

**Placer County Water Agency
Middle Fork American River Project
(FERC No. 2079)**

FINAL

**AQ 11 - WATER QUALITY
TECHNICAL STUDY REPORT - 2007**



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1.0 INTRODUCTION

This report describes water quality studies conducted by the Placer County Water Agency (PCWA) in accordance with the AQ 11 - Water Quality Technical Study Plan (AQ 11 - TSP) for the Middle Fork American River Project (MFP or Project). The stakeholder-approved TSP was included in Supporting Document (SD) H of the Pre-Application Document (PAD) filed with the Federal Energy Regulatory Commission (FERC or Commission) on December 13, 2007 (PCWA 2007). A draft report was distributed to the Aquatics Technical Working Group (TWG) on February 1, 2008 for a 60 day comment period. The comment period ended on April 4, 2008. Oral comments were received at the March 10, 2008 Aquatics TWG meeting and have been addressed in this report. No written comments were received.

Water quality studies were conducted in the vicinity of the MFP during the spring and fall 2007 to characterize the physical, chemical, and bacterial water quality conditions upstream and downstream of Project facilities. The study consisted of summarizing current water quality objectives from the literature, implementing a water quality field sampling field program, and comparing water quality data from field with pertinent regulatory objectives and criteria. In addition, a screening level study of methyl mercury concentrations in sport fish tissue muscle was completed.

The water quality field sampling program included: (1) *in-situ* measurements; (2) collection of water quality samples for laboratory chemical analysis, hereafter referred to as the general water quality sampling; (3) voluntary water quality sampling that enhanced the approach described in the AQ 11 - TSP; (4) coliform sampling; and (5) measurement of water temperature and dissolved oxygen (profiles) in Project reservoirs. Fish for the methyl mercury muscle tissue analysis were also collected from the Project reservoirs and one location in the Middle Fork American River peaking reach (downstream of Oxbow Powerhouse, the lowermost Project facility) near Otter Creek.

The following sections provide a detailed description of the study objectives, study implementation, extent of the study area, study approach, study results, and literature cited.

2.0 STUDY OBJECTIVES

The objective of the water quality studies described in the AQ 11 - TSP is to characterize physical, chemical, and bacterial water quality conditions in the bypass reaches and the peaking reach, comparison reaches, and Project reservoirs and diversion pools and compare to the Central Valley Regional Water Quality Control Board (CVRWQCB 1998) Basin Plan objectives and water quality objectives.

3.0 STUDY IMPLEMENTATION

Figure 11-1 shows the AQ 11 - TSP objective and the study elements and activities that relate to completion of the study. It also shows how information developed through the water quality studies will be documented and provided to the stakeholders. The

following sections summarize the study elements completed, any deviations from the TSP and the rationale, outstanding study elements, and proposed modifications to the TSP.

3.1 STUDY ELEMENTS COMPLETED

The following study elements have been completed:

- Collected *in-situ* and general water quality measurements on the bypass reaches, peaking reaches, reservoirs, and diversion pools in spring (39 locations) and fall (36 locations).
- Collected fecal coliform samples at 17 sites.
- Collected fish samples at Project reservoirs (Hell Hole, French Meadows, Ralston Afterbay, Middle Fork Interbay) and at one river site (Middle Fork American River downstream of Ralston Afterbay) for mercury fish tissue analyses.
- Provided water quality samples to State-certified laboratories approved by the State Water Resources Control Board for chemical analyses.
- Compared water quality results to the CVRWQCB Basin Plan objectives and water quality objectives (CVRWQCB, Fourth Edition revised February 2007).
- Compared fish tissue results to the California's Office of Environmental Health Hazard Assessment (OEHHA) guidelines.

3.2 DEVIATIONS FROM TECHNICAL STUDY PLAN

The water quality studies proceeded as described in the AQ 11 - TSP except for the following deviations:

General Water Quality Sampling

- Water quality samples were not collected during high and low flow events at all of the sampling locations along the peaking reach of the Middle Fork American River during the spring and fall sampling events, as indicated in the TSP. Instead, water quality samples were collected in the peaking reach once during the spring sampling event and again during the fall sampling event. During each event, water quality samples were collected at each of the locations identified in the TSP, under a range of flow conditions.
- One metal (manganese) was not analyzed during the spring sampling event due to a transcription error. Manganese was sampled during the fall sampling event.

Coliform Sampling

- According to the fecal coliform sampling protocols, fecal coliform samples were to be collected five times within a 30 day period between July 4 and Labor Day. Two of the fecal coliform sampling locations were sampled the week after Labor

Day (the fifth sample in 30 days) because of a sampling location change late in the summer. Two of the sampling locations were changed to better meet the water quality sampling objectives. The location changes were agreed to by the Aquatics TWG.

Voluntary Enhancements

- *In-situ* measurements were taken at three additional locations (leakage channels and main channel) downstream of Hell Hole Reservoir and five additional locations (leakage channels and main channel) downstream of French Meadows Reservoir.
- Additional water samples were collected and analyzed for dissolved metals and total mercury due to the presence of a rust-color staining on the substrate and precipitate at these selected locations described above.
- The TSP states that the water quality analytical results would be compared to the Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board Central Valley Region, Fourth Edition, published in September 1998. The analytical results were compared to the most recent version of the Basin Plan, which was updated with amendments in February 2007.

Fish Tissue Sampling

- Five of the 10 recommended fish caught at French Meadows Reservoir (two brown trout and three rainbow trout) were analyzed for individual methyl mercury concentrations in the fish muscle tissue. The remaining five fish (brown trout) that were caught should have been analyzed individually. However, these five fish were analyzed as a composite.

Voluntary Enhancements

- In addition to the ten fish caught at Hell Hole Reservoir (brown trout, rainbow trout, and lake trout that were analyzed for individual methyl mercury concentration), five additional fish (brown trout) were caught and analyzed as a composite sample.

3.3 OUTSTANDING STUDY ELEMENTS

The following describes the only outstanding element of the water quality study:

- Consult with Aquatic TWG to discuss contingency water quality related studies.

3.4 PROPOSED MODIFICATION TO TECHNICAL STUDY PLAN

These are no proposed modifications to the AQ 11 - TSP.

4.0 EXTENT OF STUDY AREA

The study area included bypass and comparison reaches, the peaking reach, Project reservoirs, and diversion pools. The sampled locations are listed in Table AQ 11-1 and are shown on Maps AQ 11-1 and 11-2.

5.0 STUDY APPROACH

This section describes the study approach used to conduct the water quality studies in the study area. This section first describes the sources that were reviewed to identify the existing water quality objectives relevant to the physical, chemical, and bacterial constituents that were analyzed during this study. The section next describes the field sampling methods and associated laboratory analyses methods and reporting employed during the collection of *in-situ* measurements, general water quality sampling, coliform sampling, and fish tissue sampling. This section concludes with a discussion of quality assurance / quality control procedures.

5.1 EXISTING WATER QUALITY OBJECTIVES

Existing water quality objectives for the physical, chemical, and bacterial constituents analyzed in this study were identified by reviewing The Sacramento River Basin and San Joaquin River Basin Water Quality Control Plan (CVRWQCB, Fourth Edition revised February 2007), California Toxics Rule (CTR) “Water Quality Standards: Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California” (Federal Register, 65 FR 31682, EPA 2000) and the National Toxics Rule (NTR) “Water Quality Standards: Establishment of Numeric Criteria for Priority Toxic Pollutants” (Federal Register, 57 FR 60848, EPA 1992). The Basin Plan includes water quality objectives established by the State Water Resources Control Board (SWRCB) for waters in the Upper American River Watershed. The CTR and NTR, which consider background levels based on criteria that protect both human health and aquatic life, were also reviewed. The SWRCB selects the most controlling (most stringent) of these values to determine compliance with the Clean Water Act.

The California’s Office of Environmental Health Hazard Assessment (OEHHA) guidelines (Cal EPA 2005 and Klasing and Brodberg 2006) were also reviewed for fish tissue analysis.

5.2 WATER QUALITY FIELD SAMPLING PROGRAM

The water quality field sampling program was conducted during spring and fall 2007 and included collection of: (1) *in-situ* measurements; (2) general water quality samples; (3) voluntary enhanced water quality samples; (4) coliform samples; and (5) fish tissue samples. The locations of sampling stations for each of these sampling activities are summarized in Tables AQ 11-1 and 11-3 and are shown on Maps AQ 11-1 through 11-4.

Three spring sampling locations within the Project area were not sampled in the fall. These locations included Duncan Creek above Middle Fork American River confluence

(DC-3 RM0.2) and the Middle Fork American River above and below Duncan Creek confluence (MFAR-3 RM39.9 and MFAR-4 RM39.5). After the spring sampling event and following consultation with the Aquatic TWG, access to these locations was determined to be unsafe for continued sampling.

5.2.1 *In-situ* Measurements

In-situ measurements in the stream and river study reaches were made at each of the sampling locations listed in Table AQ 11-1 during the spring runoff period (May 14 through 31, 2007) and during the low flow (base flow) period in the fall (September 24 through October 3, 2007). The *in-situ* measurements included dissolved oxygen (DO), pH, specific conductance, and water temperature. These four parameters were measured at each sampling location on the stream and river reaches and Middle Fork Interbay using portable multi-probe water quality meters (YSI® or Hydrolab Quanta). Hach Environmental (Loveland, CO) and Equipco (Concord, CA) calibrated the water quality meters prior to the spring and fall sampling events, respectively. In addition, the DO sensor was calibrated in the field to adjust for changes in elevations and barometric pressure at each sampling location prior to data collection. The *in-situ* measurements were taken just below the water surface at representative locations within the stream.

In-situ water quality measurements were also collected during the general water quality sampling program at Project reservoirs (French Meadows Reservoir, Hell Hole Reservoir, and Ralston Afterbay) as outlined in the AQ 11 - TSP (Table AQ 11-1) using portable, multi-probe water quality meters (YSI® or Hydrolab Quanta). A secchi depth was also measured at these locations to determine the clarity of the water column. Middle Fork Interbay was only sampled at the surface as outlined in the AQ 11 - TSP.

5.2.2 General Water Quality Sampling

General water quality samples were collected once during the spring runoff period (May 14 through 31, 2007) and once during the low flow (base flow) period in the fall (September 24 through October 4, 2007) at sampling locations listed in Table AQ 11-1. The location of all the sampling sites were identified using a Global Positioning System (GPS) unit and the coordinates recorded in a field log book. Water quality samples in bypass reaches, peaking reach, and comparison reaches were collected in representative portions of the stream channel, using methods consistent with the Environmental Protection Agency (EPA) 1669 sampling protocol *Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria*. Water quality samples collected from the streams and rivers were analyzed for the parameters listed in Table AQ 11-2, which include a suite of general parameters, dissolved metals, total mercury, and total and fecal coliform.

General water quality samples were also collected once during the spring and fall at Project reservoirs (Table AQ 11-1). In Hell Hole Reservoir, French Meadows Reservoir, and Ralston Afterbay, the samples were collected at the surface and immediately below the thermocline, if the reservoir was thermally stratified. If the Project reservoir was not thermally stratified, then water quality samples were collected at mid-depth of the

reservoir. A boat with gasoline engine was used to access the various reservoir sampling locations. Prior to sample collection, the engine was turned off for five to ten minutes to minimize the potential for sample contamination.

Surface water quality samples from Project reservoirs were collected using similar methods as those used for the stream water quality collection. Sub-surface water quality samples for laboratory analysis were collected using a Teflon® Kemmerer style sampler to ensure integrity of the sample collected from depth. Water quality samples collected from the reservoirs were analyzed for the parameters listed in Table AQ 11-2. Laboratory analysis for hydrocarbons were conducted on water quality samples collected from French Meadows and Hell Hole reservoirs and Ralston Afterbay, where motorized boating may occur.

All water quality samples were decanted into laboratory-supplied sample containers. Sample bottles requiring chemical preservation (HCl, HNO₃, or H₂SO₄) were preserved by Test America Laboratory (Morgan Hill, California). Samples collected for dissolved metals were filtered in the field with pre-cleaned 0.45 µm filtration units supplied by Brooks Rand Laboratory (Seattle, Washington). The sample containers were labeled with the sampling site ID and the date and time that the sample was collected. The sample container was stored on ice and delivered to a State-certified water quality laboratory for analyses in accordance with maximum holding periods. A chain-of-custody record was also maintained with the samples at all times.

5.2.3 Voluntary Enhanced Water Quality Sampling

Voluntary enhanced water quality samples not specified in the AQ 11 - TSP were collected during the spring and fall general water quality sampling program. The additional sampling was initiated by PCWA when field personnel observed and reported the presence of rust color staining of the substrate and a precipitate at select locations below Hell Hole Dam and French Meadows Dam. Based on experience in other relicensing water quality studies, the staining was thought to be result of iron oxidation and warranted further investigation. The locations of the voluntary enhanced water quality samples are described in Table AQ 11-3 and identified on Maps AQ 11-3 and AQ 11-4. The additional samples were collected immediately downstream of Hell Hole Dam (May 22, 2007) and French Meadows Dam (August 6, 2007) in the leakage channels and river locations upstream and downstream of the confluence of the leakage channel. Water quality samples collected from the leakage and river channel were analyzed for hardness, dissolved metals (arsenic, cadmium, copper, iron, lead, manganese, nickel and total chromium), and total mercury.

5.2.4 Coliform Sampling

Total and fecal coliform sampling was conducted to determine if the study waters met Basin Plan objectives for contact recreational activities. Samples were collected at all locations listed in Table AQ 11-1 in the spring (May 14 through 31, 2007) and fall (September 24 through October 3, 2007) concurrent with the general water quality sampling program. These samples were analyzed for total and fecal coliform in accordance with the AQ 11 - TSP.

Sampling for fecal coliform also occurred at near-shore locations adjacent to recreation facilities at Project reservoirs and along bypass reaches where substantial contact recreation (swimming, fishing, rafting, etc.) occurs. These sampling locations were identified in the AQ 11 - TSP and are provided in Table AQ 11-1 and depicted on Map AQ 11-2.

The samples for fecal coliform analysis at 15 of the 17 locations with substantial contact recreation were collected five times within a thirty-day period between August 6, 2007 and Labor Day. The sampling was conducted over Labor Day weekend, rather than July 4th to attempt to capture the highest holiday recreation use. July 4 occurred in the middle of the week in 2007 and therefore recreation use was assumed to be higher during the Labor Day weekend. Two of the coliform sampling locations (FC-9 and FC-11) were not sampled during the first week (August 6, 2007) due to a location change after the first sampling event. Sampling at these two locations extended one additional week after Labor Day until September 10, 2007 in order to complete the 5 samples in a 30-day period.

The sample containers were provided by Diamond Water Laboratory (Auburn, California). The containers were labeled with the sampling site ID and the date and time that the sample was collected. The sample container was stored on ice and delivered to the local State-certified water quality laboratory for analyses in accordance with maximum holding periods. A chain-of-custody record was also maintained with the samples at all times.

5.2.5 Water Quality Laboratory Analysis and Reporting

Water quality samples collected during the general water quality sampling program and coliform sampling were submitted for laboratory analysis at a State-certified laboratory approved by the State Water Resources Control Board (SWRCB) for chemical analysis (total of 31 analytes). The analytes tested are listed in Table AQ 11-2 and are described in Appendix A. Twenty analytes (general parameters and hydrocarbons) were submitted to Test America Laboratory, nine analytes (a suite of dissolved metals and total mercury) were submitted to Brooks Rand Laboratory, and two analytes (total and fecal coliform) were submitted to Diamond Water Laboratory. The laboratories provided reports of each chemical parameter analyzed and the associated laboratory method detection limit, reporting limit, and practical quantification limit.

The reporting units from Test America and Brooks Rand laboratories were reported in mg/L (ppm), µg/L (ppb), or ng/L (ppt). To keep the data results consistent with the reporting parameters listed for the Basin Plan, CTR, and NTR, all lab results were converted to the appropriate unit, if necessary. If these sources do not have a criterion for an analyte, then the units provided in the laboratory reports were used. Conversions between the units are shown in Appendix B.

5.3 WATER TEMPERATURE AND DISSOLVED OXYGEN RESERVOIR PROFILES

Reservoir profiles were completed at selected sampling locations in Hell Hole Reservoir, French Meadows Reservoir, and Ralston Afterbay during the spring and fall sampling period as described in the AQ 11 - TSP. The reservoir profile measurements included water temperature and DO at 1-meter (m) depth intervals to determine if thermal stratification was present. If a thermocline was present, the water quality parameters were measured below the thermocline at 2-m intervals or less to the bottom of the reservoir. If a thermocline was not present, measurements were made at 2-m intervals or less below the mid-depth point to the bottom of the reservoir. Results of the sampling were compiled and presented in tabular and graphical format in Appendix C.

The sampling locations within the Project reservoirs are described below.

Hell Hole Reservoir

Water quality depth profiles and sampling were conducted at three locations on May 30, 2007 and October 1-2, 2007 (Map AQ 11-1). HH-1 was located at the front of the reservoir near the dam, HH-2 was in the middle of the reservoir near the French Meadows Powerhouse, and HH-3 was the upstream most location within the reservoir. Between the spring and fall sampling events, the reservoir water surface elevation steadily declined, resulting in a decrease in the maximum depth sampled. Reservoir storage during the spring and fall sampling events was obtained from the California Department of Water Resources website (DWR 2007), and surface elevations were estimated from PCWA storage capacity curves (PCWA 2007). Water surface elevations were estimated at:

May 30, 2007: 4,583 ft msl
October 1, 2007: 4,514 ft msl.

French Meadows Reservoir

Water quality depth profiles and sampling were conducted at three locations on May 30, 2007 and October 3, 2007 (Map AQ 11-1). FM-1 was located at the front of the reservoir near the dam, FM-2 was in the middle of the reservoir, and FM-3 was just downstream from the French Meadows boat ramp in the middle of the reservoir. Between the spring and fall sampling events, the reservoir water surface elevation steadily declined, resulting in a decrease in the maximum depth sampled. Reservoir storage during the spring and fall sampling events was obtained from the California Department of Water Resources website (DWR 2007), and surface elevations were estimated from PCWA storage capacity curves (PCWA 2007). Water surface elevations during the spring and fall sampling events were estimated at:

May 30, 2007: 5,243 ft msl
October 3, 2007: 5,206 ft msl.

Ralston Afterbay

Water quality depth profiles and sampling were conducted at one location just behind the float barriers on May 29, 2007 and September 26, 2007 (Map AQ 11-1). Water surface elevations during the spring and fall sampling events were estimated by PCWA at:

May 29, 2007: 1,177 ft msl

September 26, 2007: 1,175 ft msl.

Monthly reservoir profiles (consisting of temperature, DO, and specific conductance) at the same reservoir locations described above were also completed by PCWA in 2005-2007 as part of early relicensing studies. The results of the 2005 and 2006 reservoir profiles are presented in the PAD, SD (G) (PCWA 2007). The 2007 reservoir profile results will be summarized in early 2008 and provided to the Aquatics TWG under separate cover.

5.4 FISH TISSUE COLLECTION AND ANALYSIS FOR METHYL MERCURY

A screening level study of methyl mercury concentrations in sport fish muscle tissue was conducted at selected locations in the study area. As identified in the AQ 11 - TSP, at least 10 non-hatchery sport fish of edible size were collected from each of the following locations: Hell Hole Reservoir, French Meadows Reservoir, Middle Fork Interbay, Ralston Afterbay, and the Middle Fork American River near the Otter Creek confluence. Larger fish and species with greater potential for bioaccumulation were targeted for collection and analysis. The initial goal of the study was to collect five fish each of two different species from each location based on the following priority ranking. The two species present with the highest priority ranking would be targeted for collection (1 = highest priority) as follows:

- 1) bass
- 2) pikeminnow
- 3) lake trout
- 4) brown trout
- 5) rainbow trout

If five fish of two different species were not caught, then fish from a third species was included in the analysis.

At the four reservoirs, fish were captured in clean nylon gill nets. In the Middle Fork American River near Otter Creek fish were captured by electrofishing and hook-and-line sampling. For each fish collected, the species, fork length, total length, and weight were recorded.

The field handling procedures were consistent with those outlined in California Environmental Protection Agency (Cal EPA 2005) and those used at the Department of Fish and Game Marine Pollution Studies Laboratory at Moss Landing (Method # MPSL-

102a). The fish were placed into zipper-closure bags and immediately placed on ice in a cooler. The fish were then stored in a freezer prior to shipment to the analytical laboratory. All fish were shipped in an ice chest packed with ice and delivered by an overnight courier to Brooks Rand Laboratory (Seattle, Washington). Each cooler was shipped with a chain of custody form showing the sample identification number and collection date and time of each sample.

Muscle tissue from individual fish was analyzed for concentrations of methyl mercury in accordance with the General Protocol for Sport Fish Sampling and Analysis developed by the Cal EPA (2005) and with methods comparable to those used at the Department of Fish and Game Marine Pollution Studies Laboratory at Moss Landing. The results of the fish fillet analyses were reported in ng/g. These were converted to mg/kg fish (ppm) to be consistent with the OEHHA guidelines. The conversion is provided in Appendix B.

In one instance at French Meadows Reservoir, five brown trout were sent to the laboratory for analysis as one composite sample. For Hell Hole Reservoir, in addition to the 10 individual fish analyzed, a composite sample of five brown trout was analyzed.

5.5 QUALITY ASSURANCE/ QUALITY CONTROL PROCEDURES

Standard precautions were established for the collection of water quality samples. At each station, all samples were collected by the same person, wearing ultra-trace sampling gloves. Water quality samples were collected using the designated collection bottle supplied by the appropriate laboratory. Upon collection, each sample was immediately labeled with the date and time and logged on a chain-of-custody form and placed into a cooler filled with ice.

Water quality samples were delivered to the analytical laboratory within the appropriate holding times. Coliform samples were delivered to the laboratory on the same day of collection, while all other samples were delivered between 24 to 48 hours of the sample collection time by courier. A chain-of-custody form accompanied all samples from the time of collection to delivery and submittal to the analytical laboratory.

In-stream water samples were collected just below the water surface in areas of steady flow. Water samples from the reservoirs and impoundments were collected below the water surface following the same quality control (QC) procedures. Additional precautions were followed when sampling from a motorized boat. Samples were collected from the bow of the boat after the motor was turned off for at least five to ten minutes to avoid possible hydrocarbon contamination from the motor boat. Sampling equipment was cleaned with a cleaning solution and distilled water prior to sample collection.

Standard quality assurance (QA) procedures were performed by the laboratories during analyses of water samples. These included matrix and laboratory spikes and spike duplicates, matrix duplicates, and method blanks as appropriate. A summary of the QA measures were included with each certified laboratory report.

A QA/QC screening level review was also conducted on all of these laboratory analytical reports. Results of the QA/QC review are presented in Appendix D.

6.0 STUDY RESULTS

6.1 REVIEW OF EXISTING WATER QUALITY OBJECTIVES

The Basin Plan identifies specific water quality objectives of allowable limits or levels of water quality constituents. These objectives are established for the protection of beneficial uses of the waters associated with the MFP (CVRWQCB 2007). If water quality is maintained at levels that meet these objectives, the beneficial uses of the waters are considered to be protected. The beneficial uses identified in the Basin Plan that pertain to water associated with the MFP include: (1) municipal and domestic supply; (2) agricultural irrigation and stock watering; (3) power generation; (4) contact recreation; (5) non-contact recreation; (6) coldwater habitat and spawning habitat for fisheries; and (7) wildlife habitat. The definition of each of these beneficial uses is provided in Table AQ 11-4.

Water quality objectives include both numeric and narrative objectives (Table AQ 11-2). The Basin Plan provides specific numeric objectives for bacteria, *in-situ* measurements, and for chemical or metal constituents. The objectives for chemical and metal constituents are derived from various sources such as maximum contaminant levels (MCLs) that are provided in Title 22 of the California Code of Regulations or from the CTR or NTR. The most stringent objectives were used for this study.

Often more stringent objectives are provided by the CTR and the NTR to protect aquatic life and human health. The CTR and NTR numeric objective for cadmium (Cd), copper (Cu), lead (Pb) and nickel (Ni) is more stringent than the Basin Plan objective. The CTR and NTR have established more stringent criteria for these metals to protect freshwater aquatic life. The CTR and NTR set acute and chronic criteria that are hardness-dependent and must be calculated on a location-by-location basis. For each of these metals, the water quality criterion decreases with decreasing water hardness. These calculated criteria and laboratory results are shown in Tables AQ 11-9, AQ 11-12, and AQ 11-15. The formulas for calculating hardness-dependent criteria are provided in the CTR and NTR guidance documents (US EPA 2007 and 2007a).

The Basin Plan also specifies a water temperature thermal heating objective that states, "Natural water temperatures shall not be altered unless it can be demonstrated to the satisfaction of the Regional Board that such alteration does not adversely affect beneficial uses. At no time or place shall the temperature be increased more than 5°F (2.8°C) above the natural receiving water."

Several of the parameters analyzed do not have established objectives. Various literature sources were reviewed for each parameter to identify guidelines or ranges of the different parameters that might be expected for the MFP area. The ranges are described in Appendix A.

The results of the water quality sampling field program were compared to the most stringent water quality objectives identified Table AQ 11-2. The locations where the objectives have not been met were identified and are discussed in the following results section.

6.2 WATER QUALITY SAMPLING AND ANALYTICAL RESULTS

The following sections provide a discussion of the results of the water quality field sampling program (including the *in-situ* measurements, general water quality sampling, voluntary enhanced water quality sampling, and coliform sampling) associated with the spring and fall sampling events. Within this section the results from the stream and river reaches are discussed first, followed by the results of the sampling on Project reservoirs. The results of the *in-situ* measurements and coliform sampling for the spring and fall sampling events are summarized below. For the other general water quality parameters in the streams and rivers, only those that do not meet the most stringent Basin Plan, CTR, or NTR water quality objective are summarized.

6.2.1 Water Quality Results from Streams and Rivers

All the parameters measured in Project area streams and rivers during the spring and fall sampling event met with the Basin Plan, CTR, and NTR objectives with the exception of dissolved oxygen at three locations near the confluence of Duncan Creek and Middle Fork American River in the spring, and manganese in the fall at one location on the Middle Fork American River below French Meadows Dam at the gaging station.

***In-situ* Field Measurements**

The results of *in-situ* measurements collected in streams and rivers in the vicinity of the MFP during the sampling periods are shown in Tables AQ 11-5 and 11-6. The results of the measurements indicate that three sampling locations did not meet the Basin Plan objectives for dissolved oxygen in the spring. All measurements met the Basin Plan objectives for pH. There are no Basin Plan objectives for temperature, and specific conductance, but measurements were all within expected ranges.

Dissolved Oxygen

According to the Basin Plan objectives, DO concentrations shall not be reduced below a minimum level of 7.0 mg/L for waters designated as COLD. DO concentration will vary with other parameters such as temperature, elevation, photosynthetic activity, biotic activity, stream discharge, and the concentration of other solutes (Hem 1989, Michaud 1994). Increasing temperature or elevation will result in lower DO (MELP 1998).

Dissolved oxygen measurements typically ranged between 7.1 and 11.7 during the spring and fall sampling events. These measurements are consistent with Basin Plan objective. However, at three locations during the spring sampling event, DO was below the Basin Plan objective of 7.0 mg/L. These locations included Duncan Creek above Middle Fork American River confluence (DC-3 RM0.2) and the Middle Fork American River above and below the Duncan Creek confluence (MFAR-3 RM39.9 and MFAR-4

RM39.5). DO concentrations at these locations were measured at 6.2 and 6.3. Based on DO concentrations measured at locations upstream and downstream from these sampling locations, these data are believed to be incorrect due to instrument malfunction or sampling error. These locations were not sampled in the fall due to the unsafe field conditions accessing the sampling locations.

Water Temperature

Measured surface water temperatures generally warm in the downstream direction during both the spring and fall sampling events (Tables AQ 11-5 and AQ 11-6).

Additional water temperature monitoring in rivers and streams in the vicinity of the MFP have been conducted by PCWA as part of ongoing studies. Water temperature data has been collected annually from 2005 through 2007. This monitoring program will continue through summer 2008. The data collected will be summarized and used to evaluate compliance with temperature objectives defined in the Basin Plan. Preliminary water temperature data are presented in the PAD, SD (G), 2005 Water Temperature Report and the 2006 Water Temperature Report (PCWA 2007).

pH

According to the Basin Plan, pH should not be below 6.5 or above 8.5. Furthermore, changes in normal ambient pH levels shall not exceed 0.5 in fresh waters designated as COLD or WARM beneficial uses. Values above 9.5 or below 4.5 are considered lethal to aquatic organisms (EPA 1996; MELP 1998).

Measured pH values were within the range required in the Basin Plan (between 6.5 and 8.5) at all sampling locations.

Specific Conductance

There are no specific Basin Plan objectives for specific conductance. The conductivity of freshwater at 25° C varies between 50 and 1,500 µS/cm (Hem 1989; MELP 1998).

Specific conductance measurements during the spring sampling event ranged from 51 to 82 µS/cm and ranged from 16 to 107 µS/cm during the fall sampling event (Tables AQ 11-5 and AQ 11-6).

General Water Quality Parameters

The laboratory analytical results for the spring and fall sampling programs are summarized in Tables AQ 11-7 through AQ 11-12. Electronic copies of laboratory reports are available on CD. The analytes collected and submitted for laboratory analysis including 17 general parameters, eight dissolved metals, and total mercury. Refer to Table AQ 11-2 for the list of analytes.

During the spring and fall sampling events, all general parameters measured and total mercury samples met the Basin Plan, CTR, or NTR objectives, or were within the expected ranges for the ones that do not have established objectives. All dissolved metal analyses with the exception of dissolved manganese at one location (Middle Fork American River below French Meadows Dam at gaging station) met Basin Plan, CTR, or NTR objectives. The results of the general water quality parameters are summarized in Tables AQ 11-7 through AQ 11-12.

Manganese

The Basin Plan objectives for manganese is 50 µg/L. One sampling location below French Meadows Reservoir, MFAR-2 RM46.6 (Middle Fork American River below French Meadows Dam at gaging station) did not meet the Basin Plan objective (Figure AQ 11-2). The laboratory measured a concentration of 57.7 µg/L. Manganese was not analyzed during the spring sampling event, so it is unknown if MFAR-2 RM46.6 met the Basin Plan objective in the spring (runoff flow). Manganese concentrations in the fall (base flow) met the Basin Plan objective at the sampling locations farther downstream on the Middle Fork American River (Table AQ 11-10).

Voluntary Enhanced Water Quality Sampling

Voluntary enhanced water quality samples, not specified in the AQ 11 - TSP, were collected immediately downstream of Hell Hole Dam (May 22, 2007) and French Meadows Dam (August 6, 2007) in the leakage channels and river locations upstream and downstream of the confluence of the leakage channel. Three locations were sampled below Hell Hole Dam and five locations were sampled below French Meadows Dam. Analyses included *in-situ* measurements, calculated hardness, eight dissolved metals, and total mercury. Flows within the leakage weirs below French Meadows and Hell Hole dams are provided in Appendix E.

Similar to the discussion above, the *in-situ* measurements collected are summarized at each location and only the water quality objectives that did not meet the Basin Plan, CTR or NTR objectives are discussed. The *in-situ* measurements and sampling results are presented in Tables AQ 11-13 through 11-15.

Hell Hole Dam

In Situ Field Measurements

All in-situ field measurements collected below Hell Hole Dam met Basin Plan objectives or were within the expected ranges for the ones that do not have established objectives.

General Water Quality Parameters

The three voluntary enhanced water quality samples collected below Hell Hole Dam met all listed Basin Plan, CTR and NTR objectives.

French Meadows Dam

In Situ Field Measurements

In-situ measurements results indicated that pH and DO did not meet water quality objectives.

- *pH*

The five sampling locations below French Meadows Dam were all below the Basin Plan objective of 6.5 and ranged between 5.3 and 5.3. The results are listed in Table AQ 11-13.

- *Dissolved Oxygen*

Two sampling locations (FM-D and FM-E, both located within the main channel) below French Meadows Dam met the Basin Plan objective of 7.0 mg/L. Three sampling locations in the leakage channel (FM-A, FM-B, and FM-C) did not meet the Basin Plan objective and were below 7.0 mg/L. The results are listed in Table AQ 11-13 and are shown in Figure AQ 11-2.

General Water Quality Parameters

Iron and manganese concentrations in the five samples collected below French Meadows Dam exceeded Basin Plan or NTR objectives. These locations are shown with the sampled locations further downstream in Figure AQ 11-2. All other analytes met the listed Basin Plan or NTR objectives (Tables AQ 11-14 and AQ 11-15).

- *Iron*

The Basin Plan objective for iron is 0.3 mg/L and the NTR objective is 1 mg/L. The Basin Plan specifies a criterion for iron of 0.3 mg/L, based on secondary maximum contaminant levels for drinking water. This criterion is based on a taste, odor, and visual threshold (CTR 2000). When iron is precipitated out of solution due to oxidation, it causes a reddish brown color in the water. The EPA has recommended a value of 1.0 mg/L for a 4-day average continuous concentration for the protection of freshwater aquatic life.

Three of the five samples collected below French Meadows Dam did not meet the Basin Plan and NTR objectives for iron and ranged from 16.0 mg/L to 20.4 mg/L. All of these locations are in the small leakage channels draining from the base of French Meadows Dam. These locations are shown on Map AQ 11-4. The laboratory results for iron are summarized in Table AQ 11-14 and Figure AQ 11-2.

Iron staining was observed along the ground and drainage channels at these three locations, as well as in the Middle Fork American River channel downstream. However, iron results in the plunge pool at the outlet pipe for French Meadow Reservoir (FM-E) and several hundred feet downstream (FM-D) met the Basin Plan and NTR objectives.

- *Manganese*

The Basin Plan objective for manganese is 50 µg/L and is based on secondary maximum contaminant levels for drinking water. Four of the five locations sampled below French Meadows Dam did not meet the Basin Plan objective. Three of these locations are in the small leakage channels draining from the base of French Meadows Dam (results range from 3,610 µg/L and 4,040 µg/L) and the fourth is in the channel downstream of the dam (62.6 µg/L). These locations are shown on Map AQ 11-4. The laboratory results are summarized in Table AQ 11-14 and Figure AQ 11-2.

Coliform Sampling

Total and fecal coliform samples were collected from streams and rivers in the vicinity of the MFP to determine if study waters met Basin Plan objectives for recreational activities. Coliform concentrations are reported at the number of bacteria colonies per 100 mL of sample water (MPN/100 mL). An objective of 200 colonies/100 mL was used to determine if fecal coliform concentrations met Basin Plan objectives for contact recreational activities. There are no Basin Plan objectives for total coliform.

Total and fecal coliform samples were collected during the spring and fall sampling events (Map AQ 11-2). The laboratory results of the total and fecal coliform concentrations are provided in Tables AQ 11-7 and AQ 11-10 and are summarized below.

The fecal coliform results met Basin Plan objectives during the spring sampling event and ranged from less than 2 to 4/100 mL. Total coliform results during the spring sampling event ranged from less than 2/100 mL to 30/100 mL.

During the fall sampling event, one location (NFLC-2 RM2.9) exceeded the objective for fecal coliform (300/100 mL). The remainder of the fecal coliform results met Basin Plan objectives. Total coliform results ranged from less than 2/100 mL to 900/100 mL.

30-Day, Five Sample Fecal Coliform Sampling

The Basin Plan states that "...the fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a geometric mean of 200/100 mL, nor shall more than ten percent of the total samples during any 30-day period exceed 400/100 mL." Seventeen locations throughout the study area were sampled five times over a 30-day period (Table AQ 11-16 and Map AQ 11-2). Sampling began on August 6, 2007 and continued for five subsequent weeks and concluded on Labor Day. At two locations (FC-9 and FC-11), sampling continued until September 10, 2007 due to a sampling location change after the first sampling event on August 6, 2007.

The geometric mean at each of the 17 sampling locations was below the objective of 200/100 mL. However, at one location (FC-15, Ralston Afterbay near the Ralston picnic area) on August 27, 2007, the sample result was 1,600/100 mL. Although, the

geometric mean at this location was 30/100 mL, which is below the Basin Plan objective.

6.2.2 Water Quality Results: Reservoir Profiling and Laboratory Analysis

Water quality depth profiles and the water quality sampling program (including *in-situ* measurements, secchi depth, general water quality sampling, and coliform sampling) associated with the spring and fall sampling events were conducted at various locations in Hell Hole Reservoir, French Meadows Reservoir, and Ralston Afterbay. The following provides a summary of the water quality profiling and sampling results for Ralston Afterbay, Hell Hole Reservoir, and French Meadows Reservoir. The temperature and DO profiling measurements are presented in Appendix C. The results of the profiles and *in-situ* measurements are summarized for each reservoir. For the other general water quality parameters, only those that do not meet the most stringent Basin Plan, CTR, or NTR water quality objectives are summarized.

All parameters measured in Hell Hole Reservoir, French Meadows Reservoir, and Ralston Afterbay during the spring and fall sampling program met with the Basin Plan, CTR, and NTR objectives with the exception of dissolved oxygen in Hell Hole and French Meadows reservoirs.

Hell Hole Reservoir

Water Quality Temperature and Dissolved Oxygen Profile Results

The spring water temperature profiles at the three sampling locations were similar. Spring surface temperatures ranged from 12.7°C at HH-3 to 14.5°C at HH-1. Temperatures steadily declined with depth until 30 to 35m below the water surface, where temperatures remained relatively steady at 6 to 7°C down to the bottom of the reservoir. The fall temperature profiles at the three locations were also similar. Fall surface temperatures were slightly warmer than spring surface water temperatures. Fall water temperatures varied only slightly with depth from the surface to approximately 35 to 40 m. At greater depths, temperatures steadily declined to 11 to 15°C. Reservoir bottom temperatures were approximately 5 to 7°C warmer in the fall than those recorded during the spring sampling event. There was no distinct thermal stratification or thermocline measured in either the spring or fall temperature profiles.

The DO profiles during the spring sampling were similar between the three locations. DO concentrations ranged from 8.1 mg/L to 8.8 mg/L at the surface and ranged from 8.4 mg/L to 8.7 mg/L near the bottom. DO concentrations varied little with depth. The spring DO profiles were also similar between each sampling location. Fall concentrations were slightly lower than those measured during the spring sampling event. Surface concentrations ranged from 6.3 mg/L to 7.1 mg/L and decreased to 5.4 mg/L to 5.8 mg/L near the bottom of the reservoir. DO concentrations had a slight decreasing trend with depth. The DO concentrations for most of the three sampling locations during the fall sampling events were below the Basin Plan objective of 7.0 mg/L for COLD water bodies except at the surface for HH-1. The lowest DO

measurement of 5.4 mg/L was recorded at the bottom of the reservoir at the HH-2 sampling location. Based on other DO concentrations collected in the fall in 2005 and 2006 from Hell Hole Reservoir (PCWA 2007), these fall 2007 data from Hell Hole Reservoir are believed to be incorrect due to instrument malfunction or sampling error.

In-Situ Field Measurements

In-situ measurements were collected at the surface and at approximately mid-depth in the profile. The sampling depths at the three locations for the spring and fall sampling events are shown below.

Site ID	Spring Sampling Depths (m)	Fall Sampling Depths (m)
HH-1	0 and 30	0 and 23
HH-2	0 and 30	0 and 27
HH-3	0 and 30	0 and 20

The results of the measurements are shown in Tables AQ 11-5 and AQ 11-6.

In-situ temperature and DO measurements followed the same trends as discussed above in the profiles for the spring and fall sampling events. Surface water temperatures were warmer than the mid-depth measurements. DO concentration measurements were slightly higher at mid-depth than at the surface for the spring sampling, but were slightly lower at two of the three sampling locations in the fall.

All pH measurements are within the objective listed in the Basin Plan. Surface pH measurements were higher than mid-depth measurements for all three sampling locations during the spring and fall sampling events. Surface pH measurements ranged from 6.9 to 7.1 in the spring and 6.7 to 7.9 in the fall. Mid-depth pH measurements ranged from 6.7 to 6.8 in the spring and 6.8 to 7.1 in the fall. Surface pH measurements were greater in the fall than in the spring at HH-1 and HH-3, but were less at HH-2. All mid-depth pH measurements were greater during the fall sampling event than in the spring sampling event.

Specific conductance measurements were similar between the surface and mid-depth and between the spring and fall sampling events. Spring measurements were approximately 20 μ S/cm and fall measurements were ranged between 30 and 40 μ S/cm.

Secchi depth measurements were conducted at the three sampling locations. The secchi depths for each sampling location during the spring and fall sampling events are shown below.

Site ID	Spring Sampling Secchi Depth (m)	Fall Sampling Secchi Depth (m)
HH-1	9	10
HH-2	11	10
HH-3	8	9.4

General Water Quality Parameters

All the spring and fall parameters analyzed met the Basin Plan, CTR, or NTR objectives. All sampling locations were within or below the suggested ranges discussed in Appendix A for parameters analyzed without established objectives.

Coliform Sampling

All fecal coliform concentrations met the 200/100 mL objective during the spring and fall sampling events.

French Meadows Reservoir

Water Quality Temperature and Dissolved Oxygen Profile Results

The spring water temperature profiles at the three locations were similar (surface temperatures at approximately 16°C). Temperatures steadily declined until approximately 20 m in depth, where temperatures remained relatively steady at 7 to 8°C down to the bottom. The fall temperature profiles at the three locations were similar with surface temperatures (approximately 15°C) and were slightly cooler than spring surface water temperatures. Fall water temperature profiles were different from the spring water temperature profiles. In the fall, water temperatures varied only slightly in depth from the surface to approximately 20 m. Below this depth, temperatures rapidly declined to 8°C at FM-1 and FM-2. Bottom temperatures were warmer at FM-3 (the shallowest location) than at the other two sampling locations. A thermocline was measured in the spring temperature profiles between 10 and 15 m and during the fall between 20 and 25 m.

The DO profiles during the spring sampling were similar at the three locations. Spring DO concentrations ranged from 7.7 mg/L to 7.9 mg/L at the surface and generally increased to the thermocline, then slowly decreased to the bottom of the reservoir. DO concentrations near the bottom of the reservoir ranged from 6.1 mg/L to 8.4 mg/L. The fall DO profiles were also similar at each sampling location. Fall DO surface concentrations were slightly higher than during the spring sampling event. Surface concentrations ranged from 8.2 mg/L to 8.5 mg/L and stayed relatively constant down to the thermocline. DO concentrations then increased at the thermocline (only at FM-1 and FM-2), followed by decreasing concentrations to the bottom of the reservoir (4.3 mg/L to 7.4 mg/L). The DO concentrations for most of the three sampling locations during the spring and fall sampling events met the Basin Plan objective of 7.0 mg/L for COLD water bodies. DO measurements below 7 mg/L were measured at FM-1 during the spring, and at FM-2 during the spring and fall near the bottom of the reservoir sampling areas.

In-Situ Field Measurements

In-situ measurements were collected at the surface and at approximately mid-depth or at the thermocline. The sampling depths at the three locations for the spring and fall

sampling events are shown below. The results of the measurements are shown in Tables 11-5 and 11-6.

Site ID	Spring Sampling Depths (m)	Fall Sampling Depths (m)
FM-1	0 and 30	0 and 22.5
FM-2	0 and 20	0 and 22.5
FM-3	0 and 15	0 and 22.5

In-situ temperature and DO measurements followed the same trends as discussed above in the profiles for the spring and fall sampling events. Surface water temperatures were warmer than the mid-depth measurements. DO concentration measurements were slightly higher at mid-depth than at the surface for the spring sampling. In comparison, in the fall, DO concentrations were greater at the surface than at mid-depth.

All pH measurements were within the acceptable ranges of 6.5 to 8.5, as listed in the Basin Plan. Surface pH measurements were higher than mid-depth measurements for all three sampling locations during the spring and fall sampling events. Spring surface and mid-depth pH measurements were overall slightly higher during the fall sampling event. Surface pH measurements ranged from 6.6 to 6.9 in the spring and from 7.2 to 7.9 in the fall. Mid-depth pH measurements ranged from 6.5 to 6.6 in the spring and from 6.5 to 6.7 in the fall.

Specific conductance measurements were similar between the surface and mid-depth and between the spring and fall sampling events. Spring measurements were approximately 30 $\mu\text{S}/\text{cm}$ and fall measurements were approximately 20 $\mu\text{S}/\text{cm}$.

Secchi depth measurements were conducted at the three sampling locations during the spring event. Measurements were taken at only one location during the fall event due to high winds on the reservoir later in the day. The winds and water currents would have prevented accurate secchi depth measurements, as the disk would not drop vertically, skewing the results. At the one sampling location, water clarity was better during the fall than during the spring. The secchi depths for each sampling locations during the spring and fall sampling events are shown below.

Site ID	Spring Sampling Secchi Depth (m)	Fall Sampling Secchi Depth (m)
FM-1	6.5	9.5
FM-2	7.5	Too Windy*
FM-3	7	Too Windy*

*Conditions on the reservoir were too windy for collecting accurate measurements.

General Water Quality Parameters

All the spring and fall parameters analyzed met the Basin Plan, CTR, or NTR objectives. All sampling locations were within or below the expected ranges discussed in Appendix A for parameters analyzed without established objectives.

Coliform Sampling

All fecal coliform concentrations met the 200/100 mL objective during the spring and fall sampling events.

Ralston Afterbay

Water Quality Temperature and Dissolved Oxygen Profile Results

Spring surface temperature in Ralston Afterbay was measured at 19 °C and decreased to 10.5 °C near the bottom of the afterbay. In comparison, temperatures in the fall were fairly constant with depth, ranging from 13.5 °C at the surface to 12 °C near the bottom. Some thermal stratification was present during the spring profiling event, but not during the fall profiling event.

The DO at the surface was 10.3 mg/L and 11.0 mg/L for the spring and fall sampling events, respectively. The concentration of DO generally increased with increasing depth (and with decreasing water temperature) to 10 m below the water surface. During the spring when the depth exceeded 10 m, DO concentrations decreased. DO concentrations ranged between 10.0 mg/L and 11.6 mg/L during both sampling events throughout the entire profile.

In-Situ Field Measurements

In-situ measurements were collected at the surface and at approximately mid-depth in the profile. The sub-surface measurements were collected at 6 m and at 5 m during the spring and fall sampling events, respectively. The results of the measurements are shown in Tables AQ 11-5 and AQ 11-6.

In-situ temperature and DO measurements followed the same trend as discussed above in the profiles for the spring and fall sampling events. Surface water temperatures were warmer than the mid-depth measurements and conversely, DO measurements were higher at mid-depth than at the surface.

In-situ pH measurements were between 6.0 and 7.0, acceptable limits within the Basin Plan. Spring pH measurements were 6.6 at the surface and 6.5 at mid-depth. Fall pH measurements were 7.0 at the surface and 6.8 at mid-depth.

Specific conductance measurements were similar between the surface and mid-depth and between the spring and fall sampling events. Spring measurements ranged between 30 and 50 μ S/cm. Fall measurements ranged between 30 and 40 μ S/cm.

Secchi depth measurements were also collected at the sampling location. Water clarity remained the same between the two sampling periods, with secchi depth readings of 7 m for both the spring and fall sampling events.

General Water Quality Parameters

All the spring and fall parameters analyzed met the Basin Plan, CTR, or NTR objectives. In addition, the results of the analyses for the parameters without established objectives were within the expected ranges discussed in Appendix A.

Coliform Sampling

All fecal coliform concentrations met the 200/100 mL objective during the spring and fall sampling events.

6.3 FISH TISSUE ANALYSIS

The following section provides a discussion of the fish tissue analysis from the Project reservoirs, Ralston Afterbay, Middle Fork Interbay, and the Middle Fork American River near Otter Creek. Laboratory analyses of methyl mercury were conducted on muscle tissue samples from individual and composite fish samples. The screening value for methyl mercury in fish established by the OEHHA to determine if additional studies are warranted is 0.08 ppm (which is equal to 0.08 mg/kg fish).

Methyl mercury concentrations in at least one fish from each location exceeded the OEHHA screening value of 0.08 mg/kg fish. Twenty-three of the 45 individual fish analyzed exceeded the screening value. The highest concentrations (up to 1.140 mg/kg) were measured in fish from Hell Hole Reservoir, where the largest fish were caught. A summary of the fish that were caught, including the species, fork and total lengths, and weight, is provided in Table AQ 11-17. The direct relationship between methyl mercury concentrations and the weight of the fish for each of the sampling locations is shown in Figure AQ 11-3. The results of the fish tissue sampling at each location are summarized below.

In Hell Hole Reservoir, eight of the ten individual fish analyzed (brown trout, lake trout, and rainbow trout), as well as the composite sample of brown trout, exceeded the OEHHA guidelines. Methyl mercury concentrations in the fish tissue from Hell Hole Reservoir ranged from 0.004 mg/kg fish to 1.14 mg/kg fish. All the brown trout analyzed exceeded the screening level.

In French Meadows Reservoir, three of the five individual fish, including both brown trout exceeded 0.08 ppm. The composite sample of five brown trout also exceeded the screening value. The highest methyl mercury concentration measured in the fish from French Meadows Reservoir was 0.357 mg/kg fish.

Only one of the ten brown and rainbow trout caught in Middle Fork Interbay exceeded the screening value. The concentration of the rainbow trout measured was 0.135 mg/kg fish.

Eight of the ten fish caught, including all the Sacramento pikeminnows and the four largest brown trout, in Ralston Afterbay exceeded the screening value. The highest concentration measured in the fish caught in Ralston Afterbay was 0.348 mg/kg fish.

Methyl mercury concentrations in three of the ten fish caught in the Middle Fork American River near Otter Creek exceeded 0.08 mg/kg fish. Only rainbow trout were caught at this location. The exceedances occurred in the three of the four largest fish caught at this location. The greatest concentration measured in fish from the Middle Fork American River was 0.130 mg/kg fish.

6.4 QUALITY ASSURANCE/ QUALITY CONTROL PROCEDURES

A detailed summary of the QA/QC review of these reports can be found in Appendix D, Tables D-1 through D-4. A summary of potential issues identified in the QA/QC reports from each laboratory and sampling event is also provided in Appendix D.

The QA/QC review from the Test America (TA) and Brooks Rand (BR) laboratories indicated that most sample results (spring and fall sampling event, voluntary enhanced sampling below Project reservoirs, and fish tissue sampling) were acceptable, with only four sample results considered estimates. The results that were considered estimates include the spring sample at FM-3 (S) for TOC, and for three of the additional samples below French Meadows Dam (FM-A, FM-B, and FM-C) for manganese.

7.0 LITERATURE CITED

California Department of Water Resources (DWR). 2007. California Data Exchange Center, Reservoir Information. <http://cdec.water.ca.gov/misc/resinfo.html>. Site accessed on November 15, 2007.

California Environmental Protection Agency (Cal EPA). 2005. General Protocol for Sport Fish Sampling and Analysis. Pesticide and Environmental Toxicology Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. December 2005.

Central Valley Regional Water Quality Control Board (CVRWQCB). 1998. Basin Plan. Fourth Edition, The Sacramento River Basin and the San Joaquin River Basin. September 1998.

Hem, J.D. 1989. Study and Interpretation of the Chemical Characteristics of Natural Water. Third Edition. U. S. Geological Survey Water-Supply Paper 2254.

Klasing, S. and R. Brodberg. 2006. Draft Development of Guidance Tissue Levels and Screening Values for Common Contaminants in California Sport Fish: Chloradane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene.

Pesticide and Environmental Toxicology Branch Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. <http://www.oehha.ca.gov/fish/gtllsv/pdf/draftGTLSCchddt.pdf>.

Michaud, J. 1994. A Citizen's Guide to Understanding and Monitoring Lakes and Streams. January 1994. Washington State, Department of Ecology. 73 pp.

Ministry of Environment, Lands and Parks, British Columbia (MELP). 1998. Guidelines for Interpreting Water Quality Data. Resources Inventory Committee Publications. Available: <http://ilmbwww.gov.bc.ca/risc/pubs/aquatic/interp/index.htm>.

Placer County Water Agency (PCWA). 2007. Placer County Water Agency Middle Fork American River Project, FERC Project No. 2079, Pre-Application Document.

Placer County Water Agency (PCWA). 2008. Annual Dam Surveillance and Monitoring Report. February 27, 2008.

Regional Water Quality Control Board (CVRWQCB). 2007. The Sacramento River Basin and San Joaquin River Basin Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board - Central Valley Region (CVRWQCB, Fourth Edition revised February 2007).

State Water Resources Control Board (SWRCB). 1991. California Inland Surface Waters Plan: Water Quality Control Plan for Inland Surface Waters in California. Water Resources Control Board of California. April 1991.

United States Environmental Protection Agency (EPA). 1992. Water Quality Standards: Establishment of Numeric Criteria for Priority Toxic Pollutants. Federal Register, 57 FR 60848.

United States Environmental Protection Agency (EPA). 1996. The Metals Translator: Guidance for calculating a total recoverable permit limit for a dissolved criterion. June 1996. EPA 823-B-96-007.

United States Environmental Protection Agency (EPA). 2000. Water Quality Standards: Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California. Federal Register, 65 FR 31682.

United States Environmental Protection Agency (EPA). 2007. Water Quality Standards; Established of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule. August 2007, 40 CFR Part 131.

United States Environmental Protection Agency (EPA). 2007a. Water Quality Standards; Established of Numeric Criteria for Priority Toxic Pollutants. Federal Register, 57 FR 60848.

TABLES

Table AQ 11-1. Water Quality Monitoring and Sampling Station Locations for 2007 Sampling Program.

Sample ID	Location Name	GPS Coordinates		Spring Sampling Program May 14-31	Weekly Sampling						Fall Sampling Program Sept. 24-Oct. 3
		UTM10_ NAD 83 X	UTM10_ NAD 83 Y		Aug 6	Aug. 13	Aug. 20	Aug. 27	Sept. 3	Sept. 10	
Duncan Creek											
DC-1 RM8.9	Duncan Creek above diversion	718058	4334904	X							X
DC-2 RM8.8	Duncan Creek below diversion	717492	4334534	X							X
DC-3 RM0.2	Duncan Creek above Middle Fork American River confluence	712310	4324261	X							
Middle Fork American River											
MFAR-1 RM52.8	Middle Fork American River above French Meadows Reservoir	724030	4334663	X							X
FM-1 (S)	French Meadows Reservoir surface (lower)	718930	4332295	X							X
FM-1	French Meadows Reservoir sub-surface (lower)	718930	4332295	X							X
FM-2 (S)	French Meadows Reservoir surface (middle)	720708	4332155	X							X
FM-2	French Meadows Reservoir sub-surface (middle)	720708	4332155	X							X
FM-3 (S)	French Meadows Reservoir surface (upper)	722241	4332680	X							X
FM-3	French Meadows Reservoir sub-surface (upper)	722241	4332680	X							X
MFAR-2 RM 46.6	Middle Fork American River below French Meadows Dam at gaging station	717789	4331977	X							X
MFAR-3 RM39.9	Middle Fork American River above Duncan Creek confluence	712707	4324155	X							
MFAR-4 RM39.5	Middle Fork American River below Duncan Creek confluence	712202	4323824	X							
MFAR-5 RM36.3	Middle Fork American River above Interbay Reservoir	708507	4322669	X							X
IR-1 RM35.7	In Middle Fork Interbay	717789	4331977	X							X
MFAR-6 RM35.5	Middle Fork American River below Middle Fork Interbay	707362	4322470	X							X
MFAR-7 RM26.1	Middle Fork American River above Ralston Afterbay	696379	4320205	X							X
Ralston Afterbay Downstream											
RA-1(S)	Ralston Afterbay surface	695348	4319604	X							X
RA-1	Ralston Afterbay sub-surface	695348	4319604	X							X
MFAR-8 RM24.7	Middle Fork American River below dam	694987	4319551	X							X
MFAR-9 RM24.3	Middle Fork American River below Oxbow Powerhouse tailrace	695104	4319974	X							X

Table AQ 11-1. Water Quality Monitoring and Sampling Station Locations for 2007 Sampling Program (continued).

Sample ID	Location Name	GPS Coordinates		Spring Sampling Program May 14-31	Weekly Sampling						Fall Sampling Program Sept. 24-Oct. 3
		UTM10_ NAD 83 X	UTM10_ NAD 83 Y		Aug 6	Aug. 13	Aug. 20	Aug. 27	Sept. 3	Sept. 10	
MFAR-10 RM9.1	Middle Fork American River below the Drivers Flat Road Rafting Take-Out	679156	4314631	X							X
MFAR-11 RM0.1	Middle Fork American River above North Fork American River	670249	4309058	X							X
NFAR-1 RM20.6	North Fork American River below Middle Fork American River	669795	4308943	X							X
Rubicon River											
RR-1 RM35.9	Rubicon River above Reservoir	729518	4328802	X							X
HH-1 (S)	Hell Hole Reservoir surface (lower)	724117	4326670	X							X
HH-1	Hell Hole Reservoir sub-surface (lower)	724117	4326670	X							X
HH-2 (S)	Hell Hole Reservoir surface (middle)	724599	4328282	X							X
HH-2	Hell Hole Reservoir sub-surface (middle)	724599	4328282	X							X
HH-3 (S)	Hell Hole Reservoir surface (upper)	726090	4329264	X							X
HH-3	Hell Hole Reservoir sub-surface (upper)	726090	4329264	X							X
RR-2 RM30.2	Rubicon River below dam at gaging station	724209	4326071	X							X
RR-3 RM 22.8	Rubicon River above South Fork Rubicon River confluence	719372	4316701	X							X
SFRR-1 RM0.2	South Fork Rubicon River above Rubicon River confluence	719482	4316246	X							X
RR-4 RM22.5	Rubicon River below South Fork Rubicon River confluence	719153	4316364	X							X
RR-5 RM3.8	Rubicon River above Long Canyon Creek confluence	700507	4318147	X							X
RR-6 RM3.5	Rubicon River below Long Canyon Creek confluence	700162	4318171	X							X
RR-7 RM0.7	Rubicon River above Ralston Afterbay	697119	4319216	X							X
Long Canyon Creek											
NFLC-1 RM3.2	North Fork Long Canyon Creek above diversion	717980	4325629	X							X
NFLC-2 RM2.9	North Fork Long Canyon Creek below diversion	717848	4325174	X							X
NFLC-3 RM0.3	North Fork Long Canyon Creek above Long Canyon Creek confluence	715004	4322534	X							X
SFLC-1 RM3.4	South Fork Long Canyon Creek above diversion	719042	4325646	X							X
SFLC-2 RM3.1	South Fork Long Canyon Creek below diversion	718669	4325275	X							X
SFLC-3 RM0.2	South Fork Long Canyon Creek above Long Canyon Creek confluence	715314	4322198	X							X

Table AQ 11-1. Water Quality Monitoring and Sampling Station Locations for 2007 Sampling Program (continued).

Sample ID	Location Name	GPS Coordinates		Spring Sampling Program May 14-31	Weekly Sampling						Fall Sampling Program Sept. 24-Oct. 3
		UTM10_ NAD 83 X	UTM10_ NAD 83 Y		Aug 6	Aug. 13	Aug. 20	Aug. 27	Sept. 3	Sept. 10	
LCC-1 RM11.3	Long Canyon Creek below North Fork and South Fork Long Canyon creeks confluence	714962	4321986	X							X
LCC-2 RM0.3	Long Canyon Creek above Rubicon River confluence	700544	4318487	X							X
Fecal Coliform											
FC-1	Middle Fork American River below Ahart Campground	724066	4336067		X	X	X	X	X		
FC-2	Middle Fork American River below Gates Group Campground	723679	4335535		X	X	X	X	X		
FC-3	Middle Fork American River below Coyote and Lewis Campground	723578	4334312		X	X	X	X	X		
FC-4	French Meadows Reservoir near McGuire Picnic Area	722892	4333328		X	X	X	X	X		
FC-5	French Meadows Reservoir near McGuire Boat Ramp	722565	4333376		X	X	X	X	X		
FC-6	French Meadows Reservoir near French Meadows Campground	722654	4332703		X	X	X	X	X		
FC-7	French Meadows Reservoir near French Meadows Boat Ramp	722249	4332433		X	X	X	X	X		
FC-8	French Meadows Reservoir near Poppy Campground	721628	4333151		X	X	X	X	X		
FC-9	Hell Hole Reservoir near Upper Hell Hole Reservoir Campground	728501	4329059			X	X	X	X	X	
FC-10	Hell Hole Reservoir near Hell Hole Boat Ramp	723737	4326842		X	X	X	X	X		
FC-11	South Fork Long Canyon Creek above Big Meadows Campground	722744	4328540			X	X	X	X	X	
FC-12	South Fork Long Canyon Creek below Big Meadows Campground	722119	4328056		X	X	X	X	X		
FC-13	South Fork Long Canyon Creek above Middle Meadows Campground	719274	4325849		X	X	X	X	X		
FC-14	South Fork Long Canyon Creek below Middle Meadows Campground	718907	4325560		X	X	X	X	X		
FC-15	Ralston Afterbay near Ralston Picnic Area	696326	4319720		X	X	X	X	X		
FC-16	Middle Fork American River below Oxbow Powerhouse (Horseshoe Bar Area)	695159	4320291		X	X	X	X	X		
FC-17	Middle Fork American River below the Drivers Flat Road Camping and Rafting Take-out	679156	4314631		X	X	X	X	X		

Table AQ 11-2. Summary of Water Quality Analytical Tests, Including Laboratory Methods and Detection Limits, and Chemical Water Quality Objectives.

Analyte	Units ¹	Analysis Method ²	Method Detection Limit (MDL) ³	Practical Quantitation Limit (PQL) ⁴	State and Federal Criteria			Sample Container	Hold Time	Preservative/Comment
					Basin Plan ⁵	CA Toxics Rule (CTR) ⁶	National Toxics Rule (NTR) ⁷			
In-Situ Measurements										
Oxygen, dissolved (DO)	mg/L	Water Quality Meter	Not Applicable	Not Applicable	7.0 ⁸	NS	NS ⁹	Not Applicable	Not Applicable	None
Secchi Depth	meter	Secchi Disc	Not Applicable	Not Applicable	NS	NS	NS	Not Applicable	Not Applicable	None
pH	unitless	Water Quality Meter	Not Applicable	Not Applicable	6.5 – 8.5 ¹⁰	NS	6.5 – 9.0 ¹¹	Not Applicable	Not Applicable	None
Water Temperature	Celsius	Water Quality Meter	Not Applicable	Not Applicable	NS	NS	NS	Not Applicable	Not Applicable	None
Specific Conductance	uS/cm at 25 °C	Water Quality Meter	Not Applicable	Not Applicable	NS	NS	NS	Not Applicable	Not Applicable	None
General Parameters										
Calcium	mg/L	EPA-200.7	Not Applicable	0.50	NS	NS	NS	1L plastic	180 days	Refrigerate
Chloride	mg/L	EPA-300.0	Not Applicable	1.0	250 ¹²	NS	230/860 ¹³	1L plastic	28 days	Refrigerate
Hardness (as CaCO ₃)	mg/L	SM2340B	Not Applicable	1.0	NS	NS	NS	1L plastic	180 days	HNO ₃ , refrigerate
Magnesium	ug/L	EPA-200.7	Not Applicable	100	NS	NS	NS	1L plastic	180 days	HNO ₃ , refrigerate
Nitrate/Nitrite (NO ₃)	mg/L	EPA-300.0	Not Applicable	0.20	1	NS	NS	1L plastic	28 days	Refrigerate
Ammonia as N	mg/L	EPA-350.3	Not Applicable	0.1	1.5 ¹⁴	NS	(15)	1L plastic	28 days	H ₂ SO ₄ , Refrigerate
Total Kjeldahl Nitrogen (TKN)	mg/L	EPA-351.2	Not Applicable	0.100	NS	NS	NS	1L plastic	28 days	H ₂ SO ₄ , Refrigerate
Total Phosphorus	mg/L	EPA-365.3	Not Applicable	0.1	NS	NS	NS	1L plastic	28 days	H ₂ SO ₄ , Refrigerate
Ortho-phosphate	mg/L	SM4500P-E	Not Applicable	0.010	NS	NS	NS	1L plastic	48 hours	Refrigerate
Potassium	mg/L	EPA-200.7	Not Applicable	2.0	NS	NS	NS	1L plastic	180 days	HNO ₃ , refrigerate
Sodium	mg/L	EPA-200.7	Not Applicable	0.50	NS	NS	NS	1L plastic	180 days	HNO ₃ , refrigerate
Sulfate (SO ₄)	mg/L	EPA-300.0	Not Applicable	0.50	250 ¹²	NS	NS	1L plastic	28 days	Refrigerate
Total Dissolved Solids	mg/L	SM2540C	Not Applicable	10	500 ¹²	NS	NS	1L plastic	7 days	Refrigerate
Total Suspended Solids	mg/L	SM2540D	Not Applicable	10	NS	NS	NS	1L plastic	7 days	Refrigerate
Turbidity	NTU	EPA-180.1	Not Applicable	0.10	(16)	NS	NS	1L plastic	48 hours	Refrigerate
Organic Carbon, Total (TOC)	mg/L	SM5310B	Not Applicable	1.00	NS	NS	NS	250 mL amber glass	28 days	HCL, refrigerate
Total Alkalinity (as CaCO ₃)	mg/L	SM2320B	Not Applicable	5.0	NS	NS	>20 ¹⁷	1L plastic	14 days	Refrigerate
Metals-Dissolved										
Arsenic	ug/L	EPA-1368	0.06	0.20	10	150/340 ¹³	150/340 ¹³	250 mL plastic	180 days	Field filtered, refrigerate
Cadmium	ug/L	EPA-1368	0.004	0.01	5	Hardness Dependent ^{13, 18}	Hardness Dependent ^{13, 18}	250 mL plastic	180 days	Field filtered, refrigerate
Copper	mg/L	EPA-1368	0.00004	0.0002	1 ¹²	1.3 ²⁰ , Hardness Dependent ^{13, 18}	1.3 ²⁰ , Hardness Dependent ^{13, 18}	250 mL plastic	180 days	Field filtered, refrigerate
Iron	mg/L	EPA-1368	0.0014	0.005	0.3 ¹²	NS	1 ¹⁹	250 mL plastic	180 days	Field filtered, refrigerate
Lead	ug/L	EPA-1368	0.01	0.05	15	Hardness Dependent ^{13, 18}	Hardness Dependent ^{13, 18}	250 mL plastic	180 days	Field filtered, refrigerate
Manganese	ug/L	EPA-1368	0.01	0.05	50 ¹²	NS	NS	250 mL plastic	180 days	Field filtered, refrigerate
Nickel	ug/L	EPA-1368	0.04	0.20	100	610 ²⁰ , 4,600 ²¹ , Hardness Dependent ^{13, 18}	610 ²⁰ , 4,600 ²¹ , Hardness Dependent ^{13, 18}	250 mL plastic	180 days	Field filtered, refrigerate
Chromium-Total	ug/L	EPA-1368	0.03	0.15	50	NS	NS	250 mL plastic	180 days	Field filtered, refrigerate
Metals-Total										
Mercury	ug/L	EPA-1361e	0.00015	0.0004	NS	0.05	0.77/1.4 ¹³	250 mL plastic	180 days	Refrigerate
Methyl mercury	mg/Kg fish	EPA-1630 mod./MSPL-102a	0.001-0.01	0.003-0.029	NS	NS	0.3 ²²	Teflon sheet and ziplock bag	Not Applicable	Freeze

Table AQ 11-2. Summary of Water Quality Analytical Tests, Including Laboratory Methods and Detection Limits, and Chemical Water Quality Objectives (continued).

Analyte	Units ¹	Analysis Method ²	Method Detection Limit (MDL) ³	Practical Quantitation Limit (PQL) ⁴	State and Federal Criteria			Sample Container	Hold Time	Preservative/Comment
					Basin Plan ⁵	CA Toxics Rule (CTR) ⁶	National Toxics Rule (NTR) ⁷			
Hydrocarbons										
Methyl-tertiary-butyl Ether (MtBE)	ug/L	EPA-8260	Not Applicable	0.50	5 ¹²	NS	NS	40mL VOA	14 days	HCL, refrigerate
Total Petroleum Hydrocarbons (as gasoline and as diesel)	ug/L	EPA-8020	Not Applicable	50	NS	NS	(23)	40mL VOA	14 days	HCL, refrigerate
Oil and Grease	mg/L	EPA-1664	Not Applicable	4.8	(24)	NS	(25)	1L amber glass	48 hours	HCL, refrigerate
Bacteria										
Total Coliform (3x5, 6 hr hold)	MPN/100 mL ²⁶	EPA-SM9222B	Not Applicable	2	NS	NS	NS	NS	24 hours	Refrigerate
Fecal Coliform (3x5)	MPN/100 mL ²⁶	EPA-SM922B	Not Applicable	2-1600	200	NS	NS	100 mL plastic	24 hours	Refrigerate

¹Units follow listed criterion standards. If standards were not available, laboratory supplied units were used. (Note: µg/L=ppb and mg/L=ppm)

²Analysis methods are periodically updated by the EPA. The most recent methods available were used for the water quality analysis.

³MDL: "the minimum concentration of a substance that can be reported with a 99% confidence that the analyte concentration is greater than zero." (40 CFR Part 136)

⁴PQL: "the lowest concentration of an analyte that can be reliably measured within specified limits of precision and accuracy during routine laboratory operating conditions." (50 FR 46906)

⁵The Basin Plan for the Sacramento and San Joaquin River Basins rely on California primary and secondary Maximum Concentration Level objectives as criteria for water quality to be used as a municipal and domestic supply for human consumption.

⁶California Toxics Rule (CTR) criteria are based primarily on USEPA standards developed under the Clean Water Act for human consumption of water and aquatic organisms with an adult risk for carcinogens estimated to be one in one million as contained in the Integrated Risk Information System (IRIS) as of October 1, 1996.

⁷The National Toxics Rule (NTR) criteria are based on USEPA standards developed under the Clean Water Act for human consumption of water and aquatic organisms with an adult risk for carcinogens estimated to be one in one million as contained in the IRIS as of October 1, 1996. These criteria are to be applied to all states not complying with the Clean Water Act section 303(c)(2)(B).

⁸For water designated as COLD.

⁹The water column concentration of 9.5 mg/L for a 7-day mean is recommended to achieve the required intergravel dissolved oxygen concentrations.

¹⁰pH shall not be depressed below 6.5 or raised greater than 8.5. Changes in normal ambient pH should not exceed 0.5.

¹¹Instantaneous maximum value. This limit has a range of values between the first and second numbers shown.

¹²The criteria listed are secondary Maximum Concentration Levels for California drinking water quality objectives that do not necessarily indicate a toxic amount of contaminate. Rather these standards dictate water quality objectives designed to preserve taste, odor, or appearance of drinking water.

¹³Freshwater Aquatic Life Protection, continuous concentration (4-day average)/maximum concentration (1-hour average).

¹⁴Taste and odor threshold.

¹⁵pH, temperature and life cycle dependent.

¹⁶Increases in turbidity attributable to controllable water quality factors shall not exceed the following limits: where natural turbidity is between 0 and 5 NTU's, increases shall not exceed 1 NTU. Where natural turbidity is between 5 and 50 NTU's, increases shall not exceed 20%. Where natural turbidity is between 50 and 100 NTU's, increases shall not exceed 10 NTU's. Finally, where natural turbidity is greater than 100 NTU's, increases shall not exceed 10%.

¹⁷20 mg/L or more of CaCO₃ for freshwater aquatic life except where natural concentrations are less (USEPA's 1976 'Red Book'). The 'Red Book' also recommends that natural alkalinity not be reduced by more than 25%.

¹⁸Criterion is hardness dependent which is expressed as a function of hardness and decreases as hardness decreases. The actual criteria are calculated based on the hardness (as CaCO₃) of the sample water.

¹⁹NTR Freshwater Aquatic Life Protection, continuous concentration (4-day average).

²⁰CTR and NTR human health (30-day average); Drinking Water Sources (consumption of water an aquatic organisms).

²¹CTR human health (30-day average); Other Waters (aquatic organism consumption only).

²²This value is an Ambient Water Quality Criteria (AWQC) for methyl mercury and was published by the USEPA in a document titled Water Quality Criterion for the Protection of Human Health: Methyl mercury-Final (EPA-823-R-01-001, January 2001). This AWQC for total mercury published in 1980 and partially updated in 1997.

²³From Compilation of Water Quality Goals – TPH-diesel: taste and odor threshold and proposed USEPA SNARL = 100 ug/L. TPH-gasoline: taste and odor threshold and proposed USEPA SNARL = 5 mg/L.

²⁴Waters shall not contain oils, greases, waxes, or other materials in concentrations that cause nuisance, result in a visible film or coating on the surface of the water or on objects in the water, or otherwise adversely affect beneficial uses.

²⁵For domestic water supply: Virtually free from oil and grease, particularly from the tastes and odors that emanate from petroleum products (USEPA's 1986 'Gold Book').

²⁶MPN: Most probable number of bacterial colonies per 100 mL of water.

Items in parentheses () are footnotes.

NS: no standard available

MPN: Most probable number of bacterial colonies per 100 mL of water.

Table AQ 11-3. List of Voluntary Enhanced Water Quality Sampling Locations.

Hell Hole Reservoir

Sample ID	Sample Location Description	GPS Coordinates	
		UTM10_ NAD 83X	UTM10_ NAD 83Y
RR-2A	Rubicon River below Hell Hole Reservoir outlet pipe	724275	4326213
RR-EC	Leakage channel below Hell Hole Reservoir	724237	4326112
RR-BEC	Rubicon River below Hell Hole Reservoir and leakage channel	724232	4326108

French Meadows Reservoir

Sample ID	Sample Location Description	GPS Coordinates	
		UTM10_ NAD 83X	UTM10_ NAD 83Y
FM-A	Leakage channel A below French Meadows Reservoir	718622	4332105
FM-B	Leakage channel B below French Meadows Reservoir	718569	4332212
FM-C	Leakage channel C below French Meadows Reservoir	718569	4332226
FM-E*	Middle Fork American River below French Meadows Reservoir outlet pipe	718551	4332220
FM-D*	Middle Fork American River below French Meadows Reservoir and spillway channel	718304	4332195

*Sampling IDs are listed in upstream to downstream order

Table AQ 11-4. The Sacramento River Basin and San Joaquin River Basin Water Quality Control - Definition of Beneficial Uses.

Beneficial Use	Definition
Municipal and Domestic Supply (MUN)	Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.
Agricultural Supply (AGR)	Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation (including leaching of salts), stock watering, or support of vegetation for range grazing.
Hydropower Generation (POW)	Uses of water for hydropower generation.
Water Contact Recreation (REC-1)	Uses 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, whitewater activities, fishing, or use of natural hot springs.
Non-contact Water Recreation (REC-2)	Uses 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, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.
Cold Freshwater Habitat (COLD)	Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
Spawning, Reproduction and/or Early Development (SPWN)	Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.
Wildlife Habitat (WILD)	Uses of water that support terrestrial or wetland ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats or wetlands, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Source: Table II of *The Sacramento River Basin and San Joaquin River Basin Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board –Control Valley Region Fourth Edition revised February 2007.*

Table AQ 11-5. Summary of *In-Situ* Stream Measurements Collected During the Spring 2007 Sampling Event.

Sample ID	Location Name	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm at 25 °C)	pH	Sample Water Depth ¹ (m)	Secchi Depth ² (m)
Duncan Creek								
DC-1 RM8.9	Duncan Creek above diversion	5/22/2007	7.24	8.9	57	7.6	0	
DC-2 RM8.8	Duncan Creek below diversion	5/22/2007	7.97	8.8	57	7.9	0	
DC-3 RM0.2	Duncan Creek above Middle Fork American River confluence	5/17/2007	11.16	6.3	67	8.2	0	
Middle Fork American River								
MFAR-1 RM51.6	Middle Fork American River above French Meadows Reservoir	5/22/2007	8.23	9.0	53	7.7	0	
FM-1 (S)	French Meadows Reservoir surface (lower)	5/30/2007	16.32	7.9	25	6.9	0	6.5
FM-1	French Meadows Reservoir sub-surface (lower)	5/30/2007	7.17	8.2	23	6.5	30	
FM-2 (S)	French Meadows Reservoir surface (middle)	5/31/2007	16.12	7.7	25	6.6	0	7.5
FM-2	French Meadows Reservoir sub-surface (middle)	5/31/2007	8.25	8.4	24	6.5	20	
FM-3 (S)	French Meadows Reservoir surface (upper)	5/31/2007	16.45	7.9	25	6.6	0	7
FM-3	French Meadows Reservoir sub-surface (upper)	5/31/2007	9.89	8.8	23	6.6	15	
MFAR-2 RM 46.6	Middle Fork American River below French Meadows Dam at gaging station	5/22/2007	10.60	9.0	54	7.4	0	
MFAR-3 RM39.9	Middle Fork American River above Duncan Creek confluence	5/17/2007	13.17	6.3	66	7.7	0	

Table AQ 11-5. Summary of *In-Situ* Stream Measurements Collected During the Spring 2007 Sampling Event (continued).

Sample ID	Location Name	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm at 25 °C)	pH	Sample Water Depth ¹ (m)	Secchi Depth ² (m)
MFAR-4 RM39.5	Middle Fork American River below Duncan Creek confluence	5/17/2007	12.44	6.2	67	7.8	0	
MFAR-5 RM36.3	Middle Fork American River above Middle Fork Interbay	5/16/2007	13.25	8.9	68	8.4	0	
IR-1 RM35.7	In Middle Fork Interbay	5/16/2007	13.77	8.8	66	7.2	0	
MFAR-6 RM35.5	Middle Fork American River below Middle Fork Interbay	5/16/2007	10.02	9.3	60	7.7	0	
MFAR-7 RM26.1	Middle Fork American River above Ralston Afterbay	5/22/2007	15.44	8.5	82	7.4	0	
Ralston Afterbay Downstream								
RA-1(S)	Ralston Afterbay surface	5/29/2007	19.15	10.3	53	6.6	0	
RA-1	Ralston Afterbay sub-surface	5/29/2007	12.03	11.4	36	6.5	6	7
MFAR-8 RM24.7	Middle Fork American River below dam	5/21/2007	18.76	8.0	63	7.0	0	
MFAR-9 RM24.3	Middle Fork American River below Oxbow Powerhouse tailrace	5/21/2007	15.32	8.9	66	7.3	0	
MFAR-10 RM9.1	Middle Fork American River below the Drivers Flat Road Rafting Take-Out	5/14/2007	16.53	9.7	64	6.8	0	
MFAR-11 RM0.1	Middle Fork American River above North Fork American River	5/16/2007	19.73	8.7	67	7.3	0	
NFAR-1 RM20.6	North Fork American River below Middle Fork American River	5/16/2007	18.51	8.7	72	7.4	0	

Table AQ 11-5. Summary of *In-Situ* Stream Measurements Collected During the Spring 2007 Sampling Event (continued).

Sample ID	Location Name	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm at 25 °C)	pH	Sample Water Depth ¹ (m)	Secchi Depth ² (m)
Rubicon River								
RR-1 RM35.9	Rubicon River above Reservoir	5/24/2007	9.60	10.3	52	7.8	0	
HH-1 (S)	Hell Hole Reservoir surface (lower)	5/30/2007	14.52	8.5	28	7.0	0	9
HH-1	Hell Hole Reservoir sub-surface (lower)	5/30/2007	6.65	8.7	27	6.7	30	
HH-2 (S)	Hell Hole Reservoir surface (middle)	5/30/2007	14.72	8.1	28	6.9	0	11
HH-2	Hell Hole Reservoir sub-surface (middle)	5/30/2007	7.99	8.8	27	6.7	30	
HH-3 (S)	Hell Hole Reservoir surface (upper)	5/30/2007	12.72	8.8	29	7.1	0	8
HH-3	Hell Hole Reservoir sub-surface (upper)	5/30/2007	7.79	9.0	26	6.8	30	
RR-2 RM30.2	Rubicon River below dam at gaging station	5/22/2007	7.13	9.8	54	7.1	0	
RR-3 RM 22.8	Rubicon River above South Fork Rubicon River confluence	5/23/2007	12.19	8.8	75	7.4	0	
SFRR-1 RM0.2	South Fork Rubicon River above Rubicon River confluence	5/23/2007	11.83	8.8	51	7.5	0	
RR-4 RM22.5	Rubicon River below South Fork Rubicon River confluence	5/23/2007	12.78	8.9	69	7.5	0	
RR-5 RM3.8	Rubicon River above Long Canyon Creek confluence	5/21/2007	16.30	8.4	75	6.9	0	

Table AQ 11-5. Summary of *In-Situ* Stream Measurements Collected During the Spring 2007 Sampling Event (continued).

Sample ID	Location Name	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm at 25 °C)	pH	Sample Water Depth ¹ (m)	Secchi Depth ² (m)
RR-6 RM3.5	Rubicon River below Long Canyon Creek confluence	5/21/2007	16.26	8.4	72	7.3	0	
RR-7 RM0.7	Rubicon River above Ralston Afterbay	5/21/2007	19.61	8.6	71	7.3	0	
Long Canyon Creek								
NFLC-1 RM3.2	North Fork Long Canyon Creek above diversion	5/15/2007	12.86	8.8	55	7.5	0	
NFLC-2 RM2.9	North Fork Long Canyon Creek below diversion	5/15/2007	13.80	8.7	54	7.7	0	
NFLC-3 RM0.3	North Fork Long Canyon Creek above Long Canyon Creek confluence	5/15/2007	10.81	9.2	63	7.3	0	
SFLC-1 RM3.4	South Fork Long Canyon Creek above diversion	5/15/2007	11.31	8.8	59	6.5	0	
SFLC-2 RM3.1	South Fork Long Canyon Creek below diversion	5/15/2007	11.68	9.1	58	6.6	0	
SFLC-3 RM0.2	South Fork Long Canyon Creek above Long Canyon Creek confluence	5/15/2007	9.51	9.3	60	7.2	0	
LCC-1 RM11.3	Long Canyon Creek below North Fork and South Fork Long Canyon creeks confluence	5/15/2007	9.61	9.3	60	7.3	0	
LCC-2 RM0.3	Long Canyon Creek above Rubicon River confluence	5/21/2007	15.14	8.8	69	7.5	0	

1: Water sample was collected just below the water surface unless otherwise noted.

2: Secchi depth measurements were only collected in the reservoirs.

3: Instrument malfunction, no in-situ measurements available.

Table AQ 11-6. Summary of *In-Situ* Stream Measurements Collected During the Fall 2007 Sampling Event.

Sample ID	Location Name	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm at 25 °C)	pH	Sample Water Depth ¹ (m)	Secchi Depth ²
Duncan Creek								
DC-1 RM8.9	Duncan Creek above diversion	9/25/2007	12.25	7.2	67	7.8	0	
DC-2 RM8.8	Duncan Creek below diversion	9/25/2007	11.61	7.0	65	7.1	0	
DC-3 RM0.2	Duncan Creek above Middle Fork American River confluence	NS	NS	NS	NS	NS	NS	
Middle Fork American River								
MFAR-1 RM51.6	Middle Fork American River above French Meadows Reservoir	10/3/2007	8.79	13.6	33	7.5	0	
FM-1 (S)	French Meadows Reservoir surface (lower)	10/3/2007	15.07	8.3	34	7.8	0	9.5
FM-1	French Meadows Reservoir sub-surface (lower)	10/3/2007	10.07	7.3	33	6.7	22.5	
FM-2 (S)	French Meadows Reservoir surface (middle)	10/3/2007	15.23	8.3	33	7.9	0	Too windy
FM-2	French Meadows Reservoir sub-surface (middle)	10/3/2007	10.23	7.7	30	6.6	22.5	
FM-3 (S)	French Meadows Reservoir surface (upper)	10/3/2007	15.36	8.6	33	7.2	0	Too windy
FM-3	French Meadows Reservoir sub-surface (upper)	10/3/2007	11.36	7.7	33	6.5	22.5	
MFAR-2 RM 46.6	Middle Fork American River below French Meadows Dam at gaging station	10/3/2007	8.93	11.7	16	7.5	0	
MFAR-3 RM39.9	Middle Fork American River above Duncan Creek confluence	NS	NS	NS	NS	NS	NS	

Table AQ 11-6. Summary of *In-Situ* Stream Measurements Collected During the Fall 2007 Sampling Event (continued).

Sample ID	Location Name	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm at 25 °C)	pH	Sample Water Depth ¹ (m)	Secchi Depth ²
MFAR-4 RM39.5	Middle Fork American River below Duncan Creek confluence	NS	NS	NS	NS	NS	NA	
MFAR-5 RM36.3	Middle Fork American River above Middle Fork Interbay	9/24/2007	11.75	7.8	62	8.0	0	
IR-1 RM35.7	In Middle Fork Interbay	9/24/2007	12.14	7.8	66	8.0	0	
MFAR-6 RM35.5	Middle Fork American River below Middle Fork Interbay	9/24/2007	12.41	7.7	39	7.8	0	
MFAR-7 RM26.1	Middle Fork American River above Ralston Afterbay	9/26/2007	13.52	10.5	54	7.4	0	
Ralston Afterbay Downstream								
RA-1(S)	Ralston Afterbay surface	9/26/2007	13.24	10.9	41	7.0	0	7
RA-1	Ralston Afterbay sub-surface	9/26/2007	12.38	11.3	36	6.8	5	
MFAR-8 RM24.7	Middle Fork American River below dam	9/26/2007	17.58	9.9	42	6.9	0	
MFAR-9 RM24.3	Middle Fork American River below Oxbow Powerhouse tailrace	9/26/2007	13.08	11.3	39	7.1	0	
MFAR-10 RM9.1	Middle Fork American River below the Drivers Flat Road Rafting Take-Out	9/24/2007	13.90	10.2	46	7.7	0	
MFAR-11 RM0.1	Middle Fork American River above North Fork American River	9/25/2007	13.62	10.5	49	7.7	0	
NFAR-1 RM20.6	North Fork American River below Middle Fork American River	9/25/2007	14.45	10.0	63	7.7	0	

Table AQ 11-6. Summary of *In-Situ* Stream Measurements Collected During the Fall 2007 Sampling Event (continued).

Sample ID	Location Name	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm at 25 °C)	pH	Sample Water Depth ¹ (m)	Secchi Depth ²
Rubicon River								
RR-1 RM35.9	Rubicon River above Reservoir	10/2/2007	11.74	7.8	107	7.1	0	
HH-1 (S)	Hell Hole Reservoir surface (lower)	10/1/2007	16.66	7.2	36	7.9	0	10
HH-1	Hell Hole Reservoir sub-surface (lower)	10/1/2007	15.81	6.3	31	6.8	23	
HH-2 (S)	Hell Hole Reservoir surface (middle)	10/1/2007	16.10	6.4	33	6.7	0	10
HH-2	Hell Hole Reservoir sub-surface (middle)	10/1/2007	15.82	6.3	32	7.0	27	
HH-3 (S)	Hell Hole Reservoir surface (upper)	10/2/2007	15.80	6.3	44	7.8	0	9.4
HH-3	Hell Hole Reservoir sub-surface (upper)	10/2/2007	15.76	6.3	40	7.2	20	
RR-2 RM30.2	Rubicon River below dam at gaging station	10/3/2007	8.97	9.9	18	6.9	0	
RR-3 RM 22.8	Rubicon River above South Fork Rubicon River confluence	9/25/2007	11.34	7.6	54	7.1	0	
SFRR-1 RM0.2	South Fork Rubicon River above Rubicon River confluence	9/25/2007	11.56	7.7	25	8.4	0	
RR-4 RM22.5	Rubicon River below South Fork Rubicon River confluence	9/25/2007	11.64	7.3	30	7.0	0	
RR-5 RM3.8	Rubicon River above Long Canyon Creek confluence	9/27/2007	15.40	8.4	56	7.7	0	
RR-6 RM3.5	Rubicon River below Long Canyon Creek confluence	9/27/2007	15.27	8.3	59	7.3	0	
RR-7 RM0.7	Rubicon River above Ralston Afterbay	9/26/2007	17.86	9.7	62	7.2	0	

Table AQ 11-6. Summary of *In-Situ* Stream Measurements Collected During the Fall 2007 Sampling Event (continued).

Sample ID	Location Name	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm at 25 °C)	pH	Sample Water Depth ¹ (m)	Secchi Depth ²
Long Canyon Creek								
NFLC-1 RM3.2	North Fork Long Canyon Creek above diversion	10/2/2007	8.46	9.7	41	7.4	0	
NFLC-2 RM2.9	North Fork Long Canyon Creek below diversion	10/2/2007	10.52	9.0	42	7.4	0	
NFLC-3 RM0.3	North Fork Long Canyon Creek above Long Canyon Creek confluence	10/2/2007	8.46	9.8	29	7.3	0	
SFLC-1 RM3.4	South Fork Long Canyon Creek above diversion	10/2/2007	8.81	8.8	34	7.1	0	
SFLC-2 RM3.1	South Fork Long Canyon Creek below diversion	10/2/2007	8.85	9.6	34	7.4	0	
SFLC-3 RM0.2	South Fork Long Canyon Creek above Long Canyon Creek confluence	10/2/2007	7.52	9.7	29	7.0	0	
LCC-1 RM11.3	Long Canyon Creek below North Fork and South Fork Long Canyon creeks confluence	10/2/2007	8.17	7.6	29	7.5	0	
LCC-2 RM0.3	Long Canyon Creek above Rubicon River confluence	9/27/2007	14.30	8.6	92	7.4	0	

1: Water sample was collected just below the water surface unless otherwise noted.

2: Secchi depth measurements were only collected in the reservoirs.

NS: No sample was collected at this location during the fall sampling event due to dangerous access conditions.

Table AQ 11-7. Summary of Analytical Results for Water Quality Samples Collected during the Spring 2007 Sampling Event.

Station	DC-1 RM8.9	DC-2 RM8.8	DC-3 RM0.2	MFAR-1 RM51.6	FM-1(S)	FM-1	FM-2(S)	FM-2	FM-3(S)	FM-3	MFAR-2 RM 46.6	MFAR-3 RM39.9	MFAR-4 RM39.5	MFAR-5 RM36.3	IR-1 RM35.7	MFAR-6 RM35.5	MFAR-7 RM26.1	RA-1(S)	RA-1	MFAR-8 RM24.7	MFAR-9 RM24.3	MFAR-10 RM9.1	MFAR-11 RM0.1	NFAR-1 RM20.6					
Date	5/22/2007	5/22/2007	5/1707	5/22/2007	5/31/2007	5/31/2007	5/31/2007	5/31/2007	5/31/2007	5/31/2007	5/22/2007	5/17/2007	5/17/2007	5/16/2007	5/16/2007	5/16/2007	5/22/2007	5/29/2007	5/29/2007	5/21/2007	5/21/2007	5/14/2007	5/16/2007	5/16/2007					
Time	9:45	10:40	11:00	11:40	9:30	8:40	10:00	10:40	13:15	12:15	12:30	12:30	12:00	9:25	10:10	8:50	8:00	12:30	10:40	14:00	13:30	15:50	15:10	14:30					
General Parameters	Units	PQL	WQ Criteria																										
Calcium	mg/L	0.5	NS	2.7	2.8	4.8	2.3	2.1	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.6	4.5	4.7	5.3	4.9	3.5	7.4	5.7	4.3	4.8	4.8	4.7	5.1	6
Chloride	mg/L	1.0	250 ¹	ND	ND	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.3	1.2	1.2	1.1	1.1	1.2	1.7	1.2	1.5	1.8	1.5	1.6	1.5
Hardness (as CaCO ₃)	mg/L	1.0	NS	9.5	9.8	16	8.2	7.5	8.1	7.8	7.9	7.8	7.8	7.8	9	15	15	17	16	12	23	18	14	16	16	16	17	18	21
Magnesium	µg/L	100	NS	680	690	910	600	540	570	560	580	570	570	570	620	800	890	970	920	730	1200	1000	810	980	910	1200	1300	1500	
Nitrate/Nitrite (NO ₃)	mg/L	0.20	1 ¹	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia as N	mg/L	0.100	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Kjeldahl Nitrogen (TKN)	mg/L	0.100	NS	4.2	8.4	0.56	3.1	1.4	2	1.1	2.5	78	5	7	0.56	0.56	3.9	1.1	0.56	2.8	1.4	1.7	0.56	0.56	0.84	0.56	0.56	0.56	
Total Phosphorus	mg/L	0.100	NS	ND	0.49	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.13	ND	ND	ND	ND	ND	ND	ND
Ortho-phosphate	mg/L	0.010	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	mg/L	0.20	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	0.50	NS	1.3	1.3	1.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.9	1.8	1.8	1.8	1.5	2	2.3	1.9	1.9	2	1.8	1.7	1.8	
Sulfate (SO ₄)	mg/L	0.50	250 ¹	0.56	0.58	0.98	ND	ND	ND	ND	ND	ND	ND	ND	0.73	0.88	0.74	0.75	0.72	2.9	1.4	0.76	1.5	1.3	1.7	1.8	1.8	2	
Total Dissolved Solids	mg/L	10	500 ¹	32	24	30	30	40	44	40	44	38	40	28	50	38	46	34	24	44	48	26	36	50	38	60	38		
Total Suspended Solids	mg/L	10	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Turbidity	NTU	0.10	(5)	ND	0.16	3.8	ND	1.1	1.1	1.1	1.2	0.78	0.6	0.44	1.2	0.13	0.86	2.2	0.44	0.12	0.41	1.2	0.38	0.15	0.27	0.44	0.53		
Organic Carbon, Total (TOC)	mg/L	1.00	NS	ND	ND	ND	1.3	1	1.1	1.6	1.2	1.6	1.4	1.1	ND	ND	ND	ND	ND	1.4	1.3	1.9	ND	ND	ND	ND	ND	ND	
Total Alkalinity	mg/L	5.0	>20 ¹	16	14	16	14	22	22	24	20	20	22	14	18	20	22	18	16	20	22	16	20	20	16	22	26		
Metals-Dissolved																													
Arsenic	µg/L	0.20	10 ¹	0.060 ^U	0.060 ^U	0.060 ^U	0.090 ^B	0.130 ^B	0.120 ^B	0.130 ^B	0.110 ^B	0.110 ^B	0.120 ^B	0.130 ^B	0.120 ^B	0.090 ^B	0.100 ^B	0.090 ^B	0.170 ^B	0.230	0.220	0.200 ^B	0.170 ^B	0.170 ^B	0.220	0.240	0.450		
Cadmium	µg/L	0.010	(6)	0.005 ^B	0.005 ^B	0.004 ^U	0.006 ^B	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	
Copper	mg/L	0.00020	(6)	0.00015 ^B	0.00016 ^B	0.000130 ^B	0.000160 ^B	0.000190 ^B	0.000220	0.000190 ^B	0.000180 ^B	0.000180 ^B	0.000180 ^B	0.000190 ^B	0.000140 ^B	0.000160 ^B	0.000180 ^B	0.000590	0.000240	0.000330	0.000340	0.000390	0.000310	0.000340	0.000410	0.00030	0.000430		
Iron	mg/L	0.005	0.3 ¹	0.0014 ^U	0.019300	0.0028 ^B	0.005 ^B	0.0014 ^U	0.0022 ^B	0.0014 ^U	0.0014 ^U	0.00410 ^B	0.0014 ^U	0.135000	0.013100	0.008400	0.006600	0.005300	0.007400	0.00260 ^B	0.005400	0.008300	0.071600	0.022100	0.008200	0.007400	0.014600		
Lead	µg/L	0.050	(6)	0.010 ^U	0.010 ^U	0.010 ^U	0.030 ^B	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U		
Manganese	µg/L	0.05	50 ¹	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Nickel	µg/L	0.20	(6)	0.180	0.170	0.160 ^B	0.080 ^B	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.060 ^B	0.070 ^B	0.110 ^B	0.100 ^B	0.120 ^B	0.090 ^B	0.210	0.090 ^B	0.090 ^B	0.150 ^B	0.130 ^B	0.230	0.250	0.380	
Chromium-Total	µg/L	0.15	50 ¹	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U		
Metals-Total																													
Mercury	µg/L	0.0004	0.05 ²	0.000360 ^B	0.000270 ^B	0.0004 ^B	0.000430	0.000290 ^B	0.000860	0.000350 ^B	0.000420	0.000340 ^B	0.000610	0.000330 ^B	0.000350 ^B	0.000400 ^B	0.000530	0.000380 ^B	0.000560	0.000330 ^B	0.000340 ^B	0.000680	0.000370 ^B	0.000360 ^B	0.000850	0.000610	0.001480		
Hydrocarbons																													
Methyl-tertiary-butyl Ether (MTBE)	µg/L	0.50	5 ¹																										
Total Petroleum Hydrocarbons (as gasoline and as diesel)	µg/L	50	NS																										
Oil and Grease	mg/L	4.8	NS																										
Bacteria																													
Total Coliform (3x5, 6 hr hold)	MPN/100 mL	2	NS	<2	<2	<2	4	<2	70	<2	<2	<2	23	<2	4	<2	<2	4	<2	23	4	6	2	13	30	2	7		
Fecal Coliform (3x5)	MPN/100 mL	2-1600	200/100 ¹	<2	<2	<2	4	<2	70	<2	<2	<2	23	<2	4	<2	<2	4	<2	23	4	6	2	13	30	2	7		

Table AQ 11-7. Summary of Analytical Results for Water Quality Samples Collected during the Spring 2007 Sampling Event (continued)

Station	RR-1 RM35.9	HH-1(S)	HH-1	HH-2(S)	HH-2	HH-3(S)	HH-3	RR-2 RM30.2	RR-3 RM 22.8	SFRR-1 RM0.2	RR-4 RM22.5	RR-5 RM3.8	RR-6 RM3.5	RR-7 RM0.7	NFLC-1 RM3.2	NFLC-2 RM2.9	NFLC-3 RM0.3	SFLC-1 RM3.4	SFLC-2 RM3.1	SFLC-3 RM0.2	LCC-1 RM11.3	LCC-2 RM0.3			
Date	5/24/2007	5/22/2007	5/22/2007	5/22/2007	5/22/2007	5/22/2007	5/22/2007	5/22/2007	5/23/2007	5/23/2007	5/23/2007	5/23/2007	5/21/2007	5/21/2007	5/21/2007	5/15/2007	5/15/2007	5/15/2007	5/15/2007	5/15/2007	5/15/2007	5/15/2007	5/21/2007		
Time	10:40	13:45	13:00	11:00	10:30	12:00	11:30	14:00	11:40	11:00	12:20	9:20	10:15	14:45	13:30	14:10	10:20	11:30	11:55	9:30	8:50	9:40			
General Parameters	Units	PQL	WQ Criteria																						
Calcium	mg/L	0.5	NS	2.5	3.2	2.9	2.8	2.9	2.9	2.8	2.8	4.4	2.4	3.6	5.2	5	5.3	2.5	2.6	2.9	2.7	3.2	2.6	3	4.7
Chloride	mg/L	1.0	250 ¹	1.2	ND	ND	ND	ND	ND	ND	ND	5.3	ND	4.2	3.5	3	2.9	1	1.1	1.2	1	1	1.1	1	1.4
Hardness (as CaCO ₃)	mg/L	1.0	NS	8.3	11	9.6	9.3	9.6	9.6	9.3	9.3	14	8.2	12	17	16	17	9.2	9.6	11	10	12	9.7	11	17
Magnesium	µg/L	100	NS	ND	670	570	560	580	570	560	550	730	530	640	900	950	1000	730	750	830	810	970	780	880	1200
Nitrate/Nitrite (NO ₃)	mg/L	0.20	1 ¹	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2	ND	ND	ND	ND	ND	ND	ND
Ammonia as N	mg/L	0.100	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.62	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Kjeldahl Nitrogen (TKN)	mg/L	0.100	NS	ND	ND	ND	0.56	2.2	1.1	0.84	0.56	ND	ND	ND	0.84	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56
Total Phosphorus	mg/L	0.100	NS	ND	ND	ND	ND	ND	ND	ND	0.56	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ortho-phosphate	mg/L	0.010	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	mg/L	0.20	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	0.50	NS	ND	1.7	1.4	1.3	1.4	1.4	1.4	1.4	3.8	1.5	3	2.9	2.9	2.9	1.8	1.9	2.3	1.7	2.1	1.9	2.3	2.6
Sulfate (SO ₄)	mg/L	250 ¹		ND	0.59	0.62	0.66	0.62	0.69	0.61	0.77	0.74	ND	0.66	1.3	1.1	1.3	ND	ND	ND	ND	ND	ND	ND	0.67
Total Dissolved Solids	mg/L	10	500 ¹	40	38	20	20	20	20	16	28	50	34	90	62	60	48	22	50	48	48	40	44	36	86
Total Suspended Solids	mg/L	10	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Turbidity	NTU	0.10	(5)	0.16	0.44	0.25	0.32	0.35	0.19	0.15	0.15	0.29	0.24	0.15	0.25	0.12	0.11	0.18	0.22	0.46	ND	ND	0.3	0.44	0.19
Organic Carbon, Total (TOC)	mg/L	1.00	NS	2.3	1.7	1.9	1.7	2	1.7	2.1	1.2	ND	1	ND	ND	ND	ND	1.1	ND	ND	ND	ND	ND	ND	ND
Total Alkalinity	mg/L	5.0	>20 ³	22	12	12	9.8	9.8	12	12	12	16	12	14	22	22	20	12	12	18	18	16	14	16	22
Metals-Dissolved																									
Arsenic	µg/L	0.20	10 ¹	0.330	0.220	0.200 ^B	0.190 ^B	0.210	0.200 ^B	0.210	0.210	0.190 ^B	0.060 ^U	0.170 ^B	0.160 ^B	0.140 ^B	0.160 ^B	0.060 ^U	0.070 ^B	0.150 ^B	0.080 ^B	0.090 ^B	0.140 ^B	0.140 ^B	0.160 ^B
Cadmium	µg/L	0.010	(6)	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U
Copper	mg/L	0.00020	(6)	0.000200 ^B	0.000270	0.000490	0.000270	0.000290	0.000250	0.000260	0.000310	0.000430	0.000130 ^B	0.000380	0.000360	0.000330	0.000350	0.000100 ^B	0.000090 ^B	0.000200 ^B	0.000100 ^B	0.000110 ^B	0.000130 ^B	0.000150 ^B	0.000200 ^B
Iron	mg/L	0.005	0.3 ¹	0.014700	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.0091	0.001400 ^U	0.003100 ^B	0.001400 ^U	0.003600 ^B	0.001600 ^B	
Lead	µg/L	0.050	(6)	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.050 ^B	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U
Manganese	µg/L	0.05	50 ¹	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Nickel	µg/L	0.20	(6)	0.090 ^B	0.100 ^B	0.100 ^B	0.100 ^B	0.100 ^B	0.090 ^B	0.090 ^B	0.090 ^B	0.100 ^B	0.100 ^B	0.090 ^B	0.130 ^B	0.120 ^B	0.140 ^B	0.040 ^U	0.040 ^U	0.050 ^B	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.100 ^B
Chromium-Total	µg/L	0.15	50 ¹	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U
Metals-Total																									
Mercury	µg/L	0.0004	0.05 ²	0.000480	0.000510	0.000650	0.000350 ^B	0.000680	0.000520	0.000740	0.000480	0.000370 ^B	0.000410	0.000320 ^B	0.000230 ^B	0.000240 ^B	0.000200 ^B	0.000610	0.000770	0.001010	0.000310 ^B	0.000430	0.000440	0.000750	0.000540
Hydrocarbons																									
Methyl-tertiary-butyl Ether (MtBE)	µg/L	0.50	5 ¹	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Petroleum Hydrocarbons (as gasoline and as diesel)	µg/L	50	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Oil and Grease	mg/L	4.8	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bacteria																									
Total Coliform (3x5, 6 hr hold)	MPN/100 mL	2	NS	7	<2	<2	<2	<2	<2	<2	8	30	8	17	30	23	4	<2	<2	2	<2	4	2	2	17
Fecal Coliform (3x5)	MPN/100 mL	2-1600	200/100 ¹	7	<2	<2	<2	<2	<2	<2	8	30	8	17	30	23	4	<2	<2	2	<2	4	2	2	17

Note: Bold results do not meet the listed criteria
 within specified limits of precision and accuracy during routine laboratory operation conditions.
 ND: Not Detected above the PQL
 NS: No standard
 *: Not sampled
 U: Results are less than or equal to the method detection limit (MDL) and are considered 'non-detect'.
 B: Results are above the MDL and less than or equal to the practical quantitation limit (PQL) and should be considered estimates.
 1: Basin Plan criteria for the Sacramento and San Joaquin Rivers Basins.
 2: California Toxics Rule Criteria (CTR)
 3: National Toxics Rule Criteria (NTR)
 4: pH, temperature and life cycle dependent. See Table 11-11 for criteria and results.
 5: Increases in turbidity attributable to controllable water quality factors shall not exceed the following limits: where natural turbidity is between 0 and 5 NTU's, increases shall not exceed 1 NTU. Where natural turbidity is between 5 and 50 NTU's, increases shall not exceed 20%. Where natural turbidity is between 50 and 100 NTU's, increases shall not exceed 10 NTU's. Finally, where natural turbidity is greater than 100 NTU's, increases shall not exceed 10%.
 6: Criteria is hardness dependent which is expressed as a function of hardness and decreases as hardness decreases. The actual criteria are calculated based on the hardness (as CaCO₃) of the sample water. Refer to Table 11-12 for sample site criteria and results.

Table AQ 11-8. Calculated Ammonia Concentration Criteria for the Spring 2007 Sampling Event.

Sample ID	Location Name	Date	pH	Temperature	Ammonia Criteria Continuous Concentration with fish early life stages present (NTR) ¹	Ammonia Concentration
				(°C)	mg/L	mg/L
DC-1 RM8.9	Duncan Creek above diversion	5/22/2007	7.6	7.24	3.98	#N/A
DC-2 RM8.8	Duncan Creek below diversion	5/22/2007	7.9	7.97	2.99	#N/A
DC-3 RM0.2	Duncan Creek above Middle Fork American River confluence	5/17/2007	8.2	11.16	1.85	#N/A
MFAR-1 RM52.8	Middle Fork American River above French Meadows Reservoir	5/22/2007	7.7	8.23	3.74	#N/A
FM-1 (S)	French Meadows Reservoir surface (lower)	5/30/2007	6.9	16.32	5.43	#N/A
FM-1	French Meadows Reservoir sub-surface (lower)	5/30/2007	6.5	7.17	6.68	ND
FM-2 (S)	French Meadows Reservoir surface (middle)	5/31/2007	6.6	16.12	5.89	#N/A
FM-2	French Meadows Reservoir sub-surface (middle)	5/31/2007	6.5	8.25	6.71	ND
FM-3 (S)	French Meadows Reservoir surface (upper)	5/31/2007	6.6	16.45	5.76	#N/A
FM-3	French Meadows Reservoir sub-surface (upper)	5/31/2007	6.6	9.89	6.55	ND
MFAR-2 RM 46.6	Middle Fork American River below French Meadows Dam at gaging station	5/22/2007	7.4	10.60	4.73	#N/A
MFAR-3 RM39.9	Middle Fork American River above Duncan Creek confluence	5/17/2007	7.7	13.17	3.66	#N/A
MFAR-4 RM39.5	Middle Fork American River below Duncan Creek confluence	5/17/2007	7.8	12.44	3.07	#N/A
MFAR-5 RM36.3	Middle Fork American River above Middle Fork Interbay	5/16/2007	8.4	13.25	1.29	ND
IR-1 RM35.7	In Middle Fork Interbay	5/16/2007	7.2	13.77	5.42	#N/A
MFAR-6 RM35.5	Middle Fork American River below Middle Fork Interbay	5/16/2007	7.7	10.02	3.42	ND
MFAR-7 RM26.1	Middle Fork American River above Ralston Afterbay	5/22/2007	7.4	15.44	4.46	#N/A
RA-1(S)	Ralston Afterbay surface	5/29/2007	6.6	19.15	4.89	ND
RA-1	Ralston Afterbay sub-surface	5/29/2007	6.5	12.02	6.70	ND
MFAR-8 RM24.7	Middle Fork American River below dam	5/21/2007	7.0	18.76	4.43	#N/A
MFAR-9 RM24.3	Middle Fork American River below Oxbow Powerhouse tailrace	5/21/2007	7.3	15.32	4.88	#N/A
MFAR-10 RM9.1	Middle Fork American River below the Drivers Flat Road Rafting Take-Out	5/14/2007	6.8	16.53	5.58	#N/A
MFAR-11 RM0.1	Middle Fork American River above North Fork American River	5/16/2007	7.3	19.73	3.74	ND
NFAR-1 RM20.6	North Fork American River below Middle Fork American River	5/16/2007	7.4	18.51	3.66	#N/A
RR-1 RM35.9	Rubicon River above Reservoir	5/24/2007	7.8	9.60	3.18	#N/A
HH-1 (S)	Hell Hole Reservoir surface (lower)	5/30/2007	7.0	14.52	5.89	#N/A
HH-1	Hell Hole Reservoir sub-surface (lower)	5/30/2007	6.7	6.65	6.49	ND
HH-2 (S)	Hell Hole Reservoir surface (middle)	5/30/2007	6.9	14.72	6.02	#N/A
HH-2	Hell Hole Reservoir sub-surface (middle)	5/30/2007	6.7	7.99	6.46	ND
HH-3 (S)	Hell Hole Reservoir surface (upper)	5/30/2007	7.1	12.72	5.59	#N/A
HH-3	Hell Hole Reservoir sub-surface (upper)	5/30/2007	6.8	7.79	6.28	ND
RR-2 RM30.2	Rubicon River below dam at gaging station	5/22/2007	7.2	7.13	5.53	#N/A
RR-3 RM 22.8	Rubicon River above South Fork Rubicon River confluence	5/23/2007	7.4	12.19	4.59	#N/A
SFR-1 RM0.2	South Fork Rubicon River above Rubicon River confluence	5/23/2007	7.5	11.83	4.29	#N/A
RR-4 RM22.5	Rubicon River below South Fork Rubicon River confluence	5/23/2007	7.5	12.78	4.55	ND
RR-5 RM3.8	Rubicon River above Long Canyon Creek confluence	5/21/2007	6.9	16.30	5.42	#N/A
RR-6 RM3.5	Rubicon River below Long Canyon Creek confluence	5/21/2007	7.3	16.26	4.65	#N/A
RR-7 RM0.7	Rubicon River above Ralston Afterbay	5/21/2007	7.3	19.61	3.61	ND
NFLC-1 RM3.2	North Fork Long Canyon Creek above diversion	5/15/2007	7.5	12.86	4.40	ND
NFLC-2 RM2.9	North Fork Long Canyon Creek below diversion	5/15/2007	7.7	13.8	3.58	#N/A
NFLC-3 RM0.3	North Fork Long Canyon Creek above Long Canyon Creek confluence	5/15/2007	7.3	10.81	4.94	#N/A
SFLC-1 RM3.4	South Fork Long Canyon Creek above diversion	5/15/2007	6.5	11.31	6.66	ND
SFLC-2 RM3.1	South Fork Long Canyon Creek below diversion	5/15/2007	6.6	11.68	6.54	ND
SFLC-3 RM0.2	South Fork Long Canyon Creek above Long Canyon Creek confluence	5/15/2007	7.2	9.51	5.53	#N/A
LCC-1 RM11.3	Long Canyon Creek below North Fork and South Fork Long Canyon creeks confluence	5/15/2007	7.3	9.61	5.08	#N/A
LCC-2 RM0.3	Long Canyon Creek above Rubicon River confluence	5/21/2007	7.5	15.14	4.27	#N/A

¹Ammonia criteria calculated using guidelines from the National Toxics Rule (NTR), which is based on ambient pH and temperature conditions.

ND: Not detected

Table 11-9. Hardness-based Water Quality Criteria for Cadmium, Copper, Lead, and Nickel for the Spring 2007 Sampling Event.

Station ID	DC-1 RM8.9	DC-2 RM8.8	DC-3 RM0.2	MFAR-1 RM51.6	FM-1(S)	FM-1	FM-2(S)	FM-2	FM-3(S)	FM-3	MFAR-2 RM 46.6	MFAR-3 RM39.9	MFAR-4 RM39.5	MFAR-5 RM36.3	IR-1 RM35.7	MFAR-6 RM35.5	MFAR-7 RM26.1	RA-1(S)	RA-1	MFAR-8 RM24.7	MFAR-9 RM24.3	MFAR-10 RM9.1	MFAR-11 RM0.1
Date Sampled	5/22/2007	5/22/2007	5/17/07	5/22/2007	5/31/2007	5/31/2007	5/31/2007	5/22/2007	5/31/2007	5/31/2007	5/22/2007	5/17/2007	5/17/2007	5/16/2007	5/16/2007	5/16/2007	5/22/2007	5/29/2007	5/29/2007	5/21/2007	5/21/2007	5/14/2007	5/16/2007
Time Sampled	9:45	10:40	11:00	11:40	9:30	8:40	10:00	10:40	13:15	12:15	12:30	12:30	12:00	9:25	10:10	8:50	8:00	12:30	10:40	14:00	13:30	15:50	15:10
Hardness (CaCO ₃) (mg/L)	9.5	9.8	16	8.2	7.5	8.1	7.8	7.9	7.8	7.8	9	15	15	17	16	12	23	18	14	16	16	17	18
Cadmium (Cd)																							
Laboratory Result (ug/L)	0.005 ^B	0.005 ^B	0.004 ^U	0.006 ^B	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U
Maximum Criterion (ug/L)	0.20	0.21	0.34	0.18	0.16	0.17	0.17	0.17	0.17	0.17	0.19	0.32	0.32	0.36	0.34	0.26	0.48	0.38	0.30	0.34	0.34	0.36	0.38
Continuous Criterion (ug/L)	0.05	0.05	0.07	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.07	0.07	0.07	0.07	0.06	0.09	0.07	0.06	0.07	0.07	0.07	0.07
Copper (Cu)																							
Laboratory Result (mg/L)	0.000150 ^B	0.000160 ^B	0.000130 ^B	0.000160 ^B	0.000190 ^B	0.000220	0.000190 ^B	0.000180 ^B	0.000180 ^B	0.000180 ^B	0.000190 ^B	0.000140 ^B	0.000160 ^B	0.000180 ^B	0.000590	0.000240	0.000330	0.000340	0.000390	0.000310	0.000340	0.000410	0.000300
Maximum Criterion (mg/L)	0.0015	0.0015	0.0024	0.0013	0.0012	0.0013	0.0012	0.0012	0.0012	0.0012	0.0014	0.0022	0.0022	0.0022	0.0025	0.0024	0.0018	0.0034	0.0027	0.0021	0.0024	0.0025	0.0027
Continuous Criterion (mg/L)	0.0012	0.0012	0.0019	0.0011	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0011	0.0018	0.0018	0.0020	0.0019	0.0015	0.0026	0.0021	0.0017	0.0019	0.0019	0.0020	0.0021
Lead (Pb)																							
Laboratory Result (ug/L)	0.010 ^U	0.010 ^U	0.010 ^U	0.030 ^B	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U
Maximum Criterion (ug/L)	4.63	4.79	8.38	3.91	3.53	3.85	3.69	3.74	3.69	3.69	4.35	7.79	7.79	8.98	8.38	6.04	12.64	9.58	7.20	8.38	8.38	8.98	9.58
Continuous Criterion (ug/L)	0.18	0.19	0.33	0.15	0.14	0.15	0.14	0.15	0.14	0.14	0.17	0.30	0.30	0.35	0.33	0.24	0.49	0.37	0.28	0.33	0.33	0.35	0.37
Nickel (Ni)																							
Laboratory Result (ug/L)	0.180 ^B	0.170 ^B	0.160 ^B	0.080 ^B	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.060 ^B	0.070 ^B	0.110 ^B	0.100 ^B	0.120 ^B	0.090 ^B	0.210	0.090 ^B	0.090 ^B	0.150 ^B	0.130 ^B	0.230	0.250
Maximum Criterion (ug/L)	63.92	65.62	99.35	56.44	52.33	55.85	54.10	54.68	54.10	54.10	61.06	94.07	94.07	104.57	99.35	77.88	135.05	109.76	88.73	99.35	99.35	104.57	109.76
Continuous Criterion (ug/L)	7.10	7.29	11.03	6.27	5.81	6.20	6.01	6.07	6.01	6.01	6.78	10.45	10.45	11.61	11.03	8.65	15.00	12.19	9.86	11.03	11.03	11.61	12.19

Station ID	NFAR-1 RM20.6	RR-1 RM35.9	HH-1(S)	HH-1	HH-2(S)	HH-2	HH-3(S)	HH-3	RR-2 RM30.2	RR-3 RM 22.8	SFRR-1 RM0.2	RR-4 RM22.5	RR-5 RM3.8	RR-6 RM3.5	RR-7 RM0.7	NFLC-1 RM3.2	NFLC-2 RM2.9	NFLC-3 RM0.3	SFLC-1 RM3.4	SFLC-2 RM3.1	SFLC-3 RM0.2	LCC-1 RM11.3	LCC-2 RM0.3
Date Sampled	5/16/2007	5/24/2007	5/22/2007	5/22/2007	5/22/2007	5/22/2007	5/22/2007	5/22/2007	5/23/2007	5/23/2007	5/23/2007	5/23/2007	5/21/2007	5/21/2007	5/21/2007	5/15/2007	5/15/2007	5/15/2007	5/15/2007	5/15/2007	5/15/2007	5/15/2007	5/21/2007
Time Sampled	14:30	10:40	13:45	13:00	11:00	10:30	12:00	11:30	14:00	11:40	11:00	12:20	9:20	10:15	14:45	13:30	14:10	10:20	11:30	11:55	9:30	8:50	9:40
Hardness (CaCO ₃) (mg/L)	21	8.3	11	9.6	9.3	9.6	9.6	9.3	9.3	14	8.2	12	17	16	17	9.2	9.6	11	10	12	9.7	11	17
Cadmium (Cd)																							
Laboratory Result (ug/L)	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U
Maximum Criterion (ug/L)	0.44	0.18	0.23	0.21	0.20	0.21	0.21	0.20	0.20	0.30	0.18	0.26	0.36	0.34	0.36	0.20	0.21	0.23	0.21	0.26	0.21	0.23	0.36
Continuous Criterion (ug/L)	0.08	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.04	0.06	0.07	0.07	0.07	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.07
Copper (Cu)																							
Laboratory Result (mg/L)	0.000430	0.000200 ^B	0.000270	0.000490	0.000270	0.000290	0.000250	0.000260	0.000310	0.000430	0.000130 ^B	0.000380	0.000360	0.000330	0.000350	0.000100 ^B	0.000090 ^B	0.000200 ^B	0.000100 ^B	0.000110 ^B	0.000130 ^B	0.000150 ^B	0.000200 ^B
Maximum Criterion (mg/L)	0.0031	0.0013	0.0017	0.0015	0.0014	0.0015	0.0015	0.0014	0.0014	0.0021	0.0013	0.0018	0.0025	0.0024	0.0025	0.0014	0.0015	0.0017	0.0015	0.0018	0.0015	0.0017	0.0025
Continuous Criterion (mg/L)	0.0024	0.0011	0.0014	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0017	0.0011	0.0015	0.0020	0.0019	0.0020	0.0012	0.0012	0.0014	0.0013	0.0015	0.0012	0.0014	0.0020
Lead (Pb)																							
Laboratory Result (ug/L)	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.050 ^B	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U
Maximum Criterion (ug/L)	11.40	3.96	5.47	4.68	4.51	4.68	4.68	4.51	4.51	7.20	3.91	6.04	8.98	8.38	8.98	4.46	4.68	5.47	4.91	6.04	4.74	5.47	8.98
Continuous Criterion (ug/L)	0.44	0.15	0.21	0.18	0.18	0.18	0.18	0.18	0.18	0.28	0.15	0.24	0.35	0.33	0.35	0.17	0.18	0.21	0.19	0.24	0.18	0.21	0.35
Nickel (Ni)																							
Laboratory Result (ug/L)	0.380	0.090 ^B	0.100 ^B	0.100 ^B	0.110 ^B	0.100 ^B	0.090 ^B	0.090 ^B	0.090 ^B	0.100 ^B	0.100 ^B	0.090 ^B	0.130 ^B	0.120 ^B	0.140 ^B	0.040 ^U	0.040 ^U	0.050 ^B	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.100 ^B
Maximum Criterion (ug/L)	125.04	57.02	72.36	64.49	62.78	64.49	64.49	62.78	62.78	88.73	56.44	77.88	104.57	99.35	104.57	62.21	64.49	72.36	66.75	77.88	65.05	72.36	104.57
Continuous Criterion (ug/L)	13.89	6.33	8.04	7.16	6.97	7.16	7.16	6.97	6.97	9.86	6.27	8.65	11.61	11.03	11.61	6.91	7.16	8.04	7.41	8.65	7.23	8.04	11.61

Note: Bold results do not meet the calculated criteria

U: Results are less than or equal to the method detection limit (MDL) and are considered 'non-detect'.

B: Results are above the MDL and less than or equal to the practical quantitation limit (PQL) and should be considered estimates.

California Toxics Rule (CTR) standard was used for Cu, Pb, and Ni. National Toxics Rule (NTR) standard was used for Cd.

Formulas used are provided in Appendix C.

Table AQ 11-10. Summary of Analytical Results of Water Quality Sampling for Fall 2007.

General Parameters	Units	PQL	WQ Criteria	Station	DC-1 RM8.9	DC-2 RM8.8	DC-3 RM0.2	MFAR-1 RM51.6	FM-1(S)	FM-1	FM-2(S)	FM-2	FM-3(S)	FM-3	MFAR-2 RM 46.6	MFAR-3 RM39.9	MFAR-4 RM39.5	MFAR-5 RM36.3	IR-1 RM35.7	MFAR-6 RM35.5	MFAR-7 RM26.1	RA-1(S)	RA-1			
				Date	9/25/2007	9/25/2007	*	10/3/2007	10/3/2007	10/3/2007	10/3/2007	10/3/2007	10/3/2007	10/3/2007	10/3/2007	10/3/2007	10/3/2007	10/3/2007	*	*	9/24/2007	9/24/2007	9/24/2007	9/26/2007	9/26/2007	9/26/2007
				Time	15:30	16:00	*	12:00	9:30	9:00	11:00	10:15	13:00	12:30	11:25	*	*	11:15	10:40	11:50	13:15	10:15	10:40			
Calcium	mg/L	0.5	NS	7	6.3	*	4.9	2.4	2.4	2.4	2.5	2.5	2.4	2.4	2.7	*	*	6.9	6.8	3.7	6	4	3.7			
Chloride	mg/L	1.0	250 ¹	1	1	*	3.7	1.1	ND	2.2	1	1.3	2.3	2	*	*	1.4	1.3	1.1	1.5	1.8	1.5				
Hardness (as CaCO ₃)	mg/L	1.0	NS	25	22	*	18	8.4	8.4	8.4	8.7	8.8	8.5	9.3	*	*	22	22	12	19	13	12				
Magnesium	µg/L	100	NS	1900	1600	*	1300	590	590	580	600	610	600	630	*	*	1200	1200	670	980	710	660				
Nitrate/Nitrite (NO ₃)	mg/L	0.20	1 ¹	ND	ND	*	ND	ND	ND	ND	ND	ND	ND	ND	*	*	ND	ND	ND	ND	ND	ND				
Ammonia as N	mg/L	0.100	1.5	ND	ND	*	0.121	0.167	0.133	0.117	0.207	0.101	0.122	ND	*	*	ND	ND	ND	ND	ND	ND				
Total Kjeldahl Nitrogen (TKN)	mg/L	0.100	NS	0.268	ND	*	ND	ND	0.173	0.211	0.148	0.102	ND	ND	*	*	0.26	0.32	0.352	0.374	0.317	0.293				
Total Phosphorus	mg/L	0.100	NS	ND	ND	*	ND	ND	ND	ND	ND	ND	ND	ND	*	*	0.058	ND	ND	ND	ND	ND				
Ortho-phosphate	mg/L	0.010	NS	ND	ND	*	ND	ND	ND	ND	ND	ND	ND	ND	*	*	ND	ND	ND	ND	ND	ND				
Potassium	mg/L	0.20	NS	ND	ND	*	ND	ND	ND	ND	ND	ND	ND	ND	*	*	ND	ND	ND	ND	ND	ND				
Sodium	mg/L	0.50	NS	2.8	2.5	*	2.8	1.3	1.3	1.2	1.3	1.3	1.3	1.2	*	*	2	2.2	1.6	1.7	1.8	1.7				
Sulfate (SO ₄)	mg/L	0.50	250 ¹	1.4	1.4	*	1.2	0.65	0.72	0.57	2.9	0.68	0.66	0.83	*	*	1.5	1.5	0.94	2.3	1.1	0.98				
Total Dissolved Solids	mg/L	10	500 ¹	52	52	*	76	58	66	46	52	58	54	52	*	*	52	52	38	38	26	26				
Total Suspended Solids	mg/L	10	NS	ND	ND	*	ND	ND	ND	ND	ND	ND	ND	ND	*	*	ND	ND	ND	ND	ND	ND				
Turbidity	NTU	0.10	(5)	ND	0.8	*	0.41	0.36	0.3	0.5	0.4	0.42	0.41	0.44	*	*	0.19	ND	0.25	0.4	0.76	0.25				
Organic Carbon, Total (TOC)	mg/L	1.00	NS	ND	ND	*	ND	1.59	ND	ND	ND	ND	ND	ND	*	*	ND	ND	1.5	ND	ND	ND				
Total Alkalinity	mg/L	5.0	>20 ¹	31	30	*	21	14	14	14	13	13	13	14	*	*	24	29	17	24	17	17				
Metals-Dissolved																										
Arsenic	µg/L	0.20	10 ¹	0.090 ^B	0.150 ^B	*	0.120 ^B	0.150 ^B	0.110 ^B	0.120 ^B	0.150 ^B	0.150 ^B	0.150 ^B	0.110 ^B	*	*	0.100 ^B	0.110 ^B	0.200 ^B	0.200 ^B	0.170 ^B	0.170 ^B				
Cadmium	µg/L	0.010	(6)	0.004 ^U	0.004 ^U	*	0.005 ^B	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	*	*	0.004 ^U	0.004 ^U	0.005 ^B	0.004 ^U	0.004 ^U	0.005 ^B				
Copper	mg/L	0.00020	(6)	0.000170	0.000310	*	0.000210	0.000190	0.000170	0.000200	0.000220	0.000180	0.000220	0.000170	*	*	0.000160	0.000220	0.000380	0.000320	0.000330	0.000310				
Iron	mg/L	0.005	0.3 ¹	0.012300	0.196000	*	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	*	*	0.016500	0.017100	0.018300	0.016300	0.012800	0.012200				
Lead	µg/L	0.050	(6)	0.010 ^U	0.010 ^U	*	0.0510	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	*	*	0.010 ^U	0.022 ^B	0.033 ^B	0.010 ^U	0.010 ^U	0.010 ^U				
Manganese	µg/L	0.05	50 ¹	0.406	46.820	*	1.520	0.299	1.800	0.570	0.355	0.595	1.850	57.700	*	*	1.200	1.100	4.970	0.937	6.700	6.780				
Nickel	µg/L	0.20	(6)	0.050 ^B	0.120 ^B	*	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	*	*	0.050 ^B	0.040 ^U	0.060 ^B	0.080 ^B	0.050 ^B	0.040 ^U				
Chromium-Total	µg/L	0.15	50 ¹	0.030 ^U	0.030 ^U	*	0.050 ^B	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	*	*	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U				
Metals-Total																										
Mercury	µg/L	0.0004	0.052	0.000230 ^B	0.000410	*	0.000240 ^B	0.000210 ^B	0.000250 ^B	0.000190 ^B	0.000330 ^B	0.000230 ^B	0.000240 ^B	0.000390 ^B	*	*	0.000360 ^B	0.000360 ^B	0.00069	0.000180 ^B	0.000340 ^B	0.000320 ^B				
Hydrocarbons																										
Methyl-tertiary-butyl Ether (MtBE)	µg/L	0.50	5 ¹					ND	ND	ND	ND	ND	ND									ND				
Total Petroleum Hydrocarbons (as gasoline and as diesel)	µg/L	50	NS					ND	ND	ND	ND	ND	ND									ND				
Oil and Grease	mg/L	4.8	NS					ND	ND	ND	ND	ND	ND									ND				
Bacteria																										
Total Coliform (3x5, 6 hr hold)	MPN/100 mL	2	NS	50	70	*	50	<2	2	<2	2	2	<2	13	*	*	220	500	130	80	27	22				
Fecal Coliform (3x5)	MPN/100 mL	2-1600	200/100 ¹	4	<2	*	17	<2	<2	<2	<2	<2	<2	<2	*	*	4	7	<2	11	2	<2				

Table AQ 11-10. Summary of Analytical Results of Water Quality Sampling for Fall 2007 (continued).

Station	MFAR-8	MFAR-9	MFAR-10	MFAR-11	NFAR-1 RM20.6	RR-1 RM35.9	HH-1(S)	HH-1	HH-2(S)	HH-2	HH-3(S)	HH-3	RR-2	RR-3 RM 22.8	SFR-1 RM0.2	RR-4 RM22.5			
	RM24.7	RM24.3	RM9.1	RM0.1									RM30.2						
Date	9/26/2007	9/26/2007	9/24/2007	9/25/2007	9/25/2007	10/2/2007	10/1/2007	10/1/2007	10/1/2007	10/1/2007	10/2/2007	10/2/2007	10/3/2007	9/25/2007	9/25/2007	9/25/2007			
Time	14:15	14:45	13:25	9:00	9:40	11:40	14:55	14:15	12:00	12:50	10:15	9:00	10:20	13:00	12:30	13:30			
General Parameters	Units	PQL	WQ Criteria																
Calcium	mg/L	0.5	NS	4.2	3.8	4.2	5	7	7.9	2.8	2.9	2.8	2.9	2.9	3	4.3	2.1	4	
Chloride	mg/L	1.0	250 ¹	1.4	1.6	1.5	1.5	1.8	24	1	ND	ND	ND	ND	2.4	6.1	ND	5.1	
Hardness (as CaCO ₃)	mg/L	1.0	NS	14	12	14	17	24	25	9.3	9.3	9.3	9.6	9.5	9.8	13	6.6	12	
Magnesium	µg/L	100	NS	810	680	940	1100	1700	1200	550	590	570	560	560	560	620	330	600	
Nitrate/Nitrite (NO ₃)	mg/L	0.20	1 ¹	ND	ND	ND	ND	ND	0.29	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Ammonia as N	mg/L	0.100	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.118	ND	
Total Kjeldahl Nitrogen (TKN)	mg/L	0.100	NS	ND	0.462	0.277	0.253	0.324	ND	ND	0.341	0.246	0.293	ND	ND	0.524	0.601	0.328	
Total Phosphorus	mg/L	0.100	NS	0.106	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Ortho-phosphate	mg/L	0.010	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Potassium	mg/L	0.20	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Sodium	mg/L	0.50	NS	1.7	1.7	1.8	1.9	2.5	7.3	1.4	1.5	1.4	1.5	1.4	1.3	3.5	1.1	3.2	
Sulfate (SO ₄)	mg/L	0.50	250 ¹	1.2	1	1.5	1.6	2.4	1.2	0.67	0.63	0.72	0.63	0.65	0.94	0.77	0.86	0.78	
Total Dissolved Solids	mg/L	10	500 ¹	36	60	44	34	46	94	46	44	46	50	34	38	86	52	14	32
Total Suspended Solids	mg/L	10	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Turbidity	NTU	0.10	(5)	0.56	0.46	ND	0.2	0.27	ND	0.21	0.34	0.3	0.36	0.34	0.3	0.54	0.13	ND	
Organic Carbon, Total (TOC)	mg/L	1.00	NS	ND	ND	1.3	ND	ND	ND	ND	1.47	ND	ND	ND	ND	ND	ND	ND	
Total Alkalinity	mg/L	5.0	>20 ¹	17	17	18	22	28	17	15	15	14	15	14	15	17	11	14	
Metals-Dissolved																			
Arsenic	µg/L	0.20	10 ¹	0.170 ^B	0.180 ^B	0.210	0.240	0.340	0.280	0.210	0.210	0.220	0.190 ^B	0.220	0.200 ^B	0.190 ^B	0.180 ^B	0.060 ^U	0.160 ^B
Cadmium	µg/L	0.010	(6)	0.013	0.004 ^U	0.004 ^U	0.004 ^U	0.005 ^B	0.008 ^B	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	
Copper	mg/L	0.0020	(6)	0.000340	0.000310	0.000320	0.000290	0.000330	0.000140	0.000270	0.000280	0.000260	0.000280	0.000270	0.000510	0.000370	0.000130	0.000290	
Iron	mg/L	0.005	0.3 ¹	0.049400	0.012700	0.016600	0.014900	0.021300	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.001400 ^U	0.015700	0.008800	0.006400	0.007700	
Lead	µg/L	0.050	(6)	0.015 ^B	0.010 ^U	0.010 ^U	0.012 ^B	0.015 ^B	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.025 ^B	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	
Manganese	µg/L	0.05	50 ¹	16.700	7.720	3.560	1.120	1.290	0.847	0.871	0.391	0.354	0.479	1.190	0.696	44.900	0.188	0.334	
Nickel	µg/L	0.20	(6)	0.015 ^B	0.040 ^U	0.130 ^B	0.140 ^B	0.140 ^B	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.050 ^B	0.040 ^U	
Chromium-Total	µg/L	0.15	50 ¹	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.130 ^B	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	
Metals-Total																			
Mercury	µg/L	0.0004	0.052	0.000320 ^B	0.000350 ^B	0.000740	0.000540	0.000460	0.000150 ^U	0.000350 ^B	0.000430	0.000320 ^B	0.000400 ^B	0.000300 ^B	0.000280 ^B	0.001260	0.000150 ^U	0.000200 ^B	0.000230 ^B
Hydrocarbons																			
Methyl-tertiary-butyl Ether (MtBE)	µg/L	0.50	5 ¹						ND	ND	ND	ND	ND	ND					
Total Petroleum Hydrocarbons (as gasoline and as diesel)	µg/L	50	NS						ND	ND	ND	ND	ND	ND					
Oil and Grease	mg/L	4.8	NS						ND	ND	ND	ND	ND	ND					
Bacteria																			
Total Coliform (3x5, 6 hr hold)	MPN/100 mL	2	NS	7	6	240	50	140	8	2	13	2	<2	<2	<2	4	30	8	27
Fecal Coliform (3x5)	MPN/100 mL	2-1600	200/100 ¹	<2	<2	4	7	4	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2

Table AQ 11-10. Summary of Analytical Results of Water Quality Sampling for Fall 2007 (continued).

General Parameters	Units	PQL	WQ Criteria	Station	RR-5 RM3.8	RR-6 RM3.5	RR-7 RM0.7	NFLC-1 RM3.2	NFLC-2 RM2.9	NFLC-3 RM0.3	SFLC-1 RM3.4	SFLC-2 RM3.1	SFLC-3 RM0.2	LCC-1 RM11.3	LCC-2 RM0.3		
				Date	9/27/2007	9/27/2007	9/26/2007	10/2/2007	10/2/2007	10/2/2007	10/2/2007	10/2/2007	10/2/2007	10/2/2007	10/2/2007	10/2/2007	9/27/2007
				Time	9:45	10:20	13:45	12:10	12:30	11:10	13:00	13:20	11:20	10:00	10:00		
Calcium	mg/L	0.5	NS		5	5.2	5.8	5.8	5.7	3.7	4.6	4.7	3.7	3.6	9.6		
Chloride	mg/L	1.0	250 ¹		5.2	5.2	4.9	ND	ND	1.5	ND	ND	1.9	1.7	3.8		
Hardness (as CaCO ₃)	mg/L	1.0	NS		16	17	19	21	21	13	17	18	13	13	33		
Magnesium	µg/L	100	NS		870	930	1100	1700	1700	980	1400	1400	1000	970	2100		
Nitrate/Nitrite (NO ₃)	mg/L	0.20	1 ¹		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Ammonia as N	mg/L	0.100	1.5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Kjeldahl Nitrogen (TKN)	mg/L	0.100	NS		2.72	0.34	0.267	ND	ND	ND	ND	ND	0.123	0.108	0.32		
Total Phosphorus	mg/L	0.100	NS		ND	ND	ND	ND	ND	0.103	ND	ND	ND	ND	ND		
Ortho-phosphate	mg/L	0.010	NS		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Potassium	mg/L	0.20	NS		2	ND	2.2	ND	ND	ND	ND	ND	ND	ND	ND		
Sodium	mg/L	0.50	NS		3	3.1	3.3	4	4	3.9	2.7	2.7	3.3	3.5	4.2		
Sulfate (SO ₄)	mg/L	0.50	250 ¹		1.4	1.5	1.8	0.98	ND	0.63	ND	ND	1	0.88	2.1		
Total Dissolved Solids	mg/L	10	500 ¹		38	46	50	64	92	84	84	66	66	66	72		
Total Suspended Solids	mg/L	10	NS		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Turbidity	NTU	0.10	(5)		ND	0.1	0.27	ND	0.28	0.15	0.16	0.1	ND	0.2	ND		
Organic Carbon, Total (TOC)	mg/L	1.00	NS		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Alkalinity	mg/L	5.0	>20 ²		19	20	22	35	32	24	29	28	23	23	40		
Metals-Dissolved																	
Arsenic	µg/L	0.20	10 ¹		0.120 ^B	0.130 ^B	0.130 ^B	0.150 ^B	0.140 ^B	0.260	0.100 ^B	0.110 ^B	0.180 ^B	0.210	0.210		
Cadmium	µg/L	0.010	(6)		0.004 ^U	0.004 ^U	0.005 ^B	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U		
Copper	mg/L	0.0020	(6)		0.000280	0.000270	0.000280	0.00013 ^B	0.00012 ^B	0.000400	0.000150	0.00012 ^B	0.0002 ^B	0.000300	0.000300		
Iron	mg/L	0.005	0.3 ¹		0.001400 ^U	0.001400 ^U	0.013100	0.001400 ^U	0.007100	0.001400 ^U	0.001400 ^U	0.015200	0.001400 ^U	0.001400 ^U	0.001400 ^U		
Lead	µg/L	0.050	(6)		0.010 ^U	0.011 ^B	0.064	0.010 ^U	0.010 ^U	0.048 ^B	0.011 ^B	0.010 ^U	0.010 ^U	0.015 ^B	0.015 ^B		
Manganese	µg/L	0.05	50 ¹		0.183	0.203	0.404	0.097	21.200	0.716	1.020	6.700	0.434	0.703	0.636		
Nickel	µg/L	0.20	(6)		0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U		
Chromium-Total	µg/L	0.15	50 ¹		0.060 ^B	0.060 ^B	0.030 ^U	0.030 ^U	0.030 ^U	0.030 ^U	0.050 ^B	0.040 ^B	0.050 ^B	0.040 ^B	0.030 ^U		
Metals-Total																	
Mercury	µg/L	0.0004	0.052		0.000150 ^U	0.000170 ^B	0.000150 ^U	0.00050	0.001040	0.001230	0.000180 ^B	0.000260 ^B	0.000320 ^B	0.000770	0.000360		
Hydrocarbons																	
Methyl-tertiary-butyl Ether (MtBE)	µg/L	0.50	5 ¹														
Total Petroleum Hydrocarbons (as gasoline and as diesel)	µg/L	50	NS														
Oil and Grease	mg/L	4.8	NS														
Bacteria																	
Total Coliform (3x5, 6 hr hold)	MPN/100 mL	2	NS		300	900	170	4	300	80	170	11	13	23	30		
Fecal Coliform (3x5)	MPN/100 mL	2-1600	200/100 ¹		<2	<2	2	<2	300	2	170	2	2	8	2		

Note: Bold results do not meet the listed criteria

PQL: Practical Quantitation Limit: the lowest concentration of an analyte that can be reliably measured within specified limits of precision and accuracy during routine laboratory operating conditions.

ND: Not detected above the PQL.

NS: No standard.

*: Sample location was not sampled during the fall sampling event due to dangerous access conditions.

U: Results less than or equal to the method detection limit (MDL) and are considered 'non-detect'.

B: Results are above the MDL and less than or equal to the practical quantitation limit (PQL) and should be considered estimates.

1: Basin Plan criteria for the Sacramento and San Joaquin Rivers Basins.

2: California Toxics Rule Criteria (CTR)

3: National Toxics Rule Criteria (NTR)

4: pH, temperature and life cycle dependent. See Table 11-14 for criteria and results.

5: Increases in turbidity attributable to controllable water quality factors shall not exceed the following limits: where natural turbidity is between 0 and 5 NTU's, increases shall not exceed 1 NTU. Where natural turbidity is between 5 and 50 NTU's, increases shall not exceed 20%. Where natural turbidity is between 50 and 100 NTU's, increases shall not exceed 10 NTU's. Finally, where natural turbidity is greater than 100 NTU's, increases shall not exceed 10%.

6: Criteria are hardness dependent which is expressed as a function of hardness and decreases as hardness decreases. The actual criteria are calculated based on the hardness (as CaCO₃) of the sample water. Refer to Table 11-15 for sample site criteria and results.

Table AQ 11-11. Calculated Ammonia Concentration Criteria for the Fall 2007 Sampling Event.

Sample ID	Location Name	Date	pH	Temperature	Ammonia Criteria Continuous Concentration with fish early life stages present (NTR) ¹	Ammonia Concentration
					mg/L	mg/L
				(°C)		
DC-1 RM8.9	Duncan Creek above diversion	9/25/2007	7.8	12.25	3.22	#N/A
DC-2 RM8.8	Duncan Creek below diversion	9/25/2007	7.1	11.61	5.79	#N/A
DC-3 RM0.2	Duncan Creek above Middle Fork American River confluence	*	*	*	*	*
MFAR-1 RM52.8	Middle Fork American River above French Meadows Reservoir	10/3/2007	7.5	8.79	4.51	#N/A
FM-1 (S)	French Meadows Reservoir surface (lower)	10/3/2007	7.8	15.07	3.00	#N/A
FM-1	French Meadows Reservoir sub-surface (lower)	10/3/2007	6.7	10.07	6.43	0.133
FM-2 (S)	French Meadows Reservoir surface (middle)	10/3/2007	7.9	15.23	2.74	#N/A
FM-2	French Meadows Reservoir sub-surface (middle)	10/3/2007	6.6	10.23	6.52	0.207
FM-3 (S)	French Meadows Reservoir surface (upper)	10/3/2007	7.2	15.36	4.99	#N/A
FM-3	French Meadows Reservoir sub-surface (upper)	10/3/2007	6.5	11.36	6.64	0.122
MFAR-2 RM 46.6	Middle Fork American River below French Meadows Dam at gaging station	10/3/2007	7.5	8.93	4.33	#N/A
MFAR-3 RM39.9	Middle Fork American River above Duncan Creek confluence	*	*	*	*	*
MFAR-4 RM39.5	Middle Fork American River below Duncan Creek confluence	*	*	*	*	*
MFAR-5 RM36.3	Middle Fork American River above Middle Fork Interbay	9/24/2007	8.0	11.75	2.58	ND
IR-1 RM35.7	In Middle Fork Interbay	9/24/2007	8.0	12.14	2.33	#N/A
MFAR-6 RM35.5	Middle Fork American River below Middle Fork Interbay	9/24/2007	7.8	12.41	3.18	ND
MFAR-7 RM26.1	Middle Fork American River above Ralston Afterbay	9/26/2007	7.4	13.52	4.70	#N/A
RA-1(S)	Ralston Afterbay surface	9/26/2007	7.0	13.24	6.02	ND
RA-1	Ralston Afterbay sub-surface	9/26/2007	6.8	12.38	6.23	ND
MFAR-8 RM24.7	Middle Fork American River below dam	9/26/2007	6.9	17.58	5.01	#N/A
MFAR-9 RM24.3	Middle Fork American River below Oxbow Powerhouse tailrace	9/26/2007	7.1	13.08	5.64	#N/A
MFAR-10 RM9.1	Middle Fork American River below the Drivers Flat Road Rafting Take-Out	9/24/2007	7.7	13.9	3.70	#N/A
MFAR-11 RM0.1	Middle Fork American River above North Fork American River	9/25/2007	7.7	13.62	3.50	ND
NFAR-1 RM20.6	North Fork American River below Middle Fork American River	9/25/2007	7.7	14.45	3.78	#N/A
RR-1 RM35.9	Rubicon River above Reservoir	10/2/2007	7.1	11.74	5.59	#N/A
HH-1 (S)	Hell Hole Reservoir surface (lower)	10/1/2007	7.9	16.66	2.44	#N/A
HH-1	Hell Hole Reservoir sub-surface (lower)	10/1/2007	6.8	15.81	5.84	ND
HH-2 (S)	Hell Hole Reservoir surface (middle)	10/1/2007	6.7	16.10	5.79	#N/A
HH-2	Hell Hole Reservoir sub-surface (middle)	10/1/2007	7.0	15.82	5.35	ND
HH-3 (S)	Hell Hole Reservoir surface (upper)	10/2/2007	7.8	15.80	2.79	#N/A
HH-3	Hell Hole Reservoir sub-surface (upper)	10/2/2007	7.2	15.76	5.08	ND
RR-2 RM30.2	Rubicon River below dam at gaging station	10/3/2007	6.9	8.97	6.21	#N/A
RR-3 RM 22.8	Rubicon River above South Fork Rubicon River confluence	9/25/2007	7.1	11.34	5.56	#N/A
SFRR-1 RM0.2	South Fork Rubicon River above Rubicon River confluence	9/25/2007	8.4	11.56	1.38	#N/A
RR-4 RM22.5	Rubicon River below South Fork Rubicon River confluence	9/25/2007	7.0	11.64	5.89	ND
RR-5 RM3.8	Rubicon River above Long Canyon Creek confluence	9/27/2007	7.7	15.40	3.23	#N/A
RR-6 RM3.5	Rubicon River below Long Canyon Creek confluence	9/27/2007	7.3	15.27	4.84	#N/A
RR-7 RM0.7	Rubicon River above Ralston Afterbay	9/26/2007	7.2	17.86	4.27	ND
NFLC-1 RM3.2	North Fork Long Canyon Creek above diversion	10/2/2007	7.4	8.46	4.77	ND
NFLC-2 RM2.9	North Fork Long Canyon Creek below diversion	10/2/2007	7.4	10.52	4.66	#N/A
NFLC-3 RM0.3	North Fork Long Canyon Creek above Long Canyon Creek confluence	10/2/2007	7.3	8.46	5.14	#N/A
SFLC-1 RM3.4	South Fork Long Canyon Creek above diversion	10/2/2007	7.1	8.81	5.61	ND
SFLC-2 RM3.1	South Fork Long Canyon Creek below diversion	10/2/2007	7.4	8.85	4.66	ND
SFLC-3 RM0.2	South Fork Long Canyon Creek above Long Canyon Creek confluence	10/2/2007	7.0	7.52	5.84	#N/A
LCC-1 RM11.3	Long Canyon Creek below North Fork and South Fork Long Canyon creeks confluence	10/2/2007	7.5	8.17	4.51	#N/A
LCC-2 RM0.3	Long Canyon Creek above Rubicon River confluence	9/27/2007	7.4	14.3	4.73	#N/A

¹:Ammonia criteria calculated using guidelines from the National Toxic Rule (NTR), which is based on ambient pH and temperature conditions

ND: Not detected

*: No sample was collected at this location during the fall sampling event due to dangerous access condition.

Table AQ 11-12. Hardness-based Water Quality Criteria for Cadmium, Copper, Lead, and Nickel for the Fall 2007 Sampling Event.

Station ID	DC-1 RM8.9	DC-2 RM8.8	DC-3 RM0.2	MFAR-1 RM51.6	FM-1(S)	FM-1	FM-2(S)	FM-2	FM-3(S)	FM-3	MFAR-2 RM 46.6	MFAR-3 RM39.9	MFAR-4 RM39.5	MFAR-5 RM36.3	IR-1 RM35.7	MFAR-6 RM35.5	MFAR-7 RM26.1	RA-1(S)	RA-1	MFAR-8 RM24.7	MFAR-9 RM24.3	MFAR-10 RM9.1	MFAR-11 RM0.1
Date Sampled	9/25/2007	9/25/2007	*	10/3/2007	10/3/2007	10/3/2007	10/3/2007	10/3/2007	10/3/2007	10/3/2007	10/3/2007	10/3/2007	*	*	9/24/2007	9/24/2007	9/24/2007	9/26/2007	9/26/2007	9/26/2007	9/26/2007	9/24/2007	9/25/2007
Time Sampled	15:30	16:00	*	12:00	9:30	9:00	11:00	10:15	13:00	12:30	0:48	*	*	11:15	10:40	11:50	13:15	10:15	10:40	14:15	14:45	13:25	9:00
Hardness (CaCO3) (mg/L)	25	22	*	18	8.4	8.4	8.4	8.7	8.8	8.5	9.3	*	*	22	22	12	19	13	12	14	12	14	17
Cadmium (Cd)																							
Laboratory Result (ug/L)	0.004 ^U	0.004 ^U	*	0.005 ^B	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	*	*	0.004 ^U	0.004 ^U	0.005 ^B	0.004 ^U	0.004 ^U	0.005 ^B	0.013	0.004 ^U	0.004 ^U	0.004 ^U
Maximum Criterion (ug/L)	0.52	0.46	*	0.38	0.18	0.18	0.18	0.19	0.19	0.18	0.20	*	*	0.46	0.46	0.26	0.40	0.28	0.26	0.30	0.26	0.30	0.36
Continuous Criterion (ug/L)	0.09	0.09	*	0.07	0.04	0.04	0.04	0.04	0.05	0.04	0.05	*	*	0.09	0.09	0.06	0.08	0.06	0.06	0.06	0.06	0.06	0.07
Copper (Cu)																							
Laboratory Result (mg/L)	0.000170 ^B	0.000310	*	0.000210	0.000190 ^B	0.000170 ^B	0.000200 ^B	0.000220	0.000180	0.000220	0.000170	*	*	0.000160 ^B	0.000220	0.000380	0.000320	0.000330	0.000310	0.000340	0.000310	0.000320	0.000290
Maximum Criterion (mg/L)	0.0036	0.0032	*	0.0027	0.0013	0.0013	0.0013	0.0013	0.0013	0.0014	0.0013	*	*	0.0032	0.0032	0.0018	0.0028	0.0020	0.0018	0.0021	0.0018	0.0021	0.0025
Continuous Criterion (mg/L)	0.0027	0.0025	*	0.0021	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0012	*	*	0.0025	0.0025	0.0015	0.0022	0.0016	0.0015	0.0017	0.0015	0.0017	0.0020
Lead (Pb)																							
Laboratory Result (ug/L)	0.010 ^U	0.010 ^U	*	0.051	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	*	*	0.010 ^U	0.022 ^B	0.033 ^B	0.010 ^U	0.010 ^U	0.010 ^U	0.015 ^B	0.010 ^U	0.010 ^U	0.0120 ^B
Maximum Criterion (ug/L)	13.88	12.02	*	9.58	4.02	4.02	4.02	4.18	4.24	4.07	4.51	*	*	12.02	12.02	6.04	10.18	6.62	6.04	7.20	6.04	7.20	8.98
Continuous Criterion (ug/L)	0.54	0.47	*	0.37	0.16	0.16	0.16	0.16	0.17	0.16	0.18	*	*	0.47	0.47	0.24	0.40	0.26	0.24	0.28	0.24	0.28	0.35
Nickel (Ni)																							
Laboratory Result (ug/L)	0.050 ^B	0.120 ^B	*	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	*	*	0.050 ^B	0.040 ^U	0.060 ^B	0.080 ^B	0.050 ^B	0.040 ^U	0.150 ^B	0.040 ^U	0.130 ^B	0.140 ^B
Maximum Criterion (ug/L)	144.92	130.06	*	109.76	57.60	57.60	57.60	59.91	58.18	62.78	59.33	*	*	130.06	130.06	77.88	114.89	83.34	77.88	88.73	77.88	88.73	104.57
Continuous Criterion (ug/L)	16.10	14.45	*	12.19	6.40	6.40	6.40	6.59	6.65	6.46	6.97	*	*	14.45	14.45	8.65	12.76	9.26	8.65	9.86	8.65	9.86	11.61

Station ID	NFAR-1 RM20.6	RR-1 RM35.9	HH-1(S)	HH-1	HH-2(S)	HH-2	HH-3(S)	HH-3	RR-2 RM30.2	RR-3 RM 22.8	SFRR-1 RM0.2	RR-4 RM22.5	RR-5 RM3.8	RR-6 RM3.5	RR-7 RM0.7	NFLC-1 RM3.2	NFLC-2 RM2.9	NFLC-3 RM0.3	SFLC-1 RM3.4	SFLC-2 RM3.1	SFLC-3 RM0.2	LCC-1 RM11.3	LCC-2 RM0.3
Date Sampled	9/25/2007	10/2/2007	10/1/2007	10/1/2007	10/1/2007	10/1/2007	10/2/2007	10/3/2007	9/25/2007	12/00	9/25/2007	9/25/2007	9/27/2007	9/27/2007	9/26/2007	10/2/2007	10/2/2007	10/2/2007	10/2/2007	10/2/2007	10/2/2007	10/2/2007	9/27/2007
Time Sampled	9:40	11:40	14:55	14:15	12:00	12:50	10:15	9:00	10:20	13:00	12:30	13:30	9:45	10:20	13:45	12:10	12:30	11:10	13:00	13:20	11:20	10:00	10:00
Hardness (CaCO3) (mg/L)	24	25	9.3	9.7	9.3	9.3	9.6	9.5	9.8	13	6.6	12	16	17	19	21	21	13	17	18	13	13	33
Cadmium (Cd)																							
Laboratory Result (ug/L)	0.005 ^B	0.008 ^B	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.005 ^B	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U
Maximum Criterion (ug/L)	0.50	0.52	0.20	0.21	0.20	0.20	0.21	0.20	0.21	0.28	0.14	0.26	0.34	0.36	0.40	0.44	0.44	0.28	0.36	0.38	0.28	0.28	0.68
Continuous Criterion (ug/L)	0.09	0.09	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.04	0.06	0.07	0.07	0.08	0.08	0.08	0.06	0.07	0.07	0.06	0.06	0.11
Copper (Cu)																							
Laboratory Result (mg/L)	0.000330	0.000140 ^B	0.000270	0.000280 ^U	0.000260	0.000280	0.000280	0.000270	0.000510	0.000370	0.000130 ^B	0.000290	0.000280	0.000270	0.000280	0.000130 ^B	0.000120 ^B	0.000400	0.000150 ^B	0.000120 ^B	0.000200 ^B	0.000300	0.000300
Maximum Criterion (mg/L)	0.0035	0.0036	0.0014	0.0015	0.0014	0.0014	0.0015	0.0015	0.0015	0.0020	0.0010	0.0018	0.0024	0.0025	0.0028	0.0031	0.0031	0.0020	0.0025	0.0027	0.0020	0.0020	0.0047
Continuous Criterion (mg/L)	0.0026	0.0027	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0016	0.0009	0.0015	0.0019	0.0020	0.0022	0.0024	0.0024	0.0016	0.0020	0.0021	0.0016	0.0016	0.0035
Lead (Pb)																							
Laboratory Result (ug/L)	0.015 ^B	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.025 ^B	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.011 ^B	0.064	0.010 ^U	0.010 ^U	0.048 ^B	0.011 ^B	0.010 ^U	0.010 ^U	0.015 ^B	0.015 ^B
Maximum Criterion (ug/L)	13.26	13.88	4.51	4.74	4.51	4.51	4.68	4.63	4.79	6.62	3.05	6.04	8.38	8.98	10.18	11.40	11.40	6.62	8.98	9.58	6.62	6.62	18.96
Continuous Criterion (ug/L)	0.52	0.54	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.26	0.12	0.24	0.33	0.35	0.40	0.44	0.44	0.26	0.35	0.37	0.26	0.26	0.74
Nickel (Ni)																							
Laboratory Result (ug/L)	0.140 ^B	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.050 ^B	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U	0.040 ^U
Maximum Criterion (ug/L)	140.00	144.92	62.78	65.05	62.78	62.78	64.49	63.92	65.62	83.34	46.97	77.88	99.35	104.57	114.89	125.04	125.04	83.34	104.57	109.76	83.34	83.34	183.29
Continuous Criterion (ug/L)	15.55	16.10	6.97	7.23	6.97	6.97	7.16	7.10	7.29	9.26	5.22	8.65	11.03	11.61	12.76	13.89	13.89	9.26	11.61	12.19	9.26	9.26	20.36

Table AQ 11-13. Summary of *In-Situ* Measurements for Voluntary Enhanced Water Quality Sampling Locations.

Sample ID	Location Name	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm at 25 °C)	pH	Sample Water Depth ¹ (m)
Additional Sampling below Project Reservoirs							
RR-2A	Rubicon River below Hell Hole Reservoir outlet pipe	5/22/2007	6.88	9.0	59	6.9	0
RR-EC	Leakage weir channel below Hell Hole Reservoir	5/22/2007	(3)	(3)	(3)	(3)	0
RR-BEC	Rubicon River below Hell Hole Reservoir and leakage weir channel	5/22/2007	7.13	9.8	54	7.2	0
FM-A	Leakage weir A below French Meadows Reservoir	8/6/2007	13.3	1.1	165	5.3	0
FM-B	Leakage weir B below French Meadows Reservoir	8/6/2007	11.57	5.2	180	5.6	0
FM-C	Leakage weir C below French Meadows Reservoir	8/6/2007	9.65	2.9	181	5.5	0
FM-D	Middle Fork American River below French Meadows Reservoir and spillway channel	8/6/2007	4.21	9.3	26	5.3	0
FM-E	Middle Fork American River below French Meadows Reservoir outlet pipe	8/6/2007	8.22	9.1	25	5.4	0

1: Water sample was collected just below the water surface unless otherwise noted.

2: Secchi depth measurements were only collected in reservoirs.

3: Instrument malfunction, no in-situ measurement available.

Table AQ 11-14. Summary of Analytical Results for Voluntary Enhanced Water Quality Samples.

				RR-2A	RR-2EC	RR-2DEC	FM-A	FM-B	FM-C	FM-D	FM-E
				5/22/2007	5/22/2007	5/22/2007	8/7/2007	8/7/2007	8/7/2007	8/7/2007	8/7/2007
Water Quality Parameters	Units	PQL	WQ Criteria	15:10	14:40	14:45	10:15	10:50	11:10	12:00	12:30
Metals-Dissolved											
Arsenic	ug/L	0.20	10 ¹	0.210	0.060 ^U	0.230	2.760	5.540	4.800	0.160 ^B	0.120 ^B
Cadmium	ug/L	0.01	(3)	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U
Copper	mg/L	0.0002	(3)	0.000320	0.000300	0.000300	0.000110 ^B	0.000060 ^B	0.000060 ^B	0.000190 ^B	0.000180 ^B
Iron	mg/L	0.0014	0.3 ¹	0.001400 ^U	0.001400 ^U	0.001400 ^U	20.400	16.000	19.400	0.137	0.0348
Lead	ug/L	0.05	(3)	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U
Manganese	ug/L	0.05	50 ¹	NS	NS	NS	4040	3610	3860	62.600	22.000
Nickel	ug/L	0.20	(3)	0.080 ^B	0.300	0.090 ^B	0.390	0.310	0.240	0.070 ^B	0.060 ^B
Chromium-Total	ug/L	0.15	50 ¹	0.030 ^U	0.030 ^U	0.030 ^U	0.140 ^B	0.100 ^B	0.090 ^B	0.030 ^U	0.030 ^U
Metals-Total											
Mercury	ug/L	0.0004	0.05 ²	0.000540	0.000750	0.000630	0.000100 ^U	0.000100 ^U	0.000100 ^U	0.000410	0.000220 ^B

Note: Bold results do not meet the listed criteria

NS: Not sampled

U: Results are less than or equal to the method detection limit (MDL) and are considered 'non-detect'.

B: Results are above the MDL and less than or equal to the practical quantitation limit (PQL) and should be considered estimates.

1: Basin Plan criteria for the Sacramento and San Joaquin Rivers Basins.

2: California Toxics Rule Criteria

3: Criteria is hardness dependent which is expressed as a function of hardness and decreases as hardness decreases. The actual criteria are calculated based on the hardness (as CaCO₃) of the sample water. Refer below for sample site criteria and results.

Table AQ 11-15. Hardness-based Water Quality Criteria for Cadmium, Copper, Lead, and Nickel for Voluntary Enhanced Water Quality Sampling Locations.

Station ID	RR-2A	RR-2EC	FM-A	FM-B	FM-C	FM-D	FM-E
Date Sampled	5/22/2007	5/22/2007	8/7/2007	8/7/2007	8/7/2007	8/7/2007	8/7/2007
Time Sampled	15:10	14:40	10:15	10:50	11:10	12:00	12:30
Hardness (CaCO3) (ppm)	9	9.3	41.9	54.9	49.3	9.16	9.02
Cadmium (Cd)							
Laboratory Result (ug/L)	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U	0.004 ^U
Maximum Criterion (NTR) (ug/L)	0.19	0.20	0.86	1.12	1.01	0.20	0.19
Continuous Criterion (NTR) (ug/L)	0.05	0.05	0.13	0.16	0.15	0.05	0.05
Copper (Cu)							
Laboratory Result (mg/L)	0.000320	0.000300	0.000110 ^B	0.000060 ^B	0.000060 ^B	0.000190 ^B	0.000180 ^B
Maximum Criterion (mg/L)	0.0014	0.0014	0.0059	0.0076	0.0069	0.0014	0.0014
Continuous Criterion (mg/L)	0.0011	0.0012	0.0043	0.0054	0.0049	0.0012	0.0011
Lead (Pb)							
Laboratory Result (ug/L)	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U	0.010 ^U
Maximum Criterion (ug/L)	4.35	4.51	24.76	33.43	29.67	4.44	4.36
Continuous Criterion (ug/L)	0.17	0.18	0.96	1.30	1.16	0.17	0.17
Nickel (Ni)							
Laboratory Result (ug/L)	0.080 ^B	0.300	0.390	0.310	0.240	0.070 ^B	0.060 ^B
Maximum Criterion (ug/L)	61.06	62.78	224.31	281.93	257.40	61.98	61.17
Continuous Criterion (ug/L)	6.78	6.97	24.91	31.31	28.59	6.88	6.79

Note: Bold results do not meet the listed criteria

U: Results less than or equal to the method detection limit (MDL) and are considered 'non-detect'.

B: Results are above the MDL and less than or equal to the practical quantitation limit (PQL) and should be considered estimates.

California Toxics Rule (CTR) standard was used unless otherwise noted.

Calculations are provided in Appendix C.

Table AQ 11-16. Summary of 30-Day, 5-Sample Fecal Coliform Results (MPN).

Sample ID	Location	GPS Coordinates		Sampling Period					Geometric Mean ¹
		UTM10_ NAD 83 X	UTM10_ NAD 83 Y	Week 1	Week 2	Week 4	Week 4	Week 5	
FC-1	Middle Fork American River below Ahart Campground	724066	4336067	4	13	2	11	<2	5 ²
FC-2	Middle Fork American River below Gates Group Campground	723679	4335535	8	2	<2	8	<2	3 ²
FC-3	Middle Fork American River below Coyote and Lewis Campground	723578	4334312	2	<2	13	2	<2	3 ²
FC-4	French Meadows Reservoir near McGuire Picnic Area	722892	4333328	<2	4	2	<2	<2	2 ²
FC-5	French Meadows Reservoir near McGuire Boat Ramp	722565	4333376	<2	<2	<2	<2	<2	<2
FC-6	French Meadows Reservoir near French Meadows Campground	722654	4332703	<2	<2	<2	2	<2	<2 ²
FC-7	French Meadows Reservoir near French Meadows Boat Ramp	722249	4332433	<2	<2	<2	<2	<2	<2
FC-8	French Meadows Reservoir near Poppy Campground	721628	4333151	<2	<2	<2	<2	2	<2 ²
FC-9 ³	Hell Hole Reservoir near Upper Hell Hole Reservoir Campground	728501	4329059	23	30	17	4	8	13
FC-10	Hell Hole Reservoir near Hell Hole Boat Ramp	723737	4326842	<2	<2	<2	2	<2	<2 ²
FC-11 ³	South Fork Long Canyon Creek above Big Meadows Campground	722744	4328540	4	7	30	130	23	19
FC-12	South Fork Long Canyon Creek below Big Meadows Campground	722119	4328056	<2	<2	<2	2	<2	<2 ²
FC-13	South Fork Long Canyon Creek above Middle Meadows Campground	719274	4325849	2	80	50	80	17	26

Table AQ 11-16. Summary of 30-Day, 5-Sample Fecal Coliform Results (MPN) (continued).

Sample ID	Location	GPS Coordinates		Sampling Period					Geometric Mean ¹
		UTM10_NAD 83 X	UTM10_NAD 83 Y	Week 1	Week 2	Week 3	Week 4	Week 5	
FC-14	South Fork Long Canyon Creek below Middle Meadows Campground	718907	4325560	8	13	8	23	22	13
FC-15	Ralston Afterbay near Ralston Picnic Area	696326	4319720	110	<2	4	1600	17	30 ²
FC-16	Middle Fork American River below Oxbow Powerhouse (Horseshoe Bar Area)	695159	4320291	2	<2	<2	<2	<2	<2 ²
FC-17	Middle Fork American River below the Drivers Flat Road Camping and Rafting Take-out	679156	4314631	13	30	13	4	11	12

MPN: Most Probable Number of Bacterial colonies per 100 mL of water.

Criteria: Geometric mean of 5 samples within a 30-day period shall not exceed a geometric mean of 200 MPN/100 mL, nor shall >10% of total samples exceed 400/100mL.

¹ Geometric Mean: nth root of the product of 'n' numbers.

² Values of '<2' were changed to '2' for the calculation of the geometric mean to represent the maximum geometric mean possible.

³ Sampling location was adjusted during the first week of sampling and a sample was not collected. A sample was collected at this site for 5 subsequent weeks.

Table AQ 11-17. Summary of Fish Specimens Collected for Fish Tissue Analysis.

Location	Fish Sample ID	Date Collected	Time Collected	Species ¹	Total Length (mm)	Fork Length (mm)	Weight (g)	Weight (lbs)	Methyl mercury Concentration ⁴ (mg/Kg)
Individual Fish Analysis									
Hell Hole Reservoir									
	HH-1-DS-1-BNT-2	10/11/2007	13:30	BNT	398	393	650	1.43	0.66
	HH-1-MID1-BNT-1	10/11/2007	11:50	BNT	485	480	1200	2.64	1.08
	HH-1-MID3-BNT-3	10/11/2007	10:30	BNT	495	490	1175	2.59	0.92
	HH-1-US2-RBT-1	10/11/2007	9:30	RBT	230	220	125	0.28	0.05
	HH-1-US2-BNT-2	10/11/2007	9:30	BNT	422	415	925	2.04	0.60
	HH-1-US2-BNT-3	10/11/2007	9:30	BNT	477	470	1075	2.37	1.03
	HH-3B-BT-1	9/11/2007	14:20	BNT	571 ³	561	2150	4.73	1.14
	HH-1-MIDL-LT-1	10/11/2007	11:50	LKT	360	330	450	0.99	0.00
	HH-1-MID3-LT-1	10/11/2007	10:30	LKT	265	235	160	0.35	0.24
	HH-1-US1-LT-1	10/11/2007	8:30	LKT	270	245	125	0.28	0.21
French Meadows Reservoir									
	FM-2B-BT-3	9/12/2007	15:50	BNT	615 ³	605	2000	4.40	0.21
	FM-2C-BT-1	9/13/2007	10:20	BNT	740	730	3900	8.58	0.36
	FM-1E-RT-1	9/13/2007	17:00	RBT	240	230	100	0.22	0.05
	FM-2F-RT-1	9/13/2007	15:30	RBT	290	280	180	0.40	0.07
	FM-3D-RT-2	9/13/2007	11:24	RBT	335	325	270	0.59	0.18
Middle Fork Interbay									
	I-US-1-BNT-1	9/20/2007	14:46	BNT	345	338	450	0.99	0.02
	I-US1-BNT-2	9/21/2007	10:30	BNT	370	360	625	1.38	0.03
	I-US-1-BNT-3	9/21/2007	10:30	BNT	320	310	420	0.92	0.03
	I-U2-BNT-1	9/20/2007	14:56	BNT	323	315	390	0.86	0.05
	I-US-2-BNT-2	9/21/2007	11:15	BNT	355	350	570	1.25	0.03
	I-US-2-BNT-3	9/21/2007	11:15	BNT	330	320	430	0.95	0.01
	I-L1-RBT-1	9/21/2007	11:15	RBT	255	245	225	0.50	0.03
	I-US1-RBT-1	9/21/2007	10:30	RBT	285	270	200	0.44	0.02
	I-US2-RBT-1	9/21/2007	11:15	RBT	315	307	410	0.90	0.14
	I-US2-RBT-5	9/21/2007	11:15	RBT	263	253	210	0.46	0.03
Ralston Afterbay									
	RA-2A-BT-14	9/14/2007	13:05	BNT	476	465	925	2.04	0.08
	RA-2A-BT-7	9/14/2007	12:40	BNT	470	464	1050	2.31	0.10
	RA-2B-BT-6	9/14/2007	13:30	BNT	477	474	1250	2.75	0.11
	RA-3B-BT-7	9/14/2007	14:50	BNT	462	460	1100	2.42	0.06
	RA-3B-RT-19	9/14/2007	15:10	RBT	375	365	550	1.21	0.04
	RA-1D-SPM-4	9/14/2007	16:19	SPM	405 ³	385	510	1.12	0.31
	RA-2B-SPM-7	9/14/2007	13:31	SPM	470	445	840	1.85	0.35
	RA-2B-SPM-8	9/14/2007	13:35	SPM	405	384	640	1.41	0.21
	RA-3A-SPM-20	9/14/2007	14:25	SPM	239	225	100	0.22	0.11
	RA-3A-SPM-21	9/14/2007	14:30	SPM	260	245	50	0.11	0.12
Middle Fork American River near Otter Creek									
	OC-1-BNT-1	10/9/2007	9:40	BNT	390 ³	385	634	1.39	0.08
	OC-RBT-1	10/16/2007	14:00	RBT	365	344	380	0.84	0.08
	OC-1-RBT-1	10/2/2007	11:30	RBT	308	300	282	0.62	0.03
	OC-1-RBT-2	10/2/2007	11:30	RBT	202	193	65	0.14	0.01
	OC-1-RBT-3	10/2/2007	11:30	RBT	202	200	66	0.15	0.02
	OC-1-RBT-4	10/2/2007	11:30	RBT	249	238	139	0.31	0.02
	OC-1-RBT-5	10/2/2007	11:30	RBT	303	311	236	0.52	0.04
	OC-1-RBT-6	10/2/2007	11:30	RBT	374	363	463	1.02	0.08
	OC-1-RBT-7	10/9/2007	10:30	RBT	310 ³	300	282	0.62	0.03
	OC-1-RBT-8	10/9/2007	13:30	RBT	415 ³	395	468	1.03	0.13
Composite Fish Analysis									
Hell Hole Reservoir									
	Composite-HH-BT-1								1.07
	HH-1A-BT-34 ²	9/11/2007	10:00	BNT	449 ³	432	940	2.07	
	HH-1B-BT-15 ²	9/11/2007	11:00	BNT	483 ³	473	1040	2.29	
	HH-2A-BT-6 ²	9/11/2007	12:15	BNT	419 ³	411	760	1.67	
	HH-3A-BT-3 ²	9/11/2007	13:45	BNT	485 ³	475	1260	2.77	
	HH-2C-BT-1 ²	9/11/2007	9:45	BNT	360	350	310	0.68	
French Meadows Reservoir									
	Composite-FM-BT-1								0.18
	FM-2B-BT-4 ²	9/12/2007	15:50	BNT	360 ³	353	420	0.92	
	FM-2A-BT-2 ²	9/12/2007	16:20	BNT	355	348	430	0.95	
	FM-1A-BT-1 ²	9/12/2007	18:30	BNT	410	400	470	1.03	
	FM-1D-BT-1 ²	9/13/2007	9:50	BNT	408	392	590	1.30	
	FM-3D-BT-3 ²	9/13/2007	11:30	BNT	400	393	600	1.32	

¹ BNT: Brown Trout; RBT: Rainbow Trout; SPM: Sacramento Pikeminnow; LKT: Lake Trout² These fish were analyzed as a composite.³ Total length was not measured in the field. Total length is estimated based on fish size, species, and fork length.⁴ Bold numbers indicate screening value of 0.08 mg/Kg were exceeded (Cal EPA 2005; Klasing and Brodberg 2006).

FIGURES

Figure AQ 11-1. Water Quality Objectives and Related Study Elements and Reports.

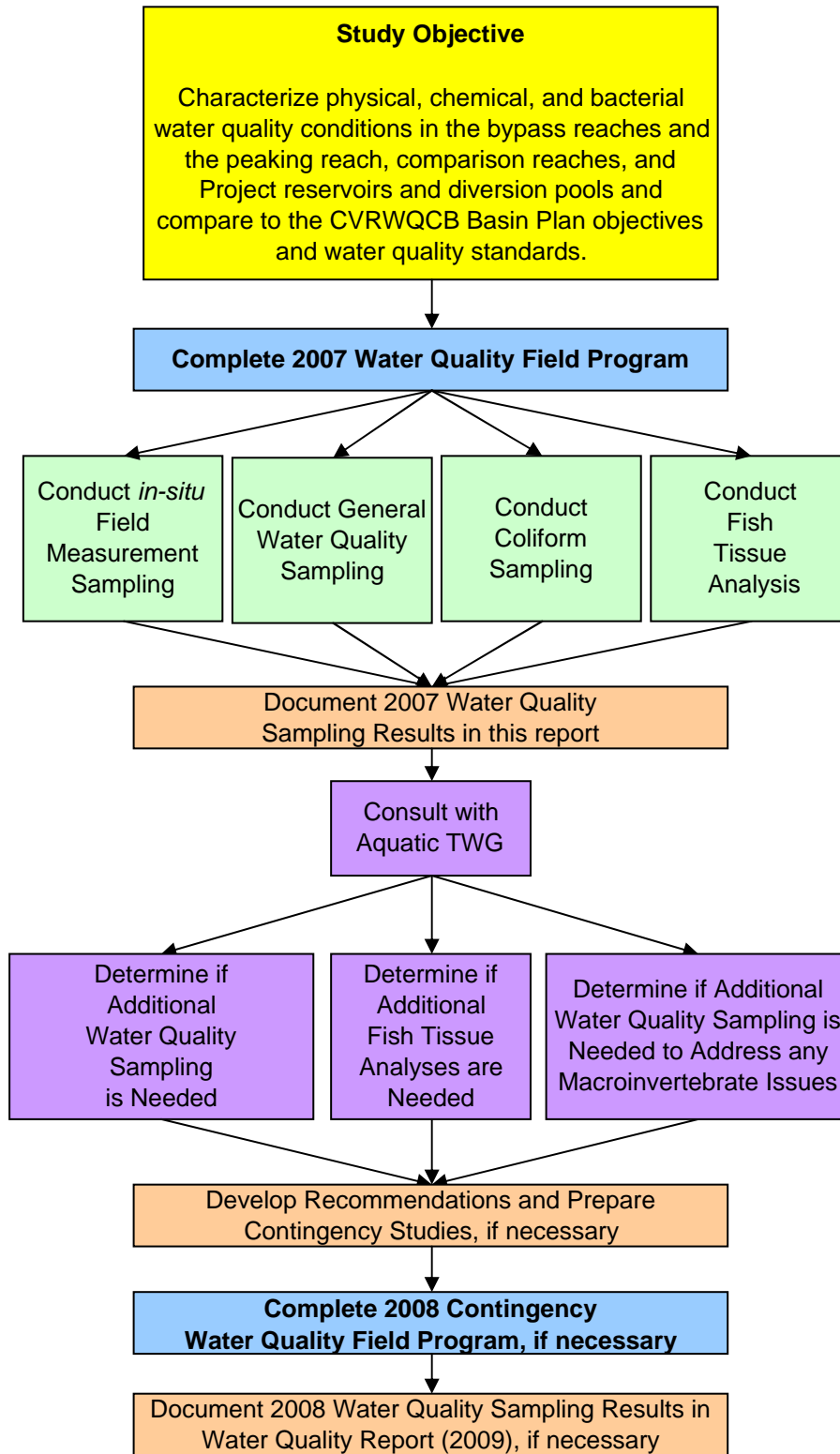


Figure AQ 11-2. Dissolved Oxygen and Metal Concentrations in French Meadows Leakage Channels and the Middle Fork American River.

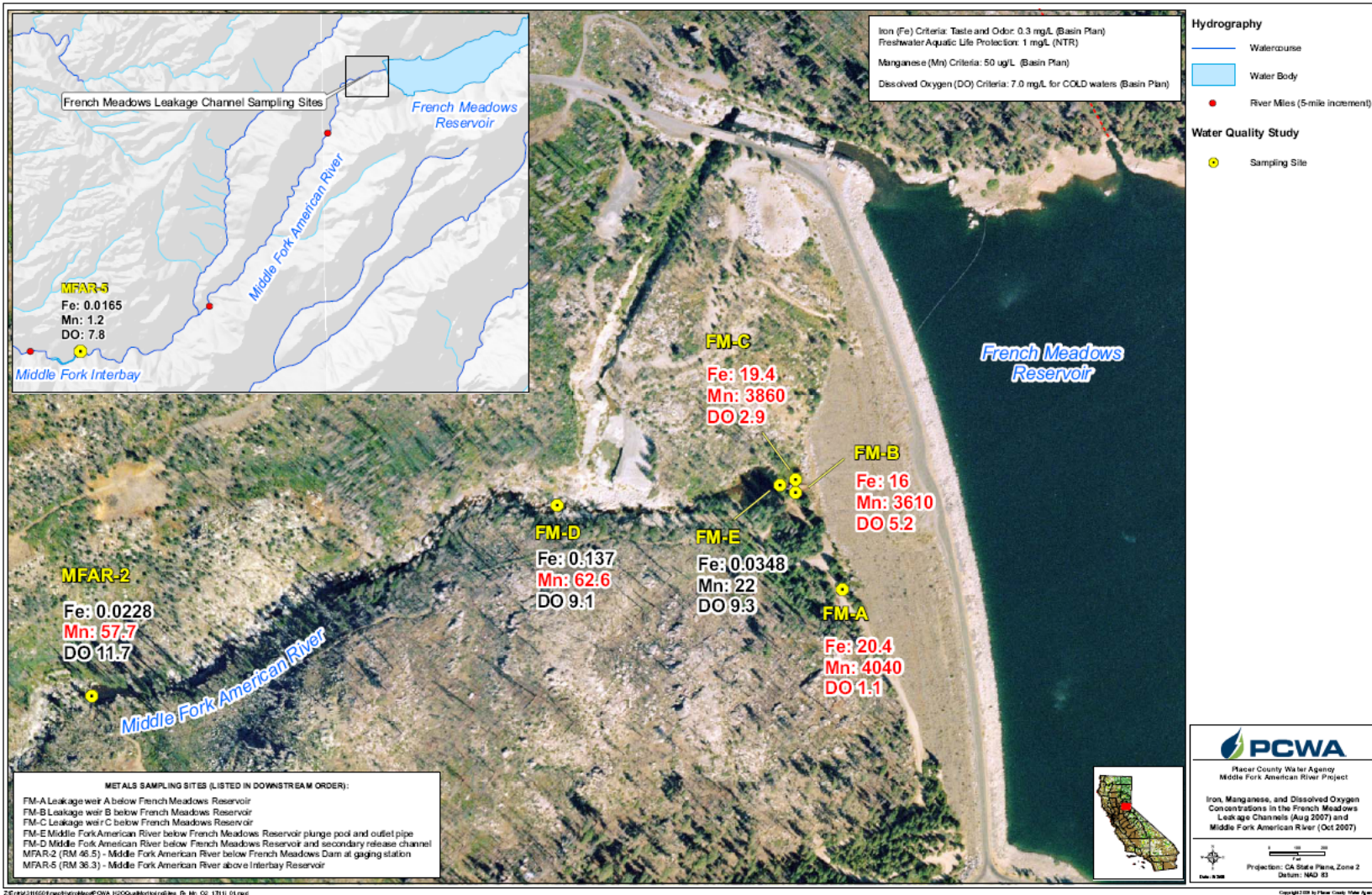
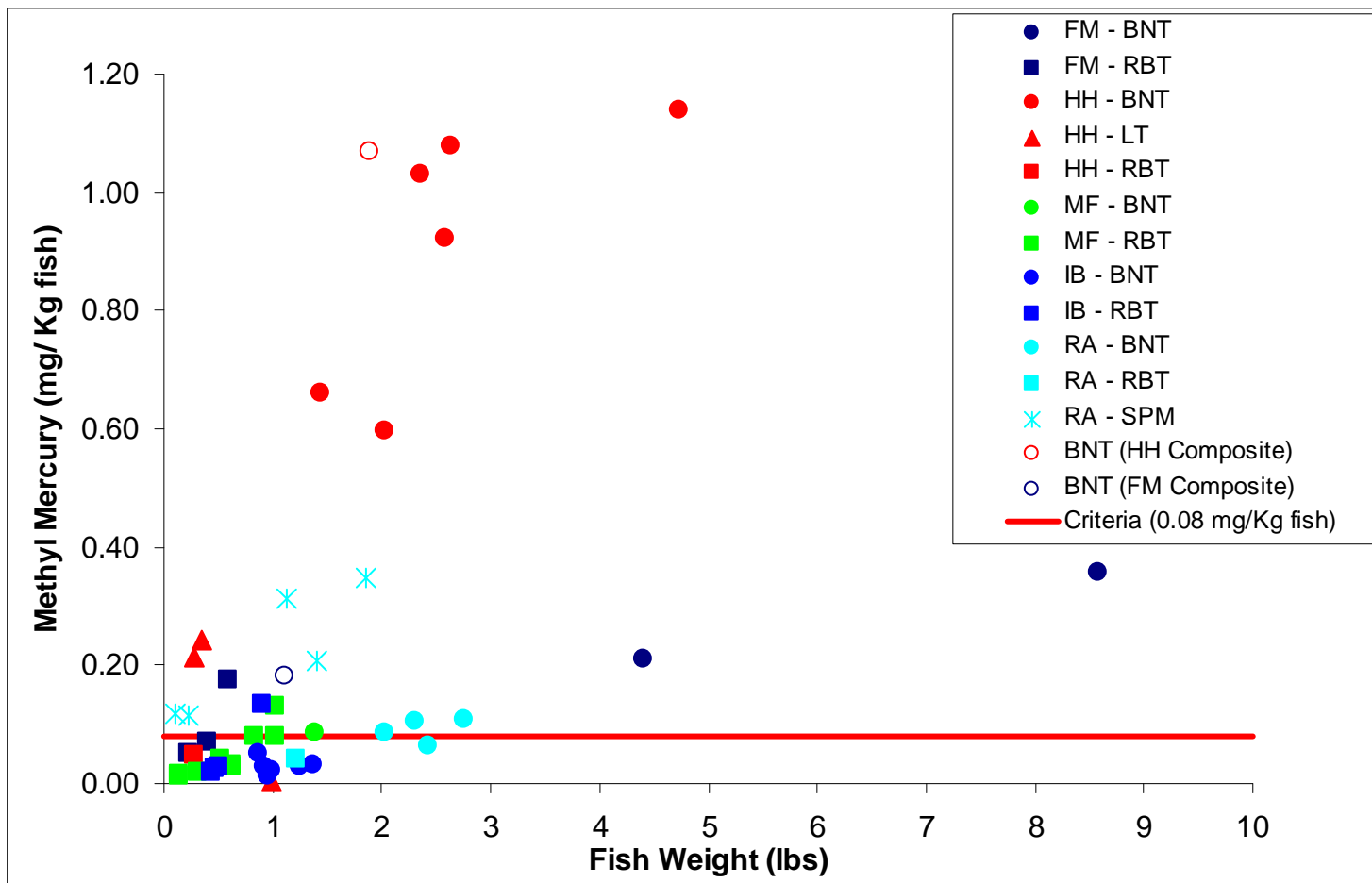


Figure AQ 11-3. Methyl Mercury Fish Tissue Analyses Results by Sampling Location and Fish Species.



APPENDIX A
Overview of Water Quality Parameters

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1.0 WATER QUALITY MONITORING PARAMETER

1.1 IN-SITU MEASUREMENTS

Dissolved Oxygen (DO)

Dissolved oxygen (DO) is a measure of the amount of oxygen dissolved in water. Values for DO in water analyses are commonly provided in mg/L, although a percentage of saturation may also be used. The concentration of DO in surface water is usually less than 10 mg/L (MELP 1998; EPA 2006). The actual concentration will vary with other parameters such as temperature, elevation, photosynthetic activity, biotic activity, stream discharge, and the concentration of other solutes (Hem 1989, Michaud 1994). The maximum solubility of oxygen (fully saturated) at sea level is 12.75 mg/L at 5° C and 8 mg/L at 25° C. DO concentrations decrease within increasing temperatures or elevation (MELP 1998).

Dissolved oxygen is derived from the atmosphere and photosynthetic production by aquatic plants. Atmospheric oxygen is changed to dissolved oxygen when it enters the water, with more mixing occurring in turbulent waters. Dissolved oxygen is essential for the respiration of fish and other aquatic organisms (Michaud 1994). As water moves past their breathing apparatus (such as gills in fish), oxygen gas bubbles in the water (DO) are transferred from the water to their blood. The transfusion is efficient only above certain concentrations. Oxygen is also used for the decomposition of organic matter and other biological and chemical processes. Anoxic waters have obvious detrimental effects on aerobic organisms. These conditions can also lead to the accumulation of chemically reduced compounds, such as ammonium and hydrogen sulfide, in the bottom sediments that can be toxic to benthic organisms (Michaud 1994).

Nutrient solubility and availability rely partly on DO levels, and thus it also affects the productivity of aquatic ecosystems. In low-nutrient lakes, the deeper waters tend to have higher DO concentrations than the surface waters. In comparison, in lakes with high nutrient concentrations, the surface waters tend to have higher concentrations of DO compared to the deeper waters (MELP 1998). In streams, DO concentrations tend to be higher in faster moving waters. During the summer, in particular, when discharges and velocities decrease in streams, DO concentrations can be quite low.

Pollution can cause decreases in average DO concentrations by contributing organic matter that uses oxygen or nutrients and stimulates the growth of algae.

Secchi Depth

Secchi depth or secchi disk depth is a measure of water clarity. It is primarily used as an indicator of algal abundance and general lake productivity. The measurement is often made in a lake over time to monitor water clarity trends. A secchi disk is a circular plate that is divided into alternating black and white painted quarters. The disk is attached to a rope and lowered into the water until it is no longer visible. This depth is then noted. Secchi depth is usually reported in feet to the nearest tenth of a foot or

meters to the nearest tenth of a meter. Higher secchi depth readings mean that the disk is visible at greater depths and the water is clearer. Lower readings indicate turbid or colored water. Clarity is affected by numerous factors, including algae, soil particulates, and other suspended materials (Michaud 1994; EPA 2006).

Clear water is important for aquatic life as it allows light to penetrate deeper in the lake than murky or cloudy water. The light allows photosynthesis to occur and oxygen to be produced. In general, light can penetrate 1.7 times the measured secchi depth. Secchi depth naturally varies seasonally with changes in photosynthesis and algal growth. As a result, secchi depth readings often are lowest in the summer when algal growth is greatest, and increase with cooler weather as growth decreases. Secchi depths may also decrease in the fall with fall turnover. Rainstorms that may increase suspended particulate concentrations in inflowing streams may also decrease secchi depth readings (Michaud 1994).

pH

A pH value is a measure of the activity of hydrogen ions in a water sample. Various types of chemical reactions that occur in natural waters produce hydrogen ions, which are then consumed by participating in subsequent chemical reactions in the system. These interrelated chemical reactions that produce and consume hydrogen ions control the pH value of a water body. It is a useful index of the status of equilibrium reactions in which the water participates. A pH of 7 is considered neutral, values less than 7 are acidic, and values greater than 7 are basic. The units of pH are logarithmic; so a difference of one unit represents a 10-fold change in hydrogen ion concentration. The higher the pH, the fewer free hydrogen ions are present in the water. The pH of natural fresh waters ranges from 4.0 to 10.0, with most waters falling between 6.5 and 8.5 (EPA 1986; Hem 1989; MELP 1998).

The pH of water determines the solubility (the amount that can be dissolved in water) and biological availability (the amount that can be used by aquatic biota) of chemical constituents, such as nutrients (i.e. carbon, nitrogen and phosphorus) and heavy metals (i.e. lead, copper). Unusually high or low pH can have adverse effects on aquatic biota. Values above 9.5 and below 4.5 are considered lethal to aquatic organisms (EPA 1996; MELP 1998). For heavy metals, the degree to which they are soluble determines their toxicity. They tend to be more toxic when pH is lower because they are more soluble and bioavailable.

The pH of water is naturally variable, although the amount of change in natural waters tends to be very small due to many chemical reactions. This ability of the water to maintain a stable pH is called buffering capacity. The initial pH of water is influenced by the geology of the watershed and the original source of the water. In particular, alkalinity, which is typically low in granitic drainages, is usually the primary factor that influences pH values. This causes the waters to be more acidic (pH <7.0) in these types of watersheds (Wetzel 2001). The greatest natural cause for variation is the daily and seasonal changes in photosynthesis. Photosynthesis uses up hydrogen molecules and therefore increases the pH. The pH increases during the day (with maximum

values up to 9.0) and decreasing at night. Respiration and decomposition processes lower pH. The pH also tends to be higher during the growing season when photosynthesis is greater. As a result, most streams that drain coniferous forests tend to be slight acidic (6.5 to 6.8). A pH may also vary with depth in a lake, due to changes in photosynthesis and other chemical reactions. During the summer, the upper portions of a lake tend to have higher pH values, ranging between 7.5 and 8.5. The lower portions of the lake where production by aquatic organisms is less tend to more acidic (pH ranging between 6.5 and 7.5) (Hem 1989; Michaud 1994; Wetzel 2001).

Temperature

Ambient water temperature is a measurement of the intensity of heat stored in a volume of water and is generally reported in degrees Celsius (°C) or Fahrenheit (°F). Natural heat sources include solar radiation, air transfer, condensation of water vapor at the water surface, sediments, precipitation, surface runoff, and groundwater. Anthropogenic sources of heat include industrial effluents, agriculture, and forest harvesting, decrease in streamside vegetation coverage, urban development, and mining.

Water temperature has important effects on aquatic biota. Increased water temperature reduces oxygen solubility while elevating metabolic oxygen demand. This causes lower oxygen concentrations that may be detrimental to some aquatic organisms. Reproductive and other biological activities, such as migration, spawning, egg incubation, and fry rearing, are often triggered by water temperature. A rise in water temperature can also provide conditions for the growth of disease-causing organisms. Temperature also influences the solubility of many chemical compounds, thus affecting their toxicity to aquatic life (EPA 1986, MELP, 1998).

Specific Conductance

Specific conductivity is a measurement of the ability of water to conduct an electric current and provides an estimate of the concentration of dissolved solids. This property is related to water temperature and total ion content (e.g. chloride, sulfate, sodium, and calcium), and depends on the concentration of dissolved metals and other dissolved materials. Water carries more current with increased ion content in the water. Specific conductivity is lower in cooler waters. Specific conductivity is measured in terms of resistance and reported in microsiemens per centimeter ($\mu\text{m}/\text{cm}$) at 25°C. Water source and geologic composition of the watershed are important controlling factors of specific conductivity. Streams that flow through granite bedrock, for example, have lower conductivity than those that flow through limestone or clay soils. The conductivity of pure waters is 0.055 $\mu\text{S}/\text{cm}$. The conductivity of freshwater at 25° C varies between 50 and 1,500 $\mu\text{m}/\text{cm}$ (Hem 1989; MELP 1998). Specific conductivity measurements in streams flowing through granitic, siliceous, or other igneous rocks usually range between 10 and 50 $\mu\text{S}/\text{cm}$. In comparison, it generally ranges between 150 and 500 $\mu\text{S}/\text{cm}$ in streams that are flowing through limestones.

Conductivity itself is not an aquatic health concern, but serves as an indicator of other water quality concerns.

2.0 LABORATORY ANALYSIS PARAMETER

2.1 GENERAL PARAMETERS

Calcium

Calcium (Ca) is the most abundant of the alkaline-earth metals and is a major constituent of many common rock minerals and of the solutes present in the water (Hem 1989). It is generally the main cation in surface waters. It is most commonly present as the calcium ion (Ca²⁺) and is generally derived from weathering or dissolution of minerals in soil and rocks. Under conditions of high bicarbonate or sulfate concentration, calcium bicarbonate or calcium sulfate may exist (Hem 1989). It contributes to the total hardness of water. Calcium is reported in mg/L. Water bodies with less than 10 mg/L are considered calcium poor, whereas greater than 20 mg/L are considered calcium rich. Average dissolved concentration in river waters ranges from 13.4 mg/L to 15 mg/L, but can vary substantially due to geology and climate (Hem 1989). Although calcium is an important constituent of igneous rocks, its concentration in associated water bodies is generally low (Hem 1989) (0.039 mg/L for granitic watersheds, Wetzel 2001) due to slow decomposition rates of igneous rock materials (Hem 1989).

Calcium is an essential element for metabolism in most plants and animals (Hem 1989). The distribution of many freshwater species, particularly invertebrates, is related to calcium concentration. Significant changes in calcium concentration in a water body can influence the presence or absence of these organisms. Most calcium in surface waters is derived from waters flowing over limestone, dolomite, gypsum, and other calcium-containing sedimentary rocks and minerals.

Chloride

Chloride (Cl⁻) is among the important anions found in natural waters (Hem 1989). Chloride is reported in mg/L. It originates from the dissociation of salts, such as sodium chloride or calcium chloride, in water. Concentrations tend to be low in fresh waters (8.3 mg/L, on average) (Schlesinger 1997; MELP 1998), and essentially zero in granite drainages (Wetzel 2001). Water will taste salty when the chloride concentrations are greater than 250 to 400 mg/L.

Chloride influences osmotic salinity balance and ion exchange in aquatic organisms, thus making it an important ion for metabolic processes. Increased chloride levels may reduce the toxicity of nitrite to aquatic life (MELP 1998). Fish and invertebrates appear to be more sensitive to increases in chloride levels than aquatic plants. High chloride content can adversely affect plant growth. Fairly low concentrations can be lethal to fish (EPA 1986). Chloride is common in areas with limestone deposits. It is uncommon in most other soils, rocks, or minerals (Hem 1989). Anthropogenic sources of chloride

include municipal water supplies, sewage plant effluents, urban development, rock salt, agricultural runoff, and industrial effluents (MELP 1998).

Hardness

The hardness of water is based on its content of calcium and magnesium salts, combined with bicarbonate and carbonate (temporary hardness) and with sulfates, chlorides, and other anions of mineral acids (permanent hardness) (MELP 1989). Hardness is expressed in degrees of hardness or mg/L of calcium carbonate (CaCO₃). Values greater than 120 mg/L are considered hard, while values less than 60 mg/L are considered soft (Hem 1989; MELP 1989). The EPA (1986) utilizes the following hardness classification:

Concentration CaCO ₃ (mg/L)	Description
<75	Soft Water
75-150	Moderately Hard Water
150-300	Hard Water
>300	Very Hard Water

Water hardness can have indirect effects on aquatic biota, primarily affecting the toxicity of certain metals (MELP 1989). The binding activity of major ions such as calcium and magnesium with metals such as copper, lead, and zinc, will lower the toxicity of these metals by decreasing the bioavailability. Therefore, when water hardness is low, the toxic effects of these metals may increase.

Hardness is influenced by the underlying rock-types, such as limestone. Anthropogenic sources of hardness include the inorganic chemical industry and mines (EPA 1986). The effects of hardness on freshwater fish and other aquatic life appear to be related to the ions causing the hardness rather than hardness (EPA 1986). For this reason, technical guidance groups recommend providing the concentrations of specific ions, rather than using hardness.

Magnesium

Magnesium (Mg) is a common alkaline-earth metal found in igneous, sedimentary, and other rock types. It contributes to the total hardness of water. Magnesium concentration is reported in mg/L or µg/L. It is much more soluble than calcium, with an average concentration of 5 mg/L in North American rivers (Schlesinger 1997) and 0.031 mg/L in granite drainage basins (Wetzel 2001).

Magnesium is an essential nutrient in the metabolic activity of plants and animals. It is commonly present as an ion (Mg²⁺) and is typically derived from weathering of ferromagnesian minerals in soil and rocks or dissolution of limestone. Similar to calcium, magnesium may exist as magnesium bicarbonate or magnesium sulfate under

certain conditions. Magnesium concentrations are not strongly influenced by anthropogenic activities (Hem 1989).

Nitrate/Nitrite

Nitrate (NO_3^-) and nitrite (NO_2^-) ions are produced during nitrification of reduced and organic forms of nitrogen. Nitrate and nitrite are typically reported in mg/L or $\mu\text{g/L}$. Nitrite is usually present in only minute quantities in water (<0.001 mg/L) because it is an intermediate, unstable form of nitrogen within the nitrogen cycle (MELP 1998). It is formed from nitrate or ammonium ions by certain microorganisms found in soil and water (EPA 1986). Nitrate is formed by the complete oxidation of ammonium by microorganism in the soil and water. It is the most oxidized and stable form of nitrogen in water, and therefore is the principle form of combined nitrogen. Most surface waters contain less than 0.01 mg/L of nitrite and less than 0.2 mg/L nitrate (MELP 1998; Wetzel 2001).

Nitrate is the primary form of nitrogen used during plant growth. Excessive amounts of nitrate may cause phytoplankton or macrophyte outbreaks. Nitrite is toxic to aquatic life at relatively low concentrations (MELP 1998). Although it is an essential plant nutrient, excessive nitrogen can cause proliferation of algae and macrophytes, resulting in eutrophic water conditions. Eutrophication causes decreased oxygen levels which may cause stress or mortality of fish and invertebrates (EPA 1986). Sources of elevated nitrate and nitrite come from municipal and industrial wastewaters, agricultural runoff, urban development, and automobile exhausts.

Ammonia

Ammonia is found in two forms, ammonium (NH_4^+) that is not toxic and NH_3 , which is (ESA 1986). Ammonium is readily adsorbed onto mineral surfaces (Hem 1989). It is reported as mg/L or $\mu\text{g/L}$, with typical surface water values less than 0.1 mg/L (MELP 1998; Wetzel 2001). Ammonia as NH_3 is reported to be toxic to various aquatic organisms over a range of concentrations (0.53 to 22.8 mg/L) (Oram 2007).

Complex nitrogen cycling and processes occur within aquatic systems. Nitrogen is an essential plant nutrient which contributes to the productivity of a water body. However, excessive ammonia over-stimulates the growth of algae and other plants, leading to eutrophication of a water body. The resulting decrease of oxygen levels may cause stress and mortality of fish and invertebrates (EPA 1986). High ammonia concentrations are also toxic to aquatic life. The specific concentration at which ammonia is harmful to organism depends upon the temperature and pH of the water. At higher temperatures and pH, a greater proportion of the total ammonia is present as NH_3 , increasing the toxicity of the water (EPA 1986). The distribution of ammonia in surface waters varies spatially and seasonally depending upon productivity and the amount of organic matter. Anthropogenic sources of ammonia include fertilizers, livestock wastes, residential effluents (e.g. cleaning products), mining, sewage treatments plans, and effluent from various types of industries (Oram 2007).

Total Kjeldahl Nitrogen

Total kjeldahl nitrogen (TKN) is a measure of both the ammonia and organic forms of nitrogen. Organic nitrogen includes organic compounds, such as proteins, polypeptides, amino acids, and urea. TKN is reported in mg/L or $\mu\text{g/L}$ (MELP 1998). In lakes and reservoirs in the western United States, total phosphorus concentrations are usually between 0.01 and 3.52 mg/L (EPA 2000a). In Sierra Nevada rivers and streams, TKN values typically range between 0.025 and 0.65 mg/L (EPA 2000).

High ammonia concentrations can be deleterious to aquatic life, as it contributes to the eutrophication of water bodies. Organic nitrogen is not biologically available. As a result, it does not influence plant growth or water quality condition until it is transformed to the inorganic forms of nitrogen (MELP 1998). Natural sources of TKN include decaying organic material such as plants and animals wastes. Some species of streamside vegetation, such as alders, are nitrogen fixers. Elevated nitrogen concentrations have been measured in waters with decaying alder leaves (Wetzel 2001). Anthropogenic sources of TKN include effluents from sewage treatment plants and industry, agriculture (fertilizers), urban developments, paper plants, recreation, and mining.

Total Phosphorus

Phosphorus (P) is a nutrient that is essential for growth, and is a measure of both organic and inorganic forms of phosphorus. It can be measured as total phosphorus or ortho-phosphate. Total phosphorus is the total amount of phosphorus in the sample. Ortho-phosphate is the portion that is available to organisms for growth. Total phosphorus measurements include phosphorus that is in biological tissue, as well as the insoluble mineral particles (Michaud 1991; MELP 1998). Phosphorus is fairly abundant in sediments, but concentrations are usually less than a few tenths of a milligram per liter in surface waters (Hem 1989). In lakes and reservoirs in the western United States, total phosphorus concentrations are usually between 0 and 508 $\mu\text{g/L}$ (EPA 2000a). Total phosphorus concentrations in the rivers and streams in the Sierra Nevada typically range between 2.5 and 485 $\mu\text{g/L}$ (EPA 2000). It is usually reported in $\mu\text{g/L}$ or mg/L.

Phosphorus is essential for plant growth and is often the most limiting nutrient for plant growth in surface waters. As a result, inputs of phosphorus into surface waters can cause algal blooms. In lakes unaffected by anthropogenic inputs, total phosphorus values are generally less than 10 $\mu\text{g/L}$. Lakes with total P values greater than 25 $\mu\text{g/L}$ are considered eutrophic (MELP 1998). Anthropogenic sources of phosphorus include effluents from sewage treatment plants and industry, agriculture, and urban developments (EPA 1986; Hem 1989; MELP 1998).

Ortho-phosphate

Ortho-phosphate (PO_4) is a measure of the inorganic oxidized form of soluble phosphorus. It is generally reported in mg/L or $\mu\text{g/L}$. Background concentrations of orthophosphate in surface waters generally average 10 $\mu\text{g/L}$ (Hem 1989).

Along with nitrogen, phosphorus is a necessary nutrient for plant growth. Ortho-phosphate is the most readily available form of phosphorus for uptake during photosynthesis. Animals obtain phosphorus through the consumption of plant materials. Excess ortho-phosphate causes prolific algal growth, causing the same detrimental water conditions as described for nitrogen and total phosphorus (MELP 1998). Since phosphorus is typically the most limiting nutrient for plant growth in fresh water, additions of this element are often the primary causes of eutrophication of water bodies. Phosphate ions readily and strongly adsorb onto soils, suspended solids, and streambed sediments. As a result, soil erosion can be a source of ortho-phosphate. Other sources include agricultural, urban, and industrial wastewater effluents.

Potassium

Potassium (K) is a common element in most rock types, but occurs in generally lower concentrations and is less soluble than calcium and magnesium (Hem 1989). Potassium is reported in mg/L or $\mu\text{g/L}$, with an average concentration of 1.4 mg/L in North American rivers and 0.008 mg/L in granite drainage basins (Wetzel 2001).

Potassium is important in the cellular ion transport and exchange processes of plants and animals, especially for algae growth (Wetzel 2001). Potassium is derived during the weathering of feldspar and mica minerals from rocks and soil. Another potential source of potassium is release through the decay of plant materials (Hem 1989). The alteration of potassium concentration in natural waters is not common, except when effluent from industrial, agricultural, or urban sources exist or runoff from road salts reaches a water body (Wetzel 2001). This type of pollution can cause significant alteration in the ionic composition of water bodies and ultimately change the balance of plant and animal productivity.

Sodium

Sodium (Na) is the most abundant of the alkaline-earth metals and is commonly found in solution (Hem 1989). It generally has lower water concentrations than calcium, except in igneous dominated watersheds (Wetzel 2001). Sodium is typically reported in mg/L, with concentrations that range from less than 1 mg/L to more than 500 mg/L. An average sodium concentration of 9.0 mg/L is found in North American rivers (Schlesinger 1997) and 0.088 mg/L in granite drainage basins (Wetzel 2001).

Sodium is important in the cellular ion transport and exchange processes of plants and animals (Wetzel 2001). Certain species of cyanobacteria require high amounts of sodium for photosynthesis, metabolism, and nitrogen fixation. The enrichment of water with high levels of sodium and phosphorus from domestic effluents can result in large

cyanobacteria populations (Wetzel 2001). Sodium is typically present as an ion (Na^+) and is commonly derived from the weathering of rocks and soil or the dissolution of sodium salts (Hem 1989). Similar to potassium, sodium concentrations in natural water bodies are not easily altered, except by pollutants such as road salts, industrial effluent, and agricultural runoff (Hem 1989; Wetzel 2001).

Sulfate

Sulfate (SO_4^{2-}) is a relatively common anion produced during geochemical weathering of sulfides (reduced form) from igneous and sedimentary rocks and soils (Hem 1989; Wetzel 2001). Sulfate is reported in mg/L or $\mu\text{g/L}$, with an average concentration of 20 mg/L in North American rivers (Schlesinger 1997) and 0.031 mg/L in granite drainage basins (Wetzel 2001).

Sulfur is essential for proper metabolic functioning of all organisms. The primary sources of sulfur compounds to water bodies is atmospheric precipitation, which is largely due to the combustion of fossil fuels, oxidation of metallic sulfides, and smelting of ores (Hem 1989; Wetzel 2001). Sulfate is naturally released from volcanic regions, during rock weathering, and through sulfur-reducing bacterial activity (Hem 1989; Wetzel 2001). The most extensive natural occurrence of sulfate is in evaporate sediments and rocks. Sulfate tends to form complex ions with sodium and calcium (Hem 1989). Strong acids associated with sulfate are major contributors to acidifications of lakes and rivers (Hem 1989; Wetzel 2001).

Total Dissolved Solids

Total dissolved solids (TDS) is a measure of the concentration of inorganic salts (e.g. sodium, chloride, potassium, calcium, magnesium, and sulfate), small amounts of organic material, and dissolved materials in the water column and is reported in mg/L. The value of TDS in fresh water naturally ranges from 0 to 1,000 mg/L (EPA 1986; MELP 1998). Concentrations tend to be comparatively low in streams in granitic and sandstone-dominated watersheds than watersheds with abundant limestone.

The effect of elevated TDS levels on aquatic biota depends on the ionic composition of the dissolved material and the extent of the increase in concentration. Under natural conditions, all aquatic life must be able to survive a range of TDS concentrations (EPA 1986). Sources of total dissolved solids include sewage, stormwater and agricultural runoff, salts from roads, and industrial and water treatment plant wastewater discharges. Total dissolved solids can also be derived from natural sources, including carbonate and salt deposits and mineral springs.

Total Suspended Solids

Total suspended solids (TSS) is a measurement of particulate matter suspended in the water column and is typically reported in mg/L (MELP 1998). Turbidity units (NTUs) correspond approximately to TSS concentrations. Total suspended solids fluctuate with stream flow and may increase significantly during snowmelt and runoff from rain events.

Streams in forested watersheds tend to have low TSS concentrations, usually less than 50 mg/L, although concentrations can be naturally much higher in some streams and rivers (Windell 1992). Waters with TSS concentrations less than 20 mg/L are usually considered to be clear. Concentrations between 40 and 80 mg/L are considered to be cloudy. Waters with concentrations greater than 150 mg/L appear dirty.

High TSS concentrations can increase turbidity, resulting in reduced light penetration, reduced primary productivity, damage to fish gills, and impaired fish feeding ability. Once the suspended solids settle on the stream or lake bottom, invertebrate and other benthic organisms and fish spawning can be adversely affected (EPA 1986).

The freshwater aquatic life criterion for TSS set forth in the EPA's *Quality Criteria for Water* (1976) states that 'settled and suspended solids should not reduce the depth of the composition point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life.' In other words, light penetration should not be decreased more than 10 percent.

Turbidity

Turbidity is a measurement of the amount of light that is scattered or absorbed from a water sample. It is an indicator of suspended particulate matter in a water body. More suspended particles in the water cause greater scattering. Materials that contribute to turbidity include silt, clay, finely divided organic material, soluble organic compounds, and microorganisms (Michaud 1994; MELP 1998). Turbidity values are reported in Nephelometric Turbidity Units (NTU). In general, turbidity values in lakes of 10 NTU or less represent very clear water; 50 NTU is cloudy; and 100 to 500 NTU is very cloudy or muddy. Rivers and streams in the Sierra Nevada are typically very clear, with turbidity measurements ranging between 1.65 and 5.73 NTU (EPA 2000).

High turbidity levels can have adverse effects in aquatic ecosystems. High turbidity reduces light penetration, which impairs photosynthesis of submerged vegetation and algae (MELP 1998; Michaud 1994). A reduction in plant growth will reduce the production of aquatic invertebrates and fish species. In addition, as particulates settle, they can adversely affect larvae by filling in the spaces between the rocks that may be used as habitat. High turbidity also affects the ability of fish to find and capture food and can impair gill function in some fish under chronically high levels (Michaud 1994). High turbidity also increases the total available surface area of suspended solids upon which metals and other pollutants can attach and bacteria can grow.

Turbidity values can be naturally variable. Waters are often more turbid following rain events, which may increase erosion and urban runoff. In lakes, variations in turbidity are often caused by seasonal changes in algal growth through the year. These algal blooms may result from higher temperatures in the summer, longer daylight hours, or increased nutrients from decomposition (Michaud 1994). Turbidity increases can also be caused by effluents from wastewater and septic systems, decaying plants and animals, and bottom-feeding fish.

TOC

Total Organic Carbon (TOC) is a measure of the dissolved and particulate organic carbon in water, which is primarily composed of humic substances and decomposing plant and animal materials. Total organic carbon is reported as mg/L. Values in natural waters are usually between 1 and 30 mg/L (Hem 1989; MELP 1998). In small streams, the proportion of dissolved organic carbon relative to particulate organic carbon increases downstream as particles are broken down and decomposed. In slower moving larger rivers, TOC can also be derived from phytoplankton growth and rooted plants (Schlesinger 1997).

Carbon is required for biological processes. Dissolved oxygen concentrations are inversely related to organic carbon concentrations. The amount of TOC in the water varies with flow with generally higher concentrations at higher flows (Schlesinger 1997). Natural sources include decomposing leaves and roots that may enter directly into a stream or waterbody, particularly from the adjacent riparian zone and floodplain. Dissolved sources include soluble carbohydrates and amino acids that are leached from decomposing leaves and roots and humic acids from soil organic matter (Schlesinger 1997). Sources of TOC include agriculture and municipal and industrial water discharges (MELP 1998).

Total Alkalinity (as CaCO₃)

Alkalinity is a measurement of the ability of water to neutralize acids (buffering capacity). Alkalinity is the concentration of bases in dissolved in water. These bases are usually carbonate and bicarbonate, but can also be hydroxides. These buffers are important because they slow the rate at which the pH changes. The pH can change naturally as a result of photosynthetic activity of the aquatic vegetation. When the pH is very high (greater than 9) hydroxide ions may also be present. In addition, carbonate and bicarbonate reduce the toxicity of some toxic heavy metals (EPA 1986; Hem 1989; Wetzel 2001). Alkalinity is typically expressed as an equivalent amount of calcium carbonate (CaCO₃) in mg/L and generally ranges from 0 to 500 mg/L in fresh waters (MELP 1998). Alkalinity levels up to 400 mg/L are not considered to be detrimental to human health (EPA 1986). Alkalinity values less than 10 mg/L are considered very low and the pH of these waters is very susceptible to acid inputs. Alkalinity values are often very low in granitic drainages (Wetzel 2001). Values between 10 and 20 mg/L are considered moderately susceptible to acid inputs.

In general, very low or high alkalinity itself does not cause detrimental effects to aquatic organisms. However, the concentration of the dissolved materials (alkalinity) and their ratio to one another determines the actual pH and buffering capacity in a given water system (EPA 1986; Wetzel 2001). Waters with very low alkalinity values have little capacity to buffer acid inputs and are thus susceptible to acidification (MELP 1998). As previously discussed, extreme pH values can adversely affect aquatic biota, particularly in low pH (acidic) waters. Acidified drainage basins are known to possess increased sulfate and dissolved aluminum concentrations, as well as significant changes in the ion species and ratios (Wetzel 2001). In some inland waters of extremely high salinity,

hydroxide, borate, silicate, phosphate, and sulfide may be the major sources of alkalinity (Wetzel 2001). Relatively few aquatic organisms are adapted to these unusual conditions.

2.2 METALS DISSOLVED

Arsenic

Arsenic (As) is a widely distributed element in the Earth's crust (ATSDR 2007). It is highly volatile and is an important component in many biochemical processes (Hem 1989). In its elemental form, it appears as a metal-like substance but it is usually found in compounds with other elements and appears as white or colorless powder. Inorganic arsenic results from compounds with elements such as oxygen, chlorine, or sulfur. Organic arsenic results from compounds with hydrogen and carbon. Organic arsenic is generally less harmful than inorganic arsenic (ATSDR 2007). Arsenic is measured in $\mu\text{g/L}$ or mg/L . Natural surface water normally contains an arsenic concentration of about $1 \mu\text{g/L}$.

Arsenic can be highly toxic to most organisms in excess concentrations. Concentrations above $5 \mu\text{g/L}$ have been shown to reduce growth and reproduction in aquatic invertebrates and algae (MELP 1998). Concentrations of $550 \mu\text{g/L}$ have produced mortality in fish (MELP 1998). In addition, organic arsenic can bioaccumulate in fish and shellfish (ATSDR 2007). Concentrations above $25 \mu\text{g/L}$ can have negative effects on livestock and, therefore, are potentially toxic to wildlife (MELP 1998). Arsenic is used as a preservative for wood, and is used in pesticides, metal alloys (especially in automobile batteries), and semiconductors and light diodes. Anthropogenic sources of arsenic include coal-fired power plants, industrial water discharge, and agricultural runoff (Hem 1989). It occurs naturally in soil and can enter water from wind-blown dust, runoff, and leaching. Volcanoes are another natural source of arsenic (ATSDR 2007).

Cadmium

Cadmium (Cd) is an element that occurs naturally in the environment. It is usually found combined with other elements, such as zinc and lead rather than occurring as a pure metal (MELP 1998; ATSDR 1999). It can be measured in either the dissolved (as in this study) or in the total state in water. It dissolves in water at varying degrees depending on which other elements it is combined. Cadmium most easily dissolves in water when it is in a compound with chlorides and sulfates. These compounds are usually present only in small amounts in the environment (ATSDR 1999). It is reported in mg/L or $\mu\text{g/L}$. It usually found in very small concentrations (less than $0.1 \mu\text{g/L}$) (Wetzel 2001).

Cadmium has highly toxic effects on aquatic plants and animals in all chemical forms. It is extremely toxic to fish and zooplankton, and has been found to accumulate in plant cells and some aquatic organisms. It also diminishes plant growth. Its toxicity increases with the presence of other metals, including zinc and copper (MELP 1998; Odum 2007). The majority of cadmium is released into the environment from natural

sources, primarily from the weather of rocks that naturally contain various amounts of cadmium. In addition, it can be released into the environment by forest fires and volcanoes. Anthropogenic sources of cadmium include industrial effluents, fossil fuels burning, and mining (ATSDR 1999).

Copper

Copper (Cu) is a metallic element, which can occur as a free native metal or combined with ionic metals (Hem 1989). It is measured in either the total or dissolved state in water samples, and reported in $\mu\text{g/L}$ or mg/L . Copper is typically found in trace concentrations from 1 to 10 $\mu\text{g/L}$ (MELP 1998) and levels near 10 $\mu\text{g/L}$ are common in river water (Hem 1989). The fresh water aquatic life criterion for copper depends on the hardness of the water body being tested. Copper toxicity decreases with increasing hardness and increases with increasing pH (EPA 1986; Wetzel 2001).

Copper is an essential element in plant and animal metabolism, but quantities above normal trace concentrations are highly toxic to most aquatic life forms (MELP 1998). Many of the deleterious effects of copper, such as inhibition of phosphorus uptake in green algae, are highly variable depending on other environmental conditions such as pH, alkalinity, total organic carbon, and water hardness (EPA 1986; Wetzel 2001). Copper may be released during industrial, agricultural, and mining activities. Other common sources include copper plumbing and equipment (Hem 1989; MELP 1998).

Iron

Iron (Fe) is the second most abundant metallic element in the Earth's outer crust, but concentrations in water tend to be small (Hem 1989). Iron can be measured in either the total or dissolved state and reported as $\mu\text{g/L}$ or mg/L . Average iron concentrations of 40 $\mu\text{g/L}$ are found in the world's lakes and rivers. The typical amount found in neutral and alkaline surface waters ranges from 0.05 to 0.20 mg/L (Wetzel 2001), with an average of 0.16 mg/L in surface waters in North America (Schlesinger 1997). High concentrations of iron are generally only found in acidic waters (pH less than 3 to 4), such as in runoff of streams from strip mines (Wetzel 2001). Concentrations of iron above 0.3 mg/L cause undesirable taste, and when precipitated out of solution due to oxidation, cause a reddish brown color to the water.

Iron is an essential element in plant and animal respiration and its availability in lakes and streams can limit photosynthetic productivity (Wetzel 2001). The chemical behavior of iron is highly dependent on oxidation intensity and is a function of pH and temperatures (Hem 1989; Wetzel 2001). Iron is released in sediment when igneous rock minerals are broken down by water. Iron is also present in organic matter in soils and can be processed into surface water through oxidation and reduction activities that often involve microorganisms (Hem 1989). Industrial effluent, acid mine drainage, and smelters are also sources of iron (MELP 1998).

Lead

Lead (Pb) is a metallic element, which is widely dispersed in sedimentary rocks, but has low natural mobility due to low solubility (Hem 1989). The criterion for lead is expressed in terms of dissolved metal in the water column (MELP 1998). Lead concentration is reported in $\mu\text{g/L}$. The relative abundances of different species of lead are pH dependent and solubility increases with increasing alkalinity (EPA 1986). The freshwater aquatic life criterion for lead depends on the hardness of the water body being tested. The toxic effects of lead decreases as DO and hardness concentrations increase (MELP 1998).

Lead is toxic to all animals (MELP 1998) and is particularly toxic to aquatic organism at relatively low concentrations (Wetzel 2001). Fossil fuel combustion, especially of leaded gasoline, contributed greatly to the deposition of lead in waterways in the twentieth century. Other sources of lead include industrial effluent, smelting and refining, batteries, and lead pipe used to transport drinking water (Wetzel 2001).

Manganese

Manganese (Mn) is one of the more abundant metallic elements, although there is only one-fiftieth the amount of manganese in the Earth's crust as there is iron (Hem 1989). It does not naturally occur as a metal, but is found in association with various salts and minerals, often with iron compounds (EPA 1986). Its chemical reactivity is very similar to that of iron and they behave much the same way in freshwater systems (Wetzel 2001). It is a minor constituent of many igneous and metamorphic minerals (Hem 1989). It can substitute for iron, magnesium, or calcium in silicate structures, but it is not an essential element of silicate rock minerals (Hem 1989). Small amounts of manganese are often present in dolomite or limestone as a substitute for calcium. Concentrations in lake basins range between 10 and 850 $\mu\text{g/L}$, depending on lithology and other characteristics of the drainage basin. The average concentration of manganese in surface waters is about 35 $\mu\text{g/L}$ (Wetzel 2001). It is rarely found in surface waters at concentrations greater than 1 mg/L (EPA 1986).

Manganese is an essential nutrient for microflora, plants, and animals as an enzyme catalyst and as an important component of photosynthesis and nitrogen fixation (EPA 1986; Hem 1989). High concentrations of manganese can have an inhibitory effect on cyanobacteria and green algae and tend to favor diatom growth (Wetzel 2001). Divalent manganese is released into aqueous solution during weathering of rock and through organic processes (Hem 1989).

Nickel

Nickel (Ni) is one of the five ferromagnetic elements. It only occurs as a very small fraction (0.018%) in the Earth's crust (HSDB 2007). It can be combined with various other metals, including iron, copper, chromium, and zinc, and may substitute for iron in igneous rocks. Nickel also may be precipitated with iron oxides and manganese oxides (Hem 1989; ATSDR 2005). In addition, nickel can also be combined with other elements, most commonly sulfur, and oxygen. Many of the compounds containing

nickel easily dissolve in water (ATSDR 2005). Concentrations in natural surface waters are usually low (10 µg/L, Hem (1989)).

Nickel is an essential element in some enzymes found in bacteria and plants. It is an important component in nitrogen fixation and some enzymes (Wetzel 2001). However, when it occurs in large quantities and is combined with some elements, for example nitrate, sulfur, and chloride, nickel can be very toxic to aquatic biota. It may accumulate in some plants (ATSDR 2005). The toxicity of nickel to aquatic biota is dependent on hardness. Toxicity is greater when the water is softer compared to harder water conditions. It can also be released from volcanoes. Nickel is naturally found in all soils, and strongly attaches to particles that contain iron or magnesium. When this occurs, it is not readily available for uptake by plants and animals. Nickel is found in surface waters as a result of weathering of rocks containing nickel. Anthropogenic sources of nickel include industrial effluent, oil-burning and coal-burning power plants, mining, and trash incinerators (ATSDR 2005).

Chromium

Chromium (Cr) is naturally present in the environment and has a number of oxidation states. The most common forms are chromium (0), trivalent (chromium (III)), and hexavalent (chromium (VI)). Hexavalent chromium (chromium VI) compounds are the most toxic state. It is usually measured as total chromium. Naturally, chromium concentrations in surface water are usually less than 10 µg/L (Hem 1989).

Chromium (VI) compounds adversely affect all aquatic biota, including algae. It does not appear to bioaccumulate in plants and animals. It is also a known human carcinogen (EPA 1986). The toxicity of chromium (VI) increases as hardness and pH increase. Chromium (III) is more toxic in soft waters. Chromium naturally occurs in rocks and soil, but in very small amounts. It is also released during volcanic eruptions. Anthropogenic sources of chromium (0), (III) and (VI) include emissions from coal and oil burning and industrial effluents (ATSDR 2000).

2.3 METALS - TOTAL

Mercury

Mercury (Hg) is a trace element in the Earth's crust that normally occurs in quantities of only 1 to 2 ng/L in natural waters (MELP 1998). It may be present in the environment as elemental mercury (Hg^0), inorganic mercury (Hg^{2+}), or organic mercury (primarily methyl mercury, MeHg). Elemental mercury was commonly used in thermometers. Methyl mercury is the most toxic of these mercury compounds (EPA 1986). It is a serious neuron-toxin and has been found in high concentrations in lakes far removed from sources of mercury (EPA 1986). Methyl mercury bioaccumulates, which is the process by which organisms that are exposed to chemicals either from their diet, water, or other sources accumulate and retain the chemicals. Inorganic mercury does not accumulate in aquatic organisms. Various chemical and biological processes can readily convert the various forms of mercury. Anaerobic bacteria in sediments readily

convert inorganic mercury into methyl mercury. With the exception of gold mining areas where elemental mercury is used, mercury is typically present in surface waters, sediment, or soils as inorganic mercury.

Mercury is highly toxic and has a long retention time in animal cells. Rates of methyl mercury production and bioaccumulation depend not only on the abundance of inorganic mercury but also on a complex assortment of environmental variables which affect the activities and species composition of the bacteria and the availability of the inorganic mercury for methylation (USGS 2003; HSDB 2007). These variables include, but are not limited to, pH of the water, the length of the food chain, dissolved organic matter, soil type, and the proportion of wetlands in the watershed. Once converted to methyl mercury by bacteria, it can bioaccumulate in aquatic organisms and be passed up the food chain (Hem 1989). Temperature, pH, alkalinity, suspended sediment load, and the geomorphology of the watershed are known to affect the accumulation of mercury in fish (Klasing et al 2006). In addition to bioaccumulating, methyl mercury also biomagnifies (higher concentrations at higher levels in the food chain) (USGS 2003). Because bacteria mediate the rate of methyl mercury formation, fish living in even mildly contaminated waters are not safe to eat.

Detectible levels of mercury are found in almost all fish, with more than 95% of it occurring as methyl mercury (Klasing et al 2006). People primarily become exposed to methyl mercury by consuming fish (Klasing et al 2006). Fish at the highest trophic levels (higher up the food chain) tend to have higher levels of methyl mercury than those lower in the food chain. Larger and older fish of a given species also tend to have higher methyl mercury levels than smaller and younger fish of the same species. It is particularly toxic to the fetus and young children and can cause serious neurological abnormalities to a fetus even without symptoms in the mother. Recent studies indicate that the fetus is more sensitive to methyl mercury than adults. As a result, the OEHHA has established separate 'reference doses', which is "the daily exposure likely to be without significant risk of deleterious health effects during a lifetime". The reference dose for women of childbearing age and children aged 17 and younger is 1×10^{-4} mg/kg-day. For men and women beyond childbearing age, the reference dose is 3×10^{-4} mg/kg-day (Klasing et al 2006).

Mercury contamination can occur from both natural processes and human activities. Mercury is highly volatile and thus, atmospheric deposition is a major pathway into aquatic systems (Hem 1989; MELP 1998). Impounded water and flooding also cause the release of sedimentary mercury (MELP 1998). Sources of mercury contamination include coal combustion, water incineration, mining and smelting and production of fertilizers (MELP 1998; USGS 2003). Mercury is typically measured as the total mercury in water, soil, or tissue samples. Water samples containing just 5 to 10 ng/L are considered polluted (MELP 1998). OEHHA has reviewed studies that have reported mercury levels in fish in numerous watersheds in the Sierra Nevada and others near the MFP area. In the Lower Feather River, mercury levels ranged between 0.13 to 2.26 ppm (ppm = mg/kg) in Sacramento pikeminnow (total length range: 256 to 500 mm), 0.18 to 2.35 ppm in large mouth bass (total length range: 305 to 495 mm), and 0.32 to 3.50 ppm in striped bass (total length range: 533 to 817 mm) (Klasing et al 2006). In

the lower American River and Lake Natoma, average mercury concentrations in rainbow trout was 0.02 ppm (average total length: 324 mm), 0.57 ppm in Sacramento pikeminnow (average total length: 292 mm), and 0.28 ppm in striped bass (average total length: 559 mm) (Klasing and Brodberg 2004). In addition, composite mercury analyses were conducted on fish tissue samples from various reservoirs as part of the SMUD relicensing studies (FERC Project Number 2101). Mercury levels in brown trout from Loon Lake, Gerle Creek Reservoir, and Slab Creek Reservoir were 0.137 ppm (fork length range: 342 to 374 mm), 0.321 ppm (fork length: 510 mm), and 0.595 ppm (fork length: 485 mm), respectively. Mercury levels in rainbow trout in Ice House Reservoir were 0.036 ppm (fork length range: 214 to 340 mm). In Chili Bar Reservoir, mercury levels in a composite of Sacramento pikeminnows was 0.075 ppm (fork length range: 238 to 325 mm) (SMUD 2005).

2.4 HYDROCARBONS

Methyl-tertiary Butyl Ether (MtBE)

MtBE is a chemical compound manufactured by the reaction of methanol and isobutylene. It is produced in mass quantities and used as an additive to raise the oxygen content of gasoline. It had been added to gasoline in relatively low concentrations beginning in the late 1970's. Since the 1990's it has been added in considerably higher concentration (up to 15%) to reduce the emissions of carbon monoxide and other pollutants. This has contributed to significant reductions in carbon monoxide and ozone levels in many areas in California (USGS 2007). The EPA has not set a national standard for MtBE nor has the CTR set a standard. MtBE is measured in parts per billion, mg/L, or µg/L.

MtBE readily dissolves in water, can rapidly move through the soil and aquifers, and is not affected by microbial decomposition. It is classified as a carcinogen by the EPA (USGS 2007). Lakes subjected to recreational activities are at the greatest potential risk of ecological effects from MtBE (Zogorski et. al. 2001). Recreational watercraft with two-cycle engines pass as much as 25% of their fuel into the water column through their exhaust. Although MtBE seems to be relatively persistent in groundwater, it does volatilize from surface water. Volatilization from surface waters is dependent on a number of factors, including the depth and flow velocity of the water. Rates are slower in fast moving, shallow waters (Squillace et. al. 1998). MtBE binds weakly to soils (Squillace et. al. 1998). MtBE does not appear to bioaccumulate in fish and is rapidly metabolized or excreted. The typical levels of MtBE that are found in surface waters are considerable less than those that would be toxic to various aquatic biota. For example, negative affects were not observed in algae until concentrations reaches 2,400 mg/L. In invertebrates, amphibians, and fish, the lowest concentrations at which negative effects were observed were 44 mg/L, 2,500 mg/L, and 574 mg/L, respectively (Werner and Hinton 1998). In addition to two-stroke engines, MtBE can enter surface waters from fuel spill, leaking storage tanks and pipelines, storm run-off, and precipitation from atmospheric MtBE (Squillace et. al. 1998; Zogorski et. al. 2001).

Total Petroleum Hydrocarbons

Total petroleum hydrocarbons (TPH) is a term used to describe a large family of chemical compounds originating from crude oil. These chemical compounds are made up primarily of hydrogen and carbon and are called hydrocarbons. It is impractical to measure each hydrocarbon individually because there are so many of them. Instead, TPH are used to measure hydrocarbon contamination (ATSDR 1999b). Some of the chemicals in TPH include hexane, benzene, toluene, xylenes, naphthalene, and flourene, as well as jet fuels and mineral oils (ATSDR 1999b).

Total petroleum hydrocarbon compounds can affect the lungs, liver, kidneys, and central nervous systems of animals as well as reproduction and fetus development (ASTDR 1999b). Total petroleum hydrocarbons can be released into water through spills or leaks or directly through storm runoff. Sources include industrial release, automobiles, and manufacturing.

2.5 OIL AND GREASE

The 'oil and grease' category includes thousands of organic compounds with different physical, chemical, and toxicological properties. Volatility, solubility, and persistence of the compound also vary considerably among the different compounds. Petroleum and non-petroleum oils can occur throughout a lake or stream system, including floating on the water's surface, emulsified in the water column, solubilized, or settled on the river or lake bottom (EPA 1986).

Oil can be very toxic to various aquatic organisms, as well as birds. Oil and gasoline spills, in particular, can be lethal to a wide variety of organisms. Petroleum products can be harmful to aquatic organisms at low levels (as low as 1 µg/L). Oil pollutants may also be buried in the sediments, relatively unchanged, which can cause long-term detrimental effects to benthic organisms (EPA 1986).

2.6 BACTERIA

Total Coliform

Coliform bacteria are a group of several genera of relatively harmless microorganisms that live in soil, water, and the intestines of cold- and warm-blooded animals including humans (Murphy 2007). Total coliform concentrations are reported as the number of bacteria colonies present per 100 mL of sample water (#/100 mL, Michaud 1994).

Total coliform bacteria occur naturally in surface and shallow ground waters and are essential in the breakdown of organic matter in water. Oxygen is not a requirement for these bacteria, but they can use it. They produce acid and gas from the fermentation of lactose. Coliform bacteria are not pathogenic and are only mildly infectious. The total coliform group is relatively easy to culture in the lab, and therefore, has been selected as the primary indicatory bacteria for the presence of disease-causing organisms. If large numbers of coliform bacteria are found in water, there is a high probability that pathogenic bacteria or organisms, such as *Giardia* may be present. Coliform bacteria,

rather than actual pathogens, are used to assess water quality because they are easier to isolate and identify (Murphy 2007).

Fecal Coliform

Fecal coliform is a subgroup of the coliform bacteria that live in the intestinal tract and feces of warm-blooded animals (Murphy 2007). The most common member of this group is *Escherichia coli*. Fecal coliform concentrations are reported as the number of bacteria colonies present per 100 mL of sample water (#/100 mL, Michaud 1991). Fecal coliform bacteria can multiply quickly under optimum growing conditions and die off rapidly when conditions change. For this reason, fecal coliform counts are difficult to predict (Michaud 1994).

Fecal coliform species by themselves are not usually harmful, but are an indicator of the possible presence of pathogenic organisms, such as bacteria, viruses, and parasites, that live in the same environment (Windell 1992; Murphy 2007). Thus, it is used as a parameter for testing the quality of waters used for recreation. The presence of fecal coliform indicates contamination from the feces of humans or other animals. Swimming in waters with high levels of fecal coliform bacteria (over 200 colonies/100 mL) presents a health risk of contracting diseases such as typhoid fever, hepatitis, gastroenteritis, ear infection, and dysentery (Windell 1992; Murphy 2007). Some strains of *E. coli*, such as *E. coli* O157:H7, which is found in the digestive tract of cattle, can cause intestinal illness. The major sources of fecal coliform to freshwater are wastewater treatment plant effluent, failing septic systems, and human and animal wastes. Human and animal wastes can be washed into storm drains, streams, and lakes during storms (Michaud 1994; Murphy 2007).

3.0 REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological Profile for Cadmium. Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service. Available: <http://www.atsdr.cdc.gov/toxprofiles/phs5.html>. Last modified October 2007.

Agency for Toxic Substances and Disease Registry (ATSDR). 1999b. Toxicological profile for total petroleum hydrocarbons (TPH). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. <http://www.atsdr.cdc.gov/>.

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. Toxicological Profile for Chromium (Update). Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service. Available: <http://www.atsdr.cdc.gov/>.

Agency for Toxic Substances and Disease Registry (ATSDR). 2005. Toxicological Profile for Nickel (Update). Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service. Available: <http://www.atsdr.cdc.gov/>.

- Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological Profile for Arsenic (Update). Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service. Available: <http://www.atsdr.cdc.gov/>.
- Brigham, M.E., D. K. Krabbenhoft, and P.A. Hamilton. 2003. Mercury in Stream Ecosystems – New Studies Initiated by the U.S. Geological Survey. Available: <http://pubs.water.usgs.gov/fs01603>. Last modified 22-Aug-2005.
- Hazardous Substances Data Bank (HSDB). 2007. Methylmercury. Available at: <http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f./temp/~ZtXdUB:3>. Accessed October 2007.
- Hem, J.D. 1989. Study and Interpretation of the Chemical Characteristics of Natural Water. Third Edition. U. S. Geological Survey Water-Supply Paper 2254.
- Klasing, S., and R. Brodberg. 2004. Fish Consumption Guidelines for Lake Natoma (Including Nearby Lakes and Ponds) and the Lower American River (Sacramento County). Pesticide and Environmental Toxicology Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.
- Klasing, S., M. Gassel, S. Roberts, R. Brodberg. 2006. Health Advisory Safe Eating Guidelines for Fish from the Lower Feather River (Butte, Yuba, and Sutter Counties). Pesticide and Environmental Toxicology Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.
- Michaud, J. 1994. A Citizen's Guide to Understanding and Monitoring Lakes and Streams. January 1994. Washington State, Department of Ecology. 73 pp.
- Ministry of Environment, Lands and Parks, British Columbia (MELP). 1998. Guidelines for Interpreting Water Quality Data. Resources Inventory Committee Publications.
Available: <http://ilmbwww.gov.bc.ca/risc/pubs/aquatic/interp/index.htm>.
- Murphy, S. 2007. General Information on Fecal Coliform. Boulder Area Sustainability Information Network (BASIN).
Available: <http://bcn.boulder.co.us/basin/data/FECAL/info/FColi.html>. Last modified 23 April 2007.
- Oram, B. 2007. Watershed Assessment, Education, Training, Monitoring Resources In Northeastern Pennsylvania. Wilkes University Center for Environmental Quality Environmental Engineering and Earth Sciences. Available: <http://www.water-research.net/Watershed>.

- Sacramento Municipal Utility District (SMUD). 2005. Sacramento Municipal Utility District Upper American River Project (FERC Project Number 2101) and Pacific Gas and Electric Project (FERC Project Number 2155) Water Quality Technical Report. Prepared by Devine Tarbill & Associated, Inc. May 2005 version 3.
- Schlesinger, W.H. 1997. Biogeochemistry An Analysis of Global Change. San Diego, California: Academic Press, Inc. Chapter 8: pp. 261-290.
- Squillace, P. J.; Pankow, J. F.; Korte, N. E.; Zogorski, J. S. 1998. Environmental Behavior and Fate of Methyl tert-Butyl Ether (MTBE). U.S. Geological Survey Fact Sheet 203-96.
- United States Environmental Protection Agency (EPA). 2006. Lake and Reservoir Bioassessment and Biocriteria. Technical Guidance Document. Office of Wetlands, Oceans, and Watersheds (4503F). Office of Science and Technology (4304). Office of Water. U.S. Environmental Protection Agency. Washington, DC. Last updated on Thursday, November 30th, 2006. Available at: <http://www.epa.gov/owow/monitoring/tech/lakes.html>
- United States Environmental Protection Agency (EPA). 2000. Ambient Water Quality Criteria Recommendations Information Supporting the Development of State and Tribal Nutrient Criteria for Rivers and Streams in Nutrient Ecoregion II. EPA-822-B-00-015. Office of Water, Office of Science and Technology, Health and Ecological Criteria Division, Washington DC.
- United States Environmental Protection Agency (EPA). 2000a. Ambient Water Quality Criteria Recommendations Information Supporting the Development of State and Tribal Nutrient Criteria for Lakes and Reservoirs in Nutrient Ecoregion II. EPA-822-B-00-007. Office of Water, Office of Science and Technology, Health and Ecological Criteria Division, Washington DC.
- United States Environmental Protection Agency (EPA). 1996. The Metals Translator: Guidance for calculating a total recoverable permit limit for a dissolved criterion. June 1996. EPA 823-B-96-007.
- United States Environmental Protection Agency (EPA). 1986. Quality Criteria for Water, 1986. EPA 440/5-86-001. Office of Water Regulations and Standards, Environmental Protection Agency, Washington D.C.
- United States Geological Survey (USGS). 2007. Methyl Tertiary-Butyl Ether (MTBE). U.S. Department of the Interior. Available: <http://ca.water.usgs.gov/mtbe/index.html>. Last modified 25-Apr-2007.
- Windell, J.T. 1992. Stream Riparian and Wetland Ecology. TRUIS Corp for the Colorado Division of Wildlife. Pp. 95-114.

- Werner, I. and D.E. Hinton. 1998. Toxicity of MTBE to freshwater organisms. UC Substances Research and Training Program. University of California, Davis. Available: http://www.tsrtp.ucdavis.edu/public/mtbe/mtberpt/vol3_3.pdf.
- Wetzel, R.G. 2001. Limnology Lake and River Ecosystems. Third Edition. New York: Academic Press. Pp 169-186; 205-237; 289-330.
- Zogorski, J.S., M.J. Moran, and P.A. Hamilton. 2001. MTBE and other volatile organic compounds – New findings and implications on the quality of source waters used for drinking-water supplies. U.S. Department of the Interior. U.S. Geological Survey. FS-105-01/ October 2001. Available: <http://www.usgs.gov/nawqa>.

APPENDIX B

Glossary of Analytical Laboratory Terminology, Units of Measurements and Calculations

Glossary

Method Detection Limit (MDL):

Is a measure of the method sensitivity. The MDL is the lowest concentration that can be detected by an instrument with correction for the effects of sample matrix and method-specified parameters such as sample preparation. It is the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero, as defined in 40 CFR 136, Appendix B, revised as of July 1, 2003.

Practical Quantitation Limit (PQL):

The concentration that can be reliably measured within specified limits and accuracy during routine laboratory operating conditions. It is typically determined by a combination of the IDL (instrument detection limit-the lowest the instrument is capable of seeing with specified confidence limits) and the lowest calibration standard used. The calibration level is selected (usually greater than the IDL) based upon the needs of the specified batch of samples being run.

Reference Dose (RfD):

The daily exposure of mercury likely to be without significant risk of deleterious health effects during a lifetime. It is an estimate, with uncertainty spanning perhaps an order of magnitude (Klasing and Brodberg 2006).

Screening Value (SV):

Concentration of mercury in fish or shellfish tissue that are of potential public health concern and that are used as threshold values against which levels of contamination in similar tissue collected from the ambient environment can be compared. Exceedance of these SVs should be taken as an indication that more intensive site-specific monitoring and/or evaluation of human health risk should be conducted (Cal EPA 2005).

Units of Measure

The following table summarizes common mass ratios for solutions and solids.

Unit	Solutions		Solids	
ppm (parts per million) 10^{-6}	mg/L	$\mu\text{g/mL}$	mg/kg	$\mu\text{g/g}$
ppb (parts per billion) 10^{-9}	$\mu\text{g/L}$	ng/mL	$\mu\text{g/kg}$	ng/g
ppt (parts per trillion) 10^{-12}	ng/L	pg/mL	ng/kg	pg/g

The following table summarizes the laboratory units and conversions used in the report.

Water Quality Analytes	Laboratory Given Unit	Water Quality Standard Unit	Conversion to Water Quality Standard Unit
General Parameters			
Calcium	mg/L	mg/L	No conversion
Chloride	mg/L	mg/L	No conversion
Hardness (as CaCO_3)	mg/L	mg/L	No conversion
Magnesium	mg/L	$\mu\text{g/L}$	Multiply by 1,000
Nitrate/Nitrite (NO_3)	mg/L	mg/L	No conversion
Ammonia as N	mg/L	mg/L	No conversion
Total Kjeldahl Nitrogen (TKN)	mg/L	mg/L	No conversion
Total Phosphorus	mg/L	mg/L	No conversion
Ortho-phosphate	mg/L	mg/L	No conversion
Potassium	mg/L	mg/L	No conversion
Sodium	mg/L	mg/L	No conversion
Sulfate (SO_4)	mg/L	mg/L	No conversion
Total Dissolved Solids	mg/L	mg/L	No conversion
Total Suspended Solids	mg/L	mg/L	No conversion
Turbidity	NTU	NTU	No conversion
Organic Carbon, Total (TOC)	mg/L	mg/L	No conversion
Total Alkalinity (as CaCO_3)	mg/L	mg/L	No conversion
Metals-Dissolved			
Arsenic	$\mu\text{g/L}$	$\mu\text{g/L}$	No conversion
Cadmium	$\mu\text{g/L}$	$\mu\text{g/L}$	No conversion
Copper	$\mu\text{g/L}$	mg/L	Divide by 1,000
Iron	$\mu\text{g/L}$	mg/L	Divide by 1,000
Lead	$\mu\text{g/L}$	$\mu\text{g/L}$	No conversion
Manganese	$\mu\text{g/L}$	$\mu\text{g/L}$	No conversion
Nickel	$\mu\text{g/L}$	$\mu\text{g/L}$	No conversion
Chromium-Total	$\mu\text{g/L}$	$\mu\text{g/L}$	No conversion
Metals-Total			
Mercury	ng/g	$\mu\text{g/L}$	Divide by 1,000
Methyl mercury	ng/g fish	mg/Kg fish	Divide by 1,000
Hydrocarbons			
Methyl-tertiary-butyl Ether (MtBE)	$\mu\text{g/L}$	$\mu\text{g/L}$	No conversion
Total Petroleum Hydrocarbons (as gasoline and as diesel)	$\mu\text{g/L}$	$\mu\text{g/L}$	No conversion
Oil and Grease	mg/L	mg/L	No conversion
Bacteria			
Total Coliform (3x5, 6 hr hold)	MPN/100 mL	MPN/100 mL	No conversion
Fecal Coliform (3x5)	MPN/100 mL	MPN/100 mL	No conversion

Calculations

Several criteria must be calculated on a site-by-site basis. The following equations apply to those analytes.

Ammonia:

Criteria are temperature and pH dependent.

Criteria Continuous Concentration (CCC) with fish early life stages present (mg/L)=

$$CCC = \left(\frac{0.0577}{1 + 10^{7.588 - \text{pH}}} + \frac{2.487}{1 + 10^{\text{pH} - 7.588}} \right) \times \text{MIN} \left(2.85, 1.45 \times 10^{0.028 \times (25 - T)} \right)$$

Where T = temperature in degrees C.

Cadmium (Cd):

Criteria are hardness dependent.

California Toxics Rule (CTR) Criteria to Protect Freshwater Aquatic Life:

Criteria Continuous Concentration (CCC) (4-day Average, dissolved, ug/L)=
(exp{0.7852[ln(hardness in mg/L)]-2.715}) x (1.101672- {[ln(hardness in mg/L)] x [0.041838]})

Criteria Maximum Concentration (CMC) (24-hour Average, dissolved, ug/L)=
(exp{1.128[ln(hardness in mg/L)]-3.6867}) x (1.136672- {[ln(hardness in mg/L)] x [0.041838]})

National Toxics Rule (NTR) Criteria to Protect Freshwater Aquatic Life (more stringent):

Criteria Continuous Concentration (CCC) (4-day Average, dissolved, ug/L)=
(exp{0.7409[ln(hardness in mg/L)]-4.719}) x (1.101672- {[ln(hardness in mg/L)] x [0.041838]})

Criteria Maximum Concentration (CMC) (24-hour Average, dissolved, ug/L)=
(exp{1.0166[ln(hardness in mg/L)]-3.924}) x (1.136672- {[ln(hardness in mg/L)] x [0.041838]})

Copper (Cu):

Criteria are hardness dependent.

California Toxics Rule (CTR) Criteria to Protect Freshwater Aquatic Life:

Criteria Continuous Concentration (CCC) (4-day Average, dissolved, mg/L)=
(e{0.8545[ln(hardness in mg/L)]-1.702}) x (0.960)

Criteria Maximum Concentration (CMC) (24-hour Average, dissolved, mg/L)=
(e{0.9422[ln(hardness in mg/L)]-1.700}) x (0.960)

Lead (Pb):

Criteria are hardness dependent.

California Toxics Rule (CTR) Criteria to Protect Freshwater Aquatic Life:

Criteria Continuous Concentration (CCC) (4-day Average, dissolved, ug/L)=
(e{1.273[ln(hardness in mg/L)]-4.705}) x (1.46203- {[ln(hardness in mg/L)] x [0.145712]})

Criteria Maximum Concentration (CMC) (24-hour Average, dissolved, ug/L)=
(e{1.273[ln(hardness in mg/L)]-1.460}) x (1.46203- {[ln(hardness in mg/L)] x [0.145712]})

Nickel (Ni):

Criteria are hardness dependent.

California Toxics Rule (CTR) Criteria to Protect Freshwater Aquatic Life:

Criteria Continuous Concentration (CCC) (4-day Average, dissolved, ug/L)=
($e^{0.8460[\ln(\text{hardness in mg/L})+0.0584]}$) x (0.997)

Criteria Maximum Concentration (CMC) (24-hour Average, dissolved, ug/L)=
($e^{0.8460[\ln(\text{hardness in mg/L})+2.255]}$) x (0.998)

APPENDIX C

Temperature and Dissolved Oxygen Profile Measurements

Spring 2007	5/9/2007		5/9/2007		5/9/2007		5/9/2007		5/9/2007		5/9/2007	
	PK1 Spring	PK2 Spring	PK1 Spring	PK2 Spring	PK1 Spring	PK2 Spring	PK1 Spring	PK2 Spring	PK1 Spring	PK2 Spring	PK1 Spring	PK2 Spring
Depth (m)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)
0	10.15	10.29	14.12	8.61	14.72	8.13	12.72	8.70	10.32	10.32	16.12	7.71
1	17.32	10.49	14.12	8.31	14.64	8.17	12.17	8.82	10.95	7.75	16.04	7.7
2	17.63	10.49	13.93	8.25	14.16	8.25	10.97	8.65	10.98	7.87	15.79	7.76
3	15.46	11.01	13.88	8.29	14.07	8.24	11.99	8.75	14.98	7.86	15.38	7.81
4	13.61	11.25	13.94	8.26	14.02	8.19	11.97	8.75	14.95	7.85	15.17	7.81
5	12.3	11.29	13.81	8.11	13.98	8.21	11.95	8.67	14.95	7.88	14.83	7.85
6	12.03	11.35	13.8	8.12	13.94	8.22	11.94	8.65	14.87	7.88	14.68	7.85
7	11.37	11.8	13.75	8.13	13.1	8.34	11.87	8.65	14.67	7.87	13.95	7.84
8	11.23	11.38	13.68	8.12	11.7	8.73	14.28	8.84	13.95	8.2	13.26	8.15
9	10.8	11.33	13.44	8.21	12.8	8.38	11.18	8.77	11.86	8.49	12.13	8.41
10	10.56	11.64	13.25	8.11	12.81	8.35	10.85	8.83	12.25	8.11	11.27	8.51
11	10.52	10.79	13	8.18	12	8.46	10.78	8.82	9.54	8.73	10.91	8.64
12	10.35	10.59	12.84	8.26	11.82	8.5	10.61	8.83	8.89	8.67	10.76	8.7
13	10.49	10.85	12.72	8.29	11.22	8.55	10.52	8.86	8.88	8.57	10.56	8.68
14	10.49	10.94	12.68	8.32	11.21	8.53	10.23	8.88	8.81	8.49	10.48	8.66
15	10.5	10.81	11.54	8.34	11.11	8.52	10.14	8.93	8.14	8.5	9.1	8.64
16	10.32	10.48	11.15	8.44	10.84	8.63	10.09	8.92	7.95	8.46	8.3	8.61
17	10.48	10.71	10.41	8.53	10.83	8.61	10.09	8.9	7.85	8.47	8.72	8.56
18	10.48	10.62	9.88	8.57	10.75	8.57	10.05	8.92	7.82	8.47	8.55	8.54
19	10.49	10.64	9.68	8.58	10.68	8.54	9.79	8.92	7.72	8.45	8.37	8.47
20	10.49	10.53	9.2	8.53	9.98	8.52	9.39	8.95	7.6	8.39	8.25	8.4
21	10.48	10.38	8.9	8.55	10.38	8.56	9.34	8.94	7.51	8.39	8.11	8.43
22	10.49	10.33	8.83	8.51	9.37	8.54	9.14	8.96	7.4	8.37	8.02	8.41
23	10.48	10.45	8.15	8.58	8.86	8.76	8.97	8.93	7.29	8.38	7.95	8.41
24	10.49	10.58	7.7	8.69	8.73	8.69	8.92	8.97	7.28	8.31	7.88	8.4
25	10.48	10.65	7.25	8.75	8.69	8.7	8.83	8.96	7.28	8.34	7.88	8.4
26	10.48	10.67	7.21	8.77	8.38	8.71	8.71	8.99	7.27	8.32	7.9	8.41
27	10.51	10.76	6.89	8.74	8.29	8.74	8.58	8.94	7.23	8.31	7.8	8.4
28	10.5	10.77	6.78	8.76	8.31	8.73	8.55	8.95	7.21	8.29	7.85	8.4
29	10.51	10.76	6.68	8.7	8.32	8.74	8.37	9.03	7.2	8.21	7.76	8.41
30	10.51	10.76	6.65	8.67	7.99	8.75	7.97	9.03	7.17	8.19	7.71	8.42
31	10.51	10.68	6.61	8.68	7.87	8.76	7.8	9.02	7.15	8.24		
32	10.51	10.62	6.55	8.69	7.58	8.78	7.53	9.04	7.12	8.28		
33	10.51	10.62	6.53	8.69	7.37	8.82	7.55	9	7.11	8.18		
34	10.52	10.65	6.53	8.68	6.93	8.77	7.33	9.02	7.08	8.2		
35	10.52	10.71	6.42	8.74	6.8	8.73	7	9.02	7.05	8.18		
36	10.52	10.64	6.43	8.76	6.77	8.74	6.98	9	7.03	8.22		
37	10.52	10.7	6.36	8.76	6.64	8.79	6.76	9	7.02	8.25		
38	10.56	10.67	6.34	8.75	6.47	8.77	6.65	9.03	7.02	8.26		
39	10.53	10.56	6.33	8.75	6.27	8.73	6.65	9.03	7	8.27		
40	10.53	10.56	6.32	8.76	6.5	8.76	6.43	9	6.98	8.25		
41			6.29	8.79	6.54	8.76	6.38	9.02				
42			6.46	8.76	6.38	8.76	6.37	8.97	6.97	8.24	Total Depth 42 m	
43			6.46	8.74	6.37	8.74	6.37	8.97				
44	6.28	8.8	6.33	8.79	6.34				6.98	8.16		
45			6.3	8.57	6.3				6.97	7.25		
46	6.28	8.71	6.38	8.71	6.35				6.98	7.02		
47			6.35	8.75	6.29	8.84						
48	6.27	8.74	6.32	8.75	6.28	8.97			6.98	7.58		
49			6.27	8.8	6.24	8.97						
50	6.28	8.73	6.28	8.78	6.22	8.98			6.97	7		
51			6.28	8.73	6.21	8.99						
52	6.24	8.74	6.28	8.75	6.2	9			6.98	6.78		
53			6.25	8.75								
54	6.24	8.71	6.28	8.73	6.2	8.97			6.98	6.55		
55												
56	6.23	8.68	6.25	8.74	6.2	8.93			6.99	6.35		
57			6.23	8.69	6.25	8.74	6.2	8.98		6.98	6.22	
58			6.2	8.67	6.24	8.76	6.19	8.86	6.99	6.1		
59			6.2	8.64	6.24	8.73	6.19	8.84				
60			6.19	8.68	6.23	8.74	6.19	8.41				
61			6.19	8.56	6.2	8.76						
62			6.19	8.57	6.2	8.67						
63			6.18	8.68	6.21	8.68						
64												
65												
66												
67												
68												
69												
70												
71												
72												
73												
74												

Depth (m)	HR1	
	Temp (C)	DO (mg/L)
0	14.12	8.49
1	14.12	8.31
2	13.93	8.33
3	13.88	8.29
4	13.84	8.26
5	13.81	8.11
6	13.8	8.13
7	13.75	8.13
8	13.63	8.15
9	13.44	8.21
10	13.25	8.11
11	13	8.18
12	12.84	8.26
13	12.72	8.29
14	12.68	8.32
15	11.54	8.34
16	11.55	8.44
17	10.41	8.53
18	9.98	8.57
19	9.68	8.58
20	9.3	8.53
21	8.9	8.55
22	8.63	8.51
23	8.15	8.58
24	7.7	8.69
25	7.25	8.75
26	7.21	8.77
27	6.89	8.84
28	6.76	8.76
29	6.68	8.7
30	6.65	8.67
31	6.61	8.68
32	6.55	8.69
33	6.53	8.59
34	6.53	8.66
35	6.42	8.74
36	6.43	8.76
37	6.35	8.76
38	6.34	8.75
39	6.33	8.75
40	6.32	8.76
41	6.29	8.79
42	6.28	8.79
43	6.28	8.8
44	6.27	8.71
45	6.27	8.74
46	6.26	8.73
47	6.24	8.74
48	6.23	8.68
49	6.23	8.68
50	6.2	8.67
51	6.2	8.64
52	6.19	8.68
53	6.19	8.58
54	6.19	8.57
55	6.19	8.68

Fall 2007	9/26/2007		10/1/2007		10/1/2007		10/2/2007		10/3/2007		10/2/2007		10/2/2007	
	RA-1 Fall		HH-1 Fall		HH-2 Fall		HH-3 Fall		FM-1 Fall		FM-2 Fall		FM-3 Fall	
Depth (m)*	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)	Temp (C)	DO (mg/L)
0	13.55	10.93	16.13	7.15	15.97	6.44	15.8	6.31	15.07	8.23	15.23	8.25	15.37	8.52
1	13	11.17	16.27	6.77	15.94	6.45	15.81	6.31	15.07	8.23	15.23	8.24	15.37	8.52
2	12.72	11.29	16.16	6.65	15.92	6.45	15.8	6.32	15.07	8.24	15.23	8.24	15.37	8.52
3	12.32	11.38	16.03	6.6	15.91	6.45	15.79	6.31	15.07	8.24	15.22	8.23	15.37	8.51
4	12.35	11.38	15.96	6.58	15.89	6.45	15.78	6.32	15.07	8.25	15.19	8.23	15.37	8.51
5	12.25	11.34	15.92	6.56	15.88	6.44	15.77	6.31	15.07	8.26	15.19	8.22	15.37	8.51
6	12.21	11.32	15.89	6.55	15.88	6.44	15.77	6.32	15.07	8.26	15.19	8.22	15.36	8.5
7	12.21	11.32	15.88	6.53	15.88	6.43	15.77	6.31	15.07	8.25	15.18	8.22	15.35	8.5
8	12.2	11.33	15.87	6.52	15.87	6.43	15.77	6.32	15.07	8.25	15.17	8.22	15.31	8.5
9	12.19	11.16	15.86	6.51	15.87	6.43	15.77	6.31	15.07	8.26	15.17	8.21	15.3	8.49
10	12.19	11.16	15.85	6.5	15.87	6.43	15.77	6.31	15.07	8.25	15.17	8.21	15.28	8.48
11			15.84	6.49	15.87	6.43	15.77	6.31	15.07	8.25	15.16	8.2	15.26	8.47
12			15.84	6.48	15.87	6.42	15.77	6.31	15.07	8.24	15.16	8.2	15.25	8.46
13			15.84	6.48	15.87	6.41	15.77	6.32	15.07	8.24	15.16	8.2	15.25	8.45
14			15.83	6.46	15.87	6.41	15.77	6.31	15.07	8.24	15.15	8.2	15.24	8.44
15			15.83	6.47	15.87	6.42	15.77	6.31	15.07	8.24	15.15	8.2	15.24	8.44
16			15.83	6.46	15.87	6.41	15.77	6.31	15.07	8.23	15.15	8.19	15.23	8.43
17			15.83	6.46	15.87	6.4	15.76	6.31	15.07	8.23	15.14	8.19	15.22	8.42
18			15.83	6.46	15.86	6.4	15.76	6.3	15.07	8.23	15.14	8.18	15.2	8.41
19			15.83	6.45	15.87	6.4	15.76	6.3	15.07	8.22	15.13	8.18	15.19	8.4
20			15.82	6.45	15.86	6.41	15.76	6.3	15.07	8.22	15.05	8.19	15.17	8.39
21			15.82	6.42	15.86	6.4	15.76	6.27	14.82	8.23	12.34	8.69	15.13	8.35
22			15.82	6.42	15.86	6.41	15.76	6.27	11.7	8.64	11.1	8.21	14.68	8.32
23			15.82	6.42	15.86	6.41	15.76	6.27	9.93	7.25	10	7.63	13.13	7.41
24			15.82	6.42	15.86	6.4	15.74	6.27	9.71	7.28	9.5	7.52		
25			15.81	6.42	15.86	6.4	15.69	6.24	9.08	7.26	9.27	7.41		
26			15.81	6.42	15.86	6.4	15.68	6.22	8.75	7.08	8.99	7.22		
27			15.81	6.42	15.84	6.38	15.66	6.18	8.58	6.92	8.93	7.19		
28			15.81	6.42	15.81	6.36	15.63	6.14	8.47	6.83	8.74	7.1		
29			15.81	6.42	15.81	6.35	15.62	6.12	8.39	6.7	8.64	7.06		
30			15.8	6.42	15.76	6.32	15.58	6.1	8.33	6.59	8.46	6.81		
31			15.8	6.41	15.73	6.28	15.56	6.07	8.31	6.53	8.39	6.66		
32			15.8	6.41	15.72	6.29	15.53	6.06	8.29	6.46	8.39	6.62		
33			15.77	6.4	15.7	6.29	15.5	6.05	8.27	6.39	8.33	6.55		
34			15.73	6.39	15.58	6.28	15.45	6.01	8.23	6.31	8.27	6.42		
35			15.7	6.36	15.55	6.27	15.34	5.91	8.21	6.27	8.26	6.37		
36			15.69	6.37	15.48	6.27	15.31	5.84	8.19	6.14				
37			15.5	6.32	15.44	6.26	15.29	5.75	8.18	6.06				
38			15.4	6.3	15.4	6.22	15.28	5.74	8.16	5.95				
39			15.36	6.29	15.39	6.21	15.17	5.4	8.15	5.86				
40			15.32	6.28	15.34	6.2			8.13	5.74				
41			15.3	6.28	15.27	6.21			8.12	5.66				
42			15.16	6.26	15.22	6.22			8.12	5.58				
43			15.11	6.24	15.13	6.23			8.12	5.53				
44			15.01	6.23	14.82	6.23			8.1	5.47				
45			14.96	6.22	14.77	6.21			8.09	5.43				
46			14.92	6.21	14.76	6.19			8.07	5.32				
47			14.88	6.2	14.75	6.17			8.05	5.15				
48			14.8	6.2	14.74	6.14			8.04	4.25				
49			14.71	6.17	14.7	6.12								
50			14.63	6.15	14.55	6.13								
51			14.53	6.15	14.52	6.14								
52			14.27	6.07	14.32	6.09								
53			13.97	5.98	14.07	6.08								
54			13.57	5.86	14.01	6.08								
55					13.61	6.06								
56					13.41	6.05								
57					12.19	5.71								
58					11.83	5.64								
59					11.33	5.62								
60					11.24	5.64								

*Depth is approximate: for all depths >=1, the vlookup formula was used, so the DO and temp values correspond to the highest measured depth <=depth

Table C-1. Summary Table of *In-situ* Ralston Afterbay Profile Measurements.

Date: 5/29/2007
 Site ID: RA-1

Depth below Water			
Surface (m)	Depth (ft)*	Temperature (deg)	Dissolved Oxygen (mg/L)
0	1,177	19.15	10.3
1	1,174	17.92	10.5
2	1,170	17.63	10.5
3	1,167	15.46	11.0
4	1,164	13.61	11.3
5	1,161	12.30	11.3
6	1,157	12.03	11.4
7	1,154	11.37	11.6
8	1,151	11.23	11.4
9	1,147	10.80	11.3
10	1,144	10.56	11.6
11	1,141	10.52	10.8
12	1,138	10.55	10.6
13	1,134	10.49	10.9
14	1,131	10.49	10.7

Date: 9/26/2007
 Site ID: RA-1

Depth below Water			
Surface (m)	Depth (ft)*	Temperature (deg)	Dissolved Oxygen (mg/L)
0	1,175	13.55	10.9
1	1,172	13.00	11.2
2	1,168	12.72	11.3
3	1,165	12.32	11.4
4	1,162	12.35	11.4
5	1,159	12.25	11.3
6	1,155	12.21	11.3
7	1,152	12.21	11.3
8	1,149	12.20	11.3
9	1,145	12.19	11.2
10	1,142	12.19	11.2

*Maximum operating water surface elevation: 1,178 feet

Table C-2. Summary Table of *In-situ* Hell Hole Reservoir Profile Measurements.

Date: 5/30/2007
 Site ID: HH-1

Date: 10/1/2007
 Site ID: HH-1

Depth below Water Surface		Temperature	Dissolved Oxygen
(m)	Depth (ft)*	(deg)	(mg/L)
0	4,583	14.52	8.5
1	4,580	14.12	8.3
2	4,576	13.93	8.3
3	4,573	13.88	8.3
4	4,570	13.84	8.3
5	4,567	13.81	8.1
6	4,563	13.80	8.1
7	4,560	13.75	8.1
8	4,557	13.63	8.2
9	4,553	13.44	8.2
10	4,550	13.25	8.1
11	4,547	13.00	8.2
12	4,544	12.84	8.3
13	4,540	12.72	8.3
14	4,537	12.38	8.3
15	4,534	11.54	8.3
16	4,531	11.15	8.4
17	4,527	10.41	8.5
18	4,524	9.88	8.6
19	4,521	9.68	8.6
20	4,517	9.20	8.5
21	4,514	8.90	8.6
22	4,511	8.63	8.5
23	4,508	8.15	8.6
24	4,504	7.70	8.7
25	4,501	7.25	8.8
26	4,498	7.21	8.8
27	4,494	6.89	8.8
28	4,491	6.76	8.8
29	4,488	6.68	8.7
30	4,485	6.65	8.7
31	4,481	6.61	8.7
32	4,478	6.55	8.7
33	4,475	6.53	8.6
34	4,471	6.53	8.7
35	4,468	6.42	8.7
36	4,465	6.43	8.8
37	4,462	6.35	8.8
38	4,458	6.34	8.8
39	4,455	6.33	8.8
40	4,452	6.32	8.8
42	4,445	6.29	8.8
44	4,439	6.28	8.8
46	4,432	6.28	8.7
48	4,426	6.27	8.7
50	4,419	6.26	8.7
52	4,412	6.24	8.7
54	4,406	6.24	8.7
56	4,399	6.23	8.7
58	4,393	6.23	8.7
60	4,386	6.20	8.7
62	4,380	6.20	8.6
64	4,373	6.19	8.7
66	4,366	6.19	8.6
68	4,360	6.19	8.6
70	4,353	6.18	8.7

Depth below Water Surface		Temperature	Dissolved Oxygen
(m)	Depth (ft)*	(deg)	(mg/L)
1	4,514	16.13	7.2
2	4,511	16.27	6.8
3	4,507	16.16	6.7
4	4,504	16.03	6.6
5	4,501	15.96	6.6
6	4,498	15.92	6.6
7	4,494	15.89	6.6
8	4,491	15.88	6.5
9	4,488	15.87	6.5
10	4,484	15.86	6.5
11	4,481	15.85	6.5
12	4,478	15.84	6.5
13	4,475	15.84	6.5
14	4,471	15.84	6.5
15	4,468	15.83	6.5
16	4,465	15.83	6.5
17	4,462	15.83	6.5
18	4,458	15.83	6.5
19	4,455	15.83	6.5
20	4,452	15.83	6.5
21	4,448	15.82	6.5
22	4,445	15.82	6.4
23	4,442	15.82	6.4
24	4,439	15.82	6.4
25	4,435	15.82	6.4
26	4,432	15.81	6.4
27	4,429	15.81	6.4
28	4,425	15.81	6.4
29	4,422	15.81	6.4
30	4,419	15.81	6.4
31	4,416	15.80	6.4
32	4,412	15.80	6.4
33	4,409	15.80	6.4
34	4,406	15.77	6.4
35	4,402	15.73	6.4
36	4,399	15.70	6.4
37	4,396	15.69	6.4
38	4,393	15.50	6.3
39	4,389	15.40	6.3
40	4,386	15.36	6.3
41	4,383	15.32	6.3
42	4,379	15.30	6.3
43	4,376	15.16	6.3
44	4,373	15.11	6.2
45	4,370	15.01	6.2
46	4,366	14.96	6.2
47	4,363	14.92	6.2
48	4,360	14.88	6.2
49	4,357	14.80	6.2
50	4,353	14.71	6.2
51	4,350	14.63	6.2
52	4,347	14.53	6.2
53	4,343	14.27	6.1
54	4,340	13.97	6.0
55	4,337	13.57	5.9

*Maximum operating water surface elevation: 4,630 feet

Table C-2. Summary Table of *In-situ* Hell Hole Reservoir Profile Measurements (continued).

Date: 5/30/2007
 Site ID: HH-2

Date: 10/1/2007
 Site ID: HH-2

Depth below Water Surface (m)	Depth (ft)*	Temperature (deg)	Dissolved Oxygen (mg/L)
0	4,583	14.72	8.1
1	4,580	14.64	8.2
2	4,576	14.16	8.3
3	4,573	14.07	8.2
4	4,570	14.02	8.2
5	4,567	13.98	8.2
6	4,563	13.95	8.2
7	4,560	13.10	8.3
8	4,557	13.09	8.4
9	4,553	12.80	8.4
10	4,550	12.61	8.5
11	4,547	12.00	8.5
12	4,544	11.62	8.5
13	4,540	11.22	8.6
14	4,537	11.21	8.5
15	4,534	11.11	8.5
16	4,531	10.84	8.6
17	4,527	10.63	8.6
18	4,524	10.75	8.6
19	4,521	10.68	8.5
20	4,517	9.98	8.6
21	4,514	10.38	8.6
22	4,511	9.37	8.6
23	4,508	8.86	8.8
24	4,504	8.73	8.7
25	4,501	8.59	8.7
26	4,498	8.36	8.7
27	4,494	8.29	8.7
28	4,491	8.31	8.7
29	4,488	8.32	8.7
30	4,485	7.99	8.8
31	4,481	7.87	8.8
32	4,478	7.58	8.8
33	4,475	7.27	8.8
34	4,471	6.93	8.8
35	4,468	6.80	8.7
36	4,465	6.77	8.7
37	4,462	6.54	8.8
38	4,458	6.47	8.8
39	4,455	6.52	8.7
40	4,452	6.50	8.8
41	4,448	6.54	8.8
42	4,445	6.46	8.8
43	4,442	6.46	8.7
44	4,439	6.33	8.8
45	4,435	6.30	8.6
46	4,432	6.36	8.7
47	4,429	6.35	8.8
48	4,426	6.32	8.8
49	4,422	6.27	8.8
50	4,419	6.26	8.8
51	4,416	6.26	8.7
52	4,412	6.26	8.8
53	4,409	6.25	8.8
54	4,406	6.26	8.7
56	4,399	6.25	8.7
58	4,393	6.25	8.7
60	4,386	6.24	8.8
62	4,380	6.24	8.7
64	4,373	6.23	8.7
66	4,366	6.20	8.8
68	4,360	6.20	8.7
70	4,353	6.21	8.7

Depth below Water Surface (m)	Depth (ft)*	Temperature (deg)	Dissolved Oxygen (mg/L)
0	4,514	15.97	6.4
1	4,511	15.94	6.5
2	4,507	15.92	6.5
3	4,504	15.91	6.5
4	4,501	15.89	6.5
5	4,498	15.88	6.4
6	4,494	15.88	6.4
7	4,491	15.88	6.4
8	4,488	15.87	6.4
9	4,484	15.87	6.4
10	4,481	15.87	6.4
11	4,478	15.87	6.4
12	4,475	15.87	6.4
13	4,471	15.87	6.4
14	4,468	15.87	6.4
15	4,465	15.87	6.4
16	4,462	15.87	6.4
17	4,458	15.87	6.4
18	4,455	15.86	6.4
19	4,452	15.87	6.4
20	4,448	15.86	6.4
21	4,445	15.86	6.4
22	4,442	15.86	6.4
23	4,439	15.86	6.4
24	4,435	15.86	6.4
25	4,432	15.86	6.4
26	4,429	15.86	6.4
27	4,425	15.84	6.4
28	4,422	15.81	6.4
29	4,419	15.81	6.4
30	4,416	15.76	6.3
31	4,412	15.73	6.3
32	4,409	15.72	6.3
33	4,406	15.70	6.3
34	4,402	15.58	6.3
35	4,399	15.55	6.3
36	4,396	15.48	6.3
37	4,393	15.44	6.3
38	4,389	15.40	6.2
39	4,386	15.39	6.2
40	4,383	15.34	6.2
41	4,379	15.27	6.2
42	4,376	15.22	6.2
43	4,373	15.13	6.2
44	4,370	14.82	6.2
45	4,366	14.77	6.2
46	4,363	14.76	6.2
47	4,360	14.75	6.2
48	4,357	14.74	6.1
49	4,353	14.70	6.1
50	4,350	14.55	6.1
51	4,347	14.52	6.1
52	4,343	14.32	6.1
53	4,340	14.07	6.1
54	4,337	14.01	6.1
55	4,334	13.61	6.1
56	4,330	13.41	6.1
57	4,327	12.19	5.7
58	4,324	11.83	5.6
59	4,320	11.33	5.6
60	4,317	11.24	5.6

*Maximum operating water surface elevation: 4,630 feet

Table C-2. Summary Table of *In-situ* Hell Hole Reservoir Profile Measurements (continued).

Date: 10/1/2007
 Site ID: HH-3

Date: 10/2/2007
 Site ID: HH-3

Depth below Water Surface		Temperature	Dissolved Oxygen
(m)	Depth (ft)*	(deg)	(mg/L)
0	4,583	12.72	8.8
1	4,580	12.17	8.8
2	4,576	12.03	8.7
3	4,573	11.99	8.8
4	4,570	11.97	8.8
5	4,567	11.95	8.7
6	4,563	11.94	8.7
7	4,560	11.87	8.7
8	4,557	11.70	8.7
9	4,553	11.18	8.8
10	4,550	10.85	8.8
11	4,547	10.76	8.8
12	4,544	10.61	8.8
13	4,540	10.52	8.8
14	4,537	10.23	8.9
15	4,534	10.14	8.9
16	4,531	10.09	8.9
17	4,527	10.09	8.9
18	4,524	10.05	8.9
19	4,521	9.79	8.9
20	4,517	9.39	9.0
21	4,514	9.34	8.9
22	4,511	9.14	9.0
23	4,508	8.97	8.9
24	4,504	8.92	9.0
25	4,501	8.83	9.0
26	4,498	8.71	9.0
27	4,494	8.53	8.9
28	4,491	8.55	9.0
29	4,488	8.37	9.0
30	4,485	7.97	9.0
31	4,481	7.80	9.0
32	4,478	7.53	9.0
33	4,475	7.55	9.0
34	4,471	7.33	9.0
35	4,468	7.00	9.0
36	4,465	6.98	9.0
37	4,462	6.76	9.0
38	4,458	6.65	9.0
39	4,455	6.55	9.0
40	4,452	6.43	9.0
41	4,448	6.38	9.0
42	4,445	6.38	9.0
43	4,442	6.37	9.0
44	4,439	6.84	9.0
45	4,435	6.30	9.0
46	4,432	6.39	9.0
47	4,429	6.29	8.9
48	4,426	6.28	9.0
49	4,422	6.24	9.0
50	4,419	6.22	9.0
51	4,416	6.21	9.0
52	4,412	6.20	9.0
54	4,406	6.20	9.0
56	4,399	6.20	8.9
58	4,393	6.20	9.0
60	4,386	6.19	8.9
62	4,380	6.19	8.4
63	4,376	6.19	8.4

Depth below Water Surface		Temperature	Dissolved Oxygen
(m)	Depth (ft)*	(deg)	(mg/L)
0	4,514	15.80	6.3
1	4,511	15.81	6.3
2	4,507	15.80	6.3
3	4,504	15.79	6.3
4	4,501	15.78	6.3
5	4,498	15.77	6.3
6	4,494	15.77	6.3
7	4,491	15.77	6.3
8	4,488	15.77	6.3
9	4,484	15.77	6.3
10	4,481	15.77	6.3
11	4,478	15.77	6.3
12	4,475	15.77	6.3
13	4,471	15.77	6.3
14	4,468	15.77	6.3
15	4,465	15.77	6.3
16	4,462	15.77	6.3
17	4,458	15.76	6.3
18	4,455	15.76	6.3
19	4,452	15.76	6.3
20	4,448	15.76	6.3
21	4,445	15.76	6.3
22	4,442	15.76	6.3
23	4,439	15.76	6.3
24	4,435	15.74	6.3
25	4,432	15.69	6.2
26	4,429	15.68	6.2
27	4,425	15.66	6.2
28	4,422	15.63	6.1
29	4,419	15.62	6.1
30	4,416	15.58	6.1
31	4,412	15.56	6.1
32	4,409	15.53	6.1
33	4,406	15.50	6.1
34	4,402	15.45	6.0
35	4,399	15.34	5.9
36	4,396	15.31	5.8
37	4,393	15.29	5.8
38	4,389	15.28	5.7
39	4,386	15.17	5.4

*Maximum operating water surface elevation: 4,630 feet

Table C-3. Summary Table of *In-situ* French Meadows Reservoir Profile Measurements.

Date: 5/30/2007
 Site ID: FM-1

Date: 10/3/2007
 Site ID: FM-1

Depth below Water Surface (m)	Depth (ft)*	Temperature (deg)	Dissolved Oxygen (mg/L)
0	5,243	16.32	7.9
1	5,240	15.95	7.8
2	5,236	15.08	7.9
3	5,233	14.98	7.9
4	5,230	14.95	7.9
5	5,227	14.95	7.9
6	5,223	14.87	7.9
7	5,220	14.67	7.9
8	5,217	14.28	7.8
9	5,213	11.66	8.5
10	5,210	9.91	8.8
11	5,207	9.54	8.7
12	5,204	8.89	8.7
13	5,200	8.68	8.6
14	5,197	8.51	8.5
15	5,194	8.14	8.5
16	5,191	7.95	8.5
17	5,187	7.85	8.5
18	5,184	7.82	8.5
19	5,181	7.72	8.5
20	5,177	7.60	8.4
21	5,174	7.51	8.4
22	5,171	7.40	8.4
23	5,168	7.29	8.4
24	5,164	7.28	8.3
25	5,161	7.28	8.3
26	5,158	7.27	8.3
27	5,154	7.23	8.3
28	5,151	7.21	8.3
29	5,148	7.20	8.2
30	5,145	7.17	8.2
31	5,141	7.13	8.2
32	5,138	7.12	8.3
33	5,135	7.11	8.2
34	5,131	7.08	8.2
35	5,128	7.05	8.2
36	5,125	7.03	8.2
37	5,122	7.02	8.3
38	5,118	7.02	8.3
39	5,115	7.00	8.3
40	5,112	6.98	8.3
42	5,105	6.97	8.2
44	5,099	6.96	8.2
45	5,095	6.97	7.3
46	5,092	6.98	7.0
48	5,086	6.98	7.6
50	5,079	6.97	7.0
52	5,072	6.98	6.8
54	5,066	6.98	6.6
56	5,059	6.99	6.4
58	5,053	6.98	6.2
60	5,046	6.99	6.1

Depth below Water Surface (m)	Depth (ft)*	Temperature (deg)	Dissolved Oxygen (mg/L)
0	5,206	15.07	8.2
1	5,203	15.07	8.2
2	5,199	15.07	8.2
3	5,196	15.07	8.2
4	5,193	15.07	8.3
5	5,190	15.07	8.3
6	5,186	15.07	8.3
7	5,183	15.07	8.3
8	5,180	15.07	8.3
9	5,176	15.07	8.3
10	5,173	15.07	8.3
11	5,170	15.07	8.3
12	5,167	15.07	8.2
13	5,163	15.07	8.2
14	5,160	15.07	8.2
15	5,157	15.07	8.2
16	5,154	15.07	8.2
17	5,150	15.07	8.2
18	5,147	15.07	8.2
19	5,144	15.07	8.2
20	5,140	15.07	8.2
21	5,137	14.82	8.2
22	5,134	11.70	8.6
23	5,131	9.93	7.3
24	5,127	9.71	7.3
25	5,124	9.08	7.3
26	5,121	8.75	7.1
27	5,117	8.58	6.9
28	5,114	8.47	6.8
29	5,111	8.39	6.7
30	5,108	8.33	6.6
31	5,104	8.31	6.5
32	5,101	8.29	6.5
33	5,098	8.27	6.4
34	5,094	8.23	6.3
35	5,091	8.21	6.3
36	5,088	8.19	6.1
37	5,085	8.18	6.1
38	5,081	8.16	6.0
39	5,078	8.15	5.9
40	5,075	8.13	5.7
41	5,071	8.12	5.7
42	5,068	8.12	5.6
43	5,065	8.12	5.5
44	5,062	8.10	5.5
45	5,058	8.09	5.4
46	5,055	8.07	5.3
47	5,052	8.05	5.2
48	5,049	8.04	4.3

*Maximum operating water surface elevation: 5,262 feet

Table C-3. Summary Table of *In-situ* French Meadows Reservoir Profile Measurements (continued).

Date: 5/31/2007
 Site ID: FM-2

Date: 10/2/2007
 Site ID: FM-2

Depth below Water Surface (m)	Depth (ft)*	Temperature (deg)	Dissolved Oxygen (mg/L)
0	5,243	16.12	7.7
1	5,240	16.04	7.7
2	5,236	15.73	7.8
3	5,233	15.38	7.8
4	5,230	15.17	7.8
5	5,227	14.83	7.9
6	5,223	14.56	7.8
7	5,220	13.95	7.9
8	5,217	12.95	8.2
9	5,213	12.13	8.4
10	5,210	11.37	8.5
11	5,207	10.91	8.6
12	5,204	10.75	8.7
13	5,200	10.56	8.7
14	5,197	9.28	8.7
15	5,194	9.10	8.6
16	5,191	8.90	8.6
17	5,187	8.72	8.6
18	5,184	8.55	8.5
19	5,181	8.37	8.5
20	5,177	8.25	8.4
21	5,174	8.11	8.4
22	5,171	8.02	8.4
23	5,168	7.95	8.4
24	5,164	7.88	8.4
25	5,161	7.88	8.4
26	5,158	7.90	8.4
27	5,154	7.90	8.4
28	5,151	7.85	8.4
29	5,148	7.75	8.4
30	5,145	7.71	8.4

Depth below Water Surface (m)	Depth (ft)*	Temperature (deg)	Dissolved Oxygen (mg/L)
0	5,206	15.23	8.3
1	5,203	15.23	8.2
2	5,199	15.23	8.2
3	5,196	15.22	8.2
4	5,193	15.19	8.2
5	5,190	15.19	8.2
6	5,186	15.19	8.2
7	5,183	15.18	8.2
8	5,180	15.17	8.2
9	5,176	15.17	8.2
10	5,173	15.17	8.2
11	5,170	15.16	8.2
12	5,167	15.16	8.2
13	5,163	15.16	8.2
14	5,160	15.15	8.2
15	5,157	15.15	8.2
16	5,154	15.15	8.2
17	5,150	15.14	8.2
18	5,147	15.14	8.2
19	5,144	15.13	8.2
20	5,140	15.05	8.2
21	5,137	12.34	8.7
22	5,134	11.10	8.2
23	5,131	10.00	7.6
24	5,127	9.50	7.5
25	5,124	9.27	7.4
26	5,121	8.99	7.2
27	5,117	8.93	7.2
28	5,114	8.74	7.1
29	5,111	8.64	7.1
30	5,108	8.46	6.8
31	5,104	8.39	6.7
32	5,101	8.39	6.6
33	5,098	8.33	6.6
34	5,094	8.27	6.4
35	5,091	8.26	6.4

*Maximum operating water surface elevation: 5,262 feet

Table C-3. Summary Table of *In-situ* French Meadows Reservoir Profile Measurements (continued).

Date: 5/31/2007
 Site ID: FM-3

Date: 10/2/2007
 Site ID: FM-3

Depth below Water Surface (m)	Depth (ft)*	Temperature (deg)	Dissolved Oxygen (mg/L)
0	5,243	16.45	7.9
1	5,240	16.42	7.7
2	5,236	16.32	7.8
3	5,233	15.90	7.8
4	5,230	15.91	7.8
5	5,227	15.93	7.5
6	5,223	14.36	8.1
7	5,220	13.83	8.1
8	5,217	13.35	8.2
9	5,213	13.05	8.3
10	5,210	12.37	8.4
11	5,207	11.15	8.6
12	5,204	10.66	8.7
13	5,200	10.30	8.7
14	5,197	10.02	8.8
15	5,194	9.89	8.8
16	5,191	9.75	8.7
17	5,187	9.68	8.7
18	5,184	9.48	8.5
19	5,181	9.31	8.5
20	5,177	9.15	8.5
22	5,171	8.86	8.5
24	5,164	8.76	8.4
26	5,158	8.19	8.4

Depth below Water Surface (m)	Depth (ft)*	Temperature (deg)	Dissolved Oxygen (mg/L)
0	5,206	15.37	8.5
1	5,203	15.37	8.5
2	5,199	15.37	8.5
3	5,196	15.37	8.5
4	5,193	15.37	8.5
5	5,190	15.37	8.5
6	5,186	15.36	8.5
7	5,183	15.35	8.5
8	5,180	15.31	8.5
9	5,176	15.30	8.5
10	5,173	15.28	8.5
11	5,170	15.26	8.5
12	5,167	15.25	8.5
13	5,163	15.25	8.5
14	5,160	15.24	8.4
15	5,157	15.24	8.4
16	5,154	15.23	8.4
17	5,150	15.22	8.4
18	5,147	15.20	8.4
19	5,144	15.19	8.4
20	5,140	15.17	8.4
21	5,137	15.13	8.4
22	5,134	14.68	8.3
23	5,131	13.13	7.4

*Maximum operating water surface elevation: 5,262 feet

Figure C-1. Ralston Afterbay (RA-1) Temperature Profiles for the Spring and Fall Sampling Events.

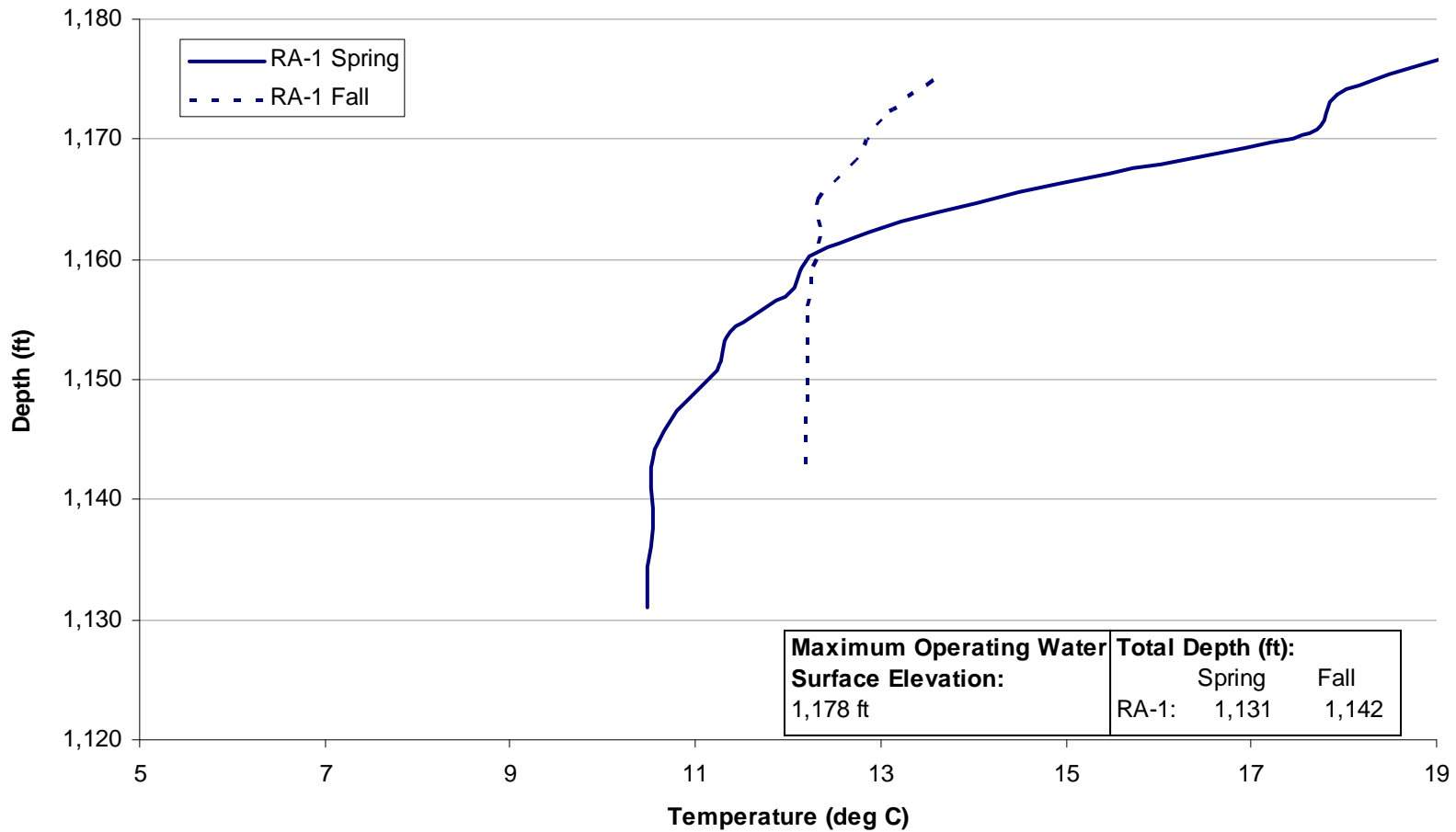


Figure C-2. Ralston Afterbay (RA-1) Dissolved Oxygen Profiles for the Spring and Fall Sampling Events.

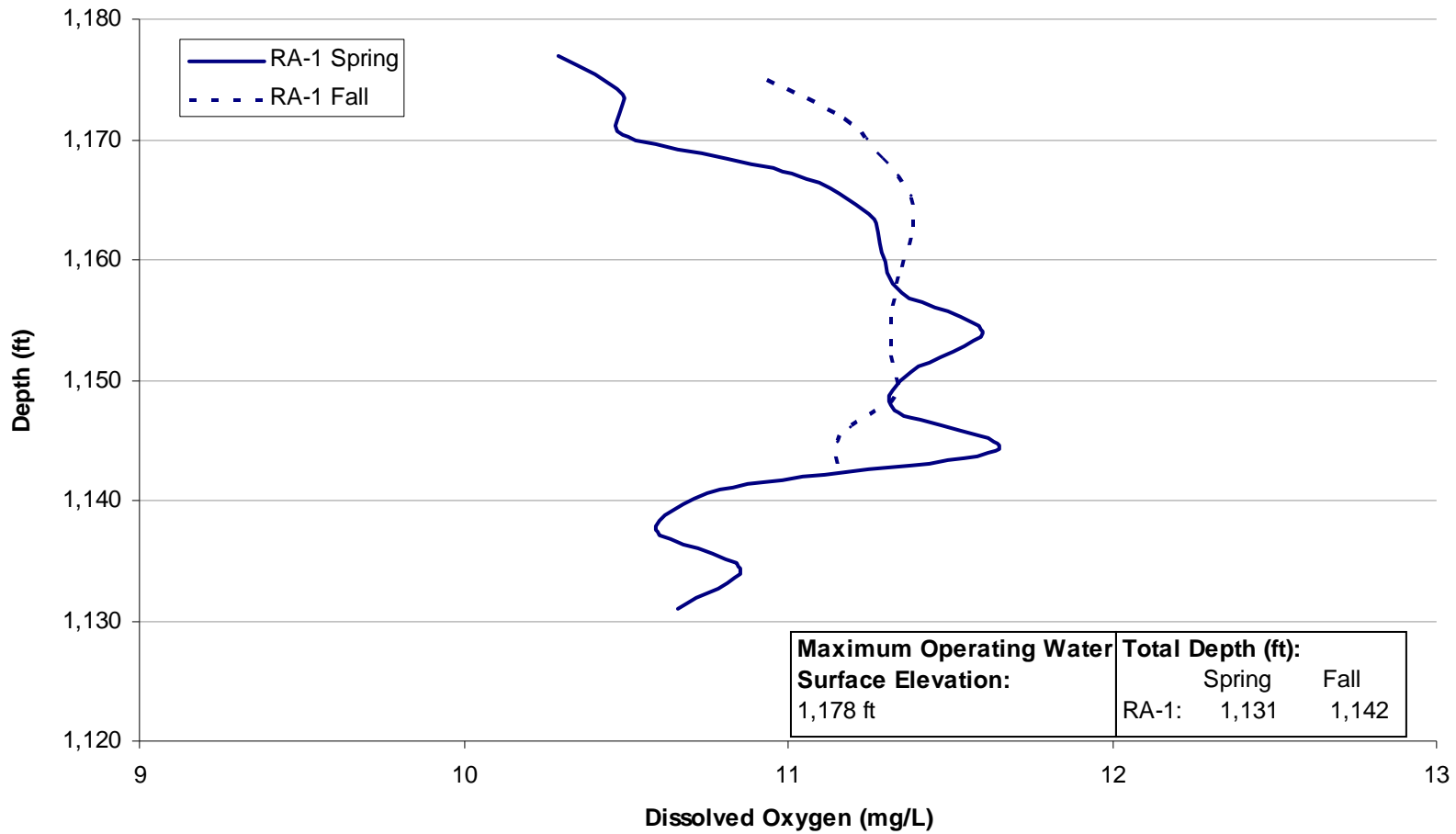
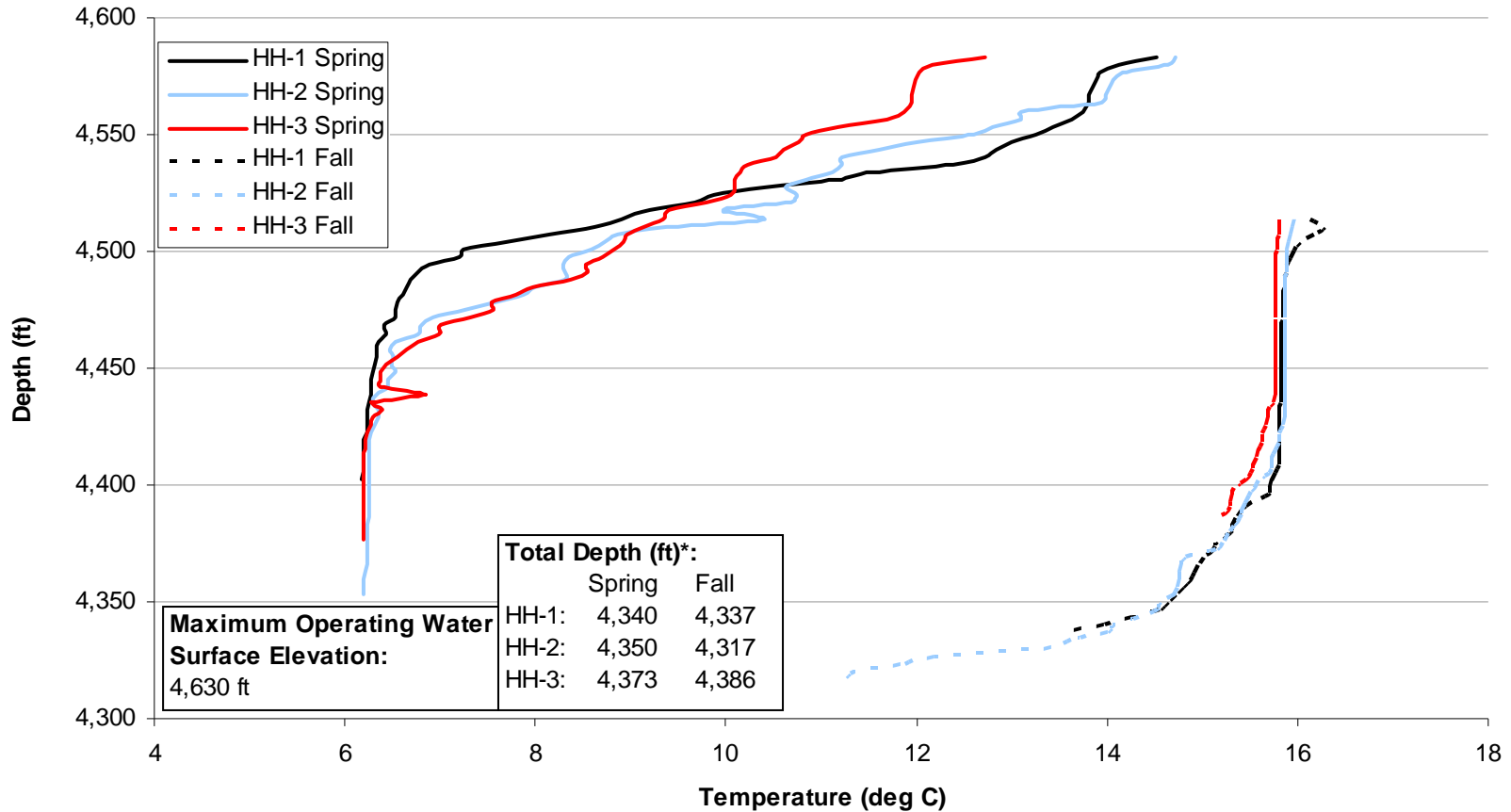
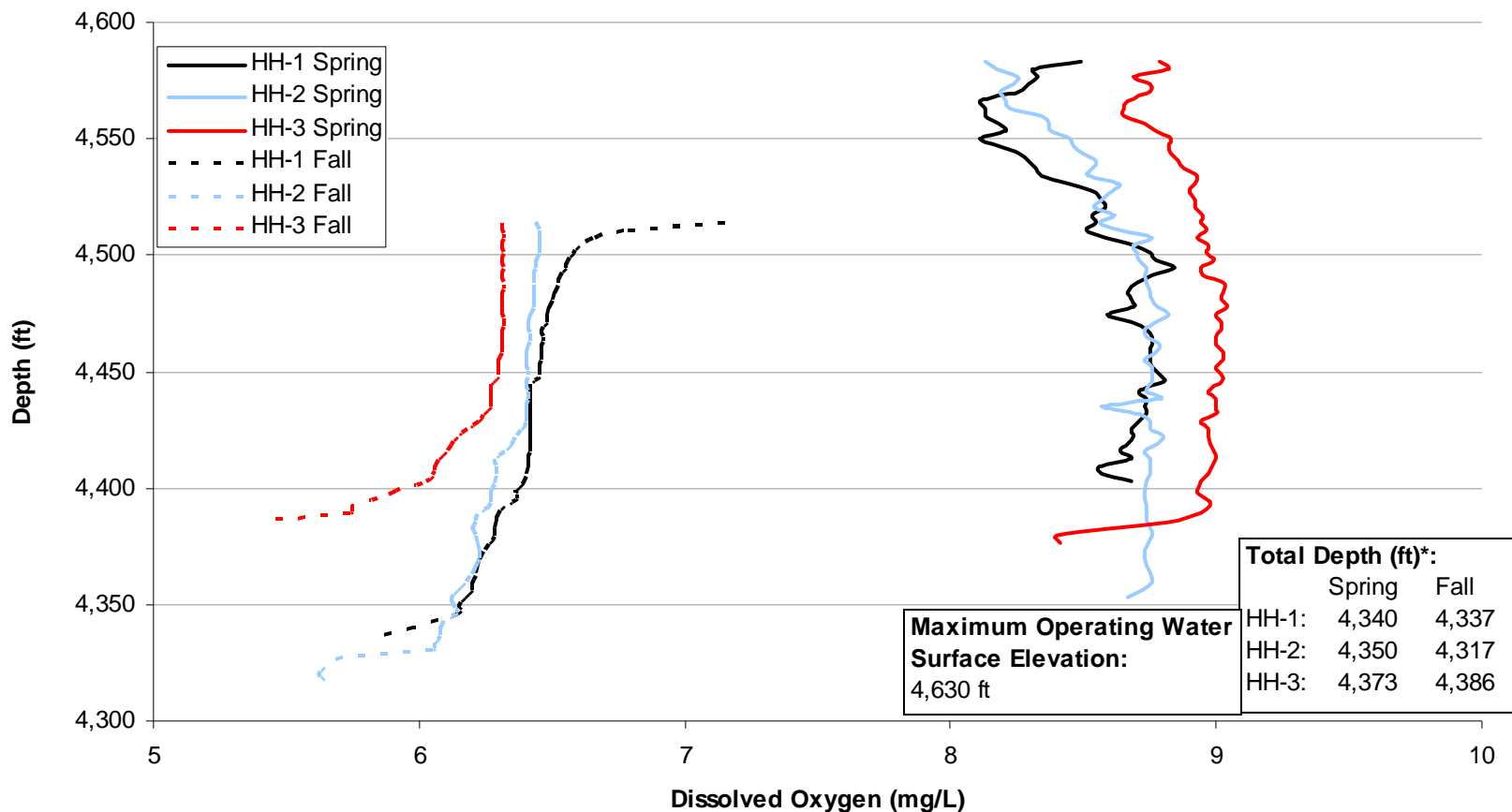


Figure C-3. Hell Hole Reservoir (HH-1, HH-2, HH-3) Temperature Profiles for the Spring and Fall Sampling Events.



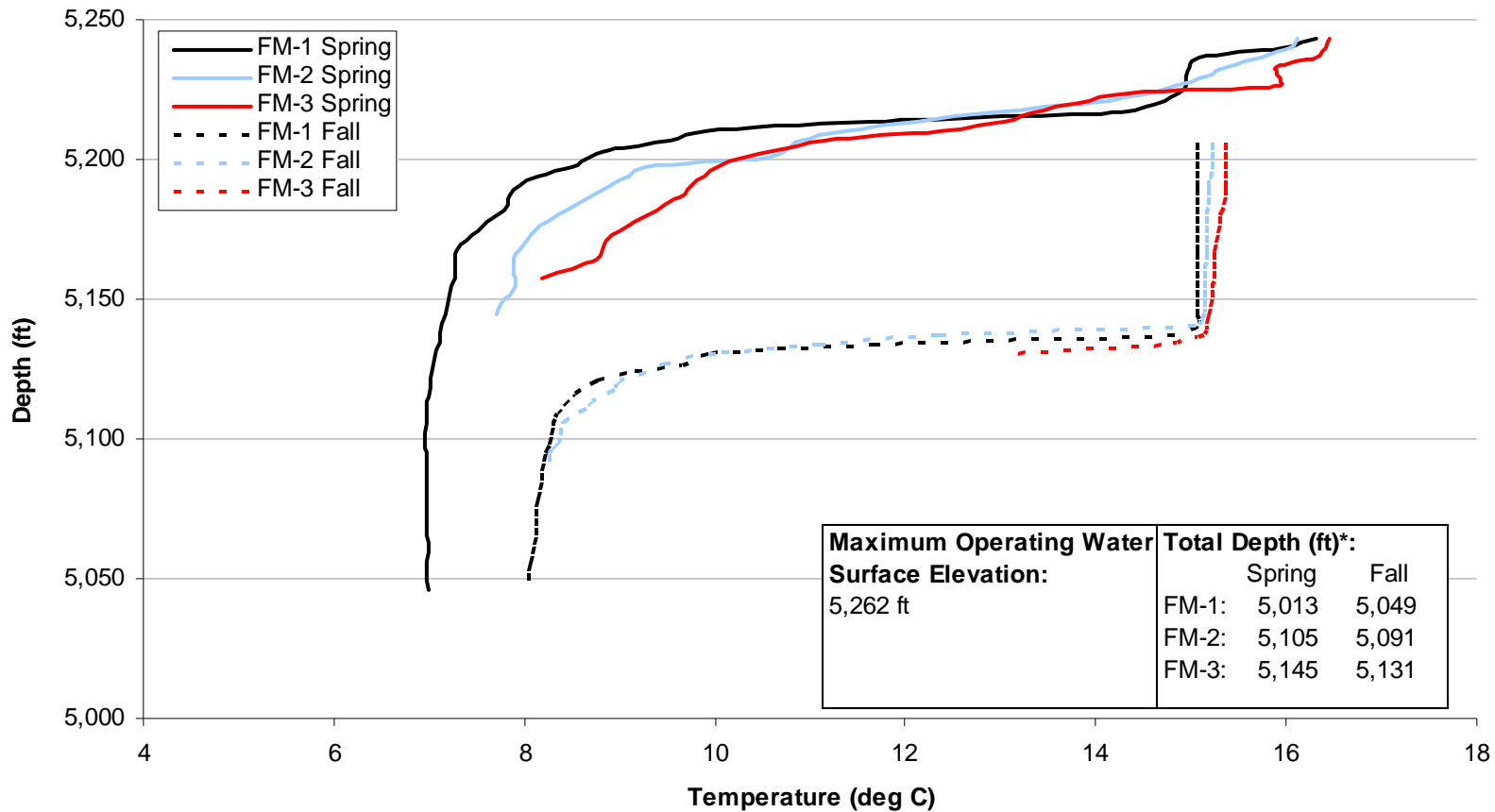
*It was difficult to measure to the bottom of the reservoir because submerged rocks or trees are located near the bottom of the reservoir. Measurements may not have been taken at the bottom to avoid damaging or losing the probe.

Figure C-4. Hell Hole Reservoir (HH-1, HH-2, HH-3) Dissolved Oxygen Profiles for the Spring and Fall Sampling Events.



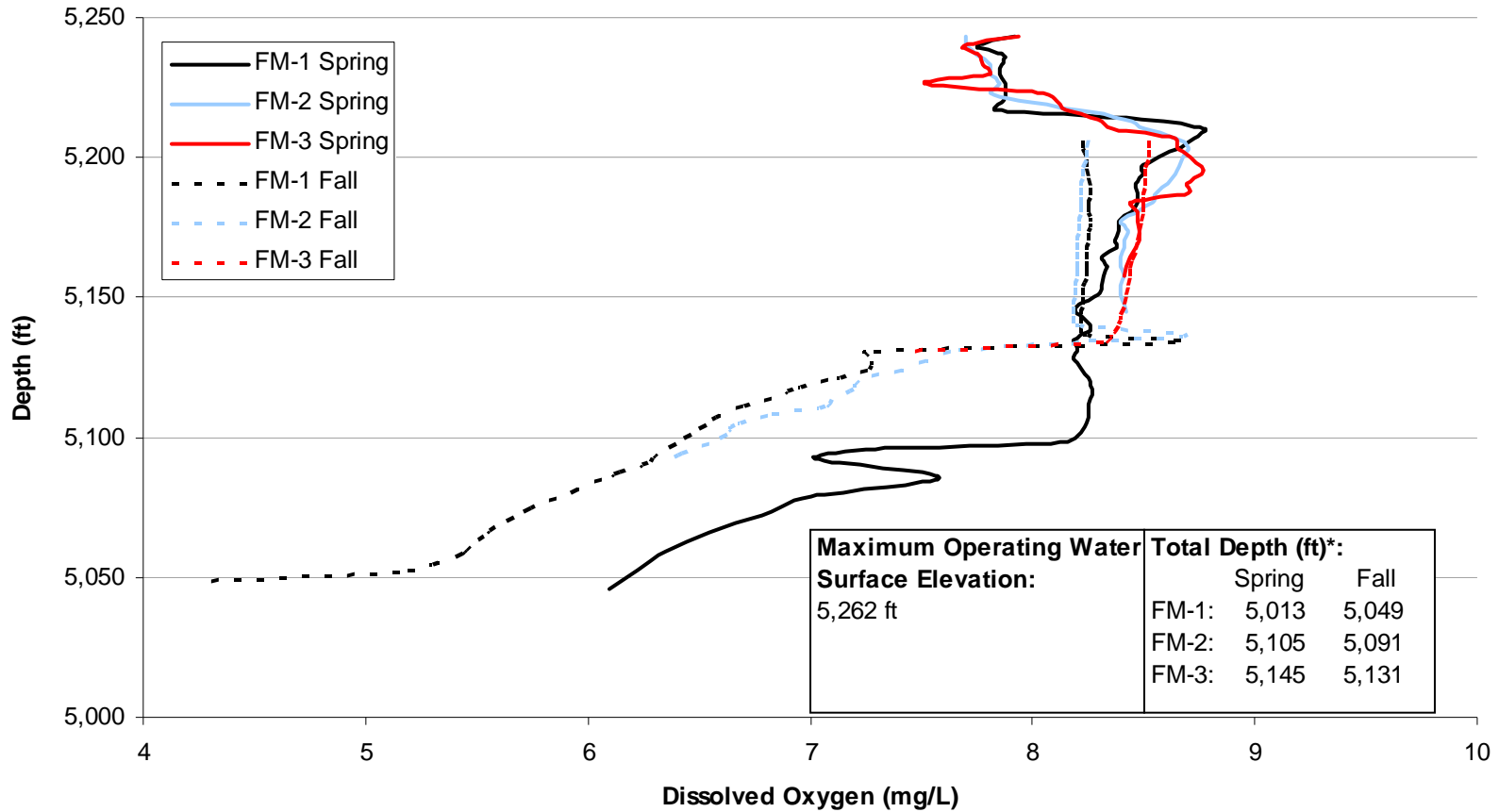
*It was difficult to measure to the bottom of the reservoir because submerged rocks or trees are located near the bottom of the reservoir. Measurements may not have been taken at the bottom to avoid damaging or losing the probe.

Figure C-5. French Meadows Reservoir (FMH-1, FM-2, FMH-3) Temperature Profiles for the Spring and Fall Sampling Events.



*It was difficult to measure to the bottom of the reservoir because submerged rocks or trees are located near the bottom of the reservoir. Measurements may not have been taken at the bottom to avoid damaging or losing the probe.

Figure C-6. French Meadows Reservoir (FMH-1, FMH-2, FMH-3) Dissolved Oxygen Profiles for the Spring and Fall Sampling Events.



*It was difficult to measure to the bottom of the reservoir because submerged rocks or trees are located near the bottom of the reservoir. Measurements may not have been taken at the bottom to avoid damaging or losing the probe.

APPENDIX D

Quality Assurance/Quality Control Laboratory Review

Table D-1. Quality Assurance/Quality Control Review of Spring 2007 Sample Laboratory Analyses.

Report ID	TA: MQE0598	TA: MQE0596	BR: 07BR0665 and 07BR0671	TA: MQE0595	BR: 07BR0681 and 07BR0701	TA: MQE0642	TA: MQE0742	TA: MQE0796
Sample Locations	MFAR-10 RM9.1	LCC-1 RM11.3, SFLC-1 RM3.4, SFLC-2 RM3.1, SFLC-3 RM0.2, NFLC-1 RM3.2, NFLC-2 RM2.9, NFLC-3 RM0.3	MFAR-10 RM9.1, LCC-1 RM11.3, NFLC-1 RM3.2, NFLC-2 RM2.9, NFLC-3 RM0.3, SFLC-1 RM3.4, SFLC-2 RM3.1, SFLC-3 RM0.2	MFAR-5 RM36.3, MFAR-6 RM35.5, MFAR-11 RM0.1, NFAR-1 RM20.6, IR-1 RM35.7	MFAR-3 RM39.9, MFAR-4 RM39.5, MFAR-5 RM36.3, MFAR-6 RM35.5, MFAR-8 RM24.7, MFAR-9 RM24.3, MFAR-11 RM0.1, NFAR-1 RM20.6, DC-3 RM0.2, IR-1 RM35.7, LCC-2 RM0.3, RR-5 RM3.8, RR-6 RM3.5, RR-7 RM0.7	MFAR-3 RM39.9, MFAR-4 RM39.5, DC-3 RM0.2	RR-5 RM3.8, RR-6 RM3.5, RR-7 RM0.7, MFAR-8 RM24.7, MFAR-9 RM24.3, LCC-2 RM0.3	MFAR-1 RM51.6, MFAR-2 RM46.6, MFAR-7 RM26.1, DC-1 RM8.9, DC-2 RM8.8, RR-2A, RR-2B
Date Sampled	5/14/2007	5/15/2007	5/14/07, 5/15/07	5/16/007	5/16/07, 5/17/07, 5/21/07	5/17/2007	5/21/2007	5/22/2007
Analysis	General Parameters	General Parameters	Metals (Dissolved and Total)	General Parameters	Metals (Dissolved and Total)	General Parameters	General Parameters	General Parameters
Do all samples match COC?	Yes	Yes	No: Sample ID SFLC-2 RM 3.1 was listed as SFLC-2 RM3.1 QC on the COC, but "QC" was not listed with the ID on the bottle label. Sample date and time were checked to confirm sample bottle and site consistency	Yes	Yes	Yes	Yes	Yes
Is sample ID consistent throughout report?	Yes	No: NFLC-1 RM3.2 and NFLC-2 RM2.9 were labeled in the report as NFLC-1 and 2. It appears to be a transcription error by the lab. Sample river miles and times match.	Yes	Yes	No: NFLC-2 RM 2.9 was labeled as NFLC-1 RM3.2 for sample ID 07BR0671-11. The times and river miles were checked to confirm the laboratory transcription error on this sample ID.	Yes	Yes	Yes
Were all sample holding times met?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were there any quality control data issues?	Yes M7: Sodium for MFAR-10 RM9.1	Yes M7: Sodium for all samples M8: Nitrite/Nitrate for LCC-1 RM11.3, SFLC-1 RM3.2	No	Yes M7: Sodium for all samples	No	Yes M7: Turbidity for all samples	Yes M7: Sodium for all samples M8: Calcium for all samples M7, M8: Hardness for all samples R2: Nitrite/Nitrate for all samples	Yes M7: Ammonia for MFAR-1 RM51.6, MFAR-2 RM46.6, MFAR-7 RM26.1, DC-1 RM8.9, DC-2 RM8.8, RR-2B M7: Sodium for all samples M8: Calcium for all samples M7, M8: Hardness for all samples
Were there any quality control data issues that potentially effect the sample result?	No	No	No	No	No	No	No	No

Table D-1. Quality Assurance/Quality Control Review of Spring 2007 Sample Laboratory Analyses (continued).

Report ID	TA: MQE0964	BR: 07BR0714 and 07BR0741	TA: MQE0868	TA: MQE0992	BR: 07BR0763 and 07BR0771	TA: MQE0980	TA: MQF0012	BR: 07BR1155
Sample Locations	HH-1, 2, and 3, HH-1(S), 2(S), and 3(S)	MFAR-1 RM51.6 MFAR-2 RM46.6, MFAR-7 RM26.1, DC-1 RM8.9, DC-2 RM8.8, RR-1 RM35.9, RR-2 RM30.2, RR-4 RM22.5, RR-2A, RR-2B, RR-2EC, RR-2DEC, HH-1, HH-2, HH-3, HH-1(S), HH-1(S), HH-3(S), SFRR-1 RM0.2	RR-3 RM22.8, RR-4 RM22.5, SFRR-1 RM0.2	RR-1 RM35.9, HH-2	RA-1, RA-1(S), FM-1, FM-2, FM-3, FM-1(S), FM-2(S), FM-3(S)	RA-1, RA-1(S)	FM-1, FM-2, FM-3, FM-1(S), FM-2(S), FM-3(S)	FM-A, B, C, D, and E
Date Sampled	5/22/2007	5/22/07, 5/23/07, 5/24/07	5/23/2007	5/24/2007	5/29/07, 5/31/07	5/29/2007	5/31/2007	8/7/2007
Analysis	General Parameters and Hydrocarbons	Metals (Dissolved and Total)	General Parameters	General Parameters and Hydrocarbons	Metals (Dissolved and Total)	General Parameters and Hydrocarbons	General Parameters and Hydrocarbons	Metals (Dissolved and Total)
Do all samples match COC?	No: VOAs (TPH and MtBE) of HH-2 were not received. VOAs for HH-2 were collected at a later date	No: RR-4 RM22.5 was mislabeled with the wrong RM, sample date and time were confirmed for correct sample. Sample dates were accidentally omitted on the COC for 5/23/07, relinquished date on COC and sample bottled confirmed sample date.	Yes	Yes	Yes	Yes	Yes	Yes
Is sample ID consistent throughout report?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were all sample holding times met?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were there any quality control data issues?	Yes M2: TKN for all samples M8: Calcium for HH-1, HH-2, HH-3, HH-2(S), HH-3(S) M8: Hardness for HH-1, HH-2, HH-3, HH-2(S), HH-3(S) M7: Hardness for HH-1(S) R2: Oil and grease for all samples	No	Yes L: Potassium for all samples R2: TDS for all samples	Yes M2: TKN for RR-1 M7: Hardness for RR-1	No	Yes M2: TKN for all samples R2: TDS for all samples M7: Hardness for all samples M8: Chloride and Sulfate for all samples	Yes M2: Ammonia for FM-1, FM-2, FM-3, FM-1(S), FM-2(S) M8: Sulfate and Chloride for all samples	Yes BR1: Calcium for all samples
Were there any quality control data issues that potentially effect the sample result?	Yes MNR1: Oil and grease for all samples	No	Yes L1: TDS for RR-3 RM22.8, RR-4 RM22.5	No	No	Yes MNR1: Oil and Grease for all samples	Yes MHA: MtBE for FM-2, FM-3, FM-1(S), FM-2(S), FM-3(S) MNR1: Oil and grease for all samples pH: TOC for FM-3(S)	No

TA: Test America Laboratory

BR: Brooks Rand Laboratory

Brooks Rand Laboratory QC Code:

BR1: Method blank in trace metals batch #07-0863 produced results that were greater than the PQL. These blank results were omitted as Grubb's outliers and were not used to method correct the results.

All results from these batches were blank-corrected with the average of the three remaining method blanks.

Test America Laboratory QC Code:

H: Sample analysis performed past method-specified holding time.

L1: Laboratory control sample/laboratory control sample duplicate (LCS/LCSD) recovery was above acceptable limits.

L: LCS/LCSD recovery was above acceptable limits. Analyte not detected, data not impacted.

M1: The MS/MSD were above the acceptance limits due to sample matrix interference.

M2: The MS/MSD were below the acceptance limits due to sample matrix interference.

M7: The MS/MSD were above the acceptance limits.

M8: The matrix spike/matrix spike duplicate (MS/MSD) were below the acceptance limits.

MHA: Due to high levels of analyte in the sample, the MS/MSD calculation does not provide useful spike recovery information.

MNR: No results were reported for the MS/MSD. The sample used for the MS/MSD required dilution due to the sample matrix. Because of this, the spike compounds were diluted below the detection limit.

MNR1: There was no MS/MSD analyzed with the batch due to insufficient sample volume.

pH: pH=7. Preservative was not present in the sample.

R2: The relative percent difference (RPD) was greater than acceptance levels.

Table D-2. Quality Assurance/Quality Control Review of Fall 2007 Sample Laboratory Analyses.

Report ID	TA: MQI0723	TA: MQI0774	BR: 07BR1361	TA: MQI0807	BR: 07BR1389 and 07BR1397	TA: MQJ0097	TA: MQJ0128	MNR: Ammonia for FM-1 and FM-1(S)	BR: 07BR1399
Sample Locations	MFAR-5 FM36.3, MFAR-6 RM35.5, MFAR-10 RM9.1, IR-1 RM35.7	RR-3 RM22.8, RR-4 RM22.5, SFRR-1 RM 0.2, NFAR-1 RM20.6, MFAR-11 RM0.1, DC-1 RM 8.9, DC-2 RM8.8	MFAR-7 RM26.1, MFAR-8 RM24.7, MFAR9 RM24.3, MFAR-10 RM9.1, MFAR-11 RM0.1, NFAR-1 RM20.6, RR-3 RM22.8, RR-4 RM22.5, RR-7 RM0.7, SFRR-1 RM0.2, DC-1 RM8.9, DC-2 RM8.8, RA-1, RA-1(S)	RA-1, RA-1(S); MFAR-7 RM26.1, MFAR-8 RM24.7, MFAR-9 RM24.3; RR-5 RM3.8, RR-6 RM3.5, RR-7 RM0.7, LCC-2 RM0.3	LCC-2 RM0.3, RR-5 RM3.8, RR-6 RM3.5, HH-1, HH-2, HH-1(S), HH-2(S)	HH-1, HH1(S), HH-2, HH-2(S)	RR-1 RM35.9, HH-3, HH-3(S), NFLC-1 RM3.2, NFLC-2 RM2.9, NFLC-3 RM0.3, SFLC-1 RM3.4, SFLC-2 RM3.1, SFLC-3 RM0.2, LCC-1 RM11.3	FM-1, FM-2, FM-3, FM-1(S), FM-2(S), FM-3(S), MFAR-1 RM51.6, MFAR-2 RM46.6, RR-2 RM30.2	MFAR-1 RM51.6, MFAR-2 RM46.6, RR-1 RM35.9, RR-2 RM30.2, LCC-1 RM11.3, NFLC-1 RM3.1, NFLC-2 RM2.9, NFLC-3 RM0.3, SFLC-1 RM3.4, SFLC-2 RM3.1, SFLC-3 RM0.2, HH-3, HH-3(S), FM-1, FM-2, and FM-3, FM-1(S), FM1-2(S), FM-3(S)
Date Sampled	9/24/2007	9/25/2007	9/24/2007-9/26/2007	9/26/2007-9/27/2007	9/27/07 and 10/1/07	10/1/2001	10/2/2007	10/3/2007	10/2/07-10/3/07
Analysis	General Parameters	General Parameters	Metals (Dissolved and Total)	General Parameters and Hydrocarbons	Metals (Dissolved and Total)	General Parameters and Hydrocarbons	General Parameters and Hydrocarbons	General Parameters and Hydrocarbons	Metals (Dissolved and Total)
Do all samples match COC?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is sample ID consistent throughout report?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were all sample holding times met?	No, TDS at IR-1 RM35.7 was sampled on the 9th day. Holding times are only 7 days.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were there any quality control data issues?	Yes M1: TOC at MFAR-5 RM36.3 R2: TDS at IR-1 RM 35.7 M8: for Ortho-Phosphate at all locations M7: Nitrate/Nitrite, Chloride and Sulfate at all locations R2: Nitrite/Nitrate at all locations R2: TKN for all locations	Yes L: Phosphorus for all samples R:TDS for all samples M8: Sulfate and Chloride for RR-4 RM22.5, SFRR-1 RM0.2, NFAR-1 RM20.6, MFAR-11 RM0.1, DC-1 RM8.9, DC-2 RM8.8 R2: TKN for RR-3 RM22.8, RR-4 RM22.5, SFRR-1 RM0.2, NFAR-1 RM20.6, MFAR-11 RM0.1, DC-1 RM8.9 R2, M2, R8: TKN for DC-2 RM8.8	No	Yes R: TDS for RA-1and RA-1(S), MFAR-7 RM26.1, MFAR-8 RM24.7, RR-5 RM3.8, RM-6 RM3.5, and RM-7 RM0.7, LCC-2 RM0.3 R2: TDS for MFAR-9 RM24.3 M7: Hardness for all samples M8, R2: TKN for all samples	Yes BR2: Fe for all samples BR3: Fe for LCC-2 RM0.3	Yes R2: TDS for all samples M8: Chloride for all samples M8: TKN for all samples	Yes R2: TDS for all samples M8: Chloride for HH-3, HH-3(S), NFLC-1 RM3.1, NFLC-2 RM2.9, NFLC-3 RM0.3, SFLC-1 RM3.4, SFLC-2 RM3.1, SFLC-3 RM0.2, LCC-1 RM11.3 M8: TKN for all samples	Yes R2: TDS for all samples R2: Ammonia for FM-2, FM-3, FM-2(S), FM-3(S), MFAR-1 RM51.6, MFAR-2 RM 46.6, RR-2 RM30.2	Yes BR2: Fe for all samples
Where there any quality control data issues that potentially effect the sample result?	No	No	Yes BR4: Mn for RR-4 RM22.5	No	No	Yes MNR1: Oil and Grease for all samples	Yes MHA: Chloride for RR-1	Yes MNR: Ammonia for FM-1 and FM-1(S)	No

TA: Test America Laboratory

BR: Brooks Rand Laboratory

Brooks Rand Laboratory (BR) QC Code:

BR2: Sample results produced high negative results due to a polyatomic interference. All samples were reported as non-detected, thus this interference does not affect the results.

BR3:The MS/MSD produced low recoveries of Fe and did not meet the spike recovery criteria. This sample displayed the greatest influence of possibly polyatomic interference indicating potentially stronger matrix effects with this sample. However, the sample was reported as non-detect, thus this interference does not affect the result.

BR4: The method duplicate (MD) exceeded the acceptance criterion for the relative percent difference.

Test America Laboratory (TA) QC Code:

H: Sample analysis performed past method-specified holding time

L1: Laboratory control sample/laboratory control sample duplicate (LCS/LCSD) recovery was above acceptable limits.

L: LCS/LCSD recovery was above acceptable limits. Analyte not detected, data not impacted.

M1: The MS/MSD were above the acceptance limits due to sample matrix interference.

M2: The MS/MSD were below the acceptance limits due to sample matrix interference.

M7:The MS/MSD were above the acceptance limits.

M8:The matrix spike/matrix spike duplicate (MS/MSD) were below the acceptance limits.

MHA: Due to high levels of analyte in the sample, the MS/MSD calculation does not provide useful spike recovery information

MNR: No results were reported for the MS/MSD. The sample used for the MS/MSD required dilution due to the sample matrix. Because of this, the spike compounds were diluted below the detection limit.

MNR1: There was no MS/MSD analyzed with the batch due to insufficient sample volume

pH: pH=7. Preservative was not present in the sample.

R2: The relative percent difference (RPD) was greater than acceptance levels.

Table D-3. Quality Assurance/Quality Control Review of Additional Sampling below Project Reservoir Laboratory Analyses.

Report ID	BR: 07BR0714	BR: 07BR1155
Sample Locations	RR-2A, RR-2EC, RR-2DEC	FM-A, FM-B, FM-C, FM-D, and FM-E
Date Sampled	5/22/2007	8/7/2007
Analysis	Metals (Dissolved and Total)	Metals (Dissolved and Total)
Do all samples match COC?	Yes	Yes
Is sample ID consistent throughout report?	Yes	Yes
Were all sample holding times met?	Yes	Yes
Were there any quality control data issues?	No	Yes BR1: Calcium for all samples
Were there any quality control data issues that potentially effect the sample result?	No	Yes BR5: Mn for FM-A, FM-B, FM-C

TA: Test America Laboratory

BR: Brooks Rand Laboratory

Brooks Rand Laboratory QC Code:

BR1: Method blank in trace metals batch #07-0863 produced results that were greater than the PQL. These blank results were omitted as Grubb's outliers and were not used to method correct the results. All results from these batches were blank-corrected with the average of the three remaining method blanks estimates.

Table D-4. Quality Assurance/Quality Control Review of Fish Tissue Sampling of Methyl Mercury Laboratory Analyses.

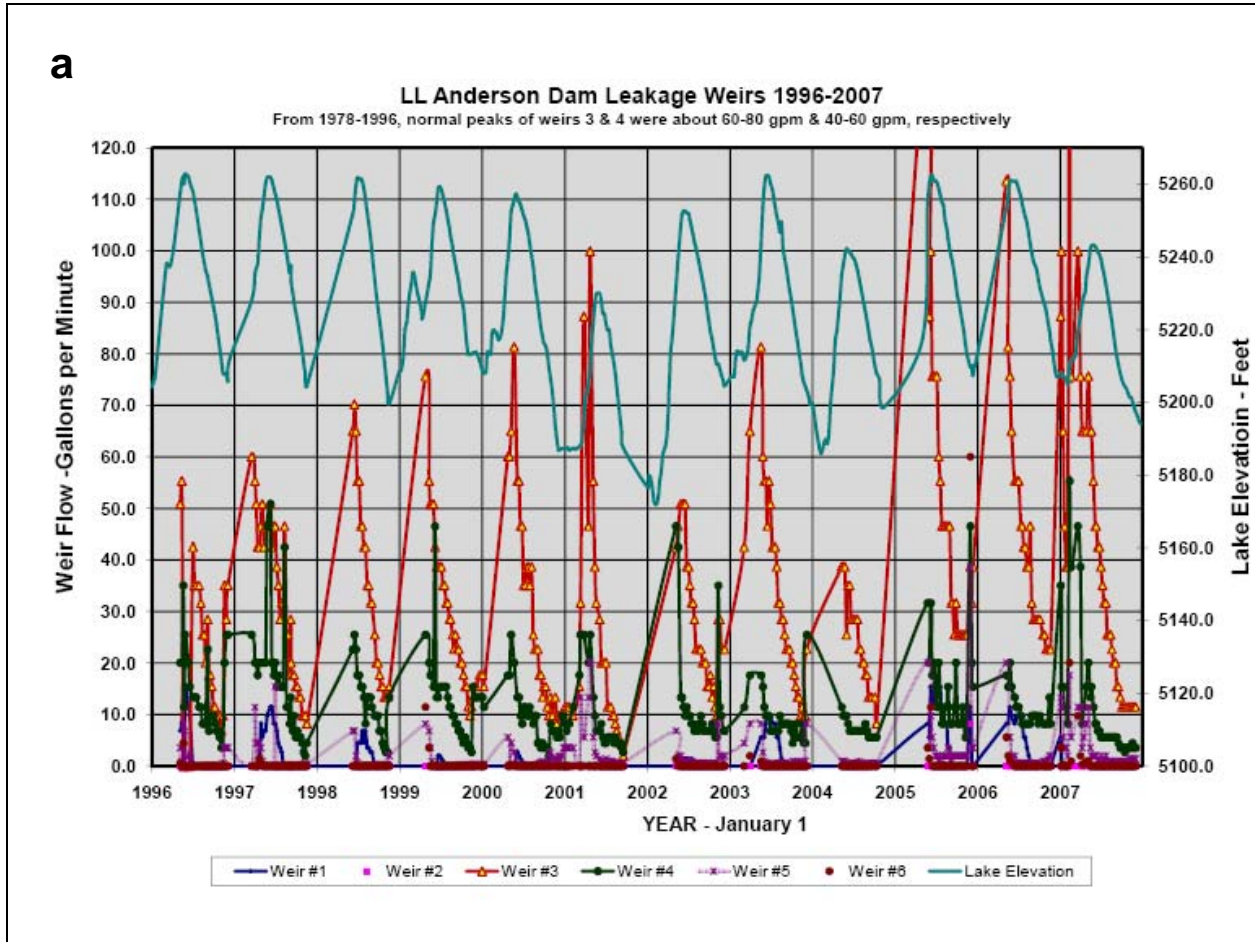
Report ID	BR: 07BR1337	BR: 07BR1353	BR: 07BR1467	BR: 07BR1438
Sample Locations	FM-2B-2B-3, FM-2C-BT-1, HH-3B-BT-1, FM-3D-RT-2, FM-2F-RT-1, RA-3A-SPM-20, RA-3A-SPM-21, RA-2B-SPM-8, RA-2B-SPM-7, RA-1D-SPM-4, RA-3B-BT-7, RA-2B-BT-6, RA-2A-BT-14, RA-2A-BT-7, RA-3B-RT-19, FM-1E-RT-1	HH-BT-1, FM-BT-1	I-U2-BNT-1, OC-RBT-1	HH-1-US2-RBT-1, HH-1-MIDL-LT-1, HH-1-US1-LT-1, HH-1-MID3-LT-1, HH-1-MID1-BNT-3, HH-1-MID1-BNT-3, HH-1-DS-1-BNT-2, HH-1-US2-BNT-2, HH-1-US2-BNT-3, I-US2-RBT-5, I-LT-RBT-1, I-US1-RBT-1, I-US1-BNT-2, I-US2-BNT-2, I-US2-BNT-3, I-US1-BNT-3, I-US-1-BNT-1, OC-1-RBT-1, OC-1-RBT-2, OC-1-RBT-3, OC-1-RBT-4, OC-1-RBT-5, OC-1-RBT-6, OC-1-RBT-7, OC-1-RBT-8, OC-1-BNT-
Date Sampled	9/11/2007, 9/12/2007, 9/13/2007, 9/14/2007	9/11/2007, 9/12/2007	9/21/2007, 10/16/2007	9/21/2007, 10/2/2007, 10/11/2007
Analysis	Methyl Mercury	Methyl Mercury	Methyl Mercury	Methyl Mercury
Do all samples match COC?	Yes	Yes	No OC-RBT-1: sample time was not entered on COC, field notes indicate fish was caught at 14:00	No OC-1-BNT-1: sample date was wrong on COC (10/2/2007), fish was caught on 10/9/2007, field notes confirmed with fish ID and sample time. OC-1-RBT-7: sample date was wrong on COC (10/2/2007), fish was caught on 10/9/2007, field notes confirmed with fish ID and sample time. OC-1-RBT-8: sample date was wrong on COC (10/2/2007), fish was caught on 10/9/2007, field notes confirmed with fish ID and sample time.
Is sample ID consistent throughout report?	Yes	Yes	Yes	Yes
Were all sample holding times met?	Yes	Yes	Yes	Yes
Were there any quality control data issues?	No	No	No	No
Were there any quality control data issues that potentially effect the sample result?	No	No	No	No

BR: Brooks Rand Laboratory

APPENDIX E

Flows within the Leakage Channels below French Meadows Dam and Hell Hole Dam

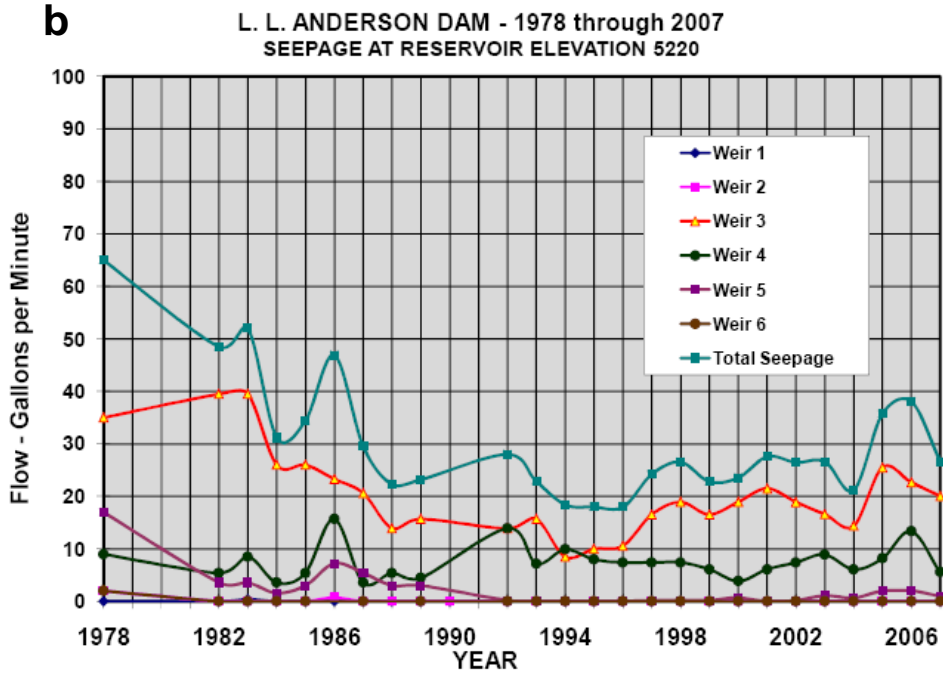
Figure E-1. Flows in Leakage Channels below French Meadows Dam with Changes in Reservoir Water Surface Elevations (a), at Reservoir Elevation 5,220 feet (b), and at Reservoir Elevation 5,250 feet.¹



Note: FM-A was collected from Weir 5; FM-B was collected from Weir 4; and FM-C was collected from Weir 3.

¹ Figures are from PCWA (2008).

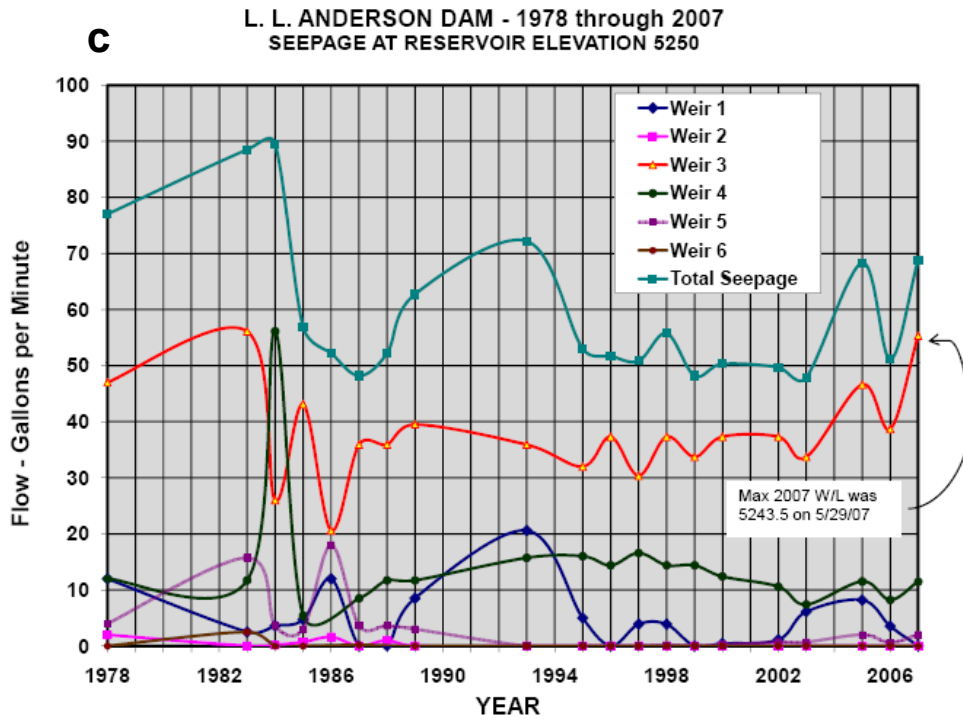
Figure E-1. Flows in Leakage Channels below French Meadows Dam with Changes in Reservoir Water Surface Elevations (a), at Reservoir Elevation 5,220 feet (b), and at Reservoir Elevation 5,250 feet (continued).



Note: Some rain during 2005 reading

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Figure E-1. Flows in Leakage Channels below French Meadows Dam with Changes in Reservoir Water Surface Elevations (a), at Reservoir Elevation 5,220 feet (b), and at Reservoir Elevation 5,250 feet (continued).



Note: 2007 reading was at 5243.25 (max reached)

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Figure E-2. Flows in Leakage Channel below Hell Hole Dam with Changes in Reservoir Water Surface Elevations 1978 to 1985 (a), Changes in Reservoir Water Surface Elevations 1986 to 1995 (b), Changes in Reservoir Water Surface Elevations 1996 to 2007 (c), and at Reservoir Elevations 4,580 and 4,540 feet (d).

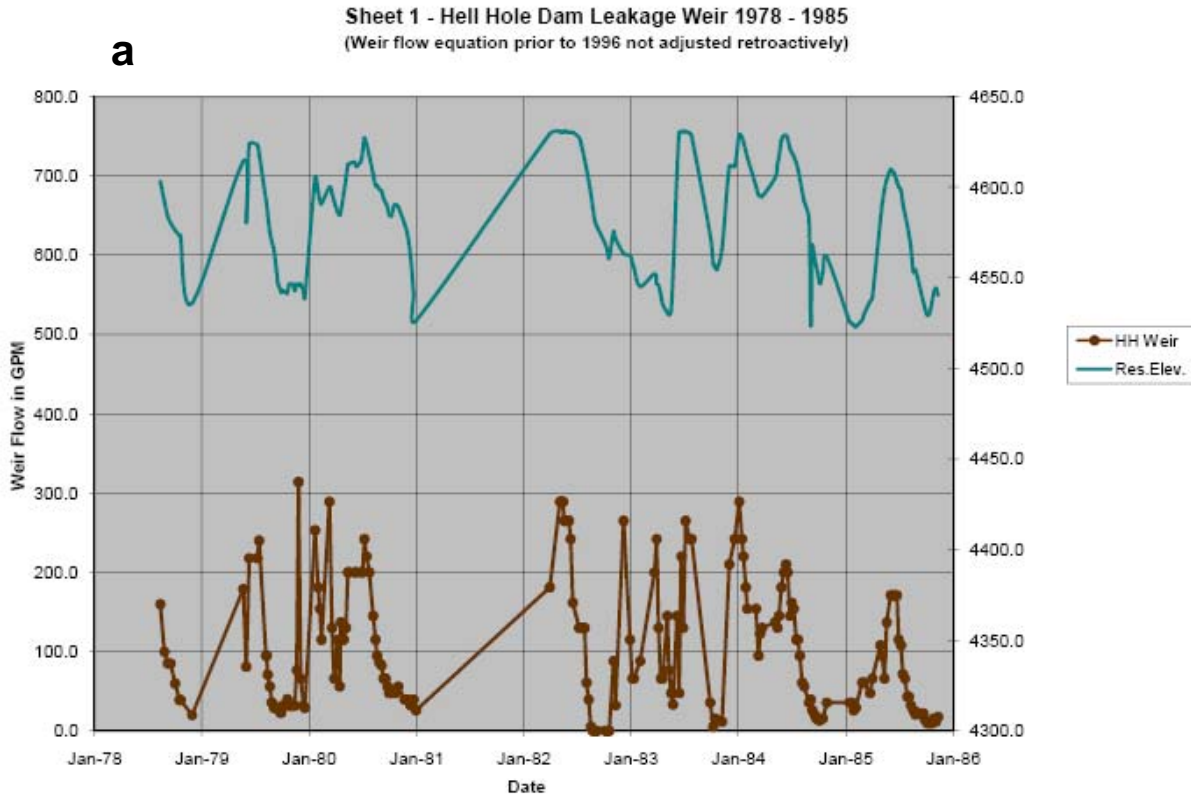


Figure E-2. Flows in Leakage Channel below Hell Hole Dam with Changes in Reservoir Water Surface Elevations 1978 to 1985 (a), Changes in Reservoir Water Surface Elevations 1986 to 1995 (b), Changes in Reservoir Water Surface Elevations 1996 to 2007 (c), and at Reservoir Elevations 4,580 and 4,540 feet (d) (continued).

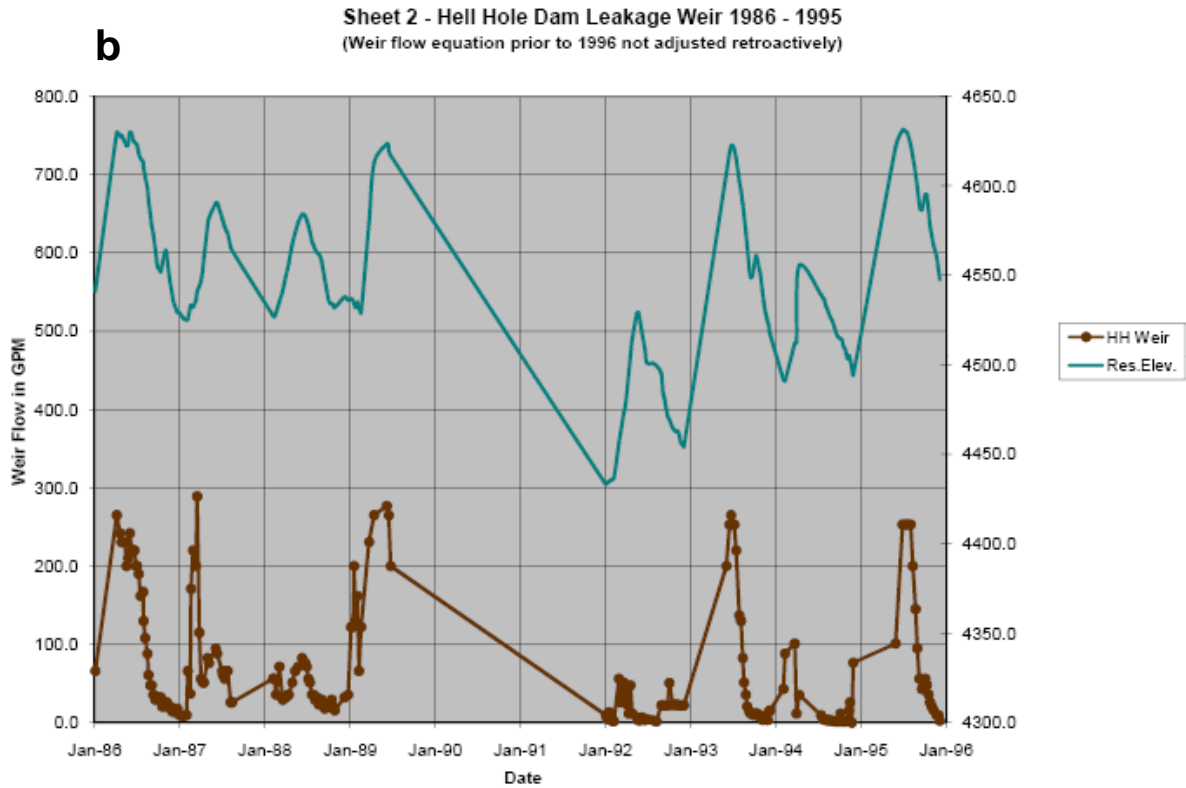


Figure E-2. Flows in Leakage Channel below Hell Hole Dam with Changes in Reservoir Water Surface Elevations 1978 to 1985 (a), Changes in Reservoir Water Surface Elevations 1986 to 1995 (b), Changes in Reservoir Water Surface Elevations 1996 to 2007 (c), and at Reservoir Elevations 4,580 and 4,540 feet (d) (continued).

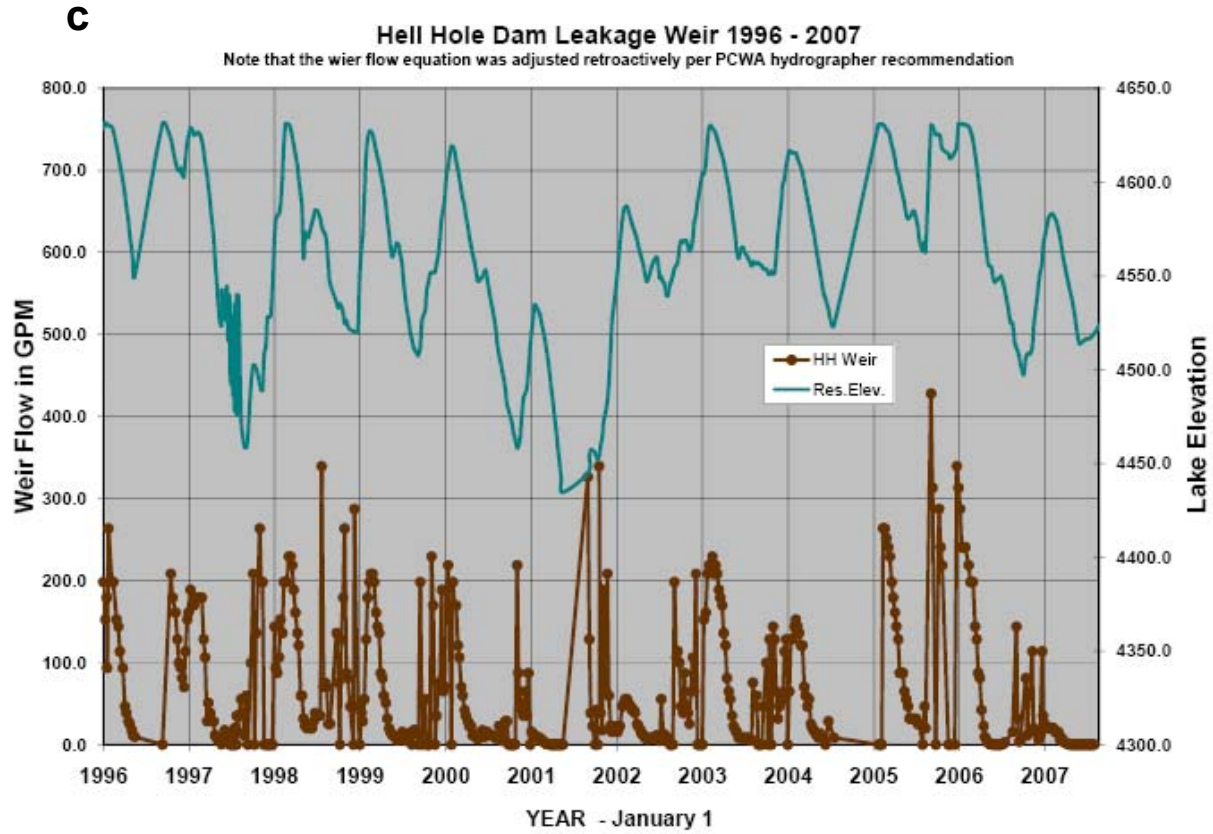


Figure E-2. Flows in Leakage Channel below Hell Hole Dam with Changes in Reservoir Water Surface Elevations 1978 to 1985 (a), Changes in Reservoir Water Surface Elevations 1986 to 1995 (b), Changes in Reservoir Water Surface Elevations 1996 to 2007 (c), and at Reservoir Elevations 4,580 and 4,540 feet (d) (continued).

