approach. Since that time, DWR has stocked over 1.9 million chinook salmon in Lake Oroville and expanded the Feather River Fish Hatchery for Lake Oroville stocking. Some fish tagged with reward tags have been documented downstream of the lake in the Lower Feather River, which suggests the potential for interactions between hatchery and natural salmonids (Eric See, DWR, personal communication). Additionally, the DWR has implemented many warmwater fish enhancement projects, including the planting of over 25,000 willow trees and construction of hundreds of microcover habitat structures. Fish enhancement projects, chinook stocking in Lake Oroville, and other management activities may impact natural fishes present in the study area and could affect the balance between warm and coldwater fishes in Lake Oroville and between fisheries in the lake and salmonid fisheries downstream. Recognizing that FERC-related management actions affect the balanced fishery at Oroville facilities, DWR has worked with CDFG to conduct various fisheries studies at Lake Oroville and develop current fisheries management plan. The fisheries management plan was submitted to FERC on February 15, 2000 and is currently under review.

Note: an introductory paragraph on existing FERC management plan, including sections on purpose, goals, and analysis about goal attainment will be included here. This information was not available for inclusion at this time.

2.0 OBJECTIVES

The main objective of this study is to evaluate how existing and proposed FERC-required management plans, activities, and requirements affect balanced fisheries in Lake Oroville and associated waters. This objective will be accomplished through a desktop literature review that includes analysis of fish and species interactions in Lake Oroville and associated Project waters, effects of fish habitat enhancement projects, disease transmission, fish stocking, Feather River Fish Hatchery practices, and potential interactions between FERC-related and other management plans.

3.0 RELATIONSHIP OF THE STUDY PLAN TO RELICENSING PROJECT PROCESS / NEED FOR THE STUDY

Coldwater and warmwater fishing are important facets of recreation at the Lake Oroville project. DWR has been required under the current FERC license to implement projects that benefit both fisheries at Lake Oroville, such as the development of a balanced fish management plan that includes provisions for fish stocking and fish habitat enhancement. It is anticipated that balanced

fish management plans for all FERC project waters will be required under a new license. First, understanding the activities and requirements of management plans identified for waters within the Project boundary will be necessary to develop appropriate management plans for all waters that maximize the benefits to all types of recreational fishes. In addition, several fish management activities have been proposed or carried out in the FERC project area (e.g., fish stocking) that have the potential to affect a balanced cold and warmwater fishery at the Project and downstream in the Feather River. The information collected in this proposed study will identify what fishery management plans and activities are proposed and are currently being conducted, and will evaluate how these plans affect the goal of achieving balance between warm and coldwater fisheries in Lake Oroville as well as between Lake Oroville and Lower Feather River anadromous fisheries.

4.0 SCOPE – STUDY AREA

Anadromous fish species listed under the ESA are present in the Feather River basin. These fish use habitats in the Feather River downstream of Oroville facilities for reproduction and as a migratory corridor during the reproductive phases of their life history. Salmonids and warmwater fish also may use areas upstream of the lake. Thus, tributaries and the mainstem Feather River upstream of the lake also will be included in the study area. Project-affected waters within the FERC boundary, tributaries upstream to the current migratory limit, and the Feather River downstream to the confluence with the Sacramento River will be the focus for evaluating how FERC-required management plans' affect balance of the multiple fisheries in and downstream of the Project area.

5.0 GENERAL APPROACH

The first step of this study will be a review (Task 1) of existing and proposed fish management plans and activities that may affect fisheries resources within the study area. The literature review will collect data on recreational fisheries management in the Project-affected waters and fish harvest through CDFG Fish Bulletins, administrative reports, and fishery management plans. Proposed activities related to state and federal programs such as CALFED, Central Valley Power Improvement Act (CVPIA), and ESA will be reviewed from associated proceedings. The literature review also will include information related to balanced warm and coldwater recreational fisheries, especially in California reservoirs with similar fish species. Data collection and review will be coordinated with other fisheries study plans (see section 7.0, Study Plan Coordination).

In Task 2, five categories of effects will be analyzed for their impact to fisheries in the study area. First, data gathered in Task 1 will be used to assess how proposed management activities might influence intra-specific and intra-specific competition, predation, and interactions between other species. Second, an evaluation of how habitat alteration activities (e.g., tree planting) identified in FERC management plans affect the ability to manage the system for a balanced fishery will be included. Third, fish diseases that are present in the study area will be identified and their potential effects on fish populations in the Feather River basin will be described. Fourth, stocking practices in the study area will be described and their potential effect on the maintenance of balanced fisheries in and below Lake Oroville will be analyzed. Finally, the

Feather River Fish Hatchery will be described and impacts associated with hatchery operation and practices will be evaluated on the ability to manage the Lake Oroville system for balanced fisheries in and below the lake.

A third task will assess the potential for consistency and conflict between FERC-related management plans and "outside" management plans. Examples of "outside" management plans include the Anadromous Fish and Restoration Program (AFRP) and CALFED programs.

In summary, this study plan has been divided into four desktop tasks:

(1) Complete literature review and gather data on fisheries resources and FERC-related management plans at the Project;
(2) Evaluate impacts of FERC-related management plans and actions on balanced fisheries at Oroville facilities;
(3) Assess the potential for consistency and conflict between FERC-related and "outside" management programs; and
(4) Produce draft and final reports.

Descriptions for the identified tasks are provided below.

Task 1 – Perform Literature Review and Gather Data on Fish Management Activities at Lake Oroville and Associated Project Waters.

The first phase of this study will be a literature review of existing and proposed fish management plans and activities that may affect fisheries resources within Project waters. This review would generally include:

- a summary of fisheries management strategies, techniques, and programs related to the creation and/or maintenance of balanced fisheries;
- an evaluation of the presence and extent of inter- and intra-specific competition and predation that occurs in the Project area, with an emphasis on interactions between native and introduced species;
- a survey of hatchery management plans to assess compliance with current FERC stocking guidelines;
- an assessment of existing and proposed fish habitat restoration efforts in Project waters; and
- a review of the potential effects of disease transmission in fish populations related to the Project (see fish diseases SP-2).

Specific information sources include, but are not limited to the following:

- Survival and contribution rate of natural and hatchery-produced salmon via tagging programs;
- Surveys, maps, and other references that describe habitat within Project waters;
- Historic flows and temperature data in Project waters;
- Ongoing macroinvertebrate studies that quantify the food base for rearing salmon;
- Laboratory studies on steelhead growth and thermal biology;

- Temperature and flow modeling data for Project-affected waters;
- NMFS Habitat Conservation Plan with CDFG on striped bass stocking program;
- Data presented in other Project-related study and/or management plans;
- DWR-ESO fish stranding studies; and
- DWR and CDFG fish enhancement projects.

All of this information will be compiled into a report to assist an analysis that evaluates the effects of current and proposed management activities on a balanced fishery in Project waters (Task 2).

Task 2 – Evaluate Project's Impacts on a Balanced Fishery from Literature Review

The second phase of this study will be an evaluation of proposed management activities on a balanced cold and warmwater fishery at Oroville facilities. A balanced cold and warmwater recreation fishery will be defined and a description of how this definition applies to the FERC project waters will be developed. The existing and proposed fisheries management plans, activities, and requirements in the study area that may have an effect on these recreational fisheries will be listed, and each of these will be evaluated for its effect on a balanced cold and warmwater recreational fishery in each of the Project waters. Finally, a resource assessment matrix will be constructed to highlight potential impacts of management actions on native and introduced fish species present in the project area. The matrix will include important life history information for each species of management importance and qualitatively categorize impacts from FERC-license management plans. A sample matrix is presented in Table 2.

Task 3 – Identify Conflicts and Develop Consistency with FERC-related and Other "Outside" Management Plans

This task will identify areas of potential conflict between FERC-related management plans and "outside" management plans and assess their potential for consistency. Management programs may contain conflicting stock recovery goals, hatchery practices, and stocking procedures or may differ in their priorities for fisheries management activities. This task will identify each conflict and propose a framework for resolution on each issue. This task would include, but is not limited to, "outside" management plans such as the Anadromous Fish and Restoration Program (AFRP) and the CALFED program.

Task 4 – Final Report

The objective of this task is to summarize the information gathered during the first three tasks of this study. The report will develop recommendations for minimizing potential adverse Project effects on balanced fisheries at Oroville facilities.

6.0 RESULTS, PRODUCTS / DELIVERABLES AND SCHEDULE

Results

Results of this study will be used to evaluate the effects and potential effects of existing and proposed fishery management plans on balanced warm and coldwater recreational fisheries in Project waters. This information will be used to guide the development of fishery management plans for the Project consistent with the "balanced" fishery management approach.

Report

A report will be prepared that evaluates the effects of fisheries management plans and activities on fisheries within Project waters. The report will contain a definition of a "balanced" warm and coldwater fishery, and it will describe how this definition applies to Project waters. The influence of FERC-related and "other" fisheries management plans and activities on fish populations within the Project will be analyzed. Each action or strategy will be evaluated for its effect or potential effect on a balanced cold and warmwater recreational fishery in Project waters. The report will conclude with a discussion of a suitable approach to balanced cold and warmwater fisheries management in Project waters. This approach will then be used to guide development of fish management plans in these waters.

The final report will: (a) summarize fisheries management strategies, techniques, and programs related to the creation and/or maintenance of balanced fisheries; (b) evaluate the presence and extent of inter-specific and intra-specific competition and predation that occurs in the Project area; (c) review hatchery management plans to assess compliance with current FERC stocking guidelines; (d) assess existing and proposed fish habitat restoration efforts in Project waters; (e) review of the potential effects of disease transmission in fish populations related to the Project (see fish diseases SP-2); (f) evaluate the operation and practices of Feather River fish hatchery to determine how it affects the balanced fishery within and below the lake; and (g) identify areas of potential conflict between FERC-related management plans and "outside" management plans and assess their potential for consistency.

Each of these report components will become a chapter within a larger report that evaluates the Project's effect on balanced fisheries at Oroville facilities. A draft report will be prepared and distributed for review. Comments from the review process will then be incorporated into the final report.

Schedule

The literature review will begin March 1, 2002 and continue to June 30, 2003. This will allow enough time to integrate results from other study plans into this study. The definition of a "balanced" fishery and final evaluation of effects from fishery management plans will be completed by December 31, 2003. A final report will be finished by April 1, 2004.

7.0 STUDY PLAN COORDINATION

COORDINATION WITH OTHER RESOURCE AREAS / STUDIES

A comprehensive evaluation of the potential effects of Project operations on balanced fisheries will require coordination with other relicensing studies.

Information gathered during the following studies is relevant to this fisheries management study and will be required to assess the impact of current and future management programs, actions, and requirements to fisheries resources in the basin:

SP-F1 -- Effects of Project on Non-Fish Aquatic Resources: SP-F1 will provide information associated with macroinvertebrate distribution and abundance in the Project area. The study will describe the baseline condition in the Project area and potentially examine macroinvertebrate production as a possible limiting factor for fishes.

SP-F2 – Effects of Project Operations on Fish Diseases: SP-F2 will provide information crucial to the evaluation of stocking practices and artificial production as it pertains to management of fish resources at Oroville facilities.

SP-F3 -- Evaluation of Project Effects on Resident Fish Habitat (includes F3.1, F3.2, and F3.3): SP-F3 will provide information on resident species in the Project area, which is needed to evaluate potential inter-specific competition and predation at the Project.

SP-F4 – Passage of Resident Fish Upstream of Lake Oroville: The assessment of resident fish for Lake Oroville and the upper Feather River will be used during Task 1 of this study. Characterization of resident fish populations and their habitat availability will be necessary for evaluating whether existing or improved habitat conditions would support the restoration of anadromous salmonid migration to upstream tributaries, including the West Branch Feather River, and the North, Middle, and South Forks of the Feather River.

SP-F7 -- Evaluation of Impact of Oroville Reservoir Fisheries on Tributary Fisheries: This study will identify impacts of the Project on tributary fish species outside Project waters. Results from this investigation will support the development of comprehensive plans addressing fisheries resources (Task 2).

SP-F8 -- Transfer of Energy and Nutrients by Anadromous Fish Migrations: Information on the nutrient dynamics of the Oroville Project waters has important implications for the health of fish populations in the basin. Excess nutrients can accelerate disease transmission or impact fishes indirectly through excessive primary production. Information from this study will be used in conjunction with SP-F2 to assess potential disease transmission/susceptibility of fish populations at Oroville facilities and the potential productivity of the basin.

SP-F9 – Effects of Feather River Hatchery on Naturally Spawning Salmonids: This study will describe the operations of the Feather River Hatchery and may include information on wild and hatchery stock abundance, run timing, and general hatchery practices.

SP-F10 -- Project Impacts on Anadromous Fish and Their Habitat (includes F10.A to F10.G): The Feather River anadromous salmonid life history and habitat requirements information compiled for the SP-F10 study plan will be used in Task 1 to help assess competition and predation and potential habitat restoration efforts at Oroville facilities.

SP-F13 -- Project Effects on California and Federal ESA-Related Fish Species: Information on California and Federal ESA-Listed Fish Species will be used in Task 1 and 2 of this study to supplement existing information on their status, abundance, distribution, and overall health within the Feather River basin.

SP-F15 – Evaluation of the Feasibility to Provide Safe Passage for Anadromous Salmonids Past Oroville Dam: SP-F15 will provide information regarding potential alternative methods for the passage or transport of adult and juvenile salmonids past Oroville dam. This study plan will provide a general discussion of the potential sources of higher predation risk that could be related to potential alternative methods of passage or transport for consideration in the evaluation of feasibility to providing such access to Oroville Dam. Fish passage past Oroville Dam would affect management strategies and actions in providing a balanced fishery at Project facilities.

SP-F16 – Evaluation of Project Effects on Instream Flows and Fish Habitat (PHABSIM): This study will determine and describe instream habitat characteristics, including project area hydraulics and habitat flow relationships for the study area (from the Feather River Fish Barrier Dam downstream to the Yuba River). Information on the quantity of fish habitat in the Project area will be incorporated into descriptions of existing and proposed management actions.

SP-F20 -- Evaluation of the Project Effects on the Upstream Migration of Adult Anadromous Salmonids in the Feather River Below Oroville Dam: The discussion of potential barriers to upstream migration of anadromous salmonids will be used to supplement existing information on coldwater fisheries management in Project waters.

SP-F21 -- Project Effects on Predators of Feather River Anadromous Salmonids: This study will provide information on the abundance and distribution of predator species that feed on juvenile salmonids. This information will be used to assess FERC-licensed management actions on coldwater species at the Project.

SP-F22 -- Literature Review of Life History and Potential Impacts on Striped Bass, American Shad, Green Sturgeon, and White Sturgeon: Information on these fish species will be used in Task 1 and 2 of this study to supplement existing information on their status, abundance, distribution, and overall health within the Feather River basin. These four anadromous species are an important part of the fish assemblage downstream of Lake Oroville. Further information about these species will be incorporated into management plans developed in Task 2.

8.0 REFERENCES

A complete list of references used in the completion of the study will be provided.

Table 1. List of California salmon and steelhead ESUs and their status under ESA.

Species	Run	ESU	ESA Status (Federal)
Oncorhynchus mykiss	Winter Steelhead	Central Valley Winter Steelhead ESU	Threatened
Oncorhynchus tshawytscha	Winter Run Chinook Salmon	Sacramento River Winter Run ESU	Endangered
Oncorhynchus tshawytscha	Spring Run Chinook Salmon	Central Valley Spring Run ESU	Threatened
Oncorhynchus tshawytscha	Fall Run Chinook Salmon	Central Valley Fall Run ESU	Candidate
Oncorhynchus tshawytscha	Late-Fall Run Chinook Salmon	Central Valley Fall Run ESU	Candidate

Table 2. A sample matrix that evaluates effects of FERC-related management actions on components of a balanced fishery. This matrix could be used to summarize Project impacts (Task 2) on a balanced fishery from data collected during the desktop literature review (Task 1).

	FERC-related Management Actions	
Components	**Tree and Shrub Planting for Warmwater Species in Lake Oroville**	**Stocking Chinook Salmon in Lake Oroville**
Largemouth bass (LMB)	Planting willow trees and other tree brush shelters will provide cover for LMB juveniles in areas normally affected by fluctuating water levels. The increased cover will provide protection from predation and has the potential to increase largemouth bass populations in Lake Oroville.	Maintaining the current "trophy fish" (> 5 lb.) philosophy in Lake Oroville probably will not affect populations of largemouth bass in the Project area. LMB and chinook salmon may compete for some resources, but their habitat use is largely segregated. In previous studies, stocking rates of chinook salmon did not appear to affect the quality or conditions of the LMB fishery (Beer, Lee, and Paulson 1999).
Wakasagi	Wakasagi are usually found in open-water areas in large reservoirs and tributaries. Thus, this species likely would not be directly affected by tree and shrub planting in some shoreline areas. However, since wakasagi are a key forage species for reservoir predators (e.g., black bass or chinook salmon), populations of wakasagi may decline if bass populations correspondingly increase from this management action.	Previous fisheries studies at Lake Oroville have identified wakasagi as a key forage species for salmonids (Beer, Lee, and Paulson 1999). An inverse relationship also has been found for growth to trophy size and stocking density for chinook salmon, suggesting food sources within the lake may be a limiting factor. Increasing stocking densities of chinook salmon in the lake has the potential to limit their growth in the reservoir. Conversely, decreasing stocking densities from current levels may help more chinook salmon reach trophy size.

DWR OROVILLE FACILITIES RELICENSING PROJECT
(FERC Project No. 2100)

ENVIRONMENTAL WORK GROUP
DRAFT STUDY PLAN

SP-F8. TRANSFER OF ENERGY AND NUTRIENTS BY ANADROMOUS FISH MIGRATIONS

1.0 INTRODUCTION

The construction of the Oroville Facilities (including the Fish Barrier Dam, the Thermalito Diversion Dam, and Oroville Dam) ~~Oroville and other dam~~ blocked the migrations of fall-run and spring-run chinook salmon and steelhead to their historical spawning streams in the upper basin of the Feather River. Studies in a number of streams have shown that spawning, excretion and death of upstream migrating chinook salmon and steelhead enrich the nutrient and energy supply of the fish's spawning streams, thereby enhancing their productivity (Bilby et al. 2001; Gresh et al. 2000; Cederholm et al. 1999). Feeding by terrestrial organisms on the salmon and their eggs and carcasses results in the enrichment of terrestrial habitats as well. The elimination of anadromous chinook salmon and steelhead from the upper basin ~~of the Feather River~~ removed a source of energy and nutrients, and potentially reduced the productivity of the basin's aquatic and terrestrial biological resources. ~~This study applies to that portion of the upper Feather River Basin represented by the area inundated by Lake Oroville up to other, non-project dams which restricted migration of anadromous salmonids.~~

2.0 OBJECTIVES

The main objective of this study is to assess the effect that the Oroville Project d~~D~~ams, by blocking chinook salmon and steelhead runs, has had on the energy/nutrient conditions and biological resources of the North, Middle and South f~~F~~orks and West Branch of the Feather River and their tributaries and associated terrestrial ecosystems. If significant effects are identified, the information developed by this study ~~will~~ can be used to develop protection, mitigation, and enhancement (PM&E) measures and evaluate the potential impacts of such measures.

3.0 RELATIONSHIP OF THE STUDY PLAN TO RELICENSING ~~PROJECT PROCESS~~/ ~~-~~NEED FOR ~~THE~~ STUDY

~~RELATIONSHIP OF THE STUDY PLAN TO THE RELICENSING PROJECT PROCESS~~

The potential loss of ecological productivity due to the elimination of andromous chinook salmon and steelhead runs from the Feather River ~~Basin~~ basin upstream of Oroville Dam is a potentially continuing impact of the Oroville Facilities FERC Relicensing Project on biological resources. Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in an Application for License to the FERC for a major hydropower project, including a discussion of the fish, wildlife and botanical resources in the vicinity of the project. The discussion needs to identify the impacts of the project on those resources, including a description of any anticipated continuing impact associated with continued operation of the project.

~~**NEED FOR STUDY**~~

Little is currently known about the productivity or nutrient status of the Feather River and its tributaries upstream of Lake Oroville.~~, although r~~Results of water quality sampling indicate that the North, Middle and South ~~F~~forks of the Feather River have relatively low levels of potentially limiting nutrients such as phosphates and nitrates (DWR 2001). It is not known how much nutrients and energy have been lost as a result of the elimination of the chinook salmon and steelhead runs, nor what the effect of such losses ~~have~~ has been on resident fish and wildlife populations in the upper basin. To estimate the net loss of nutrients and energy, it is necessary to estimate not only the effect of eliminating the adult upstream migrations, but also the effect of eliminating ~~the~~ smolt ~~outmigrations~~downstream migrations, which removed nutrients and energy from the basin. Nutrient and energy transfers to the upper basin from Lake Oroville resulting from spawning runs by fish currently residing in the reservoir and from consumption of fish in the reservoir by terrestrial species may partially compensate for the losses resulting from the elimination of the anadromous spawning runs. However, we know little about the level or significance of such transfers.

4.0 SCOPE - STUDY AREA

The geographic scope of this study includes the FERC project boundary waters and the tributaries upstream to the pre-project upper migratory limits for fall-run and spring-run chinook salmon and steelhead. However, the scope excludes the stream reaches and terrestrial habitat areas that are currently inundated by Lake Oroville~~.~~ because their ecosystems are very different from the reservoir ecosystem that replaced them. The scope ~~se~~ includes~~are~~ all~~the~~ stream reaches ~~areas~~ upstream of the reservoir from which the anadromous species have been eliminated by the construction of Oroville Project. It also includes ~~and the basin~~ lands upslope of these stream reaches and Lake Oroville. ~~that potentially have been affected by reductions in energy and nutrients as a result of the blockage of the salmon and steelhead runs by the Oroville Project.~~ The ~~geographic~~ scope also includes Lake Oroville because of the potential for partial compensation of lost energy and nutrients that may result~~ing~~ from ~~spawning migrations of~~ fish migrating from the reservoir and from consumption of fish in the reservoir by terrestrial species~~,~~, and because of potential impacts on water quality and fish production of the reservoir if PM&E measures are implemented to increase productivity of the upper basin streams.

5.0 GENERAL APPROACH

This study will be conducted in two phases. Phase 1 primarily will be a desktop study and will estimate the potential loss of fish biomass to the upper basin resulting from the elimination of the anadromous fish migrations. Reviewers of this study plan have suggested several approaches for estimating this lost fish biomass. One approach would use existing information such as agency reports and interviews and old newspaper articles to estimate the size of the runs that historically visited the upper basin stream reaches. This approach was rejected as too unreliable. A second approach would use recent estimates from chinook salmon and steelhead spawning escapement surveys and estimates of the proportion of the returning fish that would have spawned in the accessible stream reaches upstream of Lake Oroville. This approach was rejected because sizes of the chinook salmon and steelhead runs since the construction of the Oroville Project have been greatly influenced by Feather River Hatchery production. The hatchery is part of the Oroville Facilities and would probably not exist if Oroville Dam did not exist. The third approach would use estimates of currently available spawning habitat for chinook salmon and steelhead in the accessible stream reaches upstream of the reservoir to estimate the fish biomass. This approach will be adopted for this study because it is more straightforward and less speculative than the other approaches.

Estimates of the spawning habitat areas will be obtained by reviewing existing information including reports, scientific papers, surveys by DWR and other agencies, photographs and maps. This information will be obtained from SP-F15. Existing information also will be used to estimate the biomass of fish per unit measure of suitable spawning habitat. If the results of Phase 1 indicate that the losses of fish biomass to the upper basin are potentially large enough to significantly affect the nutrient and energy conditions in the upper basin, then Phase 2 will implemented.

Phase 2, will include desktop and field studies, ~~This study~~ It will seek to answer two basic questions: (1) What is the net change in the amount of energy and nutrients available in the Feather River b~~B~~asin upstream of Lake Oroville resulting from the elimination of chinook salmon and steelhead runs upstream of the Fish Barrier Dam and (2) What effect has the change in the energy and nutrients had on the biological resources of the basin? Different approaches will be used for answering these two questions. The first question will be addressed using a quantitative modeling approach, while the second question~~, which will require much more speculation than the first question,~~ will be addressed using a more qualitative narrative approach based on a general understanding of the basin's ecology.

Phase 1 will include the following tasks:

~~The five identified tasks include:~~

(1) Establish Pre-Project Distributions of Upstream Chinook Salmon and Steelhead Migrations;

(2) Identify Suitable Chinook Salmon and Steelhead Spawning Habitat within Stream Reaches with Pre-Project Runs Upstream of Lake Oroville;

(3) Estimate Potential Biomass of Chinook Salmon and Steelhead Using Currently Available Spawning Habitat.

Phase 2 will include the following tasks:

~~(2)~~(1) Develop Conceptual ~~Model~~ Framework for Energy and Nutrient Changes in the Basin;

~~(3)Perform Literature Review and Gather Data;~~

~~(4)Conduct Surveys to Estimate Biomass and Fate of Fish Currently Migrating from Lake Oroville to the Tributary Streams; and~~

(2) Conduct Water Quality Sampling to Assess Potential Effects of ~~Adding~~ Changing Nutrient Status~~s~~ of ~~to~~ the ~~Upper Basin~~ Affected Stream~~s~~ Reaches.

METHODOLOGY AND ANALYSIS

Phase 1

Task 1 – Establish Pre-Project Distributions of Upstream Chinook Salmon and Steelhead Migrations

To determine the geographic scope of the effect of the historical chinook salmon and steelhead runs on the energy and nutrient status of the upper basin streams, ~~we~~ the study plan will need to identify all stream channel obstructions that would have limited upstream migration of chinook salmon and steelhead prior to construction of Oroville Dam. The principal obstructions are generally known and may include Big Bend Dam and Poe Dam on the North Fork Feather River, Ponderosa Diversion Dam on the South Fork Feather River, and Curtain Falls on the Middle Fork Feather River. Big Bend Dam had a fish ladder, but the efficiency of the ladder is not known (Taylor 2001). Reports and newspaper articles will be reviewed to estimate chinook salmon and steelhead passage over this dam. Maps and agency reports will be consulted to determine the probable upstream limits of migration on all the streams that are tributary to Lake Oroville. If necessary, field surveys of obstructions also will be conducted. Only obstructions likely to have been established for a long period of time would be included in the assessment of the historical upstream migration limits. The information necessary to complete this task will be obtained from study plans SP-F3.1, *Evaluation of Project Effects on Resident Fish and Their Habitat within Lake Oroville, the Thermalito Complex*

and Upstream Areas within Project Boundaries and SP-F4, *Passage of Resident Fish Upstream of Lake Oroville.*

Task 2 – Identify Suitable Chinook Salmon and Steelhead Spawning Habitat within Stream Reaches with Pre-Project Runs Upstream of Lake Oroville

~~Besides determining the upstream limits of the salmon and steelhead migrations, estimates of the size of the runs that visited each stream or stream reach are necessary. Agency reports and old newspaper articles will be reviewed for any information about the salmon and steelhead runs in the different upper basin streams. Resource agency staff and older fishermen also will be interviewed regarding the historical migrations. Most, if not all, of the information necessary to complete this task will be obtained from Study Plans SP-F3.1, SP-F4, and SP-F10.~~
The information necessary to accomplish this subtask will be provided by SP-F3.1, SP-F4, *Passage of Resident Fish Upstream of Lake Oroville* and SP-F15, *Evaluation of the Feasibility to Provide Passage for Anadromous Salmonids Past Oroville Facility Dams*. Specific application of this information in this task includes:

- Identification and mapping of the streams and creeks that constitute the watershed of the West Branch and the North, Middle and South forks of the Feather River, using 7.5 minute quadrangle U.S. Geological Survey (USGS) topographic maps (it is anticipated that the mapping effort and resources will be developed and provided through coordination of the geomorphology study plan efforts and GIS work group);

- Review of available historic and recent aerial photographs and topographic maps of the upper basin streams to identify potential salmonid spawning grounds;

- Review of existing water quality, sediment and riparian vegetation information for the upper basin streams (to be obtained in coordination with other environmental study plans, including water quality, geomorphology, and terrestrial disciplines);

- Review of data and reports from upper basin stream surveys performed by federal and state agencies, as well as private parties, to locate or assess salmonid spawning habitat;

- Review of data and reports from upper basin stream surveys performed by federal and state agencies, as well as private parties, to identify seasonal temperature and flow conditions;

Task 3 – Estimate Potential Biomass of Chinook Salmon and Steelhead Using Available Spawning Habitat

Existing information on biomass of spawning salmon and steelhead per area or length of suitable spawning habitat will be used to convert estimates of suitable spawning habitat in the upper basin stream reaches to estimates of fish biomass. To the extent possible, biomass information from streams that have fall-run and spring-run chinook

salmon and steelhead runs and that are similar in size and other characteristics to the upper basin streams will be used. The required information will be sought from reports of resource agency surveys and independent scientific research.

Phase 2

Task 1~~2~~ – Develop Conceptual ~~Model~~ Framework for Energy and Nutrient Changes in the Basin

A conceptual ~~model~~ framework for energy and nutrient changes in the basin will be ~~developed~~ used to identify information needs, organize the information obtained and guide the analyses. The ~~model~~ framework for estimating energy and nutrient changes in the basin will include the following system inflows, outflows and processes:

- Total biomass of fish that would migrate upstream of Oroville Dam site each month, if the dam were absent (would use Phase 1 results and run timing information from SP-F10, *Project Effects on Anadromous Fish and Their Habitat*);
- Final distribution of the fish biomass in the upper Feather River and tributaries (note that most of the biomass, particularly of fall-run chinook salmon, which typically have more abbreviated migrations than spring-run chinook, would have remained in the stream channels currently inundated by the reservoir and would therefore have no effect on the current upper basin resources) (would use Phase 1 results);
- Energy densities (e.g., calories per gram of fish) and nutrient concentrations (e.g., milligrams of nitrogen or phosphorous per gram of fish) in adult salmon and steelhead tissues, eggs and metabolic products;
- Fate of energy and nutrients contained in fish biomass (amount to eggs and milt, amount excreted, amount remaining in the small percentage of adult fish that return to ocean, amount in carcasses consumed by other fish ~~(~~[including juvenile salmon and steelhead~~),~~], amount consumed by aquatic invertebrates, amount consumed by terrestrial invertebrates, amount consumed by wildlife species, amount absorbed by algae and other plants, amount flushed out of system);
- Water temperatures and flows in streams when energy and nutrients from migrating fish are most available (water temperatures drive metabolic processes that cycle energy and nutrients through the system, and flows affect retention of the energy and nutrients in the system, therefore, fish biomass arriving to the streams during summer months would likely be more completely used than biomass arriving during winter months) (would use information from SP-W1, *Project Effects on Water Quality Designated Beneficial Uses for Surface Waters* for water temperatures and SP-W8, *Project Effects on Hydrology* for flows);
- Life history cycles of aquatic and terrestrial species that would exploit energy and nutrients made available by ~~up~~migrating chinook salmon (the life cycles would influence how the salmon were utilized each month);

- Biomass of chinook salmon and steelhead smolts that would exit the upper basin streams each month were the chinook salmon and steelhead runs continuing (would use information from SP-F10, *Project Effects on Anadromous Fish and their Habitat,* for run timing);
- Energy density and nutrient concentrations of chinook salmon and steelhead smolts;
- Biomass of fish currently migrating each month from Lake Oroville into the upper basin streams (if available, would use information obtained from field studies for SP-F7, *Evaluation of Project Effects of Project Fisheries on Tributary Fisheries)*;
- Biomass of living and dead fish in Lake Oroville consumed by terrestrial species (birds and mammals); and
- Energy densities and nutrient concentrations and fate of energy and nutrients (eggs, carcasses, return to lake, consumed, etc.) of fish that currently migrate from the reservoir and of fish removed from the reservoir by terrestrial species.

~~Task 3 – Perform Literature Review and Gather Data~~

~~–Resource agency reports and other literature sources, particularly information from other study plans, will be reviewed to collect available information regarding historical sizes of fall-run and spring-run salmon and steelhead runs in the Feather River upstream of the Oroville Dam site and the timing of these runs;~~

~~–The agency reports and old newspaper articles will be reviewed to determine, as closely as possible, the size of salmon and steelhead runs that visited the different upper basin streams. Resource agency staff and older fishermen will also be interviewed regarding the historical migrations;~~

–For the most part, existing information will be used to estimate values for the parameters listed above. Anticipated information sources includes, but are not limited to, the following: ~~Results of studies of salmon and steelhead egg, juvenile and smolt survival will be used to gather data on the biomass of salmon and steelhead smolts produced per adult fish;~~

- Results of scientific studies of chinook salmon and steelhead egg, juvenile and smolt survival will be used to derive estimates of biomass of chinook salmon and steelhead smolts produced per adult fish;
- Scientific fisheries articles will be searched to obtain estimates of energy density and nutrient concentrations of chinook salmon and steelhead and to estimate the fate in the ecosystem of the energy and nutrients released from the adult salmonid population. Recent review articles in *Fisheries* magazine provide many useful references;
- Resource agency documents and fishing reports will be examined and interviews with agency staff and local fishing experts will be conducted to develop estimates of run sizes for any Lake Oroville fish species that currently migrate into tributary streams; and

- A search of the literature will be conducted to estimate the amount of feeding by terrestrial species on chinook salmon and steelhead and their eggs and carcasses that would likely have occurred prior to the elimination of the chinook salmon and steelhead runs, as well as that currently likely to occur on living and dead fish in Lake Oroville. The search will focus on reports from river basins with chinook salmon and steelhead runs and terrestrial species similar to those of the Feather River ~~B~~basin.

~~Task 4 – Conduct Surveys to Estimate Biomass and Fate of Fish Currently Migrating from Lake Oroville to the Tributary Streams~~

As necessary, ~~supplement literature and interview~~the existing information~~, as well as~~and information from other study plans~~,~~ will be supplemented with field studies. In particular, count surveys of migrating fish and fish carcasses may be required to estimate~~on~~ the biomass ~~and fate~~ of fish that currently migrate from Lake Oroville to tributary streams and observations of wildlife species may be needed to estimate feeding of terrestrial species on live and dead fish in the upper stream reaches and the lake. ~~with count surveys of migrating fish and fish carcasses.~~

Task ~~5~~ 2 – Conduct Water Quality Sampling to Assess Potential Effects of Adding Nutrients to the Upper Feather River Basin Streams

This task will assess the effects of reductions in nutrients, if any have occurred, on the upper basin stream reaches. The assessment will help to determine the environmental impacts of a loss of nutrients and how enhancement measures to increase these nutrients would affect the stream and reservoir ecosystems. For example, the results could indicate that these nutrients do not limit stream production at the times of year when the chinook salmon and steelhead runs historically affected the streams and, therefore, a reduction in the level of the nutrients with the elimination of the runs probably would have had no effect on production. Augmenting nutrients under such conditions could lead to undesirable eutrophication of the streams and reservoir.

Much of the information necessary to accomplish this task will be provided by SP-W1, *Project Effects on Water Quality Designated Beneficial Uses for Surface Waters*. Specific application of this task includes collection~~Collect~~ of water samples from Lake Oroville and the tributary streams historically visited by chinook salmon and steelhead runs, and analysis~~ze~~ of the samples for nitrogen and phosphorous levels. ~~Collection of this data will be coordinated with efforts undertaken in the Water Quality study plans. Regardless, s~~Standard EPA methods will be used to measure nitrogen and phosphorous concentrations. Results of the analyses will be used to assess potential effects of increased nutrients in the streams and the reservoir. ~~The assessments will help to determine how the loss of nutrients may have affected the upper basin streams and how enhancement measures to increase these nutrients would affect the stream and reservoir ecosystems. For example, the results could indicate that these nutrients do not limit stream production at the times of year when the salmon and steelhead runs historically affected the streams and, therefore, a reduction in the level of the nutrients~~

~~with the elimination of the runs probably would have had no effect on production. Augmenting nutrients under such conditions could lead to undesirable eutrophication of the streams and reservoir.~~

6.0 RESULTS AND PRODUCTS/DELIVERABLES

RESULTS

The results for Phase 1 will provide an assessment of the amount of anadromous fish biomass in the upper Feather River basin stream reaches that was lost as a result of construction of the Oroville Facilities. Phase 2, which will be implemented only if the results of Phase 1 indicate that the loss of biomass was potentially significant, will quantify the net changes of energy and nutrients to the streams and will assess the ecological significance of the changes. The net changes will be determined as the balance of losses resulting from the elimination of anadromous fishes and gains resulting from migrations and terrestrial consumption of fish produced in Lake Oroville.

Phase 1 Results

Results for each task will be presented in a summary report that will include a narrative as well as tables, figures and maps summarizing results. ~~of Tasks 1, 2, 4 and 5 performed for this study will be presented in summary reports. Results for Task 3, the literature review, will be used to supplement results of the other tasks.~~ The summary reports will provide the following:

- Task 1, *Pre-Project Distribution of Upstream Chinook Salmon and Steelhead Migrations*, will include a full discussion of all the sources of information, including assessments of their reliability. The principal product will be a map showing the distribution of the different chinook salmon and steelhead runs in the upper basin streams and identifying all obstructions that would have limited upstream migration. It is anticipated that most of this information will be provided ~~from~~ by studies SP-F3.1 and SP-F4.
- Task 2, *Suitable Chinook Salmon and Steelhead Spawning Habitat within Stream Reaches with Pre-Project Runs Upstream of Lake Oroville,* will include a full description of all sources of information and will provide assessments of the reliability of the information. Summary tables will describe the quantity and quality of existing habitats for anadromous salmonid spawning and the location of these habitats will be shown on maps. It is anticipated that most of this information will be provided by studies SP-F3.1, SP-F4 and SP-F15.
- Task 3, *Estimate Potential Biomass of Chinook Salmon and Steelhead Utilizing Available Spawning Habitat,* will include a full description of all sources of information and will provide assessments of the reliability of the information. Tables will list estimates of chinook salmon and steelhead biomass per area or

length of spawning habitat obtained from the literature review. Final estimates of biomass for each chinook salmon and steelhead run will be presented. A discussion of the computations used to derive these estimates will be presented, including the assumptions used in the computations and their validity.

Phase 2 Results

Assuming the Environmental Work Group decides to implement Phase 2, the results will be provided as follows in a summary report for each task:

- Task 1~~2~~, *Develop Conceptual ~~Model~~ Framework for Energy and Nutrient Changes in the Basin*, will include a full description of all sources of information and will provide assessments of the reliability of the information. Much of the information will necessarily be obtained from studies of runs of different salmon species and ecosystems with very different characteristics than those of the Feather River basin. The significance of such differences will be carefully examined and discussed. The principal product provided in the summary report for this task will be a flow chart that describes the conceptual ~~model~~framework. A discussion of the ~~model~~ framework will provide the principal ~~model~~ conclusions and will identify major weaknesses of the ~~model~~framework and~~,~~ where additional information would be most useful. If field work is required to estimate effects on the energy and nutrient status of the streams and terrestrial ecosystems resulting from spawning migrations of fish from the reservoir to the streams or from consumption of reservoir fish by terrestrial species, the report will provide a description of sampling protocols and methods and analytical procedures employed. Results of field studies will be presented in tables of raw data and derived estimates of biomass, energy and nutrients, including statistical measures of precision. The field work may not be necessary as much of the information on current biomass of spawning fish in the upper basin stream reaches may be provided by other studies (i.e., SP-F3.1 or SP-F7).
- ~~Task 4, Conduct Surveys to Estimate Biomass and Fate of Fish Currently Migrating from Lake Oroville to the Tributary Streams,~~
- Task 2~~5~~, *Conduct Water Quality Sampling to Assess Potential Effects of Adding Nutrients to the Upper Feather River Basin Streams*, will provide a description of sampling protocols and methods and analytical procedures, including detection limits. All or part of this information may be obtained from study SP-W1, *Project Effects on Water Quality Designated Beneficial Uses for Surface Waters* ~~Water Quality study plans~~. ~~Regardless, r~~Results will be provided in tabular form. Potential nutrient limitation and/or eutrophication will be discussed.

PRODUCTS/DELIVERABLES

The results of Phase 1 of this study plan will be presented in a report that synthesizes the results of the phase's three tasks. The report will present final conclusions regarding the amount of fish biomass lost as a result of the Oroville Facilities and the

potential significance of this loss. Based on the findings of Phase 1, a determination will be made by the Environmental Work Group whether it is appropriate to pursue Phase 2 of the study plan. If Phase 2 is implemented, the results will be presented in a~~A~~ comprehensive report synthesizing all of the study results and presenting final conclusions regarding the effects of eliminating the chinook salmon and steelhead runs from the upper basin stream reaches ~~will be prepared following the completion of the summary reports~~. The study results will be used to assess the need for PM&E measures. If PM&E measures are required, the results will help to guide the selection of appropriate measures and to evaluate any potential adverse impacts.

SCHEDULE

It is anticipated that the Phase 1 final report will be completed by December 2002. The Phase 2 report, if needed, will be completed by December 2003.

7.0 STUDY PLAN COORDINATION

COORDINATION WITH OTHER RESOURCE AREAS/STUDIES

This study and possible PM&E measures developed as a result of the study may require coordination with the following study plans:

SP-W1 - Project Effects on Water Quality Designated Beneficial Uses for Surface Waters

This study, which will evaluate the effects of exisiting and future water projects and facilities on all designated beneficial uses of water, will include sampling for nitrogen, phosphorous and other water quality parameters at a number of locations in stream reaches above Lake Oroville.

SP-W3 –Recreational Facilities and Operations Effects on Water Quality

Effects of existing and future project operations on the physical, chemical and biological components of water quality of the Feather River, affected tributaries, and downstream waters.

SP-F1 – Evaluation of Project Effects on Non-fish Aquatic Resources

The scope of this study is currently under development and will be incorporated when available, as appropriate.

SP-F3.1 – Evaluation of Project Effects on Resident Fish and Their Habitat within Lake Oroville, the Thermalito Complex and Upstream ~~to~~ Areas within Project Boundaries

This study plan will provide information that characterizes existing fish habitat conditions of Lake Oroville and its four primary tributaries, including the North, Middle and South Forks of the Feather River and the West Branch Feather River.

SP-F4 –Evaluation of Project Effects on Resident Fish Passage Upstream of Lake Oroville

SP-F4 will provide information on the current upstream migratory barriers in the four primary tributaries to Lake Oroville.

~~This study will include North Fork Feather River at Big Bend, tributary streams, and project affected waters.~~

~~*SP-F5 – Effects of Fishery Management Plans on a Balanced Fishery*~~

~~Those fisheries management plans identified as encompassing the anadromous fish that spawned upstream of Lake Oroville will be reviewed for direct and indirect influences. This will include information regarding management practices, recreational fisheries rules and guidelines, and commercial fisheries influences.~~

SP-F7 –Evaluation of Impact of Oroville Reservoir Fisheries on Tributary Fisheries

Project effects on interactions, including predation and competition, among lake and tributary fish populations that affect species abundance, growth, reproduction and survival. The study may include fish population sampling in the upper basin stream reaches using snorkeling and/or electroshocking and other methods.

SP-F9 – Effects of the Feather River Hatchery on Naturally Spawning Salmonids

This study will describe the Feather River Hatchery operations which may include information on wild and hatchery stocks abundance, hatchery practices, run timing, straying, and straying rates of production.

SP-F10 – Project ~~Impacts~~ Effects on Anadromous Fish and their Habitat

The Feather River anadromous salmonid life history and habitat requirements information compiled for the SP-F10 study plan will be ~~incorporated~~ referenced for this study. Graphical representations of the lifestage periodicity also will be obtained from SP-F10 for these species. This will include information on the quantity and quality of existing upstream habitat conditions and potential sources of mortality for anadromous salmonid spawning, rearing, and juvenile emigration.

SP-F15 - Evaluation of the Feasibility to Provide Passage for Anadromous Salmonids Past Oroville Facility Dams

SP-F15 will compile information from other fisheries study plans that summarizes the locations, quantity and quality of existing habitats for anadromous salmonid spawning. This information will be utilized under Phase 1, Task 2.

~~*SP-F17 – Recreation Fishery Survey of FERC Project Waters*~~

~~This study will incorporate the recreational fisheries characteristics as they relate to the state and federal listed species. This will include effort, catch rates, timing, species sought, and fishing practices that may impact the abundance of anadromous salmonids.~~

~~*SP-F20 – Evaluation of Project Effects on the Upstream Migration of Adult Anadromous Salmonids in the lower Feather River*~~

~~This study will incorporate information on upstream migration, such as attraction flow conditions, straying trends to other waterbodies, water temperatures, critical riffle passages, habitat-flow relationships, and passage barriers that may influence estimates of anadromous salmonid abundance upstream of Lake Oroville.~~

SP-F21 – Project Effects on Predation ~~ors~~ of Feather River Anadromous Salmonids

The description of available information regarding the extent of predation on juvenile salmonids will be considered in the completion of this study plan. This includes predatory species identification, distribution and abundance of predators, mortality rates, and alternatives for protection.

~~*SP-W3 – Recreational Facilities and Operations Effects on Water Quality*~~

~~Effects of existing and future project operations on the physical, chemical and biological components of water quality of the Feather River, affected tributaries, and downstream waters.~~

Terrestrial Resource Study Plans

Coordination with wildlife biology surveys also will be required to assess the amount of feeding by terrestrial species on fish in the streams and the lake.

ISSUES, CONCERNS, COMMENT~~S~~ TRACKING AND/OR COMPLIANCE REQUIREMENTS

~~To be provided in final study plan.~~

Stakeholder Issue Statements Addressed by the *Transfer of Energy and Nutrients by Anadromous Fish Migrations* Study Plan

Issue	Description
FE29	Protection of upstream resources energy balance issues – historic uses salmon-steelhead moving upstream – biomass – nutrient dispersal.
FE82	Prior to construction of Oroville Dam anadromous fish had access to the POE reach of the North Fork Feather River. These fish provided a source of energy to the river ecosystem. Construction of the dam severed that connection. There is an interest in determining the contribution of anadromous fish as an energy source for aquatic dependent species located in the North Fork Feather River and devising a strategy for replacing this loss.

Source: NEPA Scoping Document 1 and CEQA Notice of Preparation, DWR 2001.

8.0 REFERENCES

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OUTLINE

DWR OROVILLE FACILITIES RELICENSING PROJECT (FERC PROJECT NO. 2100)

ENVIRONMENTAL WORK GROUP
DRAFT STUDY PLAN

SP-F10. EVALUATION OF PROJECT EFFECTS ON ANADROMOUS SALMONIDS AND THEIR HABITAT

1.0 INTRODUCTION

Project operations have the potential to impact flow, water temperature, floodplain habitat, instream habitat, shaded riverine aquatic habitat, coarse sediment supply and other instream conditions in the lower Feather River. These potential impacts vary both seasonally and geographically, and can either act independently or in combination to affect anadromous salmonids and their habitat in the lower Feather River downstream of the Fish Barrier Dam.

Anadromous salmonids in the lower Feather River include fall-run chinook salmon, spring-run chinook salmon, and steelhead. The timing of the lifecycle of each of these races or species are different. Therefore, at any given time, project operations affect different lifestages (e.g., adult immigration, spawning and incubation, juvenile rearing, emigration) of the various anadromous salmonids and their habitat (e.g., spawning and rearing habitat). To account for seasonal and geographical differences in potential project effects and to address any such effects in a comprehensive fashion, project effects on anadromous salmonids and their habitat in the lower Feather River will be evaluated species-by-species and lifestage-by-lifestage.

2.0 OBJECTIVES

The main objective of this study is to evaluate the potential effects of project operations on fall-run chinook salmon, spring-run chinook salmon and steelhead and their habitat in the Feather River below the Fish Barrier Dam.

3.0 RELATIONSHIP OF THE STUDY PLAN TO RELICENSING PROJECT PROCESS/NEED FOR STUDY

Since construction of the Oroville Facilities, anadromous salmonids have been restricted to the lower Feather River downstream of the Fish Barrier Dam. Project effects on this area include potential impacts to flow, water temperature, floodplain habitat, instream habitat, shaded riverine

aquatic habitat, coarse sediment supply and other in-river conditions that will be evaluated for their influence on the various lifestages (e.g., adult immigration, spawning and incubation, rearing, emigration) of anadromous salmonids and their habitat (e.g. spawning and rearing habitat). Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the FERC Application License for major hydropower projects, including a discussion of the fish, wildlife and botanical resources in the vicinity of the project. The discussion needs to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operation of the project. This study plan partially fulfills these requirements, addressing project effects on anadromous salmonids and their habitat in the lower Feather River.

4.0 SCOPE - STUDY AREA

The study area for this study plan includes the Feather River from the Oroville Facilities Fish Barrier Dam to the confluence with the Sacramento River. This includes the portions of the Feather River within the Project Boundary, and that portion of the Feather River used by anadromous salmonids and potentially influenced by project operations.

5.0 GENERAL APPROACH

METHODOLOGY AND PROCEDURES

Task 1 Evaluation of project effects on the upstream migration of adult anadromous salmonids in the Feather River below the Fish Barrier Dam

Subtask 1.1 - Evaluate the timing, magnitude and frequency of attraction flows and their effects on anadromous salmonids in the lower Feather River

Subtask 1. 2 - Evaluate the timing, magnitude and frequency of attraction water temperatures in the lower Feather River

Subtask 1. 3 - Evaluate flow-related physical impediments in the Feather River below the Fish Barrier Dam

Subtask 1.4 - Evaluate project operation water temperature-related effects on anadromous pre-spawning adults

Task 2 Evaluation of project effects on the spawning, incubation and initial rearing period of anadromous salmonids in the Feather River

Subtask 2.1 - Evaluate spawning and initial rearing habitat availability and suitability for anadromous salmonids in the Feather River

Subtask 2.2 - Evaluate the timing, magnitude and frequency of water temperatures and their effects on anadromous salmonid egg and alevin survival

Subtask 2.3 - Evaluate project operation flow fluctuation-related effects on redd dewatering and fry stranding

Task 3 Evaluation of project effects on juvenile rearing of anadromous salmonids in the Feather River

Subtask 3.1 - Evaluate juvenile rearing habitat availability and suitability for anadromous salmonids in the Feather River

Subtask 3.2 - Evaluate the timing, magnitude and frequency of flows and their effects on anadromous salmonid juvenile rearing

Subtask 3.3 - Evaluate the timing, magnitude and frequency of water temperatures and their effects on anadromous salmonid juvenile rearing

Subtask 3.4 - Evaluate project operation flow fluctuation-related effects on juvenile stranding

Task 4 Evaluation of project effects on emigration of juvenile anadromous salmonids in the Feather River

Subtask 4.1 - Evaluate the timing, magnitude and frequency of flows and their effects on anadromous salmonid juvenile emigration

Subtask 4.2 - Evaluate the timing, magnitude and frequency of water temperatures and their effects on anadromous salmonid juvenile emigration

6.0 RESULTS, PRODUCTS/DELIVERABLES AND SCHEDULE

RESULTS AND PRODUCTS/DELIVERABLES

SCHEDULE

7.0 STUDY PLAN COORDINATION

COORDINATION WITH OTHER RESOURCE AGENCIES/STUDIES

ISSUES, CONCERNS, COMMENTS TRACKING AND/OR COMPLIANCE REQUIREMENTS

Issue Statements Addressed by the *Evaluation of Project Impacts on Anadromous Salmonids and Their Habitat* Study Plan.

Issue	Description
FE32	Ongoing studies in the lower Feather River include adult and juvenile steelhead snorkel surveys and a habitat inventory, beach seine surveys to determine the temporal and spatial rearing extent of juvenile steelhead and salmon, rotary screw trap sampling of Chinook salmon to monitor the timing and number of emigrants, Chinook egg survival studies, particularly in the low-flow channel, Chinook spawning escapement surveys, redd de-watering and juvenile surveys in the Lower Reach, effects of water temperatures on juvenile steelhead rearing, steelhead creel surveys to gather adult steelhead life history data, and invertebrate research;
FE34	Is additional Physical Habitat Simulations modeling (PHABSIM) necessary to determine what streamflows are necessary for spawning and rearing steelhead and fall, late-fall, and spring-run Chinook salmon in the low-flow section and in the river downstream of Thermalito Afterbay;
FE35	Is riparian vegetative cover in the low-flow section and in the river downstream of Thermalito Afterbay adequate under present flow conditions for rearing steelhead and fall, late-fall, and spring-run Chinook salmon;
FE36	Under existing conditions, does the diversity and abundance of benthic macroinvertebrates in the low-flow section and in the river downstream of Thermalito Afterbay suggest a healthy stream channel;
FE37	Under existing conditions, are there adequate amounts of suitable gravel for salmonid spawning in the low-flow section and in the river downstream of Thermalito Afterbay;
FE38	Preserve natural riparian flood control abilities. Remove only those log jams or major debris accumulations that have a high potential of causing channel damage, block fish passage, or could be transported downstream by high flows and cause loss of property;
FE41	Early on and clearly identify flow rates and temperature requirements downstream of the dam;
FE44	Increase emphasis on steelhead protection and habitat and less on salmon;
FE45	Evaluate salmon numbers;
FE46	Clearly identify species, landowners along river, flow rates and temperature requirements downstream of the dam;
FE53	Are the present project related flow ramping/fluctuation restraints adequately protecting rearing Salmonid species from being stranded in the low-flow section and in the river downstream of Thermalito Afterbay;
FE54	Are the present project related flow ramping/fluctuation restraints adequately protecting Salmonid redds and juveniles, conserving their habitat and forage, and spawning gravel from being scoured out from the low-flow section and from the river downstream of Thermalito Afterbay;
FE55	What engineering or other reasonable and prudent solutions are available that would prevent the interbreeding of fall and spring-run Chinook salmon in the low-flow section of the Father River (migration barrier and/or flow and temperature changes in low-flow section);
FE56	The Feather River's low-flow reach has historically provided spawning habitat for a cold-water fishery. How have reduced flows to this stream reach affected water temperature and gravel substrate necessary for successful salmonid reproduction?
FE69	Page 8 Bullet 8 – split into two issues
FE84	Evaluate indicators of hydrological alteration (IHA analysis);

Issue	Description
FE86	Adequacy of current ramping rate to protect anadromous salmonids and conserve their habitats and forage. This includes providing a range of schedule of flows necessary to optimize habitat, stable flows during spawning and incubation of in gravel forms, flows necessary to ensure redd replacement in viable areas, and flows necessary for channel forming processes, riparian habitat protection and maintenance of forage communities. This also includes impacts of flood control or other project structures or operations that act to displace individuals or their forage or destabilizes, scours, or degrades habitat;
FE89	Impact of project structures and operations on water quality conditions necessary to sustain anadromous salmonids and their habitats;
FE90	Adequacy of current project operating regimes and structures to optimize water quality conditions for anadromous salmonids and their habitats;
FE91	Current condition of habitat potentially impacted by project and alternatives to conserve or enhance anadromous salmonids;
FE93	Introgression occurring between fall-run and spring-run Chinook populations in the Feather River due to hatchery practices and impassable migration barriers;
FE95	The lower Feather River provides habitat to support a variety of anadromous fish species including Chinook salmon, steelhead, striped bass, American shad and sturgeon. Potential changes in license conditions could adversely impact habitat supporting these species. Habitat investigations should evaluate the existing quality and quantity of habitat and determine alternative improvements for the various life history needs of anadromous species including flow, water temperature, instream and riparian cover, substrate and spatial area;
FE97	The habitat for fishes in the lower Feather River is affected by the flow releases from the project. Seasonal timing, volume, and rate of release all have an affect on fish habitat conditions. Potential changes in license conditions for flow releases could adversely affect habitat conditions for one or more fish species. Fishery investigations should examine the adequacy of flows for maintaining all life history needs for anadromous and resident species. There should be evaluation of potential for flow improvements in the low-flow section. Fishery investigations should be sufficient to determine how best to meet the combined needs of the various anadromous and resident fish species;
FE98	Fish passage is an essential survival element for anadromous species and obstructed passage can also have serious adverse impact on resident species biodiversity and populations. Both upstream and downstream-unobstructed fish passage below the project should occur. Fishery investigations should examine the adequacy of passage for all species in the reaches of the lower Feather River downstream of the project. Evaluations should cover a sufficient range of flows and include examination of instream pits or gravel ponds;
G1	Effects of existing and future project operations on natural geomorphic processes. These include physical attributes and functions (e.g., channel morphology, channel stability, sediment transport and deposition, spawning gravel and large woody debris recruitment, habitat diversity) and subsequent effects on biological resources (e.g., aquatic macroinvertebrates, riparian vegetation) in the low-flow section and in the Feather River downstream of Thermalito Afterbay under wet and dry year criteria;
GE3	Alterations in stream hydrology affect the natural fluvial geomorphologic processes of a riverine system. How has the change in magnitude, frequency and timing of peak flows and rates of flow change on the Feather River affected riparian vegetation recruitment in the low-flow reach and immediately downstream of the Afterbay, under wet and dry year criteria;
GE4	Under existing conditions, are bankfull flows frequent enough to maintain channel morphology, sediment transport, habitat diversity and adequate gravels for salmonid spawning and rearing in the low-flow section and in the river downstream of Thermalito Afterbay;
GE5	Under existing conditions, are the moderate winter floods and bankfull flows adequately recruiting the amount of large woody debris needed to maintain adequate salmonid rearing habitat in the low-flow section and in the river downstream of Thermalito Afterbay;

Issue	Description
GE20	Indicators of hydrological alteration (IHA analysis);
GE23	Releases that reflect nature cycles benefit biological cycles – how have changes in seasonal release patterns affected fish, invertebrates, and their habitat
W10	Effects of existing and future water releases and operations on water temperatures in the Diversion Pool, Forebay, Afterbay, Oroville Wildlife Area, low-flow section of the river and downstream areas; at the hatchery; for agriculture; and the quality and availability of habitat for salmonids and other aquatic resources.
WE28	Does the increase in river water temperature that results from warmer Thermalito Afterbay releases during the spring, summer, and fall months limit the amount of suitable steelhead and salmon habitat in the river downstream of Thermalito Afterbay;
WE29	Does the increase in river water temperature that results from warmer Thermalito Afterbay releases during the spring and early summer months affect survival of salmonid species outmigrating from the Feather and Yuba River
WE54	Impact of project structures and operations on water quality conditions necessary to sustain anadromous salmonids and their habitat. Adequacy of current project operating regimes and structures to optimize water quality conditions for anadromous salmonids and their habitats.

Source: NEPA Scoping Document 1 and CEQA Notice of Preparation, DWR 2001

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DWR OROVILLE FACILITIES RELICENSING PROJECT
(FERC Project No. 2100)

ENVIRONMENTAL WORK GROUP
DRAFT STUDY PLAN

SP-F15. EVALUATION OF THE FEASIBILITY TO PROVIDE PASSAGE FOR ANADROMOUS SALMONIDS PAST OROVILLE FACILITY DAMS

1.0 INTRODUCTION

The Oroville Facilities, completed in 1968, provide for multiple project purposes including water supply, power generation, flood protection, recreation, and fish and wildlife enhancement. The Feather River Fish Barrier Dam was constructed in the early 1960s (1962 to 1964). Located upstream of the Feather River Hatchery and approximately five miles below Oroville Dam, it is identified as the first impassable salmonid migration barrier on the Feather River (Yoshiyama et al. 1996; California Department of Water Resources (DWR) and U.S.Bureau of Reclamation (USBR) 2000). Historically, the upper Feather River watershed provided habitats for anadromous and resident salmonids. Spring-run chinook salmon and steelhead were known to ascend the very highest streams and headwaters of the Feather River watershed while fall-run chinook salmon occupied the lower foothill reaches (Yoshiyama et al. 1998; California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (USBR) 2000).

The spatial distribution of spring-run chinook salmon were considerably reduced prior to the 1960s by the construction of hydropower dams and diversion projects upstream of Oroville. For instance, in 1959 CDFG found substantial overlap in the spawning distributions of fall-run and spring-run chinook salmon upstream of the Oroville Dam site (DWR and USBR 2000).

Since construction of the Oroville Facilities, most of the spawning activity of spring-run and fall-run chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) has been limited to the section of river referred to as the Low Flow Channel, located downstream of the Fish Barrier Dam (DWR 2001). A considerable amount of fall-run salmon spawning also occurs downstream of the low flow channel, between the Thermalito Outlet and Honcut Creek.

~~The Feather River Fish Barrier Dam, located immediately upstream of the Feather River Hatchery approximately five miles below Oroville Dam, is the first impassable salmonid migration barrier on the Feather River (Yoshiyama et al. 1996; DWR and USBR 2000). Construction of the Oroville Facilities (including the Fish Barrier Dam, the Thermalito Diversion Dam, and Oroville Dam) blocked the upstream migration of anadromous salmonids to historic spawning and rearing areas. Historically, the upper Feather River watershed provided habitats for anadromous and resident salmonids. However, salmonid habitats in the upper Feather River watershed have been lost by the construction of dams and water diversions, and other human activities (Yoshiyama et al. 1998). Prior to the construction of hydropower dams and diversions, spring-run chinook salmon ascended the very highest streams and headwaters of the Feather~~

~~River watershed, while fall-run chinook salmon occupied lower-foothill reaches (Yoshiyama et al. 1998; DWR and USBR 2000). Today, both runs spawn in the lower Feather River below the Fish Barrier Dam. The degree to which the construction of the Oroville Facilities affected the distribution of the spring and fall runs of chinook salmon, as opposed to the impact caused by the construction of other dams in the upper Feather River watershed, has not been clearly documented. The spatial distribution of spring-run chinook salmon might have been considerably reduced well before the construction of Oroville Dam. For instance, in 1959 CDFG found substantial overlap in the spawning distributions of fall-run and spring-run chinook salmon upstream of the Oroville Dam site (DWR and USBR 2000).~~

For the purpose of this study "anadromous salmonids" includes the three runs of Feather River salmonids that are reported to spawn below the Feather River Fish Barrier Dam (i.e., fall-run and spring-run chinook salmon, and steelhead). This study plan relies on the compilation of fish lifestage and habitat characterization information for these three target species from other FERC Relicensing Project study plans. The evaluation of the feasibility to provide passage for anadromous salmonids is proposed in three distinct phases.

2.0 OBJECTIVES

The study plan objective~~s~~ is ~~are~~ to ~~evaluate spawning habitat availability in the tributaries upstream of Oroville Dam and between the Fish Barrier Dam and Thermalito Diversion Dam and to~~ evaluate the feasibility of restoring passage for anadromous salmonids to areas upstream of the Fish Barrier Dam, including the area between the Fish Barrier Dam and Thermalito Diversion Dam and upstream of Oroville Dam to the next salmonid migration barrier~~.~~

3.0 RELATIONSHIP OF THE STUDY PLAN TO RELICENSING ~~PROJECT PROCESS~~/NEED FOR ~~THE~~ STUDY

Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the application to FERC for licensing of major hydropower projects, including discussions of the fish, wildlife and botanical resources in the project study area. The purpose of the discussion is to identify the impacts of the project on those resources, and describe any anticipated continuing impacts related to future project operations.

The study will provide an evaluation based on available information including reports, scientific papers, past surveys and other ~~miscellaneous~~ information such as photographs, maps and/or newspaper articles, to evaluate the feasibility of providing passage for adult and juvenile anadromous salmonids past the Oroville Facility~~ies~~ dams. Although data characterizing the study area has been collected by DWR, most of this information has not been included in an assessment of the feasibility to provide passage for anadromous salmonids past the Oroville Facility~~ies~~ dams ~~for anadromous salmonids~~. There remains a need to augment existing information regarding anadromous salmonid habitat availability and suitability in tributaries upstream of Oroville Dam and between the Fish Barrier Dam and the Thermalito Diversion Dam, and to collect, catalogue and evaluate the experiences and knowledge gained at other dams

that attempted the use of passage facilities (e.g., fish ladders, fish elevators, bypass systems) and transportation methods (e.g., trap-and-truck, trap-and-barge) to provide passage for adult and juvenile anadromous salmonids. ~~For the purpose of this study "anadromous salmonids" includes the three runs of Feather River salmonids that are reported to spawn below the Feather River Fish Barrier Dam (i.e., fall-run and spring-run chinook salmon, and steelhead).~~

The feasibility evaluation provided by this study will complement the assessments of project-related effects on the passage of resident fish to and from available fish habitat upstream of Lake Oroville, and within the lower Feather River (SP-F4 and SP-F~~2~~10, respectively). These assessments and the present feasibility study will be important components in the evaluation of ~~direct, indirect and cumulative~~ effects of the Oroville Facilities required to comply with National Marine Fisheries Service (NMFS) federal Endangered Species Act (ESA) consultation information requirements.

4.0 SCOPE – STUDY AREA

~~The study area extends from the Feather River Fish Barrier Dam to the next likely current upper migratory barriers located upstream of Lake Oroville, including the West Branch Feather River and the North, Middle and South Forks of the Feather River.~~ The study area encompasses the FERC project waters upstream of the Fish Barrier Dam, including Lake Oroville and its upstream tributaries. This includes areas of the upper Feather River watershed within the fluctuation zone of Lake Oroville and areas above the high water mark still within the FERC boundary.

The portion of the study area upstream of Lake Oroville will be the same as SP-G1, *Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam*. Specifically, the proposed study area for tributaries to Lake Oroville extend to stream channel obstructions that would limit upstream migration of salmon and steelhead. The principal obstructions are generally known and may include Big Bend Dam on the North Fork Feather River, Ponderosa Diversion Dam on the South Fork Feather River, Curtain Falls on the Middle Fork Feather River and Miocene Dam on the West Branch Feather River. Big Bend Dam had a fish ladder, but the efficiency of the ladder is not known (Taylor 2001). The final determination of the upstream tributary study area boundaries (i.e., identification of current upper migratory limit) will be completed in coordination with SP-G1 as well as SP-F3.1.

5.0 GENERAL APPROACH

The evaluation of providing anadromous salmonid passage past Oroville Facility dams is proposed in three phases. Phase 1, detailed in this study plan, ~~is primarily a desktop study~~ consists~~ing~~ of a desktop study review, comparison and assessment of available information regarding life history and habitat requirements of Feather River anadromous salmonids, and habitat availability for anadromous salmonid spawning and juvenile rearing upstream of the Fish Barrier Dam and Oroville Dam. The review will utilize available information including reports, scientific papers, surveys by DWR and other agencies, and other ~~miscellaneous~~ information

(e.g., photographs, maps and/or newspaper articles) to summarize chinook salmon and steelhead lifecycle periodicity, and to characterize the habitat potential between the Fish Barrier Dam and Oroville Dam, and upstream of Lake Oroville. Much of this information will be obtained from SP-F10 and SP-F3.1. Phase 1 also includes an evaluation of potential gains or losses to salmonid production obtained from providing passage to and from upstream habitats for anadromous salmonids, relative to the existing condition. If, based on Phase 1 results, the Environmental Work Group determines that there are potential gains to salmonid production by providing passage past Oroville Facility dams, then all or part of Phase 2 of the study will be conducted.

Phase 2 ~~of this study plan~~ is a desktop study ~~consisting of a~~ review, comparison and assessment of available information focusing on alternative fish passage facilities and methods for passage of anadromous salmonids and their potential application to the Oroville Facilities for passing and transporting adult and juvenile salmonids through dams, reservoirs and diversions (e.g., fish ladder, fish elevator, bypass channel). Facilities and techniques for capturing and transporting adult and juvenile salmonids around dams and reservoirs (e.g., trap-and-truck, trap-and-barge) also will be evaluated for potential application ~~applicability~~ to the Oroville Facilities.

The ~~review~~ feasibility assessment will be general ~~in context~~, with minimal consideration of engineering design features. The Phase 2 summary report ~~prepared to summarize Phase 2 findings~~ will include a general discussion of the overall feasibility of providing anadromous fish passage in terms of successes and failures of the alternative passage and transport methods applied at the various dams reviewed, and of similarities of these dams with the Oroville Facilities. It is possible ~~expected~~ that the ~~various~~ review~~s~~ and assessment~~s~~ of information included in Phase 2 ~~of this study will~~ may lead to the evaluation of the feasibility of alternative methods to provide passage for adult and juvenile anadromous salmonids past Oroville Facility dams, including an initial identification of potential sites for passage facilities.

If the Environmental Work Group finds that the Phase 2 study results ~~determines~~ indicate that it is feasible to provide passage for Feather River salmonids past Oroville Facility dams, a third phase ~~of this study~~ (Phase 3) could be implemented during the evaluation of potential protection, mitigation and enhancement measures. Phase 3 ~~not detailed in this study plan,~~ would include more detailed hydrologic, hydraulic and design evaluations and considerations, and preliminary cost estimates required to actually provide passage past Oroville Facility dams. A separate study plan ~~will~~ would be prepared for Phase 3, if ~~it is~~ determined appropriate by the Environmental Work Group.

~~Phase 1 will include the following tasks:~~

~~(1) Describe the life history and habitat requirements of Feather River anadromous salmonids (applying information from SP-F10);~~

~~(2) Evaluate upstream habitat availability for anadromous salmonids (applying information from SP-F3 and SP-F4); and~~

~~(3) Evaluate potential salmonid production gains or losses from providing passage to upstream habitats, relative to the existing condition.~~

~~Phase 2 will include the following tasks:~~

~~(1) Describe and evaluate the characteristics of the potential passage area;~~

~~(2) Review alternative passage and transport methods for adult anadromous salmonids applied at other similar facilities, and discuss the applicability to the Oroville Facilities;~~

~~(3) Review passage and transport methods for juvenile anadromous salmonids applied at other similar facilities, and discuss the applicability to the Oroville Facilities; and~~

~~(4) Describe the reported responses of adult and juvenile salmonids to various alternative methods of passage or transport around migratory barriers.~~

METHODOLOGY AND ANALYSIS

Phase 1

Task 1 – Describe the Life History and Habitat Requirements of Feather River Anadromous Salmonids

Information on the specific life history and habitat requirements of Feather River anadromous salmonids is necessary to effectively evaluate the timing of juvenile and adult migrations, the factors affecting timing, and the success of juvenile and adult migrations. Much of this information will be compiled as part of SP-F10, *Project Effects on Anadromous Fish and ~~t~~Their Habitat*. However, a~~A~~dditional information specifically related to the conditions required for the successful passage of anadromous salmonids to and from reservoirs will be collected under this study plan ~~(SP-F15)~~, as ~~needed~~ available. This effort will include collection and compilation of information on the habitat suitability characteristics ~~of~~ for chinook salmon and steelhead. A description of the information obtained from SP-F10 and that collected specific to reservoir passage will be included in draft form. The following topics will be included in the review and description:

- Adult upstream migration (timing, and prevalent water temperature and flow conditions);
- Adult holding habitat (habitat availability, water temperature, holding pool or stream characteristics);
- Spawning (habitat availability and suitability, abundance and distribution, timing, and factors affecting timing and success such as substrate conditions and water temperatures);
- Early development (factors affecting embryo incubation survival through emergence);
- Juvenile rearing (habitat availability and utilization, distribution and abundance, water temperature, substrate characteristics, refuges, shade, cover, food availability, predation, stranding); and
- Juvenile out-migration and movements (timing, prevalent flow, water temperature and other abiotic conditions).

Task 1 is divided into three subtasks, each corresponding to one of the three target species or runs to be evaluated. Each species-specific review and compilation of information will address the topics identified above taking into consideration the characteristics innate to each target species.

Subtask 1.1 – Life History and Habitat Suitability Characteristics of Feather River Spring-Run Chinook Salmon

Subtask 1.2 – Life History and Habitat Suitability Characteristics of Feather River Fall-Run Chinook Salmon

Subtask 1.3 – Life History and Habitat Suitability Characteristics of Feather River Steelhead

Task 2 – Evaluate Upstream Habitat Availability for Anadromous Salmonids

Subtask 2.1 – Inventory of Potentially Available Habitat for Adult and Juvenile Anadromous Salmonids Between the Thermalito Diversion Dam and the Fish Barrier Dam

~~Much of the i~~Information necessary to complete ~~accomplish~~ this subtask will be obtained from other Oroville Facilities FERC Relicensing Project study plans, including ~~provided by~~ SP-F3.1~~0~~, *Evaluation of Project Effects on ~~Anadromous Salmonids and Their Habitat~~ Resident Fish and Their Habitat within Lake Oroville, the Thermalito Complex and Upstream Areas within the Project Boundaries*, SP-G2, *Effects of Project Operations on Geomorphic Processes Downstream of Oroville Dam*, as well as other fishery, water quality, terrestrial, engineering and GIS efforts.~~.~~ This subtask will consist of a review of available data and reports on physical, hydrological and operational characteristics of the project facilities for the area located between the Fish Barrier Dam and the Thermalito Diversion Dam. Specific application of this information in this subtask includes:

- Identification and mapping of the area between the Fish Barrier Dam and Thermalito Diversion Dam (using 7.5 minute quadrangle U.S. Geological Survey (USGS) topographic maps);
- Review of available historic and recent aerial photographs and topographic maps of the area between the Fish Barrier Dam and the Thermalito Diversion Dam to document and describe historical channel movements and morphological changes in the area to characterize potential habitat availability;
- Review of existing water quality, sediment and riparian vegetation information for the area between the Fish Barrier Dam and the Thermalito Diversion Dam (to be obtained in coordination with other environmental study plans);
- Review, document, describe and synthesize data and reports on monthly and daily flow fluctuations in the area between the Fish Barrier Dam and the Thermalito Diversion Dam;
- Review, document, describe and synthesize data and reports on monthly and daily mean water temperatures in the area between the Fish Barrier Dam and the Thermalito Diversion Dam; and

- Review of reports, creel census surveys and other information, as available, on the harvest of salmonids in the area.

Subtask 2.2 – Inventory of Potentially Available Habitat for Adult and Juvenile Salmonids Upstream of Lake Oroville

Successful introduction of anadromous salmonids to the upper tributaries of the Feather River depends on providing reliable passage for adult and juvenile fish through Oroville Dam, as well as on the existence of adequate habitats for adults and juvenile fish in the upper Feather River watershed. Most of the pristine salmonid habitats in the upper Feather River tributaries that existed historically have been considerably altered by mining, farming, logging and railroad construction activities. Moreover, the construction of dams and water diversion projects has resulted in further loss of those originally pristine upper watershed habitats.

Much of the information necessary to accomplish this subtask will be provided by SP-F3.1, *Evaluation of Project Effects on Resident Fish and Their Habitat within Lake Oroville, the Thermalito Complex and Upstream Areas within the Project Boundaries,~~Evaluation of Project Effects on Resident Fish Habitat within Lake Oroville and Upstream to Project Boundaries~~* and ~~by SP-F4, *Passage of Resident Fish Upstream of Lake Oroville*~~. Additionally, completion of this study plan will draw upon information collected and evaluated by water quality and geomorphology study plans.~~–~~ The information from these study plans will be reevaluated to assure that it is applicable to both anadromous salmonids as well as resident fish. Specific application of this information in this subtask includes mapping of streams and creeks in the study area; review of aerial photographs and maps; consideration of existing water quality, sediment and riparian vegetation data; and review of available watershed studies or surveys that describe salmonid habitat including water temperature and flow conditions and other factors (e.g. predator and prey distribution).

~~- Identification and mapping of the streams and creeks that constitute the watershed of the West Branch Feather River and the North, Middle and South Fork Feather Rivers, using 7.5 minute quadrangle U.S. Geological Survey (USGS) topographic maps (it is anticipated that the mapping effort and resources will be developed and provided through coordination of the geomorphology study plan efforts and GIS work group);~~

~~- Review of available historic and recent aerial photographs and topographic maps of the streams and creeks of the watershed of the West Branch Feather River and the North, Middle and South Fork Feather Rivers to identify potential salmonid spawning grounds and juvenile rearing habitat (i.e., backwaters, side channels, riffles, pools). (Base information (photographs and maps) will be obtained through coordination with other environmental work group resource study plans, likely terrestrial and geomorphology, as well as through the GIS work group);~~

~~- Review of existing water quality, sediment and riparian vegetation information for the upper watershed (to be obtained in coordination with other environmental study plans, including water quality, geomorphology, and terrestrial disciplines);~~

- ~~Review of data and reports from upper watershed surveys performed by federal and state agencies, as well as private parties, to locate or assess spawning and juvenile rearing habitat for salmonids;~~
- ~~Review of data and reports from upper watershed surveys performed by federal and state agencies, as well as private parties, to identify temperature and flow conditions in streams and creeks of the watershed of the West Branch Feather River and the North, Middle and South Fork Feather Rivers;~~
- ~~Identification and mapping of the dams and water diversions located in the watershed of the West Branch Feather River, the North Fork Feather River, the Middle Fork Feather River and the South Fork Feather River (using 7.5 minute quad USGS hydrological maps); and~~
- ~~Review of data and reports from upper watershed surveys performed by federal and state agencies, as well as private parties, to identify and evaluate the distribution of fish and other fauna that may constitute potential prey, predators or competitors for resident salmonids.~~

Subtask 2.3 – Habitat Characterization of Lake Oroville

Similar to Subtask 2.2, t~~T~~his subtask will rely on information from other environmental and engineering group study plans to describe the habitat characteristics of Lake Oroville. The effort under this subtask will be to describe these characteristics as they relate to the passage of anadromous salmonids. ~~consist of a review of data and reports on physical, hydrological and operational characteristics of Lake Oroville, and on Lake Oroville ichthyo- and invertebrate faunas, collected by DWR or other parties.~~ Elements to be considered ~~of this review will~~ include~~:~~ lake topography, annual lake water level cycles and temperature profiles, annual changes in water quality and information on fish and invertebrate species present in the lake, including discussion of common ecological interrelationships.

- ~~Lake topography, in particular at the confluence with the West Branch Feather River and the North, Middle and South Fork Feather Rivers;~~
- ~~Annual cycle of Lake Oroville water levels, describing monthly and inter-annual variation;~~
- ~~Water temperature profiles throughout the year (if possible, differences between the central part of the lake and the area of confluence with the West Branch Feather River and the North, Middle and South Fork Feather Rivers will be indicated);~~
- ~~Changes in dissolved oxygen, pH, turbidity, and nutrient and mineral contents throughout the year;~~
- ~~Catalogue of fish species present in Lake Oroville, detailing the timing and location (water layer) of their different lifecycle stages;~~
- ~~Catalogue of invertebrate species present in Lake Oroville, detailing the timing and location (water layer) of their lifecycle stages; and~~
- ~~Identification of most common ecological relationships among fish and invertebrate species, detailing, when possible, interannual changes.~~

Task 3 – Evaluate Potential Salmonid Production Gains or Losses from Providing Passage to Upstream Habitats, Relative to the Existing Conditions

Evaluation of the feasibility of providing anadromous salmonid passage past Oroville Facility dams must include an evaluation of the merits, relative to the existing condition, of reintroducing anadromous salmonids to the upper tributaries of the Feather River. An important part of this evaluation consists of an assessment of the relative gains of passing anadromous salmonids to the upper Feather River watershed. Provision of upstream passage would be detrimental if upstream passage results in significant losses of salmon production, with respect to current Feather River salmon production.

This task will integrate the results of Tasks 1 and 2 with other FERC Relicensing Project study plans including ~~the previous two tasks~~, information on: (1) the life history and study area habitat characterization, provided in part by SP-F3.1 as well as SP-F10, *Project Effects on Anadromus Fish and Their Habitat*~~as well as information on~~ ; (2) predation on anadromous salmonid juveniles provided by SP-F21, *Project Effects on* ~~*Predators*~~ *Predation of Feather River Anadromous Salmonids*~~,~~; and ~~information on~~ (3) current anadromous salmonid spawning and juvenile emigration provided by SP-F10~~, *Project Effects on Anadromous Fish and their Habitat*~~. In addition to the information obtained from these ~~three~~ study plans, this task will review available scientific and technical literature on sources and estimates of juvenile and adult salmonid mortality associated with dam passage. The review ~~will~~ also will evaluate reports, CDFG creel census surveys and other information on the harvest of salmonids in the area. The following topics will be included in the review and presented in the Summary Report:

- Sources and estimates of spawning adult mortality associated ~~to~~ with ~~the~~ physical passage through ladders and similar facilities or ~~to~~ adult transportation;
- Sportfishing harvest considerations in the study area~~Lake Oroville and~~, including the upper Feather River watershed;
- Pre-spawning mortality considerations (e.g., egg retention, fertilization rates, viability) ~~considerations~~ associated with spawning habitat conditions (e.g., elevated water temperatures);
- Consideration of adult straying associated with environmental homing cues (e.g., attraction flows, stream temperatures and water quality);
- Identification of sources, and evaluation of egg and alevin mortality associated with incubation habitat conditions;
- Evaluation of residualization potential of juvenile salmonids in Lake Oroville (i.e., the fish take up residence within the lake);
- Evaluation of predation on juvenile salmonids in the study area, including ~~Lake Oroville and~~ the upper Feather River watershed; and
- Sources and estimates of juvenile mortality associated with physical passage through bypasses and other juvenile-passage facilities.

Phase 2

Upon completion of Phase 1, the Environmental Work Group will review and evaluate the results of the study and decide whether to continue with part or all of Phase 2 of the study plan. The criteria for determining whether to proceed into Phase 2 will be identified in the final study plan.

Phase 2 will include the following tasks:

(1) Describe and evaluate the characteristics of the potential passage areas;

(2) Review alternative passage and transport methods for adult anadromous salmonids applied at other similar facilities, and discuss the applicability to the Oroville Facilities;

(3) Review passage and transport methods for juvenile anadromous salmonids applied at other similar facilities, and discuss the applicability to the Oroville Facilities; and

(4) Describe the reported responses of adult and juvenile salmonids to various alternative methods of passage or transport around migratory barriers.

Task 1 – Describe and Evaluate the Characteristics of the Potential Passage Areas

The Feather River Fish Barrier Dam, located upstream of the Feather River Hatchery and approximately five miles below Oroville Dam, diverts fish into a fish ladder that leads to the hatchery. The dam is 91 feet high, and the crest elevation and length are 181 feet and 600 feet, respectively. The Thermalito Diversion Dam is located approximately four miles downstream of Oroville Dam. The Thermalito Diversion Dam has a height of 143 feet, a crest length of 1,300 feet and an elevation of 233 feet. Oroville Dam is the highest earthfill dam in the United States. It is 770 feet high, with a dam crest of 6,920 feet long and 51 feet wide.

The evaluation of the characteristics of the study area is ~~proposed as~~ divided into two interdependent subtasks, identified below.

Subtask 1.1 – Describe Features and Characteristics Between the Feather River Fish Barrier Dam and the Thermalito Diversion Dam

The following activities will be included in this subtask:

- Review of available aerial photographs and topographic maps of the area occupied by the Fish Barrier Dam and the Thermalito Diversion Dam.
- Review plans, specifications and designs for the Fish Barrier Dam and Thermalito Diversion Dam areas and cross-sections of the dam structures; and
- Review available studies on flow dynamics in the areas immediately above the Fish Barrier Dam and Thermalito Diversion Dam and at the base of the spillways during normal project operations.

Subtask 1.2 – Describe Features and Characteristics of Oroville Dam

This subtask will include review of aerial photographs, topographic maps, and data and reports on physical, hydrological, hydraulic and operational characteristics of Oroville Dam and its reservoir. Elements of this subtask will include:

- Review of available aerial photographs and topographic maps of the area occupied by Oroville Dam;
- Review, document, describe and synthesize data and reports on the annual cycle of Lake Oroville water levels, describing monthly and inter-annual variation;
- Review, document, describe and synthesize data and reports regarding water temperature profiles throughout the year in the area immediately above Oroville Dam;
- Review plans, specifications and designs for the Oroville Dam area and cross-section of the dam structure; and
- Review available studies on flow dynamics in the area immediately above Oroville Dam and at the base of the spillway during normal project operations.

Task 2 – Review Alternative Passage and Transport Methods for Adult Anadromous Salmonids

To develop information regarding the ability to pass anadromous salmonids past the Oroville Facility dams, the experiences and knowledge gained at other dams that have attempted the construction and operation of fish passage devices and fish transport methods will be reviewed. The similarities of those dams with Oroville Facility dams will be recorded to assess the applicability of those experiences to this study. Many dams that have attempted the construction and operation of fish passage devices and fish transport methods are in river basins outside of California including, for example, Priest Rapids, Rocky Reach and McNary dams on the Columbia River, Lower Monumental and Little Goose dams on the Snake River, and Pelton Dam on the Deschutes River.

Review of the experiences at California Central Valley dams and other dams similar to the Oroville Facility dams that have implemented passage or transport systems for adult salmonids should provide insights into the potential for constructing and operating successful fish ladders, bypass channels and other fish passage devices or transport programs in the study area. Contingent on the available information, the review performed under this subtask will involve the following activities:

- Inventory, document and synthesize descriptions of California Central Valley dams with passage or transport systems. The inventory of dams will be ordered by passage or transport system, degree of similarity with Oroville Facility dams, and degree of success. Success criteria, as reported in the literature, also will be described. Applicability to the Oroville Facility ~~Facilities~~ dams of the main characteristics associated with each facility included in the review will be provided;

- Inventory of dams with passage or transport system in other river basins. As for the Central Valley dams, information will be ordered by passage or transport system, degree of similarity with Oroville Facility dams and degree of success (as reported in the literature). Applicability to the Oroville Facility dams of the main characteristics associated with each facility will be provided;
- Evaluation of the operation and maintenance of fish ladders (e.g., regular monitoring and adjustment of ladders to maintain optimal flow through ladders, and flow rates for effective ladder operation);
- Evaluation of dam-~~caused~~related delays of upstream migration of adult salmon and steelhead, including problems adult fish may have in locating and ascending ladders (e.g., spillway configuration and location of downstream entrance to ladders, attraction flows, fallback, etc.);
- General comparison of the relative success of adult passage structures (e.g., fish ladders, elevators) and transportation ~~transporting~~ methods (e.g., adult trap-and-truck); and
- Identification of the potential feasibility of alternatives for passing adult salmonids past Oroville Facility dams.

Task 3 – Review Alternative Passage and Transport Methods for Juvenile Anadromous Salmonids

This task also will review available information on the experiences gained at California Central Valley dams and other dams, but it will be centered on the implementation of passage or transport systems for juvenile salmonids. Contingent on the information available, this review will include the following topics:

- Inventory, documentation, description and synthesis of information on California Central Valley dams with passage or transport systems. Information will be ordered by passage or transport system, degree of similarity with the Oroville Facility dams, and degree of success. Applicability to the Oroville Facility dams of the main characteristics of the implemented system will be provided;
- Inventory of dams with passage or transport systems in other river basins. Information will be ordered by passage or transport system, degree of similarity with the Oroville Facility dams, and degree of success. Applicability to the Oroville Facility dams of the main characteristics of the implemented system will be provided;
- Synthesis and description of available information regarding the extent of predation and juvenile salmonids, and the physical environments associated with dam passage infrastructure and configurations. Considerations will include structures such as passage intakes, outfalls, diversion canals, and juvenile bypass structures;
- General comparison of the relative success of juvenile passage structures (e.g., juvenile bypass systems, elevators) and transporting methods (e.g., juvenile trap-and-truck); and
- Identification of the potential feasibility of alternatives for passing juvenile salmonids.

Task 4 – Describe the Reported Responses of Adult and Juvenile Salmonids to Alternative Passage and Transport Methods

This task will review the increasing literature on experiments performed at various dams to evaluate the behavior of salmonid species at dams with adult and juvenile bypass systems and fish ladders. Many of the studies that involve tagging of adult or juvenile salmonids have been designed to evaluate issues such as routes used by juveniles and adult salmonids approaching dams with fish passage devices (i.e., longitudinal, latitudinal and depth positioning of fish attempting passage with respect to the passage device). These studies also evaluate responses to attraction flows and guidance devices, passage times, probability of passing through the passage device as opposed to other alternative passage routes (e.g., spillway, turbine intake) and probability of the fish falling back. Adult salmonids often pass upstream through the fish ladder and fall back via the spill, the juvenile bypass or the turbines. If they have not been seriously harmed by the fallback they reascend the ladder. Many tagging experiments also have evaluated and contrasted the survival of fish that pass a dam through different passage routes (e.g., spillway, juvenile bypass and turbines) or have been transported by truck or barge for various salmonid species. The review of these studies will help to evaluate the feasibility of alternative methods for passing and transporting adult and juvenile salmonids past Oroville Facility dams because they will provide insight on the potential success of each method, conditioned on the species' behavioral responses and survival. For example, a particular juvenile bypass system might constitute an adequate passage alternative for juvenile chinook salmon, but not for steelhead, because juvenile chinook salmon may tend to find and pass the bypass more easily, faster and in greater numbers than steelhead juveniles.

Contingent on the information available, this review will include the following topics for each of the three target salmonid species/races:

- Routing considerations for adult fish approaching dams with fish ladders;
- Routing considerations for juvenile fish approaching dams with juvenile bypass systems;
- Species response to attraction flows, water turbulence and temperature;
- Species reaction to guidance devices (e.g., screens, surface flow deflectors);
- Estimates of residence and passing times;
- Probability of fall-back;
- Survival associated with passing through by-pass systems, spills and turbines;
- Survival associated with trap-and-trucking; and
- Survival associated with trap-and-barging.

6.0 RESULTS, PRODUCTS/DELIVERABLES AND SCHEDULE

The results from Phase 1 will provide an evaluation of the potential advantage of providing passage past the Oroville Facility dams regarding the expected salmon production, only

accounting for the current condition of upstream salmonid habitat and potential sources of mortality. The results from Phase 2, if determined to be necessary based on Phase 1 results, will provide an evaluation regarding the feasibility of alternative methods for provision of fish passage for adult and juvenile anadromous salmonids past the Oroville Facility dams, including initial identification of potential sites suitable for installation of passage facilities.

PHASE 1 RESULTS

Results will be presented in a summary report including ~~organized following the task and subtask headings indicated above. Each task will include~~ a narrative ~~of the relevant findings~~ as well as tables, figures and maps ~~summarizing~~ presenting the main results ~~findings~~relevant to the potential for production gains or losses with the restoration of the Oroville Facility dams. ~~After the results of the~~ I~~i~~ndividual task results will be ~~are~~ presented, as appropriate and the relationships among the ~~findings~~ results of the individual tasks ~~of the report sections~~ will be integrated to obtain general answers to the main questions of the study. The main issues of the study and the likely ways to link the individual task findings to address them are identified below.

- Quantity and quality of existing upstream habitats for anadromous salmonid spawning, and juvenile rearing (Tasks 1 and 2);
- Existing Lake Oroville conditions for survival of adult and juvenile anadromous salmonids (Tasks 1 - 3); and
- Likely production effects of facilitating or enhancing the passage of resident salmonids through Oroville Facility dams (Tasks 1 - 3).

The maps, graphical representation of reviewed data (e.g., charts, and graphs) and summary figures and tables anticipated for the study include those listed below. To the extent practical, graphics and other information will be obtained in coordination with other resource study plans. The specifics of these coordination efforts remain under development and will be identified in the final study plan.~~:~~

- Figure summarizing spring-run chinook salmon lifecycle periodicity for the Feather River;
- Figure summarizing fall-run chinook salmon lifecycle periodicity for the Feather River;
- Figure summarizing steelhead lifecycle periodicity for the Feather River;
- Tables summarizing main habitat suitability characteristics of fall-run chinook salmon for spawning, juvenile rearing and adult and juvenile migrations;
- Tables summarizing main habitat suitability characteristics of spring-run chinook salmon for spawning, juvenile rearing and adult and juvenile migrations;
- Tables summarizing main habitat suitability characteristics of steelhead for spawning, juvenile rearing and adult and juvenile migrations;
- Tables summarizing sources and estimates of juvenile salmonid mortality in Lake Oroville and upstream habitat;

- Tables summarizing sources and estimates of adult salmonid mortality in Lake Oroville and upstream habitat; and
- Species-specific tables or figures comparing potential salmonid production assuming passage to currently available upstream habitats, relative to current salmonid production.

PHASE 2 RESULTS

Presentation of Phase 2 r~~R~~esults will ~~be organized following the task and subtask headings indicated above. Each task will~~ include a narrative of the relevant ~~findings~~ information as well as summary tables, figures and maps. ~~summarizing the main findings. After the~~ R~~r~~esults of the individual tasks will be ~~are~~ presented, and the relationships among the tasks ~~findings of the report sections~~ will be identified~~connected~~ to obtain general answers to the main questions of the study. The main issues of the study and the likely ways to link the results ~~individual task findings~~ to address them are identified below.

- Efficacy of alternate methods for passage or transport of anadromous adult salmonids past large dams (Phase 1 and Phase 2 Tasks 1, 2 and 4);
- Efficacy of alternate methods for passage or transport of anadromous juvenile salmonids past large dams (Phase 1 and Phase 2 Tasks 1, 3 and 4);
- Efficacy of providing physical structures for the passage of anadromous salmonids past dams relative to transport methods (Phase 2 Tasks 2 - 4);
- Potential sites for installation of juvenile bypass structures or facilities for capturing and transporting juvenile salmonids past Oroville Facility dams (Phase 2 Tasks 1 - 4);
- Potential sites for installation of adult bypass structures, or facilities for capturing and transporting adult salmonids past Oroville Facility dams (Phase 2 Tasks 1 - 4); and
- Feasibility of alternative methods of providing passage for adult and juvenile anadromous salmonids past Oroville Facility dams (Phase 2 Tasks 1 - 4).

The maps, graphical representation of reviewed data (e.g., charts, and graphs) and summary figures and tables anticipated for the study include those listed below. Development of these maps will be performed in coordination with other resource study plan efforts, including the GIS work group.~~:~~

- Topographic maps of the area extending from the Feather River Fish Barrier to Oroville Dam, including facilities, showing contours of the water level during periods of minimum and maximum flow;
- Topographic maps of the area extending from the Feather River Fish Barrier to Oroville Dam, including facilities, showing average water-temperature contours (isoclines) for the months of chinook salmon and steelhead spawning migrations;
- Topographic maps of the area extending from the Feather River Fish Barrier Dam to Oroville Dam, including facilities, showing sites of observed concentrations of predators of juvenile salmonids;

- Plans and cross-sections of main facilities in the area extending from the Feather River Fish Barrier Dam to Oroville Dam showing main flow dynamics;
- Summary tables listing dams with passage or transport systems for adult salmonids by name, location, main physical and operational characteristics, degree of similarity with the Oroville Facility dams and degree of success;
- Summary tables listing dams with passage or transport system for juvenile salmonids by name, location, main physical and operational characteristics, degree of similarity with the Oroville Facility dams and degree of success;
- Species-specific summary tables comparing success of passage and transport systems for juvenile and adult salmonids in terms of survival and behavioral responses; and
- Summary table with characteristics of passage and transport systems recommended for the study area and identification of potential sites.

PRODUCTS/DELIVERABLES

The results of the tasks performed under Phase 1 of this study plan will be presented in a summary report. Based on the findings of Phase 1, a determination will be made by ~~DWR~~ the Environmental Work Group, through coordination and consultation with fisheries resource agencies whether it is appropriate to pursue Phase 2, and ultimately development of a Phase 3 study plan. This determination will be made upon ~~findings~~ results related to project effects on anadromous salmonid fish passage, the feasibility of implementing one of the alternative methods for providing fish passage past the migratory barriers created by the Oroville Facilities, and conclusions regarding the potential suitability of habitat upstream of Lake Oroville.

Regulatory reporting requirements, and the report distribution procedure and list, will be indicated at least four months before the completion of the final report. By that time, the agency review and approval requirements will be determined.

It is anticipated that the summary reports for Phase 1, and Phase 2 ~~Summary Report~~ (if conducted), will include the following general structure:

- Executive Summary
- Table of Contents
- List of Tables
- List of Figures
- Introduction
- Narratives of relevant findings by task
- Discussion addressing study questions and indication of any complications or data concerns
- Conclusions related to study plan objectives

~~Recommendations relevant to next phase evaluation~~

- References
- Appendices

SCHEDULE

It is anticipated that the Phase 1 final report will be completed by September 2002. The Phase 2 report, if needed, will be completed by December 2003.

7.0 STUDY PLAN COORDINATION

COORDINATION WITH OTHER RESOURCE AREAS/STUDIES

~~It is anticipated that~~Completion of this study will require information from other resource study plans being prepared for the Oroville Facilities FERC Relicensing Project including water quality ~~(water temperature)~~, engineering and operations (project operations and hydrologic and water temperature modeling results), geomorphology (river channel characterization), as well as other fisheries studies. It is noted that further coordination among study plans is currently underway to ensure consistency and efficiency in obtaining needed information.

Information or data gathered or generated by the following studies is relevant to the study of the feasibility to provide passage for anadromous salmonids past Oroville Facility dams:

SP-F3.1 – Evaluation of Project Effects on Resident Fish and Their Habitat within Lake Oroville, the Thermalito Complex and Upstream Areas Within the Project Boundaries

~~Study plans~~ SP-F3.1~~, SP-F3.2, and SP-F3.3~~ evaluates the project effects on resident fish habitat within Lake Oroville ~~upstream to the project boundaries, within~~ the Thermalito Complex~~, and in the Feather River downstream of the Fish Barrier Dam, respectively.~~and in upstream tributaries. ~~Available information will be obtained from these plans to characterize fish habitat conditions for this study.~~ Information characterizing the availability and suitability of upstream fish habitat conditions, developed in SP-F3.1, will be reviewed and adapted for use in the evaluation of anadromous salmonid habitat conditions. This information will be used in the evaluation of the potential salmonid production gains or losses from providing passage past the Oroville Facility dams (Phase 1, Task 3). The information to be obtained from SP-F3.1 will consider the availability of habitat for adult and juvenile anadromous salmonids between the Fish Barrier Dam and Thermalito Diversion Dam as well as the area above Oroville Dam. The specific information anticipated to be obtained from SP-F3.1 for the review of passage issues and for presentation in summary report(s) includes those items listed below. It is noted that SP-F3.1 also will rely on other resource study plans to compile this detailed information.

- Identification and mapping of the area between the Fish Barrier Dam and Thermalito Diversion Dam (using 7.5 minute quadrangle U.S. Geological Survey (USGS) topographic maps);
- Review of available historic and recent aerial photographs and topographic maps of the area between the Fish Barrier Dam and the Thermalito Diversion Dam to document and describe historical channel movements and morphological changes in the area to characterize potential habitat availability;

- Review of existing water quality, sediment and riparian vegetation information for the area between the Fish Barrier Dam and the Thermalito Diversion Dam;
- Review, document, describe and synthesize data and reports on monthly and daily flow fluctuations in the area between the Fish Barrier Dam and the Thermalito Diversion Dam;
- Review, document, describe and synthesize data and reports on monthly and daily mean water temperatures in the area between the Fish Barrier Dam and the Thermalito Diversion Dam; and
- Review of reports, creel census surveys and other information, as available, on the harvest of salmonids in the area.

- Identification and mapping of the streams and creeks that constitute the watershed of the West Branch Feather River and the North, Middle and South Forks of the Feather River, using 7.5 minute quadrangle USGS topographic maps;
- Review of available historic and recent aerial photographs and topographic maps of the streams and creeks of the watershed of the West Branch Feather River and the North, Middle and South Forks of the Feather River to identify potential salmonid spawning grounds and juvenile rearing habitat (i.e., backwaters, side channels, riffles, pools). (Base information (photographs and maps);
- Review of existing water quality, sediment and riparian vegetation information for the upper watershed;
- Review of data and reports from upper watershed surveys performed by federal and state agencies, as well as private parties, to locate or assess spawning and juvenile rearing habitat for salmonids;
- Review of data and reports from upper watershed surveys performed by federal and state agencies, as well as private parties, to identify temperature and flow conditions in streams and creeks of the watershed of the West Branch Feather River and the North, Middle and South Fork Feather Rivers;
- Identification and mapping of the dams and water-diversions located in the watershed of the West Branch Feather River, the North Fork Feather River, the Middle Fork Feather River and the South Fork Feather River (using 7.5 minute quad USGS hydrological maps); and
- Review of data and reports from upper watershed surveys performed by federal and state agencies, as well as private parties, to identify and evaluate the distribution of fish and other fauna that may constitute potential prey, predators or competitors for resident salmonids.

Additionally, information specific to Lake Oroville habitat characterization will be provided by SP-F3.1. Specific information anticipated to be obtained include those items listed below.

- Lake topography, in particular at the confluence with the West Branch Feather River and the North, Middle and South Fork Feather Rivers;

- Annual cycle of Lake Oroville water levels, describing monthly and inter-annual variation;
- Water temperature profiles throughout the year (if possible, differences between the central part of the lake and the area of confluence with the West Branch Feather River and the North, Middle and South Fork Feather Rivers will be indicated);
- Changes in dissolved oxygen, pH, turbidity, and nutrient and mineral contents throughout the year;
- Catalogue of fish species present in Lake Oroville, detailing the timing and location (water layer) of their different lifecycle stages;
- Catalogue of invertebrate species present in Lake Oroville, detailing the timing and location (water layer) of their lifecycle stages; and
- Identification of most common ecological relationships among fish and invertebrate species, detailing, when possible, interannual changes.

~~*SP-F4 – Passage of Resident Fish Upstream of Lake Oroville*~~

~~The review and assessment of habitat distribution for Lake Oroville and the upper Feather River watershed will be utilized by this study plan. Additionally, the evaluation of habitat availability and suitability provided by SP-F4 will be an important element in the completion of Phase 1 of this study plan. The findings that characterize the condition of upstream habitat suitability for migratory fish within and upstream of Lake Oroville will be considered in the evaluation of the feasibility of providing fish passage for anadromous salmonids past Oroville Facility dams. Consideration of this information will include whether existing or improved habitat conditions would support the restoration of anadromous salmonid migration to the upstream tributaries of Lake Oroville, including the West Branch Feather River, and the North, Middle and South Forks of the Feather River.~~

SP-F10 – Evaluation of Project Effects on Anadromous Fish and Their Habitat

Information on the ~~The~~ Feather River anadromous salmonid specific life history and habitat requirements ~~information~~ will be compiled under ~~for the~~ SP-F10 ~~study plan~~ and will be used ~~under Task~~ in Phase1 of this study plan ~~(SP-F15)~~ for each of the three target species (fall-run chinook salmon, spring-run chinook salmon, and steelhead). Graphical representations of the lifestage periodicity also will be obtained from SP-F10 for these three species. This information will include collection and compilation of information on the habitat suitability characteristics of chinook salmon and steelhead. The following topics will be included in the description:

- Adult upstream migration (timing, and prevalent water temperature and flow conditions);
- Adult holding habitat (habitat availability, water temperature, holding pool or stream characteristics);
- Spawning (habitat availability and suitability, abundance and distribution, timing, and factors affecting timing and success such as substrate conditions and water temperatures);
- Early development (factors affecting embryo incubation survival through emergence);

- Juvenile rearing (habitat availability and utilization, distribution and abundance, water temperature, substrate characteristics, refuges, shade, cover, food availability, predation, stranding); and
- Juvenile out-migration and movements (timing, prevalent flow, water temperature and other abiotic conditions).

~~*SP-F16 – Evaluation of Feather River Flow-Habitat Relationships through Physical Habitat Simulation (PHABSIM)*~~

~~Information provided in SP-F16 relative to habitat-flow relationships for spawning and rearing lifestages for chinook salmon and steelhead, other physical habitat information (e.g., critical riffle flow-passage relationships or substrate particle incipient motion analysis), and other project-and site-specific hydraulic data will be useful in the assessment of applicability of other fish passage or transport methods to the Oroville Facilities.~~

SP-F21 – Project Effects on Predation of Feather River Juvenile Anadromous Salmonids

The description of available information regarding the extent of predation on juvenile salmonids and the physical environment created by passage intakes and bypass structures associated with predation will be considered in the completion of this study plan.

Other Environmental Work Group Study Plans

Coordination among environmental work group study plan authors has been initiated to determine appropriate links and abilities to share information, thereby minimizing redundant efforts and reducing overall costs of study plan implementation. For example, completion of SP-F15 will include use of aerial photographs that may be produced for geomorphology or terrestrial study plan efforts. Additionally, information obtained under the geomorphology study plans SP-G1, *Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam* and SP-G2, *Effects of Project Operations on Geomorphic Processes Downstream of Oroville Dam* will be ~~used, to the extent it is applicable, for the characterization of habitat conditions~~relied upon for site-specific characterization of habitat elements (e.g., water depth, substrate composition).

Engineering and Operations Work Group Study Plans

The descriptions and evaluations of study area characteristics will incorporate the results from hydrologic and water temperature modeling completed for the project. Preliminary, anticipated specific information to be obtained ~~would~~ include:

- Daily and monthly flow fluctuations between the Feather River Fish Barrier and Oroville dams;
- Daily and monthly mean water temperatures between the Feather River Fish Barrier and Oroville dams;
- Lake Oroville water level fluctuations; and

- Lake Oroville water temperature profiles.

ISSUES, CONCERNS, COMMENTS TRACKING AND/OR COMPLIANCE REQUIREMENTS

Issue Statements Addressed by the *Evaluation of the Feasibility to Provide Passage for Anadromous Salmonids Past Oroville Facility Dams* Study Plan.

Issue	Description
FE10	Provide for fish passage on any drainage or stream where spawning activity occurs.
FE14	Provide for fish passage and maintain natural channel character at stream crossings within project area and/or project-affected areas.
FE62	Reintroduce anadromous fish above dam.
FE 64	Effect of project on available upstream fishery habitat (incorporate all project facilities).
FE85	Impact of project facilities and operations on fish passage includes structures, flows, and/or water quality conditions that impede or block passage within and from current and/or historic habitat and operations that impact passage or have the potential to enhance passage. Passage includes movement of spawning or holding adults, emigrating smolts, and juveniles searching for areas where to feed, avoid predators, or shelter.
FE 91	Current conditions of habitat potentially impacted by project and alternatives to conserve or enhance anadromous salmonids.
FE98	Fish passage is an essential survival element for anadromous species and obstructed passage can also have serious adverse impact on resident species biodiversity and populations. Both upstream and downstream unobstructed fish passage below the project should occur. Fishery investigations should examine the adequacy of passage for all species in the reaches of the lower Feather River downstream of the project. Evaluations should cover a sufficient range of flows and include examination of instream pits or gravel ponds.

Source: NEPA Scoping Document 1 and CEQA Notice of Preparation, DWR 2001.

8.0 REFERENCES

A complete list of references used in the completion of the study will be part of the summary report. The references cited in the present plan are listed below.

DWR 2000. 1999 Lake Oroville Annual Report of Fish Stocking and Fish Habitat Improvements, February 2000.

DWR 2001. Initial Information Package, Relicensing of the Oroville Facilities, January 2001.

DWR and USBR 2000. Biological Assessment: Effects of the Central Valley Project and State Water Project on Steelhead and Spring-run Chinook Salmon, November 2000.

Yoshiyama, R. M., E. R. Gerstrung, F. W. Fisher, and P. B. Moyle. 1996. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California in Sierra

Nevada Ecosystem Project. Final Report to Congress, vol. III: Assessments, Commissioned Reports and Background Information. (University of California, Davis, Centers for Water and Wildland Resources, 1996.)

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California. North American Journal of Fisheries Management 18: 487-521.

DWR OROVILLE FACILITIES RELICENSING PROJECT
(FERC Project No. 2100)

ENVIRONMENTAL WORK GROUP
DRAFT STUDY PLAN

SP-F16. EVALUATION OF PROJECT EFFECTS ON INSTREAM FLOWS AND FISH HABITAT ~~(PHABSIM)~~

1.0 INTRODUCTION

~~Flows in the Feather River below the Thermalito Diversion Dam are maintained at a minimum level of 600 cubic feet per second (cfs) for fishery purposes.~~ In 1995, the Feather River Technical Team (FRTT) of the Anadromous Fish Restoration Program Core Group listed instream flows ~~as a~~the key limiting factor for chinook salmon and steelhead production in the Feather River ~~Basin~~ (USFWS 1995). The FRTT further suggested that inadequate flows may limit spawning and rearing habitat for anadromous salmonids.

Minimum flows in the lower Feather River are established by a 1983 agreement between DWR and CDFG~~, Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife~~. The agreement establishes criteria for flow and temperature for the Low Flow Channel of the Feather River and the reach of the Feather River below the Thermalito Afterbay outlet to the confluence with the Sacramento River for preservation of salmon spawning and rearing habitat (DWR 2001). The agreement specifies that DWR release a minimum of 600 cfs into the low flow channel for fishery purposes. This is the total volume of flows from the diversion dam outlet, diversion dam powerplant, and the Feather River Fish Hatchery pipeline. The agreement also specifies minimum flow requirements in the lower reach of the Feather River ranging from 1200-1700 cfs during the primary spawning and incubation period (October-February), and from 1,000-1,700 cfs during March, dependent upon Lake Oroville storage and unimpaired runoff near Oroville. There is an additional requirement that if during October 15 through November 30 the hourly flow is greater than 2,500 cfs, then the flow minus 500 cfs must be maintained until the following March unless the high flow was due to flood control operation or mechanical problems. This requirement is to protect any spawning that could occur in overbank areas during the higher flow rate by maintaining flow levels high enough to keep the overbank areas submerged. In practice, the flows are maintained below 2,500 cfs from October 15 to November 30 to prevent spawning in the overbank areas (DWR 2001).

The FRTT suggested that instream flow studies be completed to determine what flows might be required to enhance the ~~basin's~~ river's salmonid stocks. Additional flow through the low-flow channel during at least September through May may enhance spawning habitat without an adverse effect on rearing (USFWS 1995). Initial results from a jointly conducted Department of Water Resources (DWR) and Department of

Fish and Game (DFG) instream flow study suggested that spawning habitat in the low-flow channel would be maximized at higher flows than the present level of 600 cfs (Sommer 1994). Based upon preliminary results of previous unpublished physical habitat simulation (PHABSIM) studies, they recommended temporarily increasing the minimum level flows to "enhance and maintain spawning and rearing habitat" for chinook salmon and steelhead. There was substantial uncertainty about the appropriate model to use for river management, so team members recommended an experimental approach. Under the FRTT initial proposed experimental flow levels ("Schedule A"), the eight miles of the Feather River downstream of the Thermalito Diversion Dam (commonly called the low flow channel) would be operated during September through May at a minimum flow of 2,500 cfs in wet and normal water years, and 1,700 cfs in dry water years. Schedule A minimum flows during June through August would be 1,100 cfs in wet and normal water years, and 800 cfs in dry years. If subsequent monitoring of the experimental Schedule A flows suggested that salmon spawning habitat was reduced, the FRTT recommended alternative flows ("Schedule B"). Under schedule B, flows in all months and years would be 800 cfs in the low flow channel.

Sommer et al. (2001) presented additional Additional PHABSIM study results suggest~~ing~~ that maximum suitable spawning habitat in the low flow channel occurr~~ed~~ at a flow of about 1,000 cfs. In the fifteen miles of river between the Thermalito Afterbay Outlet and Honcut Creek, maximum suitable spawning habitat area was present at a flow of about 3,250 cfs (Sommer et al. 2001).

Currently, a maximum flow of 2,500 cfs is recommended in the Feather River below the Thermalito Afterbay Outlet from 15 October through 30 November to prevent spawning by fall-run chinook salmon in overbank areas that might later become dewatered (DWR 2001).

For several reasons, additional studies are needed to identify appropriate instream flow levels in the lower Feather River. New PHABSIM studies using more recent modeling and analysis techniques may help to resolve some of the differing results from previous studies. Moreover, extreme flood events in 1997 substantially changed the configuration of the lower Feather River, so previous models and results may no longer be valid. Finally, earlier studies have focused on chinook salmon, primarily fall-run. Additional work is needed to identify the flow needs of other species such as spring-run, steelhead, striped bass, American shad and green sturgeon.

2.0 OBJECTIVES

PHABSIM generates an index to aquatic habitat suitability (weighted usable area, or WUA) as a function of stream discharge for target species and life stages. The WUA index can be interpreted in the context of stream hydrology and species life history to evaluate project impacts, and serves as a partial basis for determining project alternatives and mitigation measures.

A complete PHABSIM study would have the following objectives:

- ~~Verify and/or develop habitat-flow relationships for the spawning and rearing lifestages of chinook salmon and steelhead;~~
- ~~Provide a calibrated hydraulic data deck for potential application to habitat suitability indices for other fish species and/or guilds; and~~
- ~~Provide additional physical habitat information for application to other study plans (e.g., critical riffle flow-passage relationships, substrate particle incipient motion analysis, etc.)~~

The study plan objective is to analyze flow-habitat relationships to evaluate potential project effects on anadromous salmonid spawning and rearing habitat within the study area.

3.0 RELATIONSHIP OF THE STUDY PLAN TO RELICENSING ~~PROJECT PROCESS~~/NEED FOR STUDY

Flows released below hydroelectric projects are intended to protect, maintain, and enhance the aquatic ecosystem and, more specifically, those resources considered important from a commercial fishery, sport fishery, or threatened/endangered species perspective. Instream flows are almost universally specified in a FERC license and should be based on relevant site-specific information from the project area. Resource agencies participating in FERC relicensing processes commonly rely on information generated from PHABSIM instream flow studies to develop recommended instream flow regimes. FERC also will use these types of studies during their resource balancing deliberations prior to issuing long-term licenses.

~~As noted previously, a~~Additional ~~studies~~ evaluations are needed to verify or identify appropriate instream flow levels in the lower Feather River. Additional analyses of existing data (site-specific or generic) using recent modeling and analytical techniques may help reduce uncertainty associated with previous analyses and improve the applicability of PHABSIM results to water management decisions. These analyses also may identify data supplementation and augmentation necessary to develop satisfactory flow-habitat relationships. ~~Instream flow techniques have continued to improve since efforts in the early 1990s; new studies may help to resolve some of the outstanding issues. The new work will also address possible changes in channel configuration following an extreme flood in 1997, and identify flow needs of other species such as spring-run chinook salmon, steelhead, striped bass, American shad and green sturgeon.~~

4.0 SCOPE - STUDY AREA

The proposed lower Feather River study area is 23.25 miles long and consists of two river segments. The first segment is the low flow channel, which extends from the Fish Barrier Dam at river mile (RM) 67.25 to the Thermalito Afterbay Outlet (RM 59). ~~Flow in this segment is usually maintained at about 600 cfs.~~ Substrates in this low flow channel are composed of relatively large~~r~~ elements with ~~greater~~ armoring due to transport of

gravels downstream out of the area (Sommer et al. 2001). The river drops a total of 37 feet in this 8.25 mile-long segment, for a stream gradient of about 0.08 percent.

The second river segment is the ~~high flow channel~~lower reach of the Feather River, which extends from the Thermalito Afterbay Outlet downstream to the confluence with Honcut Creek, near Live Oak (RM 44). ~~Flows in the high flow channel tend to be more variable, with fluctuations during a normal year ranging from about 1,750 cfs in the fall to 17,000 cfs in the spring (DWR 2001).~~ The substrate in this segment of the Feather River tends to include relatively small~~er~~ gravel-sized particles transported downstream from the low flow channel (Sommer et al. 2001). Stream gradient in this 15 mile-long segment is about 0.06 percent.

~~The study area encompasses the remaining Feather River area where chinook salmon and steelhead spawning occurs (Sommer et al. 2001). Large deposits of dredge tailings are present throughout the study area and much of the river channel has many areas of hydraulically complex habitats created by the many river bars and island bar complexes.~~

Downstream of the study area (RM 0 to 44), the Feather River is primarily composed of slough-like, flat-water habitats with fine-grained substrates that are unsuitable for salmonid spawning. This portion of the lower Feather River, although potentially ~~important~~ utilized as a rearing area and which serves as a migration corridor for salmonids, is not proposed to be included in the detailed PHABSIM analysis.

5.0 GENERAL APPROACH

~~The objectives of this PHABSIM study are intended to be achieved in two phases, with the first phase (Phase 1) being a review and evaluation of the adequacy of the existing data used in previous instream flow studies for the lower Feather River.~~ The general approach of this study plan is to review and evaluate existing information, conducting additional analyses of existing data (site-specific or generic) using recent modeling and analytical techniques. This approach is intended to reduce uncertainty associated with previous PHABSIM analyses. Results of the review of existing information and additional analyses may identify additional data needs to further refine flow-habitat relationships in the study area.

This study plan is structured as a three-task study. *Task 1* is a review of existing studies and hydraulic and biological (habitat suitability) data. *Task 2* is to perform habitat simulations and *Task 3* is the preparation of a summary report. If it is determined that additional data are required, then field surveys will be conducted in Phase 2 in order to complete a satisfactory description of stream flow/habitat relationships in the lower Feather River.

Task 1 – Review Existing Studies and Hydraulic and Biological (Habitat Suitability) Data

~~Phase 1 would~~ *Task 1* will begin by obtaining and reviewing ~~all~~ existing hydraulic and biological information relevant to this study plan, ~~data collected and used in previous Feather River PHABSIM studies. It is anticipated that most of this material is readily available from DWR files,~~ including habitat maps and/or detailed aerial photographs of the project area. Review of available information will include, but is not limited to, the following existing sources:

- DFG surveys conducted (using various methods) every Fall since 1954 -Annual population estimates for fall and spring run salmon returning to spawn.
- DWR-ESO study begun in Spring of 1999 -Distribution and habitat use (including riparian habitat use) of juvenile salmon and steelhead which, utilizes snorkeling observations (March - August) on the Feather River between the Fish Barrier Dam and Gridley Bridge.
- DWR-ESO steelhead and salmon habitat use studies in 1999 and 2000 -Depth, current velocity, substrate, in-stream cover, over-head cover are recorded.
- DWR-ESO mapping studies in 1999, and with 1992 IFIM studies - Riffles, pools, glides and backwater habitats have been delineated on aerial photographs from the Fish Barrier Dam to the Gridley Bridge.
- DWR Northern District published Feather River gravel condition reports in 1982 and 1996.
- Historic stream flows in the low flow channel and below Thermalito Afterbay outlet.
- DWR-ESO Hourly temperature recordings at 20 sites between the Thermalito Diversion Dam and Live Oak non-continuous records since 1997.
- USGS temperature records at gage downstream from Oroville Dam, 1958 to 1992; continuous temperatures since 1995 by DWR.
- OFD mean daily water temperatures records at the Feather River Hatchery since initiation of hatchery operations and Robinson Riffle since July 31, 2000.
- USGS records of maximum and minimum daily water temperatures at the Thermalito Afterbay Outlet from October 1968 through September of 1992. Since 1992, mean daily water temperature data from OFD.
- River temperature model developed by UC Davis under contract with DWR-ESO in 2000.
- DWR-ESO instream flow study from 1992. Thirty-two transects selected between the Fish Barrier Dam and Honcut Creek. Salmon, steelhead and American shad were the target species.

- DWR-ESO study begun in Fall 2000 regarding stranding and redd dewatering. Study will identify potential stranding areas between the Fish Barrier Dam and Honcut Creek, and attempt to quantify salmonid losses.
- DFG: An Evaluation of Fish Populations and Fisheries in the Post-Oroville Project Feather River, 1977.
- Information from reports, fish surveys and creel census performed by CDFG or other agencies (e.g., Painter et al. 1977).
- 1982 DWR Feather River Spawning Gravel Baseline Study.
- Results from the current Oroville Facilities FERC Relicensing study plans.
- 2000 Spring-run and steelhead Biological Assessment.
- 2001 Spring-run and steelhead Biological Opinion.
- CVPIA working paper and restoration plan.
- CDFG plan for action.
- CDFG plan for restoration of anadromous fish.
- Yuba River flow-habitat studies related to anadromous fish.
- American River flow-habitat studies related to anadromous fish.

~~The information~~Hydraulic data will be closely examined and evaluated using newly available hydraulic simulation software to ensure that all previous data have been adequately collected and calibrated, and that resulting WUA habitat index/discharge simulations are reliable. Of specific concern ~~would be~~are the number and placement of transect cross-sections used to represent the study area (based on reach length, channel complexity, critical habitat coverage, and sample size considerations), the range and level of discharges used to calibrate the models (based on the difference between all measured discharges in the context of annual hydrology), and the rate and/or magnitude of river channel change (aggradation/degradation) since the data were collected.

In addition to a review of the hydraulic data, the biological (habitat suitability) criteria ~~curve data used in~~from prior ~~simulations~~ reports ~~also~~ will be assembled and reviewed. Review items would include the use of generic or site-specific criteria, the characteristics of source ~~generic~~ criteria (e.g., fish size, channel size, gradient, water temperature), data collection study design, and method of curve creation from data frequency analysis. Site-specific habitat suitability data have been collected by DWR. These biological data need to be independently reviewed before further use in habitat index/discharge simulations. The existing site-specific data may need to be supplemented with criteria from other basins, or by collection of additional site-specific habitat suitability criteria. Habitat suitability criteria developed for the Feather River will be compared to criteria published in the scientific literature, and to criteria developed for nearby rivers (e.g., lower American River and Yuba River) for similarity and applicability.~~After a thorough examination of the existing hydraulic and biological data~~

~~used in prior simulations is complete, a determination will be made as to the need, extent, and character of additional field data collection that would be completed as part of Phase 2.~~

~~The issue of the type and source of habitat suitability curves (HSC) that are used in any habitat simulation are critical and can profoundly affect PHABSIM results. The source of the HSC for use to evaluate the relationship between stream flow and habitat has not yet been determined, although some site-specific data have been collected by DWR. These biological data need to be independently reviewed before further use in habitat index/discharge simulations. This existing site-specific data may need to be supplemented with criteria from other basins, or by collection of additional site-specific habitat suitability criteria.~~

Task 2 – Perform Habitat Simulations

Once the hydraulic data and species-specifi~~ced~~ habitat suitability criteria data ~~has~~ have been assembled, habitat simulations will be used to generate the relationship between stream flow and habitat index (WUA) in each of the study segments. The analysis will be further refined by ~~evaluating the WUA over time using various water year types (e.g., critical, dry, below normal, above normal, wet)~~ conducting time-series analyses using hydrology from the period prior to project operation (pre-1967) and since project operation (post 1967). To develop maximum utility for licensing considerations, ~~water years~~ results will be ~~further~~ divided into seasonal periods appropriate for WUA analysis for various fish species lifestages (e.g., spawning and rearing). Lifestage and habitat information compilation will be coordinated with efforts undertaken by study plan SP-F10, *Evaluation of Project Effects on Anadromous Fish and Their Habitat*.

Task 3 – Prepare Summary Report ~~and Initiate IFIM Study Scoping with Resource Agencies~~

Following review of existing information and data, ~~a Phase 1 initial~~ a summary report ~~would~~ will be prepared and circulated to reviewing resource agencies. The summary report will fully describe the analytical procedures used to examine and develop existing information for PHABSIM application. PHABSIM generates an index to aquatic habitat suitability (weighted usable area, or WUA) as a function of stream discharge for target species and life stages. The WUA index can be interpreted in the context of stream hydrology and species life history to evaluate project impacts, and serves as a partial basis for determining project alternatives and PM~~&and~~E measures. The summary report will also include the manner in which supplemental information will be collected, if such collection deemed necessary to develop satisfactory flow-habitat relationships. If supplemental data collection is necessary, then the summary report will provide a complete description of the Instream Flow Incremental Methodology (IFIM) Phase 2 scoping process. The IFIM is a structured evaluation and decision-making process involving multiple scientific disciplines and stakeholders, in the context of which PHABSIM studies are usually designed and implemented. Critical stakeholder concurrence on study scope, design elements, and overall adequacy for decision-

making is one of the principal objectives of IFIM scoping (Bovee et al. 1998). If supplemental biological data are determined to be necessary, specific experimental design, data acquisition, sampling protocols, data reduction, and habitat suitability criteria development will be developed in the scoping process.

~~If additional field data is judged to be required after formal Phase 1 scoping,~~If supplemental hydraulic data collection is determined to be necessary, the summary report will describe the methodology to be used. ~~h~~Hydraulic data may be collected using a combination of transect-based, one-dimensional and area-based, two-dimensional (2-D) techniques. The low-gradient nature of the study area, combined with the complex hydraulics created by the presence of gravel bars and mid-channel island complexes, present a set of conditions where the use of 2-D hydraulic model may be logistically and economically feasible. Additional data collection under Phase 2 would be conducted according to standard, established PHABSIM methods, including reach delineation, macrohabitat delineation (e.g., pool, riffle, island complex, etc.), transect/site selection and placement, flow level determination, depth, velocity, and substrate/cover data acquisition, computer model construction and calibration, species evaluation and WUA computation, and further interpretation and time series analysis. Specific details on techniques for data acquisition and analysis would be contained in a comprehensive Phase 2 study plan. ~~These efforts also would be coordinated with stream channel characterization studies to be completed as part of geomorphologic processes study plan SP-G2.~~

This summary report will, at a minimum, include descriptions of:

- Verification and/or development of habitat flow relationships for the spawning and rearing lifestages of chinook salmon and steelhead;
- Analytical procedures used to generate the relationship between streamflow and habitat index;
- Analytical procedures used to conduct time series analysis~~; and~~;
- Presentation, discussion, and interpretation of ~~Results~~results; and~~ obtained from above analysis.~~
- Aa description of the Phase 2 scoping process, if necessary.

~~in anticipation of a formal Instream Flow Incremental Methodology (IFIM) scoping meeting. The IFIM is a structured evaluation and decision-making process involving multiple scientific disciplines and stakeholders, in the context of which PHABSIM studies are usually designed and implemented. Critical stakeholder concurrence on study scope, design elements, and overall adequacy for decision-making is one of the principal objectives of IFIM scoping (Bovee et al. 1998).~~

~~If additional field data is judged to be required after formal Phase 1 scoping, hydraulic data may be collected using a combination of transect-based, one-dimensional and area-based, two-dimensional (2-D) techniques. The low-gradient nature of the study area, combined with the complex hydraulics created by the presence of gravel bars and~~

~~mid-channel island complexes, present a set of conditions where the use of 2-D hydraulic model may be logistically and economically feasible. Additional data collection under Phase 2 would be conducted according to standard, established PHABSIM methods, including reach delineation, macrohabitat delineation (e.g., pool, riffle, island complex, etc.), transect/site selection and placement, flow level determination, depth, velocity, and substrate/cover data acquisition, computer model construction and calibration, species evaluation and WUA computation, and further interpretation and time series analysis. Specific details on techniques for data acquisition and analysis would be contained in a comprehensive Phase 2 study plan. These efforts also would be coordinated with stream channel characterization studies to be completed as part of geomorphologic processes study plan SP-G2.~~

6.0 RESULTS, PRODUCTS/DELIVERABLES AND SCHEDULE

RESULTS AND PRODUCTS/DELIVERABLES

The results of all evaluations, both of existing data as well as any based upon supplemental data collection, will be presented in the form of a ~~Phase 1 draft~~summary report ~~for agency review and comment before the completion of a final Phase 1 report~~as detailed in *Task 3*. ~~Both the~~The summary ~~draft and final~~ report will detail ~~all~~ prior field data collection techniques and methods, ~~all~~ the hydraulic, hydrologic, and habitat suitability data used in the simulations, as well as a discussion and interpretation of the results. ~~Conclusions based upon the analysis that might be helpful to management agencies for developing future mitigation or enhancement measures also will be included.~~If additional data collection is deemed necessary, the summary report will provide a complete description of the Phase 2 scoping process.

~~As necessary, supplemental information would be developed under a Phase 2 study plan.~~

SCHEDULE

It is anticipated that the Phase 1 Summary Report will be completed by September 2002. If Phase 2 is necessary, then ~~A~~a schedule for the Phase 2 study plan would be provided once a decision is made regarding ~~the~~ specific need for Phase 2 activities.

7.0 STUDY PLAN COORDINATION

COORDINATION WITH OTHER RESOURCE AGENCIES/STUDIES

~~The proposed PHABSIM study will be used in combination with other proposed environmental studies being conducted under the relicensing process to determine the project effects on fish and aquatic habitat particularly for salmonids. The PHABSIM study may suggest operational changes to the project that could improve or enhance salmonid stocks in the lower Feather River.~~

Examination of existing hydraulic and biological data used in all prior habitat simulations will be coordinated with the appropriate agency personnel, once the studies and personnel have been identified. It is anticipated that contacts with biologists and hydraulic modelers on staff with DWR and/or their consultants will be required.

If Phase 2 is determined to be necessary, ~~I~~it is anticipated that additional field efforts to supplement existing habitat simulations will be made through DWR, CDFG and other biologists and hydrologists currently involved with the relicensing effort. These field studies would be coordinated with other environmental studies being conducted as part of the project relicensing, such as sediment transport, recreation, riparian, and water quality studies. Coordination with NMFS may be required if additional biological data needs to be collected on Feather River stocks of chinook salmon or steelhead.

~~*SP-F1 – Effects of Project on Non-fish Aquatic Resources*~~
~~The evaluation of the project effects upon lower Feather River non-fish aquatic resources study plan may provide information useful to Task 1 of the PHABSIM study plan. The scope of the SP-F1 evaluation is currently under development. Specific information sharing between SP-F1 and SP-F16 will be further identified in the final study plans.~~

~~*SP-F2 – Effects of Project Operations on Fish Diseases*~~
~~It is anticipated that the evaluation of fish diseases would refer to information generated by the PHABSIM study plan for consideration of disease conditions relative to physical habitat characteristics, particularly flow-temperature considerations. Additional coordination to identify specific information-sharing needs is underway and will be reported in the final study plan.~~

SP-F3.2~~3~~ – Evaluation of Project Effects on Resident Fish and Their Habitat in the Feather River Downstream of the Fish Barrier Dam
~~The Feather River resident fish life history and habitat requirements information compiled for the SP-F3.3 study plan will be used to supplement information for the SP-F16 study plan. Additionally, h~~Habitat characterization information generated under SP-F16 will be shared for evaluation of impacts in SP-F3.2~~3~~.

SP-F10 – Project Impacts on Anadromous Fish and their Habitat
The Feather River anadromous salmonid life history and habitat requirements information compiled for the SP-F10 study plan will be used to supplement information for the PHABSIM evaluation. In turn, results from SP-F16 will be instrumental in the evaluation of the various components of SP-F10.

~~*SP-F20 – Evaluation of Project Effects on the Upstream Migration of Adult Anadromous Salmonids in the Feather River*~~
~~Physical habitat characteristics (e.g., critical riffle-passage relationships) determined and provided by SP-F16 will be important in the evaluation of project effects on upstream migration of adult anadromous salmonids.~~

~~*SP-F21 – Project Effects on Predators of Feather River Anadromous Salmonids*~~
~~The physical habitat characterization generated through the PHABSIM study plan tasks will be provided for consideration in the evaluation of project effects on predators.~~

Other Environmental Work Group Study Plans
This study plan will require coordination with those individuals responsible for collecting temperature and project operation data, performing biological surveys, and condiucting hydraulic and channel morphology studies, as well as with the GIS Work Group to obtain base mapping and additional resource layers to provide graphical representation of the lower Feather River and physical habitat characteristics. ~~Coordination among environmental work group study plan authors has been initiated~~ It is essential to determine appropriate links and abilities to share information, thereby minimizing duplication of efforts and reducing overall costs of study plan implementation. In addition to the preliminary links with fisheries study plans, identified above, completion of SP-F16 also will rely on information generated by water quality study plans (water temperature) and geomorphic processes (river channel substrate characterization, incipient motion analysis, channel geometry).

~~Additionally, it is expected that completion of this study plan would involve coordination with the GIS Work Group to obtain base mapping and additional resource layers to provide graphical representation of the lower Feather River and physical habitat characteristics.~~

Engineering and Operations Work Group Study Plans
Results from hydrologic and temperature modeling studies prepared by the Engineering and Operations Work Group will be used to characterize existing and anticipated project hydrologic and water temperature conditions, and will serve as input to the PHABSIM evaluation.

ISSUES, CONCERNS, COMMENTS TRACKING AND/OR COMPLIANCE REQUIREMENTS

~~To be provided in final study plan.~~
ISSUES, CONCERNS, COMMENTS TRACKING AND/OR COMPLIANCE REQUIREMENTS

Issue Statements Addressed by the *Evaluation of Project Impacts on Instream Flows and Fish Habitat (PHABSIM)* Study Plan.

Issue	Description
FE9	Use Instream Flow Incremental Methodology (IFIM) or a comparable methodology to determine stream-flow needs to ensure that trout habitat quality and quantity are not reduced within project area and/or project affected areas.
FE15	Develop and maintain a balanced fishery.

Issue	Description
FE32	Ongoing studies in the lower Feather River include adult and juvenile steelhead snorkel surveys and a habitat inventory, beach seine surveys to determine the temporal and spatial rearing extent of juvenile steelhead and salmon, rotary screw trap sampling of Chinook salmon to monitor the timing and number of emigrants, Chinook egg survival studies, particularly in the low-flow channel, Chinook spawning escapement surveys, redd de-watering and juvenile surveys in the Lower Reach, effects of water temperatures on juvenile steelhead rearing, steelhead creel surveys to gather adult steelhead life history data, and invertebrate research;
FE34	Is additional Physical Habitat Simulations modeling (PHABSIM) necessary to determine what streamflows are necessary for spawning and rearing steelhead and fall, late-fall, and spring-run Chinook salmon in the low-flow section and in the river downstream of Thermalito Afterbay;
FE35	Is riparian vegetative cover in the low-flow section and in the river downstream of Thermalito Afterbay adequate under present flow conditions for rearing steelhead and fall, late-fall, and spring-run Chinook salmon;
FE37	Under existing conditions, are there adequate amounts of suitable gravel for salmonid spawning in the low-flow section and in the river downstream of Thermalito Afterbay;
FE41	Early on and clearly identify flow rates and temperature requirements downstream of the dam;
FE44	Increase emphasis on steelhead protection and habitat and less on salmon;
FE45	Evaluate salmon numbers;
FE46	Clearly identify species, landowners along river, flow rates and temperature requirements downstream of the dam;
FE53	Are the present project related flow ramping/fluctuation restraints adequately protecting rearing Salmonid species from being stranded in the low-flow section and in the river downstream of Thermalito Afterbay;
FE54	Are the present project related flow ramping/fluctuation restraints adequately protecting Salmonid redds and juveniles, conserving their habitat and forage, and spawning gravel from being scoured out from the low-flow section and from the river downstream of Thermalito Afterbay;
FE55	What engineering or other reasonable and prudent solutions are available that would prevent the interbreeding of fall and spring-run Chinook salmon in the low-flow section of the Father River (migration barrier and/or flow and temperature changes in low-flow section);

Issue	Description
FE56	The Feather River's low-flow reach has historically provided spawning habitat for a cold-water fishery. How have reduced flows to this stream reach affected water temperature and gravel substrate necessary for successful salmonid reproduction?
FE84	Evaluate indicators of hydrological alteration (IHA analysis);
FE86	Adequacy of current ramping rate to protect anadromous salmonids and conserve their habitats and forage. This includes providing a range of schedule of flows necessary to optimize habitat, stable flows during spawning and incubation of in gravel forms, flows necessary to ensure redd replacement in viable areas, and flows necessary for channel forming processes, riparian habitat protection and maintenance of forage communities. This also includes impacts of flood control or other project structures or operations that act to displace individuals or their forage or destabilizes, scours, or degrades habitat;
FE90	Adequacy of current project operating regimes and structures to optimize water quality conditions for anadromous salmonids and their habitats;
FE91	Current condition of habitat potentially impacted by project and alternatives to conserve or enhance anadromous salmonids;
FE95	The lower Feather River provides habitat to support a variety of anadromous fish species including Chinook salmon, steelhead, striped bass, American shad and sturgeon. Potential changes in license conditions could adversely impact habitat supporting these species. Habitat investigations should evaluate the existing quality and quantity of habitat and determine alternative improvements for the various life history needs of anadromous species including flow, water temperature, instream and riparian cover, substrate and spatial area;
FE97	The habitat for fishes in the lower Feather River is affected by the flow releases from the project. Seasonal timing, volume, and rate of release all have an affect on fish habitat conditions. Potential changes in license conditions for flow releases could adversely affect habitat conditions for one or more fish species. Fishery investigations should examine the adequacy of flows for maintaining all life history needs for anadromous and resident species. There should be evaluation of potential for flow improvements in the low-flow section. Fishery investigations should be sufficient to determine how best to meet the combined needs of the various anadromous and resident fish species;
FE98	Fish passage is an essential survival element for anadromous species and obstructed passage can also have serious adverse impact on resident species biodiversity and populations. Both upstream and downstream-unobstructed fish passage below the project should occur. Fishery investigations should examine the adequacy of passage for all species in the reaches of the lower Feather River downstream of the project. Evaluations should cover a sufficient range of flows and include examination of instream pits or gravel ponds;

Issue	Description
G1	Effects of existing and future project operations on natural geomorphic processes. These include physical attributes and functions (e.g., channel morphology, channel stability, sediment transport and deposition, spawning gravel and large woody debris recruitment, habitat diversity) and subsequent effects on biological resources (e.g., aquatic macroinvertebrates, riparian vegetation) in the low-flow section and in the Feather River downstream of Thermalito Afterbay under wet and dry year criteria;
GE3	Alterations in stream hydrology affect the natural fluvial geomorphologic processes of a riverine system. How has the change in magnitude, frequency and timing of peak flows and rates of flow change on the Feather River affected riparian vegetation recruitment in the low-flow reach and immediately downstream of the Afterbay, under wet and dry year criteria;
GE4	Under existing conditions, are bankfull flows frequent enough to maintain channel morphology, sediment transport, habitat diversity and adequate gravels for salmonid spawning and rearing in the low-flow section and in the river downstream of Thermalito Afterbay;
GE5	Under existing conditions, are the moderate winter floods and bankfull flows adequately recruiting the amount of large woody debris needed to maintain adequate salmonid rearing habitat in the low-flow section and in the river downstream of Thermalito Afterbay;
GE20	Indicators of hydrological alteration (IHA analysis);
GE23	Releases that reflect nature cycles benefit biological cycles – how have changes in seasonal release patterns affected fish, invertebrates, and their habitat
W10	Effects of existing and future water releases and operations on water temperatures in the Diversion Pool, Forebay, Afterbay, Oroville Wildlife Area, low-flow section of the river and downstream areas; at the hatchery; for agriculture; and the quality and availability of habitat for salmonids and other aquatic resources.
WE28	Does the increase in river water temperature that results from warmer Thermalito Afterbay releases during the spring, summer, and fall months limit the amount of suitable steelhead and salmon habitat in the river downstream of Thermalito Afterbay;
WE54	Impact of project structures and operations on water quality conditions necessary to sustain anadromous salmonids and their habitat. Adequacy of current project operating regimes and structures to optimize water quality conditions for anadromous salmonids and their habitats.

Source: NEPA Scoping Document 1 and CEQA Notice of Preparation, DWR 2001

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DWR OROVILLE FACILITIES RELICENSING PROJECT
(FERC Project No. 2100)

ENVIRONMENTAL WORK GROUP
DRAFT STUDY PLAN

SP-F21. PROJECT EFFECTS ON PREDATION OF FEATHER RIVER JUVENILE ANADROMOUS SALMONIDS

1.0 INTRODUCTION

The Oroville Facilities, completed in 1968, provide for multiple project purposes including water supply, power generation, flood protection, recreation, and fish and wildlife enhancement. The Feather River Fish Barrier Dam was constructed in the early 1960s (1962 to 1964). Located upstream of the Feather River ~~Fish~~ Hatchery and approximately five miles below Oroville Dam, it is identified as the first impassable salmonid migration barrier on the Feather River (Yoshiyama et al. 1996; California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (USBR) 2000). Since construction of the facilities, most of the spawning activity of spring-run and fall-run chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) has been limited to the section of river referred to as the Low Flow Channel, located downstream of the Fish Barrier Dam (DWR 2001). Besides limiting the extent of Feather River anadromous salmonid distribution, the Oroville Facilities may negatively affect anadromous salmonids indirectly by influencing the abundance and distribution of predator species that feed on juvenile salmonids, potentially increasing predation pressure above natural rates.

Predation by native fish species is a natural phenomenon and should not have a serious population effect on naturally-produced chinook salmon or steelhead in areas where shaded riverine aquatic (SRA) habitat and other types of escape cover are present. Historically, Feather River salmonids co-evolved with ~~its~~ their native predators and developed life-history strategies to avoid predation. However, predation by non-native species and increased predation resulting from artificial in-water structures, restricted geographic distribution, evolutionarily asychronous lifestage occurrence, and loss of instream habitat diversity and complexity may have resulted in imbalances in the predator-prey relationships and community structure in which Feather River anadromous salmonids currently exist.

Artificial structures, such as dams, bridges, and diversions, create shadows, turbulence and eddy pools that tend to attract predator species and create an unnatural advantage for predators. Causes for higher predation risk at these sites may include: (1) disorientation of juvenile salmonids by hydraulics at diversions, bypasses and dam spillways; (2) concentration of juveniles ~~by~~ near fishways and fish screen bypasses; (3) creation of pools above and below dams~~,~~ and at diversions, which provide good habitat for pikeminnows (*Ptychocheilus spp.*) and other predators; and (4) creation of inlets that provide good habitat for nesting colonies of piscivorous birds (e.g., Roby et al. 1998).

Many fish species (pikeminnows~~, *Ptychocheilus spp.*~~; smallmouth bass, *Micropterus dolomieu*; striped bass, *Morone saxatilis*; channel catfish, *Ictalurus punctatus*; northern pike, *Essox lucius*; and walleye, *Stizostedion vitreum*) and some bird species (Caspian tern, *Sterna caspia*; double crested cormorant, *Phalacrocorax auritis*; and California gull, *Larus californicus*) have been cited as active predators of juvenile salmonids (Northwest Fisheries Science Center 2000). Some of these same fish species, such as pikeminnows and striped bass, have been ~~mentioned~~ identified as potential predators of juvenile salmonids ~~at various projects~~ in the Sacramento and San Joaquin river basins (CALFED 2000). ~~Moreover,~~ P~~p~~ikeminnows and striped bass also are known to be present in the Oroville project area and downstream areas influenced by the project (DWR 2001). However, little is known ~~on~~ about the project effects on these predators, ~~and on the~~ or about juvenile anadromous salmonid predation losses ~~to predation~~ in the Feather River downstream of the Feather River Fish Barrier Dam.

2.0 OBJECTIVES

The study plan objective is to evaluate the effects of ongoing and future Oroville Facilities operations on predation of Feather River juvenile anadromous salmonids.

~~The study plan objectives are to:~~

- ~~Identify and evaluate likely direct and indirect effects of the Oroville Facilities on the abundance and seasonal and geographic distribution of predators of Feather River anadromous salmonids;~~
- ~~Provide a preliminary assessment of the impact of predation mortality on population dynamics of Feather River anadromous salmonids associated with the Oroville Facilities; and~~
- ~~Provide a preliminary list of alternatives for predator control and management in order to protect, maintain and/or enhance Feather River anadromous salmonid populations.~~

3.0 RELATIONSHIP OF THE STUDY PLAN TO RELICENSING ~~PROJECT PROCESS~~/ NEED FOR THE STUDY

Lake Oroville facilities and operations may impact the abundance of predators and susceptibility of juvenile anadromous salmonids in the lower Feather River. ~~Information pertaining to fish and wildlife in the vicinity of a project is required for an~~in the Application for ~~a~~ License to the FERC ~~for a major hydropower project~~s~~.~~ Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the application to Federal Energy Regulatory Commission (FERC) for licensing of major hydropower projects, including discussions of the fish, wildlife and botanical resources in the project study area. The discussion needs to identify the impacts of the project on those resources, and describe any anticipated continuing impacts related to future project operations. The results of this study plan will be used to describe the existing conditions and effects of the Oroville Facilities project operations upon the predators and predation pressures affecting Feather River juvenile anadromous salmonids. ~~This study is designed to provide~~

~~general information on predators of Feather River salmonids, and on the potential effects of Oroville Facilities project operations on predation of juvenile salmonids.~~

Although data characterizing the study area, and data on the distribution, habitat use, and abundance and emigration timing of juvenile anadromous salmonids and other fish have been collected by DWR and the California Department of Fish and Game (CDFG), most of this information has not been gathered with the expressed objective of evaluating the impact of predation on Feather River anadromous salmonids. ~~Neither have t~~These data have not been processed and evaluated in conjunction with results of predation studies performed in other river basins to provide an assessment of likely impacts of predation mortality on the population dynamics of Feather River anadromous salmonids that may be associated with construction and operation of the Oroville Facilities.

Some of the information needs relevant to the Oroville relicensing process and Endangered Species Act consultation information requirements that will help achieve the objectives of this study include:

- Identification and distribution of juvenile anadromous salmonid predators in the lower Feather River;
- Impacts of predator on juvenile anadromous salmonids;
- Assessment of project facilities and operations impacts on the predator-prey relationship of juvenile anadromous salmonids in the lower Feather River;

~~This study is to will perform a reconnaissance-level or desktop study based on available information including study reports, scientific papers, biological opinions, past surveys and other miscellaneous information such as documents related to other relicensing efforts, results from simulation models, maps and/or newspaper articles, to provide a preliminary assessment of the impact of predation mortality on the population dynamics of Feather River anadromous salmonids. Analysis of available information will be augmented by site-specific field studies. This study will help to meet the objective of identifying and evaluating project-related effects that increase predation pressure on salmonids beyond natural or expected rates. Such an assessment will contribute to the identification of potential alternative protection, maintenance and enhancement (PM&E) measures for Feather River anadromous salmonids.~~

This study should complement the assessments of project-related effects on the populations of anadromous salmonids downstream of Lake Oroville. These other assessments and the present study will be important for the evaluation of potential direct, indirect and cumulative effects of the Oroville Facilities required to comply with Endangered Species Act (ESA) consultation information requirements. Such an assessment will contribute to the identification of potential alternative protection, maintenance and enhancement (PM&E) measures for Feather River anadromous salmonids.

4.0 SCOPE – STUDY AREA

The geographic scope of this study will include those areas of the Oroville Facilities FERC project boundary containing anadromous salmonids and the section of the lower Feather River potentially affected by project operations. The proposed study area extends from the Feather River Fish Barrier Dam downstream to Honcut Creek.

5.0 GENERAL APPROACH

This study will consist of a review, comparison and assessment of available information on the potential impact of project operations on predation of juvenile anadromous salmonids in the lower Feather River, and of a radio-tag study experiment to track pikeminnow and striped bass to evaluate the potential effectiveness of controlling pikeminnow and striped bass by releasing cool water (≤ 60°F) in the Low Flow Channel. The study will provide an assessment of the impact of predation mortality on population dynamics of Feather River anadromous salmonids resulting from the Oroville Facilities. The study plan is structured as a seven-task study~~ (see tasks below)~~. The first two tasks will consist of literature reviews to gather information on potential predators and their life ~~history~~histories, distribution and predator-habit characteristics, as well as on predation experiments to measure consumption rates and predation modeling efforts. The third and fourth tasks will characterize the study area in terms of their fish and environmental components (this information will be obtained from other fisheries study plans, including SP-F10, SP-F3.~~3~~ 2 and SP-F16). They will be mostly based on the review and assessment of past and current survey efforts in the study area. The fifth task will evaluate the information gathered in the previous tasks to produce preliminary estimates of juvenile salmonid losses to predation attributable to the construction and operation of the Oroville Facilities. In contrast with tasks 1 through 4, the sixth task will consist of a radio-tag field experiment specially designed to track pikeminnow and striped bass to evaluate the potential effectiveness of controlling pikeminnow and striped bass by releasing cool water (≤ 60°F) in the Low Flow Channel. If the~~se~~ field assessments ~~show~~ indicate significant project effects, Task 7 will be conducted to provide a list of alternatives for predator control and management.

The desktop study will include the following tasks:

(1) Inventory likely predators of Feather River anadromous salmonids;

(2) Review of predation impact on anadromous salmonids in other river basins;

(3) Describe the abundance and distribution of Feather River juvenile salmonids and resident fish (to be obtained from fisheries study plans SP-F~~3.3~~3.2, SP-F9, and SP-F10);

(4) Determine and describe in-stream habitat characteristics from the Feather River Fish Barrier Dam downstream to Honcut Creek (information to be provided primarily by SP-F16, and also by SP-F~~3.3~~3.2, SP-F9, and SP-F10);

(5) Assess likely responses of predators to the construction and operation of Oroville Facilities;

(6) Confirm occurrence of a Reduced Predation Zone and assess potential effectiveness of predator control by managing water temperatures in the Low Flow Channel; and

(7) Review and assess alternatives for predator control and management.

METHODOLOGY AND ANALYSIS

Task 1 – Inventory Likely Predators of Feather River Anadromous Salmonids

~~Many fish species, including pikeminnow, striped bass, smallmouth bass, channel catfish, northern pike and walleye have been cited as active predators of juvenile salmonids (Northwest Fisheries Science Center 2000, CALFED 2000). The list of known predators of juvenile salmonids also includes some bird species, such as Caspian tern, double-crested cormorant and California gull.~~

~~This task is envisioned as a~~A general literature review will be performed to identify potential predators of Feather River anadromous salmonids and describe main characteristics of their life cycle, distribution, habitat requirements and predator feeding habits.

Contingent on the information available, this review will include the following topics:

- Temporal and geographic distribution of predators;
- Habitat requirements of predators by life~~cycle~~ stage (habitat types, preferred water temperatures, flow levels);
- Association of predators to physical facilities or habitat conditions created by project operation (instream obstructions and diversions, unusual flow or water-temperature patterns);
- Predator diet by size or age group;
- Life history of predators (spawning, juvenile rearing and migration timing ~~times~~, life-span, growth, mortality); and
- Predators, competitors, parasites and diseases of predators of juvenile salmonids.

Task 2 – Review of Predation Impact on Anadromous Salmonids ~~of~~ in Other River Basins

Many project-relicensing efforts have produced system-wide studies on the significance of predation on juvenile salmonids in California (e.g., Garcia 1989; Houck et al. 1995) and other states (e.g., Shively et al. 1991). These studies not only identified potential predators but also produced estimates of losses to predation that fed on results from predation experiments to measure consumption rates and on modeling. This section will review scientific papers and reports produced to evaluate consumption rates, patterns of prey selection by predators and to model losses to predation.

Contingent on the information available, this review will include the following topics:

- Inventory of estimated rates of gastric evacuation of potential predators of juvenile salmonids;
- Review of food habits, rate of consumption, daily ration, and feeding activity of potential predators of juvenile salmonids;
- Inventory patterns of prey selection by predators as function of time, reservoir or project affected areas, and water-temperature and flow levels; and
- Review methods and/or models used to generate estimates of juvenile losses to predation.

Task 3 – Describe the Abundance and Distribution of Feather River Juvenile Salmonids and Resident Fish

This task will review historical and newly acquired information on the abundance, and temporal and geographic distribution of juvenile chinook salmon and steelhead, and of resident fish that may constitute potential predators. These abundance and distribution data will be integrated with the information evaluated in Tasks 1, 2 and 4 to assess the responses of predators of juvenile salmonids to the construction and operation of the Oroville project. The review will include:

- Information on abundance and emigration timing of juvenile salmonids and other species coming from DWR-ESO operation of rotary screw traps, fyke traps and seining started in 1996 (to be obtained from SP-F10);
- Information on distribution and habitat use of salmonids and other species, from the DWR-ESO study began in ~~S~~spring of 1999 that utilizes snorkeling observations (to be obtained from SP-F10);
- Results from the tethering study conducted by DWR in summer of 1999 to measure the frequency of predator attacks on live tethered bait fish;
- All information from reports and fish surveys performed by CDFG or other agencies (e.g., Painter et al. 1977); and
- Information from creel census conducted in the study area (to be obtained from ~~SP-F17 and~~ recreation work group studies).

Contingent on the information available, this review will include the following topics:

- Assessment of juvenile salmonid abundance in the Feather River;
- Assessment of juvenile salmonid distribution and emigration timing;
- Assessment of potential predators of juvenile salmonid abundance in the Feather River;
- Assessment of the distribution and timing of potential predators of juvenile salmonid abundance in the Feather River; and
- Description of water temperatures, flows and habitat-type preferences associated with the presence of juvenile salmonids and their potential predators in the Feather River.

Task 4 – Determine and Describe In-Stream Habitat Characteristics from the Feather River Fish Barrier Dam Downstream to Honcut Creek

Predation by pikeminnow, striped bass and other species is often greater near instream obstructions and diversions where unusual flow patterns disorient or concentrate smolts. ~~Moreover, t~~The effects of environmental stressors such as elevated water temperature in rearing habitats can affect the swimming performance and schooling behavior of juvenile anadromous salmonids~~ and make~~making them more susceptible to predation. Water temperature also can affect predator distribution and trophic behavior (e.g., rate of consumption, daily ration, and feeding activity).

The evaluation of likely responses of predators on juvenile salmonids due to Oroville Facilities project operations will require a reliable determination of the habitat available to juvenile anadromous salmonids and their potential predators in the reach extending from the Feather River Fish Barrier Dam downstream to Honcut Creek. The characteristics of these available habitats, such as distribution of potential refugia, water temperature and flow levels, at the sites and times of chinook salmon and steelhead juvenile presence, may attract or detract potential predators such as pikeminnow or striped bass. Descriptions of existing habitat characteristics and assessments of potential project effects upon these attributes will be obtained from other fisheries, terrestrial, water quality and geomorphology study plans including, but not limited to SP-F10, SP-F3.~~3~~2, SP-F16, SP-G2, and others.

This task involves review of past and present habitat information including cartographic information (e.g., aerial photographs and topographic maps), and data from water temperature and flow monitoring surveys. The review also will incorporate results from other Oroville Facilities Relicensing Project study plans. The performance of this task also will require coordination with GIS mapping and the Engineering and Operations Work Group. A base map of the study area, with all tributary streams, dams and water diversions, and habitat types (backwaters, side channels, riffle pools) will be initially required. At the end of the study, the GIS mapping group will receive all study results required to generate maps showing the general distribution of main predators of Feather River juvenile salmonids and sites with potential significant predation pressure on juvenile salmonids. Water temperature and flow model outputs will be required from the ~~DWR~~ Engineering~~/~~ and ~~Ops~~ Operations Work group.

Contingent on the information available, this review will include the following topics:

- Review of available aerial photographs and topographic maps of the area between Feather River Fish Barrier Dam downstream to Honcut Creek to describe channel characteristics, backwaters, side channels, riffles, pools, potential stable sections of the river, and diversion canals or pipes that could be accessed by juvenile salmonids (information to be coordinated with other environmental study plan efforts, including geomorphology, water quality, and other fisheries efforts, particularly SP-F16);
- Review of photographs, water elevation records and other observations;
- Synthesis and description of available information on monthly and daily flow-fluctuations in the area between the Feather River Fish Barrier Dam and Honcut Creek~~-~~; and

- Synthesis and description of available information on monthly and daily mean water temperatures in the area between the Feather River Fish Barrier Dam and Honcut Creek.

Task 5 – Assess Likely Responses of Predators to the Construction and Operation of Oroville Facilities

This task will assess the main results gathered in Tasks 1 through 4 to provide an evaluation of likely responses of potential predators of juvenile anadromous salmonids to the construction and operation of the Oroville Facilities project. Providing that potential predators (Task 1) are found to coexist with concentrations of juvenile anadromous salmonids at sites with water temperatures and flows that do not prevent their activity (Tasks 3 and 4), the predation rates (Task 2) will be applied to the abundance estimates (Task 3) to produce estimates of juvenile losses to predation. Contingent on the information available, the estimation of juvenile losses to predation may consist of very simple calculations, or may involve some simulation modeling.

In a predation model, loss of juvenile salmonids to predators during a year will be calculated as the product of predator number and prey consumption rate (obtained from Task 3 and Task 2, respectively). Separate calculations of loss will be made for each predator species, predator size class, reach within the study area and month. Total loss will be estimated as the sum of the cell specific loss estimates. Prey consumption rate for each combination of predator species, predator size-class, reach, and month will be projected as a function of prey abundance and water temperature (obtained from Task 3 and Task 4, respectively).

Task 6 – Confirm Occurrence of a Reduced Predation Zone and Assess Potential Effectiveness of Predator Control by Managing Water Temperatures in the Low Flow Channel

Mean summer water temperatures measured since late 1995 at the USGS Gage Station located 0.4 mile downstream from the Thermalito Diversion Dam (River Mile 67.3) have generally been less than 65°F for juvenile steelhead management. From August 1 through the end of August, mean water temperature remains around 60° ± 1°F~~,~~. ~~and f~~From September 1 through October 31, mean water temperature decreases and generally remains below 55°F~~,~~. These water temperatures are in compliance with the 1983 agreement between DWR and CDFG, *Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish and Wildlife*. This agreement states that the water supply for the Feather River Fish Hatchery must meet the following water temperature objectives:

Period	Temperature (^oF)
April 1 – May 15	$51^o \pm 4^o$
May 16 – May 31	$55^o \pm 4^o$
June 1 – June 15	$56^o \pm 4^o$
June 16 – August 15	$60^o \pm 4^o$
August 16 – August 31	$58^o \pm 4^o$
September 1- September 30	$52^o \pm 4^o$
October 1 – November 30	$51^o \pm 4^o$
December 1 – March 31	55°

The water temperatures recorded at the USGS gage station and at Robinson Riffle show~~s~~ that during the summer, water temperatures markedly increase downstream of the Fish Barrier Dam. Water temperatures downstream at Robinson Riffle, located 2.6 mile upstream of the Thermalito Afterbay River Outlet (River Mile 61.6), were as much as 5°F warmer than those at the USGS gage during summer 2000 (DWR 2001). Water temperature ranged as high as 66.1°F in early August, and did not cool to less than 60°F until September 1. Water temperatures uniformly less than 56°F were not achieved until late September.

Juvenile steelhead rearing occurs all year long. Snorkel surveys in 1996, 1998, and 1999 showed that steelhead juveniles rear along the margins of the channels under riparian cover and in secondary channels with riparian cover within the Low Flow Channel (DWR and USBR 2000). Water temperatures below 65°F have been suggested as suitable for steelhead juvenile rearing (DWR and USBR 2000).

Predators of juvenile salmonids in the lower Feather River include Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass. Sacramento pikeminnow has been rarely found in waters of less than 59°F (Moyle 1976). Optimum ~~spawning~~ water temperatures for adult striped bass spawning range between 60 and 68°F (Moyle 1976).

Recent surveys show that during summer, juvenile steelhead rearing activity is most frequent within three miles downstream of the Fish Barrier Dam, within the upper end of the Low Flow Channel (DWR, *unpublished data*; T. Sommers, DWR, *pers. comm.*). However, rearing activity is very scarce within the lower end of the Low Flow Channel, in proximity of the Thermalito Afterbay River Outlet, despite the presence of well-vegetated side channels in the area. It has been suggested that this pattern of occupied juvenile summer rearing habitat is the result of the warmer summer water temperatures, indicated by the water temperature readings at Robinson Riffle, on the distribution and predation activity of pikeminnow and striped bass. Because water temperatures in the rearing habitat close to the Fish Barrier Dam and the USGS gage remain around 60°F during August to meet the temperature objectives of the 1983 agreement between CDFG and DWR, it has been suggested that pikeminnow~~s~~ and striped bass would either actively avoid the area or reduce their metabolic rate, and consequently their predation rate. The upper end of the Low Flow Channel would then behave as a Reduced Predation Zone (RPZ), and juvenile salmonids would concentrate within the RPZ. Similarly, the almost 5°F warmer summer water temperatures at Robinson Riffle would increase predation risk at the otherwise suitable juvenile steelhead rearing habitat of the lower end of the Low Flow Channel and, thus,

juvenile steelhead would avoid the area. Therefore, it has been suggested that if summer water temperatures of 60°F extended downstream to Robinson Riffle, the RPZ would be extended, and juvenile steelhead also would rear in the lower end of the Low Flow Channel.

In this task, results from tasks 1 through 4 will be used in conjunction with a radio-tag field study to evaluate the reasons for, and the potential effectiveness of, a RPZ based on water temperature management objectives of 60°F. Information obtained from previous tasks such as the habitat requirements of Sacramento pikeminnow and striped bass (*Task 1*), and abundance and distribution of juvenile steelhead, adult pikeminnow and striped bass on the Feather River Low Flow Channel (*Task*s *3* and *4*) will help design the field experiment by suggesting locations and times for collection of pikeminnow and stripped bass to be tagged. The field experiment will consist of the tracking of radio-tagged pikeminnow and striped bass released from locations within and outside the RPZ to evaluate whether:

(1) Pikeminnow and striped bass actively avoid the RPZ waters, with temperatures of 60°F or less during August and September;
(2) Pikeminnow and striped bass behaviorally regulate internal temperature through selection of warmwater refugia; and
(3) Pikeminnow and striped bass consumption rates decrease with ambient temperatures below 60°F.

During late July, pikeminnow and striped bass either collected from the other Fish Study Plans referenced in Task 3, or captured by angling at sites selected from the information stemming from Tasks 3 and 4, will be anaesthetized, measured and weighed, and a temperature-sensitive radio transmitter inserted into the stomach of each fish. The characteristics of the radio transmitter used and the insertion procedure will be similar to those described in Berman and Quinn (1991). After transmitter insertion, fish will remain in a live box until equilibrium is regained. Then they will be transferred to a net pen and held for 24 hours to ensure complete fish recovery ~~by the fish~~ and ~~functioning of the~~ transmitter function. The radio-tagged fish will then be separated into two equal groups of approximately 30 fish per species. One group of fish, the control fish, will be released at approximately the same site at which they were caught. The other group, which will constitute the treatment or experimental fish, will be released proximate to the Fish Barrier Dam in waters about 60°F, within the three-mile hypothetical RPZ. Upon release in early August, individual control and experimental fish will be monitored for internal temperature and movement within the Low Flow Channel until the end of September. Once a fish is located, a digital thermograph will be used to monitor external water temperature in the vicinity of the tracked fish. The position of the fish and descriptive habitat information also will ~~also~~ be collected at that time. ~~In addition,~~ D~~d~~aily mean water temperature at the USGS g~~G~~age s~~S~~tation (RM 67.3) and at Robinson Riffle (RM 61.6) will be recorded throughout ~~during the extent of~~ the experiment (August and September) to provide the potential range of water temperature that tagged fish might experience.

The field radio tagging and tracking experiment will be accompanied by seining at various sites within the Low Flow Channel from August 1 through September 30 under the SP-F10 study plan. Seining will provide data to assess relative abundance and distribution of juvenile steelhead and their predators during the months of the radio tagging experiment. All

pikeminnow and striped bass captured during seining will be measured and weighed. Their guts will be weighed and their contents quantified by species. Water temperature at the seining site will be recorded. This information will be used to estimate the parameters of a consumption index (CI) equation similar to the one used by Petersen et al. (1991) for northern pikeminnow, or as input to other equations describing consumption rates as function of water temperature found during the literature review (Task 2).

Plots of the observed ambient and internal temperatures and locations for each experimental and control fish during the whole tracking period will be individually analyzed in search of evidence for an active avoidance of warm waters by the experimental fish. Overall statistics depicting the behavior of experimental and control fish, such as average difference between ambient and internal temperatures, average distance traveled and average travel direction, will be calculated and tested for statistical significant differences between the two groups of tagged fish using general two-sample hypothesis testing approaches (e.g., ANOVA, t-test) to infer active avoidance of the RPZ or active search for warm water refugia by pikeminnows.

Species-specific plots of internal fish temperature (T_{int}) as a function of ambient river temperature (T_{amb}) will be built using temperature records from control and experimental fish. Linear regression fitting procedures will be used to estimate the parameters of the model $T_{int.} = \alpha + \beta\ T_{amb}$. A significant difference between the model predictive line and the line $T_{int.} = T_{amb}$ will suggest that pikeminnow and striped bass behaviorally regulate internal temperature through selection of warmwater refugia. Also, the CI equation obtained from the seined pikeminnow and striped bass will be used to estimate consumption rates for the tracked fish and infer changes due to water temperature.

Task 7 – Review and Assess Alternatives for Predator Control and Management

If the results of tasks 5 indicate that substantial losses of juvenile anadromous salmonids to predation occurs in the study area, a review and assessment of potential alternatives for predator control and management will be performed. This task includes review of predator control and management actions presented in scientific papers, restoration plans, biological opinions and other documents related to FERC project licensing efforts. The available information will be evaluated in terms of its suitability to the Oroville Facilities project, and implementation feasibility. The envisioned outcome includes a list of most likely predator control and management options, which may include one or all of the following:

- Changes in habitat characteristics, including water temperature;
- Bounty fisheries on potential predators;
- Use of chemical fish control agents;
- Use of biological fish control agents; and
- Prevention of new fish introductions.

6.0 RESULTS, PRODUCTS/DELIVERABLES, AND SCHEDULE

RESULTS

The results from this study will provide a list of likely predators of salmonids present in the study area, and preliminary evaluations of likely direct and indirect effects on the abundance, seasonal distribution and geographic distribution of predators, and of likely impacts of salmonid predators on the population dynamics of Feather River anadromous salmonids that may have resulted from the construction and operation of the Oroville Facilities. If these assessments indicate significant adverse project effects, a literature review will be conducted to provide a preliminary list of alternatives for predator control and management.

Results will be organized following the task headings. Each task will include a narrative of the relevant findings as well as tables, figures and maps summarizing the key points. After the results of the seven individuals tasks are presented, the relationships among the findings of the seven sections will be identified to provide general answers to the main questions of the study. The primary issues of the study and the likely ways to link the study findings of the seven individual tasks to address them are listed below.

- Likely direct and indirect project effects on the abundance and seasonal and geographic distribution of predators of Feather River anadromous salmonids (Tasks 1, 3 and 4);
- Assessment of the project impact on predation mortality of Feather River anadromous salmonids (Tasks 1 - 5);
- Assessment of potential effectiveness of controlling pikeminnow and striped bass by releasing water below 60°F (Tasks 5 and 6); and
- Preliminary list of alternatives for predator control and management (Tasks 5 and 7).

The anticipated maps, graphical representation of reviewed data (e.g., charts, and graphs) and summary figures and tables are identified below. Information used to compile these representations will be obtained through coordination with other environmental study plans.

- Figure summarizing lifecycle periodicity for identified primary predators of Feather River juvenile anadromous salmonids;
- Tables summarizing main habitat suitability characteristics for identified primary predators of Feather River juvenile anadromous salmonids;
- Tables summarizing feeding habits of identified primary predators of Feather River juvenile anadromous salmonids;
- Maps showing the general distribution of identified primary predators of Feather River juvenile anadromous salmonids;
- Tables summarizing key topographic, hydrologic and operational characteristics of the area extending from the Feather River Fish Barrier Dam to Honcut Creek;
- Topographic maps of the area extending from the Feather River Fish Barrier Dam to Honcut Creek, including diversions and other non-project facilities, showing contours of

the water level during periods of minimum and maximum flow, and sites of potential influence on predators and predation pressures for juvenile anadromous salmonids;

- Topographic maps of the study area extending from the Feather River Fish Barrier Dam to Honcut Creek, including diversions and other non-project facilities, showing average water-temperature contours (isoclines) for the period of chinook salmon and steelhead juvenile emigrations, and sites of potential influence on predators and predation pressures for juvenile anadromous salmonids;
- Time-series plots of observed ambient and internal temperatures, and locations for tracked pikeminnow and striped bass;
- Summary tables describing main results and conclusions of tracking experiment;
- Plots of internal fish temperature as function of ambient river temperature for pikeminnow and striped bass; and
- Table summarizing and comparing the attributes of feasible predator control and management alternatives.

PRODUCTS/DELIVERABLES

The study plan summary report will include:

- Executive Summary
- Table of Contents
- List of Tables
- List of Figures
- Introduction
- Narratives of relevant findings by task
- Discussion addressing most relevant questions (see above) and indicating any complications/data concerns
- Conclusions related to study plan goals and objectives
- ~~Recommendations~~
- References
- Appendices

SCHEDULE

The results of the tasks performed under the study plan will be presented in a summary report. It is anticipated that a final report will be completed by December 2003.

Regulatory reporting requirements, and the report distribution procedure and list, will be indicated at least four months before the completion of the final report. By that time, the agency review and approval requirements will be determined. Some of the tables and maps that may constitute part of the report attachments or appendices were indicated in previous sections.

7.0 STUDY PLAN COORDINATION

COORDINATION WITH OTHER RESOURCE AREAS/STUDIES

It is anticipated that this study will require coordination with those individual responsible for collecting temperature and project operation data, performing biological surveys, and hydraulic and channel morphology studies. Contact with CDFG and USGS also are expected.

Given the nature of the tasks of this study, coordination with work groups directing and conducting other studies relevant to the Oroville Facilities FERC Relicensing Project also will be required. A preliminary list of study plans that will be related to the development of the present study are discussed below.

SP-F3.2~~3~~ – Evaluation of Project Effects on Resident Fish and Their Habitat ~~with~~in the ~~Lower~~ Feather River Downstream of the Fish Barrier Dam

SP-F3.~~3~~ 2 will characterize the abundance and distribution of Feather River resident fish and their habitat conditions within the lower Feather River. This information may be reviewed and considered in the evaluation of project effects on anadromous salmonid predators present in the lower Feather River.

SP-F5 – Effects of Fishery Management Plans on a Balanced Fishery ~~Fisheries Management Plans - Balanced Fishery~~

The preliminary list of potential alternative protection and maintenance measures for predator control and management identified to protect, maintain and/or enhance Feather River anadromous salmonid populations will be provided for incorporation into SP-F5, which involves evaluation of existing and proposed fisheries management plans, activities and requirements.

SP-F10 – Evaluation of Project Effects ~~Impacts~~ on Anadromous Salmonids ~~Fish~~ and Their Habitat

The SP-F10 study plans will provide the lifestage history and habitat information for anadromous salmonids in the Feather River, including abundance and distribution of juvenile salmonids. This information will be compared to the abundance and seasonal and geographic distribution of predators of anadromous salmonids that occur in the study area, as identified in this study plan (SP-F21), to determine if operational characteristics of the Oroville Facilities contribute to increased or unnatural levels of predation.

~~The information provided by this study plan (SP-F21) also will provide useful information to the assessment of project-related effects on populations of anadromous salmonids downstream of Lake Oroville. In SP-F10, predation will be one of several Feather River characteristics that will be considered. SP-F10 will use the information generated by this and other study plans to describe the interrelationships of project operations, existing biological and physical characteristics of the system, and how these interactions affect the anadromous salmonid populations.~~

SP-F15 – Evaluation of the Feasibility to Provide Passage for Anadromous Salmonids Past Oroville Dam

SP-F15 will provide information regarding potential alternative methods for the passage or transport of adult and juvenile anadromous salmonids past Oroville Dam. Because artificial structures can attract predator species and create an unnatural advantage for predators, this study plan will provide a general discussion of the potential sources of higher predation risk that could be related to potential alternative methods of passage or transport for consideration in the evaluation of feasibility to providing such access past Oroville Dam.

SP-F16 – Evaluation of Project Effects on Instream Flows and Anadromous Salmonid Spawning and Rearing Habitat (PHABSIM)~~Oroville Facilities Relicensing PHABSIM Draft Study Plan~~

SP-F16 will determine and describe in-stream habitat characteristics including project area hydraulics and habitat-flow relationships for the study area (from the Feather River Fish Barrier Dam downstream to the Yuba River).

~~*SP-F17 – Recreational Fishery Survey of FERC Project Waters*~~

~~SP-F17 will provide additional information on the temporal and spatial abundance and distribution of anadromous salmonids, and possibly of predators, in the lower Feather River.~~

~~*SP-F20 – Evaluation of Upstream Migration of Adult Anadromous Salmonids in the Lower Feather River*~~

~~SP-F20 will provide discussion of potential barriers to the upstream migration of adult anadromous salmonids; information related to predator habitat preferences and behavior will be provided as part of the consideration of project effects on lower Feather River conditions.~~

SP-G2 – Effects of Project Operations on Geomorphic Processes Downstream of Oroville Dam

Information obtained from SP-G2 will aide in the characterization of anadromous salmonid and predator habitat conditions and used in the assessment of the influence of these features on the attraction of potential predators.

Terrestrial Resources Study Plans

The list of known predators of juvenile salmonids includes some bird species, such as Caspian tern, double crested cormorant and California gull. Information generated by terrestrial resources study plans regarding the presence of these birds will be reviewed and considered in the evaluation of predator interactions and development of potential management actions to protect juvenile salmonids.

Recreational Resource Study Plans

SP-R_ will potentially provide information on the temporal and spatial abundance and distribution of anadromous salmonids, and possibly of predators, in the lower Feather River.

Engineering and Operations Work Group Studies and Models.

Information generated by the Engineering and Operations Work Group will include details regarding the existing and future anticipated operation of the Oroville Facilities. This information, including water temperature and flow data, will be used in the evaluation of predator populations in the lower Feather River. Additional coordination with this group will be required to obtain information for Task 4 activities involving:

- Synthesis and description of available information on monthly and daily flow-fluctuations in the area between the Feather River Fish Barrier Dam and the Yuba River ; and
- Synthesis and description of available information on monthly and daily mean water temperatures in the area between the Feather River Fish Barrier Dam and the Yuba River.

ISSUES, CONCERNS, COMMENTS TRACKING AND/OR COMPLIANCE REQUIREMENTS

Issue Statements Addressed by the *Project Effects on Predation of Feather River Juvenile Anadromous Salmonids* Study Plan.

Issue	Issue Statement
F16	Effects of existing and future project facilities and operations on the abundance of predators, their seasonal and geographic distribution, the impact of predation mortality on population dynamics of salmonids and other species, and alternatives for predator control and management (including prevention of introductions).
FE22	Prevent Northern Pike from entering Lake Oroville by eliminating them from the licensee's upstream impoundments. If Northern Pike enter Lake Oroville and the Feather River watershed, aggressively address the problem and successfully eliminate the fish.
FE75	Project structures or operations that either have in the past, or continue to introduce predators, create suitable habitat for predators, harbor predators, or are conducive to the predation of salmonids.
FE76	Prevent the introduction of new piscivorous (fish-eating) predators (e.g., northern pike, striped bass, white bass, etc.) introductions to project waters.
FE77	Predation of fish species naturally occurs under all conditions. However, project conditions could exacerbate the occurrence of predation on certain species. Changes in license conditions could lead to an unnecessary increase in predation on desirable gamefish or threatened and endangered species, or other species of concern. Occurrence (habitat, distribution and numbers of predator fish should be identified in all riverine waterways affected by project releases. Predation investigations should be comprehensive, and predator management should be available as a fishery management tool.
FE94	Evaluate the potential impacts of striped bass predation mortality on juvenile chinook salmon and steelhead within the lower Feather River and the effects of project operations on predator–prey interactions, and identify and evaluate alternative methods for controlling and reducing predation mortality by species such as striped bass on juvenile rearing and emigrating salmonids.

Source: NEPA Scoping Document 1 and CEQA Notice of Preparation, DWR 2001.

8.0 REFERENCES

A complete list of references used in the completion of the study will be part of the summary report. The references cited in the present plan are listed below.

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