E - ENVIRONMENTAL RESOURCES

2.0 WATER RESOURCES

2.1 Applicable Laws, Ordinances, Regulations, Statutes and Plans

Water resources in California are protected by a variety of federal, state, and local laws, ordinances, regulations, and statutes. In addition, numerous comprehensive plans and programs have been developed that include detailed policies and guidelines for management of water resources present in the vicinity of the Sacramento Municipal Utility District's (SMUD) Upper American River Project (Project). These laws, ordinances, regulations, statutes, and plans and their application to water resources in the Project area are summarized below.

2.1.1 Eldorado National Forest Land and Resource Management Plan, as Amended

The Eldorado National Forest (ENF) Land and Resource Management Plan (LRMP) is discussed in general terms in Section E1.1.1 of this plan and includes a section on water quality and quantity, and specifically addresses the following ENF question:

> What management practices should be used/modified on the Eldorado National Forest to maintain or improve water quality or quantity?

The ENF LRMP describes three primary methods by which water quality and quantity will be maintained or improved: application of Best Management Practices (BMPs), use of a computer model (FORPLAN) to limit cumulative watershed disturbance, and establishment of streamside management zones (SMZs). The latter is a minimum of 100 feet, but may be increased depending on stream class, slope, and soil stability. The ENF LRMP also addresses watershed rehabilitation and identifies sites that can be economically rehabilitated.

2.1.2 United States Forest Service/State Water Resources Control Board Management Agency Agreement

In conformance with the Clean Water Act (CWA) and National Forest Management Act (NFMA), the United States Forest Service (USFS) and the State Water Resources Control Board (SWRCB) entered into a Management Agency Agreement in 1981. This agreement establishes a system of:

> "…best management practices, or BMPs, for protection of water quality from non-point sources of pollution. A BMP is defined as 'a practice or combination of practices…[which is]… the most effective, practicable… means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals.'"

2.1.3 United States Department of Agriculture/United States Environmental Protection Agency Clean Water Action Plan

The Clinton Administration recently initiated the Clean Water Action Plan (CWAP) to address persistent water quality issues. The new initiative, a joint effort of the United States Department of Agriculture (USDA) and the United States Environmental Protection Agency (USEPA), aims to achieve clean water by strengthening public health protections, targeting community-based watershed protection efforts at high priority areas, and providing communities with new resources to control polluted runoff. Taking a "watershed approach" is identified as a key mechanism for priority setting and taking action. The plan recognizes the role of upper watersheds as sources of clean water for drinking water, fish, and wildlife, and notes that activities such as road building, logging, mining, grazing, hydrologic modification, and excessive recreational use can degrade the integrity of watersheds and require actions to reduce their harm. Actions to increase forest road maintenance and obliteration are specifically mentioned to address problems associated with roads and trails, which are primary sources of sediment runoff on federal lands.

2.1.4 Clean Water Act Section 404 Dredge and Fill Permit

Section 404 of the CWA is discussed in general terms in Section E1.1.2. Section 404 guidelines direct that no permit to discharge, dredge, or fill material shall be granted if it jeopardizes water quality.

2.1.5 CALFED Bay-Delta Program

The CALFED Bay-Delta Program is a cooperative, interagency effort involving over 20 state and federal agencies with management and regulatory responsibilities in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. The CALFED Program does not pertain to relicensing of the Project since, for purposes of the CALFED program, the upper limit of the American River is at Folsom Dam. Implementation of CALFED recommended actions is now in its third phase (implementation of the preferred alternative), and is likely to take place over the next several decades. An overview of this program can be found at the following web site: *http://calfed.ca.gov/general/overview.html.*

2.1.6 Sacramento River-San Joaquin River Water Quality Control Board Basin Plan

The CWA is the most significant legislation regarding water use and quality in the Project area. The CWA requires that the USEPA adopt water-quality standards for surface waters within the United States. These standards consist of designated beneficial uses and water-quality criteria to support those beneficial uses. As provided for in the CWA, the USEPA has assigned administration of the CWA for California waters to the State of California. The Porter-Cologne Water Quality Act is California’s comprehensive water-quality control legislation and designates the Regional Water Quality Control Boards (RWQCBs) responsible for CWA programs.

To meet their requirements under the CWA as well as the Porter-Cologne Water Quality Act, the RWQCBs have prepared and adopted water-quality control plans, also known as “basin plans,” for major California watersheds. These plans consist of: 1) a designation of existing and potential beneficial uses; 2) water quality objectives to protect those beneficial uses; and 3) programs of implementation needed to achieve those objectives. The RWQCBs are required to consider a number of items when establishing water quality objectives, including: 1) past, present and probable future beneficial uses; 2) environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto; 3) water quality conditions that could reasonably be achieved through the coordinated control of all factors that affect water quality in the area; and 4) economics.

The Central Valley RWQCB has developed a basin plan for the Sacramento and San Joaquin River Basins and their tributaries (Basin Plan) that encompasses waters within the Project area (RWQCB 1998). With respect to the Basin Plan, Project facilities lie in the South Fork American River (SFAR) and Middle Fork American River (MFAR) basins. The Basin Plan formally designates existing and potential beneficial uses and water-quality objectives of the SFAR from its source to Placerville, and for the MFAR from its source to Folsom Lake. These segments of the different basins are specifically designated as Hydro Unit Numbers 514.3 and 514.4, respectively. The RWQCB-designated existing and potential beneficial uses for these hydro units are shown in Table E2.1-1.

Beneficial uses that are not identified for these segments of the SFAR and MFAR include industrial service supply, industrial process supply, warm freshwater migration, cold freshwater migration, warm water spawning, and navigation.

RWQCB-designated water-quality objectives to protect the designated beneficial uses are shown in Table E2.1-2. Of the 17 objectives listed, 10 are described narrative form, and as such require professional interpretation in their application (e.g., color). Of the seven objectives for which numerical standards are established, two (water temperature and turbidity) are defined in terms of a point-source discharge and a resultant change in the receiving water body. These two objectives are not directly applicable to hydro projects since a release from a reservoir is not considered a point-source discharge under the CWA.

2.1.7 State Water Resources Control Board Water Right Permits and Licenses

The 1914 California Water Commission Act established a system of state-issued permits and licenses to appropriate water. The Act has been amended over the years and appears in Division 2 of the California Water Code. The Act allows a person to acquire a right to divert, store, and use water regardless of whether that person’s land is adjacent to the stream or within the watershed, provided that the water is used for reasonable and beneficial use and is surplus to water from the same stream used by earlier appropriators. The provisions of the Act place responsibility for administering appropriative water rights with the SWRCB. The Act also provides for adjudication of water rights. The state system of appropriative water rights

Table E2.1-1. Beneficial uses of the Middle and South Forks of the American River in the vicinity of the Upper American River Project, designated by the Central Valley Regional Water Quality Control Board in the Sacramento River and San Joaquin Basin Plan.

Designated Beneficial Use	Description	Middle	South
Municipal and Domestic Supply	Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.	Existing	Existing
Irrigation	Use of water for farming, horticulture, or ranching including but not limited to irrigation, stock watering or support of vegetation for range grazing.	Existing	
Hydropower Generation	Use of water for hydropower generation.	Existing	Existing
Water Contact Recreation	Use of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.	Existing	Existing
Non-Contact Water Recreation	Use of water for recreational activities involving proximity to water, but where there is generally no body contact with water, nor any likelihood of ingestion of water. These uses include, but are not limited to, picnicking, sunbathing, hiking, beach-combing, camping, boating, tide-pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.	Existing	Existing
Warm Freshwater Habitat	Uses of water that support warmwater ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.	Potential	Potential
Cold Freshwater Habitat	Uses of water that support coldwater ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.	Existing	Existing
Cold Freshwater Spawning	Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.	Existing	Existing
Wildlife Habitat	Uses of water that support terrestrial or wetland ecosystems including, but not limited to, preservation or enhancement of terrestrial habitats or wetlands, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.	Existing	Existing

Table E2.1-2. Water quality objectives to support designated beneficial uses of SFAR and MFAR waters in the Project area, as identified in the Basin Plan.

Water Quality Objective	Description
Bacteria for Water Contact Recreation	In terms of fecal coliform: less than a geometric mean of 200/100 ml on five samples collected in any 30-day period and less than 400/100 ml on 10 percent of all samples taken in a 30-day period.
Biostimulatory Substances	Water shall not contain biostimulatory substances that promote aquatic growth in concentrations that cause nuisance or adversely affect beneficial uses.
Chemical Constituents	Waters shall not contain chemical constituents in concentrations that exceed maximum contaminant levels specified in various provisions of Title 22 of the California Code of Regulations. This includes inorganic chemicals , Fluoride, organic chemicals, and others. Waters shall not contain lead in excess of 0.015 mg/l.
Color	Water shall be free of discoloration that causes nuisance or adversely affects beneficial uses.
Dissolved Oxygen	Monthly median of the mean daily dissolved oxygen concentration shall not fall below 85 percent of saturation in the main water mass, and the 95 percent concentration shall not fall below 75 percent of saturation. Minimum level of 7 mg/l.
Floating Material	Water shall not contain floating material in amounts that cause nuisance or adversely affect beneficial uses.
Oil & Grease	Water shall not contain oils, greases, waxes or other material in concentrations that cause nuisance, result in visible film or coating on the surface of the water or on objects in the water, or otherwise adversely affect beneficial uses.
pH	From 6.5 to 8.5, and changes of less than 0.5.
Pesticides	Waters shall not contain pesticides or combination of pesticides in concentrations that adversely affect beneficial uses. Other limits established as well.
Radioactivity	Radionuclides shall not be present in concentrations that are harmful to human, plant, animal, or aquatic life nor that result in the accumulation of radionuclides in the food web to an extent that presents a hazard to human, plant, animal, or aquatic life.
Salinity	Total dissolved solids shall not exceed 125 mg/l (90 percentile). No objectives are identified for electrical conductivity.
Sediment	The suspended sediment load and suspended-sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.
Settleable Material	Waters shall not contain substances in concentrations that result in the deposition of material that causes nuisance or adversely affect beneficial uses.
Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Tastes and Odor	Water shall not contain taste- or odor-producing substances in concentrations that impart undesirable tastes and odors to domestic or municipal water supplies or to fish flesh or other edible products of aquatic origin, or that cause nuisance, or otherwise adversely affect beneficial uses.
Temperature	An increase of less than 5º F (or 3.1 C) above natural receiving-water temperature.
Toxicity	All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by analysis indicator organisms, species diversity, population density, growth anomalies, and biotoxicity tests as specified by the RWQCB.
Turbidity	Where natural turbidity is 0 to 5 NTUs, increases shall not exceed 1 NTU; where 5 to 50 NTUs, increases shall not exceed 20 percent; where 50 to 100 NTUs, increases shall not exceed 10 NTUs; and where natural turbidity is greater than 100 NTUs, increase shall not exceed 10 percent.

functions in conjunction with riparian water rights. Under riparian water rights, owners of land have the right to divert, but not store, a portion of the natural flow of waters flowing past or through their land for reasonable and beneficial use upon their land adjacent to the stream.

2.1.8 Clean Water Act 303(d) List and TMDL Priority Schedule

Section 303 of the CWA requires that every 2 years each state must submit to the USEPA a list of rivers, lakes, and reservoirs in the state for which pollution control or requirements have failed to provide for water quality. No river reaches or Project waters are included on the Revised 1998 California 303(d) List and TMDL Priority Schedule, as shown at the SWRCB's web page on May 12, 2001.

2.1.9 Clean Water Act Section 401 Water Quality Certificate

Section 401 of the CWA requires that all applicants for federal licenses or permits that may result in a discharge of pollutants into waters of the United States must seek water quality certification from the appropriate state. The water quality certification is a determination that any likely discharge will comply with the applicable provisions of the CWA dealing with federal and state water quality standards. As mentioned above, the SWRCB is the administrator of the CWA in California. A water quality certificate was not issued for the current FERC license because the license was issued prior to the enactment of the CWA. Relicensing of the Project, however, will require a water quality certificate.

2.1.10 California Department of Water Resources California Water Plan

While not directly related to relicensing of the Project, the CDWR Water Plan is important in the context of water use for tributaries to the American River. The California Department of Water Resources (CDWR) first published its California Water Plan in 1957. Since then, CDWR has updated the plan six times, most recently in November 1998 as Bulletin 160-98 (CDWR 1998). The CDWR Water Plan predicts that the Sacramento River Region, in which the Project is located, will have a water shortage of over 85,000 acre-feet (ac-ft) in 2020, under normal water year conditions, and a shortage of over 989,000 ac-ft, should 2020 be a dry water year.

2.1.11 California Fish and Game Code Section 1601 Streambed Alteration Agreement

Sections 1600 to 1607 of the California Fish and Game Code are discussed in general terms in Section 1.1.3 of this IIP. With regards to water use and quality, Section 1600 requires that California Department of Fish and Game (CDFG) review and approve any activity that will: 1) divert, obstruct, or change the natural flow or the bed, channel, or bank of any river, stream, or lake in which there is at any time an existing fish for wildlife form or resource, or from which these resources derive benefit; 2) use material from streambeds designated by CDFG; or 3) result in the disposal or deposition of debris, waste, or other material containing crumbled, flaked, or ground pavement where it can pass into any river, stream, or lake designated by CDFG.

2.1.12 Federal Power Act

The Federal Power Act, in particular sections 4(e), 10(j) and 18 of the act, are described in Section E1.1.4.

2.2 Beneficial Uses

Beneficial uses of water in the SFAR as designated in the Basin Plan are described in Table E2.1-1. The applicability of these beneficial uses to the Project area is described below.

2.2.1 Municipal and Domestic Water Supply and Irrigation Water Supply

The Basin Plan identifies municipal and domestic water supply as a beneficial use of water in the American River (north, middle, and south forks). The City of Sacramento is downstream of the Project and depends, in part, on flows in the SFAR for drinking water purposes, and holds consumptive water rights for use of the American River and its tributaries. The City's water rights permits for tributaries of the American River allow "rediversion of stored water released from SMUD's Upper American River Reservoirs."

Upstream of the Project, the El Dorado Irrigation District (EID) combined irrigation and hydroelectric project (FERC Project No. 184) diverts flows of the SFAR, near the community of Kyburz (EID 1999). Up to about 165 cfs of flow in the SFAR is diverted at this point into the El Dorado Canal, a 22.5-mile-long water conveyance system that delivers water to the Project forebay. PG&E (former owner of the EID project) delivered water to EID and its predecessors for consumptive use for nearly 80 years. Based on a 1919 contract, water is delivered at a rate of up to 40 cfs in April through October; up to 20 cfs in March, November and December; and up to 10 cfs in January and February. The maximum annual total volume of water to be delivered is 15,080 ac-ft.

However, an existing agreement between SMUD and El Dorado County (including El Dorado County Water Agency), in general, gives the county the right to divert up to 40,000 ac-ft. (with some exceptions) of water from the White Rock Penstock or Slab Creek Reservoir for irrigation, domestic, municipal, and stock-watering purposes within the county, pursuant to permits the county may obtain from the SWRCB, subject to compensating SMUD for economic loss.

2.2.2 Hydropower Generation

As discussed in Section A of this document (Project Description), the American River Basin supports the UARP, as well as other hydropower generation projects. Hydropower generation is the sole purpose of the Project; as mentioned, there are no consumptive rights. A summary of the water rights permits that govern SMUD's operation of the Project is provided in Table B2.2-1.

2.2.3 Water Contact Recreation

Water contact recreation activities in the Project area include swimming, wading, boating, whitewater activities, and fishing in the river and at the reservoirs. Recreational opportunities and use are discussed in detail in the recreation section of this document (Section E8).

2.2.4 Non-Contact Water Recreation

Non-contact water recreation activities in the Project area include picnicking, sunbathing, hiking, camping, hunting, sightseeing, and aesthetic enjoyment. As with water contact activities, these non-contact activities may occur throughout the area but are most concentrated at developed recreation facilities such as those at Union Valley Reservoir. Recreational opportunities and use are discussed in detail in the recreation section of this document (Section E8).

2.2.5 Warm Freshwater Habitat

While the Basin Plan includes Warm Freshwater Habitat as a potential designated use, the water temperature regime in the Project area supports mostly Cold Freshwater Habitat. Aquatic Resources are discussed in detail in the aquatic resources section of this document (Section E3).

2.2.6 Cold Freshwater Habitat

Streams and reservoirs in the vicinity of the Project support coldwater aquatic species. Rainbow trout is the dominant fish species in the Project area. CDFG regularly stocks Ice House, Loon Lake, and Union Valley Reservoirs, as well as SFAR with salmonids (primarily rainbow trout). Aquatic resources are discussed in detail in the aquatic resources section of this document (Section E3).

2.2.7 Wildlife Habitat

Wildlife habitat exists within the Project area and is discussed in the wildlife resources section of this document (Section E5).

2.3 Water Quality

2.3.1 Overview

A total of five water quality studies were performed between 1980 and 2000 at reservoirs and stream reaches of the Upper American River Project (Table E2.3-1). Data from these and other studies conducted in the Project area provide the existing information base for describing water quality at the Project and the surrounding area. Note that the City of Sacramento does publish annual drinking water reports containing water quality data. However, the Sacramento water supply is a blend of American River, Sacramento River, and groundwater sources. Thus information contained in the City's reports does not directly reflect water quality in the Project area. Also, as required by the California Surface Water Treatment Rule, a sanitary survey has been conducted by eleven water agencies in the American River watershed (Archibald and Wallberg 1988). While the results of the survey provide a substantial amount of data, they have little practical application to a summary of water quality associated with the Project because the focus of the survey is on drinking water standards (mostly contaminant concentrations) at basin-wide water treatment facilities that are located primarily far downstream of the Project.

Table E2.3-1. Water quality studies performed at reservoirs and the Upper American River Project.

Lead Agency/Reference	Description	Period of Record
WESCO 1980	Summer water temperature in South Fork American River below Slab Creek Dam.	July-September 1980
SMUD 1981	Reservoir profile data at Union Valley and Ice House reservoirs	July and September 1980
Ecological Analysts 1982	Reservoir profile data at Loon Lake Reservoir	October 1980
Tetra Tech 2000a[1]	Reservoir profile data at all reservoirs except Robbs Peak Reservoir and spot measurements in stream segments above and below the reservoirs	November 1999
Tetra Tech 2000b[1]	Reservoir profile data at all reservoirs except Robbs Peak Reservoir and spot measurements in stream segments above and below the reservoirs	June 2000

[1] The Tetra Tech water quality reports are considered a single study effort, although separate reports document 1999 and 2000 results.

Based on the information contained in the above-mentioned reports, waters of the Project area (reservoirs and river/stream reaches) can be characterized as cold (generally less than 20° C), clear, and well oxygenated. Project reservoirs are oligotrophic (nutrient poor) waterbodies, typical of the Sierra Nevada (Nicola and Borgeson, 1970; University of California, 1996). Low nutrient levels are to be expected in these waterbodies because the granitic rock covering most of the upper watershed, and the accompanying thin soil layers, are a poor source of nutrients.

Over the course of the water quality studies performed at Project facilities, reservoir temperature measurements during summer statification have ranged between 6°-13° C in the hypolimnion and between 12-22° C in the epilimnion. Water temperatures in the stream and river systems in the Project area exhibit a similar range of values, although water temperatures measured in the lower reaches of the Project area are warmer. Dissolved oxygen (DO) concentrations vary from just over 3 mg/l (bottom of Ice House Reservoir in November 1999) to over 11 mg/l at lower depths in Slab Creek and Camino reservoirs. The pH levels are neutral, or less than 8.5, generally within a range of 6.1 to 7.8.

Specific conductance values were higher in the streams than the reservoir waters. Union Valley Reservoir showed the greatest range of values (between 5 and 60 µS/cm), while Junction Reservoir the lowest (approximately 7 to 12 µS/cm). The minimum conductance was measured in Loon Lake Reservoir during both November 1999 and June 2000 visits. The high clarity of Project waters is reflected in the turbidity measurements, which are typically at or below the detection limit of the instrument (1 to 2 NTUs). Higher turbidity levels (14.5 NTUs) were measured generally after rainfall events, such as the 14.5 NTUs reading in the SFAR upstream of Slab Creek Reservoir that followed such an event. Secchi disk depth at reservoir sites was greatest at the higher elevation reservoirs, as deep as 44 feet at Loon Lake Reservoir in November 1999. The lowest readings were recorded at the relatively shallow Junction Reservoir in November 1999 (9 to 10 feet at three locations) and at Slab Creek Reservoir in June 2000 (11 to 15 feet).

2.3.2 Water Quality in the Project Area

This section describes existing information concerning water quality for each of the Project reservoirs and river reaches, drawing primarily from the data contained in the reports listed in Table E2.3-1. There are no existing water quality data of substantive quantity available for the following Project reservoirs and reaches:

- Rubicon Reservoir
- Rubicon Dam Reach
- Rockbound Lake (non-Project facility)
- Rockbound Dam Reach
- Buck Island Reservoir
- Buck Island Dam Reach
- Robbs Peak Reservoir
- Robbs Peak Dam Reach
- Union Valley Dam Reach

2.3.2.1 Loon Lake Reservoir

Loon Lake Reservoir is one of the three primary storage reservoir in the Project, with a maximum gross storage capacity of 76,200 ac-ft at an elevation of 6,410 feet. Inflowing water to the reservoir is composed of many sources, including outflow of the Buck Island–Loon Lake Tunnel and natural inflow of Ellis and Meadow creeks. Water quality data were collected at the reservoir and the feeder streams in October 1980, November 1999 and June 2000.

In situ water quality data were collected at the mouths of the feeder streams and near the terminus of the Buck Island–Loon Lake Tunnel in November 1999 and June 2000. While limited in scope (essentially covering the days of November 5, 1999 and June 5, 2000), the data, nonetheless, demonstrated that surface water runoff into Loon Lake, such as at Ellis Creek, can rise as high as 21° C in June, while maintaining DO levels of 6.1 mg/l. The coldest inflowing water temperatures were recorded at the tunnel outlet (10° C in November and 11° C in June), along with the highest DO concentrations (9 mg/l in both seasons). Intermediate temperature and DO levels were recorded at the other feeder streams. Specific conductance was low at all of these sites with a range of 8.5 to 16.2 µS/cm. Turbidity at the stream sites was also low, less than 2 NTUs.

In general, limnological investigations at Loon Lake Reservoir reveal a cold, clear, well-oxygenated waterbody. Isothermal conditions were observed in Loon Lake Reservoir in October 1980 and November 1999, with both surveys, separated by 19 years, revealing temperatures of between 11° and 12 ° C. In June 2000, Loon Lake exhibited weak statification at all sampling locations. Maximum surface temperatures were between 13° and 15° C, while minimum temperatures at the bottom of the reservoir were approximately 8° C (reservoir bottom ranged between 45 and 70 feet below the surface). Profiles at the deepest sampling locations (70 feet) showed a broad metalimnion gradually dropping to the low temperatures (8° C) and a poorly defined hypolimnion. Similar results were obtained in a limnological survey performed by the USGS in June of 1996 (USGS website).

Dissolved oxygen concentration in Loon Lake Reservoir was consistent between the November 1999 and June 2000 sampling period, ranging between 8 and 9 mg/l throughout the water column. These results are also consistent with the October 1980 study, which yielded fairly consistent DO levels between 8.4 and 8.9 mg/l across three sampling locations. These concentration levels reveal that Loon Lake is at or near 100 percent saturation. The limnological investigations performed by the USGS in 1996 confirm these findings.

All Secchi disk transparency data that have been collected at Loon Lake Reservoir have revealed excellent water clarity. In 1980 Secchi disk observations noted transparency to a depth of 36 feet. The studies of 1999 and 2000 revealed little change in water clarity over 19 years, with Secchi disk transparency measured between 36 and 44 feet under calm conditions in November and between 25 and 32 feet in June under windy conditions.

Specific conductance, measured only in 1999 and 2000, was very low everywhere, approximately 6 μS/cm in the reservoir and 8.5 to 16.2 μS/cm in the feeder streams. Total dissolved solids (TDS) were also very low and followed a similar pattern – an approximately constant 4.0 mg/l throughout the reservoir and up to three times greater in the streams.

2.3.2.2 Loon Lake Dam Reach

Very limited data are available for this Project reach, the 8.5 mile segment of Gerle Creek between Loon Lake Dam and Gerle Creek Reservoir. *In situ* measurements of water temperature downstream of Loon Lake Dam in June 2000 revealed a temperature of 8° C, equivalent, essentially, to temperatures at depth of 60 feet in the reservoir. This phenomenon was identical in November 1999, with the Gerle Creek water temperature measured at 11° C, the same as the reservoir bottom temperature. Dissolved oxygen was approximately 9 mg/l at this location. Specific conductance and TDS were very low in Gerle Creek, again reflecting the conditions of the reservoir, as described in Section 2.3.2.1.

2.3.2.3 Gerle Creek Reservoir

Gerle Creek Reservoir is a small and shallow reservoir with a total storage capacity of 1,260 ac-ft at an elevation of 5,231 feet. The reservoir serves primarily as an afterbay for the Loon Lake Powerhouse. Hence, retention time is short, and the majority of the water entering the reservoir is powerhouse tailrace inflow, which originates from the intake structure at the bottom of Loon Lake Reservoir. Other inflow sources include Gerle Creek and Angel Creek.

The only studies conducted in Gerle Creek Reservoir were performed in November 1999 and June 2000. In November, inflowing water temperature from the Loon Lake Powerhouse tailrace was 11° C, reflecting the isothermal temperature of Loon Lake Reservoir. Water temperature profiles in the Gerle Reservoir were isothermal, at approximately 10° C. This slightly cooler temperature of the reservoir was due, in part, to the 5° C temperature of the inflowing Gerle Creek (Angel Creek was dry). A similar, but opposite, trend was observed in June. Loon Lake Powerhouse tailrace water was cold, at 9° C, reflecting Loon Lake Reservoir water temperatures just off the reservoir bottom. Gerle Creek Reservoir water temperature profiles reflected slight surface warming in the shallow center of the reservoir, but in the deeper section near the dam exhibited a constant temperature with depth (up to 33 feet deep) of 10.5° C. This warming above the tailrace water temperature was due in part to the contributions of Gerle Creek (13° C) and Angel Creek (11° C).

Dissolved oxygen was between 8.5 and 9.5 mg/l at all sites (reservoir profile and stream sites) in both November and June. Secchi disk transparency in Gerle Reservoir was close to the maximum depth (35 to 36 feet). Turbidity ranged from 2.5 to 4 NTUs, while specific conductance was between 7 and 10 µS/cm.

2.3.2.4 Gerle Dam Reach

Very limited data are available for this Project reach, the 1.2-mile segment of Gerle Creek between Gerle Creek Reservoir Dam and the confluence with the South Fork Rubicon River. *In situ* measurements of water temperature downstream of the dam were 10° C, and DO ranged between 9 and 9.5 mg/l during both the November 1999 and June 2000 surveys.

2.3.2.5 Ice House Reservoir

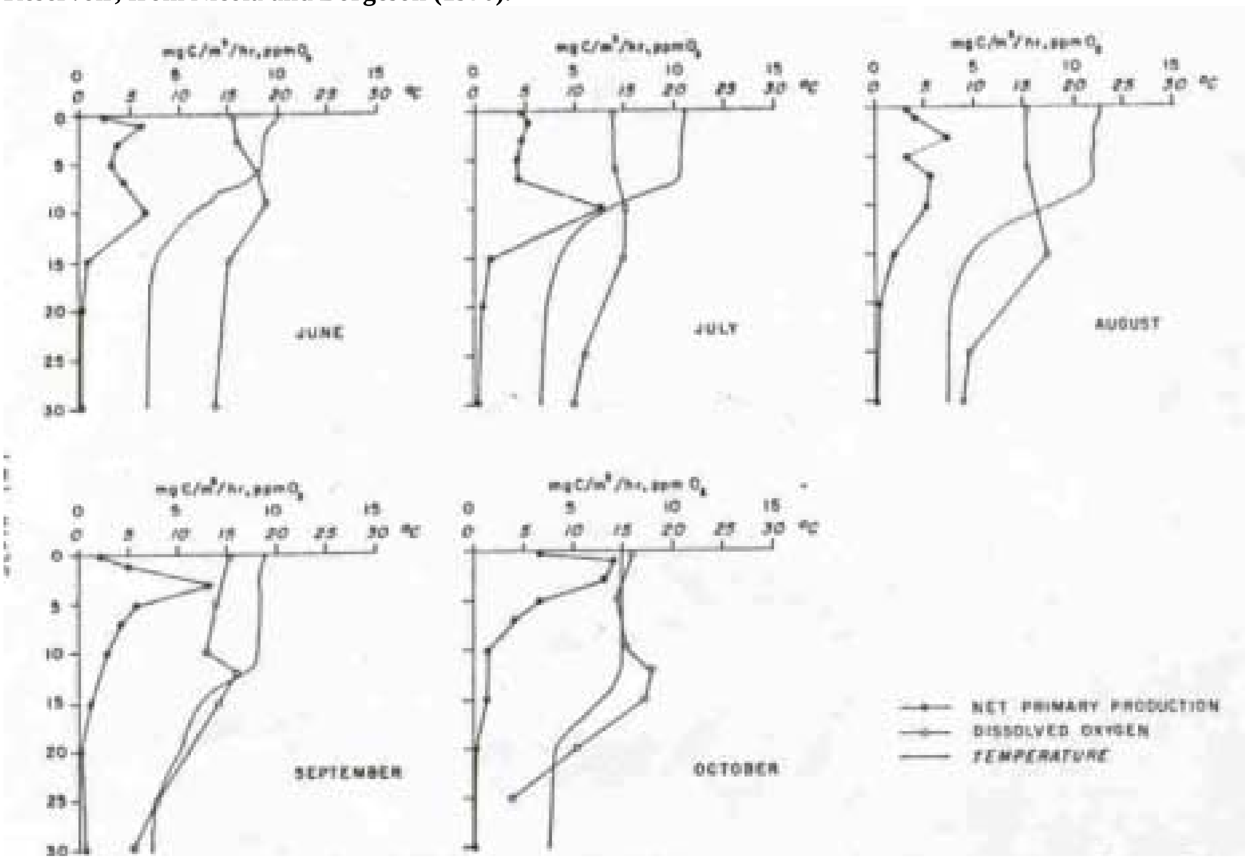
Ice House Reservoir is one of the three primary storage reservoirs of the Project, with a maximum gross storage capacity of 45,960 ac-ft at an elevation of 5,450 feet. The primary source of inflow to the reservoir is the South Fork Silver Creek. Limited data have been collected in South Fork Silver Creek as it enters the reservoir. *In situ* measurements taken in November 1999 reveal a temperature of 4.5° C, while similar measurements taken in June 2000 show a temperature of 13° C.

The earliest limnological investigations of Ice House Reservoir were performed by the California Department of Fish and Game in 1961 (shortly after Ice House Dam construction) and again in 1969 (Nicola and Borgeson 1970). In both years, chemical and biological data were collected on one-to-two-week intervals throughout the summer.

Nicola and Borgeson found that surface water temperature in Ice House Reservoir was highest in July and August. A thermocline, ranging from a depth of 15 to 60 feet, formed in June and persisted through early October. Mean monthly Secchi disk readings ranged from about 20 to 30 feet. The greatest primary production occurred in the upper 30 feet of the reservoir, with no production at depths deeper than 60 feet. Maximum carbon production always occurred above the thermocline. Mean daily net primary production was 294 mgC/m^2 in 1961 and 326 mgC/m^2 in 1966. Nicola and Borgeson estimated that the mean standing crop for zooplankton was 562.1

mg/m2 based on June through October 1966 sampling. The main groups of zooplankton found to occur were cladocerans *(Daphnia* spp., *Bosmina coregoni*, *Helopedium gibberum*), copepods (both cyclopodid and calanoid types as well as nauplii), with rotifers being the most abundant by number (about 75%) but not contributing significantly by weight. Profiles of temperature, dissolved oxygen and mean net primary production from the Nicola and Borgeson data are shown at Figure E2.3-1.

FIGURE E2.3-1.
Water temperature, dissolved oxygen and mean net primary production depth profiles in Ice House Reservoir, from Nicola and Borgeson (1970).



There is a substantial amount of recent information available on seasonal water temperatures in Ice House Reservoir. These data were recorded in July and September 1980, November 1999, and in June 2000. In each sampling effort, separate profiles were recorded at three or more sampling locations in the reservoir. At over 110 feet maximum depth, Ice House Reservoir is a relatively deep reservoir, and strong stratification was evident at the deeper sampling locations. A temperature profile in June 2000 was similar to that described above for Loon Lake Reservoir, although surface temperatures were warmer at Ice House Reservoir (17°-19° C vs. 14° C) and bottom temperatures colder (7° C vs. 8° C). The June 2000 data are nearly identical to those of July 1980, when surface water temperatures averaging 18.7° C across three sampling stations and bottom temperatures were 7° C. These data agree with the June data from the 1960s (Nicola and Borgeson 1970), which exhibited epilminetic water temperatures of approximately 20° C and bottom temperatures of 7° C.

The depth of the temperature layers and characteristics of the metalimnion between the years is somewhat variable. The November 1999 data exhibit less thermal stratification than June 2000, but Ice House Reservoir was the only Project reservoir that was not isothermal during the November 1999 sampling effort. Nicola and Borgeson (1970) found a fairly stable metalimnion throughout the summer, but a gradually deepening epilimnion (see Figure E2.3-1).

Additional water temperature data were collected at Ice House Reservoir as part of a 7-year monitoring study conducted shortly after construction of Ice House Dam (Livesay 1972). Between the years 1963-1969, weekly *in situ* temperature measurements were taken in the epilimnion of Ice House Reservoir (at surface, 3 feet, and 6 feet below surface) over a 14-week period from June-September. Temperature measurements were taken roughly between 9:00 am and noon throughout the study period. Recorded temperatures typically ranged from a low of 15°-16° C to a high of 20°-21° C, with the maximum temperatures occurring in August of most years. The warmest temperatures recorded occurred in 1964, reaching a maximum of 23° C in the first week of August.

Dissolved oxygen concentrations measured at Ice House Reservoir in 1980 were high, ranging roughly between 8.5 to 10.5 mg/l during both the July and September sampling efforts. The lower DO concentrations observed in the epilimnion of Ice House Reservoir in July 1980 are likely due to the effects of a warmer and fully mixed upper layer. The colder, unmixed hypolimnion exhibited higher and uniform water temperatures with depth. This orthograde oxygen profile is typical of moderately oligotrophic lakes at an early stage in summer stratification (Wetzel 1975).

The oligotrophic nature of Ice House Reservoir described by the oxygen profile is consistent with nutrient concentrations measured in 1980. Nitrate-nitrogen and total phosphate concentrations were very low in Ice House Reservoir, less than 0.01 mg/l. The DO profile at Ice House Reservoir in June 2000 displays a metalimnetic oxygen maximum, with lower DO concentrations observed in the epilimnion (approximately 6.5 mg/l) followed by a sharp increase in the metalimnion (to approximately 8.5 mg/l) and a decline in the hypolimnion. These dynamics suggest photosynthesis by phytoplankton reaching a peak of activity approximately 30-40 feet below the surface, in both 1980 and 2000. Higher pH from the surface to the metalimnion (6.8 to 7.0) support the existence of phytoplankton activity at that time. A similar metalimnetic oxygen maximum was observed in 1980, but it occurred in September. Thus, the data from 1980 and 1999/2000 both support the conclusion that Ice House Reservoir is moderately oligotrophic, with the onset of stratification and photosynthesis occurring at different times of the year, depending upon a variety of factors. These results are corroborated by the work of Nicola and Borgeson (1970), who observed the same metalimnetic oxygen maximum and also measured a spike of primary productivity in the metalimnion of Ice House Reservoir.

Secchi depth readings in Ice House Reservoir were relatively deep, established at 20 feet in October 1982 and ranging from 23 to 26 feet in November 1999 and June 2000. The clarity of the Ice House Reservoir supports the photosynthetic activity discussed above at a depth of 30-40 feet below the water surface. These findings were nearly identical to those of Nicola and Borgeson (1970), who measured a range of values between 18 and 28 feet, depending on month. The highest Secchi disk values were recorded in July.

Specific conductance, measured only in November 1999 and June 2000, was low in the reservoir and feeder stream. In the reservoir, values were constant with depth at about 9.5 µS/cm. Incoming stream water conductivity varied between streams, from less than 5 to greater than 23 µS/cm. Total dissolved solids were also low, between 5 and 6 mg/l at all depths in the reservoir and 3-13 mg/l in the feeder streams.

2.3.2.6 Ice House Dam Reach

Very limited data is available from the recent (1999/2000) water quality studies for this Project reach, the 11.5 mile segment of South Fork Silver Creek between Ice House Dam and the confluence with Junction Reservoir. In 1999/2000, *in situ* temperature measurements were made below the dam at the minimum release water valve and at a gage station used to monitor dam leakage. The leakage occurs at a depth of approximately 40 feet in the reservoir. Temperatures at these locations in June 2000 were 7° C at the release value and 11° C at the leakage gage, both reflecting the reservoir water temperatures at the depth of release/leakage. June 2000 DO in water released from the dam ranged from 7.7 to 8.3 mg/l.

A more substantial base of information on water temperatures in the South Fork Silver Creek is available from (Livesay 1972). This temperature monitoring report covered a 10-year period between 1960-1969. Temperatures were monitored at two sites downstream of Ice House Dam: 1) at the outlet of Ice House Reservoir, and 2) in the South Fork Silver Creek itself, 0.4 miles downstream of the dam. Between the years 1960-1969, weekly *in situ* temperature measurements were taken at the two sites over a 14-week period from June-September. At the outlet, mean monthly temperatures (based on weekly *in situ* measurements) over the 10-year period ranged from 6.5° C in June to 18.5° C in September. These values generally agree with the limnological data discussed above. At the site on the South Fork Silver Creek 0.4 miles downstream of the dam, temperatures were warmer than those immediately below the dam (Livesay 1972). Mean monthly temperatures for the period of 1960 to 1969 ranged from 8° C in June to 19° C in September.

Additional water quality data were collected in this reach of South Fork Silver Creek by the USEPA shortly after the Ice House Dam was built. Between September 1959 and March 1961, the USEPA collected monthly *in situ* measurements of several water quality parameters at a point directly downstream of the dam. These included water temperature, metals, ions and nutrients. In general, the data generated by the USEPA study (http://www.epa.gov/storet) describe a stream of good water quality. Water temperature measurements were low, ranging from a low in November of 1.1° C to a high in August of 8.8° C. Many of the metal and ionic concentrations were low, but some, chiefly boron, aluminum, iron and silica were at times high. The highest of these was an iron measurement, reported at 800 ug/l. The water was generally neutral, with pH measurements ranging from 6.6 to 7.0. Alkalinity was reported between 7 and 30 mg/l as $CaCO_3$, and nitrate ranged from 0.0 to 1.2 mg/l as NO_3.

2.3.2.7 Union Valley Reservoir

With a maximum depth of over 300 feet, Union Valley Reservoir is the deepest reservoir of the Project. Union Valley Reservoir is also the largest reservoir by volume, with a maximum gross storage capacity of 277,290 ac-ft at an elevation 4,870 feet. Inflowing water to the reservoir is composed of many sources, including tailrace outflow of the Robbs Peak and Jones Fork powerhouses, and natural inflow of Tells, Big Silver, Wolf, Yellow Jacket, and Jones Fork Silver creeks.

In situ water quality data were collected at the mouths of the streams that feed Union Valley Reservoir in 1999 and 2000. While limited in scope (essentially only covering the days of November 5, 1999 and June 5, 2000), the data, nonetheless, demonstrated that surface water runoff into Union Valley Reservoir, such as at Wolf Creek, can rise as high as 20° C in June, while maintaining DO levels of 9.5 mg/l. The coldest water inflowing water temperatures were 10° C, recorded at two small streams entering the reservoir from the south, with the DO concentrations of 9 mg/l. Specific conductance of the feeder streams ranged from 6.6 to 67.8 μS/cm.

There is a substantial amount of information available on the subject of water temperatures in Union Valley Reservoir. Water quality profile data were recorded at Union Valley Reservoir in July and September 1980, November 1999, and in June 2000. In each sampling effort, separate profiles were recorded at three or more sampling locations in the reservoir. The thermal profile data of June 2000 and July 1980 demonstrate strong summer stratification, with surface temperatures between 17-18° C and bottom temperature of 7° C , a range of temperatures that is nearly identical to that observed at Ice House Reservoir. Despite the separation of the sampling efforts by 20 years, the shape of the temperature profiles were similar in June and July. In each case, the epilimnion was about 20 feet deep, followed by a distinct metalimnion where temperatures dropped approximately 10° C within 40 feet. The data of September 1980 indicated a warming of the reservoir, with a deeper epilimnion at 20° C. In November 1999, Union Valley Reservoir was isothermal at 14.5° C.

In contrast to Ice House Reservoir, the DO profiles at Union Valley Reservoir did not indicate obvious phytoplankton activity. Dissolved oxygen profiles were mildly orthograde in both June 2000 and July 1980, exhibiting concentrations of approximately 8 mg/l in the epilimnion and 9.5 mg/l in the metalimnion and hypolimnion. There was no indication in the oxygen profile of a metalimnion maximum, as observed in Ice House Reservoir. Also, nutrient levels, measured in 1980 reveal very low concentrations of nitrate-nitrogen and total phosphate, less than 0.01 parts per million. In November 1999, Union Valley Reservoir exhibited a constant DO profile, at 7-7.5 mg/l.

Specific conductance was nearly uniform from the surface to the bottom at 10 μS/cm, and pH ranged from approximately 6.5 to 7. Turbidity in the reservoir was very low (less than instrument detection in 1999/2000), and Secchi disk depth was between 25 and 27 feet during June 2000 and 24 feet in 1980.

2.3.2.8 Junction Reservoir

Junction Reservoir serves as an afterbay to Union Valley Powerhouse and forebay for the Jaybird Powerhouse. As such, it is a small facility, capable of impounding 3,250 ac-ft at an elevation of 4,450 feet. As a result, retention time is short, estimated at 20 hours. The major sources of inflow to the reservoir are tailrace outflow of Union Valley Powerhouse and regulated inflow from South Fork Silver Creek (i.e., Ice House Dam release plus accretion).

Water quality studies were performed at Junction Reservoir in November 1999 and June 2000. Water quality profiles were recorded in the reservoir at five locations, and *in situ* measurements were taken at two inflow streams (South Fork Silver Creek and Little Silver Creek), and at a site below the dam. Stratification was evident during June 2000, but the epilimnion was very shallow and temperatures decreased sharply below approximately 15 feet. Surface temperatures approached 19° C, approximately 10° C warmer than observed in November 1999. Bottom temperatures (maximum depth of about 110 feet) were approximately 7° C. Temperatures measured at South Fork Silver Creek (tributary to the southern arm of the reservoir) exceeded 19° C. Dissolved oxygen at Junction Reservoir ranged from approximately 8 to 10 mg/l in the reservoir, and between 8 and 8.5 mg/l in tributary streams. Specific conductance was between 11 and 18 μS/cm at all locations; pH between 6.4 and 6.8, and Secchi depth between 25 and 35 feet, in June 2000. In contrast, Secchi disk depth in November at Junction Reservoir was only 8 to 10 feet deep.

2.3.2.9 Junction Dam Reach

Very limited data are available from the recent (1999/2000) water quality studies for this Project reach, the 8.3 mile segment of Silver Creek between Junction Dam and the Jaybird Powerhouse. Outflow water temperatures below Junction Reservoir were about 9° C in June 2000, and DO levels were between 8 and 9 mg/l.

2.3.2.10 Camino Reservoir

Camino Reservoir serves as an afterbay to Jaybird Powerhouse and forebay for Camino Powerhouse. As such, it is a small facility, capable of impounding 825 ac-ft of water at an elevation of 2,915 feet, with short retention time. The major sources of inflow to the reservoir are tailrace outflow of Jaybird Powerhouse and regulated inflow from Silver Creek (i.e., Jaybird Dam release plus accretion). Due to maintenance operations, the only water quality studies performed at Camino Reservoir occurred on June 2000. Water quality profiles were recorded at three locations in the reservoir, and *in situ* measurements were taken at the point of inflow to the reservoir of Silver and Jaybird creeks. Despite the short retention time, the temperature profile recorded nearest the dam, where the depth of water was nearly 50 feet, exhibited a weakly stratified water column. At this sampling station, there was no distinct epilimnion, as water temperature gradually dropped from a surface value of 11.5° C to 7.5° C at a depth of 12 feet. Deeper water, down to 47 feet, exhibited an isothermal 7.5° C. Such temperature profiles are typical of water bodies with high through-flow volumes (Wetzel 1975). Dissolved oxygen was between 9 and 11 mg/l, and specific conductance was low at the reservoir sampling sites (approximately 10 to 15 μS/cm). Turbidity was less than 2 NTUs.

2.3.2.11 Camino Dam Reach

The primary source of water quality data for the 6.2 mile reach of Silver Creek between Camino Dam and the confluence with the SFAR originates from an USEPA study conducted at the mouth of Silver Creek between September 1959 and March 1961. During this period, the USEPA collected monthly *in situ* measurements of several water quality parameters. These included water temperature, metals, ions and nutrients. In general, the data generated by the USEPA study (http://www.epa.gov.storet) describe a stream of good water quality. Water temperature measurements were rarely measured, but reach a high of 18.8° C in August. Many of the metal and ionic concentrations were low, but some, chiefly boron, iron, and silica were at times high. The highest of these was an iron measurement reported as 110 ug/l. The water was generally neutral, with pH measurements ranging from 6.5 to 7.4. Alkalinity was reported between 7 and 18 mg/l as $CaC0_{3,}$ and nitrate ranged from 0.0 to 1.2 mg/l as NO_3.

The only other data available for this reach of river stems from the June 2000 surveys, when discharge temperatures below Camino Dam were measured at 8.5°C and DO was 10 mg/l.

2.3.2.12 Brush Creek Reservoir

Brush Creek Reservoir serves as a forebay to Camino Powerhouse, and is capable of impounding 1,530 ac-ft at an elevation of 2,915 feet. Inflows to the reservoir include natural inflow from Brush Creek and periodically tailrace water from Jaybird Powerhouse, when the reservoir is operated to provide spinning reserves. The tailrace water is routed to Brush Creek Reservoir via the Camino and Brush Creek tunnels (see Section B3.6).

Due to maintenance operations, the only water quality studies performed at Brush Creek were conducted at two locations at Brush Creek Reservoir in June 2000. No metalimnion was evident in the temperature profile, although temperatures dropped steadily with depth from near 17° C at the surface to near 7° C at a maximum depth of approximately 100 feet. DO was between 7 and 9.5 mg/l, and pH ranged between approximately 6.4 and 7.2. Specific conductance was quite variable in contrast to other locations in the Project, with values increasing from approximately 20 µS/cm (nearly twice as high as most other sites monitored) to near 30 µS/cm at a depth of about 80 feet. Spring activity near the bottom of Brush Creek Reservoir is a likely explanation for these results. Turbidity was less than 2.5 NTUs and Secchi disk depth measured 29 feet.

2.3.2.13 Slab Creek Reservoir

Water inflow from the SFAR is the most important determinant of water quality in Slab Creek Reservoir, although Brush Creek, Slab Creek, and Long Canyon Creek also have an influence. SMUD's water quality studies in 1999 and 2000 included sites on Slab and Brush creeks on the north side of the reservoir, a site on the SFAR upstream of the reservoir, and a site in Long Canyon Creek on the south end of the reservoir. Temperatures of the inflow streams ranged from 12° C to 14° C, DO ranged from 9.5 to 11.5 mg/l, and pH ranged from 6.7 to 7.1 at sites upstream of the Project.

Water quality studies were performed at Slab Creek Reservoir in November 1999 and June 2000. Water quality data were collected at several locations along the 5-mile-long reservoir. Vertical profiles of temperature during June 2000 at the deepest location (140 feet) showed a relatively narrow metalimnion at approximately 20 feet, with surface temperatures near 15° C and near-bottom temperatures of approximately 11° C. DO ranged from 8.8 to 10.2 mg/l, pH approximately 6.9, and specific conductance was typical of other Project reservoirs at approximately 20 μS/cm. Turbidity was not measurable, although Secchi disk depth of 11 to 15 feet suggests some particulate matter in the water column.

2.3.2.14 Slab Creek Dam Reach

Limited water quality data is available for this 8.0 mile segment of SFAR between Slab Dam and White Rock Powerhouse. Flows in this reach of river have been regulated by a number of projects since the early part of the Twentieth Century.

Data were collected 1,500 feet downstream of Slab Creek Dam during the 1999 and 2000 water quality studies. Water temperature was approximately 12° C during June 2000 at this location, approximately 1° C warmer than temperatures at maximum depth in the reservoir. Dissolved oxygen of approximately 10 mg/l was slightly higher at this site than near-bottom values in the reservoir. Other parameters (pH, specific conductance, turbidity) were similar to reservoir values.

A more substantial base of information on water temperatures in the SFAR is available from (Livesay 1972). This temperature monitoring report covered the years 1960-1969, a period that encompassed the 1967 construction of Slab Creek Dam. Temperatures were monitored before and after the construction of Slab Creek Dam. Prior to 1967, temperatures were monitored at Chute Camp Dam, which was the diversion dam of PG&E's American River Project. Thus, 1960-1966 water temperatures were not influenced by the operation of this Project as these measurements would reflect inflowing water temperatures. Once Slab Creek Dam was built, Chute Camp Dam was inundated by Slab Reservoir, thereby forcing Livesay to move one mile downstream to the USGS gage located below the Slab Creek Dam. At the two sampling sites, weekly *in situ* temperature measurements were taken over a 14-week period from June through September, all roughly at midday. At Chute Camp Dam the outlet, mean monthly temperatures (based on weekly measurements) over the 7-year period ranged from 11° C in September to 21.5° C in September. At the Slab Creek Dam, mean monthly temperatures over the 3-year period ranged from 10.5° C to14 ° C.

SMUD conducted a water temperature study within this Project reach during the summer of 1980 (WESCO 1980). This study examined the effects of several test releases from Slab Creek Dam on water temperature, as well as temperature differences among pool and riffle habitats. Performed in consultation with CDFG and the USFWS, the study documented that the current 36 cfs minimum release requirement at the dam maintained water temperatures below a threshhold daily maximum temperature of 20° C. The results of this study served as the basis for the 1981 FERC Order that modified the minimum flow release requirement at Slab Reservoir to the values that are currently required under Article 29 of the Project License (see Section B2.2).

Another water temperature study was conducted in 1955 by PG&E at the American River Project (Cheney and Curtis 1955). The purpose of this study was to evaluate the water temperatures in the project bypass reach under 5, 10, and 20 cfs minimum flow releases. Water temperatures were continuously monitored during August 1955 at each flow regime, and in July under an unspecified flow. Nevertheless, this study provides insights into water temperatures associated with inflowing water to the project at the diversion dam. At the project diversion dam, incoming July mean daily water temperatures ranged from 61 to 71° F, while daily maximum values in July ranged from 64 to 74° F. During August inflowing water temperatures ranged from a mean daily high of 71° F to a low of 67° F. Air temperatures were generally cooler in July than August. Maximum daily values in July ranged from 82 to 106° F, while August values were consistently between 94 and 106° F.

2.4 Literature Cited

Archibald and Wallberg Consultants (In association with Montgomery Watson). 1998 American River watershed sanitary survey (1998 update).

California Department of Water Resources. 1998 The California Water Plan Update. Bulliten 160-98. Volume I, II and III. Published by the California Department of Water Resources, CA.

Cheney, W.D. and Curtis, B. 1955. Water temperature study on South Fork of American River, 1955. Pacific Gas and Electric Company. Department of Engineering. San Francisco, CA.

Ecological Analysts, Inc. 1980. Field studies of Ice House Reservoir and Union Valley Reservoir, El Dorado County, California. Prepared for SMUD, Sacramento, California.

Ecological Analysts, Inc. 1982. Draft Environmental Impact Report, South Fork Rubicon River Diversion. Prepared for SMUD, Sacramento, California.

El Dorado Irrigation District (EID). 1999. El Dorado Project (FERC Project No. 184), Draft Application for License for Major Project-Existing Dam. Volume 3 of 7, Exhibit E. El Dorado Irrigation District, Placerville, CA.

Jordan, W.P. and R.J. Brown. 1993. American River aquatic sampling (report for 1992). Prepared for SMUD by the Institute of Chemical Biology, University of San Francisco.

Livesay, R. D. 1972. Summer water temperature observations, South Fork American River, 1960-1969. USGS Pub. 6212-02, Menlo Park, CA.

Regional Water Quality Control Board (RWQCB). 1998. The Water Quality Control Plan (Basin Plan) for the Sacramento River Basin and the San Joaquin River Basin (Fourth Edition). California Regional Water Quality Control Board. Central Valley Reader. Sacramento, CA.

SMUD 1981. Application for Amendment of License for Project No. 2101, Upper American River Project. Sacramento Municipal Utility District, Sacramento, CA.

Tetra Tech. 2000a. Water quality monitoring report for the Upper American River Project. Prepared for the Sacramento Municipal Utility District, Sacramento, CA.

Tetra Tech. 2000b. Water quality monitoring report for the Upper American River Project (Final report). Prepared for the Sacramento Municipal Utility District, Sacramento, CA.

University of California. 1996. Sierra Nevada ecosystem project, final report to Congress, Volumes I-IV. Wildland Resources Center Report No. 37, Centers for Water and Wildland Resources, University of California, Davis. July 1996.

Western Ecological Services Company (WESCO) 1980. Water temperature monitoring study, South Fork American River between Slab Creek Dam and Chili Bar Reservoir. Prepared for the Sacramento Municipal Utility District, Sacramento, CA.

Wetzel, R.G., 1975. Limnology. W.B. Saunders Company, Philadelphia, PA.