PACIFIC GAS AND ELECTRIC COMPANY

Pit 1 Hydroelectric Project
FERC Project No. 2687

Water Quality Monitoring
Five-year Summary Report
2004–2008

FINAL

June 2009

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PACIFIC GAS AND ELECTRIC COMPANY

Pit 1 Project, FERC Project No. 2687

Water Quality Monitoring
Five-Year Summary Report
2004–2008

Addressing License Article 401
and
California State Water Resources Control Board Water Quality Certificate
Conditions 16 and 17

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June 2009

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Introduction

1.1 Background

On March 19, 2003, Pacific Gas and Electric Company (PG&E) received a new license from the Federal Energy Regulatory Commission (FERC) for the continued operation of the Pit 1 Hydroelectric Project, FERC No. 2687 (Project). The new license incorporates the California State Water Resources Control Board (SWRCB) 401 Water Quality Certificate, which contains terms and conditions that regulate PG&E's Project operations.

Article 401 of the license and Condition 16 of the SWRCB 401 Water Quality Certification require development and implementation of a five-year water quality and water temperature monitoring program to determine the benefits/effects on water quality of the flow releases required under the terms and conditions of the license. This report summarizes the results of five years of water quality monitoring.

The Pit 1 Project (Figure 1-1) encompasses approximately 3,500 acres of land and water, almost 3,000 of which form the upper Project, the area above the Project's 15-foot-high, 595-foot-long diversion dam on the Fall River. The upper Project includes approximately 35 kilometers of the Fall River, 8 kilometers of the Tule and Little Tule rivers, and Ja She Creek, Horr Pond and Big Lake on the upper reaches of the Tule River. Downstream of this Project are the Hat Creek (FERC No. 2661), Pit 3, 4, and 5 (FERC No. 233), and McCloud-Pit (FERC No. 2106) projects, which are all operated by the Licensee.

Below the Fall River Diversion Dam is the Project's Pit 1 Forebay, a 222-acre impoundment formed by the 40-foot-high, 586-foot-long forebay dam. The Fall River Diversion Dam is operated to divert water toward the powerhouse, or release water into the Project's forebay for later diversion to the Pit 1 Powerhouse for peaking operations. The Project's two intakes converge, and water is carried almost 4 kilometers through a canal and tunnel to the 69.3-megawatt powerhouse, which is on the Pit River, about 12.2 kilometers downstream from its confluence with the Fall River. Powerhouse flows are released into the Pit River, bypassing 1.45 kilometers of the Fall River and 12.2 kilometers of the Pit River.

Immediately downstream of the forebay is the 1.1 kilometer-long Fall River Pond, formed by the 231-foot-long Fall River Pond Weir. The pond provides water to the town of Fall River Mills for non-potable uses, and (via Knoch's Diversion) to a user with riparian rights senior to PG&E's. Downstream of the Fall River Pond Weir is a 0.35 kilometer-long reach of the Fall River ending at its confluence with the Pit River.

The Pit River in the Project area can be divided into two distinct sections with different gradients. The first section extends from Pittville (located upstream of the Pit 1 bypass reach) to the end of Big Eddy (in the bypass reach). This reach is characterized by very low gradient, seasonally low flow, and slow velocity pool morphology. The Pit River Weir is a concrete

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structure constructed to maintain minimum water levels in the Pit River to satisfy upstream water rights between Pittville and Fall River Mills for agricultural uses. The weir effectively creates a long (14.4 kilometer), shallow impoundment that receives seasonally significant inflow from agricultural returns along its length. Immediately upstream of the Pit River Weir, flows from the Fall River enter the system. Downstream of the weir the low gradient, large pool morphology continues for approximately three kilometers to the end of Big Eddy. The second section extends from the end of Big Eddy to the Pit 1 Powerhouse tailrace. The river downstream of Big Eddy, confined by a canyon for most of the reach, is characterized by a narrower channel, with steeper gradient, and higher velocity. A significant (estimated average of 100 cfs) volume of non-point colder accretion occurs in this section of the Pit 1 Reach.

This report focuses on summarizing the results of water quality monitoring (water temperature, water quality) conducted during the five-year monitoring period (2004 to 2008). The document also compares these results with those from relicensing studies conducted in 1990 to1992.

1.2 Regulatory History

1.2.1 FERC License

Condition 16 of the SWRCB Water Quality Certification requires development and implementation of a five-year water quality monitoring plan and specifies monitoring parameters. The Water Quality Monitoring Plan for the Pit 1 Project pursuant to Article 401 of the license was filed with the FERC on September 22, 2003. On November 20, 2003, FERC issued an "Order Modifying and Approving Water Quality Monitoring Plan under Article 401" for PG&E's Pit 1 Project. The FERC order stipulates that the annual reports required by Condition 17 of the Water Quality Certification, summarizing the water quality monitoring, shall be filed annually with the SWRCB by December 31 and with FERC by the following March 31. The FERC order also stipulated that the Summary Report required by Condition 17 of the Water Quality Certification be filed with FERC by April 15 following the fifth year of monitoring. The order further stipulated the summary report shall include documentation of the required consultation with the Chief of the Division of Water Rights and the Chief's determination of whether or not the beneficial uses of the Pit River described in the SWRCB's 1998 Basin Plan have been reasonably protected during project operation. The Chief may determine the beneficial uses have been protected, and that the water quality monitoring program can be terminated. If the Chief determines that the beneficial uses have not been protected and changes are needed to ensure this protection, the Licensee shall file for Commission approval, an amendment to the approved Water Quality Monitoring Plan.

On December 24, 2008, FERC issued an "Order Granting Extension of Time under Article 401 and Appendix Condition 17. This order extended the deadline to file the summary report with FERC to July 1, 2009.

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1.2.2 FERC Article 401/SWRCB Water Quality Certificate Conditions

The following section presents SWRCB Water Quality Certificate Conditions 16 and 17.

***Condition 16**:*

The Licensee shall prepare a water quality monitoring plan to be submitted to the Chief of the Division of Water Rights for written approval within 6 months of the issuance of the FERC license and shall implement the water quality monitoring plan in the first full summer monitoring season following approval of the monitoring plan. The water quality monitoring program shall be instituted for a term of no less than 5 years. The monitoring shall be used to determine the benefits/effects on water quality of the proposed flow releases outlined in terms 8 and 13. The monitoring shall include but not be limited to water temperature and dissolved oxygen (DO).

Water quality shall be monitored at eight locations:

- *Fall River just downstream of Pit 1 Forebay*
- *Fall River Pond*
- *Lower Fall River just downstream of Fall River Pond*
- *Pit River at McArthur*
- *Pit River just downstream of Big Eddy*
- *Pit River just below Pit River Falls*
- *Pit River at the footbridge upstream of the Pit 1 Powerhouse*
- *Pit River downstream of the Pit 1 Powerhouse*

Water quality shall be monitored from May 16 to October 31 of each year. Water temperature will be monitored continuously at each of the monitoring locations. The Licensee should use redundant temperature recorders to avoid a loss of temperature data. DO, pH, turbidity, and conductivity will be sampled twice per month. Sampling methods and analyses will be as described in the water quality monitoring plan.

To monitor seasonal and short-term changes in flow, which can affect temperature and water quality, flow shall be measured continuously during the monitoring period with pressure transducers installed at the lower end of Big Eddy and at the footbridge upstream of the Pit 1 Powerhouse. The transducers will be calibrated against staff gage readings and periodic flow measurements at each location. These flow measuring sites shall be maintained for the term of the water quality monitoring program and are not intended to meet the rigorous requirements established by the USGS for USGS gages. Compliance with stream flow requirements will be monitored using USGS approved methods at a gage that will be constructed at the Fall River Weir.

The water quality data collected above will be supplemented with meteorological data collected at the Pit 1 Forebay and Pit 3 Intake.

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Condition 17:

The Licensee shall provide the Chief of the Division of Water Rights the results of the water quality monitoring program by December 31 of each year. At the end of the 5th year of monitoring, the Licensee shall provide the Chief of the Division of Water Rights a report summarizing the 5 years of water quality monitoring. The Licensee shall meet with the Chief of the Division of Water Rights or a designated representative within 60 days of the submittal of the summary report. The purpose of the meeting will be to review the monitoring results and to determine if the beneficial uses identified in the Basin Plan for the Pit River are reasonably protected. Reasonable protection of beneficial uses shall be measured by and limited to factors controllable by and related to the Pit 1 Hydroelectric Project operations in the lower Fall River below the Pit 1 Forebay and the Pit River and from the confluence with the Fall River to the confluence with the Pit 1 tailrace. The Chief of the Division of Water Rights in writing may modify or terminate the water quality monitoring program after review of the 5-year monitoring report prepared by the Licensee.

If, based on the water quality data, the initial streamflow releases are not reasonably protective of the beneficial uses of the Fall River and Pit River as identified in the Basin Plan, the California Water Board reserves the authority to require the Licensee to make additional flow releases or other actions as required to protect the beneficial uses identified in the Basin Plan.

If the Chief of the Division of Water Rights determines that additional flow releases are necessary to protect water quality within the diverted reach of the Fall and Pit River they shall be adaptively implemented in increments of 50 cfs and limited to the period in which the beneficial uses are affected. The 50 cfs shall be in addition to the initial flow requirements identified in condition 8. Water quality based on the new flow release schedule shall be monitored for three years.

The results of the additional three years of monitoring shall be summarized and submitted to the Chief of the Division of Water Rights by December 31 of the year in which the third year of monitoring is completed. The Licensee can request to meet with the Chief of the Division of Water Rights or designated representative to discuss the monitoring results to determine if the beneficial uses of the Pit River are reasonably protected as described above.

If, at the end of first three year adaptive water quality management period, the Chief of the Division of Water Rights determines in writing that water quality in the Pit River is still not being reasonably protected for any season or part of the season, the Licensee shall release an additional 50 cfs from Fall River Weir in addition to the existing adaptive flow releases. The new flow schedule shall be monitored for three years. If at the end of the second three year adaptive water quality management period, the Chief of the Division of Water Rights determines in writing that water quality in the Pit River is still not being reasonably protected for any season or part of the season, the Licensee shall release an additional 50 cfs from Fall River Pond in addition to the existing adaptive flow releases. This adaptive approach to protecting water quality shall continue until the water quality flow releases have reached the following limits:

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- *The final adaptive water quality instantaneous flow releases shall not exceed a maximum of 200 cfs for the May 16 to May 31 period;*

- *The final adaptive water quality instantaneous flow releases shall not exceed a maximum release of 400 cfs for the June 1 to October 31 period;*

- *The instream flow release for November 1 to November 15 shall not exceed a maximum of 150 cfs; and the November 16 to April 30th period releases shall remain 50 cfs for the life of the new license.*

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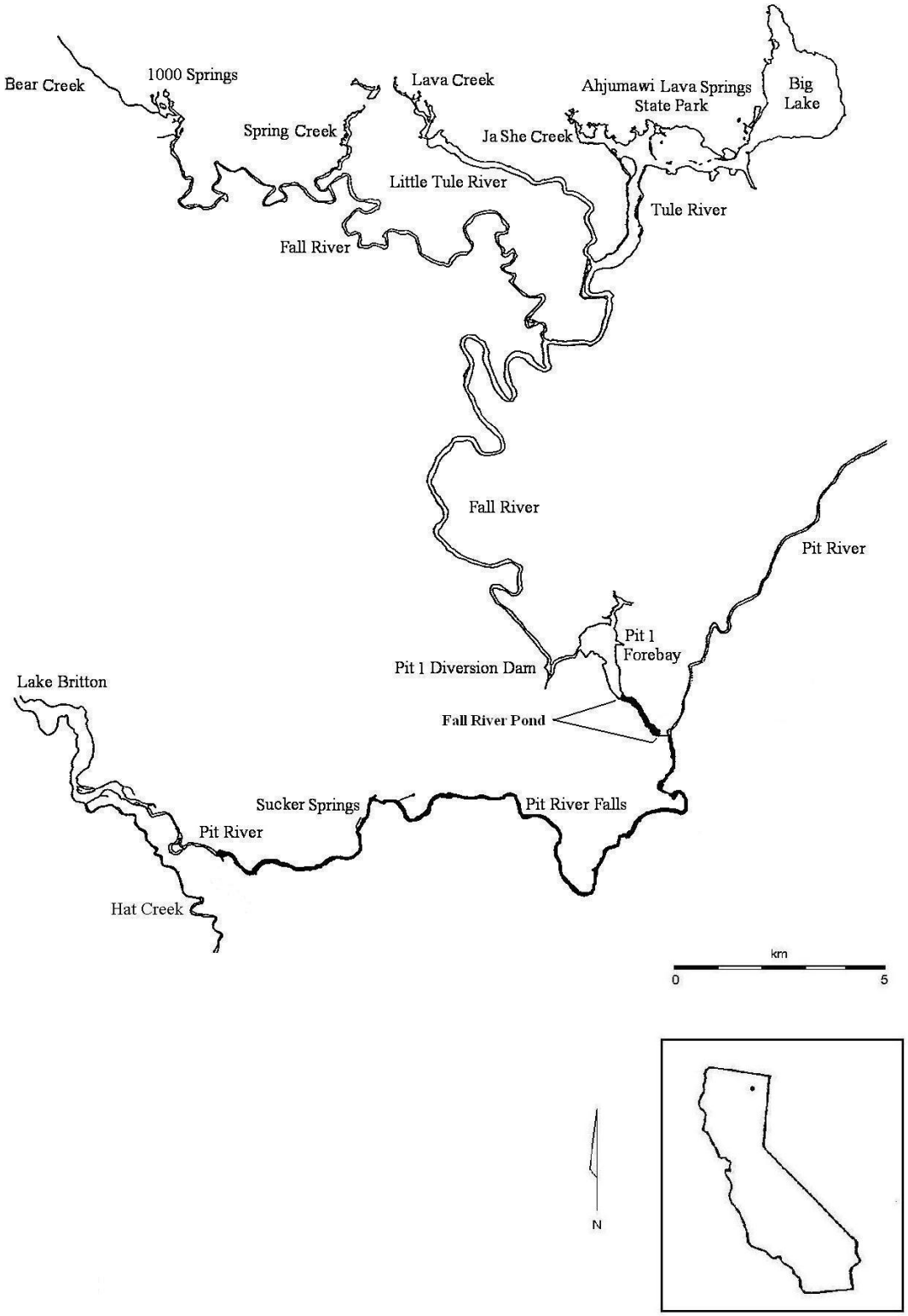
Bear Creek
1000 Springs
Lava Creek
Ahjumawi Lava Springs
State Park
Big
Lake
Spring Creek
Ja She Creek
Little Tule River
Tule River
Fall River
Fall River
Pit River
Pit 1
Forebay
Pit 1 Diversion Dam
Lake Britton
Fall River Pond
Sucker Springs
Pit River Falls
Pit River
Hat Creek
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Figure 1-1. Project Location and Major Features Map.

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Water Quality Monitoring

Section 2.1 briefly summarizes the goals and methods of the water quality monitoring program. Section 2.1 gives an outline of changes to watershed conditions before and during license implementation, as well as potential future conditions that may affect water quality.

2.1 Goals and Methods

In accordance with the SWRCB 401 Water Quality Certificate Condition 16 and 17, PG&E has been conducting the water quality monitoring program since 2004. A complete discussion of each year's monitoring activities is presented in the respective annual reports (PG&E 2004, 2005, Spring Rivers 2006, 2007, 2008). This section discusses outlines the monitoring program as implemented by PG&E.

The Water Quality Monitoring Program was implemented to define water quality conditions in the Project area under current operational conditions, as well as assess the impacts of the new license conditions on water quality resources and beneficial uses identified in the California Regional Water Quality Control Board – Central Valley Region's (RWQCB-CVR) *Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins*. (RWQCB-CVR 2007a)

2.1.1 Monitoring Network

Nine monitoring stations were selected in an effort to characterize *in situ* conditions throughout the Pit 1 Project. Stream temperatures were automatically measured continuously using digital recorders at all nine stations. Table 2-1 lists the station locations, and Figure 2-1 displays the spatial location of each station within the study area. These stations included those eight stations listed in SWRCB's Water Quality Certificate Condition 16, and a ninth station (FR1) added by PG&E to capture the background conditions in the Fall River above Pit 1 Forebay.

For the purposes of this document the bypass reach of the Fall River was defined as the reach extending from the Pit 1 Forebay Dam to the confluence with the Pit River. This section, which includes Fall River Pond and the cascade section immediately upstream of the confluence, will be identified as the Lower Fall River Reach. Similarly, the Pit River bypass reach (Pit 1 Reach) is defined as the river section extending from the confluence with the Fall River downstream to the Pit 1 Powerhouse tailrace.

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2.1.2 Quality Control Review Procedures

2.1.2.1. Water Temperature

In accordance with the Quality Assurance Program Plan (QAPP) (PG&E 2006), control of water temperature measurement accuracy was addressed by instrument calibrations at standard conditions. Quality control calibrations were performed on each recorder in a laboratory setting (i.e., American Standard Test Methods - water bath) at the end of each monitoring period. The minimum accuracy of all digital recorders was ± 0.1°C between 5°C and 40°C. A summary of applicable quality control and assurance (QA/QC) certificates and field deployment logs are presented in Appendix A.

Redundant recorders were installed at each station; data from only one recorder (by convention primary recorder "A") was used to characterize conditions at each Station. If recorder "A" had a failure, the entire data set from the secondary recorder "B" was used to define the station. At no time during the 2004-2008 monitoring efforts was data lost due to either a recorder failing or instrument being lost. In six instances, recorders failed to pass post deployment calibration (Appendix A). Calibration data from these recorders verified that the units were out of compliance at the near-zero temperature, which typically indicates low battery conditions. At calibration temperatures within the range observed during *in situ* deployment, all recorders were still within ± 0.2 to 0.4°C. As a result, no change to the *in situ* database from stations where out of tolerance recorders were deployed was made based on this in-depth evaluation of the calibration data.

2.1.2.2. *In situ* Water Quality

In accordance with the QAPP (PG&E 2006), control of *in situ* measurement accuracy was addressed by instrument calibrations at standard conditions (*e.g.*, dissolved oxygen in saturated air) and the use of standard solutions (*e.g.*, pH standards, conductivity standards, etc.). *In situ* results were corrected if post-calibration of instruments showed drift exceeding manufacturer specifications (*i.e.*, >0.5 mg/L for dissolved oxygen concentration, or >0.05 pH units for pH). Dissolved oxygen measurements were periodically verified using Winkler titration of water samples collected in the field, and results were corrected accordingly. A summary of applicable quality control and assurance (QA/QC) certificates and field calibration logs are presented in Appendix A.

2.1.3 Water Temperature

Continuous water temperature monitoring was conducted at all nine stations to characterize water temperature throughout the Project (Table 2-1). Each station was instrumented with redundant recorders as required by Condition 16 of the 401 Water Quality Certificate. All recorders were installed by May 16 of each year unless high flow conditions prevented safe access into the stream channel. Each water temperature recorder was deployed inside a protective metal housing which was locked to the stream bank with a steel chain. Every effort was made to identify stations providing representative and homogeneous thermal conditions, accessibility, and acceptable security from vandalism or theft. All recorders were left installed through October of each year.

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2.1.4 Water Quality

Water quality was measured *in situ* at each of the nine stations using a HydroLab® Quanta. The analytical parameters of interest (specific conductance (conductivity), dissolved oxygen (DO), pH, total dissolved solids (TDS), and turbidity) were measured at each location (along with synoptic water temperature) on a bi-weekly basis during the monitoring period. All instrumentation was maintained and calibrated according to manufacturer's specifications. All data were collected using standard methodologies and in conformance with the Quality Assurance Program Plan (QAPP) (PG&E 2006).

2.1.5 Stream Flow

Six flow monitoring stations were used to define the hydrological characteristics in the study area, including U. S. Geological Survey (USGS) gaging stations maintained by PG&E, powerhouse flow data, and temporary continuous flow installations at three stations. The three temporary stations were comprised of the two locations specified in Condition 16, a third station (PR1) added by PG&E on the Pit River at Pittville to capture flows entering the Project upstream of the Fall River confluence (see Table 2-1). These temporary monitoring stations were operated independent of the Licensee's operation of the official USGS flow stations. During routine site visits, stream stage was recorded and flow measurements made to define the stage-flow relationship at the temporary stations. All three temporary flow monitoring stations were instrumented with a continuous recording data recorder equipped with a pressure transducer. Streamflow measurements were made using USGS approved streamflow measurement techniques. All measurements were made using a Price AA-type flow meter and 5-foot top-setting wading rod, or float mounted Acoustic Doppler Profiler (APD) system. Measurement accuracy is considered within 10-15% due to the large substrate in the channel control.

2.1.6 Meteorology

Two meteorological stations collected data, one at the Pit 1 Diversion and another on the Pit 3 intake in Lake Britton (see Figure 2-1). A full suite of meteorological data was collected and stored on an hourly average basis. These data included air temperature, wind speed, wind direction, relative humidity and solar radiation. These stations are operated independent of any other meteorological stations located in the regional area.

2.1.7 Annual Reporting

Comprehensive data reports have been provided on an annual basis, and submitted to the SWRCB, Central Valley Regional Water Quality Control Boards (CVRWQCB), California Department of Fish and Game (CDFG) and U.S. Fish and Wildlife Service (USFWS) following each year's monitoring effort. The reports include all monitoring results for the prior year and some analysis of conditions relative to historical data (PG&E 2004, 2005, Spring Rivers 2006, 2007, 2008).

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2.2 Changes to Watershed Conditions

2.2.1 Pre 2003 License Conditions

Water resource conditions prior to the 2003 License requirements were defined by monitoring programs conducted to support relicensing of the Pit 1 Project by PG&E between 1990 and 1992. The results of this monitoring effort were presented in Exhibit E of the License Application issued in December 1993 (PG&E 1993). The complete results will not be restated as part of this document; however a few summary characterizations are presented to contrast current conditions with those existing as part of the original relicensing investigations.

PG&E's relicensing water quality studies suggested that the Project had altered the quality of water resources in the Pit River downstream of the Fall River confluence. This impact was primarily the result of the diversion of Fall River water at the Pit 1 diversion complex and the impounding of these waters in the Pit 1 Forebay. The primary area of Project-related impact occurred in the bypass reaches of the Fall and Pit rivers.

As part of the diversion of Fall River flows to Pit 1 Powerhouse, no minimum instream flow (MIF) release was made to the Lower Fall River. This effectively dewatered the final 0.35 kilometers of the Fall River channel and reduced inflow into the Pit River immediately upstream of the Pit River weir (Fall River confluence). The diversion of Fall River water from these sections effectively eliminated a major source of flow tributary to the Pit River upstream of the Pit 1 Powerhouse tailrace. As defined by the 1990–1992 monitoring effort, the Pit 1 reach experienced extended periods of elevated water temperature (greater than 20 °C), and variable dissolved oxygen (DO) concentrations that often were below some of the Basin Plan criteria. These conditions were attributable to the reduced flows from the Fall River, the impounding of the Pit River by the Pit River Weir, and the large amount of irrigation return-flow occurring upstream of the project area.

During the 1990–1992 Pit 1 relicensing investigations, measured water quality parameters in the Pit 1 reach that did not meet the various regulatory objectives were; stream temperature, pH and dissolved oxygen. The water quality of the Pit 1 bypass reach is strongly influenced by the quality of flows entering the system from upstream sources. The temperature of waters coming into the Project area from the upper Pit River system often exceeds recommended levels for cold water fisheries during the summer period (June-September), regularly exceeding 20 °C (PG&E 1992). The seasonally significant volume of irrigation and agricultural return water received by the Pit River upstream of Fall River Mills is high in biostimulating constituents (such as suspended solids and nutrient compounds). These constituents increase the production of algae, often significantly impacting DO levels in the river. These poor upstream conditions were exacerbated by the low gradient, low velocity, and high volume morphology of the river in this reach up to the end of Big Eddy. Monitoring conducted in 1991–1992 confirmed that DO levels in the Big Eddy reach were strongly affected by the diurnal cycle of algae production. Oxygen levels were highly elevated during the late afternoon and depressed to near anaerobic conditions in the early morning. Average DO concentrations however, were typically adequate for aquatic life (PG&E 1992). Water quality conditions in the Pit River downstream Big Eddy improved with distance as significant accretion occurs in the lower section of the Pit 1 Reach.

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2.2.2 Muck Valley Operations

Between the 1990–1992 monitoring, conducted as part of the Pit 1 Project relicensing, and the issuance of the new license in 2003, no change in management of diversion flows associated with the Pit 1 Project occurred. However, beginning in 1993 the flow regime in the Pit River upstream of the Project was altered by the full time operations of the Muck Valley hydroelectric facility. The operating cycle used by this facility creates a condition of both diurnally and temporally fluctuating flows in the Pit River. The diurnal cycle created by the facility is the result of a reduced-period-operating regime, with operations occurring from 1200 to 1800 hours daily (pers. com. Dan Martin (formerly Kogut) PG&E Hydrographer; Burney, California 1995). The temporal operating cycle used by the powerhouse is based on a 5-day operating period, with the facility operating Monday through Friday and shutting down Saturday through Sunday. All downstream water rights must first be fulfilled prior to operating this facility, as a result during low flow periods this facility can only operate when flows are above a minimum level. A minimum release is maintained from this facility during low flow periods. Monitoring in the Big Eddy pool was conducted by PGE in 1995 (PG&E unpublished data), and confirmed the general change in hydrologic regime created by Muck Valley operations.

2.2.3 Licensee Operational Transitional Change between 1994-2001

In the early 1990s, local residents perceived the surface aquatic vegetation on Fall River Pond as aesthetically undesirable, a source of unpleasant odors and mosquitoes, and an impediment to recreational uses of the pond, primarily fishing. In response, PG&E in 1994 began implementing periodic flushing flows through Fall River Pond to remove vegetation. Between 1994 and 2001, nine flushing flows occurred through Fall River Pond under the previous license, which had no MIF release condition to the Lower Fall River. During this period, PG&E commissioned studies to document the vegetation levels through aerial and ground level photography to evaluate the effectiveness of the flushing flow. No water quality study was conducted concurrent to the vegetation/flushing flow study until after the new license was issued in September 2003.

2.2.4 Licensee Operational Changes Associated with New License

In 2003, PG&E implemented the new MIF release schedule as specified in the 401 Certificate. Table 2-2 defines the current MIF and the potential adaptive management MIF schedule for the Fall River downstream of the Pit 1 Forebay under the adaptive water quality management periods (each of which are three years long), as described in Condition 17 of the 401 Water Quality Certificate.

In addition, as part of the compliance requirement in the Article 401 Conditions 13 and 14 in the new license, PG&E resumed periodic flushing flow events annually from Pit 1 Forebay. Flushing flow events are conducted one weekend a month in May-June, July, and August. The Flushing Flow Plan was submitted to SWRCB in July 2004 and commenced in May 2005 (the Plan was later approved by FERC in April 2006). Annual reports have been submitted since 2005 (Spring Rivers, 2006a, 2007a, 2008a and 2009). Under the new license conditions, the Pit 1 bypass reach now receives a constant inflow of 150 cfs during the period June through October.

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Table 2-1. Monitoring Stations and Descriptions.

ID	Station Location	Monitoring Activity	Rationale
FR1	Fall River above the Project diversion to Pit 1 Powerhouse/Forebay	TR, WQ	Representative of background conditions in Fall River above Project impoundment (Pit 1 Forebay).
FR2	Fall River at Pit 1 Forebay Dam (in Forebay)	TR, WQ	Characterize water quality in Fall River within Project, current operations.
FR3	Fall River Pond at Weir	TR, WQ	Characterize water quality in Fall River Pond under current operations.
FR4	Lower Fall River near confluence with Pit River	TR, WQ	Characterize water quality conditions in Lower Fall River before the confluence with the Pit River under current operations.
PR1	Pit River at Pittville	TR, WQ, F	Characterize water quality conditions in the Pit River upstream of the Project, before the confluence with the Fall River
PR2	Pit River at Big Eddy	TR, WQ, F	Characterize water quality in the Pit River upstream of the canyon reach and the inflow of natural spring accretion flows
PR3	Pit River downstream of Pit River Falls	TR, WQ	Characterize water quality in the canyon section of the Pit River
PR4	Pit River at the footbridge upstream of the Pit 1 Powerhouse	TR, WQ, F	Characterize water quality in the downstream end of the canyon, below the inflow of natural spring accretions
PR5	Pit River downstream of the Pit 1 Powerhouse	TR, WQ	Characterize water quality downstream of Pit 1 Powerhouse and the return of full volume of Fall River flows to Pit River
P1FB	Pit 1 Forebay Diversion	Met	Characterize ambient conditions within the Project area
P3IN	Pit 3 Intake Tower	Met	Characterize ambient conditions within the regional area

TR=Temperature Recorder

WQ=*In Situ* Water Quality Measurement

F=Flow Monitoring

Met=Meteorological Station

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Table 2-2. Summary of Potential Minimum Flow Requirements under the Adaptive Water Quality Management Period.

Evaluation Period	Scheduled Release by Period [1] (cfs) Nov-1 to Nov-15	Nov-16 May-15	May-16 May-31	June-1 Oct-31
Current [2]	75	50	75	150
2nd 3-yr period	125	NC [3]	125	200
3rd 3-yr period	150	NC	175	250
4th 3-yr period	NC	NC	200	300
5th 3-yr period	NC	NC	NC	350
6th 3-yr period	NC	NC	NC	400

1: The Licensee shall make continuous flow releases from the Pit 1 Forebay into the Lower Fall River thence the Pit River and maintain instantaneous flows downstream of the Fall River Pond as measured at the Fall River Weir.

2: First 5-year evaluation period (2004-2008).

3: NC = No change in schedule release.

Note: This table presents a release schedule that will be executed under the incremental adaptive water quality management periods as described in Condition 17 of the 401 Water Quality Certificate. The incremental flow schedule will be implemented if it is shown that the existing flow release is not able to reasonably protect beneficial uses. The adaptively implemented flow in increments of 50 cfs shall be limited to the period in which the beneficial uses are affected.

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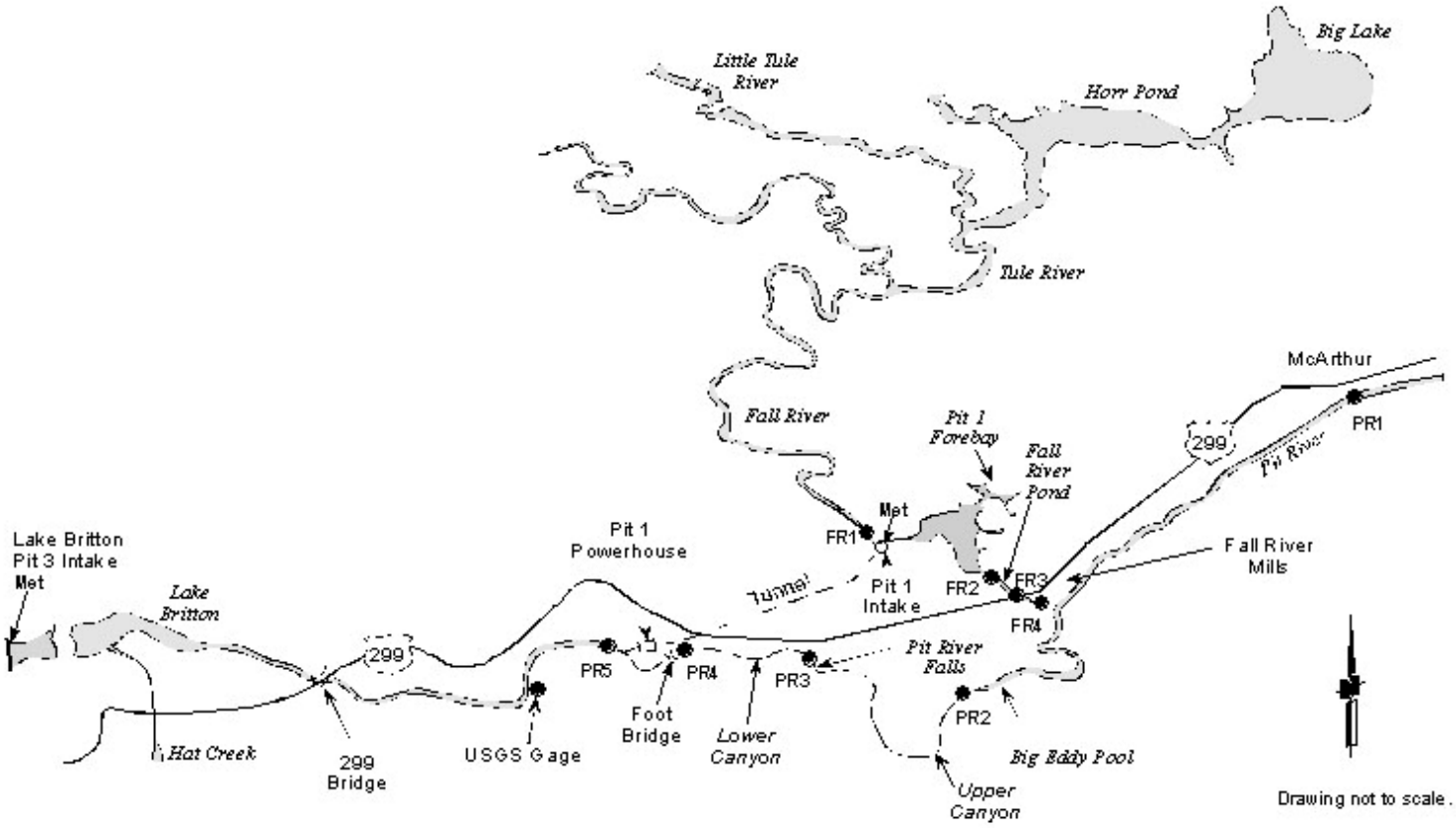

Figure 2-1. Regional map locating monitoring stations.

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Evaluation of Results and Discussion

3.1 Characterization of Monitoring Years

3.1.1 Environmental Conditions

3.1.1.1. Meteorology

A detailed presentation of data from the two temporary meteorological stations is not presented in this document; rather this information is presented in each of the annual reports (PG&E 2004, 2005, Spring Rivers 2006, 2007, 2008). Data from these locations are collected primarily in support of the annual water temperature monitoring conducted as part of the compliance monitoring effort.

Data from the National Weather Service (NWS) stations operated at the Alturas Ranger Station (RS) is presented in order to place the 2004–2008 monitoring periods in context with the historical record. Average monthly air temperature conditions reported from the Alturas RS NWS stations are presented for the 1990 to 2008 period of record in Table 3-1. Table 3-1 also contains a statistical summary of the entire period of record 1905 to 2008. Table 3-2 presents the exceedance ranking for air temperatures from the same station for the 1990–2008 period. As indicated, monitoring years with data sets that exceeded 5 missing days were discretionally considered not part of the exceedance statistics.

3.1.1.2. Hydrology

The complete data set from each of the three temporary flow monitoring stations is not presented in this document; rather this information is presented and discussed in each of the annual reports (PG&E 2004, 2005, Spring Rivers 2006, 2007, 2008). Data from these stations will be used to discuss change in the hydrologic regime in later sections.

Stream flow data from the USGS permanent gaging station located in the Pit River downstream of Pit 1 Powerhouse (downstream of Project) are summarized for the 1990 to 2008 period of record in Table 3-3. Data from the USGS Gage are presented in order to place the 2004–2008 monitoring periods in context with the recent historical record. Table 3-3 also contains a statistical summary of the entire period of record (1975 to 2008).

3.1.2 Water Year Classification

The water year types for the 2004–2008 periods are presented in Table 3-4. Water years are defined using the index generated by the Department of Water Resources (DWR) for the Sacramento River basin (CDEC 2009). Table 3-4 also presents the annual runoff exceedance at the USGS Stream Gage located on the Pit River downstream of Pit 1 Powerhouse for the 1990–2008 period. As indicated by the data presented in Table 3-4, 2004 and 2005 received below normal rainfall, 2006 was considered wet. The 2007 and 2008 years were both considered dry, with 2008 falling under the critically dry index. Based on this information, the 2004 through 2008 monitoring efforts were effectively conducted across a full spectrum of runoff conditions.

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In contrast, data in the relicensing study period (1990-1992) were obtained when a series of consecutive critical dry water years occurred, representing a unique set of worst case scenario.

3.2 Basin Plan Objectives

PG&E uses water at the Project for non-consumptive storage and power generation. PG&E also operates the Project in support of several other beneficial uses identified the Basin Plan for the Fall River and the Pit River. The Basin Plan identifies surface water bodies that drain into the upper Central Valley of California, including the Fall River and Pit River, and identifies beneficial uses for each major river. The existing and potential beneficial uses for the Project-affected reaches of the Fall River and Pit River are listed in Table 3-5.

The Fall River is designated for municipal and domestic water supply, water supply for irrigation and stock watering, power production, contact and non-contact recreation, cold and warm freshwater habitat, and wildlife habitat. The Pit River in the Project-affected reach (confluence of the forks of Pit River to the mouth of Hat Creek) is designated for all of the beneficial uses designated for the Fall River, and also warm water spawning.

The following sections discuss the specific beneficial use objectives for each parameter monitored.

3.2.1 Conductivity

No numeric or narrative criteria specific to the Fall or Pit rivers has been established in the Basin Plan.

3.2.2 Dissolved Oxygen

The Basin Plan requires that "*The monthly median of the mean daily dissolved oxygen (DO) concentration shall not fall below 85 percent of saturation in the main water mass, and the 95 percentile concentration shall not fall below 75 percent of saturation*". Furthermore, for waters designated for the COLD and SPWN beneficial uses (both the Fall River and Pit River) the dissolved oxygen concentration cannot drop below 7 mg/L at any time. For water designated for the WARM beneficial use (both the Fall River and Pit River) dissolved oxygen concentration cannot drop below 5 mg/L at any time.

3.2.3 pH

The Basin Plan states that "The pH shall not be depressed below 6.5 nor raised above 8.5. Changes in normal ambient pH levels shall not exceed 0.5 in fresh waters with designated COLD or WARM beneficial uses. In determining compliance with the water quality objective for pH, appropriate averaging periods may be applied provided that beneficial uses will be fully protected". Since the Project-affected reaches of both the Pit and Fall rivers are designated for the COLD beneficial use, these criteria apply. A pending revision to the Basin Plan (RWQCB-CVR 2007b) would eliminate the requirement of a maximum change in pH of 0.5 units when pH is between 6.5–8.5. The pending revision would also eliminate the clause allowing for appropriate averaging periods to be applied in determining compliance with Basin Plan criteria

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for pH. This amendment will take effect upon approval by the State Water Board, Office of Administrative Law, and the U.S. Environmental Protection Agency (USEPA).

3.2.4 Turbidity

The Basin Plan states that "*waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases in turbidity attributable to controllable water quality factors shall not exceed the following limits:*

- *0–5 NTUs background (natural), increases shall not exceed 1 NTU*
- *5–50 NTUs background, increases shall not exceed 20 percent*
- *50–100 NTUs background, increases shall not exceed 10 NTUs*
- *>100 NTUs, increases shall not exceed 10 percent*

In determining compliance with the above limits, appropriate averaging periods may be applied provided that beneficial uses will be fully protected". A pending amendment to the Basin Plan (CVRWQCB 2007b) would change the criteria for waters with background turbidity of less than 1 NTU to "controllable factors shall not cause downstream turbidity to exceed 2 NTUs". This amendment will take effect upon approval by the State Water Board, Office of Administrative Law, and the USEPA.

3.2.5 Water Temperature

Since the Basin Plan does not provide a numerical Water Temperature Objective other than limitations on warming (described below) that are applicable to project operations, the Licensee used background conditions as definitive of conditions outside Project influence. As such, the degree to which the Project altered temperatures was evaluated more closely than achieving a particular numerical threshold. The Basin Plan states that "*The natural receiving water temperature of interstate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Quality Control Board that such alteration in water temperature does not adversely affect beneficial uses. Increases in water temperatures must be less than 2.8°C above natural receiving-water temperature*".

3.3 Summary of 2004–2008 Monitoring Results

3.3.1 Fall River

The primary change to conditions in the Lower Fall River Reach was the implementation of MIF releases to the Lower Fall River Reach. As discussed previously, there was no MIF in the Lower Fall River Reach prior to the new license requirements. The only flow through Fall River Pond at this time was the Knochs water rights delivery. In addition to the current MIF requirement, a summer flushing flow schedule became part of the compliance requirement in 2003 based on the

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401 Certification requirements. Prior to the issuance of the 2003 license, PG&E initiated periodic flushing flows since 1994 in response to the concern raised by local residents for aquatic vegetation growth and mosquito control. None of the synoptic *in situ* water quality sampling conducted during the 2004–2008 period was performed coincident with any of the flushing flow tests. The continuous water temperature monitoring effort was in place during all flushing flow events.

3.3.1.1. Water Quality

Results of the 2004–2008 water quality monitoring are summarized in Table 3-6. A complete presentation of each year's data is contained in the individual annual reports (PG&E 2004, 2005, Spring Rivers 2006, 2007, 2008). An analysis of frequency distribution for each parameter is presented in Table 3-7.

Specific conductivity (SpC) is a measure of the total dissolved solids in a water body. The Fall River entering the Project (FR1) exhibited SpC levels ranging from 129 to 163 µS/cm (Table 3-6). For the three stations downstream of Pit 1 Forebay, SpC levels ranged from 121 to 163 µS/cm (Table 3-6). Figure 3-1 compares the results of the frequency distribution analysis for SpC levels for all stations in the Fall River. As indicated, there is no apparent alteration in SpC levels associated with Project facilities.

For Fall River water entering the Project (FR1), DO levels ranged from 8.2 to 11.5 mg/L for all periods during the 2004 through 2008 monitoring effort. In comparison, DO levels at the three stations downstream of the Pit 1 Forebay ranged from 6.1 to 12.4 mg/L during the same period (Table 3-6). Figure 3-2 compares the results of the frequency distribution analysis for DO levels for all stations in the Fall River. Figure 3-3 compares the results of the frequency distribution for DO saturation for all stations in the Fall River. As indicated by these data, the range in DO (level and saturation) seen in Pit 1 Forebay (FR2) and at the Fall River Pond weir (FR3), is slightly larger than levels measured upstream of the Project (FR1). The larger range is attributed to the high degree of biological activity present in both the Pit 1 Forebay and Fall River Pond. The increased productivity is typically manifested as algal blooms that commonly occur any time between July and September. All three of the upper stations exhibit levels of DO saturation reflective of high photosynthetic input derived from the comparatively low velocity, long residence time, highly productive environments in which they are located. The last station on the Fall River (FR4) exhibited DO saturation levels with a much smaller range. This is reflective of the high gradient, high velocity channel morphology (short residence time) observed in this section.

With regard to Basin Plan objectives, DO was never measured at levels less than the WARM criteria of 5.0 mg/L in any of the Fall River stations during the 2004 to 2008 monitoring periods. DO levels at two Fall River Stations (FR3 and FR4) had measured DO levels less than the COLD criteria of 7.0 mg/L criteria listed for COLD and SPWN uses on six occasions during the 2004–2008 monitoring efforts. At the FR3 station, five of the 55 samples had measured levels less than 7.0 mg/l. All of these samples were collected between 9:00 and 11:00 in the morning. At the FR4 station, only one of the 55 samples was measured at a level less than 7.0 mg/l. This sample was collected at 12:45. These low DO levels were never measured on consecutive biweekly visits, indicating that the conditions were transitory. For the two stations (FR3 and

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FR4) where DO levels were below the COLD criteria, the median DO saturation for all samples was 105% and 96% respectively. The 95% exceedance value for DO saturation at these stations was 80% and 89%, respectively. These measurements represent twice-a-month synoptic readings over a six month period. The Basin Plan criteria for DO saturation is based on monthly medians of daily average DO readings. As a result, these values are not directly comparable with Basin Plan criteria for DO percent saturation. Currently, DO levels in the Fall River downstream of Pit 1 Forebay occasionally do not met the Basin Plan objective for DO as defined by the COLD beneficial use criteria. However, these excursions outside the objectives are related to the high level of aquatic vegetation present in these waters (as attached aquatic plants and pelagic algal species). The measurements are collected synoptically, and some or all of the low values may reflect minima or near minima of the natural diel cycle.

For Fall River water entering the Project area (FR1), pH levels ranged from 7.6 to 9.0 units for all periods during the 2004 through 2008 monitoring effort. The naturally low buffering capacity of the Fall Rivers waters combined with seasonally elevated levels of algal activity produces pH levels that are naturally above basin plan criteria. In comparison, pH levels at the three stations downstream of the Pit 1 Forebay ranged from 7.7 to 9.5 units during the same period (Table 3-6). Figure 3-4 compares the results of the frequency distribution for pH levels for all stations in the Fall River. As indicated by the data, the range in pH coming into and leaving the Pit 1 Forebay is similar. The Project receives these elevated levels and passes them essentially unchanged through the system. With regard to the Basin Plan objectives for pH, Fall River water entering the Project consistently exceeds the 8.5 upper threshold. Since pH entering the Project regularly exceeds the Basin Plan objectives, only the change in pH was evaluated as it moved through the Project affected reach. On average, pH levels downstream of Pit 1 Forebay are less than 0.3 units higher than those measured entering the Project. Any increase in pH is attributed to the residence time in Pit 1 Forebay and the affect of algal production on pH levels resulting from the extended contact time.

Turbidity in the Fall River during the summer monitoring period was comparatively low. Levels entering the Project ranged from 0.4 to 16.4 NTU. Turbidity in the Fall River downstream of the Forebay ranged from 0.2 to 16.4. As indicated in Table 3-6, average turbidity at all four stations was very similar. Figure 3-5 compares the results of the frequency distribution for turbidity levels for all stations in the Fall River. As indicated by the data, the range in turbidity coming into and leaving the Project area is similar. Basin Plan objectives for turbidity are based on the background conditions. In the case of the Fall River during the May through October monitoring period, the following two criteria would apply: 1) When background (natural) conditions range from 0–5 NTU, any increase in turbidity shall not exceed 1 NTU, and 2) when background conditions range from 5–50 NTU, increases shall not exceed 20 percent. The 2004–2008 data indicate that Project facilities on the Fall River do not increase turbidity and meet Basin Plan Standards

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3.3.1.2. Water Temperature

Results of the 2004–2008 water temperature monitoring are summarized in Table 3-8. A complete presentation of each year's data is contained in the individual annual reports (PG&E 2004, 2005, Spring Rivers 2006, 2007, 2008). An analysis of frequency distribution for each water temperature station is presented in Table 3-9.

For the period June through September (2004–2008), daily average water temperatures entering the Project from the Fall River (FR1) ranged from 12.5 to 21.8 °C. In comparison, daily average water temperature leaving Pit 1 Forebay (FR2) ranged from 14.2 to 25.5 °C. Figure 3-6 compares the results of the frequency distribution for daily average water temperature for all stations in the Fall River. As indicated, Pit 1 Forebay exerts some level of thermal loading on waters passing through the system. Once waters have passed through the forebay, water temperatures remain relatively constant as flow moves downstream to the Pit River.

The 10% exceedance for FR1 presented in Table 3-9 is 20.3 °C; indicating that 90% of the daily average temperatures were below this value. The 10% exceedance for FR2 was 23.0 °C (Table 3-9). The 90% exceedance temperature at FR1 was 15.0 °C, while the 90% exceedance value for FR2 was 17.0 °C. This suggests the range for thermal loading is on the order 2.0 to 2.7 °C. Calculating a more exact range for thermal loading through Pit 1 Forebay is complicated by the difficulty in estimating travel time through the forebay. Travel time is affected by changes in the storage versus inflow resulting from peaking operations at Pit 1 Powerhouse. Complicating the issue further is the inflow and outflow configuration of the forebay. The Fall River flows into the Forebay immediately upstream of the Pit 1 Powerhouse Intake. The body of the forebay is downstream of this location and as such a large segment of the forebay becomes isolated with only the MIF acting as a means of volume exchange (Figure 2-1). Simplistic calculations based on the current MIF of 150 cfs suggest a residence time on the order of 9 days (replenish the forebay). This represents a dramatic reduction from past operations when no MIF flow was released (a 30-cfs release for water rights supply would require 38 days to replenish). A more realistic estimate for residence time in the forebay (based on typical generation scenario) indicates that the time required to replenish the forebay is probably reduced to some range of time greater than 30 hours but significantly less than the 9 days calculated for the 150 cfs flow rate alone.

In an effort to estimate thermal loading occurring through the forebay, the daily mean change was calculated between Stations FR1, FR2 and FR3. The results of this analysis are presented in Table 3-10. Thermal loading between FR1 and FR2 during the 2004–2008 June through September period average 2.2 °C. Thermal loading in July through August averaged 2.5 °C between the same two stations. The maximum daily thermal loading through the forebay was measured in July at 4.3 °C. Thermal loading through the entire Project affected reach of the Lower Fall River (Station FR1 to FR3), averaged 2.2 °C for the June through September 2004–2008 period.

The influence of Fall River flushing flows on the water temperature regime in the lower Fall River was evaluated on data from the August 2008 flushing flow event (on 8/16-8/17). Figure 3-7 compares the hourly average water temperature with stream discharge from Station FR3 and

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FR4 in the Lower Fall River Reach. As indicated, the flushing flow event generates a change in the pattern of diel water temperature exhibited at both stations. Temperatures at each station were essentially the same, with the diel cycle being reduced by approximately 1 to 1.5 °C during the event. The diel cycle was affected such that the daily maximum was reduced, with little effect on the daily minimum; as a result the daily average temperatures were reduced by approximately 0.7 °C. This temperature reduction is indicative of the maximum potential for minimizing heating through the forebay if a majority of incoming Fall River flows approximately 580 cfs were being released in to the Lower Fall River Reach. Under a linear assumption, the likely reduction in daily average temperature is estimated at 0.1 °C or less per 50-cfs incremental increase from the current 150 cfs MIF condition.

3.3.1.3. Stream Flow

The MIF releases from PG&E's Pit 1 Forebay required by the 401 Certification were initiated in 2004. Water travels through Fall River Pond and is spilled into the last segment of the Fall River at the Fall River Weir; additionally, some water is diverted at this location to the Knoch's Ranch via the Knoch Diversion structure. The Knoch diversion is approximately 1.1 kilometers downstream from the Pit 1 forebay dam and an agricultural diversion which takes water released from Pit 1 Forebay into the Fall River Pond and uses it on lands adjacent to the Pit River. This diversion is typically 14-16 cfs but has a maximum capacity in excess of 20 cfs.

Prior to 2008, there was no stream gage facility that recorded discharge in the Fall River below the Fall River Pond Weir. The flow release was estimated based on synoptic readings from PG&E's Pit 1 Forebay (PG&E gage No. PH-57) and Knoch Diversion (PG&E gage No. PH-40). These readings were converted to discharge based on existing stage-discharge relationships. The record from these release calculations was reviewed by the USGS (as traditional for compliance gages) because this was an interim release solution until capital improvements were made to install a new stream gaging system. FERC reviewed the 2004–2007 release data with these conditions in mind (pers. com. Dan Martin, former PG&E Hydrographer; Burney, California, 2005).

The real-time stream discharge gage became operational in 2008. The gage was constructed over the Pit 1 Forebay spill channel, and measures all flow entering Fall River Pond from the forebay. In addition, newly installed (2008) equipment at Gage PH-40 measures flow and telemeters the information to Pit 1 dam which then adjusts the water release from the forebay (if necessary) in order to meet the minimum flow release requirement at the Fall River Weir (designated PG&E gage No. PH-57C). Flow at this location is calculated as: Pit 1 Forebay release (PH-57) – Knoch Diversion (PH-40) = the net release in Fall River below Knoch Diversion (designated PH-57C). Figure 3-8 presents the daily average flow from this gage for the period May 16 through October 31, 2008. The figure illustrates the typical non-runoff period flow regime downstream of the Pit 1 Forebay including seasonal increases to meet downstream water rights deliveries and periodic flushing flows.

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3.3.2 Pit River

The primary change to conditions in the Pit 1 Reach of the Pit River was the implementation of MIF releases into the Lower Fall River Reach. As discussed previously there was no MIF in the Lower Fall River Reach prior to the 401 Certification requirements. In addition to the MIF currently required, summer flushing flows from the Fall River have also altered the flow regime in this section of the Pit River. None of the synoptic *in situ* water quality sampling conducted during the 2004–2008 period was performed coincident with any of the flushing flow tests. The continuous water temperature monitoring effort was in place during all flushing flow events.

3.3.2.1. Water Quality

Specific conductivity (SpC) is a measure of the total dissolved solids in a water body. The Pit River entering the Project exhibited SpC levels ranging from 130 to 333 µS/cm (Table 3-6). For the three stations in the Pit 1 Reach (PR2, PR3 and PR4), SpC levels ranged from 135 to 249 µS/cm (Table 3-6). Figure 3-9 compares the results of the frequency distribution analysis for SpC levels for all stations in the Pit River. Once flows are recombined below the Pit 1 Powerhouse (PR5), SpC levels ranged from 138 to 178 µS/cm reflecting the influence of the Fall River (Table 3-6). As indicated, there is a significant reduction in SpC levels at both locations where Fall River water is introduced into the Pit River. A slight decrease in SpC levels occurs in the Pit 1 Reach between Big Eddy and the Pit 1 Footbridge due to the infusion of accretion flow in the bypassed reach. Downstream of the Pit 1 Powerhouse tailrace (PR5), SpC levels are stable and consistent, due primarily to the ambient condition from Fall River (see FR1 in Figure 3-1 and Table 3-6).

For Pit River water entering the Project area (PR1), DO levels ranged from 5.6 to 12.7 mg/L for all periods during the 2004 through 2008 monitoring effort. In comparison, DO levels at the three stations in the Pit 1 Reach ranged from 6.2 to 11.0 mg/L during the same period (Table 3-6). DO levels leaving the Project area as combined Pit and Fall River flows (PR5), ranged from 7.5 to 10.2 mg/L (Table 3-6). Figure 3-10 compares the results of the frequency distribution analysis for DO levels for all stations in the Pit River. Figure 3-11 compares the results of the frequency distribution analysis for DO saturation levels for all stations in the Pit River. As indicated by the data, the range in DO values in the Pit 1 reach is smaller than that exhibited upstream of the Project. The smaller range is attributed to the dilution and flushing effect provided by the MIF release from the Fall River.

With regard to Basin Plan objectives, DO in the Pit River was never measured at levels less than the WARM criteria of 5.0 mg/L in any of the Pit River stations during the 2004–2008 monitoring periods. DO levels at four Pit River Stations (PR1, PR2, PR3, and PR4) had measured DO levels less than the COLD criteria of 7.0 mg/L criteria listed for COLD and SPWN on eight occasions during the 2004–2008 monitoring efforts. At the PR1 station, four of the 57 samples had measured levels less than 7.0 mg/l. All of these samples were collected between 8:00 and 10:00 in the morning. At the PR2 station, three of the 55 samples had measured levels less than 7.0 mg/l. All of these samples were collected between 9:00 and 12:00 in the morning. Only one occurrence of less than 7.0 mg/l was measured at either the PR3 or PR4 stations. These low DO levels were never measured on consecutive biweekly visits, indicating that the conditions were transitory. For the PR1 station, the median DO saturation for all samples was 112 % (Table 3-7).

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The 95% exceedance value for DO saturation was 80% for Station PR1. For the PR2, PR3, and PR4 stations in the Pit 1 Reach, the median DO saturation was 95%, 101%, and 98% respectively. The 95% exceedance values for DO saturation from the same three stations was 89%, 91%, and 89%, respectively (Table 3-7).

DO levels in the Pit River entering the Project area and through the Pit 1 Reach exhibited occasional exceedance of the Basin Plan objective for DO as defined by the COLD beneficial use criteria. The seasonally significant volume of irrigation and agricultural return water received by the Pit River upstream of Fall River Mills is usually high in biostimulating constituents (such as suspended solids and nutrient compounds). These constituents can increase the production of algae, often significantly impacting DO levels in the river. Consequently, Pit River from the confluence of its forks to Shasta Lake has been identified as "Nutrients' and "Organic Enrichment/Low Dissolved Oxygen" impaired segment in the recent 303(d) list with the potential sources attributed to agriculture-grazing related activities (CVRWRCB, 2009). These poor initial conditions are exacerbated by the low gradient, low velocity, and high volume morphology of the river in this reach. In addition, these measurements were collected synoptically, and some of these values may reflect minima or near minima of the natural diel cycle.

For Pit River water entering the Project area (PR1), pH levels ranged from 7.6 to 9.2 units for all periods during the 2004 through 2008 monitoring effort. In comparison, pH levels at the three downstream stations (Pit 1 Reach) ranged from 7.5 to 8.8 units during the same period (Table 3-6). The pH levels leaving the Project area as combined Pit and Fall River flows (PR5), ranged from 7.9 to 9.0 units (Table 3-6). Figure 3-12 compares the results of the frequency distribution analysis for pH levels for all stations in the Pit River. As indicated by the data, the variation in pH coming into the Project area has been neutralized to a smaller range and remained similar in the bypassed reach.

With regard to the Basin Plan objectives for pH, waters entering the Project consistently exceeded the 8.5 upper threshold. On average, pH levels downstream of the confluence with the Fall River (Pit 1 Reach) are 0.2 units lower than those measured at the upstream Pit River station (PR1) which represents conditions entering the Project. The Project receives these elevated levels, moderates the extremes as flows pass through the system. There does not appear to be any nexus between Project operations and maintenance of pH levels that exceed Basin Plan Criteria in the Pit River.

Turbidity in the Pit River during the summer monitoring period was variable depending on runoff conditions and input from upstream agricultural inputs. Levels entering the Project ranged from 2.4 to 192 NTU (Table 3-6). Turbidity in the Pit River downstream of inflow from the Fall River ranged from 2.1 to 216 (Table 3-6). As indicated in Table 3-6, average turbidity at all four stations was very similar. Figure 3-13 compares the results of the frequency distribution for turbidity levels for all stations in the Pit River. As indicated by the data, the range in turbidity coming into the Project area from the Pit River is significantly higher than levels leaving the Project. The decrease is directly attributable to increases in flow associated with the Fall River and other accretion flow occurring downstream of Big Eddy. Basin Plan objectives for turbidity are based on the background conditions. In the case of the Pit River during the May through October monitoring period, the following criteria would apply:

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1) *when background (natural) conditions range from 0–5 NTU, any increase in turbidity shall not exceed 1 NTU,*
2) *when background conditions range from 5–50 NTU, increases shall not exceed 20 percent,*
3) *when background levels range from 50–100 NTU, increases shall not exceed 10 NTU, and*
4) *when background levels are greater than 100 NTU, increases shall not exceed 10 percent.*

The 2004–2008 data indicate that the Project does not increase turbidity in the Pit River.

3.3.2.2. Water Temperature

For the period June through September (2004–2008), daily average water temperatures entering the Project from the Pit River ranged from 12.8 to 25.8 °C (PR1) (Table 3-8). In comparison, daily average water temperature downstream of the Fall River input (PR2) ranged from 13.8 to 25.0 °C (Table 3-8). Figure 3-14 compares the results of the frequency distribution for daily average water temperature for all stations in the Pit River. As indicated, daily average water temperatures in the Pit River upstream of Big Eddy are relatively similar to those entering the Project. This indicates that inflow from the Fall River does not appreciably alter the thermal regime in the Big Eddy section of the Pit 1 reach. Daily average water temperatures begin to decline after the river enters the higher gradient portion between Big Eddy and the confluence with the Pit 1 Powerhouse tailrace. This cooling is attributed to the spring accretion that occurs in the Pit 1 canyon reach. This accretion has been estimated at approximately 100 cfs during the non-runoff period (PG&E 1993a)

Cooling in the Pit 1 canyon reach was evaluated using data from 2004–2008 for the June through September period. This evaluation is summarized in Table 3-11. As indicated, the maximum cooling occurs in July and August with monthly average water temperatures at the Pit 1 Footbridge (PR4) being approximately 2 °C cooler at than those measured in Big Eddy (PR2). Further analysis indicates that July-August cooling in the reach is essentially evenly distributed between the portion of the reach between the Pit River Falls (PR3) and Big Eddy (PR2 in Table 3-11) when compared to the segment of PR3-PR4. The cooling trend per mile or the temperature gradient appears to be linear during the hottest months (July-August as indicated by the slopes for the 10% to 50% exceedance levels) throughout the bypassed reach. The linear trend of cooling suggests that the accretion flow distribution in the bypassed reach is probably uniform.

3.3.2.3. Stream Flow

Flow in the Pit River coming into the Project area (PR1) was measured upstream of the impoundment created by the Pit River Weir. Station PR1 is located at the site of an old DWR flow monitoring station at Pittville. This station is approximately 14.4 kilometers upstream of the weir. Stream flow at this location for the 2004–2008 monitoring period is summarized in

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Table 3-12. A frequency analysis of these data is summarized in Table 3-13. As indicated by the data in Table 3-12, stream flow varies considerably during the May through October period, ranging from 1.23 to greater than 90.0 cfs. Flow at Station PR1 is frequently above the rating established for this location; as a result the absolute maximum was not captured. Data from the 2008 monitoring effort is presented in Figure 3-15 to illustrate the influence of Muck Valley operations on the flow regime in the Pit River near Pittville. As illustrated, the period following the spring runoff is characterized by large diel fluctuations and a weekly cycle driven by Muck Valley operations. As Muck Valley operation end due to minimum flow requirements, and base-flow conditions begin to predominate, the flow regime is characterized by very low flows with little or no diel pattern.

Flow in the Pit River downstream of the confluence of the Pit and Fall rivers was measured at the terminal end of Big Eddy (PR2). Station PR2 is approximately 3.0 kilometers downstream of the Pit River Weir. Stream flow at this location for the 2004–2008 monitoring period is summarized in Table 3-12. A frequency analysis of these data is summarized in Table 3-13. As indicated by the data in Table 3-12, stream flow varies considerably during the May through October period, ranging from 89 to greater than 903 cfs. Flow at Station PR2 is frequently above the rating established for this location; as a result the absolute maximum was not captured. Data from the 2008 monitoring effort is presented in Figure 3-16 to illustrate the influence of Fall River flushing flows and Muck Valley operations on the flow regime in this reach of the Pit River. As illustrated, the period following the spring runoff is characterized by large diel fluctuations and a weekly cycle driven by Muck Valley operations. As Muck Valley operations end due to minimum flow requirements, and base-flow conditions begin to predominate, the flow regime is characterized by very low flows with little or no diel pattern. The Fall River flushing flow events generate significant short term increases in stream flow and stage during the summer base-flow period.

Flows in the Pit River at the terminal end of the Pit 1 Reach were measured at Station PR4. Station PR4 is approximately 9.6 kilometers downstream of the Pit River Weir, and 1.0 kilometer upstream of the Pit 1 Powerhouse tailrace. Stream flow at this location for the 2004–2008 monitoring period is summarized in Table 3-12. A frequency analysis of these data is summarized in Table 3-13. As indicated by the data in Table 3-12, stream flow varies considerably during the May through October period, ranging from 205 to greater than 900 cfs. Flow at Station PR4 is frequently above the rating established at for this location; as a result the absolute maximum was not captured. Data from the 2008 monitoring effort is presented in Figure 3-17 to illustrate the influence of Fall River flushing flows and Muck Valley operations on the flow regime in this reach of the Pit River. As illustrated, the flow regime at this location is very similar to that observed at Station PR2, however, base flow conditions reflect the approximately 100 cfs of spring accretion that occurs in the canyon portion of the Pit 1 Reach.

3.3.2.4. Short-term Temperature Change Resulting from Flushing Flow Event

The influence on Fall River flushing flows was evaluated on its effectiveness in controlling aquatic vegetation growth for each of the 2005 through 2008 monitoring years in their respective annual reports (PG&E 2005, 2006, 2007, 2008). A more detailed evaluation of the effect of the Fall River flushing flow events on the thermal regime was performed on data from the August 2008 event. Figure 3-18 compares the hourly average temperature data with stream discharge

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from Station PR2 in the Pit 1 Reach. As indicated, the flushing flow event generated a significant change in the pattern of diel water temperature. The diel cycle at Station PR2 did not return to pre-event patterns following the event (due primarily to significant change in climatic condition). During the flushing flow test, water temperatures at the end of Big Eddy (PR2) showed a daily average temperature reduction of approximately 0.7°C (comparing August 15 with August 16 daily average value, meteorologically driven change affected a longer comparison). Figure 3-19 presents data isolating Station PR4 during the same August 2008 event. As discussed, this station represents conditions in the terminal end of the Pit 1 Reach, and reflects conditions downstream of the cooling accretion sources. Figure 3-19 also plots the trend in daily average air and water temperature during the flushing flow event. As indicated, the flushing flow event caused the diel cycle to be altered such that the daily maximum was not appreciably altered, but the daily minimum was significantly raised. The resultant was an increase in the daily average temperature at PR4 of approximately 0.8°C (comparing August 15 with August 16 daily average value, meteorologically driven change affected a longer comparison). Air temperatures following the event dropped significantly and are largely responsible for the minimized diel cycle and much lower daily average temperature observed after the event ended.

The change in stage associated with the flushing flow events was also evaluated (Table 3-14). Using stage data from the August 2008 flushing flow event, the maximum hourly average change in stage on the rising limb of the hydrograph was calculated at 0.37 feet, which equated to a change in flow of 126 cfs. The maximum change in stage from pre-event conditions was 1.53 feet. The period required to reach peak stage from initial arrival of the flow event was approximately 10 hours. The maximum hourly average change in stage on the receding limb of the hydrograph was calculated at 0.22 feet, which equated to a change in flow of 85 cfs. The return of stage to pre-event levels required approximately 15 hours from the initial point of stage recession.

3.4 Comparison of 2004–2008 with 1990–1992 Conditions

This section compares the results of monitoring conducted in 1990–1992 with those from the 2004–2008 monitoring efforts. The comparison provides a good reference point to help evaluate the effectiveness of the specific measure pertinent to Conditions 16 and 17 in the Water Quality Certificate.

3.4.1 Fall River

Results of the 1990–1992 water quality monitoring are summarized in Table 3-15. Table 3-16 summarizes a frequency distribution analysis performed on the 1990–1992 similar to that presented in Table 3-7 for the 2004–2008 data set.

3.4.1.1. Water Quality

Based on the frequency analysis performed on data from the 1990–1992 monitoring effort, Fall River SpC values tended to increase slightly as they passed through the Pit 1 Forebay complex

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(Figure 3-20). In comparison, data from 2004–2008 indicates little longitudinal change in SpC levels (Figure 3-20). The comparison presented in Figure 3-20 suggests that the current MIF has positively influenced SpC levels in the Lower Fall River Reach by passing conditions present upstream of the Project largely unchanged to the Lower Fall River.

A frequency analysis was used to compare the DO and DO saturation from the 1990–1992 and 2004–2008 periods. Figure 3-21 compares DO levels from these two periods, and Figure 3-22 compares DO saturation levels. The 1990–1992 data indicated there was little change in DO conditions occurring in the Pit 1 Forebay. However, the range in DO saturation levels increased as water became nearly stagnant in Fall River Pond. In comparison, DO conditions during 2004–2008 showed little change through the Pit 1 Forebay as compared with conditions entering the project. The data do suggest that the range in DO levels in Fall River Pond were reduced in 2004–2008 due to the effect of the current MIF. The comparison presented in Figures 3-21 and 3-22 suggests that the current operation has positively influenced DO levels in the Lower Fall River Reach. A detailed discussion as to the influence the periodic flushing flow and MIF have on conditions in the Fall River Pond is presented in the 2008 Flushing Flow Report (Spring Rivers, 2009).

A frequency analysis of pH from the 1990–1992 effort indicates that pH levels were somewhat higher during this period (Figure 3-23). The data also suggest that pH levels increased as water moved through Pit 1 Forebay and the Fall River Pond. This increase is probably related to the longer contact with the biologically active conditions present in the forebay and Fall River Pond under the low release condition present during 1990–1992. In comparison, the 2004–2008 pH levels increased through the forebay, but returned to pre-Forebay conditions as water passed through the Lower Fall River Reach (Figure 3-23). The comparison presented in Figure 3-23 suggests that the current operation has positively influenced pH levels in the Lower Fall River Reach.

Turbidity in the Fall River is composed primarily of aquatic algae during the summer monitoring periods. As such a comparison of pre and post MIF conditions is somewhat subjective. However, a frequency analysis presented in Figure 3-24 indicates that 1990–1992 turbidity levels increased slightly in the forebay and then were reduced through Fall River Pond to levels less than those observed in the Fall River upstream of the Pit 1 Diversion. The 2004–2008 data suggest that turbidity levels declined through both Pit 1 Forebay and Fall River Pond as compared with upstream conditions. Turbidity levels increased at the last station in the Fall River; it is assumed this increase was related to the high energy environment in this section of the river. These changes are not considered a significant change from conditions entering the Project. During both pre and post MIF periods, summer turbidities in the Lower Fall River Reach were consistently low. The comparison presented in Figure 3-24 suggests that the current operation does not influence average turbidity levels in the Lower Fall River Reach.

3.4.1.2. Water Temperature

Results of the 1990–1992 water temperature monitoring are summarized in Table 3-17. An analysis of frequency distribution for each water temperature station is presented in Table 3-18. Figure 3-25 compares results from the frequency analysis of daily average temperatures from the 1990–1992 period with those from 2004–2008. As indicated, the thermal regime during the

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1990–1992 period was slightly warmer than that observed during the 2004–2008 period as indicated by conditions at Station FR1. The overall trend in the range of water temperatures observed in 1990–1992 was continued at Station FR2. Station FR3 exhibited minimum temperatures that appear to have increased relative to the pattern observed in 2004–2008.

Daily average change values were generated for the 1990–1992 data sets in order to compare pre and post MIF thermal loading in the forebay. Results of this analysis are presented in Table 3-19. For the 1990–1992 period, thermal loading in the forebay for the period June through September averaged 2.5 °C. Thermal loading in July and August averaged 2.7 °C for the same period. The maximum daily thermal loading was measured in July at 4.9 °C. When comparing the 1990-1992 data (Table 3-19) with similar analysis of the 2004-2008 data (Table 3-10), the data suggest there was some change to the thermal loading in the forebay resulted from the implementation of the MIF. The reduction in thermal loading (average daily change for 1990-1992 minus average for 2004-2008) was calculated at 0.3 °C (2004-2008 cooler than 1990-1992).

Thermal loading between the inflow condition and the end of Fall River Pond was also evaluated using similar methods. This evaluation covers the entire reach of Project affected impoundments. The comparison of data from FR1 and FR3 for the 1990–1992 period indicates an average thermal loading of 2.9 °C for the June through September period. The maximum daily average thermal loading was measured at 4.8 °C (Table 3-19). In comparison, the 2004–2008 data over the same period exhibited an average thermal loading of 2.2 °C, with the maximum daily average thermal loading calculated at 4.1 °C (Table 3-10). In general, the current MIF appears to have had an overall positive influence on thermal loading through the lower Fall River reach (Fall River below Pit 1 Forebay).

The current MIF creates a relatively high flow environment in Fall River Pond, as well as downstream of Fall River Pond Weir. Figure 3-26 compares daily average temperatures from each of the Fall River stations in 2008. As illustrated, the current MIF release generates essentially isothermal conditions between Pit 1 Forebay dam and the confluence of the Fall River with the Pit River.

3.4.1.3. Stream Flow

As discussed previously, no MIF release was made from Pit 1 Forebay prior to the 2003 License requirements. As a result, no comparison with pre-2003 conditions was made.

3.4.2 Pit River

This section will compare the results of Pit River monitoring conducted in 1990–1992 with those from the 2004–2008 monitoring efforts. Table 3-18 summarizes a frequency distribution analysis performed on the 1990–1992 data similar to that presented in Table 3-7 for the 2004–2008 data set.

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3.4.2.1. Water Quality

Based on the frequency analyses of the 1990–1992 and 2004–2008 data sets, Pit River SpC values tended to decrease at each station as flows progressed downstream through the Pit 1 Reach (Figure 3-27). Overall, SpC values from the 1990–1992 periods were higher than those measured during 2004–2008. However, by the time flows reach the lower Pit 1 Reach (PR4), SpC levels observed in both monitoring periods were similar. SpC conditions observed below Pit 1 Powerhouse were very similar between monitoring efforts. The comparison presented in Figure 3-27 suggests that the current MIF has positively influenced SpC levels in the Big Eddy and upper sections of the Pit 1 Reach of the Pit River.

A frequency analysis was utilized to compare the DO and DO saturation in the Pit River, from the 1990–1992 and 2004–2008 monitoring efforts. Figure 3-28 compares DO levels from these two periods, and Figure 3-29 compares DO saturation levels. The results of the 1990–1992 frequency analysis highlight the extreme range in DO levels present in the Big Eddy section of the Pit River. DO levels in the lower Pit 1 Reach were less extreme, but did exhibit minimum levels that were at or below Basin Plan objectives. In comparison, DO conditions during the 2004–2008 also exhibited significant change in the range of DO levels observed at Big Eddy; DO conditions in the lower Pit 1 Reach were above Basin Plan objectives at all times. DO levels at Big Eddy exhibited few excursion periods that fall below Basin Plan objectives; this is attributed to the reach having to absorb the low DO inflow from the Pit River above the Fall River confluence. These low DO samples represented 5 percent of total samples obtained in 2004-2008 period and were all associated with morning samples typical of the lowest portion of the diel cycle. The comparison presented in Figures 3-28 and 3-29 suggests that the current MIF has positively influenced DO levels in the Pit River, particularly the Big Eddy section of the Pit 1 Reach.

A frequency analysis of pH from the 1990–1992 efforts indicates that pH levels were somewhat higher during this period as compared with the 2004–2008 efforts (Figure 3-30). This was particularly true of pH levels in the Big Eddy section of the Pit 1 Reach. The elevated levels were probably related to the upstream conditions and the resultant high level of biological activity present in this section during 1990–1992. The change in pH levels was less pronounced at stations located in the lower Pit 1 Reach and below Pit 1 Powerhouse. The comparison presented in Figure 3-30 suggests that the current MIF has positively influenced pH levels in the Pit 1 Reach of the Pit River, particularly the Big Eddy section.

Turbidity in the Pit River is composed of seasonally significant levels of mineral sediments as well as organic material (pelagic algae and materials derived from agricultural runoff). As such, a comparison of pre and post MIF conditions are somewhat subjective. However, the frequency analysis presented in Figure 3-31 indicates that 1990–1992 turbidity levels followed a similar pattern to those observed in 2004–2008, with levels higher in the Big Eddy section of the Pit 1 Reach, and becoming lower as water moved through the lower sections of the reach. During both pre and post MIF periods, summer turbidities in the Pit River were highly variable, being dependant on runoff conditions in the upstream watersheds. The comparison presented in Figure 3-31 suggests that the current MIF has not altered turbidity levels in the Pit 1 Reach of the Pit River.

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3.4.2.2. Water Temperature

Results of the 1990–1992 water temperature monitoring are summarized in Table 3-17. An analysis of frequency distribution for each water temperature station is presented in Table 3-18. Figure 3-32 compares results from the frequency analysis of daily average temperatures from the 1990–1992 period with those from 2004–2008. Since there was no station equivalent to PR1 instrumented during 1990–1992, it is not possible to compare the thermal regime entering the projects during the two monitoring periods. The water temperature regime observed in 1990–1992 at Station PR2 was warmer than that observed in 2004–2008. The water temperature regime at Stations PR3 and PR4 was cooler in 1990–1992 than that measured in 2004–2008. The decrease in cooling is attributed to the MIF release. Water temperatures in MIF were much warmer than those of the accretion flows (temperature from various springs ranged from 13.0 to 19.4 °C; a 105-cfs accretion flow with an averaged 15.2 °C was used in the SNTEMP model, PG&E Final Application for License, 1993). As a result, its effect is to reduce the influence of the cooling accretion flows through this reach (Final Application for License, 1993) and is confirmed by observation data (personal communication, Maria Ellis). The water temperature regime at Station PR5 was similar during both the pre and post MIF monitoring periods.

The difference between daily average temperature measured at PR2 and PR4 was used to evaluate temperature change in the Pit 1 Reach. The daily average change were generated for the 1990–1992 set in order to compare pre and post MIF change to the cooling effects present in the Pit 1 Reach. Results of the 1990-1992 analysis are presented in Table 3-20. The similar analysis of the 2004-2008 data was previously presented in Table 3-11. For the 1990–1992 period, average daily change in temperature between Big Eddy (PR2) and the Pit 1 Footbridge (PR4) for the June through September period was -3.8 °C (PR4 cooler than PR2). Cooling in the reach in July and August averaged -3.1 and -4.1 °C respectively for the 1990–1992 effort. The maximum average cooling was measured in August at -6.4 °C. In comparison, the 2004–2008 data over the same reach exhibited average June through September cooling of -1.5 °C, with the maximum cooling calculated at -3.4 °C (July) (Table 3-11). In general, the current MIF has increased stream water temperature in Pit 1 Canyon reach by approximately 1 to 2 °C.

3.4.2.3. Stream Flow

Only two stations were evaluated for change between the current MIF regime and the 1990–1992 condition. These stations were those currently established at Big Eddy (PR2) and at the Pit 1 Footbridge (PR4). In addition to the 1990–1992 monitoring, PGE conducted monitoring in 1995 which was not published. Only the Big Eddy station was monitored in 1995. Table 3-21 summarizes the results of flow monitoring in Big Eddy from 1990–1992 and 1995. Table 3-22 presents the results of a frequency analysis performed on the 1990–1992 and 1995 data sets. A similar analysis was performed on the 2004-2008 data and was previously presented in Table 3-12 and 3-13. Figure 3-33 compares the results of the frequency analysis from 2004–2008 June through September with the 1990–1992 and 1995 data from the same period.

As illustrated in Figure 3-33, the flow regime during the 1990–1992 was characterized by much lower flows. This was reflective of the six successive dry water years (1987–1992) and the lack of any MIF release from the Fall River. The data from 1995 highlight the change generated by

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runoff associated with a wet water year. In addition to the elevated late season runoff, the Muck Valley hydroelectric facility was also operational at this time. Flows during the base flow period in 1995 (identified as flows associated with the 90% and 75% exceedance values) were still relatively low reflecting the lack of a MIF from the Fall River. The base flow regime associated with the 2004–2008 data set illustrates the effect of the MIF on this portion of the hydrograph.

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Table 3-1. Summary of Regional Air Temperature Data

	Monthly Average Air Temperature [1]										Annual
	May		June		July		August		September		Average
Year	(°C)	Key[2]	(°C)	Key	(°C)	Key	(°C)	Key	(°C)	Key	(°C)
1990	9.6		14.0		19.9		18.5		14.9		7.6
1991	8.0		12.8		18.0		18.6		15.7		7.9
1992	14.2		17.4		18.3		18.7		14.2		8.9
1993	11.5		12.8		14.7		17.0		14.1		6.8
1994	12.4		15.1		20.9		17.9		15.0		8.0
1995	10.5		13.6		18.4		17.4		15.4		8.9
1996	10.8		16.2		21.1		18.6		13.2		9.1
1997	13.3		14.9		18.4		17.7		14.3		8.5
1998	8.5		14.1		20.1		19.3		16.0		8.2
1999	10.0		14.3		17.8		17.5		14.7		8.1
2000	11.5	d	16.9		18.1		17.9	d	13.4		8.6
2001	13.7		15.6		18.9		19.0		14.8		8.7
2002	11.3		16.5		21.5		17.8		14.7		8.9
2003	11.8	d	17.2		21.3		18.4	b	15.4		10.2
2004	11.3		16.1		20.1		18.8		13.0	c	9.5
2005	10.7		13.1		21.3	i	18.7		11.9	d	7.3
2006	12.1		17.1		21.0		16.9		13.9	v	9.2
2007	11.1	i	13.6	g	19.2	h	17.3	m	12.5	k	2.1
2008	11.4	i	15.1	h	20.0	h	19.7	z	15.1		8.4
Period of Record Statistics (1905 to 2008)											
Average	10.9		15.0		19.0		18.0		14.1		8.2
Maximum	14.2		19.0		21.8		21.2		16.8		10.4
Minimum	6.3		11.4		14.7		14.8		10.8		6.5
No Years	90		91		88		90		90		68

1: Data source: California Climate Data Archive, Western Region Climate Center website (http://www.calclim.dri.edu/ccda/data.html).

2: Key, Alphabetical value represents the number of missing data days in the month. For example a = 1 missing day, while z = 26 missing days, no period with more than 5 missing days was included in the statistics.

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Table 3-2. Summary of Exceedance Calculations for Regional Air Temperature Data

	Monthly Air Temperature (Alturas Ranger Station)[1]									
Water	Average May		Average June		Average July		Average August		Average September	
Year	°C	Exceedance	°C	Exceedance	°C	Exceedance	°C	Exceedance	°C	Exceedance
1990	9.6	21%	15.1	71%	21.1	29%	19.6	34%	14.9	63%
1991	8.0	3%	13.9	93%	19.1	75%	19.8	31%	15.7	94%
1992	14.2	100%	18.5	6%	19.4	64%	19.8	26%	14.2	48%
1993	11.5	67%	13.9	88%	15.8	100%	18.1	72%	14.1	46%
1994	12.4	83%	16.2	47%	22	10%	19.1	45%	15.0	68%
1995	10.5	44%	14.7	79%	19.5	62%	18.5	63%	15.4	80%
1996	10.8	52%	17.3	24%	22.2	3%	19.7	32%	13.2	31%
1997	13.3	89%	16	50%	19.5	60%	18.8	54%	14.3	49%
1998	8.5	5%	15.2	67%	21.2	21%	20.4	9%	16.0	95%
1999	10.0	30%	15.4	62%	18.9	78%	18.6	62%	14.7	55%
2000	11.5	68%	18	15%	19.2	73%	19	46%	13.4	32%
2001	13.7	92%	16.7	38%	20	40%	20.1	15%	14.8	60%
2002	11.3	62%	17.7	20%	22.6	0%	18.9	49%	14.7	57%
2003	11.8	74%	18.3	9%	22.4	2%	19.5	35%	15.4	80%
2004	11.3	62%	17.2	27%	21.2	24%	19.9	22%	13.0	28%
2005	10.7	47%	14.2	85%	NA	--	19.8	23%	11.9	8%
2006	12.1	79%	18.2	12%	22.1	6%	18	75%	NA	--
2007	NA[1]	--	NA	--	NA	--	NA	--	NA	--
2008	NA	--	NA	--	NA	--	NA	--	NA	--

[1] Months with more than five days of missing data were not used in the developing exceedence statistics.

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Table 3-3. Summary of Monthly Stream Flow Data from USGS Station 11-3550.10.

Pit River below Pit 1 Powerhouse (USGS 11-3550.10)												
Month	Average Monthly Discharge (cfs) [1]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	1,425	1,416	2,124	1,355	1,246	1,463	1,102	1,099	1,134	1,186	1,274	1,248
1991	1,222	1,291	2,047	1,841	2,264	1,280	1,190	1,118	1,040	1,125	1,293	1,265
1992	1,251	1,329	1,294	1,173	1,050	1,012	1,004	976.7	1,027	1,081	1,133	1,214
1993	1,512	2,507	6,539	3,769	2,413	2,242	1,276	1,220	1,291	1,319	1,258	1,305
1994	1,308	1,268	1,706	1,222	1,411	1,152	954	828.4	784.2	938.9	1,154	1,325
1995	4,182	3,125	5,847	4,511	6,883	2,452	1,619	1,359	1,291	1,413	1,737	1,746
1996	2,296	5,756	4,176	3,147	2,680	1,679	1,370	1,275	1,289	1,372	1,563	2,418
1997	6,060	4,685	2,554	2,364	1,838	1,568	1,400	1,315	1,387	1,486	1,624	1,687
1998	3,463	3,484	3,987	3,909	5,746	4,582	1,809	1,618	1,628	1,776	2,493	3,012
1999	2,635	4,375	4,879	3,534	2,832	1,971	1,506	1,493	1,552	1,685	1,789	1,718
2000	2,210	2,637	3,076	2,222	1,786	1,466	1,425	1,471	1,476	1,592	1,672	1,660
2001	1,624	1,585	1,601	1,570	1,426	1,277	1,247	1,243	1,293	1,329	1,442	1,700
2002	2,139	1,845	1,900	1,658	1,527	1,249	1,160	1,170	1,185	1,221	1,335	1,521
2003	1,914	1,674	1,975	2,263	3,080	1,387	1,194	887.7	1,413	1,351	1,313	1,621
2004	1,935	3,114	2,505	1,682	1,377	1,194	1,042	1,043	1,075	1,206	1,345	1,505
2005	1,484	1,593	1,735	1,726	4,348	1,720	1,217	1,139	1,181	1,274	1,484	2,849
2006	4,514	2,985	4,418	5,457	3,145	1,653	1,371	1,291	1,324	1,311	1,463	1,548
2007	1,544	1,644	1,888	1,388	1,251	1,135	1,073	1,047	1,125	1,224	1,296	1,399
2008	1,522	1,660	2,538	1,511	1,515	1,447	1,137	1,097	1,123			
Period of Record Statistics (1975 to 2008)												
Average	2,278	2,714	3,062	2,496	2,312	1,624	1,291	1,244	1,297	1,381	1,586	1,805
Maximum	6,060	8,539	6,539	5,614	6,883	4,582	1,809	1,618	1,628	1,776	3,181	3,834
Minimum	1,222	1,268	1,294	1,173	1,050	1,012	954	828	784	939	1,133	1,214

1: Data Source: USGS web site (http://waterdata.usgs.gov/ca/nwis/dvstat)

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Table 3-4. Summary of Regional Conditions – 1990 to 2008.

Water Year	State Water Year [1] Classification	Index	Runoff Exceedance Pit River [2]
1990	Critical Dry	4.81	94%
1991	Critical Dry	4.21	84%
1992	Critical Dry	4.06	100%
1993	Above Norm	8.54	34%
1994	Critical Dry	5.02	97%
1995	Wet	12.89	6%
1996	Wet	10.26	25%
1997	Wet	10.82	28%
1998	Wet	13.31	0%
1999	Wet	9.8	16%
2000	Above Norm	8.94	38%
2001	Dry	5.76	72%
2002	Dry	6.35	69%
2003	Above Norm	8.21	53%
2004	Below Norm	7.51	59%
2005	Below Norm	8.49	50%
2006	Wet	13.2	19%
2007	Dry	6.19	75%
2008	Critical Dry	5.14	91%

1. Data from CDEC (http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST) Index is based on a This index, originally specified in the 1995 SWRCB Water Quality Control Plan, is used to determine the Sacramento Valley water year type as implemented in SWRCB D-1641. Year types are set by first of month forecasts beginning in February. Final determination is based on the May 1 50% exceedence forecast.
2. Pit River below Pit 1 Powerhouse (USGS 2009). Exceedance values are based on annual average runoff from the 1975 to 2008 water years.

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Table 3-5. Designated Beneficial Uses in the Fall and Pit Rivers

Designated beneficial uses (RWQCB-CVR 2007)	Fall River	Pit[a] River
Municipal and domestic supply (MUN)	E	E
Agriculture (irrigation and stock watering) (AGR)[b]	E	E
Hydropower Generation (POW)	E	E
Recreation (contact) (REC-1)	E	E
Recreation (canoeing and rafting) (REC-1)	E	E
Recreation (other non-contact) (REC-2)	E	E
Freshwater habitat (warm) (WARM)	E	E
Freshwater habitat (cold) (COLD)	E	E
Spawning (warm) (SPWN)	--	E
Spawning (cold) (SPWN)	--	--
Wildlife habitat (WILD)	E	E

Legend: E = Existing beneficial uses
P = Potential beneficial uses

Notes: [a] Beneficial uses for the Pit River from the forks to the mouth of Hat Creek, which includes the Project-affected reach.
[b] Uses of water for irrigation, stock watering, or support of vegetation for range grazing are grouped under agricultural supply.

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Table 3-6. Summary of 2004–2008 Water Quality Monitoring Data.

Station ID	Percent Exceedance	DO Level (mg/L)	DO Sat[1] (%)	pH (value)	SpC[2] (µS/cm)	Turbidity (NTU)
Fall River Stations						
FR1	Max	11.5	140	9.0	163	16.4
	Min	8.2	81	7.6	129	0.4
	Mean	9.4	109	8.4	153	3.7
	Stdev[3]	0.7	12	0.3	7	2.7
	Median	9.3	108	8.4	154	3.0
FR2	Max	12.3	157	9.5	162	8.6
	Min	7.5	90	7.8	129	0.2
	Mean	9.2	112	8.7	153	3.1
	Stdev	1.0	15	0.3	8	2.0
	Median	9.1	109	8.7	154	2.7
FR3	Max	12.4	151	9.3	163	14.3
	Min	6.1	71	7.7	130	0.2
	Mean	8.6	103	8.6	153	3.0
	Stdev	1.2	16	0.3	7	2.9
	Median	8.7	105	8.7	154	1.9
FR4	Max	10.8	116	9.2	163	16.4
	Min	6.8	80	7.7	121	0.2
	Mean	8.1	96	8.6	152	3.9
	Stdev	0.8	5	0.3	9	3.0
	Median	7.9	96	8.6	154	2.9
Pit River Stations						
PR1	Max	12.7	171	9.2	333	192.2
	Min	5.6	61	7.6	130	2.4
	Mean	9.5	114	8.4	250	19.1
	Stdev	1.7	23	0.4	45	30.5
	Median	9.7	112	8.4	241	10.2
PR2	Max	9.8	115	8.8	249	184.3
	Min	6.2	83	7.5	142	3.9
	Mean	7.9	96	8.2	191	16.9
	Stdev	0.8	5	0.3	21	27.8
	Median	7.9	95	8.2	185	8.7

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Table 3-6. (Continued).

Station ID	Percent Exceedance	DO Level (mg/L)	DO Sat[1] (%)	pH (value)	SpC[2] (µS/cm)	Turbidity (NTU)
PR3	Max	11.0	120	8.7	232	215.9
	Min	6.6	87	7.5	135	2.1
	Mean	8.5	101	8.2	186	16.4
	Stdev	0.8	6	0.2	20	34.4
	Median	8.4	101	8.2	185	5.9
PR4	Max	9.9	114	8.8	233	209.1
	Min	6.9	87	7.8	146	2.2
	Mean	8.4	98	8.3	184	15.0
	Stdev	0.7	5	0.2	16	32.3
	Median	8.3	98	8.3	179	4.9
PR5	Max	10.2	116	9.0	174	94.1
	Min	7.5	82	7.9	138	1.2
	Mean	8.8	100	8.4	159	7.2
	Stdev	0.6	6	0.3	7	13.8
	Median	8.8	99	8.5	160	3.6

1. DO Sat = Dissolved oxygen saturation
2. SpC = Specific Conductivity
3. Stdev = Standard Deviation

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Table 3-7. Frequency Distribution Analysis of 2004–2008 Water Quality Data.

Station ID	Percent Exceedance	DO Level (mg/L)	DO Sat[1] (%)	pH (value)	SpC[2] (µS/cm)	Turbidity (NTU)
FR1	90%	8.5	94	8.0	147	1.6
	75%	8.9	99	8.2	149	2.0
	50%	9.3	108	8.4	154	3.0
	25%	9.9	119	8.7	159	4.7
	10%	10.3	124	8.9	160	7.2
FR2	90%	8.1	97	8.4	144	1.0
	75%	8.5	102	8.5	149	1.6
	50%	9.1	109	8.7	154	2.7
	25%	9.7	116	9.0	159	3.9
	10%	10.4	128	9.1	160	6.5
FR3	90%	7.1	82	8.2	146	0.9
	75%	8.0	91	8.4	151	1.5
	50%	8.7	105	8.7	154	1.9
	25%	9.2	112	8.8	159	3.6
	10%	9.7	121	9.0	161	5.4
FR4	90%	7.3	91	8.2	142	1.3
	75%	7.5	94	8.4	151	1.9
	50%	7.9	96	8.6	154	2.9
	25%	8.6	98	8.8	159	5.1
	10%	9.0	101	8.9	160	6.9
PR1	90%	7.2	89	7.9	203	3.3
	75%	8.3	96	8.2	221	5.6
	50%	9.7	112	8.4	241	10.2
	25%	10.7	132	8.7	286	16.3
	10%	11.3	144	8.9	308	34.1
PR2	90%	7.2	90	7.9	175	5.2
	75%	7.4	94	8.0	179	6.5
	50%	7.9	95	8.2	185	8.7
	25%	8.4	98	8.4	198	13.8
	10%	8.9	100	8.6	220	29.5
PR3	90%	7.6	92	7.8	172	3.5
	75%	7.9	98	8.1	176	4.1
	50%	8.4	101	8.2	185	5.9
	25%	8.9	102	8.3	194	10.5
	10%	9.6	106	8.4	214	28.9

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Table 3-7. (continued).

Station ID	Percent Exceedance	DO Level (mg/L)	DO Sat[1] (%)	pH (value)	SpC[2] (µS/cm)	Turbidity (NTU)
PR4	90%	7.6	91	8.0	172	2.8
	75%	7.9	96	8.2	175	3.7
	50%	8.3	98	8.3	179	4.9
	25%	8.9	101	8.4	187	8.6
	10%	9.4	103	8.6	208	26.1
PR5	90%	8.1	94	8.1	151	1.8
	75%	8.4	96	8.2	157	2.5
	50%	8.8	99	8.5	160	3.6
	25%	9.1	104	8.6	164	6.4
	10%	9.6	108	8.7	167	9.7

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Table 3-8. Summary of 2004–2008 Water Temperature Monitoring Data.

		Monthly Temperature [1] (°C)			
Station ID	**Statistics**	**June**	**July**	**August**	**September**
Fall River Stations					
FR1	Max	20.3	21.8	20.5	18.8
	Min	14.1	18.4	17.0	12.5
	Mean	18.0	20.0	18.8	15.7
	Stdev[2]	1.5	0.7	0.8	1.4
FR2	Max	23.3	25.5	23.5	21.6
	Min	16.3	20.5	18.7	14.2
	Mean	20.0	22.6	21.2	17.7
	Stdev	1.7	1.0	1.2	1.7
FR3	Max	22.8	24.4	23.2	21.5
	Min	16.6	20.1	18.7	14.1
	Mean	19.9	22.5	21.2	17.7
	Stdev	1.6	0.9	1.1	1.7
FR4	Max	22.7	24.3	23.1	21.5
	Min	16.5	20.1	18.7	14.0
	Mean	19.8	22.4	21.1	17.7
	Stdev	1.6	0.9	1.0	1.7
Pit River Stations					
PR1	Max	24.7	25.8	23.4	21.7
	Min	15.9	20.0	18.5	12.8
	Mean	20.3	22.9	21.1	17.3
	Stdev	1.8	1.2	1.1	1.7
PR2	Max	23.4	25.0	23.6	21.7
	Min	16.8	19.3	17.2	13.8
	Mean	20.2	22.9	21.6	18.0
	Stdev	1.6	1.0	1.0	1.8
PR3	Max	22.3	23.3	21.9	20.3
	Min	17.0	19.9	18.8	14.7
	Mean	19.6	21.6	20.5	17.6
	Stdev	1.2	0.7	0.7	1.3

1 Monthly values based on daily average water temperatures
2. Stdev = Standard deviation

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Table 3-8. (continued).

		Monthly Temperature [1] (°C)			
Station ID	**Statistics**	**June**	**July**	**August**	**Sept**
PR4	Max	21.6	23.0	21.6	19.4
	Min	16.8	19.1	18.2	14.3
	Mean	19.1	20.8	19.7	17.1
	Stdev	1.0	0.7	0.7	1.2
PR5	Max	20.7	22.8	21.5	19.0
	Min	15.1	18.8	17.3	13.0
	Mean	18.4	20.3	19.1	16.1
	Stdev	1.3	0.7	0.8	1.4

1 Monthly values based on daily average water temperatures
2. Stdev = Standard deviation

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Table 3-9. Frequency Distribution Analysis of 2004–2008 Water Temperature Data.

		Fall River Stations				Pit River Stations				
Period	**Exceedance**	**FR1**	**FR2**	**FR3**	**FR4**	**PR1**	**PR2**	**PR3**	**PR4**	**PR5**
June - September	90%	15.0	17.0	17.1	17.0	16.6	17.2	17.2	16.7	15.5
	75%	16.9	19.0	18.9	18.9	19.0	19.3	18.8	18.2	17.3
	50%	18.6	20.8	20.9	20.8	20.8	21.1	20.2	19.4	18.9
	25%	19.6	22.2	22.0	22.0	22.3	22.4	21.2	20.4	19.9
	10%	20.3	23.0	22.9	22.8	23.4	23.3	21.9	21.0	20.6
June	90%	16.0	17.5	17.5	17.4	17.8	17.9	18.2	17.8	16.4
	75%	16.9	18.8	18.8	18.7	19.1	19.2	18.9	18.3	17.4
	50%	18.2	20.0	20.0	19.9	20.3	20.3	19.7	19.1	18.6
	25%	19.1	21.2	21.2	21.1	21.5	21.3	20.3	19.7	19.4
	10%	19.8	22.0	21.9	21.8	22.6	22.4	21.4	20.6	20.0
July	90%	19.2	21.3	21.3	21.3	21.5	21.7	20.7	20.0	19.5
	75%	19.5	21.9	21.9	21.8	22.1	22.4	21.1	20.3	19.8
	50%	20.1	22.6	22.6	22.5	23.0	23.0	21.7	20.8	20.4
	25%	20.5	23.1	23.2	23.1	23.6	23.6	22.1	21.3	20.7
	10%	20.9	23.8	23.5	23.5	24.4	24.1	22.4	21.6	21.1
August	90%	17.6	19.5	19.4	19.5	19.7	20.2	19.3	18.7	17.9
	75%	18.2	20.5	20.6	20.6	20.4	21.0	20.0	19.3	18.6
	50%	18.8	21.2	21.3	21.3	21.3	21.7	20.6	19.8	19.1
	25%	19.5	22.1	21.8	21.9	21.9	22.2	20.9	20.1	19.6
	10%	19.9	22.8	22.4	22.4	22.6	22.7	21.4	20.6	20.1
September	90%	13.8	15.2	15.4	15.4	15.3	15.6	15.9	15.6	14.2
	75%	14.4	16.2	16.1	16.2	16.0	16.5	16.5	16.1	14.8
	50%	15.8	17.9	18.2	18.1	17.2	18.4	17.9	17.2	16.2
	25%	16.9	19.0	19.0	19.0	19.0	19.4	18.8	18.2	17.3
	10%	17.4	19.7	19.4	19.3	19.5	20.0	19.1	18.5	17.7

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Table 3-10 Summary of Fall River Thermal Loading Statistics (2004–2008).

	June	July	August	September	July-Aug
Change through Pit 1 Forebay FR1 versus FR2 [Daily ΔT[1] (°C)]					
Max	4.3	4.3	4.2	3.4	4.3
Min	0.0	1.1	1.1	-0.6[2]	1.1
Mean	2.0	2.6	2.4	2.0	2.5
Change through Entire Project Affected Reach FR1 versus FR3 [Daily ΔT[1] (°C)]					
Max	4.1	3.9	3.5	3.2	3.9
Min	0.1	0.9	0.9	0.4	0.9
Mean	1.9	2.5	2.4	2.0	2.5

1. ΔT = Change in temperature between stations (based on daily average) (downstream minus upstream)..
2. Negative value means that the downstream station was cooler than the upstream.

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Table 3-11 Summary of Thermal Loading Statistics for the Pit 1 Reach (2004–2008).

	Change through Upper Pit 1 Reach Big Eddy (PR2) to Pit Falls (PR3) [Daily ΔT[1] (°C)]				
	June	July	August	September	July-Aug
Max	0.2	0.0	0.0	0.8	0.0
Min	-1.7[2]	-2.4	-2.0	-1.5	-2.4
Mean	-0.6	-1.3	-1.1	-0.3	-1.2

	Change through Entire Pit 1 Reach Big Eddy (PR2) to Pit Footbridge (PR4) [Daily ΔT[1] (°C)]				
	June	July	August	September	July-Aug
Max	0.2	-0.2	-0.1	0.6	-0.1
Min	-2.6	-3.4	-3.1	-2.4	-3.4
Mean	-1.1	-2.1	-1.9	-0.9	-2.0

1. ΔT = Change in temperature between stations (based on daily average) (downstream minus upstream).
2. Negative value means that the downstream station was cooler than the upstream.

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Table 3-12 Summary of 2004–2008 Stream Flow Data from Temporary Discharge Stations.

		Monthly Stream Discharge [1] (cfs)			
Station ID	**Statistics**	**June**	**July**	**August**	**September**
Pit River Stations					
PR1	Maximum	> 90.0	> 86.0	34.2	18.3
	Minimum	2.56	1.59	1.23	1.26
	Average	> 46.3	> 30.4	4.41	5.64
	No. Days	120	120	120	120
PR2	Maximum	> 902	879	684	393
	Minimum	157	152	158	89.1
	Average	> 329	244	212	184
	No. Days	129	129	129	129
PR4	Maximum	> 802	> 802	> 802	467
	Minimum	252	267	250	205
	Average	> 433	> 359	> 321	288
	No. Days	138	138	138	138

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Table 3-13 Frequency Analysis of 2004–2008 Stream Flow Data.

		Pit River Station Stream Flow (cfs)		
Period	**Exceedance**	**PR1**	**PR2**	**PR4**
June - September	90%	1.73	163	269
	75%	2.33	175	281
	50%	6.94	193	301
	25%	29.6	242	349
	10%	68.9	356	471
June	90%	6.96	180	268
	75%	16.0	197	294
	50%	42.1	271	384
	25%	86.0	382	504
	10%	89.3	534	767
July	90%	1.95	170	278
	75%	2.83	180	290
	50%	21.6	205	319
	25%	49.3	256	375
	10%	86.0	323	435
August	90%	1.33	165	275
	75%	1.76	172	281
	50%	2.28	183	294
	25%	6.37	205	307
	10%	8.72	229	330
September	90%	1.73	142	251
	75%	2.17	163	270
	50%	5.23	182	287
	25%	7.50	194	302
	10%	10.1	236	320

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Table 3-14. Summary of Stage Change during Fall River Flushing Flow Event.

Stage Change - Rising Limb of Flushing Flow Event						
Condition	Date	Time	Stage (ft)	Flow (cfs)	Change in Stage	Cumulative Change
Pre-event	08/15/08	1200	2.18	298	0.01	-0.03
Pre-event	08/15/08	1300	2.19	299	0.00	-0.02
Pre-event	08/15/08	1400	2.20	302	0.01	-0.01
Pre-event	08/15/08	1500	2.21	305	0.01	0.00
Pre-event	08/15/08	1600	2.22	307	0.01	0.01
Pre-event	08/15/08	1700	2.23	309	0.01	0.01
Pre-event	08/15/08	1800	2.23	310	0.00	0.02
Transition	08/15/08	1900	2.29	325	0.06	0.07
Transition	08/15/08	2000	2.50	387	0.21	0.29
Transition	08/15/08	2100	2.87	513	0.37	0.66
Transition	08/15/08	2200	3.22	654	0.35	1.00
Transition	08/15/08	2300	3.43	753	0.22	1.22
Transition	08/16/08	0	3.56	802 [1]	0.12	1.35
Event	08/16/08	100	3.63	802 [1]	0.07	1.42
Event	08/16/08	200	3.66	802 [1]	0.04	1.45
Event	08/16/08	300	3.69	802 [1]	0.03	1.48
Event	08/16/08	400	3.68	802 [1]	-0.01	1.47
Event	08/16/08	500	3.72	802 [1]	0.03	1.50
Event	08/16/08	600	3.68	802 [1]	-0.04	1.46
Event	08/16/08	700	3.68	802 [1]	0.01	1.47
Event	08/16/08	800	3.68	802 [1]	0.00	1.47
Event	08/16/08	900	3.68	802 [1]	-0.01	1.46
Event	08/16/08	1000	3.68	802 [1]	0.01	1.47
Event	08/16/08	1100	3.69	802 [1]	0.01	1.48
Event	08/16/08	1200	3.69	802 [1]	0.00	1.48

Stage Change - Receding Limb of Flushing Flow Event						
Condition	Date	Time	Stage (ft)	Flow (cfs)	Change in Stage	Cumulative Change
Event	08/17/08	1200	3.72	802 [1]	0.02	1.50
Event	08/17/08	1300	3.70	802 [1]	-0.02	1.49
Event	08/17/08	1400	3.71	802 [1]	0.01	1.50
Event	08/17/08	1500	3.70	802 [1]	-0.02	1.49
Event	08/17/08	1600	3.70	802 [1]	0.00	1.49
Event	08/17/08	1700	3.69	802 [1]	-0.01	1.48
Event	08/17/08	1800	3.69	802 [1]	0.00	1.48
Transition	08/17/08	1900	3.57	802 [1]	-0.12	1.36
Transition	08/17/08	2000	3.36	717	-0.22	1.15
Transition	08/17/08	2100	3.16	630	-0.20	0.95
Transition	08/17/08	2200	2.98	557	-0.18	0.77
Transition	08/17/08	2300	2.82	497	-0.16	0.61
Transition	08/18/08	0	2.70	452	-0.13	0.49
Transition	08/18/08	100	2.60	420	-0.10	0.39
Transition	08/18/08	200	2.51	392	-0.09	0.30
Transition	08/18/08	300	2.44	370	-0.07	0.23
Transition	08/18/08	400	2.39	355	-0.05	0.18
Transition	08/18/08	500	2.34	341	-0.05	0.13
Transition	08/18/08	600	2.31	332	-0.03	0.10
Transition	08/18/08	700	2.28	324	-0.03	0.07
Transition	08/18/08	800	2.26	319	-0.02	0.05
Post-event	08/18/08	900	2.24	312	-0.03	0.03
Post-event	08/18/08	1000	2.22	307	-0.02	0.00
Post-event	08/18/08	1100	2.20	303	-0.01	-0.01
Post-event	08/18/08	1200	2.19	301	-0.01	-0.02

1. The value 802 is the maximum for the PR4 stage discharge rating, flows were greater than this value.

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Table 3-15. Summary of 1990–1992 Water Quality Monitoring Data.

Station ID	Statistic	DO Level (mg/L)	DO Sat[1] (%)	pH (value)	SpC[2] (µS/cm)	Turbidity (NTU)
Fall River Stations						
FR1	Max	12.5	153	9.2	180	5.1
	Min	6.8	77	8.3	133	0.7
	Mean	9.3	107	8.8	153	2.8
	Stdev[3]	1.4	19.9	0.3	10.4	1.0
FR2	Max	13.7	196	9.6	178	10.4
	Min	6.8	77	8.2	145	1.2
	Mean	9.1	110	9.0	157	3.3
	Stdev	1.6	27.7	0.3	7.9	2.1
FR3	Max	11.6	139	9.6	168	8.0
	Min	5.6	62	7.2	149	0.5
	Mean	8.9	104	8.9	159	1.9
	Stdev	1.5	21.6	0.6	6.3	2.0
Pit River Stations						
PR2	Max	18.5	246	10.0	280	42.0
	Min	3.7	46	7.2	224	5.6
	Mean	12.1	153	8.9	243	24.3
	Stdev	6.3	90.8	1.2	22.7	13.5
PR3	Max	10.4	119	8.5	242	96.0
	Min	5.4	53	7.6	164	1.0
	Mean	8.2	93	8.4	210	11.4
	Stdev	1.4	16.8	0.2	23.0	24.7
PR4	Max	10.2	113	9.1	224	93.0
	Min	5.6	64	8.0	134	0.9
	Mean	8.2	92	8.5	197	10.7
	Stdev	1.2	15.0	0.2	22.2	23.4
PR5	Max	11.4	137	9.1	208	20.0
	Min	5.0	57	8.3	126	0.9
	Mean	8.2	93	8.8	160	3.8
	Stdev	1.7	21.8	0.2	16.8	4.6

1. DO Sat = Dissolved oxygen saturation
2. SpC = Specific Conductivity
3. Stdev = Standard Deviation

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Table 3-16. Frequency Distribution Analysis of 1990–1992 Water Quality Data.

Station ID	Statistic	DO Level (mg/L)	DO Sat[1] (%)	pH (value)	SpC[2] (µS/cm)	Turbidity (NTU)
FR1	90%	7.7	82	8.5	140	1.6
	75%	8.3	94	8.7	151	2.3
	50%	9.4	109	8.9	154	2.8
	25%	10.0	118	9.0	156	3.4
	10%	11.0	126	9.1	160	3.6
FR2	90%	7.3	83	8.6	150	1.9
	75%	8.5	95	8.8	153	2.3
	50%	9.0	109	9.1	156	2.8
	25%	9.5	120	9.2	161	3.8
	10%	10.3	127	9.3	166	4.5
FR3	90%	7.4	76	8.6	150	0.5
	75%	8.0	98	8.8	153	0.7
	50%	8.8	102	9.0	160	1.2
	25%	10.2	118	9.3	163	2.4
	10%	10.5	130	9.5	166	3.9
PR2	90%	5.7	61	7.5	224	11.0
	75%	8.6	84	7.9	225	19.0
	50%	11.6	147	9.6	240	25.0
	25%	18.1	243	9.6	244	30.0
	10%	18.3	245	9.8	266	37.2
PR3	90%	6.1	69	8.2	178	1.1
	75%	8.0	93	8.4	203	2.2
	50%	8.2	98	8.4	211	4.7
	25%	9.0	100	8.5	223	6.3
	10%	9.8	105	8.5	239	13.7
PR4	90%	6.4	71	8.3	176	1.0
	75%	8.0	81	8.4	193	1.6
	50%	8.5	96	8.5	199	3.2
	25%	8.7	102	8.6	209	5.8
	10%	9.5	109	8.8	217	18.0
PR5	90%	6.2	60	8.4	144	1.3
	75%	6.7	82	8.7	155	1.7
	50%	8.4	96	8.8	161	2.6
	25%	9.0	104	8.8	165	3.7
	10%	10.2	114	9.1	169	5.5

1. Monthly values based on daily average water temperatures
2. Stdev = Standard deviation

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Table 3-17. Summary of 1990–1992 Water Temperature Monitoring Data.

		Monthly Temperature [1] (°C)			
Station ID	**Statistics**	**June**	**July**	**August**	**September**
Fall River Stations					
FR1	Max	21.3	21.9	21.0	18.5
	Min	11.0	16.1	16.3	14.9
	Mean	18.1	20.1	18.9	16.4
	Stdev[2]	1.9	1.1	1.3	0.9
FR2	Max	23.4	25.0	24.6	21.2
	Min	17.8	19.7	16.7	13.5
	Mean	20.7	22.7	21.1	18.7
	Stdev	1.5	1.2	1.9	1.6
FR3	Max	23.3	25.7	23.9	22.4
	Min	13.6	16.8	19.0	16.4
	Mean	20.8	22.7	21.8	19.4
	Stdev	2.0	1.4	1.4	1.4
Pit River Stations					
PR2	Max	24.6	24.6	24.0	21.7
	Min	19.2	19.7	19.5	16.7
	Mean	21.9	22.4	21.9	19.1
	Stdev	1.5	1.3	1.2	1.4
PR3	Max	20.2	21.6	20.7	18.4
	Min	13.8	18.3	17.9	16.5
	Mean	18.8	20.2	19.2	17.5
	Stdev	1.3	0.9	0.8	0.5
PR4	Max	19.4	21.9	20.1	17.6
	Min	13.5	17.0	16.5	15.1
	Mean	17.4	19.1	17.8	16.3
	Stdev	1.1	1.0	0.8	0.5
PR5	Max	20.8	21.8	21.0	18.1
	Min	11.8	16.6	16.6	15.3
	Mean	18.2	20.2	19.0	16.4
	Stdev	1.7	1.1	1.3	0.7

1. Monthly values based on daily average water temperatures
2. Stdev = Standard deviation

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Table 3-18. Frequency Distribution Analysis of 1990–1992 Water Temperature Data.

		Fall River Stations				Pit River Stations				
Period	**Exceedance**	**FR1**	**FR2**	**FR3**	**FR4**	**PR1**	**PR2**	**PR3**	**PR4**	**PR5**
June - September	90%	15.9	18.5	18.9	--	--	18.9	17.4	16.0	16.1
	75%	16.9	19.5	19.7	--	--	20.1	18.2	16.6	17.1
	50%	18.5	21.3	21.6	--	--	21.8	19.2	17.6	19.1
	25%	20.1	22.4	22.7	--	--	22.9	20.0	18.5	20.2
	10%	20.8	23.5	23.5	--	--	23.4	20.9	19.4	20.8
June	90%	16.2	18.7	19.1	--	--	20.0	17.7	16.1	16.6
	75%	17.1	19.5	19.8	--	--	20.3	18.2	16.8	17.4
	50%	17.8	20.7	21.4	--	--	22.7	19.2	17.6	18.1
	25%	19.6	22.1	22.2	--	--	23.0	19.5	18.1	19.6
	10%	20.5	22.4	22.8	--	--	23.3	19.8	18.6	20.1
July	90%	18.5	21.1	21.1	--	--	20.3	19.0	17.7	18.6
	75%	19.6	21.8	21.8	--	--	21.8	19.5	18.3	19.7
	50%	20.3	22.8	22.9	--	--	22.5	20.4	19.1	20.5
	25%	20.9	23.6	23.7	--	--	23.3	21.1	19.7	21.1
	10%	21.5	24.2	24.0	--	--	23.6	21.2	20.3	21.4
August	90%	17.0	18.4	19.6	--	--	20.3	18.3	16.8	17.0
	75%	17.8	19.7	20.6	--	--	20.7	18.7	17.3	17.9
	50%	19.1	21.7	22.1	--	--	22.0	19.2	17.8	19.3
	25%	19.9	22.3	22.8	--	--	22.7	19.8	18.2	20.1
	10%	20.7	23.1	23.3	--	--	23.4	20.3	18.9	20.7
September	90%	15.2	16.3	17.5	--	--	17.3	16.8	15.5	15.5
	75%	15.6	18.1	18.5	--	--	18.0	17.2	15.9	15.7
	50%	16.5	19.1	19.6	--	--	19.0	17.5	16.2	16.4
	25%	17.0	19.5	20.0	--	--	20.1	17.9	16.6	17.1
	10%	17.6	20.5	21.0	--	--	20.7	18.2	17.0	17.3

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Table 3-19. Summary of Thermal Loading Calculations in Pit 1 Forebay (1990–1992).

Change through Pit 1 Forebay					
	FR1 versus FR2 [Daily ΔT[1] (°C)]				
	June	July	August	September	July-Aug
Max	3.5	4.9	4.1	4.3	4.9
Min	-0.2	0.8	1.3	0.8	0.8
Mean	2.2	2.5	2.9	2.5	2.7
Change through Entire Project Affected Reach					
	FR1 versus FR3 [Daily ΔT[1] (°C)]				
	June	July	August	September	July-Aug
Max	4.8	4.8	4.5	4.5	4.8
Min	1.2	1.0	1.7	1.0	1.0
Mean	3.0	2.7	2.9	3.0	2.8

1. ΔT = Change in temperature between stations (based on daily average) (downstream minus upstream).
2. Negative value means that the downstream station was cooler than the upstream.

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Table 3-20. Summary of Thermal Loading Statistics for the Pit 1 Reach (1990–1992).

	June	July	August	September	July-Aug
Change through Upper Pit 1 Reach					
Big Eddy (PR2) to Pit Falls (PR3) [Daily ΔT[1] (°C)]					
Max	-1.3	-0.6	-0.3	0.1	-0.3
Min	-4.6	-3.8	-4.3	-2.3	-4.3
Mean	-3.2	-2.1	-2.8	-1.3	-2.4
Change through Entire Pit 1 Reach					
Big Eddy (PR2) to Pit Footbridge (PR4) [Daily ΔT[1] (°C)]					
Max	-2.8	-0.3	-0.6	-1.2	-0.3
Min	-7.1	-5.4	-6.4	-4.2	-6.4
Mean	-5.0	-3.1	-4.1	-3.0	-3.7

1. ΔT = Change in temperature between stations (based on daily average) (downstream minus upstream).
2. Negative value means that the downstream station was cooler than the upstream.

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Table 3-21. Summary of Stream Flow Data from Temporary Discharge Stations.

1990–1992

		Monthly Stream Discharge [1] (cfs)			
Station ID	**Statistics**	**June**	**July**	**August**	**September**
Pit River Stations					
PR2	Maximum	39.3	631	626	44.2
	Minimum	9.68	26.5	16.8	20.4
	Average	24.3	134	85.2	30.8
	No. Days	21	31	52	60
PR4	Maximum	138	707	725	138
	Minimum	132	136	135	133
	Average	135	218	196	135
	No. Days	30	31	28	21

1995

		Monthly Stream Discharge [1] (cfs)			
Station ID	**Statistics**	**June**	**July**	**August**	**September**
Pit River Stations					
PR2	Maximum	> 902	502	233	159
	Minimum	451	108	76.4	71.6
	Average	658	253	151	109
	No. Days	14	31	22	25

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Table 3-22. Frequency Analysis of 1990 – 1992 Stream Flow Data.

		Pit River Station Stream Flow (cfs)		
		1990–1992		1995
Period	Exceedance	PR2	PR4	PR2
June - September	90%	24.3	134	82.0
	75%	27.6	135	115
	50%	33.9	137	185
	25%	42.3	142	275
	10%	72.2	166	526
June	90%	15.4	132	474
	75%	17.1	134	516
	50%	25.5	134	614
	25%	30.0	136	854
	10%	33.0	137	902
July	90%	31.7	137	117
	75%	41.1	140	170
	50%	49.7	143	258
	25%	82.9	163	281
	10%	347	388	409
August	90%	27.5	136	82.0
	75%	32.3	137	92.4
	50%	38.0	138	179
	25%	45.9	143	191
	10%	163	278	211
September	90%	24.8	134	75.5
	75%	26.9	134	80.2
	50%	30.6	135	111
	25%	34.6	135	124
	10%	36.6	136	143

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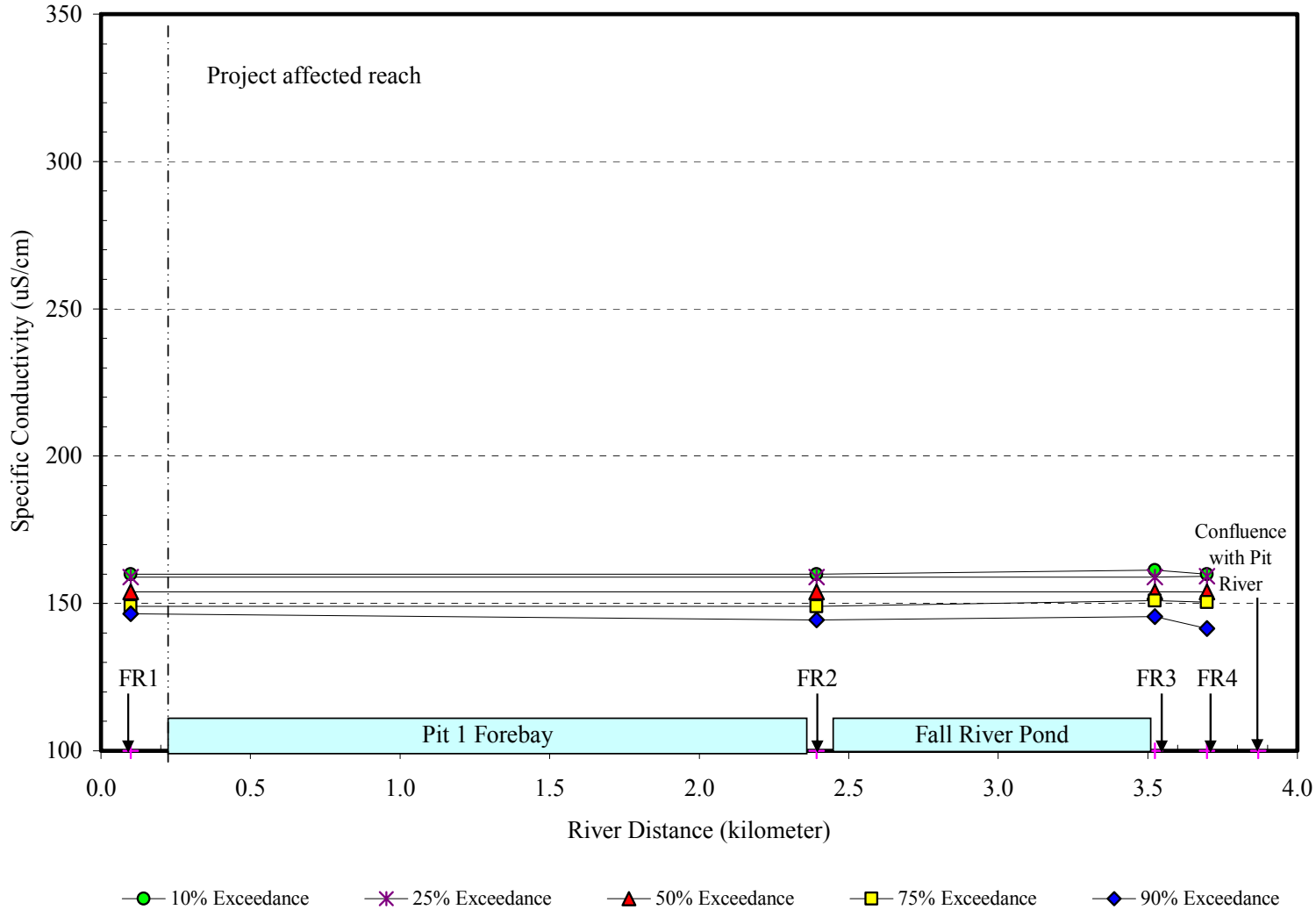

Figure 3-1. Longitudinal comparison of specific conductivity frequency distribution in the Fall River (2004–2008).

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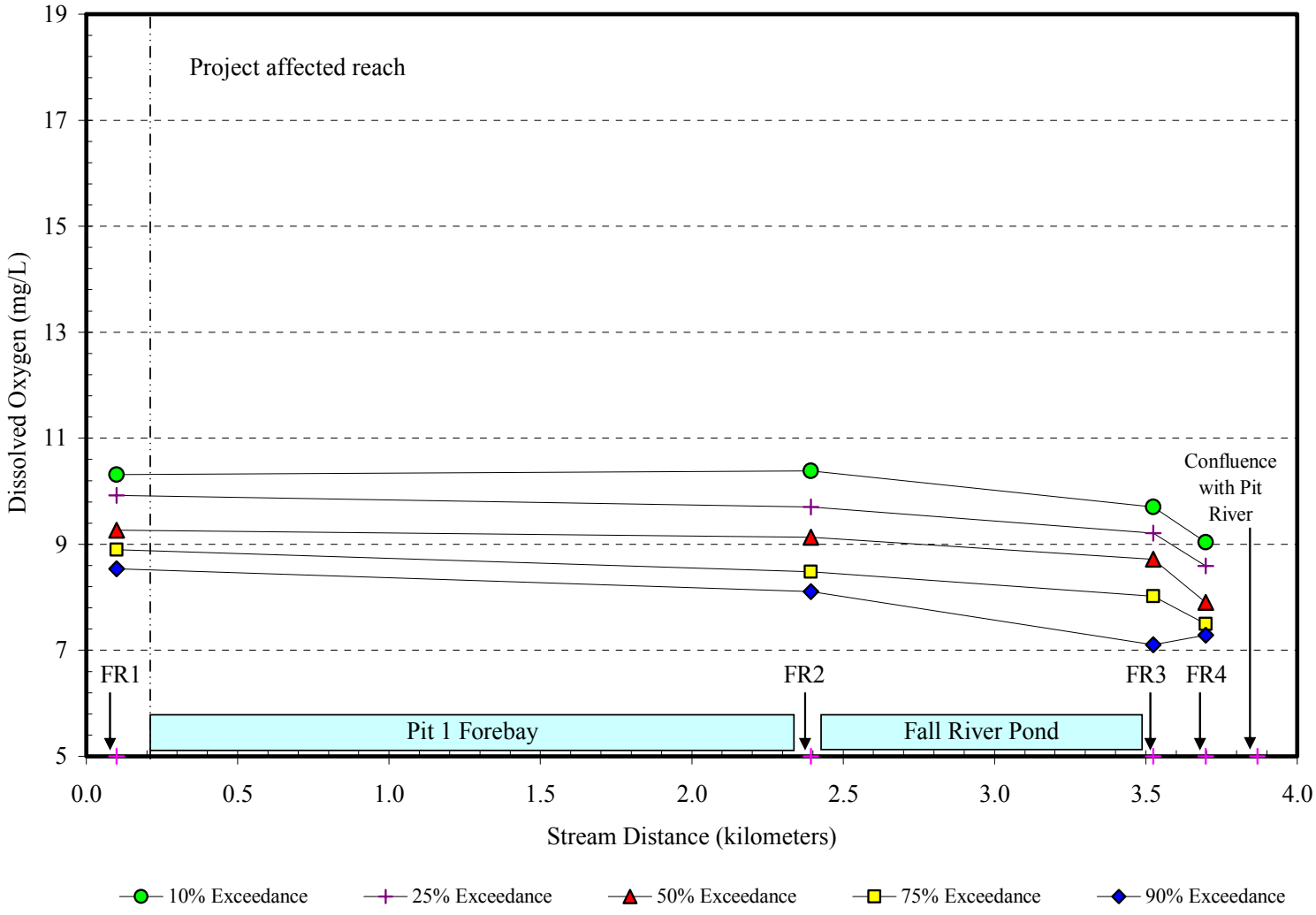

Figure 3-2. Longitudinal comparison of dissolved oxygen frequency distribution in the Fall River (2004–2008).

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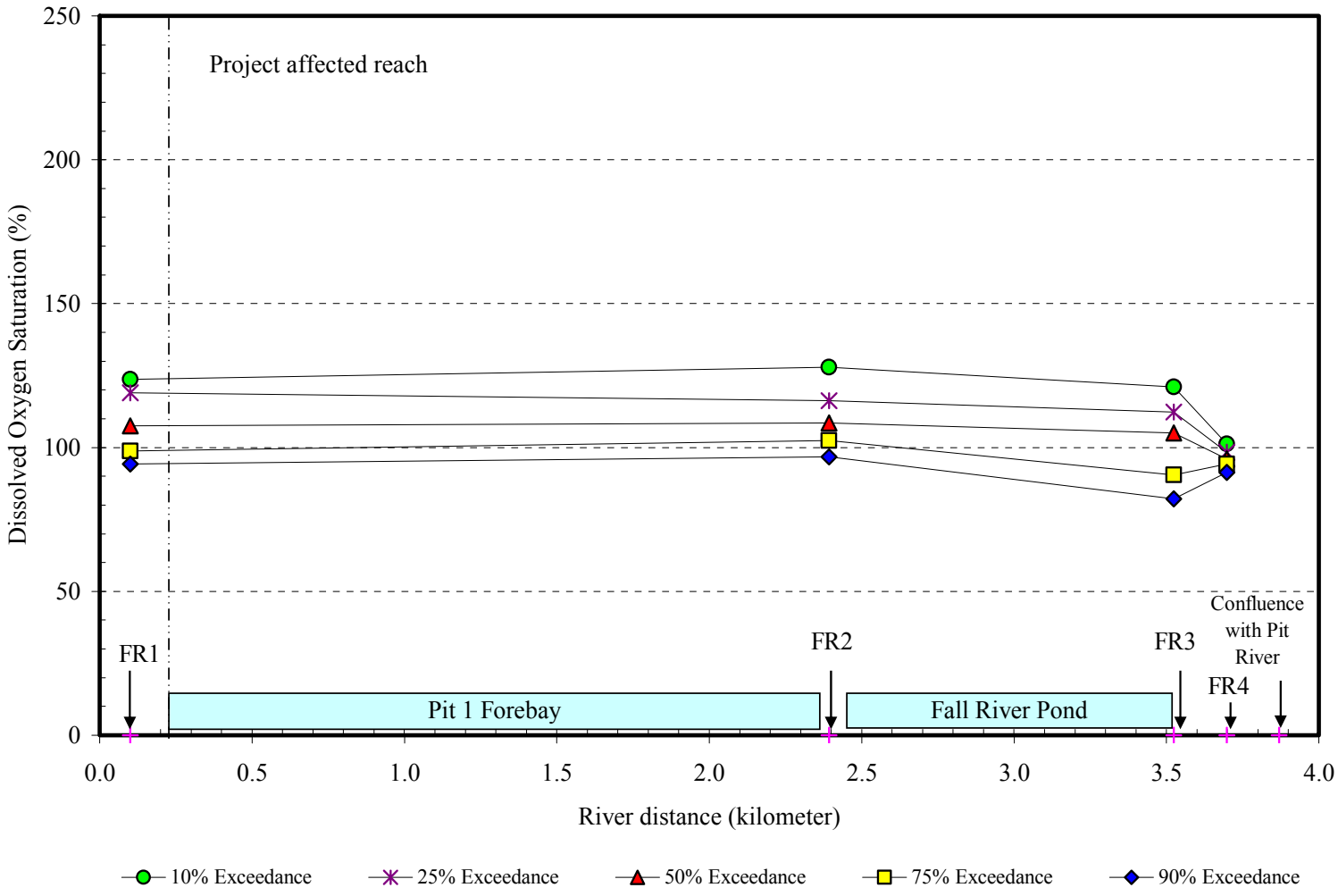

Figure 3-3. Longitudinal comparison of dissolved oxygen saturation frequency distribution in the Fall River (2004–2008).

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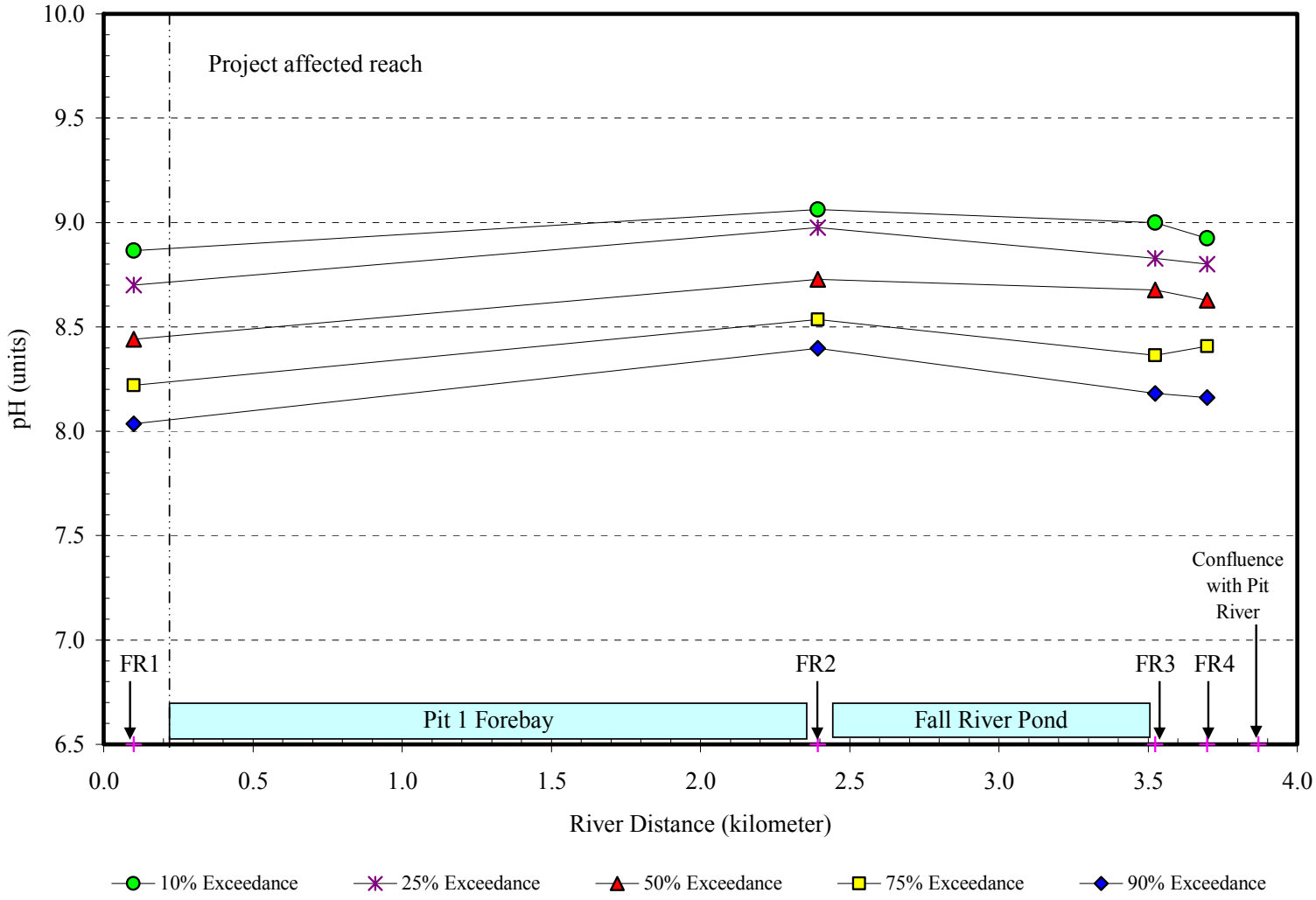

Figure 3-4. Longitudinal comparison of pH frequency distribution in the Fall River (2004–2008).

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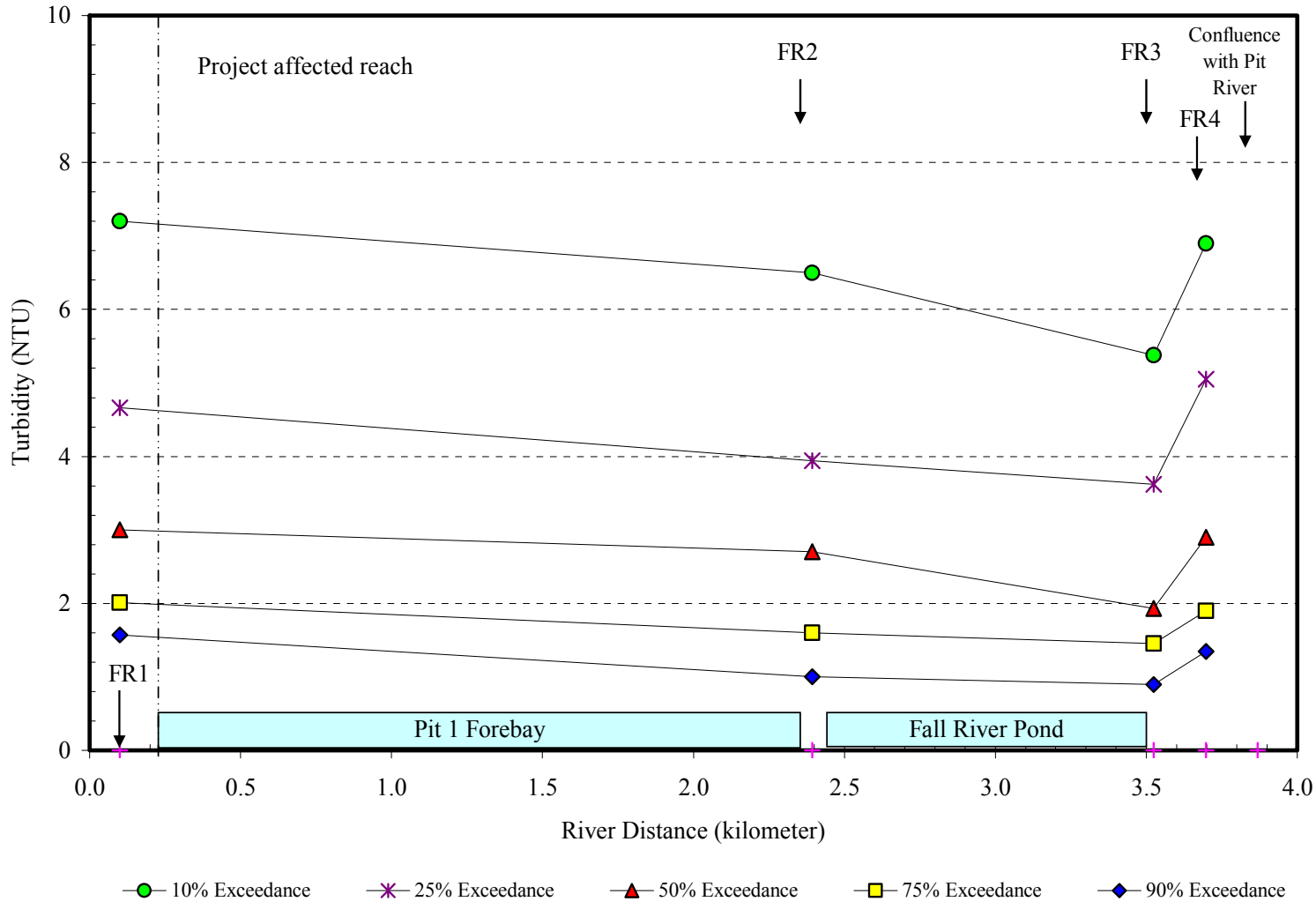

Figure 3-5. Longitudinal comparison of turbidity frequency distribution in the Fall River (2004–2008).

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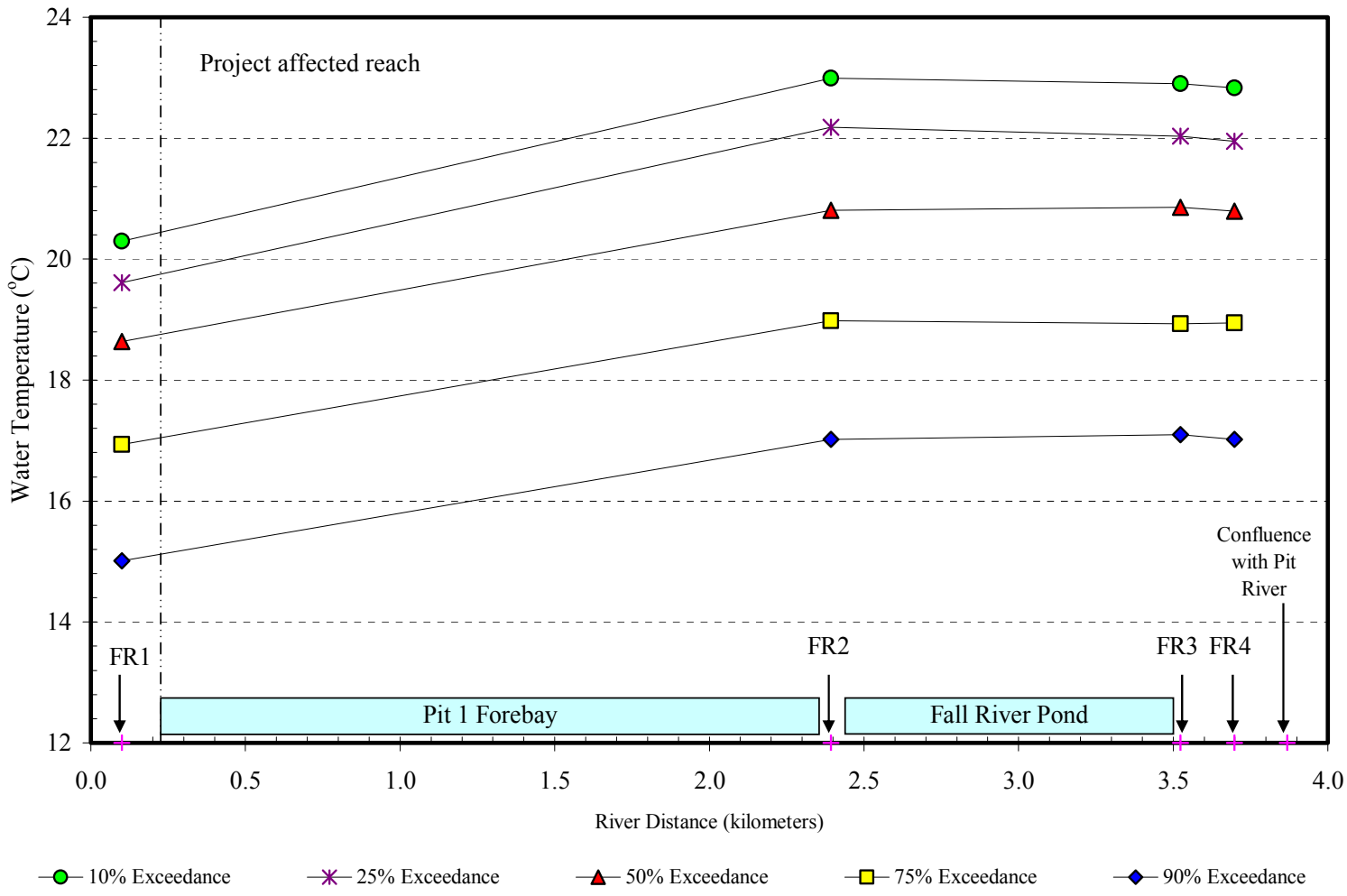

Figure 3-6. Longitudinal comparison of water temperature frequency distribution in the Fall River (2004–2008).

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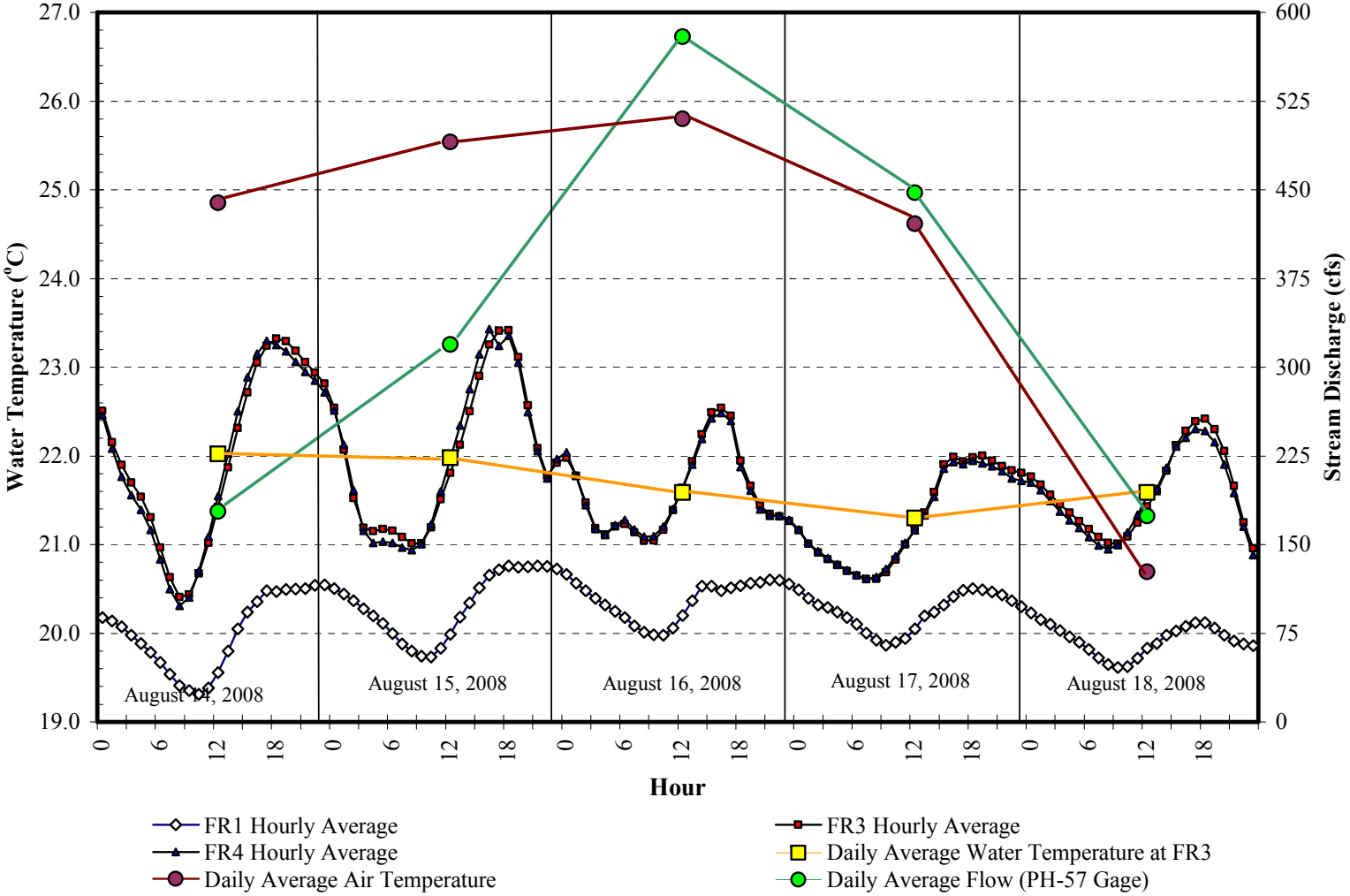

Figure 3-7. Evaluation of flushing flow effects on hourly average water temperature in the Lower Fall River – August 2008.

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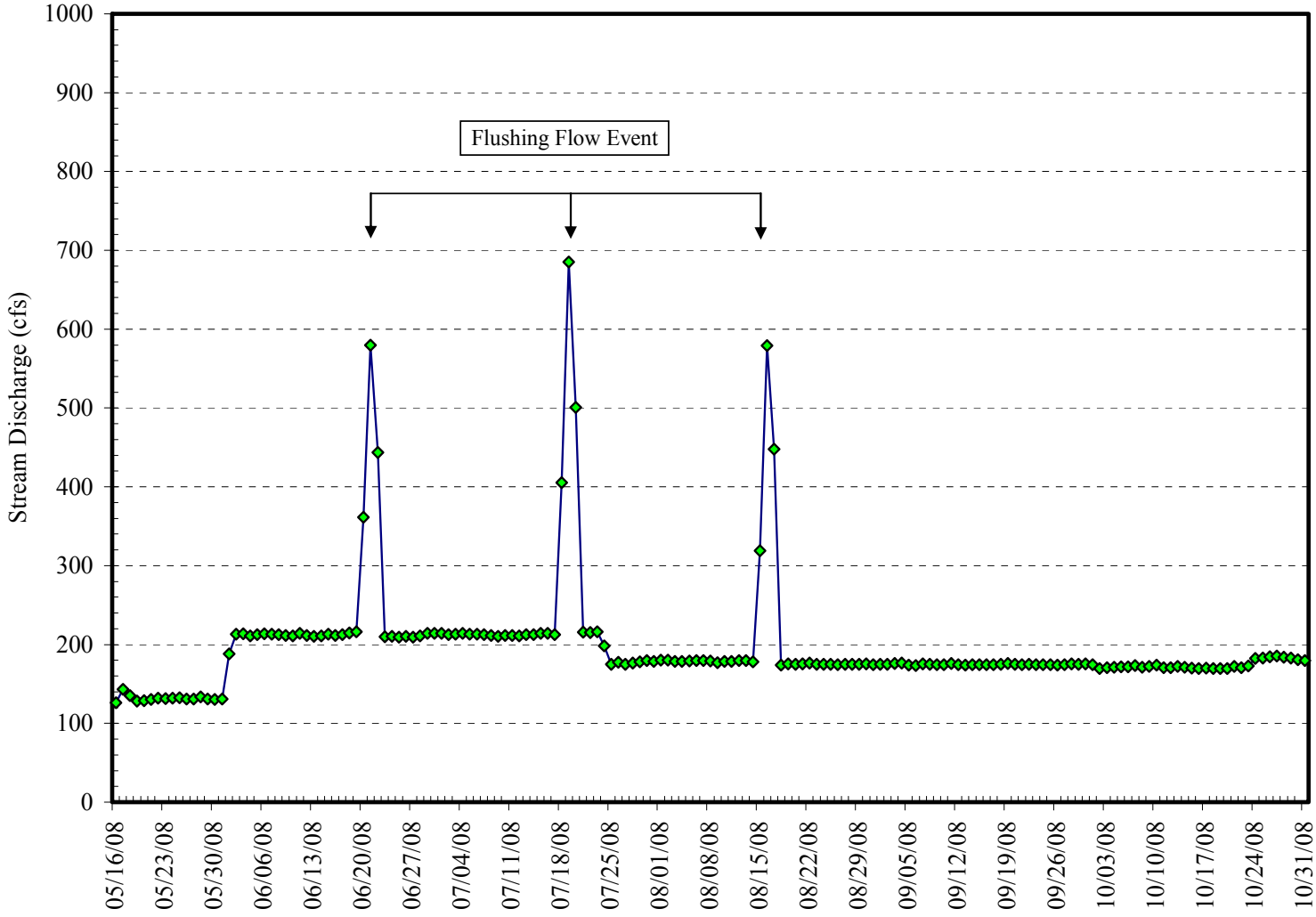

Figure 3-8. Daily average discharge from Pit 1 Forebay to Fall River (Gage PH-57 2008).

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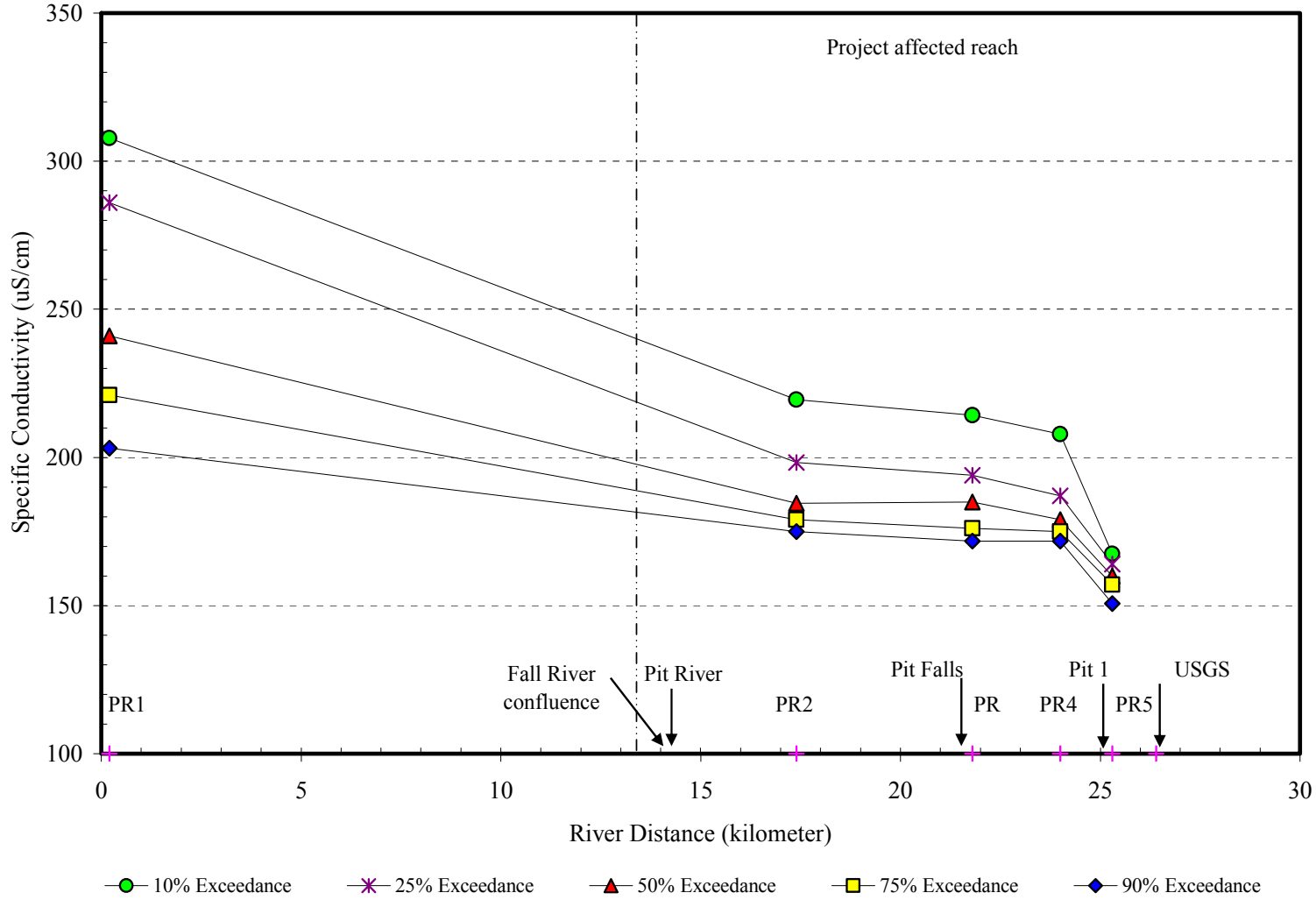

Figure 3-9. Longitudinal comparison of specific conductivity frequency distribution in the Pit River (2004–2008).

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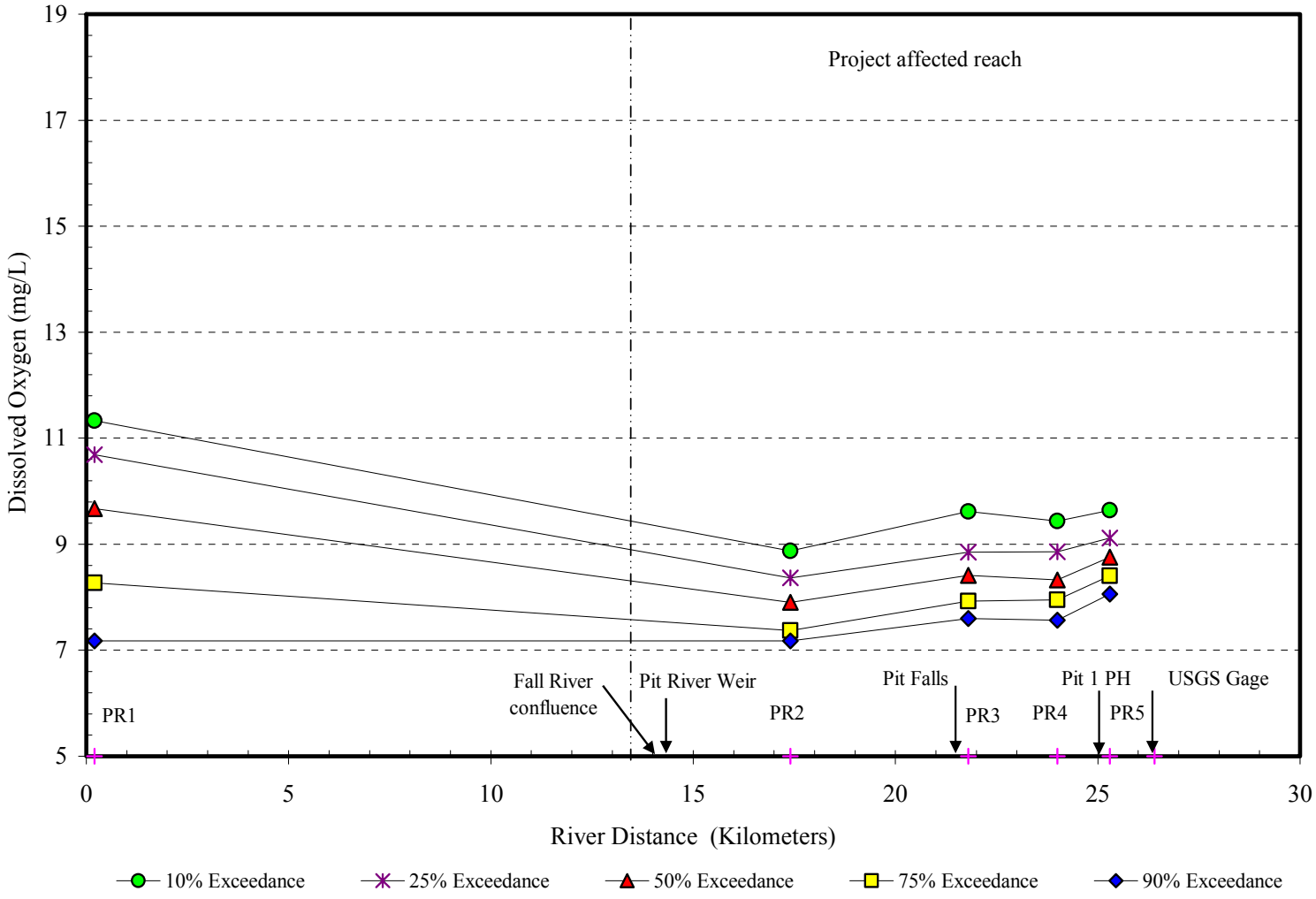

Figure 3-10. Longitudinal comparison of dissolved oxygen frequency distribution in the Pit River (2004–2008).

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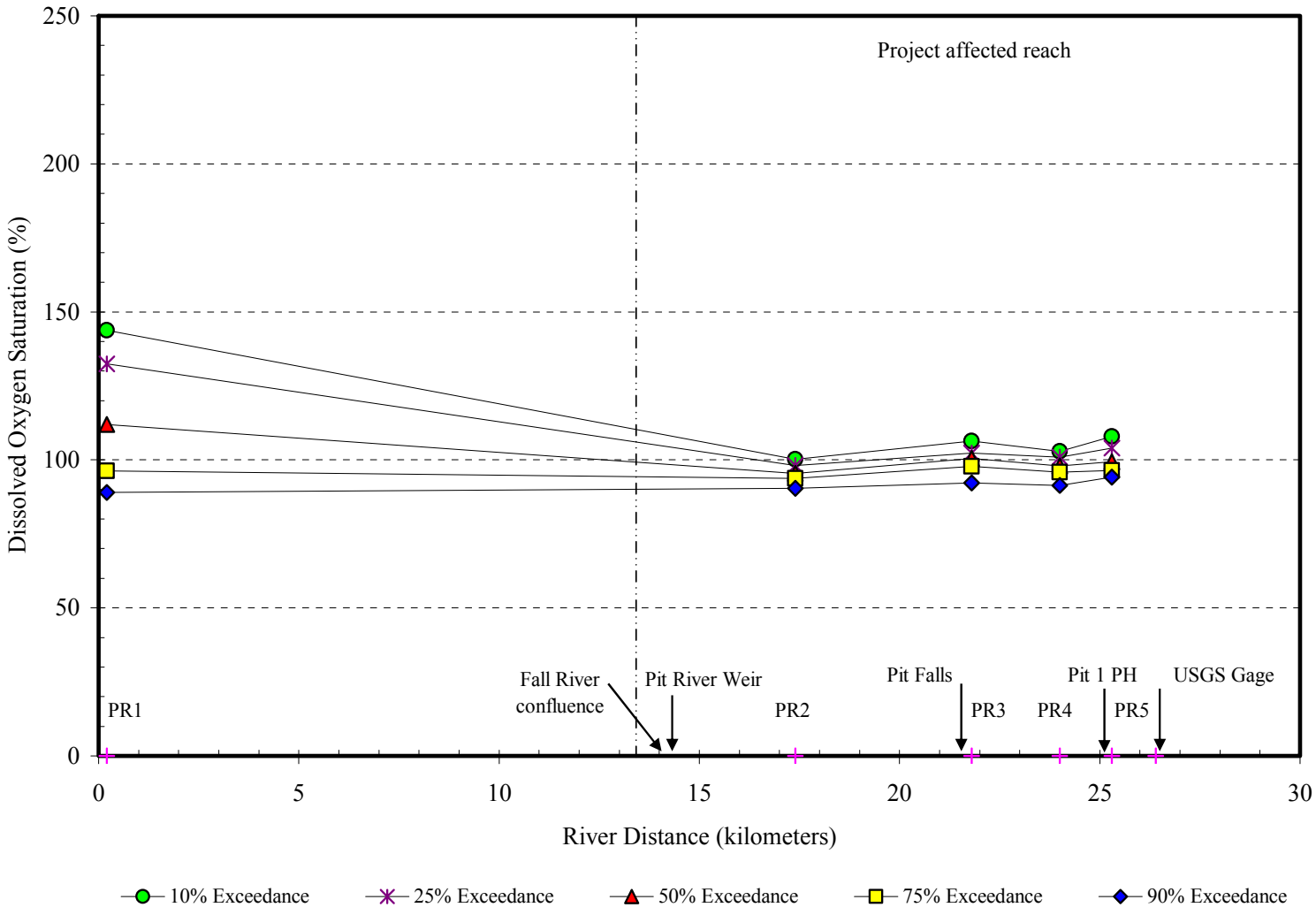

Figure 3-11. Longitudinal comparison of dissolved oxygen saturation frequency distribution in the Pit River (2004–2008).

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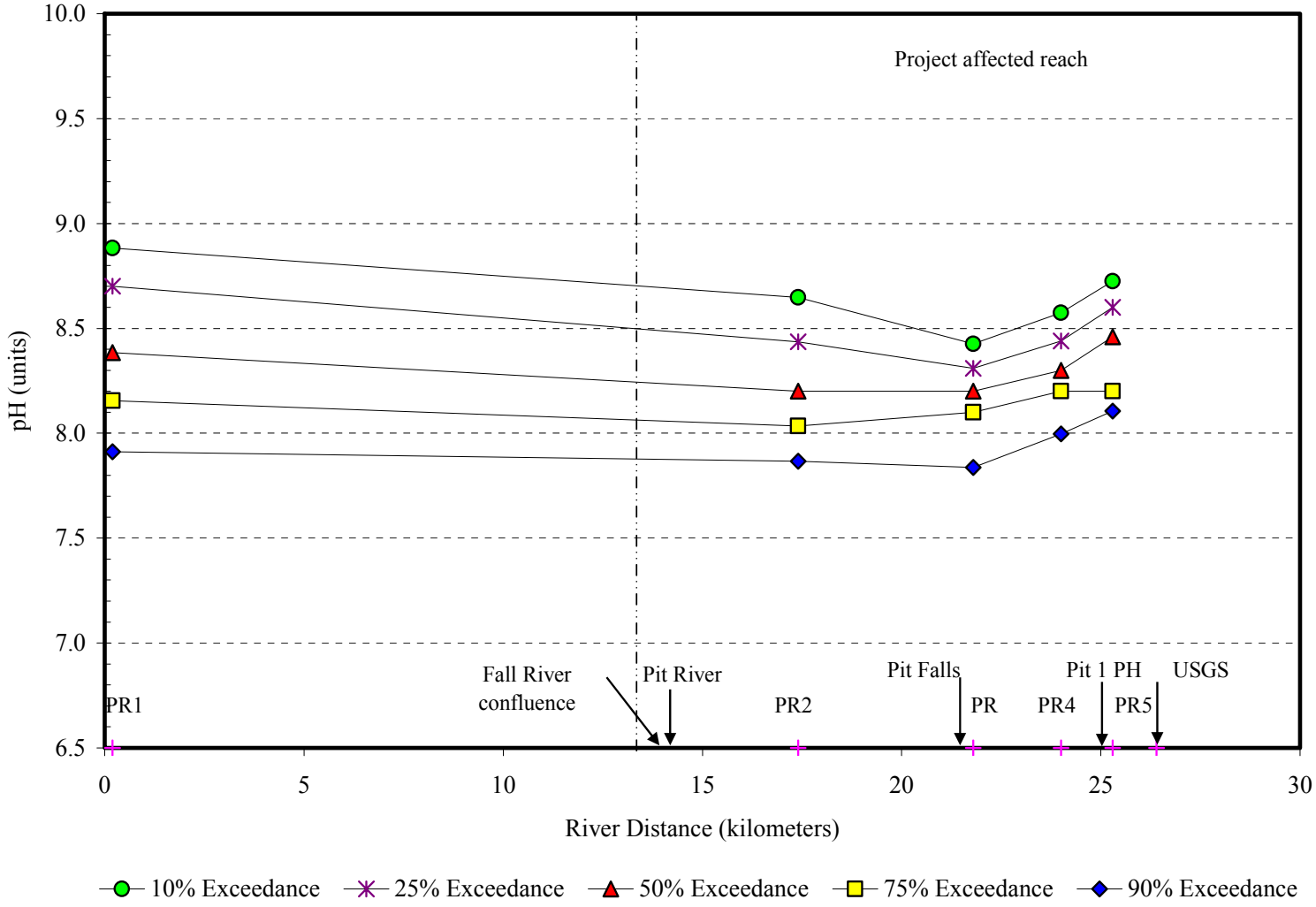

Figure 3-12. Longitudinal comparison of pH frequency distribution in the Pit River (2004–2008).

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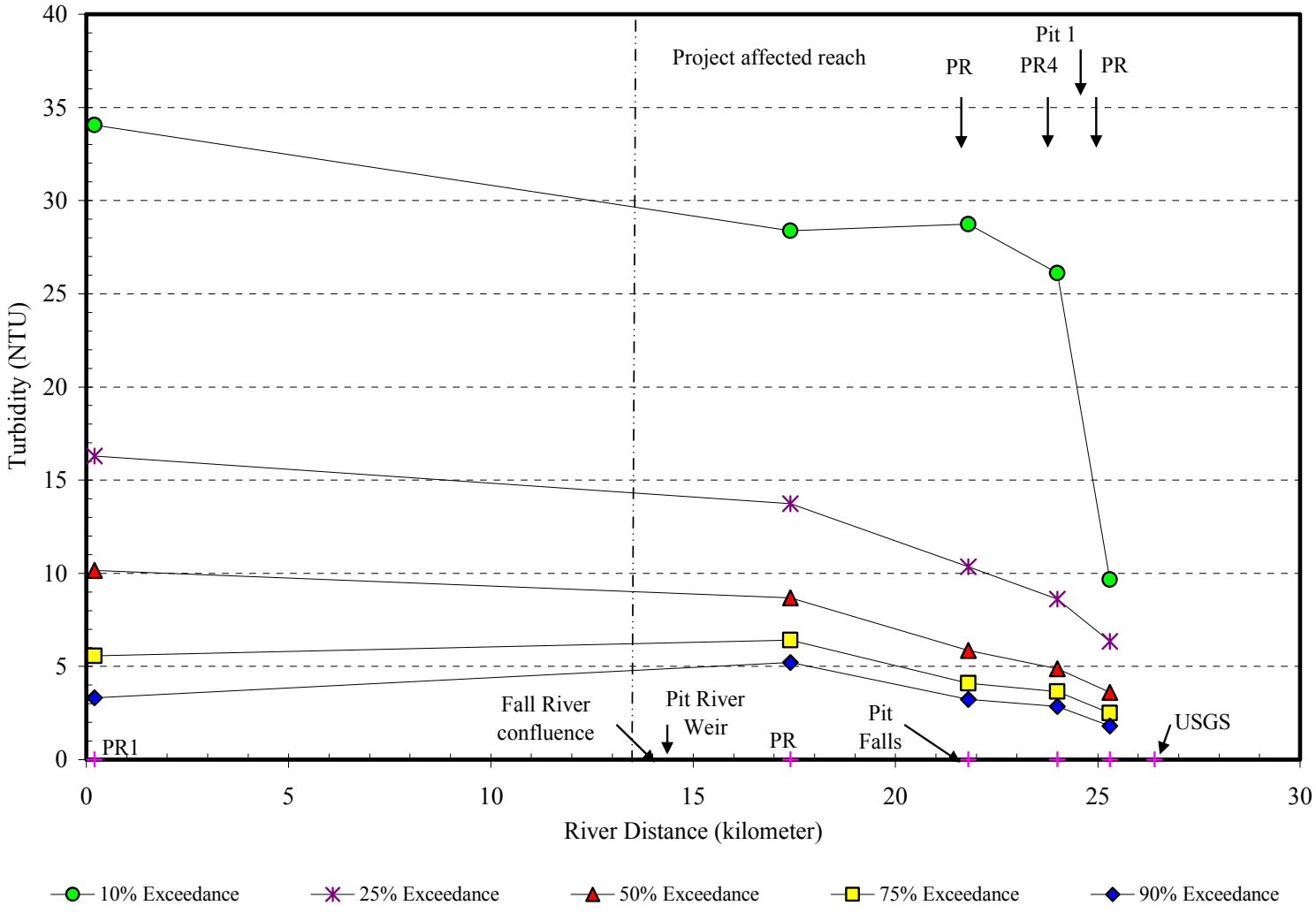

Figure 3-13. Longitudinal comparison of turbidity frequency distribution in the Pit River (2004–2008).

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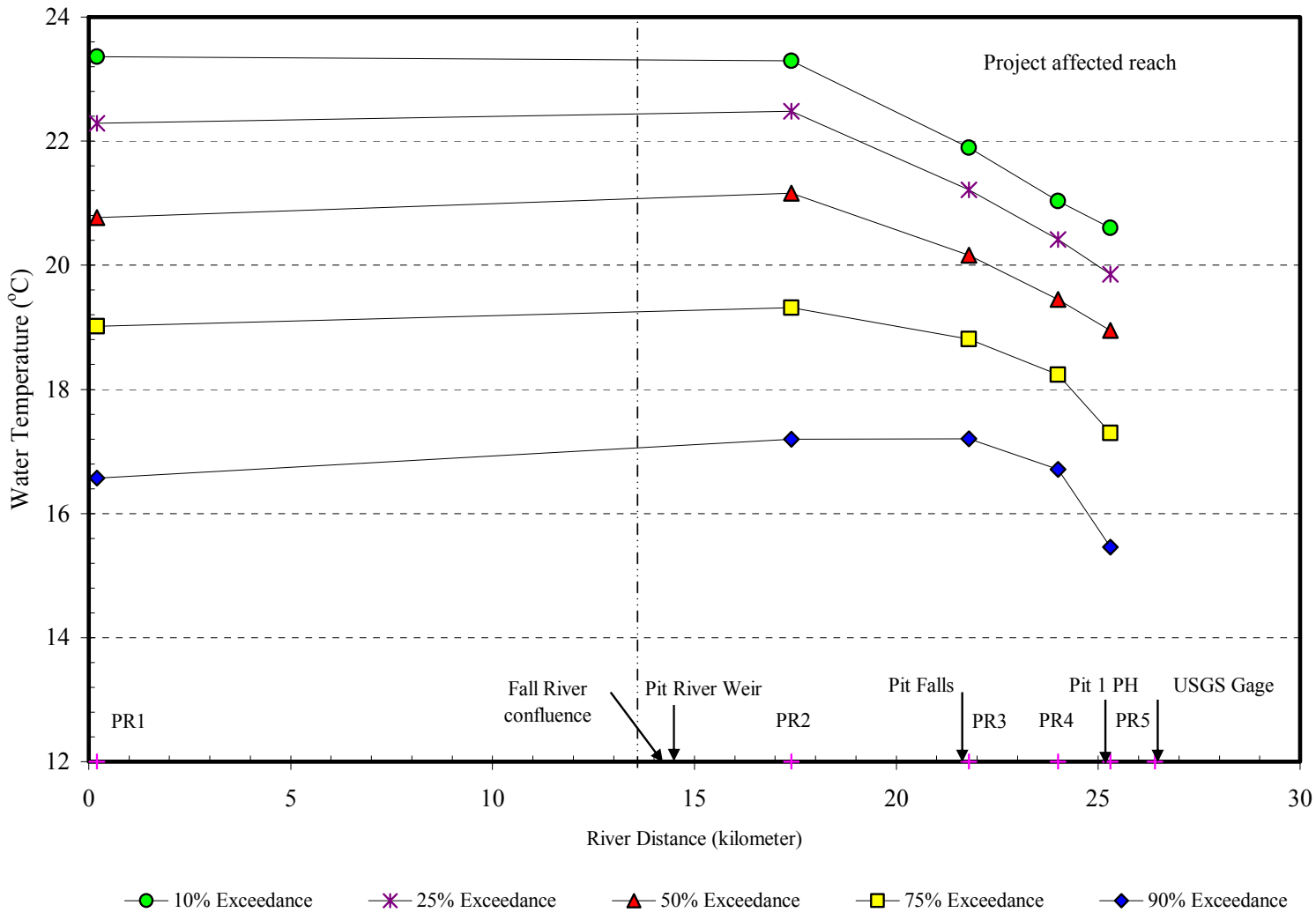

Figure 3-14. Longitudinal comparison of water temperature frequency distribution in the Pit River (2004–2008).

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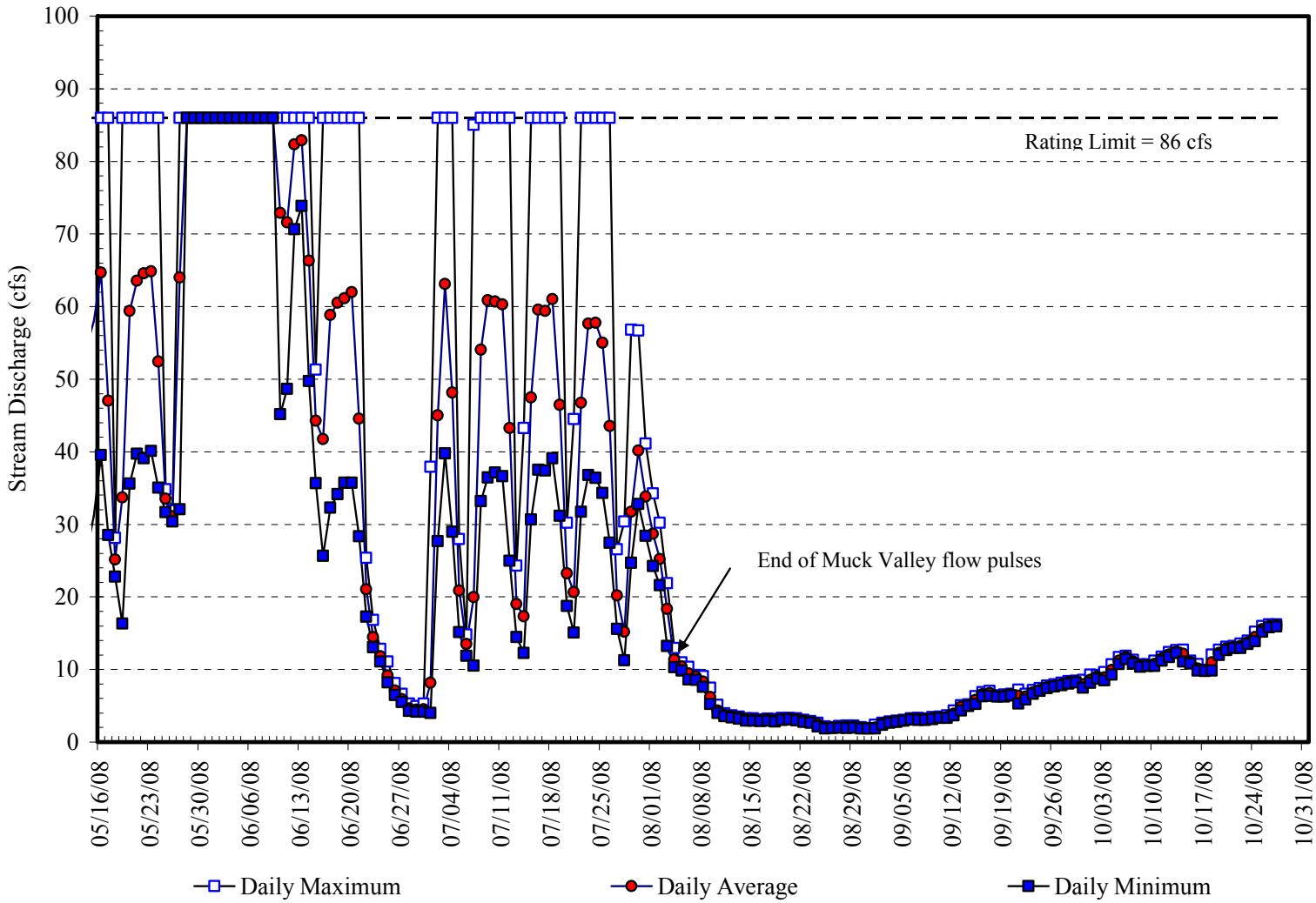

Figure 3-15. Daily stream discharge from temporary installation on Pit River at Pittville (Station PR1) – 2008.

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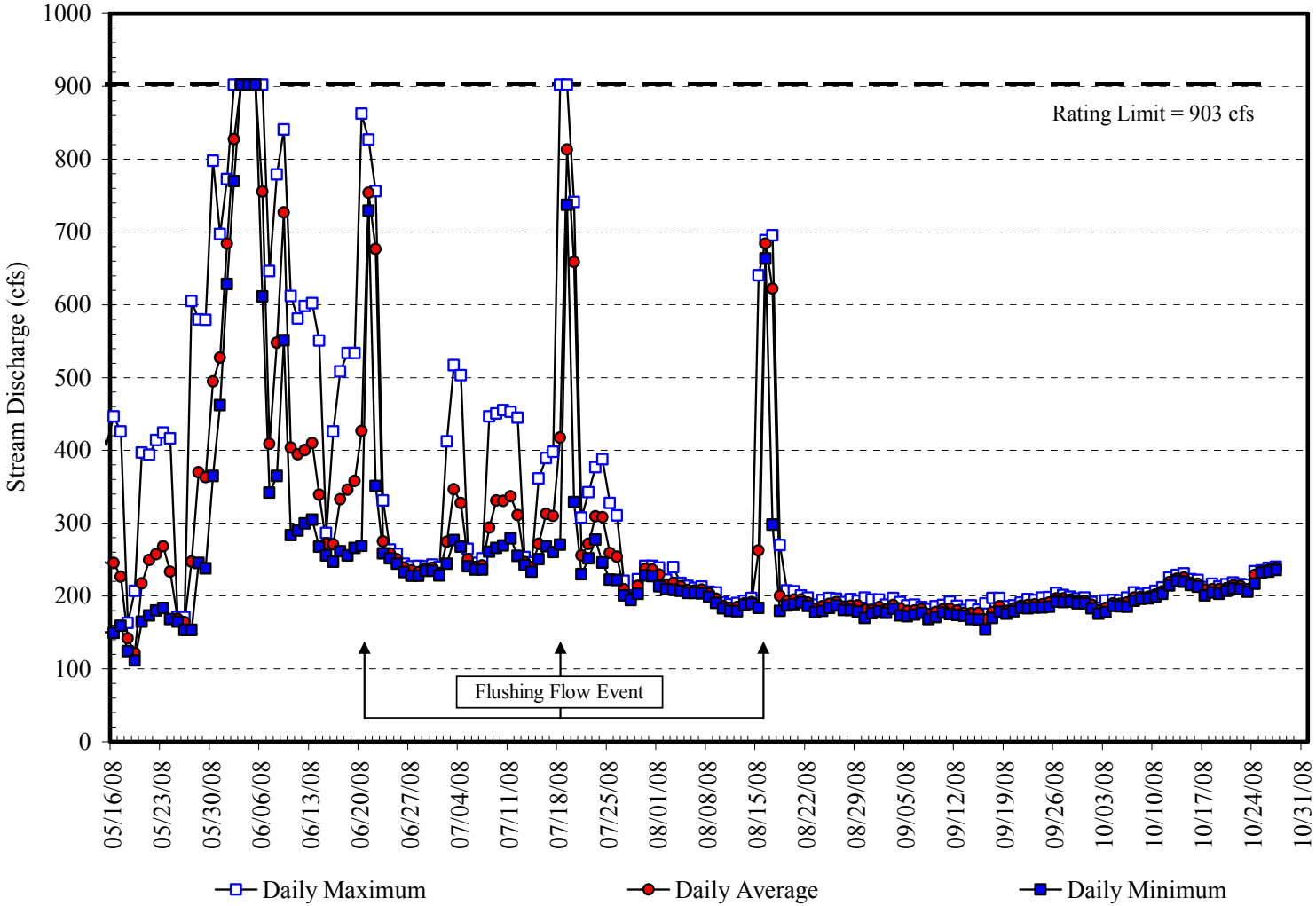

Figure 3-16. Daily stream discharge from temporary installation on Pit River at Big Eddy (Station PR2) – 2008.

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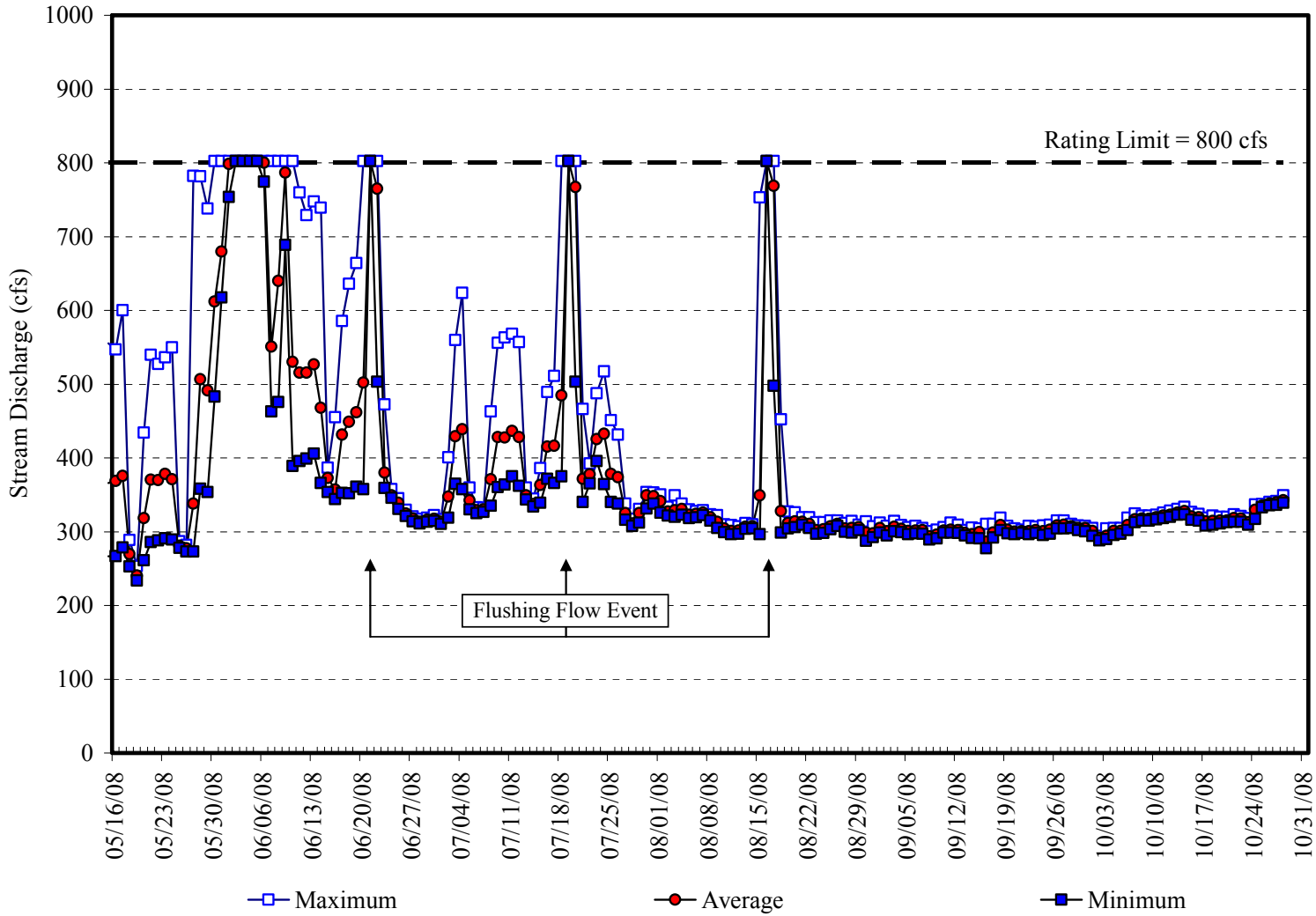

Figure 3-17. Daily stream discharge from temporary installation on Pit River at Pit 1 Footbridge (Station PR4) – 2008.

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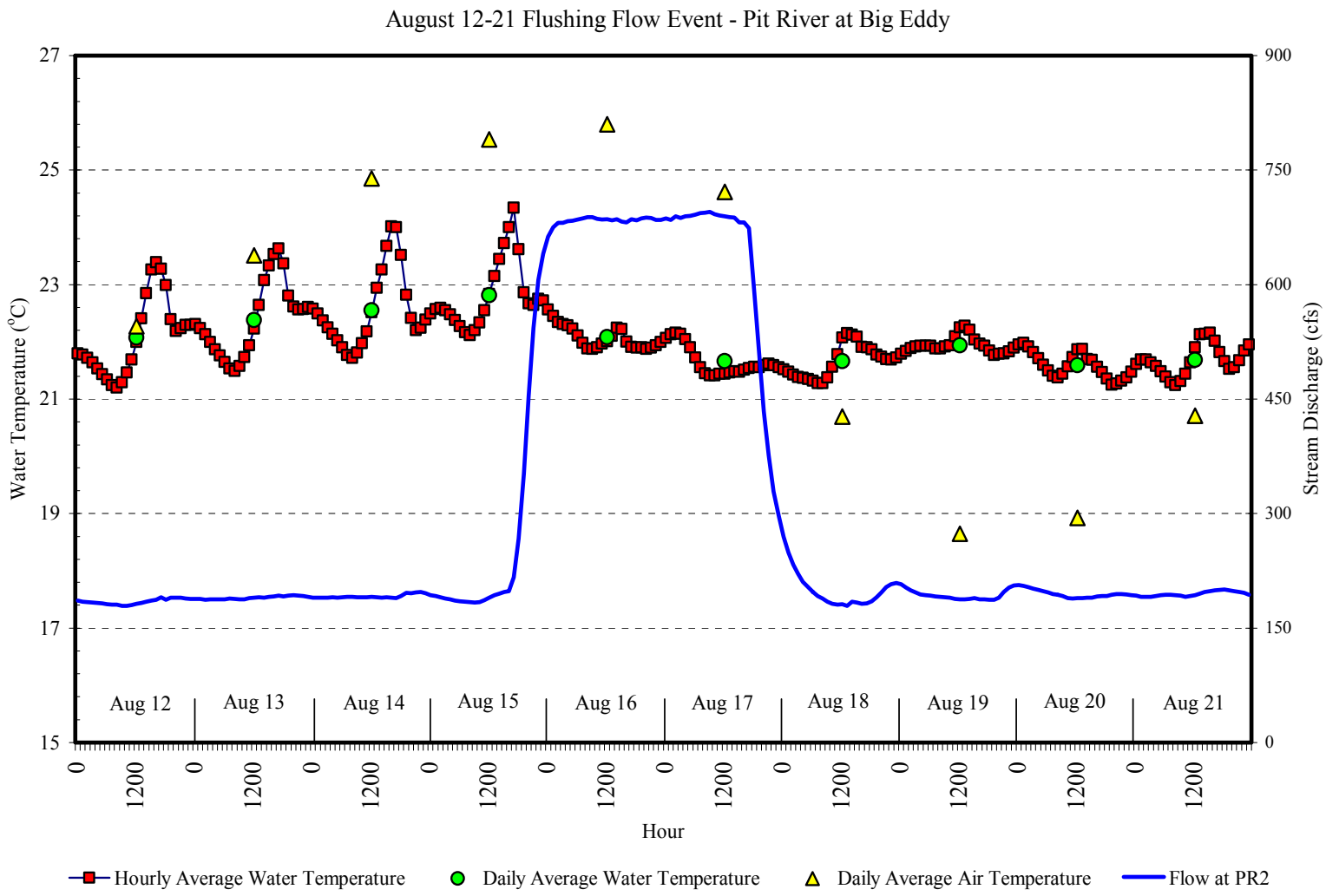

Figure 3-18. Evaluation of flushing flow effects on hourly average water temperature at Station PR2 – August 2008.

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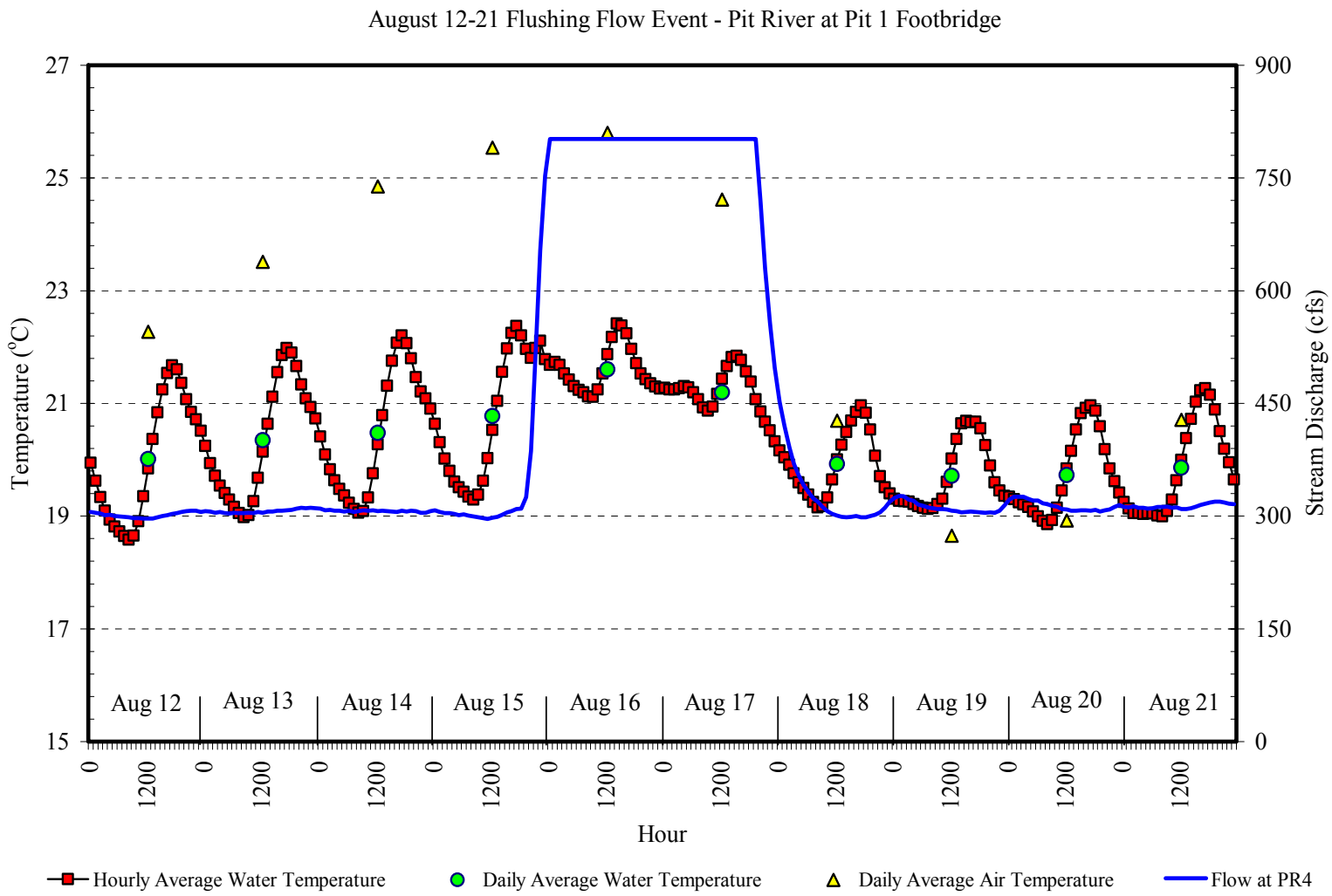

Figure 3-19. Evaluation of flushing flow effects on hourly average water temperature at Station PR4 – August 2008.

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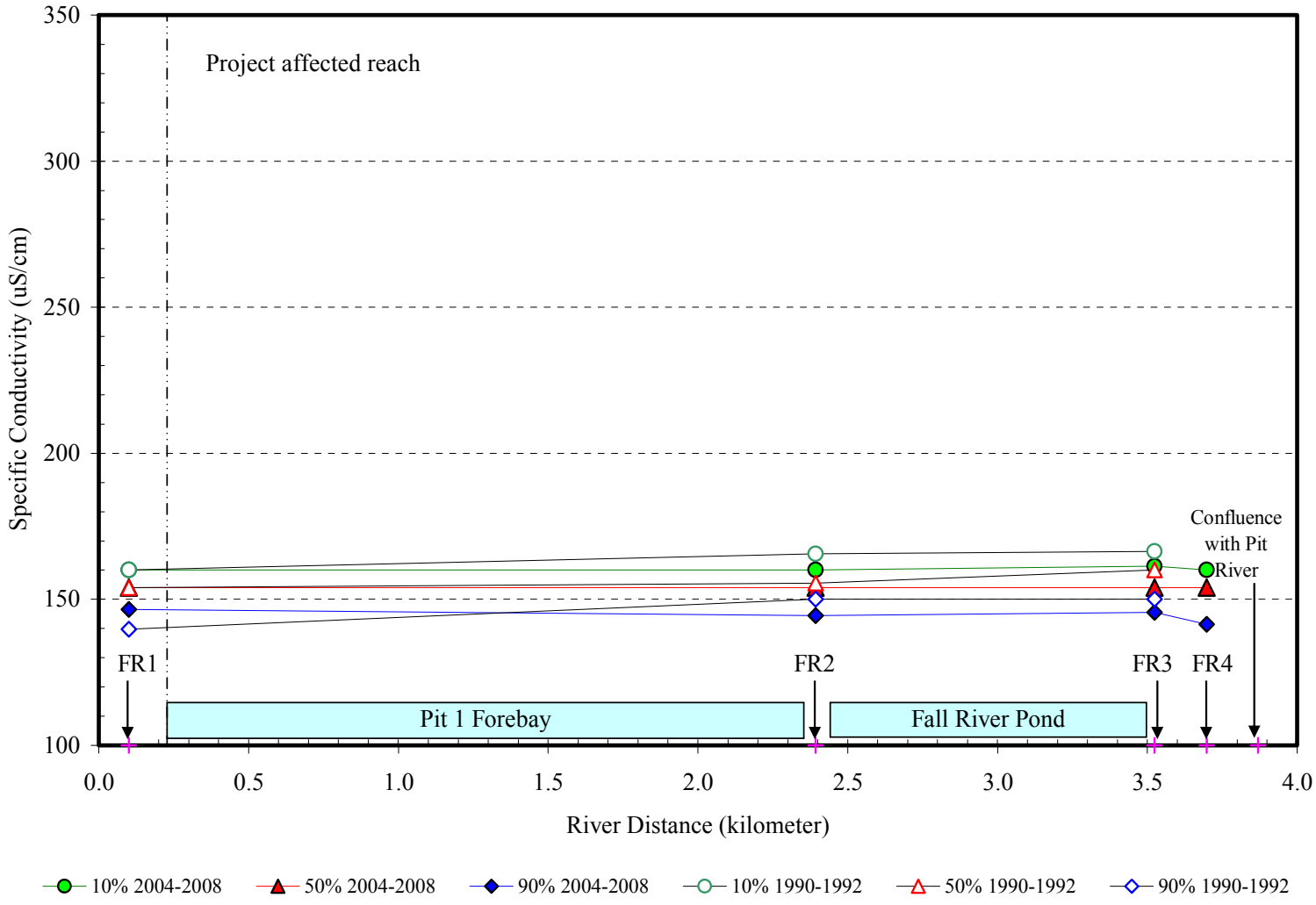

Figure 3-20. Comparison of 2004–2008 and 1990–1992 specific conductivity frequency distributions from Fall River.

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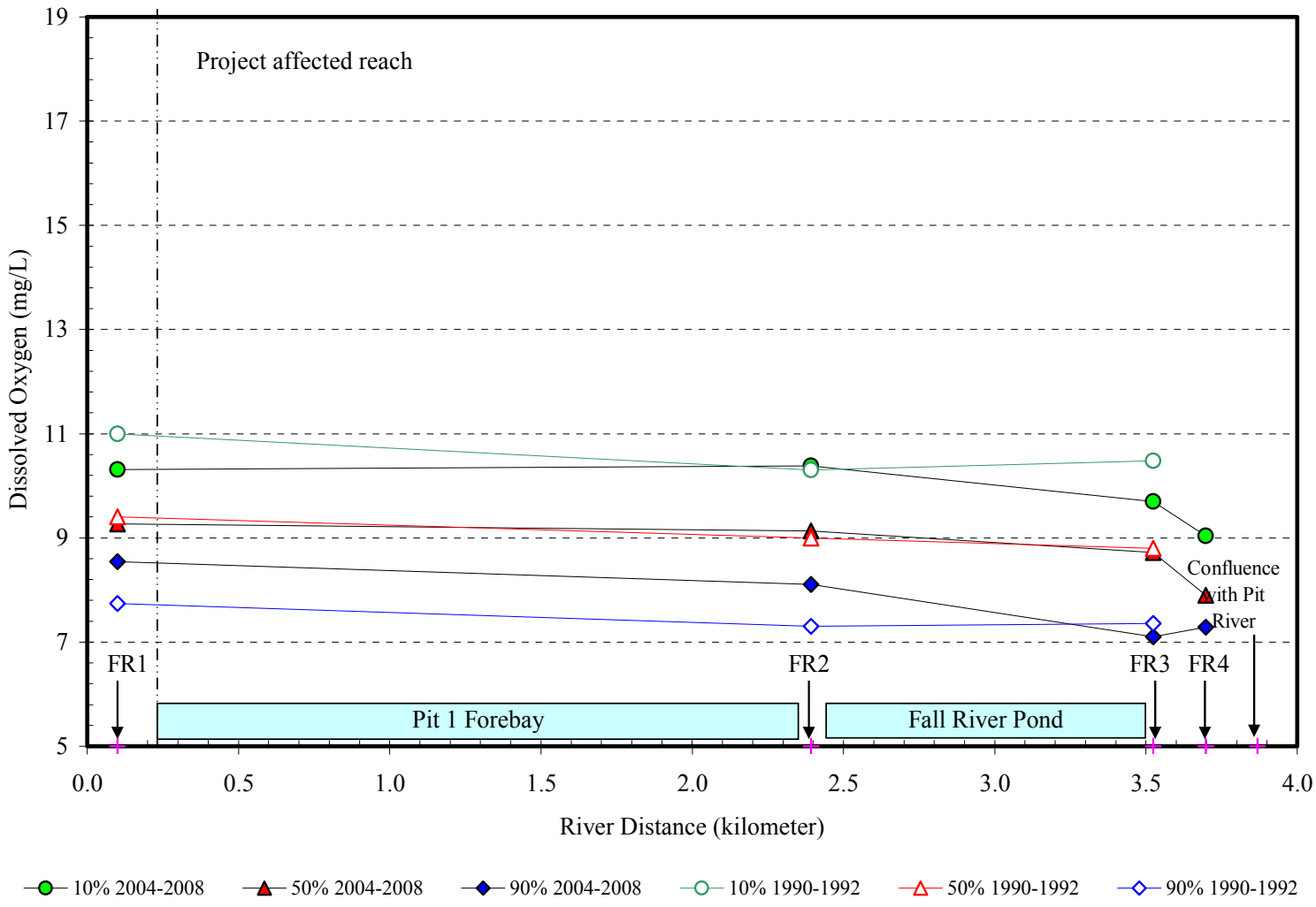

Figure 3-21. Comparison of 2004–2008 and 1990–1992 dissolved oxygen frequency distributions from Fall River.

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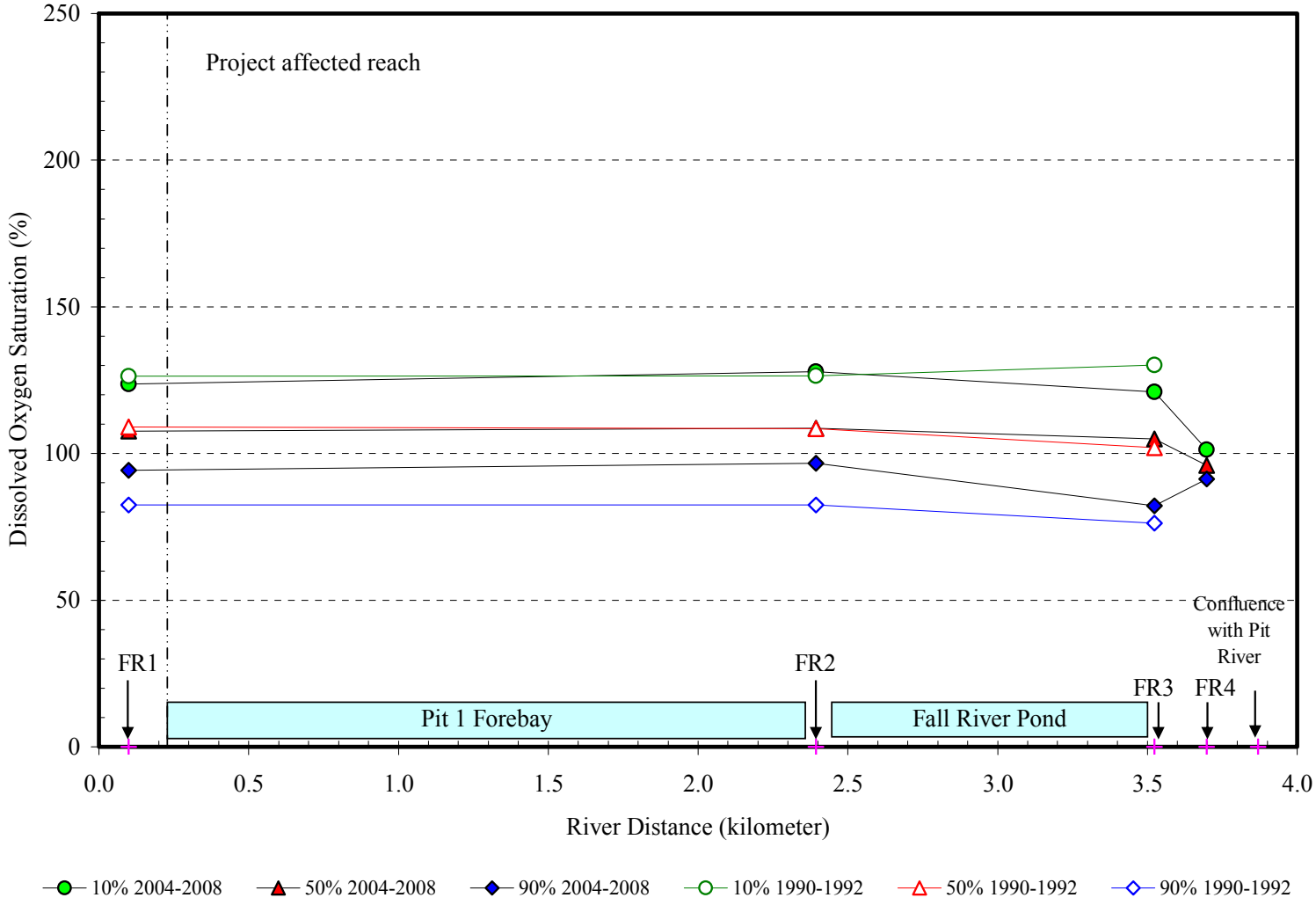

Figure 3-22. Comparison of 2004–2008 and 1990–1992 dissolved oxygen saturation frequency distributions from Fall River.

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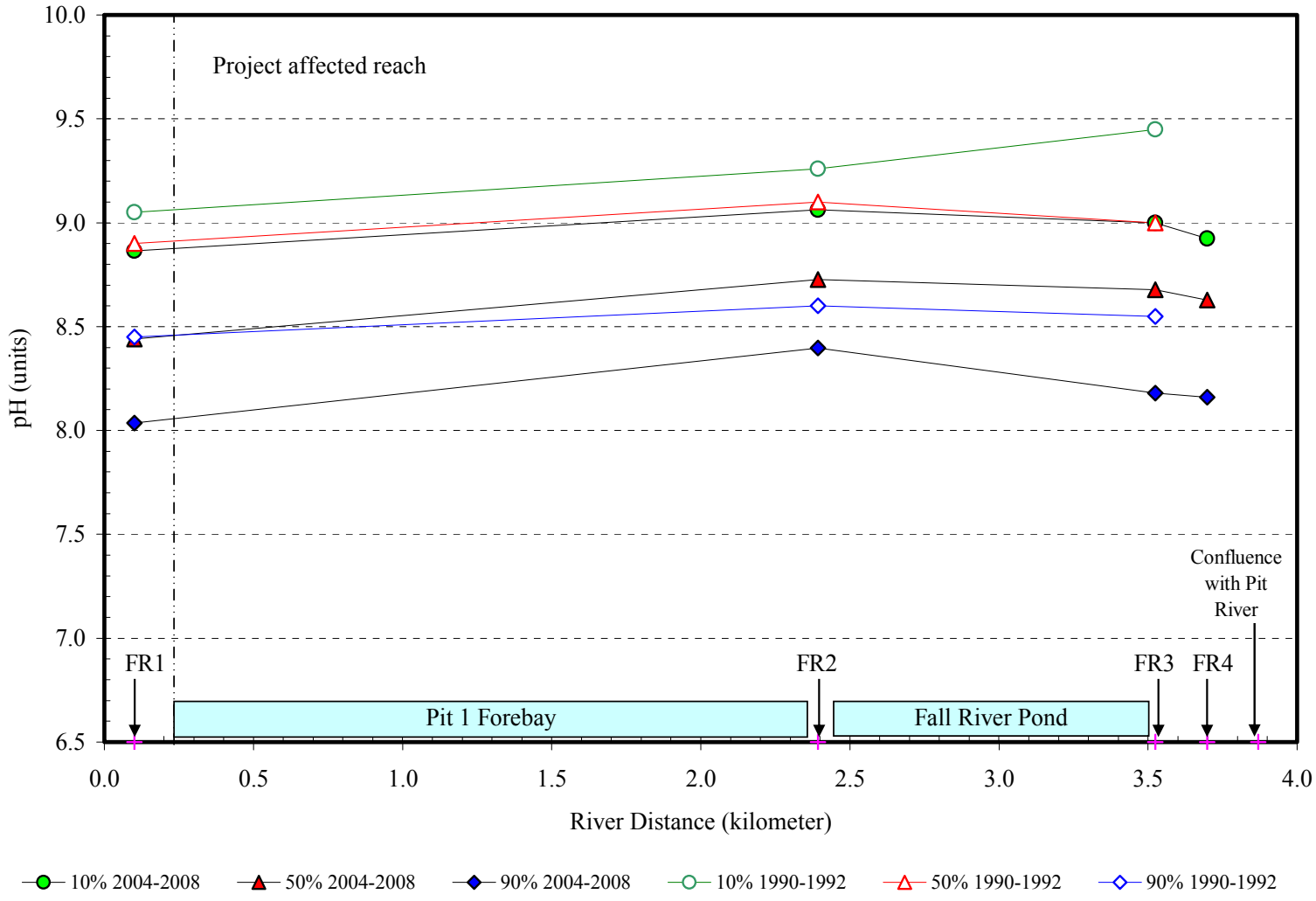

Figure 3-23. Comparison of 2004–2008 and 1990–1992 pH frequency distributions from Fall River.

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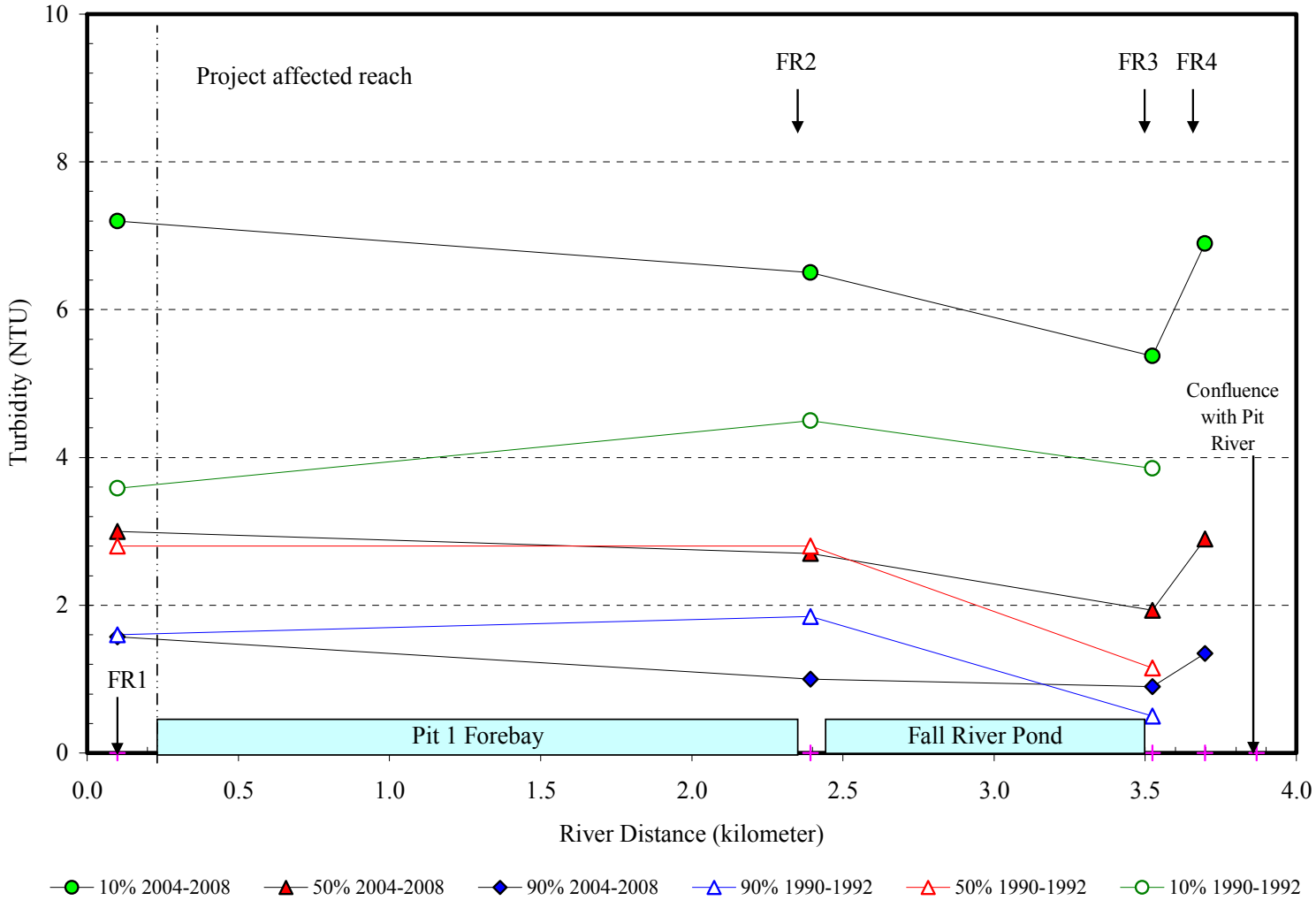

Figure 3-24. Comparison of 2004–2008 and 1990–1992 turbidity frequency distributions from Fall River.

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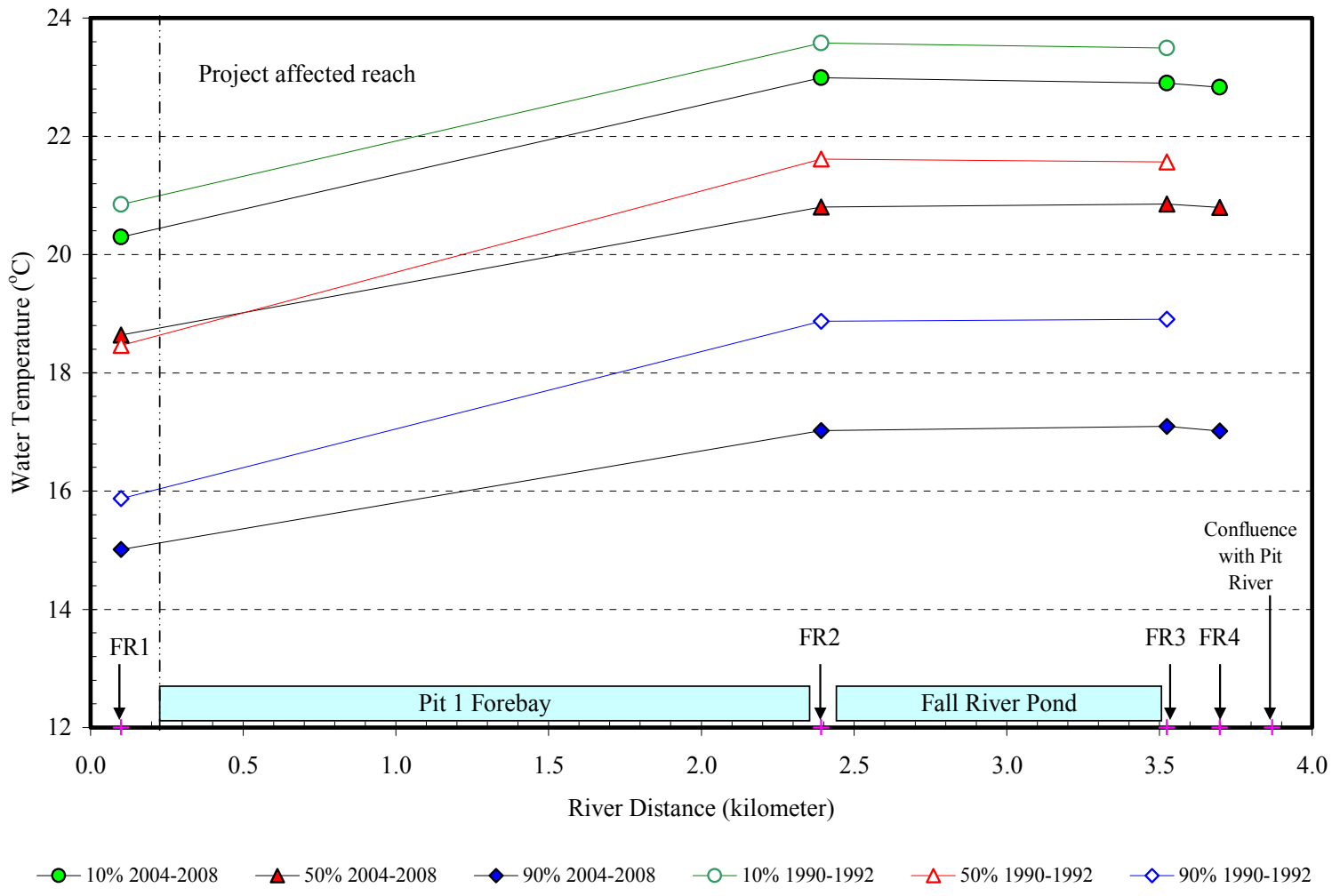

Figure 3-25. Comparison of 2004–2008 and 1990–1992 water temperature frequency distributions from Fall River.

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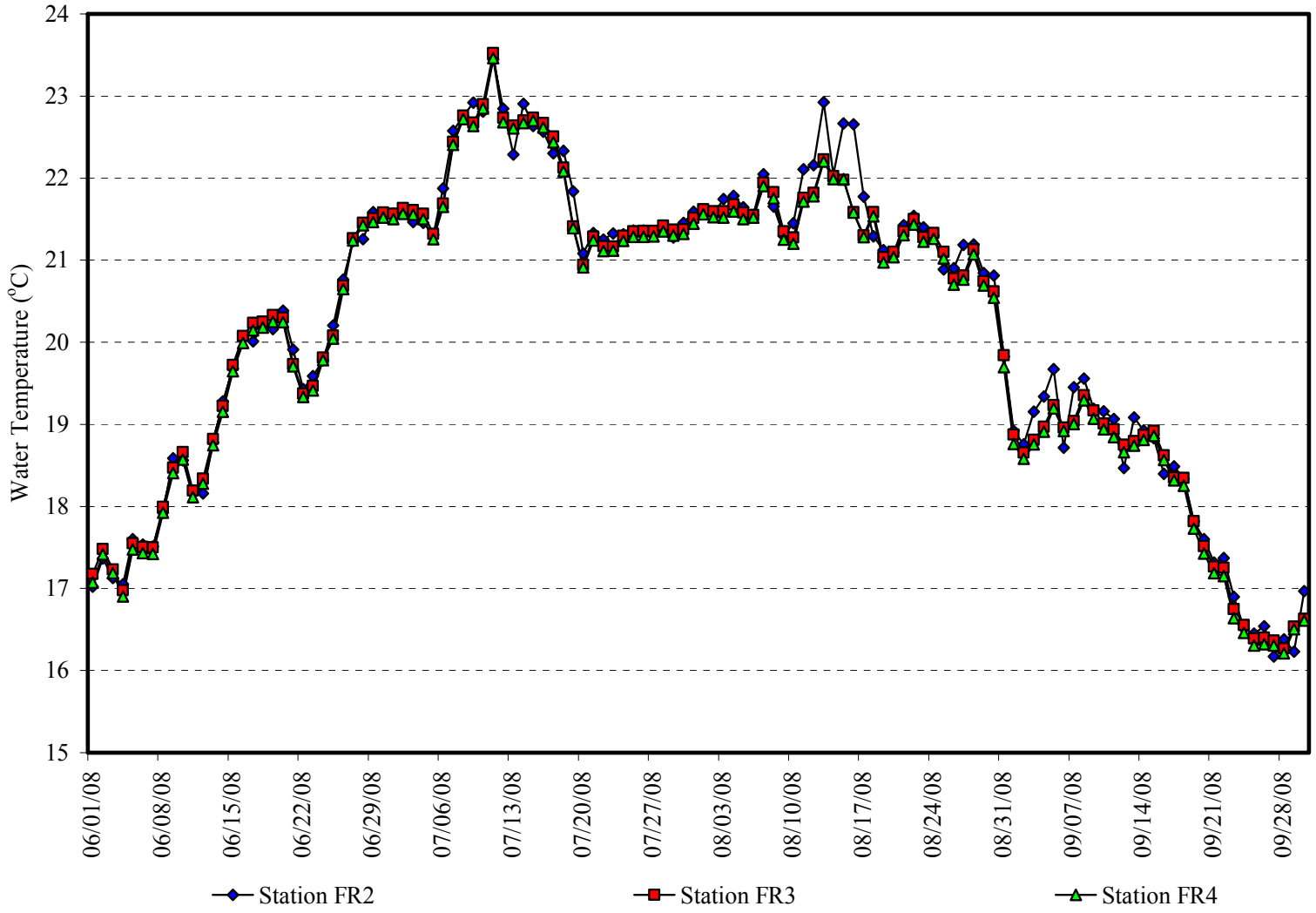

Figure 3-26. Comparison of daily average water temperatures from three stations in the Fall River – 2008.

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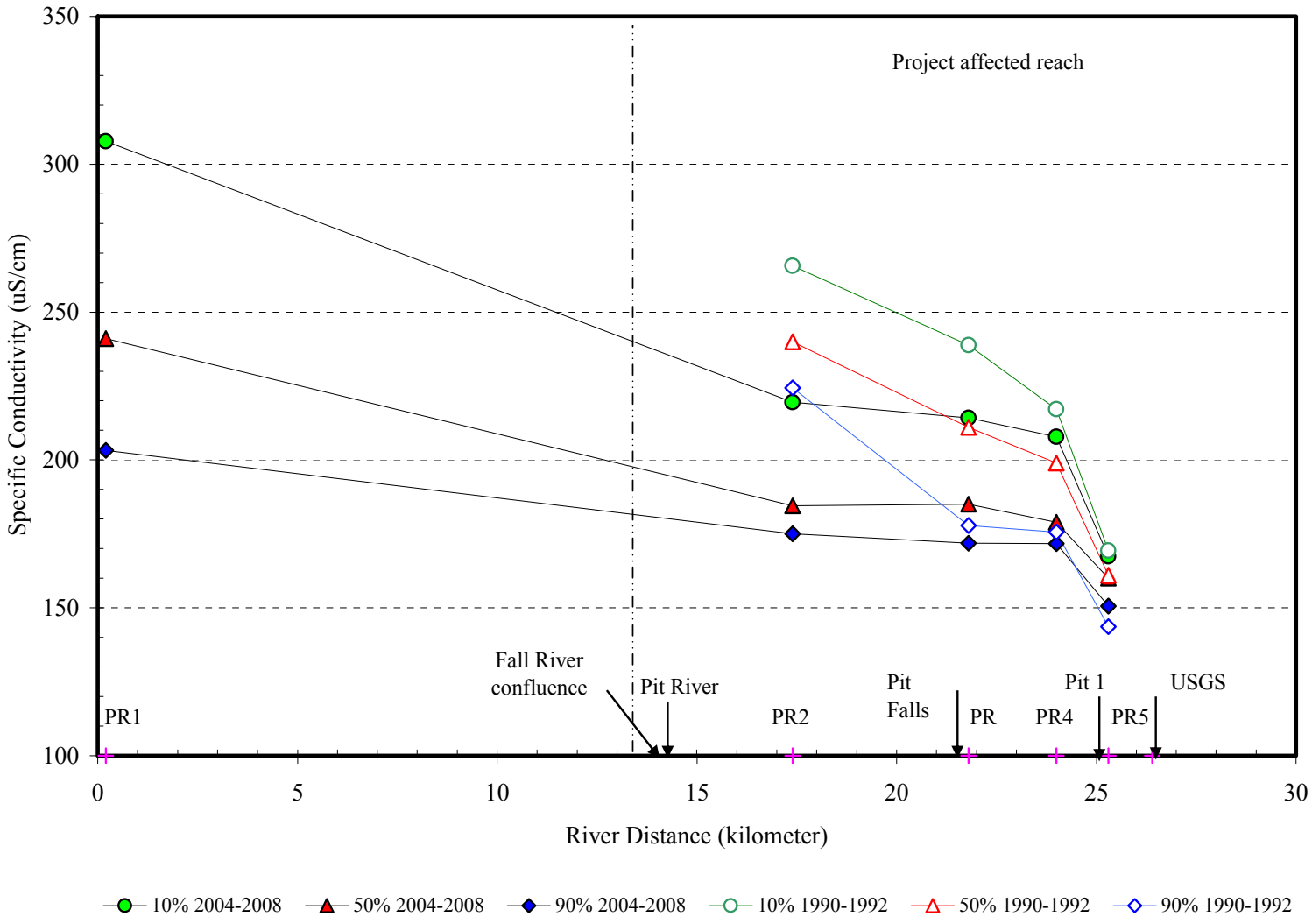

Figure 3-27. Comparison of 2004–2008 and 1990–1992 specific conductivity frequency distributions from Pit River.

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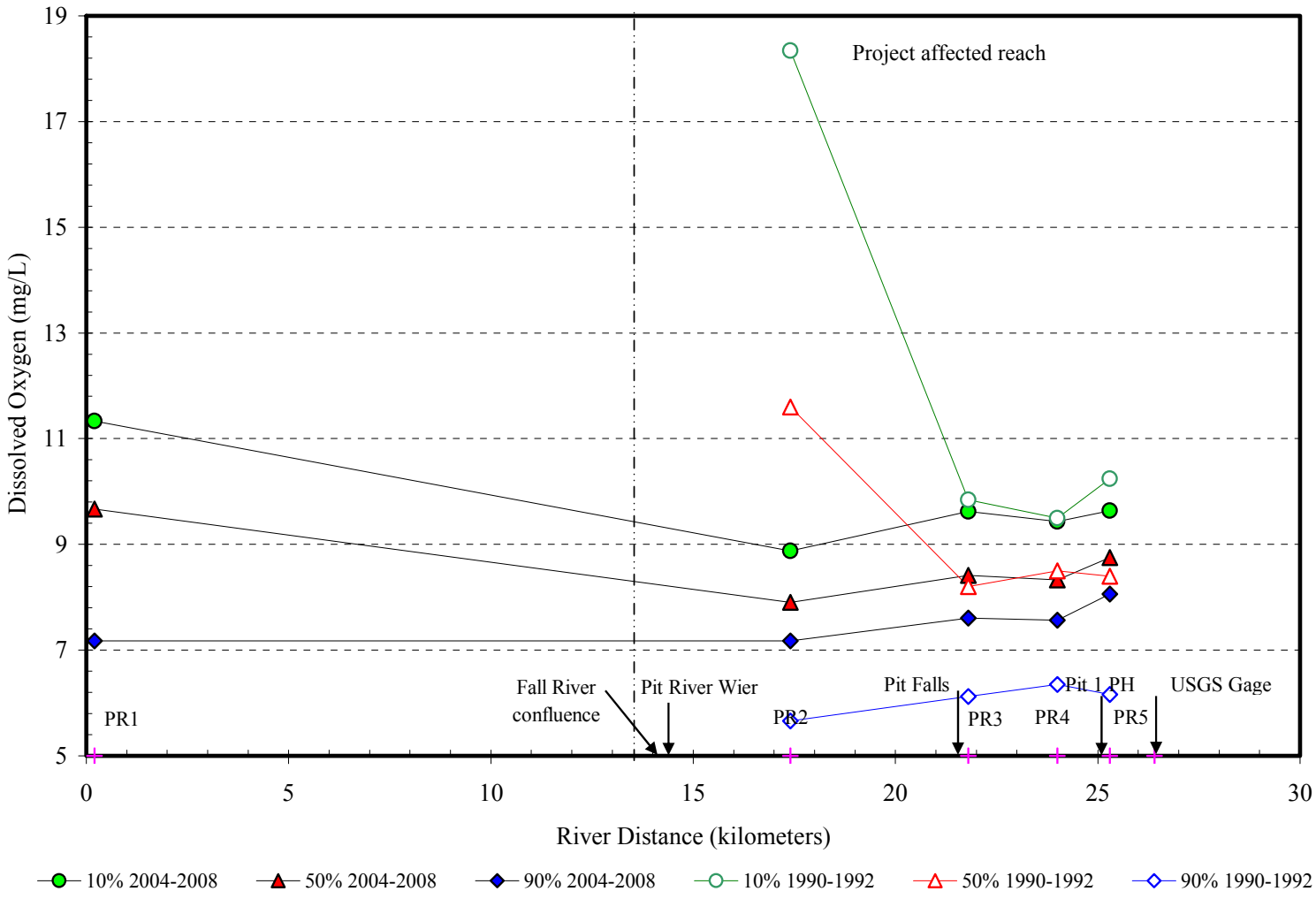

Figure 3-28. Comparison of 2004–2008 and 1990–1992 dissolved oxygen frequency distributions from Pit River.

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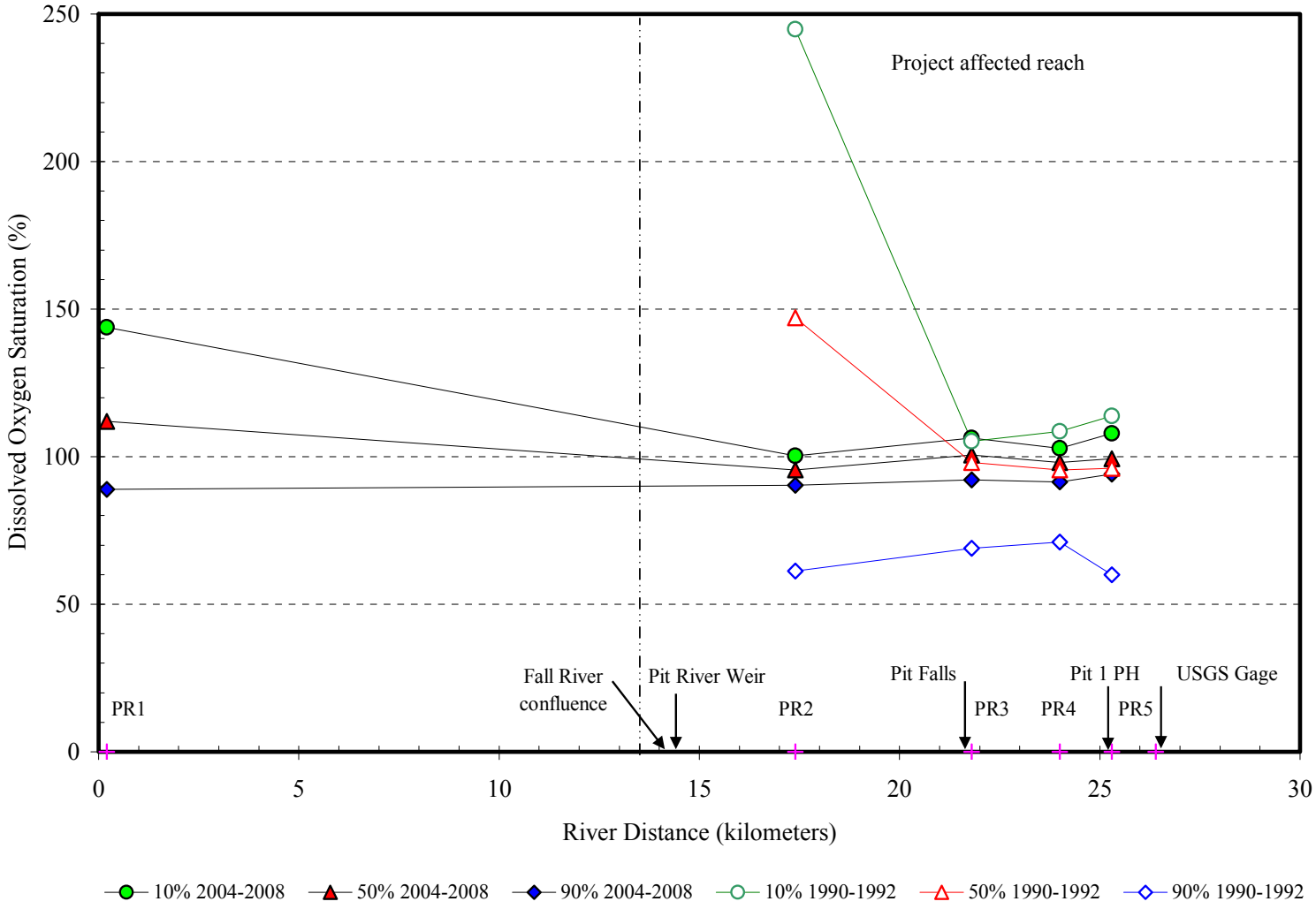

Figure 3-29. Comparison of 2004–2008 and 1990–1992 dissolved oxygen saturation frequency distributions from Pit River.

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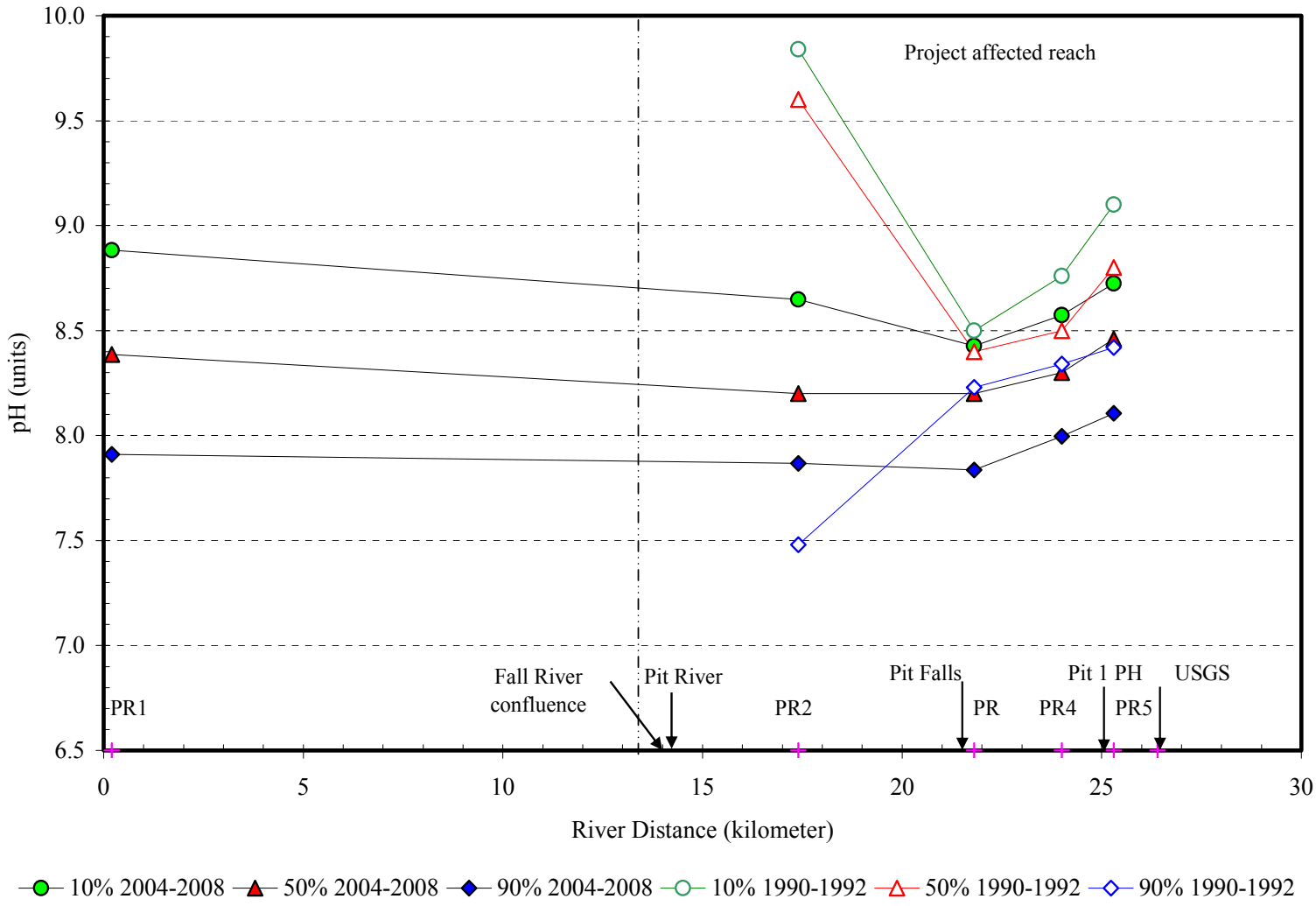

Figure 3-30. Comparison of 2004–2008 and 1990–1992 pH frequency distributions from Pit River.

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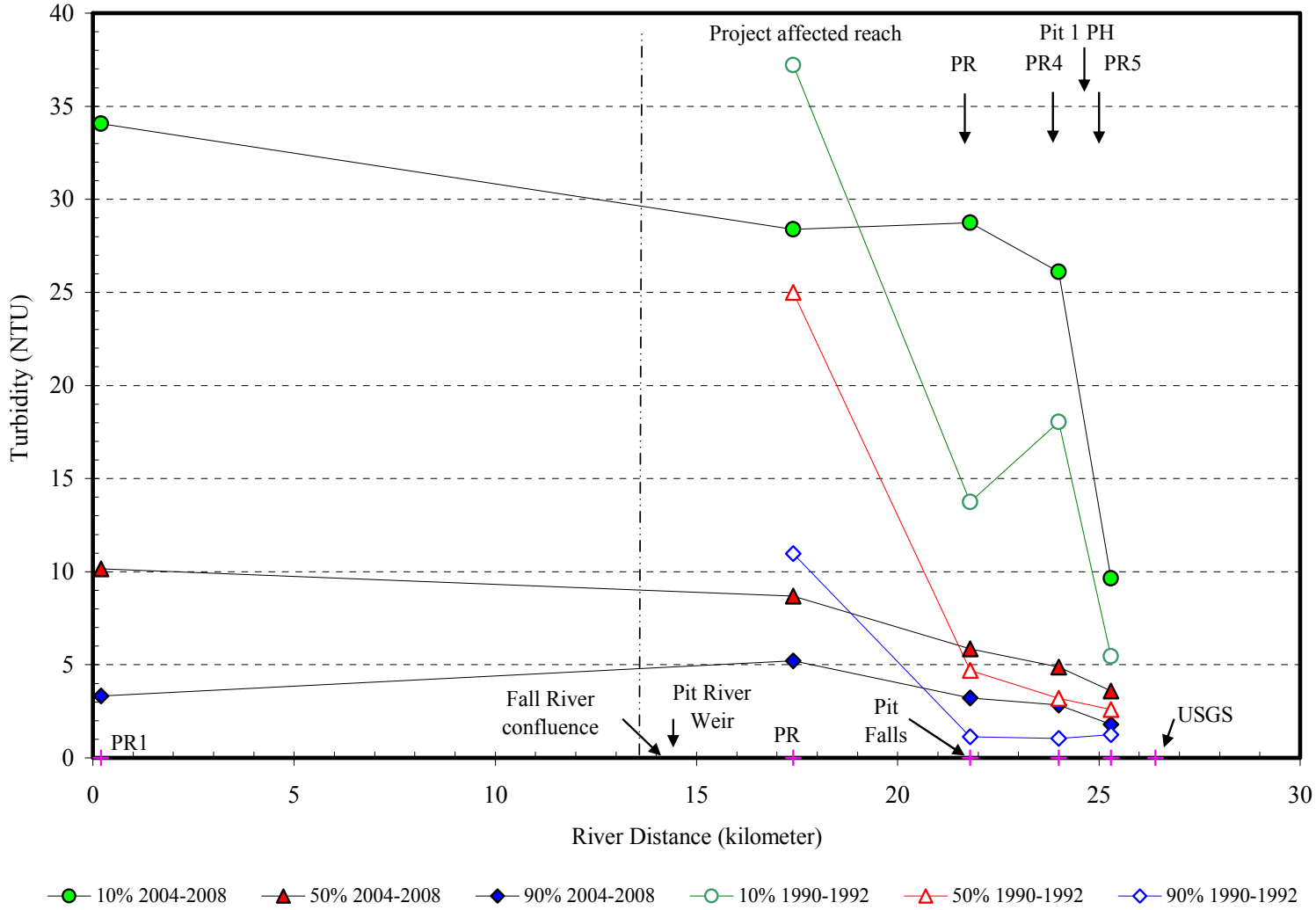

Figure 3-31. Comparison of 2004–2008 and 1990–1992 turbidity frequency distributions from Pit River.

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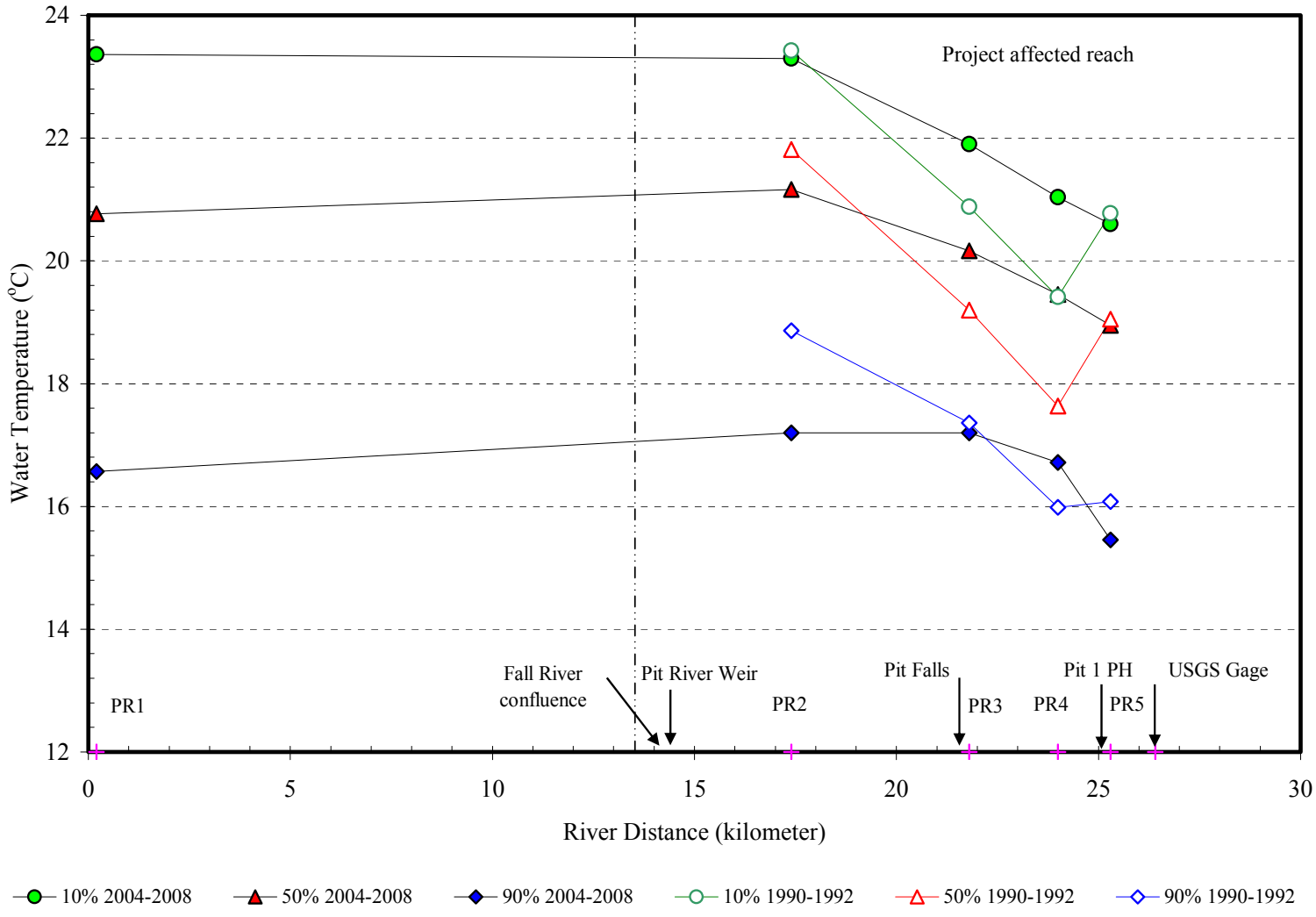

Figure 3-32. Comparison of 2004–2008 and 1990–1992 water temperature frequency distributions from Pit River.

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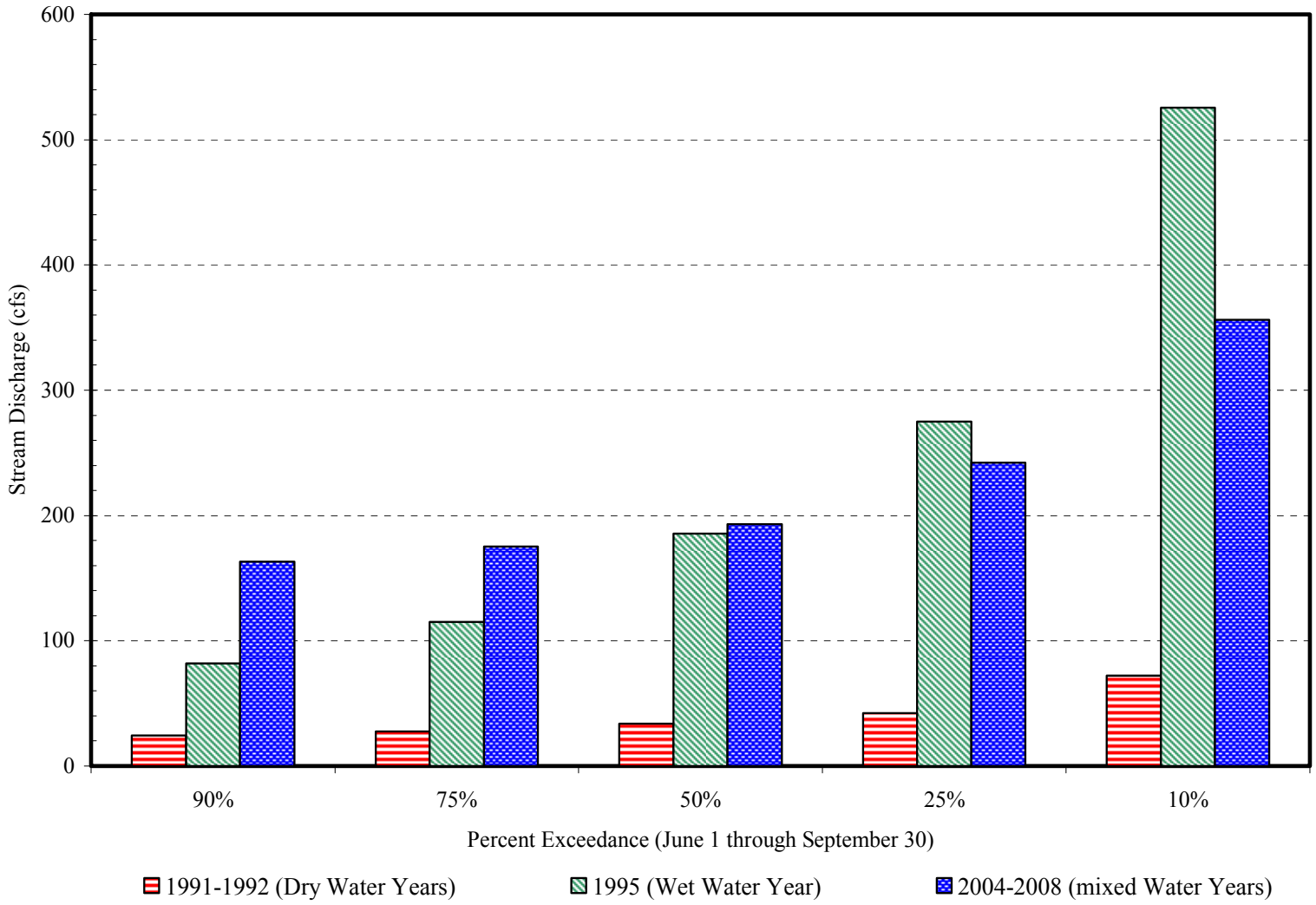

Figure 3-33. Comparison of daily average stream discharge from Pit River at Big Eddy (PR2) for the June-September period from three monitoring efforts.

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Conclusion

4.1 Summary of Monitoring Results

To comply with the conditions specified in the new license, PG&E has conducted annual water resource programs during each of the 2004 through 2008 monitoring seasons. Water quality (*in situ*) and water temperature monitoring was conducted at a total of nine stations (four in the Fall River and five in the Pit River) during each monitoring year.

Comparison of the 2004–2008 results with those from the 1990–1992 indicates that the current MIF release from the Fall River has positively affected the measured *in situ* water quality and water temperatures in the Project-affected Fall River Reach and upper Pit-1 Reach (up to the end of Big Eddy). PGE believes that the current MIF has moderated conditions in the Lower Fall River and Big Eddy Reach of the Pit River such that all current beneficial uses are supported. Periodic excursions of DO below the COLD objective are considered to be primarily related to sample collection coincident with the minimum of the diel cycle. Naturally high pH levels received by the Project from upstream sources are passed through Project facilities. Levels of both parameters (DO and pH) have been improved under the current MIF when compared with pre-MIF conditions (1990-1992). Water temperatures in the lower Pit River Reach, downstream of Big Eddy, however have been increased by the current MIF. The same trend (positive in the upper reach and negative in the lower reach) are observed during the short-term flushing flow events.

4.2 Suggested Improvements to Monitoring Program

The following sections will discuss recommended changes to the monitoring program based on the results of the 2004–2008 monitoring program.

4.2.1 Change to Monitoring Locations

1. Consolidate Lower Fall River Stations

The current MIF release made to the Lower Fall River Reach has significantly altered the flow regime in this reach compared with pre-MIF conditions. As a result, water quality and water temperature conditions in the Lower Fall River Reach are essentially the same and can be characterized using only one of the three currently active stations. Figure 4-1 compares water temperature data from the three stations in the Lower Fall River (FR2, FR3, FR4). As indicated, the average difference between FR4 and FR3 was less than the 0.1°C accuracy of the recorders. The average difference between FR2 and FR3 was also less than the 0.1°C accuracy of the recorders. However, the absolute range in the difference was 1.4 °C, which was attributed to FR2 being at a fixed depth in the Forebay and subject to periodic fluctuations in water level. It is recommended that Station FR3 be used to define conditions in the Lower Fall River. This station represents conditions in the terminal end of Fall River Pond, capturing the impact of both impoundments on water quality and water temperature.

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2. Modify Pittville Location (Station PR1)

For the Pit River system, the Licensee has re-evaluated the existing value of PR1 with regard to the overall monitoring objectives. As this station is located 14.4 kilometer above the impoundment created by Pit River Weir, it does not adequately reflect conditions entering the Project area near the Fall River confluence. The large number of agricultural inputs into the 14.4 kilometer section of river can seasonally alter the water quality, water temperature, and flow between Pittville and the Pit River weir. Currently the Pit River flow regime is determined using a temporary monitoring station located at an abandoned DWR site in Pittville. This station is suitable for defining flows less than 85 cfs that enter the upper end of the weir impoundment. The same data set can be estimated using the temporary station at Big Eddy and the new PG&E monitoring gage (PH-57C) used to determine flows in the Fall River below the Fall River Weir. Figure 4-2 compares the measured stream discharge at Pittville (PR1), with a calculated flow based on the difference between the Big Eddy station (PR2) and the PG&E PH-57 gage. As indicated, once the periods associated with the Fall River flushing flow events are removed, the calculated estimate closely matches the measured flow at PR1. Differences between the calculated and measured values are attributed to additional agricultural influences (input or withdrawal) occurring between the two stations. PG&E believes the use of the better equipped PG&E flow station at PH-57C gage in combination with the continued use of PR2 flow station will provide a legitimate surrogate for the PR1 station, as well as being more representative of conditions in the Pit River immediately upstream of the confluence with Fall River. As a result, it is recommended that the PR1 flow station be eliminated and supplemented with PH-57C gage/PR2 aggregate calculation. The corresponding *in situ* water quality and continuous temperature monitoring location will be moved downstream to the Cassel Road Bridge in the town of Fall River Mills. This location is upstream of the Fall River confluence and under most conditions reflects incoming conditions. This location is not suitable for monitoring flow in the Pit River above the confluence, monitoring would be limited to *in situ* water quality and water temperature if this new location is selected.

3. Eliminate Station at Pit Falls (PR3)

The water quality and water temperature monitoring station located near Pit River Falls (PR3) can be represented and captured by the upstream (PR2) and downstream station (PR4). This station is the most difficult, unsafe and labor intensive station among all the monitored networks. While this station can provide some intermediate conditions in the canyon section of the Pit 1 Reach, its value is limited in providing any additional characteristics in water resource condition. Furthermore, data from this station do not offer information that can be used to help shaping better resource management decision in the future adaptive process.

4. Eliminate One Metrological Station

Currently two locations are monitored for a full suite of meteorological parameters. These locations are sited at the Pit 1 Diversion and Pit 3 Intake structure. These sites were included in the original monitoring program with the idea that additional modeling efforts would be required to refine management decisions. Data have been collected from both locations during each of the five monitoring years, and the data were reported in the annual monitoring reports. These data have not been utilized as part of any additional modeling efforts and are not viewed as

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necessary to future monitoring efforts. Because of the close proximity of the two locations, it is anticipated that there will be a strong correlation between data from the two stations. PG&E will continue monitoring meteorological conditions at Pit 3 intake structure (Lake Britton) since this station is part of the compliance requirement for Pit 3, 4 and 5 Project (FERC 233). It is recommended that meteorological station at Pit 1 diversion be eliminated from the monitoring program.

4.2.2 Change to Monitoring Frequency

The current schedule of twice monthly water quality sampling has successfully generated a relatively robust data set for the selected *in situ* parameters. Data have suggested that, under the current MIF flow regime, SpC and pH, which are seasonally stable and exhibit little or no diel cycle, do not warrant continued twice-a-month monitoring. Turbidity sampling, which is seasonally variable (dependant on the quality of runoff from the upstream watersheds and agricultural returns) and whose levels are not considered a Project related impact, also does not warrant a twice-a-month sampling schedule. All of these parameters can be characterized using a monthly sampling schedule.

Dissolved oxygen fluctuates seasonally and exhibits strong diel cycles. The seasonal variation is well captured by the current twice monthly schedule, however, data have suggested that a similar measure of the general condition would be equally captured and established using a monthly schedule. If an understanding of the diel behavior of DO under the current or future adaptive MIF release schedule is necessary, then it is recommended that using a more intensive continuous monitoring over a short duration (3–5 days) effort during one or two critical periods (July or August) would be a more appropriate method of defining the diel cycle. The effort would include installing a continuously recording instrument at the selected location (Big Eddy) and allowing the instrument to record hourly average DO levels over the course of several days.

4.2.3 Adaptive Water Quality Management (401 Certification Condition 17)

Condition No. 17 of the 401 Certification states that the California Water Board reserves the authority to require the Licensee to make additional flow releases, adaptively implemented in increments of 50 cfs at three-year intervals, if the initial streamflow releases are not reasonably protective of the beneficial uses of the Fall River and Pit River as identified in the Basin Plan.

4.2.3.1 Current MIF condition

The current Fall River MIF release has been shown to have positively affected the various *in situ* water quality parameters and water temperature conditions in the Lower Fall River. The data also suggest that under the current MIF, conditions in the Lower Fall River are already similar at all three monitoring locations.

The current MIF release schedule has also positively affected water quality conditions in the Big Eddy section of the Pit 1 Reach. In general, the current MIF has reduced the observed range of both DO and pH levels in Big Eddy. The data also indicate that these parameters have probably been stabilized to a level such that incremental increases in the MIF would generate little or no

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additional improvement. The current MIF release schedule has also positively affected water temperature conditions in the Big Eddy section of the Pit 1 Reach.

However, the current MIF release has also reduced the influence of cool accretion flows present in the canyon section on water temperatures in the lower portion of the Pit 1 Reach. The reduction in cooling associated with the current MIF is on the order of 1 to 2 °C. The adverse impact to water temperature by the increased MIF flows on this reach of the Pit River is discussed in the following section.

4.2.3.2 Impact of Increased Instream MIF Release on Water Temperature

Any further increase in MIF would likely not alter water quality conditions in this reach. The effect of adaptively increased MIF releases on conditions in the Pit 1 Forebay is expected to be minimal. Although the temperature reduction in the forebay could be achieved with higher MIF, the magnitude of the reduction in daily average water temperatures would be negligible under the 50 cfs incremental increase in MIF (estimated to be at 0.1 °C or less).

The impact of changes to the current MIF under the adaptive management options included in Article 17 of the 401 Certification were evaluated using information developed from PG&E's modeling efforts conducted in 1993. Temperature trends associated with changes to the current MIF were evaluated using information projected by a Stream Network Temperature (SNTEMP) model (Theurer et al. 1984). The SNTEMP model (model) was calibrated and validated with data obtained in 1990-1992 as documented in the Exhibit E of Application for New License (PG&E 1993). The model was used to project a series of hypothetical conditions, including a range of environmental settings varying from normal to warm meteorology combined with wet to dry hydrological conditions. A simple check on the validity of model projections in 1993 was performed using two sets of more recent data, the first set of data covers general trend comparison for two data periods 1990-1992 and 2004-2008 and the second set specifically compared to a high flow event, the August 12 through August 18 of 2008 flushing flow test (Figure 3-18). A detailed evaluation of the model results as pertains to incremental changes in MIF is provided in Appendix B of this report. The comparison generally validates the model projection.

Using the SNTEMP model projection and observations made during the various flushing flow test, it is anticipated that any increase in MIF flows above the current license condition would continue the same cooling/warming trend depending on location within the Pit 1 Reach. In the upper Pit 1 Reach (Pit Weir to Big Eddy), water temperatures would experience incrementally cooler reductions (estimated at 0.2 °C at 50 cfs additional flow). Water temperatures in the lower Pit 1 Reach (Big Eddy to Pit 1 Footbridge) would exhibit incremental warming (estimated at 0.2 °C at 50 cfs additional flow) with a similar change in flow.

Based on the impact evaluation, an adaptive increase of 50 cfs would have minimal beneficial effects in the Fall River and upper portion of the Pit River bypass reach, and may actually increase summer water temperatures in the lower portion of the Pit 1 bypass reach to a level that would increase stress on cold water aquatic species, including endangered Shasta crayfish.

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4.2.3.3 Biological Impact of Increased Instream MIF Release

The biological impacts to all beneficial uses that may be associated with additional MIF are complicated and were evaluated in a collaborative format. The species of concern under consideration included cold/warm fisheries, Shasta Crayfish, special status mollusks and Bald Eagle. PG&E met with the SWRCB and CVRWQCB as well as all concerned regulatory agencies and NGO, on appropriate recommendations related to future MIF regime. The final recommendation on adaptive flow release is provided in the record of agency consultation.

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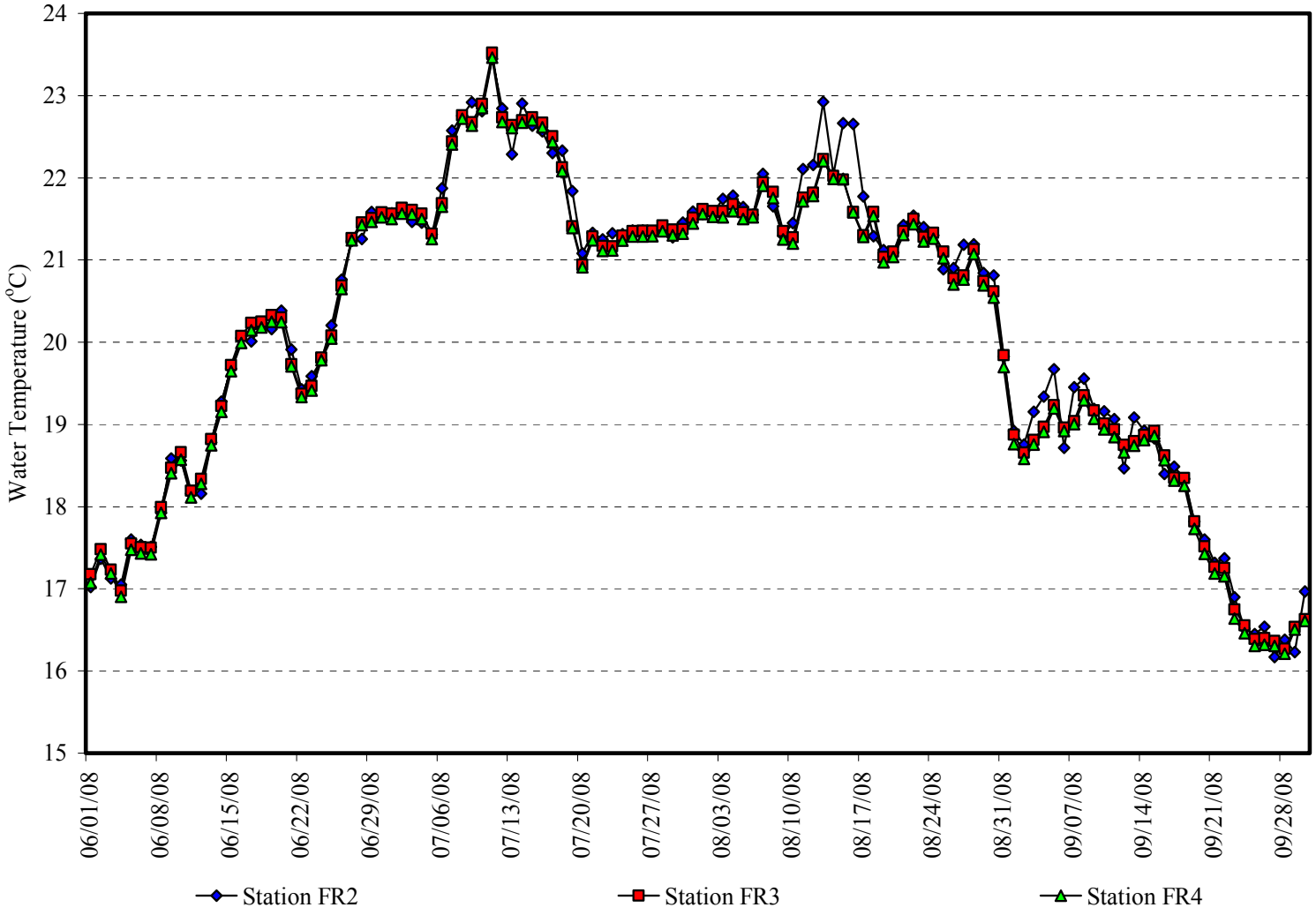

Figure 4-1. Comparison of Daily Average Water Temperature at Three Stations in the Fall River - 2008.

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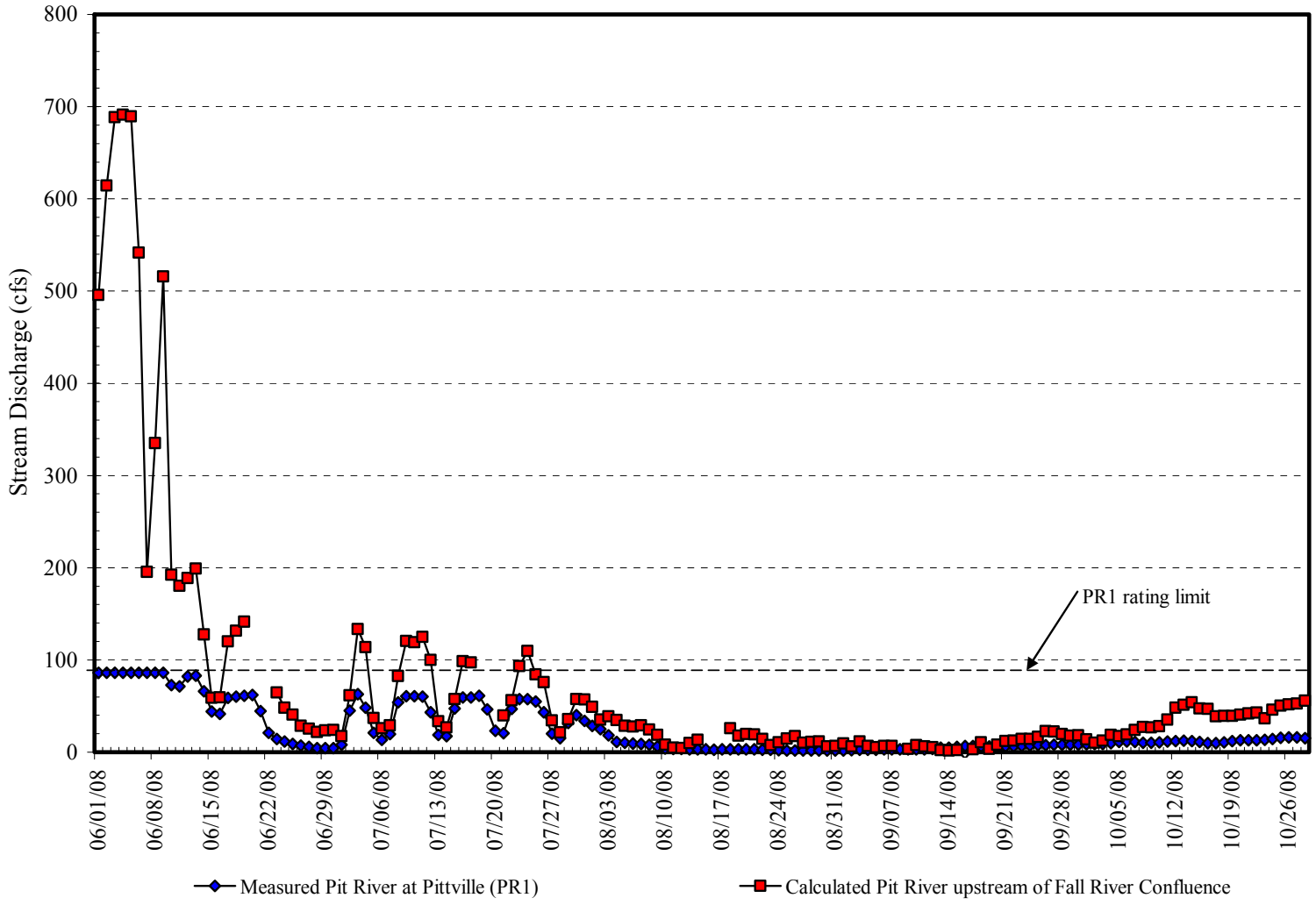

Figure 4-2. Comparison of Measured with Estimated Stream Flow in the Pit River Upstream of the Fall River Confluence - 2008.

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APPENDIX A

Quality Assurance and Control Documentation

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A1 - Calibration Certificates for Hydrolab Multi-parameter Water Quality Meter

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2007-2008 Manufactures Calibration Certification – HydroLab Multi-meter

DATE: 10-01-03	DOCUMENT#: 19002-00-QUANTA
Page 3 of 3	REVISION: 1

3.0 **Quanta and Quanta G Functional Test Sheet**

Section A:

Service Request # 56430	Customer Pacific Gas + Electric	Serial # 01602
Technician Mike	Model Type (Quanta) Quanta G	Date Started 04/09/08
Performance, Test and Evaluation		
Current MPL Rev. 2.3 Upgrade to MPL Rev N/A	DO membrane installed (Yes) No NA	PH Electrolyte and Teflon Junction installed - Yes (No) NA
Lenses cleaned (Yes) No NA	Desiccant installed (Yes) No NA	Turbidity Firmware Rev. 2.1 → 3.0

Section B:

	Submission 1 Day 1	Submission __ Day ___	Submission __ Day ___	Submission __ Day ___
Verified customer's observations	(Y) / N / NA	Y / N / NA	Y / N / NA	Y / N / NA
Verified proper operation of circulator	(Y) / N / NA	Y / N / NA	Y / N / NA	Y / N / NA
pH 7 Buffer calibration verified (+/- .2 pH)	7.00			
Conductivity calibration verified (+/- 2mS/cm) 12.856 mS/cm / (47.6 mS/cm)	47.6			
pH slope calibration verified at 10 units.	10.03			
ORP calibration verified at ____ degrees C (+/-20 mV)				
Conductivity 1.412 mS linearity verified – (+/- .15 mS)	1.448			
Conductivity .100 mS linearity verified– (+/- .005 mS)	.103			
DO 100% sat integrity window verified at +50 mmHg above current bp.	(P) / F / NA	P / F / NA	P / F / NA	P / F / NA
DO 100% sat integrity window verified – at 550	(P) / F / NA	P / F / NA	P / F / NA	P / F / NA
DO 100% saturation calibration verified – local (+/- .5%)	✓			
Turbidity calibration verified in DI water 0.0-(+/-.5NTU)	0.0			
4 Beam Turbidity calibrated at 86 NTU (+/- 1 NTU) Dilute Formazin verified against "in-house" 2100P	86			
4 Beam Turbidity linearity verified at 48.7 NTU with Dilute Formazin verified against "in-house" 2100P (+/- 10% of reading.)	46.9			
Depth calibration verified – (+/- .02 meters)	0.00			
Depth check – (+/- .1 meters) 0.62	0.6			
pH linearity verified at 4 units. (+/- 0.20 units)	4.1			

Calibrated Test Equipment Used –

Description	X-number
DVM Multimeter	X- 7212

Section C. Final Check-off Prior to Submitting for Estimate -

Exterior is clean	✓	Hach Business System updated	✓
Storage cup filled with pH 4 buffer	✓	Date Completed	04/09/08

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2004-2005 Manufactures Calibration Certification – HydroLab Multi-meter

Memorandum

Date: December 15, 2004 **File #:**

To: ENVIRONMENTAL ENGINEERING GROUP

From: ERIC KENZLER

Subject: Hyddrolab Instrument 2004 Calibration Report

Pacific Gas and Electric Company

CHARLES WHITE
BRIAN FRANTZ

I certify that between March and November, 2004 the Hydrolab® multiparameter water quality analyzers listed below were calibrated at PG&E's Technical and Ecological Services Department (TES) using manufacturer's calibration procedures and certified in tolerance. The water quality parameters pH, Conductivity, DO, and Turbidity adjusted and verified prior to field deployment.

These are field instruments for in-situ readings and although a log documenting monthly calibrations are kept in Room 151 at TES, most of the instruments were calibrated by qualified PG&E personnel in the field more often than that depending on deployment schedules.

Instrument Identification:
Hydrolab Quanta®. #1 S/N 01310/01277
Hydrolab Quanta® #2 S/N 01943/02100
Hydrolab Quanta® #3 S/N 01602/02089
Hydrolab Data Sonde 4a® S/N 37743
Hydrolab Data Sonde 3® S/N 25506

ERIC KENZLER
Technologist, TES

EMKenzler(251-5806):emk

Pc: Ed Cheslak
Scott Tu

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A2 – Field Calibration Log for Hydrolab Multi-parameter Water Quality Meter

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Dissolved oxygen meter field calibration log.

Quanta #3		DO Meter Cal Check											
		Air Calibration Data								Winkler Check			
		Elevation		Air T	DO at	% Air	Calculated	Instrument	Meter	*In situ*	Titration	Meter	Reading
Date	Time	(ft)	Site	(°C)	Saturation	Saturation	Value	Reading	Difference	Reading	Result	Difference	Adjustment
05/09/05	830	800	Lab	22.0	*8.7*	97%	8.43	8.65	-0.2	*9.4*	9.2	-0.2	No adj
05/23/05	940	3300	PR1	18.3	*9.4*	89%	8.35	8.42	0.0	----	----	----	No adj
06/07/05	915	3300	PR1	11.9	*10.9*	89%	9.66	9.02	0.6	*7.8*	*8.6*	0.8	0.8
06/23/05	1000	3300	PR1	16.6	*9.8*	89%	8.67	10.1	-1.4	----	----	----	No adj
07/12/05	900	3300	PR1	9.4	*11.5*	89%	10.25	11.38	-1.1	----	----	----	No adj
07/19/05	1015	3300	PR1	29.2	*7.6*	89%	6.77	6.93	0.0	*8.3*	*8.5*	0.2	No adj
08/05/05	930	3300	PR1	25.0	*8.2*	89%	7.28	7.52	-0.2	----	----	----	No adj
08/16/05	921	3300	PR1	21.1	*8.9*	89%	7.87	7.97	0.0	----	----	----	No adj
08/31/05	1015	3300	PR1	26.2	*8.0*	89%	7.13	7.28	0.0	----	----	----	No adj
09/14/05	1540	3300	PR1	24.4	*8.3*	89%	7.37	7.61	-0.2	----	----	----	No adj
09/27/05	1000	2460	P4	14.2	*10.3*	92%	9.43	9.37	0.0	*9.23*	*9.3*	0.1	No adj
10/11/05	905	3300	FR1	19.4	*9.2*	89%	8.15	7.85	0.3	----	----	----	No adj
11/02/05	1029	3300	PR1	16.7	*9.7*	89%	8.64	8.53	0.0	----	----	----	No adj
05/23/06	830	3270	FR1	15.0	*15.0*	89%	9.00	8.97	0.0	----	----	----	No adj
06/05/06	833	3270	FR1	15.5	*15.5*	89%	8.90	9.06	0.0	----	----	----	No adj
06/23/06	900	2617	PR4	19.6	*19.6*	91%	8.33	8.52	0.0	----	----	----	No adj
07/07/06	950	2800	PR5	19.5	*19.5*	90%	8.29	8.34	0.0	----	----	----	No adj
07/19/06	900	2700	MCA	20.5	*20.5*	91%	8.13	8.31	0.0	----	----	----	No adj
08/18/06	840	2700	MCA	12.6	*12.6*	91%	9.72	9.54	0.0	----	----	----	No adj
09/12/06	940	3270	FR1	18.5	*18.5*	89%	8.32	7.93	0.4	*7.93*	*8.3*	0.3	0.4
09/22/06	1315	2300	P4	15.3	*15.3*	92%	9.25	9.50	-0.2	----	----	----	No adj
05/15/07	838	2900	PR4	12.5	*10.7*	90%	9.70	9.90	-0.2	----	----	----	No adj
05/16/07	3300	3300	PR1	19.1	*9.2*	89%	8.20	8.00	0.3	----	----	----	No adj

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Quanta #3		DO Meter Cal Check											
		Air Calibration Data								Winkler Check			
		Elevation		Air T	DO at	% Air	Calculated	Instrument	Meter	*In situ*	Titration	Meter	Reading
Date	Time	(ft)	Site	(°C)	Saturation	Saturation	Value	Reading	Difference	Reading	Result	Difference	Adjustment
06/01/07	915	2900	PR4	22.4	*8.6*	90%	7.80	7.20	0.6	----	----	----	0.3
06/14/07	922	2900	PR4	25.9	*8.1*	90%	7.30	6.80	0.5	----	----	----	0.5
06/27/07	915	2900	PR4	23.2	*8.5*	90%	7.70	7.30	0.3	----	----	----	0.3
07/11/07	1145	3300	FR1	23.9	*8.4*	89%	*7.40*	*7.50*	-0.1	----	----	----	No adj
07/23/07	900	2900	PR4	15.7	*10.0*	90%	9.00	8.80	0.2	----	----	----	0.2
08/10/07	915	3200	PR1	22.7	*8.6*	89%	7.60	6.20	1.4	*5.6*	*6.4*	0.8	*Failed*
08/20/07	1140	3300	FR1	23.5	*8.4*	89%	7.50	7.70	-0.2	----	----	----	-0.2
09/07/07	910	3300	FR1	21.0	*8.9*	89%	7.90	8.00	-0.1	----	----	----	-0.1
09/18/07	900	3300	FR1	17.9	*9.5*	89%	8.40	8.90	-0.4	----	----	----	-0.4
10/18/07	900	3300	FR1	13.4	*10.5*	89%	9.30	9.00	0.4	----	----	----	0.4
10/31/07	955	3300	FR1	12.4	*10.7*	89%	9.60	9.40	0.2	----	----	----	No adj
10/31/07	1115	3300	FR1	12.3	*10.8*	89%	9.60	9.60	-0.1	----	----	----	No adj
05/13/08	745	3300	FR1	17.4	*9.6*	89%	8.51	8.65	0.1	----	----	----	No adj
05/14/08	845	3000	PR3	18.6	*9.3*	90%	8.37	8.62	0.3	----	----	----	No adj
05/30/08	1045	3300	PR1	17.1	*9.6*	89%	8.56	8.56	0.0	----	----	----	No adj
06/10/08	915	2900	PR4	13.6	*10.4*	90%	9.41	9.55	0.1	----	----	----	No adj
07/10/08	845	3300	PR1	27.4	*7.9*	89%	6.98	6.97	0.0	----	----	----	No adj
07/22/08	930	2900	PR4	19.9	*9.1*	90%	8.18	8.19	0.0	----	----	----	No adj
08/14/08	830	3300	FR1	21.5	*8.8*	89%	7.80	7.79	0.0	----	----	----	No adj
08/27/08	818	3300	FR1	19.8	*9.1*	89%	8.07	8.09	0.0	----	----	----	No adj
09/23/08	945	3300	FR1	19.3	*9.2*	89%	8.17	8.15	0.0	----	----	----	No adj
10/07/08	813	3300	FR1	12.9	*10.6*	89%	9.43	9.43	0.0	----	----	----	No adj
10/28/08	806	3300	FR1	11.9	*10.9*	89%	9.65	9.64	0.0	----	----	----	No adj

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pH meter calibration log.

Quanta #3		pH Sensor Calibration						
		7.0 at 25°C		10.0 at 25°C		Avg	Slope	
Date	Time	Value	Buffer	Value	Buffer	Corr	(%)	Action
05/23/05	940	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
06/07/05	915	*7.43*	*Stnd*	*10.42*	*Stnd*	*-0.4*	---	*Maint/recal*
06/07/05	----	*7.00*	*Stnd*	*9.98*	*Stnd*	---	*100%*	*New Calibration*
06/23/05	1000	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
07/12/05	900	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
07/19/05	1015	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
08/05/05	930	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
08/16/05	921	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
08/31/05	1015	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
09/14/05	1540	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
09/27/05	1000	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
10/04/05	----	*7.54*	*Stnd*	*10.61*	*Stnd*	*-0.5*	---	*Maint/recal*
10/05/05	----	*7.00*	*Stnd*	*9.98*	*Stnd*	---	*100%*	*New Calibration*
10/11/05	905	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
11/02/05	1029	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
05/12/06	900	*Check*	*Stnd*	*Check*	*Stnd*	---	*100%*	*Maint/recal*
06/05/06	830	*Check*	*Stnd*	*Check*	*Stnd*	---	*100%*	*Check okay*
07/12/06	945	*Check*	*Stnd*	*Check*	*Stnd*	---	*100%*	*Maint/recal*
08/14/06	800	*Check*	*Stnd*	*Check*	*Stnd*	---	*100%*	*Check okay*
09/18/06	900	*Check*	*Stnd*	*Check*	*Stnd*	---	*100%*	*Check okay*
05/14/07	930	---	---	---	---	---	---	*Factory Cert*
05/31/07	930	7.00	*Stnd*	*10.06*	*Stnd*	---	---	*Check okay*
08/12/07	1930	*7.62*	*Stnd*	*10.42*	*Stnd*	*-0.5*	*94%*	*Maint/recal*
08/12/07	1945	*6.99*	*Stnd*	*9.98*	*Stnd*	---	*99%*	*New Calibration*
10/08/07	1015	*6.83*	*Stnd*	*9.86*	*Stnd*	*0.2*	*99%*	*Maint/recal*

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Quanta #3		pH Sensor Calibration						
		7.0 at 25°C		10.0 at 25°C		Avg	Slope	
Date	Time	Value	Buffer	Value	Buffer	Corr	(%)	Action
10/08/07	1030	*7.03*	*Stnd*	*10.11*	*Stnd*	---	*100%*	*New Calibration*
04/29/08	Lab	*7.05*	*Stnd*	*10.03*	*Stnd*	---	*101%*	*Check okay*
06/24/08	Lab	*7.10*	*Stnd*	*7.30*	*Stnd*	-0.2	---	*Maint/recal*
06/24/08	Lab	*7.02*	*Stnd*	*10.03*	*Stnd*	---	*100%*	*New Calibration*
07/30/08	Lab	7.03	*Stnd*	*10.04*	*Stnd*	---	*100%*	*Check okay*
08/29/08	Lab	*7.13*	*Stnd*	*9.78*	*Stnd*	0.05	---	*Maint/recal*
08/29/08	Lab	7.00	*Stnd*	*10.00*	*Stnd*	---	*100%*	*New Calibration*
09/28/08	Lab	*7.38*	*Stnd*	*10.26*	*Stnd*	-0.3	---	*Maint/recal*
09/28/08	Lab	7.01	*Stnd*	*10.03*	*Stnd*	---	*100%*	*New Calibration*

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Recorder Deployment History - Fall River Stations

Date	FR1A		FR1B		FR2A		FR2B		FR3A		FR3B		FR4A		FR4B	
	S/N	Type[1]/Status[2]	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status
05/10/05	7005	Vem[1]/P[2]	9351	Vem[1]/P[2]	7000	Vem[1]/P[2]	7004	Vem[1]/P[2]	7001	Vem[1]/P[2]	7003	Vem/P	6999	Vem[1]/P[2]	935	Vem[1]/P[2]
05/23/05	7007	Vem[1]/P[2]	⇓		9352	Vem[1]/P[2]	⇓		9348	Vem[1]/P[2]	⇓		⇓		⇓	
06/07/05	6998	Vem[1]/P[2]	⇓		⇓		⇓		9346	Vem[1]/P[2]	⇓		7005	Vem[1]/P[2]	⇓	
06/23/05	9353	Vem[1]/P[2]	⇓		9348	Vem[1]/P[2]	⇓		7002	Vem[1]/P[2]	⇓		6999	Vem[1]/P[2]	⇓	
07/12/05	7005	Vem[1]/P[2]	⇓		9346	Vem[1]/P[2]	⇓		7001	Vem[1]/P[2]	⇓		9350	Vem[1]/P[2]	⇓	
08/05/05	9348	Vem[1]/P[2]	⇓		7007	Vem[1]/P[2]	⇓		7002	Vem[1]/P[2]	⇓		7006	Vem[1]/P[2]	⇓	
09/14/05	7001	Vem[1]/P[2]	⇓		9346	Vem[1]/P[2]	⇓		7005	Vem[1]/P[2]	⇓		9349	Vem[1]/P[2]	⇓	
09/27/05	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
11/02/05	Out		Out		Out		Out		Out		Out		Out		Out	
05/09/06	2199	Vem[1]/P[2]	7000	Vem[1]/OT[2]	935	Vem[1]/P[2]	7008	Vem[1]/OT[2]	2197	Vem[1]/P[2]	9353	Vem[1]/P[2]	2202	Vem[1]/P[2]	2203	Vem[1]/P[2]
05/23/06	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
06/05/06	⇓		7007	Vem[1]/P[2]	⇓		2192	Vem[1]/F[2]	9351	Vem[1]/P[2]	⇓		⇓		6998	Vem[1]/OT[2]
06/23/06	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
07/07/06	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
07/21/06	2203	Vem[1]/P[2]	⇓		2200	Vem[1]/P[2]	⇓		⇓		7000	Vem[1]/OT[2]	2201	Vem[1]/P[2]	⇓	
08/04/06	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
08/17/06	⇓		2202	Vem[1]/P[2]	⇓		2199	Vem[1]/P[2]	7001	Vem[1]/P[2]	⇓		⇓		2193	Vem[1]/P[2]
08/29/06	⇓		⇓		⇓		ß		⇓		⇓		⇓		⇓	
09/12/06	⇓		⇓		⇓		ß		⇓		⇓		⇓		⇓	
11/15/06	Out		Out		Out		Out		Out		Out		Out		Out	
05/15/07	4721	Vem[1]/P[2]	949	Vem[1]/P[2]	948	Vem[1]/F[2]	4722	Vem[1]/P[2]	2561	Vem[1]/P[2]	2564	Vem[1]/P[2]	2573	Vem[1]/P[2]	2560	Vem[1]/P[2]
06/14/07	⇓		2568	Vem[1]/P[2]	⇓		2571	Vem[1]/P[2]	2563	Vem[1]/P[2]	⇓		⇓		2570	Vem[1]/P[2]

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Date	FR1A		FR1B		FR2A		FR2B		FR3A		FR3B		FR4A		FR4B	
	S/N	Type[1]/Status[2]	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status
07/24/07	2917	Vem[1]/P[2]	⇓		2918	Vem[1]/P[2]	⇓		⇓		2908	Vem[1]/P[2]	⇓		2914	Vem[1]/P[2]
08/20/07	⇓		2912	Vem[1]/P[2]	⇓		951	Vem[1]/P[2]	2565	Vem[1]/P[2]	⇓		2570	Vem[1]/P[2]	⇓	
10/31/07	Out		Out		Out		Out		Out		Out		Out		Out	
05/13/08	D543	Starmon[1]/F[2]	1759	Seamon[1]/P[2]	1755	Seamon[1]/P[2]	D680	Seamon[1]/P[2]	1768	Seamon[1]/P[2]	D467	Seamon[1]/L[2]	1772	Seamon[1]/P[2]	D824	Seamon[1]/L[2]
06/10/08	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
07/10/08	1731	Seamon[1]/P[2]	⇓		⇓		⇓		⇓		⇓		⇓		⇓	
08/14/08	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
09/23/08	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
10/28/08	Out		Out		Out		Out		Out		Lost		Out		Lost	

1 Vem = Vemco Mint TR-12
Seamon = Seamon Mini
Starmon = Starmon Mini

2 P = Passed calibration in tolerance of ± 0.1°C
OT = Found out of tolerance during calibration
F = Failed during deployment or end of season calibration.
L = Recorder lost during high flow test

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Recorder Deployment History - Pit River Station

Date	PR1		PR2		PR3A		PR3B		PR4		PR5A		PR5B	
	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status
05/10/05	7006	Vem[1]/P[2]	7008	Vem[1]/P[2]	9353	Vem[1]/P[2]	9349	Vem[1]/P[2]	9346	Vem[1]/P[2]	6998	Vem[1]/P[2]	9350	Vem[1]/P[2]
05/23/05	936	Vem[1]/P[2]	937	Vem[1]/P[2]	ß		ß		7002	Vem[1]/P[2]	943	Vem[1]/P[2]	ß	
06/07/05	7001	Vem[1]/P[2]	7008	Vem[1]/P[2]	7006	Vem[1]/P[2]	ß		7000	Vem[1]/P[2]	ß		ß	
06/23/05	936	Vem[1]/P[2]	ß		ß		937	Vem[1]/P[2]	ß		ß		7007	Vem[1]/P[2]
07/12/05	6998	Vem[1]/P[2]	ß		9352	Vem[1]/P[2]	ß		ß		ß		9349	Vem[1]/P[2]
08/05/05	ß		ß		936	Vem[1]/P[2]	ß		ß		ß		9353	Vem[1]/P[2]
09/14/05	ß		ß		ß		ß		ß		ß		ß	
09/27/05	ß		ß		9348	Vem[1]/P[2]	ß		ß		ß		7002	Vem[1]/P[2]
11/02/05	Out		Out		Out		Out		Out		Out		Out	
05/09/06	7001	Vem[1]/OT[2]	7005	Vem[1]/OT[2]	HF	--	HF	--	2200	Vem[1]/P[2]	2198	Vem[1]/P[2]	HF	--
05/23/06	ß	--	ß	--	--	--	--	--	ß		ß		7004	Vem[1]/F[2]
06/05/06	2190	Vem[1]/P[2]	2201	Vem[1]/P[2]	2193	Vem[1]/P[2]	--	--	ß		ß		ß	
06/23/06	ß		7005	Vem[1]/OT[2]	ß		7008	Vem[1]/OT[2]	7001	Vem[1]/OT[2]	ß		ß	
07/21/06	ß		ß		ß		ß		ß		2197	Vem[1]/P[2]	ß	
08/04/06	ß		ß		9353	Vem[1]/P[2]	ß		935	Vem[1]/P[2]	ß		ß	
08/17/06	2198	Vem[1]/P[2]	ß		ß		ß		ß		ß		ß	
08/29/06	ß		6998	Vem[1]/OT[2]	ß		ß		ß		ß		ß	
09/12/06	ß		ß		ß		2190	Vem[1]/P[2]	ß		9351	Vem[1]/P[2]	7005	Vem[1]/OT[2]
11/15/06	Out		Out		Out		Out		Out		Out		Out	
05/15/07	---	---	---	---	2565	Vem[1]/P[2]	2559	Vem[1]/P[2]	---	---	2569	Vem[1]/P[2]	2562	Vem[1]/P[2]
05/16/07	1735	Seamon[1]/P[2]	1736	Seamon[1]/P[2]	ß		ß		1732	Vem[1]/P[2]	ß		ß	
06/14/07	ß		ß		ß		ß		ß		2919	Vem[1]/P[2]	ß	

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Date	PR1		PR2		PR3A		PR3B		PR4		PR5A		PR5B	
	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status
06/27/07	ß		ß		ß		2910	Vem[1]/P[2]	ß		ß		ß	
07/24/07	ß		ß		2569	Vem[1]/P[2]	ß		1732	Vem[1]/P[2]	ß		955	Vem[1]/P[2]
08/21/07	ß		ß		ß		948	Vem[1]/F[2]	ß		949	Vem[1]/P[2]	ß	
10/31/07	Out		Out		Out		Out		Out		Out		Out	
05/13/08	1382	Seamon[1]/P[2]	1758	Seamon[1]/P[2]	---	---	---	---	---	---	1388	Seamon[1]/P[2]	1754	Seamon[1]/P[2]
05/14/08	ß		ß		1732	Seamon[1]/P[2]	1395	Seamon[1]/P[2]	1390	Seamon[1]/P[2]	ß		ß	
06/10/08	ß		ß		ß		ß		ß		ß		ß	
07/10/08	ß		ß		ß		ß		ß		ß		ß	
08/14/08	ß		ß		ß		ß		ß		ß		ß	
09/23/08	ß		ß		ß		ß		ß		ß		ß	
10/28/08	Out		Out		ß		ß		ß		ß		ß	
10/29/08					Out		Out		Out		Out		Out	

1 Vem = Vemco Mint TR-12
Seamon = Seamon Mini
Starmon = Starmon Mini

2 P = Passed calibration in tolerance of ± 0.1°C
OT = Found out of tolerance during calibration
F = Failed during deployment or end of season calibration.
L = Recorder lost during high flow test

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A3 – PG&E Water Temperature Recorder Calibration Certificates

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Post 2004 Deployment Calibration - Vemco Recorders

Memorandum

Date: December 13, 2004 **File #:**

To: ENVIRONMENTAL ENGINEERING GROUP

From: ERIC KENZLER

Subject: Temperature Data Logger 2004 Calibration Report

Pacific Gas and Electric Company

CHARLES WHITE
BRIAN FRANTZ

On December 3, 2004 through December 13, 2004 the VEMCO TR-12 temperature recorders on the attached list were calibrated at TES using manufacturer's calibration procedures and certified in tolerance against National Institute of Standards and Technology traceable instrumentation.

Traceable Instrument Identification:
Model No. 15-077-8 S/N 221336702 Fisher Scientific Digital Thermometer
Probe: 15-077-7 S/N 221336677

Precision Water Bath:
Thermo Neslab RTC 17 S/N 103198062

Certificate information is located in the MS Word document S:\Vemco\2004 Calibration\Cal data sheet 2004-05.doc. Printed graphs of original calibration data are located in my files.

ERIC KENZLER
Technologist, TES

EMKenzler(251-5806):emk

Pc: Ed Cheslak
Scott Tu

Attachment

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Post 2004 Deployment Calibration - Vemco Recorders

Pacific Gas & Electric Company - Technical and Ecological Services
VEMCO TR-12 Temperature recorders calibrated in December 2004

	SN:	SN:	SN:	SN:
1	2190	2910	7003	935
2	2192	2911	7004	936
3	2193	2912	7005	937
4	2197	2913	7006	939
5	2198	2914	7007	940
6	2199	2915	7008	941
7	2200	2917	9346	942
8	2201	2918	9348	944
9	2202	2919	9349	945
10	2203	2920	9350	946
11	2204	2921	9351	947
12	2205	2922	9352	948
13	2207	3040	9353	949
14	2208	3041	943	950
15	2209	3043		951
16	2554	3044		952
17	2555	3045		953
18	2556	3048		954
19	2557	3049		955
20	2558	3050		956
21	2559	3051		9324
22	2560	3052		9325
23	2561	3053		9326
24	2562	3054		9327
25	2563	3055		9328
26	2564	3056		9329
27	2565	3057		9330
28	2566	3058		9331
29	2568	3060		9332
30	2569	3061		9333
31	2570	3062		9334
32	2571	3063		9335
33	2572	3064		9336
34	2573	3065		9337
35	2903	3066		9338
36	2904	6998		9340
37	2906	6999		9341
38	2907	7000		9342
39	2908	7001		9344
40	2909	7002		9345

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Post 2005 Deployment Calibration - Starmon Recorders

Memorandum

Date: March 9, 2009 **File #:**

To: ENVIRONMENTAL ENGINEERING GROUP

From: ERIC KENZLER

Subject: Temperature Data Logger 2005 Calibration Report

Pacific Gas and Electric Company

SCOTT TU
TIM SAGRAVES

On January 11-13, 2006 the VEMCO TR-12 temperature recorders on the attached list were calibrated at TES using manufacturer's calibration procedures and certified in tolerance against National Institute of Standards and Technology traceable instrumentation.

Traceable Instrument Identification:
Model No. 15-077-8 S/N 221336702 Fisher Scientific Digital Thermometer
Probe: 15-077-7 S/N 221336677

Precision Water Bath:
Thermo Neslab RTC 17 S/N 103198062

Calibration information is located in the Excel spreadsheet L:\ALL INDIVIDUALS FOLDERS\Kenzler.Eric\2005 Calibration Certs\05-06 Cal data.xls.

ERIC KENZLER
Technologist, TES

EMKenzler(251-5806):emk

Attachment

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Post 2005 Deployment Calibration – VEMCO Recorders

Pacific Gas & Electric Company - Technical and Ecological Services
VEMCO TR-12 Temperature Recorders Calibrated in January 2006

Count	Sn:	Sn:	Sn:
1	2190	2914	954
2	2192	2915	955
3	2193	2917	956
4	2197	2918	9324
5	2198	2919	9325
6	2199	2920	9326
7	2200	2921	9327
8	2201	2922	9328
9	2202	3040	9329
10	2203	3041	9330
11	2204	3043	9331
12	2205	3044	9332
13	2207	3045	9333
14	2208	3048	9334
15	2209	3049	9335
16	2554	3050	9336
17	2555	3051	9337
18	2556	3052	9340
19	2557	3053	9341
20	2558	3054	9342
21	2559	3055	9344
22	2560	3056	9345
23	2561	3058	
24	2562	3060	
25	2563	3061	
26	2564	3062	
27	2565	3063	
28	2568	3064	
29	2569	3065	
30	2570	3066	
31	2571	939	
32	2903	940	
33	2904	942	
34	2906	944	
35	2907	945	
36	2908	946	
37	2910	947	
38	2911	948	
39	2912	949	
40	2913	951	

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Post 2006 Deployment Calibration – Vemco Recorders

[redacted]

Date: January 25, 2007 **File #:** 026.11.06.13

To: ENVIRONMENTAL SERVICES

From: TECHNICAL AND LAND SERVICES

Subject: Temperature Data Logger 2006 Calibration Report

Pacific Gas and Electric Company

ED CHESLAK

The VEMCO TR-12 temperature recorders listed in table 1 were calibrated at PG&E's Technical and Land Services (TLS) on January 24, 2007 using manufacturer's calibration procedures and certified in tolerance (± 0.1 °C) against National Institute of Standards and Technology traceable instrumentation with the following exceptions. As noted, five of the VEMCO units were slightly out of tolerance as found and were recalibrated to meet tolerance criteria. Two units (sn.2192A and sn.7004A) failed to operate and were taken out of service.

Traceable Instrument Identification:
Model No. 15-077-8 S/N 221367532 Fisher Scientific Digital Thermometer
Probe: 15-077-7 S/N 240301157

Precision Water Bath:
Thermo Neslab RTC 17 S/N 103198062

Individual Calibration Certificates can be printed if necessary. Original calibration data are located in my files, C:/Equipment/Calibration Certificates.

ERIC KENZLER
Technologist, TLS

EMKenzler(251-5806):emk

Pc: Dan Tilly
Tim Sagraves
Attachment

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Post 2006 Deployment Calibration – Vemco Recorders

Table 1. Temperature Data Loggers Calibration Record

Pit 1 Project Count	Model	SN:	Cal Date	In Tolerance
1	Vemco TR-12	0935E	1/24/2007	Y
2	Vemco TR-12	0937E	1/24/2007	Y
3	Vemco TR-12	2190A	1/24/2007	Y
4	Vemco TR-12	2192A	1/24/2007	FAIL[2]
5	Vemco TR-12	2193A	1/24/2007	Y
6	Vemco TR-12	2197A	1/24/2007	Y
7	Vemco TR-12	2198A	1/24/2007	Y
8	Vemco TR-12	2199A	1/24/2007	Y
9	Vemco TR-12	2200A	1/24/2007	Y
10	Vemco TR-12	2201A	1/24/2007	Y
11	Vemco TR-12	2202A	1/24/2007	Y
12	Vemco TR-12	2203A	1/24/2007	Y
13	Vemco TR-12	6998A	1/24/2007	N-R[1]
14	Vemco TR-12	7000A	1/24/2007	N-R[1]
15	Vemco TR-12	7001A	1/24/2007	N-R[1]
16	Vemco TR-12	7004A	1/24/2007	FAIL[2]
17	Vemco TR-12	7005A	1/24/2007	N-R[1]
18	Vemco TR-12	7008A	1/24/2007	N-R[1]
19	Vemco TR-12	9351A	1/24/2007	Y
20	Vemco TR-12	9353A	1/24/2007	Y

1. N-R = Not in tolerance (± 0.1 °C) as found, recalibrated to within tolerance.
2. FAIL = Unable to establish communication, calibration failed.

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Post 2007 Deployment Calibration – Starmon/Vemco Recorders

[redacted]

Date: January 16, 2008 **File #:**

To: ENVIRONMENTAL SERVICES

From: APPLIED TECHNOLOGY SERVICES

Subject: Pit 1 Project - Temperature Data Logger 2007 Calibration Report

Pacific Gas and Electric Company

ED CHESLAK
TIM SAGRAVES:

The Vemco and Star-Oddi Starmon mini® temperature recorders listed in Table 1 were tested at PG&E's Applied Technology Services (ATS) laboratory on January 8 and 10, 2008 using the manufacturer's operational software and were certified to be accurate for temperature within project tolerance limits (± 0.1 °C) with one exception. As noted (Table 1), one of the Vemco units failed to start and was taken out of service. The units were tested using National Institute of Standards and Technology traceable instrumentation.

Traceable Instrument Identification:
Model No. 15-077-8 S/N 221367532 Fisher Scientific Digital Thermometer
Probe: 15-077-7 S/N 240301157

Precision Water Bath:
Thermo Neslab RTC 17 S/N 103198062

Individual Calibration Certificates can be printed if necessary. The original calibration data files are located in room 151 at the ATS San Ramon Laboratories.

ERIC KENZLER
Technologist, ATS

EMKenzler(251-5806):emk

Pc: Dan Tilly

Attachment

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Post 2007 Deployment Calibration – Starmon/Vemco Recorders

Pacific Gas and Electric Company - Applied Technology Services

Table 1. Temperature Data Logger Calibration Record

Pit 1 Project

Count	Model	SN:	Cal Date	In Tolerance
1	Vemco TR-12	0948E	1/8/2008	Fail[1]
2	Vemco TR-12	0949E	1/8/2008	Y
3	Vemco TR-12	0951E	1/8/2008	Y
4	Vemco TR-12	0955E	1/8/2008	Y
5	Vemco TR-12	0956E	1/8/2008	Y
6	Vemco TR-12	2559A	1/8/2008	Y
7	Vemco TR-12	2560A	1/8/2008	Y
8	Vemco TR-12	2561A	1/8/2008	Y
9	Vemco TR-12	2562A	1/8/2008	Y
10	Vemco TR-12	2563A	1/8/2008	Y
11	Vemco TR-12	2564A	1/8/2008	Y
12	Vemco TR-12	2565A	1/8/2008	Y
13	Vemco TR-12	2568A	1/8/2008	Y
14	Vemco TR-12	2569A	1/8/2008	Y
15	Vemco TR-12	2570A	1/8/2008	Y
16	Starmon mini	T 1732	1/10/2008	Y
17	Starmon mini	T 1735	1/10/2008	Y
18	Starmon mini	T 1736	1/10/2008	Y

1) Unit failed to operate and was taken out of service.

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Post 2008 Deployment Calibration – Starmon Recorders

[redacted]

Date: December 16, 2008 **File #:**

To: ENVIRONMENTAL SERVICES

From: APPLIED TECHNOLOGY SERVICES

Subject: Pit 1 Project - Temperature Data Logger 2008 Calibration Report

Pacific Gas and Electric Company

ED CHESLAK
TIM SAGRAVES:

The Star-Oddi Starmon mini® and Seamon temperature recorders listed in Table 1 were tested at PG&E's Applied Technology Services (ATS) laboratory on December 15, 2008 using the manufacturer's operational software and were certified to be accurate for temperature within project tolerance limits (± 0.1 °C) with one exception. As noted (Table 1), one of the Seamon units failed to start and was taken out of service. The units were tested using National Institute of Standards and Technology traceable instrumentation.

Traceable Instrument Identification:
Model No. 15-077-8 S/N 221367532 Fisher Scientific Digital Thermometer
Probe: 15-077-7 S/N 240301157

Precision Water Bath:
Thermo Neslab RTC 17 S/N 103198062

Individual Calibration Certificates can be printed if necessary. The original calibration data files are located in room 151 at the ATS San Ramon Laboratories.

ERIC KENZLER
Technologist, ATS

EMKenzler(251-5806):emk

Pc: Dan Tilly

Attachment

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Post 2008 Deployment Calibration – Starmon Recorders

Pacific Gas and Electric Company - Applied Technology Services

Table 1. Temperature Data Logger Calibration Record

Pit 1 Project

Count	Model	SN:	Cal Date	In Tolerance
1	Seamon	D543		FAIL [1]
2	Starmon mini	T1732	12/15/2008	Y
3	Starmon mini	T1754	12/15/2008	Y
4	Starmon mini	T1388	12/15/2008	Y
5	Starmon mini	T1390	12/15/2008	Y
6	Starmon mini	T1395	12/15/2008	Y
7	Seamon	D680	12/15/2008	9% battery remaining
8	Starmon mini	T1731	12/15/2008	Y
9	Starmon mini	T1755	12/15/2008	Y
10	Starmon mini	T1772	12/15/2008	Y
11	Starmon mini	T1768	12/15/2008	Y
12	Starmon mini	T1758	12/15/2008	Y
13	Starmon mini	T1382	12/15/2008	Y
14	Starmon mini	T1759	12/15/2008	Y

1) Unit failed to operate and was taken out of service.

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APPENDIX B

SNTEMP Model Results – Pit River

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APPENDIX B

SNTEMP Model Prediction Results and Interpretation

Stream Network Temperature model (SNTEMP) is a physically based mechanistic computer model developed by the Instream Flow and Aquatic Systems Group in collaboration with the SCS and the US Fish and Wildlife Service (Theurer et al. 1984). The model includes several components:

- Meteorological conditions such as air temperature, relative humidity, and atmospheric pressure as functions of elevation changes
- Shading effects of topography and riparian vegetation
- Solar radiation penetrating the water column
- Heat flux that accounts for the energy balance between the water and its environment
- Heat transport that predicts the average mean daily water temperature and diurnal fluctuations along the stream
- Specification of accretion flows either as points sources or continuous lateral inflows

The SNTEMP model (model) was calibrated and validated with data obtained in 1990-1992 as documented in the Exhibit E of Application for New License (PG&E 1993, 1993a). The model developed specifically for this watershed is generally accurate within ±0.8 °C. The model was used to predict a series of hypothetical conditions, including a range of environmental settings varying from normal to warm meteorology combined with wet to dry hydrological conditions (Figures E2-12 to E2-17 in Exhibit E of Application for New License). In order to make a quantifiable comparison, the model requires specific daily input data of hydrological and meteorological conditions. Instead of this labor intensive effort, a simple check on the validity of model predictions was performed using two sets of data, (a) general averaged conditions with data obtained from periods of 1990-1992 (Table 3-11) and 2004-2008 (Table 3-20), and (b) periodic high flow event such as those from the August 12 through August 18 2008 flushing flow test (Figure 3-18).

(a) General comparison:

Figure E2-15 from Exhibit E was re-produced in this appendix as Figure B-1. This figure was generated to simulate the monthly mean water temperature under a

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'Normal Hydrology' and 'Normal Meteorology' conditions for the summer period, June-September. The relationship of daily average temperatures at three locations (Big Eddy, P8 at Pit River Falls and P9 at footbridge above powerhouse) are projected. Visual inspection from this figure provides a rough estimate of the ΔT (temperature difference in daily average temperature between two stations) as tabulated in Table B-1. The corresponding values from actual observation periods (1990-1992 representing no MIF or 'zero' cfs in x-axis and 2004-2008 representing 150-cfs MIF) are also reproduced in the same table for comparison. In general, the model captured the cooling/warming trend in relation to the change of MIF regime for the period of 1990-1992 and 2004-2008.

(b) Specific Flushing Flow Comparison:

Prior to the event, the MIF was maintained at approximately 150 cfs, during the flushing flow event, releases were increased to approximately 700 cfs, between August 16-17, 2008. During the flushing flow, water temperatures at the end of Big Eddy (PR2) showed a daily average temperature reduction of 0.7°C; at the same time, the temperatures at the footbridge above Pit 1 Powerhouse (PR4) showed a warming of 0.8°C. Again, a quantifiable comparison would have required specific daily input data of both meteorological and hydrological conditions, particularly for a highly transient condition such as this event by which both the flow and the meteorological conditions changed rapidly and significantly. As a result, the comparison here is at best a qualitative comparison. Since 2008 was a critical dry year and the corresponding air temperatures during the event were above normal, the hypothetical prediction simulated under '*low hydrology and hot meteorological conditions*' for August was chosen as representative of similar conditions. (Figure E2-16 in Exhibit E is reproduced as Figure B-2 in this Appendix B). The model predictions in this figure illustrate the continuum of temperatures trends under various release conditions. The predicted results indicate that water temperatures at Big Eddy (PR2) would exhibit a reduction of 0.7 °C if flows were increased from 150 cfs to 700 cfs. Conversely, a warming trend of 0.4°C was projected at PR4 (P9 in Figure B-2). The actual values discussed previously (Section 3.3.2.4) generally validate the use of the 1993 model for use in predicting the affect of increased MIF on the thermal regime in the Pit 1 Reach.

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Table B-1

Comparison of Model Predicted Results with those from Actual Data Periods.

Between Stations		ΔT in Celsius			
	Environmental setting	**July**	**August**	**July**	**August**
	SNTEMP Model Prediction in Final Application for License				
		No MIF		**150-cfs MIF**	
BE-P8	Norm WYT –Norm Met.	-2.4	-2.0	-0.7	-0.5
BE-P9	Norm WYT –Norm Met.	-3.8	-3.0	-1.5	-1.0
	2004-2008 data period (150 cfs MIF)				
BE-P8	Actual observation [1]	--	--	-1.3	-1.1
BE-P9	Actual observation [1]	--	--	-2.1	-1.9
	1990-1992 data period (no MIF)				
BE-P8	Actual observation [2]	-2.1	-2.8	--	--
BE-P9	Actual Observation [2]	-3.1	-4.1	--	--

[1] Values extracted from Mean data in Table 3-11
[2] Values extracted from Mean data in Table 3-20

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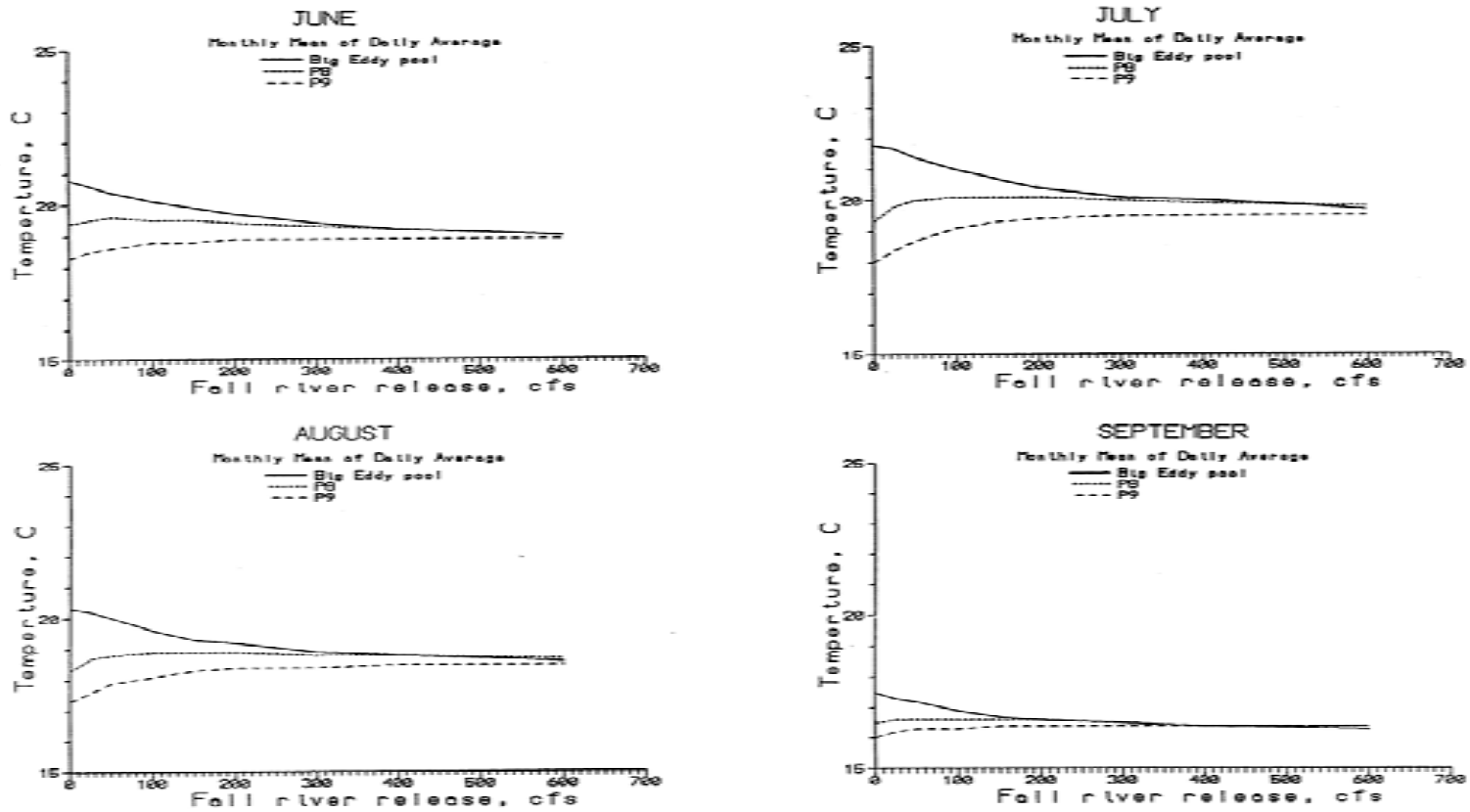

E2-60
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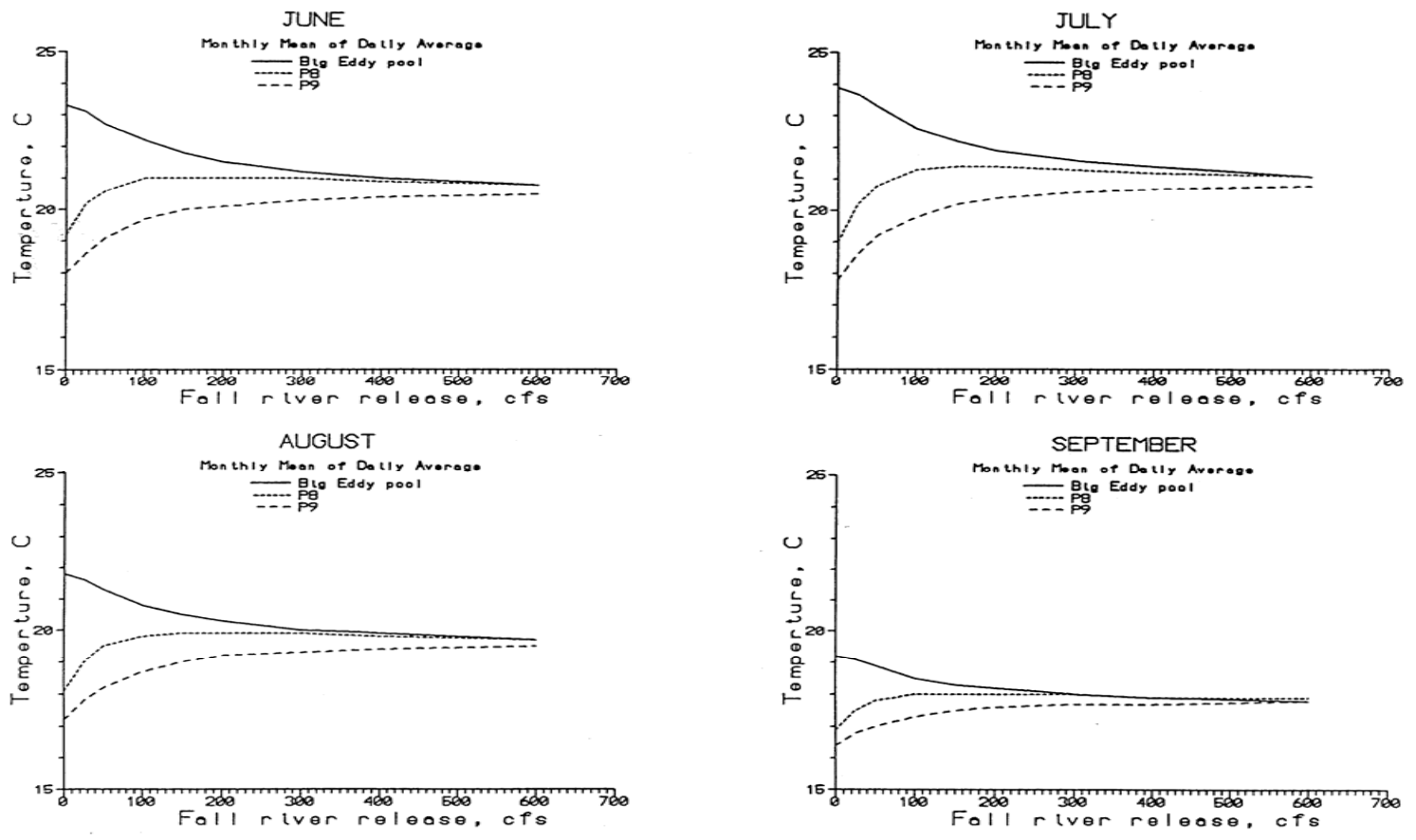
Figure B-1. Monthly Mean of Simulated Mean Daily Temperatures for Normal Hydrology and Normal Meteorology Conditions Under Various Release Flows (extracted from E2-15 in Exhibit E)



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E2-61

Figure B-2. Monthly Mean of Simulated Mean Daily Temperatures for Low Hydrology and Hot Meteorology Conditions Under Various Release Flows (extracted from E2-16 in Exhibit E)

PACIFIC GAS AND ELECTRIC COMPANY

Pit 1 Hydroelectric Project
FERC Project No. 2687

Agency Consultation
Five-year Water Quality Monitoring
2004–2008

June 2009

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General

Article 401 of the Federal Energy Regulatory Commission (FERC) license (FERC 2687) and Condition 17 of the State Water Resources Control Board (SWRCB) 401 Water Quality Certification require the Licensee

"*At the end of the 5th year of monitoring, the Licensee shall provide the Chief of the Division of Water Rights a report summarizing the 5 years of water quality monitoring. The Licensee shall meet with the Chief of the Division of Water Rights or a designated representative within 60 days of the submittal of the summary report.*"

The 5-year summary report was submitted on March 12, 2009. On May 11, 2009, PG&E met with SWRCB, and with staff from the California Regional Water Quality Control Board, California Department of Fish and Game, and the U.S. Fish and Wildlife Service. A summary of the 5-year data was presented and reviewed. The following attachments include all consultation email/letter communication information with pertinent supporting documents, as grouped by the topic.

Attachment 1: Pit 1 Water Quality Annual and Five-year Summary Reports

Attachment 2: Shasta Crayfish Concerns and Issues

Attachment 3: May 11, 2009 Agency Consultation Meeting and Supporting Documents

Attachment 4: Agency Meeting Follow-up

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Attachment 1

Pit 1 Water Quality 2009 Annual and Five-year Summary Reports

- December 22, 2008 Email from Charles White to agencies transmitting Pit 1 Water Quality Annual Report
- February 9, 2009 email from Dennis Heiman to Russ Kanz - 2008 Pit 1 Monitoring Report
- March 24, 2009 letter from Russ Kanz to Charles White - Water Quality Monitoring Results, 2008 Annual Report, Pit 1 Hydroelectric Project, FERC No. 2687
- QA/QC Document in response to March 24, 2009 additional information request (AIR) from SWRCB
- March 12, 2009 Email from Charles White to agencies transmitting Pit 1 Water Quality Five-year Summary Report

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COPY

Pacific Gas and Electric Company

Power Generation

245 Market Street
San Francisco, CA 94105

Mailing Address
Mail Code N11C
P.O. Box 770000
San Francisco, CA 94177

December 22, 2008

Ms. Victoria A. Whitney
Deputy Director, Division of Water Rights
California State Water Resources Control Board
1001 I Street, 14th Floor
Sacramento, CA 95814

RE: Pit 1 Project (FERC Project No. 2687)
License Article 401; Water Quality Monitoring Results – 2008 Annual Report

Dear Ms. Whitney:

On November 20, 2003, the Federal Energy Regulatory Commission (FERC) issued an "Order Modifying and Approving Water Quality Monitoring Plan under Article 401" for Pacific Gas and Electric Company's (PG&E) Pit 1 Hydroelectric Project, FERC No. 2687 (Project). As required by Conditions 16 and 17 of the Water Quality Certification, a report summarizing the water quality monitoring must be filed annually with the California State Water Resources Control Board (SWRCB) by December 31, and with FERC by the following March 31.

Enclosed for your review and comment is the final draft report titled *"Pit 1 Water Quality Monitoring Results – 2008 Annual Report"* dated December 2008. The enclosed report includes monitoring results for the fifth year of the five-year monitoring program. Comments PG&E receives from your agency will be addressed in the final report that will be filed with FERC by March, 31 2009. Please provide to me any comments you may have by March 2, 2009.

At the conclusion of the fifth year of sampling, PG&E is also required to submit a Summary Report, as required by Condition 17 of the SWRCB Water Quality Certification. PG&E is also required to include in the summary report documentation of the required consultation with the SWRCB's Chief of the Division of Water Rights (Chief), and the Chief's determination of whether or not the beneficial uses of the Pit River described in the Board's 1998 Basin Plan have been reasonably protected during project operation.

Currently, PG&E is required to submit the 5-year water quality summary report by April 15, 2009, however, since comments from the SWCRB on the 2008 water quality monitoring report are not due back to PG&E until March 2, 2009, PG&E has requested an approval from FERC for an extension to file the 5-year summary report by July 1, 2009. This extension would allow PG&E to incorporate any SWRCB comments on the 2008 water quality report, conduct an analyses to determine if the beneficial uses have been protected, provide SWRCB a 60-day comment period, and allow time for PG&E time to consult with

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the SWRCB on proposed recommendations. PG&E requested SWRCB concurrence for the proposed extension in an e-mail dated December 3, 2008 and Russ Kanz from your agency concurred with the proposed extension in his reply dated December 12, 2008. PG&E is currently waiting for FERC approval for the extension.

If you have any questions or wish to discuss the 2008 water quality monitoring report, or the proposed schedule for the 5-year summary report, please contact me at (415) 973-3642, or by email at COW1@pge.com.

Sincerely,

Charles O. White, Senior License Coordinator
Hydro Licensing

Enclosure

cc: Mr. Russ Kanz
State Water Resources Control Board
P.O. Box 2000
Sacramento, CA 95812-2000

Mr. Gary Stacey
Regional Manager
California Department of Fish and Game
601 Locust Street
Redding, CA 96001

Ms. Cay Goude
Acting Field Supervisor
U.S. Fish and Wildlife Service
2800 Cottage Way, Rm W-2605
Sacramento, CA 95825

Mr. Dennis Heiman
Central Valley Regional Water Quality Control Board
415 Knollcrest Drive, Suite 100
Redding, CA 96002

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White, Charles

From: Dennis Heiman [dheiman@waterboards.ca.gov]
Sent: Monday, February 09, 2009 12:39 PM
To: Russ Kanz
Cc: White, Charles; Jeff Cook; Fraser Sime
Subject: 2008 Pit 1 Monitoring Report

Russ

I have reviewed the 2008 Pit 1 Water Quality Monitoring Report (Dec 2008) and I'm offering these comments for your consideration in our official response to PG&E. Overall, I thought this was an excellent report and discussion of current Pit/Fall River water quality conditions and comparison of current conditions with pre-license study data in 1990-1992.

My understanding of significant findings include the following:

* Dissolved oxygen and pH conditions have improved in the Big Eddy reach of the Pit from the combined result of increased water releases from Fall River and at the Muck Valley Hydro Project.

* Temperature conditions in lower Fall River (i.e. Pit 1 Forebay and Fall River Pond) and at Big Eddy in the Pit River were mostly unchanged from the increased flow releases.

* Temperatures in the Pit River below Big Eddy were somewhat warmer as compared to 1990-92 conditions due to increased flow (from Fall River and Muck Valley) masking the effects of cool accretion flows from springs in this reach.

* Temperatures in the Pit River at Big Eddy and below were temporarily lowered during the two flushing flow events (presumably due to the large volume of cold Fall River water).

Regarding future Pit 1 project water quality monitoring requirements. Region 5 is attempting to establish a comprehensive ambient water quality monitoring program at strategic sites throughout the Sacramento River watershed. This program started in the fall, 2008 through a cooperative Reg. Bd./DWR agreement. On the Pit and Fall Rivers, quarterly monitoring (with continuous temperature recording) will be done at the following locations: Fall River @ Island Rd. Br., NF and SF Pit River @ Alturas, Pit River @ Canby, Pit River @ Pittville, and Pit River @ Montgomery Cr. Continuing at least some of the PG&E Pit 1 Project data sites would be a valuable addition to this ambient monitoring network. I would be most interested in seeing monitoring continued at Fall River 1 (the lower end of Fall River), at Pit River 5 (downstream of powerhouse flows from Fall River), and perhaps at Pit River 2 (Big Eddy). Also, since the USGS flow gage at Pittville is discontinued, the PG&E gaging data at this site is particularly of value.

Given our understanding of water quality conditions in Fall and Pit River and potential impacts to beneficial uses, temperature, dissolved oxygen, turbidity, pH, and flow remain the parameters of concern. Please keep me informed and involved in any future negotiations concerning Pit 1 monitoring requirements.

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State Water Resources Control Board

Linda S. Adams
Secretary for Environmental Protection

Division of Water Rights
1001 I Street, 14th Floor ♦ Sacramento, California 95814 ♦ 916.341.5300
P.O. Box 2000 ♦ Sacramento, California 95812-2000
Fax: 916.341.5400 ♦ www.waterrights.ca.gov

Arnold Schwarzenegger
Governor

MAR 2 4 2009

POWER GENERATION		
ORIG.	MAR 2 6 2009	CC:
FERC NO.	TRACK NO.	
FILE NO.	ACTION:	

Charles O. White
Pacific Gas and Electric Company
Mail Code N11C
P.O. Box 770000
San Francisco, CA 94177

WATER QUALITY MONITORING RESULTS, 2008 ANNUAL REPORT, PIT 1 HYDROELECTRIC PROJECT, FERC NO. 2687

Dear Mr. White:

Condition #17 of the water quality certification for the Pit 1 Hydroelectric Project, Federal Energy Regulatory Commission (Commission) License # 2687, requires Pacific Gas and Electric Company (PG&E) to file a report summarizing the results of water quality monitoring annually. PG&E filed the 2008 Annual Report: Pit 1 Water Quality Monitoring Results with the Deputy Director for Water Rights (Deputy Director) on December 23, 2008. State Water Resources Control Board staff has reviewed the annual report and provides the following comments.

Water quality data was collected using a HydroLab Quanta and temperature data was collected using Stamon Mini recorders. Appendix A of the report includes calibration information for dissolved oxygen and pH, but did not include calibration data for conductivity, total dissolved solids, and turbidity. The report states that all of the temperature recorders were calibrated in a water bath using American Standard Test Methods to an accuracy of ±0.1°C. It would be helpful to include additional information on the calibration of the Hydrolab for conductivity, total dissolved solids, and turbidity, and for the pre and post deployment accuracy of the temperature loggers.

Per your correspondence, a five-year summary report should be provided to the Deputy Director soon for review and comment. This report is required to be submitted to the Commission by July 1, 2009. If you have any questions, please contact me at (916) 341-5341.

Sincerely,

Russ J. Kanz
Staff Environmental Scientist

cc: See next page.

California Environmental Protection Agency

Recycled Paper

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cc: Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

Kathy Turner
US Forest Service
Hat Creek Ranger District
P.O. Box 2200
Fall River Mills, CA 96028

Matt Myers
Department of Fish and Game
601 Locust Street
Redding, CA 96001-2711

Debbie Giglio
U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2605
Sacramento, CA 95825-1846

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PACIFIC GAS AND ELECTRIC COMPANY

Pit 1 Project, FERC Project No. 2687

Additional Information Request

Supplemental Document
Quality Assurance Data Control
For Pit 1 Water Quality Data 2004-2008

Prepared by

SPRING RIVERS ECOLOGICAL SCIENCES, LLC

Post Office Box 153
Cassel, California 96016
phone (530) 335–5446
fax (530) 335–4591

Prepared for

PACIFIC GAS AND ELECTRIC COMPANY

Technical Project Support—Environmental Services
3401 Crow Canyon Road
San Ramon, California 94583

April 2009

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Introduction

1.1 Background

On December 23, 2008, Pacific Gas and Electric Company (PG&E) filed its Pit 1 Project Water Quality Monitoring Results – 2008 with the California State Water Resource Control Board (SWRCB). In its letter dated March 24, 2009, the SWRCB requested that additional information regarding PG&E's quality control data for conductivity, total dissolved solids (TDS), and turbidity as well as records of the pre and post deployment accuracy of the water temperature recorders. This document provided the following information in response to the SWRCB request.

1 Water temperature calibration certificates for all monitoring periods 2004-2008, as well as the recorder deployment history for each station for each monitoring year (Attachment A1).

2 As a specific response to the SWRCB letter, the pre and post deployment calibration data (accuracy information recorded in the laboratory) for water temperature recorders used in the 2008 annual report (Table 2).

3 Calibration certificates for the Hydrolab Multi-parameter meter for all monitoring periods 2004-2008 (Attachment A2).

4 A summary of the calibration logs from the contractor laboratory and field adjustments for the various water quality instruments used during the 2004-2008 monitoring efforts. These included the logs for the conductivity and turbidity as a specific response to the SWRCB letter (Attachment A3).

1.2 Quality Control Review Procedures

1.2.1 Water Temperature QA/QC Procedures

In accordance with the Quality Assurance Program Plan (QAPP) (PG&E 2006), control of water temperature measurement accuracy was addressed by instrument calibrations at standard conditions. Recorders purchased new, are certified by the manufacturer for accuracy and this certificate is considered the pre-deployment record where applicable. Quality control calibrations were performed on each recorder in a laboratory setting (i.e., American Standard Test Methods - water bath) at the end of each monitoring period. Post deployment calibration is typically performed December through January. This accommodates recovery of all recorders from their deployment as part of the various monitoring projects. A post-deployment certificate will be issued by the PG&E technician responsible for instrument calibration. The post-deployment certificate from the previous year is considered the pre-deployment record for the following service year.

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The minimum accuracy of all digital recorders was ± 0.1°C between 5°C and 40°C. A summary of the dates for each annual calibration certificate are summarized in Table 1. Applicable quality control and assurance (QA/QC) certificates and field deployment logs for the Pit 1 Project is presented in Attachment A1.

A clarification of recorders used during the 2004-2008 monitoring program is provided in the following narrative. For the 2004-2006 monitoring efforts stream temperatures were automatically measured *in situ* using VEMCO MiniLog 12 TR digital thermographs at all nine stations. For the 2007 monitoring effort a combination of VEMCO and Starmon Mini recorders were utilized, for the 2008 monitoring effort only the Starmon Mini recorders were utilized. The actual deployment history (location and serial numbers) of recorders deployed at each location is detailed in Attachment A1.

Redundant recorders were installed at each station; data from only one recorder (by convention primary recorder "A") was used to characterize conditions at each Station. If recorder "A" had a failure, the entire data set from the secondary recorder "B" was used to define the station. At no time during the 2004-2008 monitoring efforts was data lost due to either a recorder failing or instrument being lost. In six instances, recorders failed to pass post deployment calibration (Appendix A). Calibration data from these recorders verified that the units were out of compliance at the near-zero temperature, which typically indicates low battery conditions. At calibration temperatures within the range observed during *in situ* deployment, all recorders were still within ± 0.2 to 0.4°C. As a result, no change to the *in situ* database from stations where out of tolerance recorders were deployed was made based on this in-depth evaluation of the calibration data.

A complete record of the actual results of the calibration effort for each recorder is available. This record is quite detailed and voluminous (data loggers are sometimes intermixed within Projects), and beyond the scope of this document. However, in response to the March 24, 2009 letter from SWRCB, the results of the pre- and post-calibration effort for loggers used on the Pit 1 Project in 2008 is presented in Table 2. Calibration results are presented only for those instruments from which data was utilized in the report. The information presented in Table 2 is summarized from the calibration records which contain more detail regarding instrument performance at each temperature. This information establishes the level of accuracy for each instrument and documents the testing procedures utilized in PG&E's laboratory

1.2.2 *In situ* Water Quality QA/QC Procedures

In accordance with the QAPP (PG&E 2006), control of *in situ* measurement accuracy was addressed by instrument calibrations at standard conditions (*e.g.*, dissolved oxygen in saturated air) and the use of standard solutions (*e.g.*, pH standards, conductivity standards, etc.). All instrument calibration adjustments were made based on manufactures specifications under laboratory conditions. No changes to laboratory based meter calibration were made under in-field conditions with the exception of dissolved oxygen. A summary calibration checks and results are summarized in Table 3. Applicable quality control and assurance (QA/QC) certificates are presented in presented in Attachment A2, while field calibration logs are included in Attachment A3.

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Dissolved oxygen was the only parameter that required in-field calibration adjustments to compensate for changes in barometric pressure (altitude) as well as drift associated with changes in membrane and filling solution during use. These calibration adjustments were made during each site visit and are detailed in Appendix A3. Dissolved oxygen measurements were periodically verified using Winkler titration of water samples collected in the field.

TDS readings were generated by internal meter (firmware algorithm) calculations that convert conductivity to TDS using a widely accepted conversion coefficient. No attempt was made to re-calibrate the firmware-based TDS algorithm.

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Table 1

Summary of Water Temperature Recorder QA/QC Data

Monitoring Year	Calibration Check		QA/QC results		Recorder Certification	Deployment History
	Pre-deployment	Post-deployment	Out of tolerance	Failed		
2004	New 3/2004	12/13/04	None	None	Attachment A1	Attachment A1
2005	12/13/04	01/03/06	None	None	Attachment A1	Attachment A1
2006	01/03/06	01/25/07	5 units[1]	2 units[2]	Attachment A1	Attachment A1
2007	01/25/07	01/16/08	None	1 unit[2]	Attachment A1	Attachment A1
2008	01/16/08	12/16/08	None	1 unit[2]	Attachment A1	Attachment A1

Notes

1. Calibration data from these recorders verified that the units were out of compliance at the near-zero temperature, which typically indicates low battery conditions. At calibration temperatures within the range observed during in situ deployment, all recorders were within ± 0.2 to 0.4°C. As a result, no change to the in situ database from stations where out of tolerance recorders were deployed was made based on this in-depth evaluation of the calibration data.

2. Recorders that failed during deployment were removed from service, and replaced with functioning units. Installation of redundant recorders at each location eliminated loss of data due to failure. Typically, recorders failed during calibration due to low battery conditions which were not evidenced during deployment and did not affect the data record.

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Table 2

Summary of Water Quality QA/QC

Station	Starmon Recorder S/N	Calibration Period	Date	Temperature Range 1 Recorder[1] (°C)	Temperature Range 1 Standard[2] (°C)	Temperature Range 1 Error (°C)	Temperature Range 2 Recorder[1] (°C)	Temperature Range 2 Standard[2] (°C)	Temperature Range 2 Error (°C)	Temperature Range 3 Recorder[1] (°C)	Temperature Range 3 Standard[2] (°C)	Temperature Range 3 Error (°C)	Average Error (°C)
FR1B	T1759	Pre-deploy	01/08/07	0.6	0.5	0.0	19.9	19.9	0.0	29.9	29.9	0.0	0.0
		Post-deploy	12/15/08	0.5	0.6	0.0	19.9	19.9	-0.1	29.9	29.9	0.0	0.0
FR2A	T1755	Pre-deploy	01/08/07	0.5	0.5	0.0	19.9	19.9	0.0	29.9	29.9	0.0	0.0
		Post-deploy	12/15/08	0.5	0.6	0.0	19.9	19.9	0.0	29.9	29.9	0.0	0.0
FR3A	T1768	Pre-deploy	01/08/07	0.5	0.5	0.0	19.9	19.9	0.0	29.9	29.9	0.0	0.0
		Post-deploy	12/15/08	0.5	0.6	0.0	19.9	19.9	-0.1	29.9	29.9	0.0	0.0
FR4A	T1772	Pre-deploy	01/08/07	0.5	0.5	0.0	19.9	19.9	0.0	29.9	29.9	0.0	0.0
		Post-deploy	12/15/08	0.5	0.6	0.0	19.9	19.9	-0.1	29.9	29.9	-0.1	0.0
PR1A	T1382	Pre-deploy	Fact.Cert[3]	--	--	--	--	--	--	--	--	--	--
		Post-deploy	12/15/08	0.5	0.6	-0.1	19.8	19.9	-0.1	29.8	29.9	-0.1	-0.1
PR2A	T1758	Pre-deploy	01/08/07	0.5	0.5	0.0	19.9	19.9	0.0	29.9	29.9	0.0	0.0
		Post-deploy	12/15/08	0.5	0.6	-0.1	19.9	19.9	0.0	29.9	29.9	0.0	0.0
PR3A	T1732	Pre-deploy	01/10/07	0.6	0.5	0.1	19.9	19.9	0.0	29.9	29.9	0.0	0.0
		Post-deploy	12/15/08	0.6	0.6	0.0	19.9	19.9	0.0	29.9	29.9	0.0	0.0
PR4A	T1390	Pre-deploy	Fact.Cert[3]	--	--	--	--	--	--	--	--	--	--
		Post-deploy	12/15/08	0.5	0.6	-0.1	19.8	19.9	-0.1	29.8	29.9	-0.1	-0.1
PR5B	T1754	Pre-deploy	01/08/07	0.5	0.5	0.0	19.9	19.9	0.0	29.9	29.9	0.0	0.0
		Post-deploy	12/15/08	0.5	0.6	0.0	19.9	19.9	0.0	29.9	29.9	0.0	0.0

1. Average of 5 1-minute readings at the associated water bath temperature.
2. Average of 5 1-minute readings.
3. Recorder purchased new. Factory certificate of calibration accuracy.

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Table 3

Summary of Water Quality QA/QC

Monitoring Year	Manufactures Certification			Routine Calibration Check			
	Cert. Date	Presented in	Reason	Dissolved Oxygen	pH	Turbidity	Conductivity
2004	New 3/2004	Attachment A2	--	Attachment A3	Attachment A3	Attachment A3	Attachment A3
2005	12/15/04	Attachment A2	Repair	Attachment A3	Attachment A3	Attachment A3	Attachment A3
2006	--	Attachment A2	N/A	Attachment A3	Attachment A3	Attachment A3	Attachment A3
2007	02/06/07	Attachment A2	Repair	Attachment A3	Attachment A3	Attachment A3	Attachment A3
2008	04/09/08	Attachment A2	Repair	Attachment A3	Attachment A3	Attachment A3	Attachment A3

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Attachment A

Quality Assurance and Control Documentation

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A1 – PG&E Water Temperature Recorder Calibration Certificates

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Post 2004 Deployment Calibration - Vemco Recorders

Memorandum

Date: December 13, 2004 **File #:**

To: ENVIRONMENTAL ENGINEERING GROUP

From: ERIC KENZLER

Subject: Temperature Data Logger 2004 Calibration Report

Pacific Gas and Electric Company

CHARLES WHITE
BRIAN FRANTZ

On December 3, 2004 through December 13, 2004 the VEMCO TR-12 temperature recorders on the attached list were calibrated at TES using manufacturer's calibration procedures and certified in tolerance against National Institute of Standards and Technology traceable instrumentation.

Traceable Instrument Identification:
Model No. 15-077-8 S/N 221336702 Fisher Scientific Digital Thermometer
Probe: 15-077-7 S/N 221336677

Precision Water Bath:
Thermo Neslab RTC 17 S/N 103198062

Certificate information is located in the MS Word document S:\Vemco\2004 Calibration\Cal data sheet 2004-05.doc. Printed graphs of original calibration data are located in my files.

ERIC KENZLER
Technologist, TES

EMKenzler(251-5806):emk

Pc: Ed Cheslak
Scott Tu

Attachment

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Post 2004 Deployment Calibration - Vemco Recorders

Pacific Gas & Electric Company - Technical and Ecological Services
VEMCO TR-12 Temperature recorders calibrated in December 2004

	SN:	SN:	SN:	SN:
1	2190	2910	7003	935
2	2192	2911	7004	936
3	2193	2912	7005	937
4	2197	2913	7006	939
5	2198	2914	7007	940
6	2199	2915	7008	941
7	2200	2917	9346	942
8	2201	2918	9348	944
9	2202	2919	9349	945
10	2203	2920	9350	946
11	2204	2921	9351	947
12	2205	2922	9352	948
13	2207	3040	9353	949
14	2208	3041	943	950
15	2209	3043		951
16	2554	3044		952
17	2555	3045		953
18	2556	3048		954
19	2557	3049		955
20	2558	3050		956
21	2559	3051		9324
22	2560	3052		9325
23	2561	3053		9326
24	2562	3054		9327
25	2563	3055		9328
26	2564	3056		9329
27	2565	3057		9330
28	2566	3058		9331
29	2568	3060		9332
30	2569	3061		9333
31	2570	3062		9334
32	2571	3063		9335
33	2572	3064		9336
34	2573	3065		9337
35	2903	3066		9338
36	2904	6998		9340
37	2906	6999		9341
38	2907	7000		9342
39	2908	7001		9344
40	2909	7002		9345

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Post 2005 Deployment Calibration - Starmon Recorders

Memorandum

Date: March 9, 2009 **File #:**

To: ENVIRONMENTAL ENGINEERING GROUP

From: ERIC KENZLER

Subject: Temperature Data Logger 2005 Calibration Report

Pacific Gas and Electric Company

SCOTT TU
TIM SAGRAVES

On January 11-13, 2006 the VEMCO TR-12 temperature recorders on the attached list were calibrated at TES using manufacturer's calibration procedures and certified in tolerance against National Institute of Standards and Technology traceable instrumentation.

Traceable Instrument Identification:
Model No. 15-077-8 S/N 221336702 Fisher Scientific Digital Thermometer
Probe: 15-077-7 S/N 221336677

Precision Water Bath:
Thermo Neslab RTC 17 S/N 103198062

Calibration information is located in the Excel spreadsheet L:\ALL INDIVIDUALS FOLDERS\Kenzler.Eric\2005 Calibration Certs\05-06 Cal data.xls.

ERIC KENZLER
Technologist, TES

EMKenzler(251-5806):emk

Attachment

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Post 2005 Deployment Calibration – VEMCO Recorders

Pacific Gas & Electric Company - Technical and Ecological Services
VEMCO TR-12 Temperature Recorders Calibrated in January 2006

Count	Sn:	Sn:	Sn:
1	2190	2914	954
2	2192	2915	955
3	2193	2917	956
4	2197	2918	9324
5	2198	2919	9325
6	2199	2920	9326
7	2200	2921	9327
8	2201	2922	9328
9	2202	3040	9329
10	2203	3041	9330
11	2204	3043	9331
12	2205	3044	9332
13	2207	3045	9333
14	2208	3048	9334
15	2209	3049	9335
16	2554	3050	9336
17	2555	3051	9337
18	2556	3052	9340
19	2557	3053	9341
20	2558	3054	9342
21	2559	3055	9344
22	2560	3056	9345
23	2561	3058	
24	2562	3060	
25	2563	3061	
26	2564	3062	
27	2565	3063	
28	2568	3064	
29	2569	3065	
30	2570	3066	
31	2571	939	
32	2903	940	
33	2904	942	
34	2906	944	
35	2907	945	
36	2908	946	
37	2910	947	
38	2911	948	
39	2912	949	
40	2913	951	

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Post 2006 Deployment Calibration – Vemco Recorders

[redacted]

Date: January 25, 2007 **File #:** 026.11.06.13

To: ENVIRONMENTAL SERVICES

From: TECHNICAL AND LAND SERVICES

Subject: Temperature Data Logger 2006 Calibration Report

Pacific Gas and Electric Company

ED CHESLAK

The VEMCO TR-12 temperature recorders listed in table 1 were calibrated at PG&E's Technical and Land Services (TLS) on January 24, 2007 using manufacturer's calibration procedures and certified in tolerance (± 0.1 °C) against National Institute of Standards and Technology traceable instrumentation with the following exceptions. As noted, five of the VEMCO units were slightly out of tolerance as found and were recalibrated to meet tolerance criteria. Two units (sn.2192A and sn.7004A) failed to operate and were taken out of service.

Traceable Instrument Identification:
Model No. 15-077-8 S/N 221367532 Fisher Scientific Digital Thermometer
Probe: 15-077-7 S/N 240301157

Precision Water Bath:
Thermo Neslab RTC 17 S/N 103198062

Individual Calibration Certificates can be printed if necessary. Original calibration data are located in my files, C:/Equipment/Calibration Certificates.

ERIC KENZLER
Technologist, TLS

EMKenzler(251-5806):emk

Pc: Dan Tilly
Tim Sagraves
Attachment

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Post 2006 Deployment Calibration – Vemco Recorders

Table 1. Temperature Data Loggers Calibration Record

Pit 1 Project Count	Model	SN:	Cal Date	In Tolerance
1	Vemco TR-12	0935E	1/24/2007	Y
2	Vemco TR-12	0937E	1/24/2007	Y
3	Vemco TR-12	2190A	1/24/2007	Y
4	Vemco TR-12	2192A	1/24/2007	FAIL[2]
5	Vemco TR-12	2193A	1/24/2007	Y
6	Vemco TR-12	2197A	1/24/2007	Y
7	Vemco TR-12	2198A	1/24/2007	Y
8	Vemco TR-12	2199A	1/24/2007	Y
9	Vemco TR-12	2200A	1/24/2007	Y
10	Vemco TR-12	2201A	1/24/2007	Y
11	Vemco TR-12	2202A	1/24/2007	Y
12	Vemco TR-12	2203A	1/24/2007	Y
13	Vemco TR-12	6998A	1/24/2007	N-R[1]
14	Vemco TR-12	7000A	1/24/2007	N-R[1]
15	Vemco TR-12	7001A	1/24/2007	N-R[1]
16	Vemco TR-12	7004A	1/24/2007	FAIL[2]
17	Vemco TR-12	7005A	1/24/2007	N-R[1]
18	Vemco TR-12	7008A	1/24/2007	N-R[1]
19	Vemco TR-12	9351A	1/24/2007	Y
20	Vemco TR-12	9353A	1/24/2007	Y

1. N-R = Not in tolerance (± 0.1 °C) as found, recalibrated to within tolerance.
2. FAIL = Unable to establish communication, calibration failed.

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Post 2007 Deployment Calibration – Starmon/Vemco Recorders

[redacted]

Date: January 16, 2008 **File #:**

To: ENVIRONMENTAL SERVICES

From: APPLIED TECHNOLOGY SERVICES

Subject: Pit 1 Project - Temperature Data Logger 2007 Calibration Report

Pacific Gas and Electric Company

ED CHESLAK
TIM SAGRAVES:

The Vemco and Star-Oddi Starmon mini® temperature recorders listed in Table 1 were tested at PG&E's Applied Technology Services (ATS) laboratory on January 8 and 10, 2008 using the manufacturer's operational software and were certified to be accurate for temperature within project tolerance limits (± 0.1 °C) with one exception. As noted (Table 1), one of the Vemco units failed to start and was taken out of service. The units were tested using National Institute of Standards and Technology traceable instrumentation.

Traceable Instrument Identification:
Model No. 15-077-8 S/N 221367532 Fisher Scientific Digital Thermometer
Probe: 15-077-7 S/N 240301157

Precision Water Bath:
Thermo Neslab RTC 17 S/N 103198062

Individual Calibration Certificates can be printed if necessary. The original calibration data files are located in room 151 at the ATS San Ramon Laboratories.

ERIC KENZLER
Technologist, ATS

EMKenzler(251-5806):emk

Pc: Dan Tilly

Attachment

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Post 2007 Deployment Calibration – Starmon/Vemco Recorders

Pacific Gas and Electric Company - Applied Technology Services

Table 1. Temperature Data Logger Calibration Record

Pit 1 Project

Count	Model	SN:	Cal Date	In Tolerance
1	Vemco TR-12	0948E	1/8/2008	Fail[1]
2	Vemco TR-12	0949E	1/8/2008	Y
3	Vemco TR-12	0951E	1/8/2008	Y
4	Vemco TR-12	0955E	1/8/2008	Y
5	Vemco TR-12	0956E	1/8/2008	Y
6	Vemco TR-12	2559A	1/8/2008	Y
7	Vemco TR-12	2560A	1/8/2008	Y
8	Vemco TR-12	2561A	1/8/2008	Y
9	Vemco TR-12	2562A	1/8/2008	Y
10	Vemco TR-12	2563A	1/8/2008	Y
11	Vemco TR-12	2564A	1/8/2008	Y
12	Vemco TR-12	2565A	1/8/2008	Y
13	Vemco TR-12	2568A	1/8/2008	Y
14	Vemco TR-12	2569A	1/8/2008	Y
15	Vemco TR-12	2570A	1/8/2008	Y
16	Starmon mini	T 1732	1/10/2008	Y
17	Starmon mini	T 1735	1/10/2008	Y
18	Starmon mini	T 1736	1/10/2008	Y

1) Unit failed to operate and was taken out of service.

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Post 2008 Deployment Calibration – Starmon Recorders

[redacted]

Date: December 16, 2008 **File #:**

To: ENVIRONMENTAL SERVICES

From: APPLIED TECHNOLOGY SERVICES

Subject: Pit 1 Project - Temperature Data Logger 2008 Calibration Report

Pacific Gas and Electric Company

ED CHESLAK
TIM SAGRAVES:

The Star-Oddi Starmon mini® and Seamon temperature recorders listed in Table 1 were tested at PG&E's Applied Technology Services (ATS) laboratory on December 15, 2008 using the manufacturer's operational software and were certified to be accurate for temperature within project tolerance limits (± 0.1 °C) with one exception. As noted (Table 1), one of the Seamon units failed to start and was taken out of service. The units were tested using National Institute of Standards and Technology traceable instrumentation.

Traceable Instrument Identification:
Model No. 15-077-8 S/N 221367532 Fisher Scientific Digital Thermometer
Probe: 15-077-7 S/N 240301157

Precision Water Bath:
Thermo Neslab RTC 17 S/N 103198062

Individual Calibration Certificates can be printed if necessary. The original calibration data files are located in room 151 at the ATS San Ramon Laboratories.

ERIC KENZLER
Technologist, ATS

EMKenzler(251-5806):emk

Pc: Dan Tilly

Attachment

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Post 2008 Deployment Calibration – Starmon Recorders

Pacific Gas and Electric Company - Applied Technology Services
Table 1. Temperature Data Logger Calibration Record

Pit 1 Project

Count	Model	SN:	Cal Date	In Tolerance
1	Seamon	D543		FAIL [1]
2	Starmon mini	T1732	12/15/2008	Y
3	Starmon mini	T1754	12/15/2008	Y
4	Starmon mini	T1388	12/15/2008	Y
5	Starmon mini	T1390	12/15/2008	Y
6	Starmon mini	T1395	12/15/2008	Y
7	Seamon	D680	12/15/2008	9% battery remaining
8	Starmon mini	T1731	12/15/2008	Y
9	Starmon mini	T1755	12/15/2008	Y
10	Starmon mini	T1772	12/15/2008	Y
11	Starmon mini	T1768	12/15/2008	Y
12	Starmon mini	T1758	12/15/2008	Y
13	Starmon mini	T1382	12/15/2008	Y
14	Starmon mini	T1759	12/15/2008	Y

1) Unit failed to operate and was taken out of service.

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Recorder Deployment History - Fall River Stations

Date	FR1A		FR1B		FR2A		FR2B		FR3A		FR3B		FR4A		FR4B	
	S/N	Type[1]/Status[2]	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status
05/11/04	2200	Vem[1]/P[2]	2566	Vem[1]/P[2]	2201	Vem[1]/P[2]	3059	Vem[1]/P[2]	2205	Vem[1]/P[2]	2207	Vem[1]/P[2]	9324	Vem[1]/P[2]	9336	Vem[1]/P[2]
05/25/04	954	Vem[1]/P[2]	⇓		942	Vem[1]/P[2]	9337		9333	Vem[1]/P[2]	⇓		9335	Vem[1]/P[2]	⇓	
06/10/04	950	Vem[1]/P[2]	⇓		2560	Vem[1]/P[2]	⇓		2566	Vem[1]/P[2]	⇓		9329	Vem[1]/P[2]	⇓	
06/23/04	3051	Vem[1]/P[2]	⇓		3057	Vem[1]/P[2]	⇓		938	Vem[1]/P[2]	⇓		2200	Vem[1]/P[2]	⇓	
07/08/04	9335	Vem[1]/P[2]	⇓		2560	Vem[1]/P[2]	⇓		9344	Vem[1]/P[2]	⇓		939	Vem[1]/P[2]	⇓	
07/21/04	945	Vem[1]/P[2]	⇓		2569	Vem[1]/P[2]	⇓		2204	Vem[1]/P[2]	⇓		951	Vem[1]/P[2]	⇓	
08/04/04	9342	Vem[1]/P[2]	⇓		942	Vem[1]/P[2]	⇓		9328	Vem[1]/P[2]	⇓		3051	Vem[1]/P[2]	⇓	
08/19/04	939	Vem[1]/P[2]	⇓		3044	Vem[1]/P[2]	⇓		2203	Vem[1]/P[2]	⇓		948	Vem[1]/P[2]	⇓	
09/01/04	3060	Vem[1]/P[2]	⇓		950	Vem[1]/P[2]	⇓		2566	Vem[1]/P[2]	⇓		9337	Vem[1]/P[2]	⇓	
09/15/04	7003	Vem[1]/P[2]	⇓		3051	Vem[1]/P[2]	⇓		9328	Vem[1]/P[2]	⇓		9327	Vem[1]/P[2]	⇓	
09/29/04	3048	Vem[1]/P[2]	⇓		945	Vem[1]/P[2]	⇓		9330	Vem[1]/P[2]	⇓		938	Vem[1]/P[2]	⇓	
10/13/04	954	Vem[1]/P[2]	⇓		947	Vem[1]/P[2]	⇓		9335	Vem[1]/P[2]	⇓		9324	Vem[1]/P[2]	⇓	
10/29/04	Out		Out		Out		Out		Out		Out		Out		Out	
05/10/05	7005	Vem[1]/P[2]	9351	Vem[1]/P[2]	7000	Vem[1]/P[2]	7004	Vem[1]/P[2]	7001	Vem[1]/P[2]	7003	Vem/P	6999	Vem[1]/P[2]	935	Vem[1]/P[2]
05/23/05	7007	Vem[1]/P[2]	⇓		9352	Vem[1]/P[2]	⇓		9348	Vem[1]/P[2]	⇓		⇓		⇓	
06/07/05	6998	Vem[1]/P[2]	⇓		⇓		⇓		9346	Vem[1]/P[2]	⇓		7005	Vem[1]/P[2]	⇓	
06/23/05	9353	Vem[1]/P[2]	⇓		9348	Vem[1]/P[2]	⇓		7002	Vem[1]/P[2]	⇓		6999	Vem[1]/P[2]	⇓	
07/12/05	7005	Vem[1]/P[2]	⇓		9346	Vem[1]/P[2]	⇓		7001	Vem[1]/P[2]	⇓		9350	Vem[1]/P[2]	⇓	
08/05/05	9348	Vem[1]/P[2]	⇓		7007	Vem[1]/P[2]	⇓		7002	Vem[1]/P[2]	⇓		7006	Vem[1]/P[2]	⇓	
09/14/05	7001	Vem[1]/P[2]	⇓		9346	Vem[1]/P[2]	⇓		7005	Vem[1]/P[2]	⇓		9349	Vem[1]/P[2]	⇓	
09/27/05	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
11/02/05	Out		Out		Out		Out		Out		Out		Out		Out	
05/09/06	2199	Vem[1]/P[2]	7000	Vem[1]/OT[2]	935	Vem[1]/P[2]	7008	Vem[1]/OT[2]	2197	Vem[1]/P[2]	9353	Vem[1]/P[2]	2202	Vem[1]/P[2]	2203	Vem[1]/P[2]
05/23/06	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
06/05/06	⇓		7007	Vem[1]/P[2]	⇓		2192	Vem[1]/F[2]	9351	Vem[1]/P[2]	⇓		⇓		6998	Vem[1]/OT[2]
06/23/06	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	

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Date	FR1A		FR1B		FR2A		FR2B		FR3A		FR3B		FR4A		FR4B	
	S/N	Type[1]/Status[2]	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status
07/07/06	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
07/21/06	2203	Vem[1]/P[2]	⇓		2200	Vem[1]/P[2]	⇓		⇓		7000	Vem[1]/OT[2]	2201	Vem[1]/P[2]	⇓	
08/04/06	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
08/17/06	⇓		2202	Vem[1]/P[2]	⇓		2199	Vem[1]/P[2]	7001	Vem[1]/P[2]	⇓		⇓		2193	Vem[1]/P[2]
08/29/06	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
09/12/06	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
11/15/06	Out		Out		Out		Out		Out		Out		Out		Out	
05/15/07	4721	Vem[1]/P[2]	949	Vem[1]/P[2]	948	Vem[1]/F[2]	4722	Vem[1]/P[2]	2561	Vem[1]/P[2]	2564	Vem[1]/P[2]	2573	Vem[1]/P[2]	2560	Vem[1]/P[2]
06/14/07	⇓		2568	Vem[1]/P[2]	⇓		2571	Vem[1]/P[2]	2563	Vem[1]/P[2]	⇓		⇓		2570	Vem[1]/P[2]
07/24/07	2917	Vem[1]/P[2]	⇓		2918	Vem[1]/P[2]	⇓		⇓		2908	Vem[1]/P[2]	⇓		2914	Vem[1]/P[2]
08/20/07	⇓		2912	Vem[1]/P[2]	⇓		951	Vem[1]/P[2]	2565	Vem[1]/P[2]	⇓		2570	Vem[1]/P[2]	⇓	
10/31/07	Out		Out		Out		Out		Out		Out		Out		Out	
05/13/08	D543	Starmon[1]/F[2]	1759	Seamon[1]/P[2]	1755	Seamon[1]/P[2]	D680	Seamon[1]/P[2]	1768	Seamon[1]/P[2]	D467	Seamon[1]/L[2]	1772	Seamon[1]/P[2]	D824	Seamon[1]/L[2]
06/10/08	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
07/10/08	1731	Seamon[1]/P[2]	⇓		⇓		⇓		⇓		⇓		⇓		⇓	
08/14/08	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
09/23/08	⇓		⇓		⇓		⇓		⇓		⇓		⇓		⇓	
10/28/08	Out		Out		Out		Out		Out		Lost		Out		Lost	

1 Vem = Vemco Mint TR-12
Seamon = Seamon Mini
Starmon = Starmon Mini

2 P = Passed calibration in tolerance of ± 0.1°C
OT = Found out of tolerance during calibration
F = Failed during deployment or end of season calibration.
L = Recorder lost during high flow test

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Recorder Deployment History - Pit River Station

Date	PR1		PR2		PR3A		PR3B		PR4		PR5A		PR5B	
	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status
05/12/04	2197	Vem[1]/P[2]	3045	Vem[1]/P[2]	3048	Vem[1]/P[2]	3057	Vem[1]/P[2]	2202	Vem[1]/P[2]	2204	Vem[1]/P[2]	3051	Vem[1]/P[2]
05/25/04	935	Vem[1]/P[2]	9331	Vem[1]/P[2]	944	Vem[1]/P[2]	⇓		9326	Vem[1]/P[2]	9327	Vem[1]/P[2]	⇓	
06/09/04	9332	Vem[1]/P[2]	9344	Vem[1]/P[2]	2204	Vem[1]/P[2]	⇓		9342	Vem[1]/P[2]	9340	Vem[1]/P[2]	⇓	
06/23/04	9326	Vem[1]/P[2]	9336	Vem[1]/P[2]	942	Vem[1]/P[2]	⇓		9331	Vem[1]/P[2]	935	Vem[1]/P[2]	⇓	
07/07/04	⇓		954	Vem[1]/P[2]	936	Vem[1]/P[2]	⇓		9342	Vem[1]/P[2]	9325	Vem[1]/P[2]	⇓	
07/21/04	2203	Vem[1]/P[2]	952	Vem[1]/P[2]	2202	Vem[1]/P[2]	⇓		948	Vem[1]/P[2]	956	Vem[1]/P[2]	⇓	
08/04/04	3057	Vem[1]/P[2]	935	Vem[1]/P[2]	9326	Vem[1]/P[2]	⇓		954	Vem[1]/P[2]	7003	Vem[1]/P[2]	⇓	
08/18/04	2200	Vem[1]/P[2]	936	Vem[1]/P[2]	3043	Vem[1]/P[2]	⇓		9325	Vem[1]/P[2]	9335	Vem[1]/P[2]	⇓	
09/01/04	9338	Vem[1]/P[2]	5803	Vem[1]/P[2]	9332	Vem[1]/P[2]	⇓		9340	Vem[1]/P[2]	9333	Vem[1]/P[2]	⇓	
09/15/04	9326	Vem[1]/P[2]	942	Vem[1]/P[2]	2200	Vem[1]/P[2]	⇓		2205	Vem[1]/P[2]	936	Vem[1]/P[2]	⇓	
09/29/04	951	Vem[1]/P[2]	935	Vem[1]/P[2]	9340	Vem[1]/P[2]	⇓		948	Vem[1]/P[2]	937	Vem[1]/P[2]	⇓	
10/13/04	956	Vem[1]/P[2]	939	Vem[1]/P[2]	9344	Vem[1]/P[2]	⇓		9332	Vem[1]/P[2]	952	Vem[1]/P[2]	⇓	
10/29/04	Out		Out		Out		Out		Out		Out		Out	
05/10/05	7006	Vem[1]/P[2]	7008	Vem[1]/P[2]	9353	Vem[1]/P[2]	9349	Vem[1]/P[2]	9346	Vem[1]/P[2]	6998	Vem[1]/P[2]	9350	Vem[1]/P[2]
05/23/05	936	Vem[1]/P[2]	937	Vem[1]/P[2]	⇓		⇓		7002	Vem[1]/P[2]	943	Vem[1]/P[2]	⇓	
06/07/05	7001	Vem[1]/P[2]	7008	Vem[1]/P[2]	7006	Vem[1]/P[2]	⇓		7000	Vem[1]/P[2]	⇓		⇓	
06/23/05	936	Vem[1]/P[2]	⇓		⇓		937	Vem[1]/P[2]	⇓		⇓		7007	Vem[1]/P[2]
07/12/05	6998	Vem[1]/P[2]	⇓		9352	Vem[1]/P[2]	⇓		⇓		⇓		9349	Vem[1]/P[2]
08/05/05	⇓		⇓		936	Vem[1]/P[2]	⇓		⇓		⇓		9353	Vem[1]/P[2]
09/14/05	⇓		⇓		⇓		⇓		⇓		⇓		⇓	
09/27/05	⇓		⇓		9348	Vem[1]/P[2]	⇓		⇓		⇓		7002	Vem[1]/P[2]
11/02/05	Out		Out		Out		Out		Out		Out		Out	
05/09/06	7001	Vem[1]/OT[2]	7005	Vem[1]/OT[2]	HF	--	HF	--	2200	Vem[1]/P[2]	2198	Vem[1]/P[2]	HF	--
05/23/06	⇓	--	⇓	--	--	--	--	--	⇓		⇓		7004	Vem[1]/F[2]
06/05/06	2190	Vem[1]/P[2]	2201	Vem[1]/P[2]	2193	Vem[1]/P[2]	--	--	⇓		⇓		⇓	
06/23/06	⇓		7005	Vem[1]/OT[2]	⇓		7008	Vem[1]/OT[2]	7001	Vem[1]/OT[2]	⇓		⇓	

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Date	PR1		PR2		PR3A		PR3B		PR4		PR5A		PR5B	
	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status	S/N	Type/Status
07/21/06	⇓		⇓		⇓		⇓		⇓		2197	Vem[1]/P[2]	⇓	
08/04/06	⇓		⇓		9353	Vem[1]/P[2]	⇓		935	Vem[1]/P[2]	⇓		⇓	
08/17/06	2198	Vem[1]/P[2]	⇓		⇓		⇓		⇓		⇓		⇓	
08/29/06	⇓		6998	Vem[1]/OT[2]	⇓		⇓		⇓		⇓		⇓	
09/12/06	⇓		⇓		⇓		2190	Vem[1]/P[2]	⇓		9351	Vem[1]/P[2]	7005	Vem[1]/OT[2]
11/15/06	Out		Out		Out		Out		Out		Out		Out	
05/15/07	---	---	---	---	2565	Vem[1]/P[2]	2559	Vem[1]/P[2]	---	---	2569	Vem[1]/P[2]	2562	Vem[1]/P[2]
05/16/07	1735	Seamon[1]/P[2]	1736	Seamon[1]/P[2]	⇓		⇓		1732	Vem[1]/P[2]	⇓		⇓	
06/14/07	⇓		⇓		⇓		⇓		⇓		2919	Vem[1]/P[2]	⇓	
06/27/07	⇓		⇓		⇓		2910	Vem[1]/P[2]	⇓		⇓		⇓	
07/24/07	⇓		⇓		2569	Vem[1]/P[2]	⇓		1732	Vem[1]/P[2]	⇓		955	Vem[1]/P[2]
08/21/07	⇓		⇓		⇓		948	Vem[1]/F[2]	⇓		949	Vem[1]/P[2]	⇓	
10/31/07	Out		Out		Out		Out		Out		Out		Out	
05/13/08	1382	Seamon[1]/P[2]	1758	Seamon[1]/P[2]	---	---	---	---	---	---	1388	Seamon[1]/P[2]	1754	Seamon[1]/P[2]
05/14/08	⇓		⇓		1732	Seamon[1]/P[2]	1395	Seamon[1]/P[2]	1390	Seamon[1]/P[2]	⇓		⇓	
06/10/08	⇓		⇓		⇓		⇓		⇓		⇓		⇓	
07/10/08	⇓		⇓		⇓		⇓		⇓		⇓		⇓	
08/14/08	⇓		⇓		⇓		⇓		⇓		⇓		⇓	
09/23/08	⇓		⇓		⇓		⇓		⇓		⇓		⇓	
10/28/08	Out		Out		⇓		⇓		⇓		⇓		⇓	
10/29/08					Out		Out		Out		Out		Out	

1 Vem = Vemco Mint TR-12
Seamon = Seamon Mini
Starmon = Starmon Mini

2 P = Passed calibration in tolerance of ± 0.1°C
OT = Found out of tolerance during calibration
F = Failed during deployment or end of season calibration.
L = Recorder lost during high flow test

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A2 - Calibration Certificates for Hydrolab Multi-parameter Water Quality Meter

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2007-2008 Manufactures Calibration Certification – HydroLab Multi-meter

DATE: 10-01-03	DOCUMENT#: 19002-00-QUANTA
Page 3 of 3	REVISION: 1

3.0 **Quanta and Quanta G Functional Test Sheet**

Section A:

Service Request # 56430	Customer Pacific Gas + Electric	Serial # 01602
Technician Mike	Model Type (Quanta) Quanta G	Date Started 04/09/08
Performance, Test and Evaluation		
Current MPL Rev. 2.3 Upgrade to MPL Rev N/A	DO membrane installed (Yes) No NA	PH Electrolyte and Teflon Junction installed - Yes (No) NA
Lenses cleaned (Yes) No NA	Desiccant installed (Yes) No NA	Turbidity Firmware Rev. 2.1 → 3.0

Section B:

	Submission 1 Day 1	Submission __ Day ___	Submission __ Day ___	Submission __ Day ___
Verified customer's observations	(Y) / N / NA	Y / N / NA	Y / N / NA	Y / N / NA
Verified proper operation of circulator	(Y) / N / NA	Y / N / NA	Y / N / NA	Y / N / NA
pH 7 Buffer calibration verified (+/- .2 pH)	7.00			
Conductivity calibration verified (+/- 2mS/cm) 12.856 mS/cm / (47.6 mS/cm)	47.6			
pH slope calibration verified at 10 units.	10.03			
ORP calibration verified at ____ degrees C (+/-20 mV)				
Conductivity 1.412 mS linearity verified – (+/- .15 mS)	1.448			
Conductivity .100 mS linearity verified– (+/- .005 mS)	.103			
DO 100% sat integrity window verified at +50 mmHg above current bp.	(P) / F / NA	P / F / NA	P / F / NA	P / F / NA
DO 100% sat integrity window verified – at 550	(P) / F / NA	P / F / NA	P / F / NA	P / F / NA
DO 100% saturation calibration verified – local (+/- .5%)	✓			
Turbidity calibration verified in DI water 0.0-(+/-.5NTU)	0.0			
4 Beam Turbidity calibrated at 86 NTU (+/- 1 NTU) Dilute Formazin verified against "in-house" 2100P	86			
4 Beam Turbidity linearity verified at 48.7 NTU with Dilute Formazin verified against "in-house" 2100P (+/- 10% of reading.)	46.9			
Depth calibration verified – (+/- .02 meters)	0.00			
Depth check – (+/- .1 meters) 0.62	0.6			
pH linearity verified at 4 units. (+/- 0.20 units)	4.1			

Calibrated Test Equipment Used –

Description	X-number
DVM Multimeter	X- 7212

Section C. Final Check-off Prior to Submitting for Estimate -

Exterior is clean	✓	Hach Business System updated	✓
Storage cup filled with pH 4 buffer	✓	Date Completed	04/09/08

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2006-2007 Manufactures Calibration Certification – HydroLab Multi-meter

DATE: 10-01-03	DOCUMENT#: 19002-00-QUANTA
Page 3 of 3	REVISION: 1

3.0

Quanta and Quanta G Functional Test Sheet

Section A:

Job# 256742	Customer Pacific Gas + Elec	Serial # 0D 01602
Technician DAVE S	Model Type (Quanta) Quanta G	Date Started 2-6-07
Performance, Test and Evaluation		
Current MPL Rev. 2.3 Upgrade to MPL Rev	DO membrane installed (Yes) No NA	PH Electrolyte and Teflon Junction installed - Yes No NA
Lenses cleaned (Yes) No NA	Desiccant installed (Yes) No NA	Turbidity Firmware Rev. 2.0

Section B:

	Submission 1 Day 1	Submission __ Day	Submission __ Day	Submission __ Day
Verified proper operation of circulator	(P) /F	P /F	P /F	P /F
Verified communication with display	(P) /F	P /F	P /F	P /F
PH 7 Buffer calibration verified (+/- .2 pH)	7.00			
Conductivity calibration verified 12.856mS/cm (+/-.2mS/cm)	12.86			
PH 10 Buffer calibration verified (+/- .2 pH)	10.00			
ORP calibration verified at _____degrees C (+/-20 mV)	N/A			
Conductivity 1.412 mS linearity verified – (+/- .15 mS)	1.412			
Conductivity .100 mS linearity verified– (+/- .05 mS)	.104			
DO 100% saturation calibration verified – at 760	✓			
DO 100% saturation calibration verified – at 550	✓			
DO 100% saturation calibration verified – local (+/- .5%)	✓			
Turbidity calibration verified in DI water 0.0-(+/-.5NTU)	0.0			
4 Beam Turbidity calibrated at 100 NTU (+/- 1 NTU) Hach Stablcal	(P) /F / NA	P /F / NA	P /F / NA	P /F / NA
4 Beam Turbidity linearity verified at 40NTU – (40 NTU +/- 4) Hach Stablcal	36.6			
Depth calibration verified – (+/- .02 meters)	0.0			
Depth check – (+/- .02 meters) .7	.7			
PH and Conductivity checked in tap water- PH 8 – (+/- .5); Conductivity – .11mS/cm (+/- .05)	(P) /F	P /F	P /F	P /F

Calibrated Test Equipment Used –

Description	X-number
DVM Multimeter	X- 8708

Section C. Final Check-off Prior to Submitting for Estimate -

Exterior is clean	✓	Hach Business System updated	✓
~~Tap water~~ added to storage cup	pH4 ✓	Date Completed	3-21-07

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2004-2005 Manufactures Calibration Certification – HydroLab Multi-meter

Memorandum

Date: December 15, 2004 **File #:**

To: ENVIRONMENTAL ENGINEERING GROUP

From: ERIC KENZLER

Subject: Hyddrolab Instrument 2004 Calibration Report

Pacific Gas and Electric Company

CHARLES WHITE
BRIAN FRANTZ

I certify that between March and November, 2004 the Hydrolab® multiparameter water quality analyzers listed below were calibrated at PG&E's Technical and Ecological Services Department (TES) using manufacturer's calibration procedures and certified in tolerance. The water quality parameters pH, Conductivity, DO, and Turbidity adjusted and verified prior to field deployment.

These are field instruments for in-situ readings and although a log documenting monthly calibrations are kept in Room 151 at TES, most of the instruments were calibrated by qualified PG&E personnel in the field more often than that depending on deployment schedules.

Instrument Identification:
Hydrolab Quanta®. #1 S/N 01310/01277
Hydrolab Quanta® #2 S/N 01943/02100
Hydrolab Quanta® #3 S/N 01602/02089
Hydrolab Data Sonde 4a® S/N 37743
Hydrolab Data Sonde 3® S/N 25506

ERIC KENZLER
Technologist, TES

EMKenzler(251-5806):emk

Pc: Ed Cheslak
Scott Tu

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A3 – Field Calibration Log for Hydrolab Multi-parameter Water Quality Meter

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Dissolved oxygen sensor calibration log.

Quanta #3		DO Meter Cal Check											
		Air Calibration Data								Winkler Check			
		Elevation		Air T	DO at	% Air	Calculated	Instrument	Meter	*In situ*	Titration	Meter	Reading
Date	Time	(ft)	Site	(°C)	Saturation	Saturation	Value	Reading	Difference	Reading	Result	Difference	Adjustment
05/09/05	830	800	Lab	22.0	*8.7*	97%	8.43	8.65	-0.2	*9.4*	9.2	-0.2	No adj
05/23/05	940	3300	PR1	18.3	*9.4*	89%	8.35	8.42	0.0	----	----	----	No adj
06/07/05	915	3300	PR1	11.9	*10.9*	89%	9.66	9.02	0.6	*7.8*	*8.6*	0.8	0.8
06/23/05	1000	3300	PR1	16.6	*9.8*	89%	8.67	10.1	-1.4	----	----	----	No adj
07/12/05	900	3300	PR1	9.4	*11.5*	89%	10.25	11.38	-1.1	----	----	----	No adj
07/19/05	1015	3300	PR1	29.2	*7.6*	89%	6.77	6.93	0.0	*8.3*	*8.5*	0.2	No adj
08/05/05	930	3300	PR1	25.0	*8.2*	89%	7.28	7.52	-0.2	----	----	----	No adj
08/16/05	921	3300	PR1	21.1	*8.9*	89%	7.87	7.97	0.0	----	----	----	No adj
08/31/05	1015	3300	PR1	26.2	*8.0*	89%	7.13	7.28	0.0	----	----	----	No adj
09/14/05	1540	3300	PR1	24.4	*8.3*	89%	7.37	7.61	-0.2	----	----	----	No adj
09/27/05	1000	2460	P4	14.2	*10.3*	92%	9.43	9.37	0.0	*9.23*	*9.3*	0.1	No adj
10/11/05	905	3300	FR1	19.4	*9.2*	89%	8.15	7.85	0.3	----	----	----	No adj
11/02/05	1029	3300	PR1	16.7	*9.7*	89%	8.64	8.53	0.0	----	----	----	No adj
05/23/06	830	3270	FR1	15.0	*15.0*	89%	9.00	8.97	0.0	----	----	----	No adj
06/05/06	833	3270	FR1	15.5	*15.5*	89%	8.90	9.06	0.0	----	----	----	No adj
06/23/06	900	2617	PR4	19.6	*19.6*	91%	8.33	8.52	0.0	----	----	----	No adj
07/07/06	950	2800	PR5	19.5	*19.5*	90%	8.29	8.34	0.0	----	----	----	No adj
07/19/06	900	2700	MCA	20.5	*20.5*	91%	8.13	8.31	0.0	----	----	----	No adj
08/18/06	840	2700	MCA	12.6	*12.6*	91%	9.72	9.54	0.0	----	----	----	No adj
09/12/06	940	3270	FR1	18.5	*18.5*	89%	8.32	7.93	0.4	*7.93*	*8.3*	0.3	0.4
09/22/06	1315	2300	P4	15.3	*15.3*	92%	9.25	9.50	-0.2	----	----	----	No adj
05/15/07	838	2900	PR4	12.5	*10.7*	90%	9.70	9.90	-0.2	----	----	----	No adj
05/16/07	3300	3300	PR1	19.1	*9.2*	89%	8.20	8.00	0.3	----	----	----	No adj

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Quanta #3		DO Meter Cal Check											
		Air Calibration Data								Winkler Check			
		Elevation		Air T	DO at	% Air	Calculated	Instrument	Meter	*In situ*	Titration	Meter	Reading
Date	Time	(ft)	Site	(°C)	Saturation	Saturation	Value	Reading	Difference	Reading	Result	Difference	Adjustment
06/01/07	915	2900	PR4	22.4	*8.6*	90%	7.80	7.20	0.6	----	----	----	0.3
06/14/07	922	2900	PR4	25.9	*8.1*	90%	7.30	6.80	0.5	----	----	----	0.5
06/27/07	915	2900	PR4	23.2	*8.5*	90%	7.70	7.30	0.3	----	----	----	0.3
07/11/07	1145	3300	FR1	23.9	*8.4*	89%	*7.40*	*7.50*	-0.1	----	----	----	No adj
07/23/07	900	2900	PR4	15.7	*10.0*	90%	9.00	8.80	0.2	----	----	----	0.2
08/10/07	915	3200	PR1	22.7	*8.6*	89%	7.60	6.20	1.4	*5.6*	*6.4*	0.8	*Failed*
08/20/07	1140	3300	FR1	23.5	*8.4*	89%	7.50	7.70	-0.2	----	----	----	-0.2
09/07/07	910	3300	FR1	21.0	*8.9*	89%	7.90	8.00	-0.1	----	----	----	-0.1
09/18/07	900	3300	FR1	17.9	*9.5*	89%	8.40	8.90	-0.4	----	----	----	-0.4
10/18/07	900	3300	FR1	13.4	*10.5*	89%	9.30	9.00	0.4	----	----	----	0.4
10/31/07	955	3300	FR1	12.4	*10.7*	89%	9.60	9.40	0.2	----	----	----	No adj
10/31/07	1115	3300	FR1	12.3	*10.8*	89%	9.60	9.60	-0.1	----	----	----	No adj
05/13/08	745	3300	FR1	17.4	*9.6*	89%	8.51	8.65	0.1	----	----	----	No adj
05/14/08	845	3000	PR3	18.6	*9.3*	90%	8.37	8.62	0.3	----	----	----	No adj
05/30/08	1045	3300	PR1	17.1	*9.6*	89%	8.56	8.56	0.0	----	----	----	No adj
06/10/08	915	2900	PR4	13.6	*10.4*	90%	9.41	9.55	0.1	----	----	----	No adj
07/10/08	845	3300	PR1	27.4	*7.9*	89%	6.98	6.97	0.0	----	----	----	No adj
07/22/08	930	2900	PR4	19.9	*9.1*	90%	8.18	8.19	0.0	----	----	----	No adj
08/14/08	830	3300	FR1	21.5	*8.8*	89%	7.80	7.79	0.0	----	----	----	No adj
08/27/08	818	3300	FR1	19.8	*9.1*	89%	8.07	8.09	0.0	----	----	----	No adj
09/23/08	945	3300	FR1	19.3	*9.2*	89%	8.17	8.15	0.0	----	----	----	No adj
10/07/08	813	3300	FR1	12.9	*10.6*	89%	9.43	9.43	0.0	----	----	----	No adj
10/28/08	806	3300	FR1	11.9	*10.9*	89%	9.65	9.64	0.0	----	----	----	No adj

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pH sensor calibration log.

Quanta #3		pH Sensor Calibration						
		7.0 at 25°C		10.0 at 25°C		Avg	Slope	
Date	Time	Value	Buffer	Value	Buffer	Corr	(%)	Action
05/23/05	940	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
06/07/05	915	*7.43*	*Stnd*	*10.42*	*Stnd*	*-0.4*	---	*Maint/recal*
06/07/05	----	*7.00*	*Stnd*	*9.98*	*Stnd*	---	*100%*	*New Calibration*
06/23/05	1000	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
07/12/05	900	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
07/19/05	1015	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
08/05/05	930	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
08/16/05	921	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
08/31/05	1015	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
09/14/05	1540	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
09/27/05	1000	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
10/04/05	----	*7.54*	*Stnd*	*10.61*	*Stnd*	*-0.5*	---	*Maint/recal*
10/05/05	----	*7.00*	*Stnd*	*9.98*	*Stnd*	---	*100%*	*New Calibration*
10/11/05	905	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
11/02/05	1029	*Check*	*Stnd*	*Check*	*Stnd*	---	---	*Check okay*
05/12/06	900	*Check*	*Stnd*	*Check*	*Stnd*	---	*100%*	*Maint/recal*
06/05/06	830	*Check*	*Stnd*	*Check*	*Stnd*	---	*100%*	*Check okay*
07/12/06	945	*Check*	*Stnd*	*Check*	*Stnd*	---	*100%*	*Maint/recal*
08/14/06	800	*Check*	*Stnd*	*Check*	*Stnd*	---	*100%*	*Check okay*
09/18/06	900	*Check*	*Stnd*	*Check*	*Stnd*	---	*100%*	*Check okay*
05/14/07	930	---	---	---	---	---	---	*Factory Cert*
05/31/07	930	7.00	*Stnd*	*10.06*	*Stnd*	---	---	*Check okay*
08/12/07	1930	*7.62*	*Stnd*	*10.42*	*Stnd*	*-0.5*	*94%*	*Maint/recal*
08/12/07	1945	*6.99*	*Stnd*	*9.98*	*Stnd*	---	*99%*	*New Calibration*
10/08/07	1015	*6.83*	*Stnd*	*9.86*	*Stnd*	*0.2*	*99%*	*Maint/recal*

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Quanta #3		pH Sensor Calibration						
		7.0 at 25°C		10.0 at 25°C		Avg	Slope	
Date	Time	Value	Buffer	Value	Buffer	Corr	(%)	Action
10/08/07	1030	*7.03*	*Stnd*	*10.11*	*Stnd*	---	*100%*	*New Calibration*
04/29/08	Lab	*7.05*	*Stnd*	*10.03*	*Stnd*	---	*101%*	*Check okay*
06/24/08	Lab	*7.10*	*Stnd*	*7.30*	*Stnd*	-0.2	---	*Maint/recal*
06/24/08	Lab	*7.02*	*Stnd*	*10.03*	*Stnd*	---	*100%*	*New Calibration*
07/30/08	Lab	7.03	*Stnd*	*10.04*	*Stnd*	---	*100%*	*Check okay*
08/29/08	Lab	*7.13*	*Stnd*	*9.78*	*Stnd*	0.05	---	*Maint/recal*
08/29/08	Lab	7.00	*Stnd*	*10.00*	*Stnd*	---	*100%*	*New Calibration*
09/28/08	Lab	*7.38*	*Stnd*	*10.26*	*Stnd*	-0.3	---	*Maint/recal*
09/28/08	Lab	7.01	*Stnd*	*10.03*	*Stnd*	---	*100%*	*New Calibration*

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Conductivity sensor calibration log.

Manufactures Certification	PG&E Lab Cal Check	Contractor Field Lab Cal Check	Date	Conductivity Standards (µS/cm)				
				47.6	100	1000	1412	Action
Pass	--	--	12/15/04	--	--	--	--	*Okay*
--	Pass	--	06/01/04	--	--	--	--	*Okay*
--	Pass	--	07/01/04	--	--	--	--	*Okay*
--	Pass	--	08/01/04	--	--	--	--	*Okay*
--	--	Pass	06/07/05	--	--	--	--	*Okay*
--	--	Pass	10/04/05	--	--	--	--	*Okay*
--	--	Pass	05/12/06	--	--	--	--	*Okay*
--	--	Pass	08/14/06	--	--	--	--	*Okay*
Pass	--	--	02/06/07		104	--	1412	*Okay*
--	--	Pass	08/12/07	--	--	1001	--	*Okay*
Pass	--	--	04/09/08	47.6	103		1448	*Okay*
--	--	Pass	09/01/08	--	--	1025	--	*Okay*

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Turbidity sensor calibration log.

Hydrolab Quanta No.3

Manufactures Cal Cert.	PG&E Lab Cal Check	Contractor Field Lab Cal Check	Date	Turbidity Standards (NTU) DI Water	1.00	10.0	40.0	100	1000	Action
Pass	--	--	12/15/04	--	--	--	--	--	--	*Okay*
--	Pass	--	06/01/04	--	--	--	--	--	--	*Okay*
--	Pass	--	07/01/04	--	--	--	--	--	--	*Okay*
--	Pass	--	08/01/04	--	--	--	--	--	--	*Okay*
--	--	Pass	06/07/05	--	1.7	11.0	--	91	--	*Okay*
--	--	Pass	10/04/05	--	1.2	9.2	--	--	--	*Okay*
--	--	Pass	05/12/06	--	--	--	--	--	--	*Okay*
--	--	Failed	08/19/06	Sensor failed, used HF DRT-15CE remainder of season						*Not repaired*
Pass	--	--	02/06/07	0.0	--	--	36.6	100	--	*Okay*
--	--	Failed	06/19/07	Sensor failed, used HF DRT-15CE remainder of season						*Not repaired*
--	--	Failed	08/12/07	Sensor failed, used HF DRT-15CE remainder of season						*Not repaired*
Pass	--	--	04/09/08	0.0	--	--	--	--	--	*Okay*
--	--	Pass	05/30/08	0.0	0.00	7.4	--	--	--	*Recal*
--	--	Pass	06/23/08	0.0	0.00	6.3	--	--	--	*Recal*
--	--	Pass	06/23/08	0.0	0.80	10.0	--	--	--	*Okay*
--	--	Pass	09/25/08	--	1.40	10.0	--	89	--	*Okay*

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Turbidity sensor calibration log.

HF Scientific DRT-15CE

Manufactures Cal Cert.	PG&E Lab Cal Check	Contractor Field Lab Cal Check	Date	Turbidity Standards (NTU) 0.02	1.0	10	100	1000	1000	Action
--	--	Pass	08/28/06	--	1.00	10.0	100	--	--	*Recal*
--	--	Pass	06/11/07	--	1.00	9.6	97	--	--	*Recal*
--	--	Pass	06/11/07	--	1.05	10.0	100	--	--	*Okay*
--	--	Pass	10/08/07	--	1.13	10.3	--	--	--	*Okay*
--	--	Pass	04/08/08	0.02	--	10.8	102	--	1066	*Okay*
--	--	Pass	08/31/08	0.02	--	10.1	102	--	948	*Okay*

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CHRON

Pacific Gas and Electric Company

Power Generation

245 Market Street
San Francisco, CA 94105

Mailing Address
Mail Code N11C
P.O. Box 770000
San Francisco, CA 94177

March 12, 2009

Ms. Victoria A. Whitney
Chief, Division of Water Rights
California State Water Resources Control Board
1001 I Street, 14th Floor
Sacramento, CA 95814

RE: Pit 1 Project (FERC Project No. 2687)
License Article 401; Water Quality Monitoring Results –
Five-Year Summary Report

Dear Ms. Whitney:

On November 20, 2003, the Federal Energy Regulatory Commission (FERC) issued an "Order Modifying and Approving Water Quality Monitoring Plan under Article 401" for Pacific Gas and Electric Company's (PG&E) Pit 1 Hydroelectric Project, FERC No. 2687 (Project).

As required by Condition 17 of the SWRCB Water Quality Certification, at the conclusion of the fifth year of sampling, PG&E is also required to submit a Summary Report. PG&E is also required to include in the summary report documentation of the required consultation with the SWRCB's Chief of the Division of Water Rights (Chief), and the Chief's determination of whether or not the beneficial uses of the Pit River described in the Board's 1998 Basin Plan have been reasonably protected during project operation.

PG&E requested an approval from FERC for an extension to file the 5-year summary report by July 1, 2009. The extension would allow PG&E to incorporate any SWRCB comments on the 2008 water quality report, conduct an analyses to determine if the beneficial uses have been protected, provide SWRCB a 60-day comment period, and allow time for PG&E to consult with the SWRCB on proposed recommendations. On December 24, 2008, FERC issued "*Order Granting Extension of Time Under Article 401 and Appendix Condition 17*" granting the extension.

Enclosed is the Agency Draft of the report titled *"Pit 1 Project, FERC Project No. 2687 - Water Quality Monitoring Five-Year Summary Report 2004–2008 Addressing License Article 401 and California State Water Resources Control Board Water Quality Certificate Conditions 16 and 17"* dated March 2008. Comments PG&E receives from your agency will be addressed in the final report that will be filed to FERC by July 1, 2009.

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Please provide to me any comments you may have by May 12, 2009. PG&E would also like to schedule meeting for May 13, 2009 with your staff to discuss the results and recommendations presented in the report.

If you have any questions, or wish to discuss 5-Year water quality monitoring summary report, please contact me at (415) 973-3642, or by email at COW1@pge.com.

Sincerely,

Charles O. White, Senior License Coordinator
Hydro Licensing

Enclosure

cc: Russ Kanz
State Water Resources Control Board
P.O. Box 2000
Sacramento, CA 95812-2000

Mr. Gary Stacey
Regional Manager
California Department of Fish and Game
601 Locust Street
Redding, CA 96001

Ms. Cay Goude
Acting Field Supervisor
U.S. Fish and Wildlife Service
2800 Cottage Way, Rm W-2605
Sacramento, CA 95825

Mr. Dennis Heiman
Central Valley Regional Water Quality
Control Board
415 Knollcrest Drive, Suite 100
Redding, CA 96002

Mr. Philip Scordelis
Federal Energy Regulatory
Commission
DHAC
901 Market Street, Suite 350
San Francisco, CA 94103

Mr. Michael Pena
District Manager
Fall River Mills Community Service District
24850 Third Street
P.O. Box 427
Fall River Mills, CA 96028

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COWhite (3-3642) Pit 1 Water Quality 5-yr Agency Draft Submittal

bcc: via e-mail w/o Enclosure:
Ruth Sundermeyer
Scott Tu
Chip Stalica
Michael Spainhour
Jerry Covert
Michael Zanin
Jason Vann

File: FERC 2687, 026.1191 Environment/Recreation & Other (SAP # 2017544)

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Attachment 2

Shasta Crayfish Concerns and Issues

- May 5, 2009 email from Charles White to agencies - Transmittal of Shasta Crayfish Summary Report to agencies
- Shasta Crayfish Technical Review Committee Summary Report, May 2009

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White, Charles

From: White, Charles

Sent: Tuesday, May 05, 2009 1:37 PM

To: Dennis Heiman (dheiman@waterboards.ca.gov); Kim Squires (Kim_Squires@fws.gov); Matt Myers (mmyers@dfg.ca.gov); Steve Baumgartner (sbaumgartner@dfg.ca.gov); 'Josh_Hull@fws.gov'; Russ Kanz (rkanz@waterboards.ca.gov)

Subject: Draft Shasta Crayfish Summary Report - Ancillary Information for the 5-Year Water Quality Report Discussions

Attachments: TRC 2008 Summary Crayfish Report 5April09 DRAFT watermark.doc

The Federal Energy Regulatory Commission (FERC) licenses for Pacific Gas and Electric Company's (PG&E) Hat Creek Hydroelectric Project (FERC No. 2661) and Pit 1 Hydroelectric Project (FERC No. 2687) require the formation of a technical review committee (TRC) to oversee certain management activities for the endangered Shasta crayfish (*Pacifastacus fortis*). As stated in Article 410 of both licenses, the TRC's role is to assist in the design and implementation of the terms and conditions required in the biological opinions for the protection and recovery of the Shasta crayfish in the two project areas. In addition to license implementation, the TRC expanded its role to include species recovery throughout the range of the Shasta crayfish. As a result, the United States Fish and Wildlife Service formed the Shasta Crayfish Recovery Team, which is comprised of a subset of TRC members. TRC actions are defined as Shasta crayfish actions specifically required by a FERC license (Articles 409, 410, 411, 412, 413), whereas Recovery Team actions are not specifically required by a FERC license. All TRC members agreed that TRC actions would be done where it most benefited the Shasta crayfish and would not be restricted by FERC project boundaries.

Article 410 also requires PG&E to provide FERC with a report of activities. Based on the input from the Annual Meeting of Shasta Crayfish Technical Review Committee, it was decided that the **draft of the 2008 Shasta Crayfish Summary Report** would provide information that would be beneficial in the discussions of the Pit 1 Project (FERC No. 2687) Water Quality Monitoring Results 5-Year Summary Report that we will have on May 11, 2009.

I am forwarding the draft Shasta Crayfish Summary report for **informational purposes**. We do not need formal comments on this report. Let me know if you have any questions.

Charles White
Pacific Gas and Electric Company
245 Market Street, 1123A, San Francisco, CA 94105
Mailing: MC N11C, PO Box 770000, San Francisco, CA 94177

6/23/2009

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PACIFIC GAS AND ELECTRIC COMPANY

Hat Creek Hydroelectric Project, FERC No. 2661
Pit 1 Hydroelectric Project, FERC No. 2687

Shasta Crayfish Technical Review Committee
Draft Summary Report

May 2009

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PACIFIC GAS AND ELECTRIC COMPANY

Hat Creek Hydroelectric Project FERC No. 2661
Pit 1 Hydroelectric Project, FERC No. 2687

Shasta Crayfish Technical Review Committee
Draft Summary Report

Addressing License Articles 409, 410, 411, 412, and 413
Hat Creek Hydroelectric Project (FERC No. 2661, USFWS Biological Opinion 1-1-02-F-0182)
Pit 1 Hydroelectric Project (FERC No. 2687, USFWS Biological Opinion 1-1-00-F-0210)
Upper Fall River Crayfish Barrier Project (USFWS Biological Opinion 1-1-07-F-0333)
PG&E's USFWS Recovery Permit TE-755945-3
Spring Rivers' USFWS Recovery Permit TE-806679-3

Prepared by

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Prepared for

PACIFIC GAS AND ELECTRIC COMPANY
Environmental Services
3400 Crow Canyon Road
San Ramon, California 94583

May 2009

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DRAFT

Executive Summary

The Federal Energy Regulatory Commission (FERC) licenses for Pacific Gas and Electric Company's (PG&E) Hat Creek Hydroelectric Project (FERC No. 2661) and Pit 1 Hydroelectric Project (FERC No. 2687) require the formation of a technical review committee (TRC) to oversee certain management activities for the endangered Shasta crayfish (*Pacifastacus fortis*). Consequently, the Shasta crayfish TRC was formed in April 2003. As stated in Article 410 of both licenses, the TRC's role is to assist in the design and implementation of the terms and conditions required in the biological opinions for the protection and recovery of the Shasta crayfish in the two project areas. In addition to license implementation, the TRC expanded its role to include species recovery throughout the range of the Shasta crayfish. As a result, the United States Fish and Wildlife Service formed the Shasta Crayfish Recovery Team, which is comprised of a subset of TRC members. TRC actions are defined as Shasta crayfish actions specifically required by a FERC license (Articles 409, 410, 411, 412, 413), whereas Recovery Team actions are not specifically required by a FERC license. All TRC members agreed that TRC actions would be done where it most benefited the Shasta crayfish and would not be restricted by FERC project boundaries.

This document reports and provides multi-year summaries for all Shasta crayfish TRC and/or Recovery Team activities between April 2003 and March 2009. TRC actions include TRC/Recovery team meetings, crayfish monitoring and habitat delineation, implementation of the Crayfish Barrier Plan, development and installation of Shasta crayfish interpretive and education signs, and investigations into the reintroduction of Shasta crayfish into Rock Creek. Recovery Team actions include the Sucker Springs Restoration Project and CDFG's temperature and genetics studies. As part of this document, the 2008 annual monitoring data includes the completion of the second crayfish monitoring survey in the Pit 1 Project vicinity, non-native crayfish eradication surveys related to the Crayfish Barrier Plan, and verification and correction of delineated crayfish habitat data.

Both Crayfish Barrier Plan projects were completed in 2007. A crayfish barrier was designed and installed in the upper Fall River just downstream of the large Shasta crayfish population at

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Thousand Springs. Subsequently, annual signal crayfish (*Pacifastacus leniusculus*) eradication surveys have been conducted upstream of the barrier to reduce or eliminate that non-native, invasive species. The second project was the improvement of the Spring Creek Road crossing, whose culverts create velocity barriers to signal crayfish in lower Spring Creek and Fall River. The crossing was improved by filling in crevices and gaps surrounding the culverts thereby eliminating habitat being used by signal crayfish. Annual surveys to remove signal crayfish have also been conducted in Spring Creek upstream of the culverts.

In 2008 interpretive and education signs were designed and installed at several locations in the Hat Creek and Pit 1 project areas that are commonly visited by the public. The signs contain information about the status of the Shasta crayfish and the threat posed by the illegal use of non-native crayfish as bait.

A proposed plan for the restoration of Rock Creek and subsequent reintroduction of Shasta crayfish into Rock Creek was described to the TRC in June 2004. The plan involves the movement of the California Department of Fish and Game's diversion structure downstream about 600 feet so that a section of Rock Creek suitable for Shasta crayfish would be restored. Topographic mapping of the stream channel and tests related to percolation and volume of stream flow at the top and bottom of the proposed restoration reach were conducted between 2003 and 2006 to address concerns that the amount of water available for diversion at the new location would be reduced. A meeting of interested parties has been proposed for 2009 to determine the next steps in the restoration of Rock Creek.

Crayfish monitoring surveys began in 2003 with the baseline Hat Creek survey, which was conducted between September 2003 and February 2004. The second Hat Creek survey was done between November 2004 and February 2005, and the third survey was done between January and April 2007. The baseline survey in the Pit 1 Project vicinity was conducted between March 2004 and February 2007. The second Pit 1 survey was conducted between April 2007 and March 2009.

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During the Hat Creek surveys, Shasta crayfish were only found in Crystal Lake. A total of 162, 272, and 132 Shasta crayfish were found in 2003, 2004, and 2007, respectively. Within Crystal Lake, Shasta crayfish accounted for 13% of the crayfish captured in 2003 and 14% in 2004 and 2007; non-native signal crayfish accounted for the remaining 87% or 86%. The age-class distribution showed an increased shift towards adults from 2003 to 2007. Most of the Shasta crayfish were found in the spring areas of southwestern Crystal Lake. The number of Shasta crayfish found at the Crystal Lake Outflow decreased from 23 to 7 to 2 over the years. Shasta crayfish were least abundant in Middle Cove with two crayfish found in 2003 and 2004, and none in 2007.

In the Pit 1 Project vicinity, 786 Shasta crayfish, 5903 signal crayfish, and 350 fantail crayfish were collected during the baseline surveys. During the second monitoring survey, 550 Shasta crayfish, 6097 signal crayfish, and 117 fantail crayfish were collected. Shasta crayfish accounted for 11.2% of all crayfish encountered in the baseline surveys and 8.1% of all crayfish encountered in the second surveys. Non-native signal crayfish and fantail crayfish accounted for 83.9% and 5.0% of all crayfish encountered in the baseline surveys, respectively. Non-native signal crayfish and fantail crayfish accounted for 90.1% and 1.7% of all crayfish encountered in the second surveys, respectively. The most Shasta crayfish were found in Spring Creek and at Thousand Springs in the upper Fall River drainage.

A comparison of results from the three surveys in the Hat Creek Project vicinity and the two surveys in the Pit 1 Project vicinity under the current licenses with results from earlier surveys (1978 and the 1990s) indicates a substantial decline in Shasta crayfish distribution and abundance. Shasta crayfish have been found at 25 locations (as listed in Tables 9 and 10) in the Hat and Pit 1 project vicinities since 1978. The most recent survey confirmed Shasta crayfish present at 15 locations with fewer than 10 Shasta crayfish at 8 of these locations, including the Pit River upstream of Pit River Falls where only one dead Shasta crayfish was found in 2008. Introduced signal crayfish have continued to expand their range since the late 1970s and are now widespread and abundant throughout most of the area. The fantail crayfish (*Orconectes virilis*), another invasive, non-native species, has expanded its range in the upper Tule River and Big Lake drainage since being introduced there in 1993.

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The Sucker Springs Restoration Project involves the re-establishment of a natural channel, removal of non-native crayfish, and construction of crayfish barriers to maintain an allopatric subpopulation of Shasta crayfish. To date, most of the unnatural features that were part of the old hatchery facilities have been removed from the stream channel. Extensive efforts to remove non-native crayfish have been conducted annually since 2003 and will continue until successful. Work planned for 2009 also includes the installation of crayfish barriers upstream of two existing weirs at the downstream ends of ponds 4 and 5.

Two ongoing Recovery Team projects are being conducted by the California Department of Fish and Game. One is a temperature study, which produced results on the growth of signal crayfish but has yet to be successful with Shasta crayfish. The other is a study of the genetics of the various Shasta crayfish subpopulations that is being conducted with the University of California, Davis and Spring Rivers. Results to date have shown that each of the various subpopulations can be placed into one of three regional groups.

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Introduction

The Federal Energy Regulatory Commission (FERC) issued licenses for two Pacific Gas and Electric Company (PG&E) hydroelectric projects in northeastern California (Shasta County) within the past seven years. The licenses for the Hat Creek Hydroelectric Project (FERC No. 2661) and the Pit 1 Hydroelectric Project (FERC No. 2687) were issued on 4 November 2002 and 19 March 2003, respectively. Both licenses contain Articles designed to monitor and protect the federally and state-listed endangered Shasta crayfish (*Pacifastacus fortis*), which exists in both project areas (Figure 1). The licenses include measures to protect Shasta crayfish from non-native, invasive crayfish. The non-native signal crayfish (*Pacifastacus leniusculus*), which is both a competitor and predator of the Shasta crayfish, is considered the greatest threat to the continued existence of the Shasta crayfish (Ellis 1999).

In both the Hat Creek and Pit 1 licenses (Appendix A), Article 409 requires the development of a plan to monitor the habitat and populations of Shasta crayfish in the project area. Article 412 of each license requires the development of a Shasta crayfish management plan, including provisions to fund non-native signal crayfish removal. Article 413 of the Hat Creek license and Article 416 of the Pit 1 license require the development of recreational management plans to educate the public about the status of Shasta crayfish, including potential threats from recreational activities. Article 413 of the Pit 1 license requires the development of a plan to construct and maintain a minimum of two exclusion barriers to protect Shasta crayfish habitat from invasion by signal crayfish. Article 410 of each license requires PG&E to establish a technical review committee (TRC) to assist PG&E in the design and implementation of the terms and conditions required in the biological opinions for Shasta crayfish protection and recovery in the two project areas.

The TRC was established in April 2003 in coordination with the United States Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG), and other resource agencies and interested stakeholders. The TRC consists of representatives from USFWS, CDFG, California Department of Parks and Recreation (CDPR), Spring Rivers Ecological Sciences LLC (Spring Rivers), academia, and PG&E. In addition to helping PG&E implement the terms and

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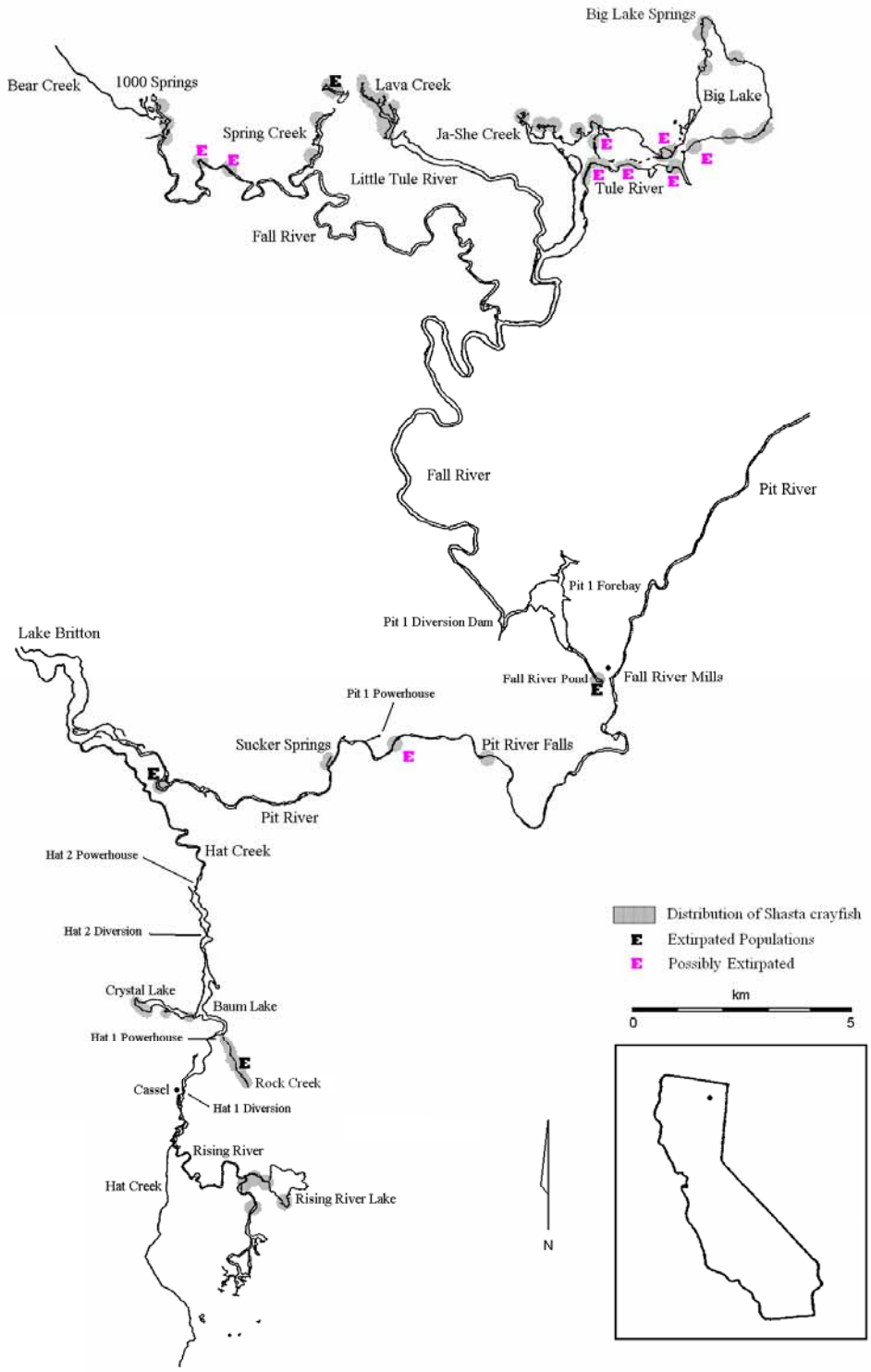

Figure 1 Known distribution of the Shasta crayfish (*Pacifastacus fortis*).

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conditions of the license, the TRC also serves as a working group for other Shasta crayfish recovery projects. As a result, the USFWS formed the Shasta Crayfish Recovery Team (Recovery Team), which is comprised of a subset of TRC members. TRC actions are defined as Shasta crayfish actions specifically required by a FERC license, whereas Recovery Team actions are not specifically required by a FERC license.

To address the requirements of Articles 409 and 412 of both project licenses, two Shasta Crayfish management plans were written in consultation with the USFWS, CDFG, Natural Resources Conservation Service (NRCS), and interested stakeholders. The Hat Creek Plan (PG&E 2003a), which includes crayfish monitoring and management and recreational management (Article 413) components, was submitted to the agencies on 14 February 2003. Comments from the agencies were addressed before the Hat Creek Plan was submitted to FERC on 30 April 2003. FERC approved the Hat Creek Plan without modification on 21 August 2003. The Pit 1 Plan (PG&E 2003b), which includes crayfish monitoring and management components, was submitted to the agencies for comment on 11 July 2003 and to FERC on 19 September 2003. FERC approved the Pit 1 Plan without modification on 7 July 2004.

On 8 December 2006, PG&E submitted the final Crayfish Barrier Plan to FERC, as specified in Article 413 of the Pit 1 license. FERC approved the Crayfish Barrier Plan on 8 March 2007. The Crayfish Barrier Plan includes four required elements: (1) provisions to fund the design and construction of two crayfish barriers; (2) detailed design drawings and map locations of the exclusion barriers; (3) a schedule for construction and initial performance testing; and (4) a monitoring and reporting schedule for long-term evaluation of barrier effectiveness.

The two Shasta crayfish management plans (PG&E 2003a, 2003b) specify the following three monitoring tasks: (1) map and quantify the existing habitat in the Project areas; (2) collect baseline data on Shasta crayfish in delineated habitat areas; and (3) monitor Shasta crayfish in delineated habitat areas over the length of the license. The crayfish monitoring surveys began with the baseline Hat Creek survey, which was done between September 2003 and February 2004. The second Hat Creek survey was conducted between November 2004 and February 2005. The baseline survey in the Pit 1 Project vicinity was conducted between March 2004 and

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February 2007. Table 1 provides the implementation schedule for these tasks over the course of the two licenses. This schedule was revised and approved during the May 2007 TRC meeting because the Pit 1 baseline crayfish monitoring surveys took three years to complete. In addition, the plans call for the removal of non-native crayfish found during the monitoring surveys. The Hat Creek Plan calls for formulation of a plan to reintroduce Shasta crayfish to Rock Creek, which is a spring-fed tributary to Baum Lake (Figure 1).

Both the Hat Creek and Pit 1 licenses (Appendix A) and Shasta crayfish management plans (PG&E 2003a, 2003b) specify that habitat and populations of Shasta crayfish will be monitored within the respective Project areas. During the 3 May 2007 meeting, however, the TRC approved the inclusion of all known Shasta crayfish locations (e.g., Rising River, Rainbow Spring, Lava Creek, Thousand Springs, etc.) in the study area for the surveys outlined in the Shasta crayfish management plans. The expansion of the study areas resulted in no additional monetary requirements, facilitated sample collection for the genetic study, and provided consistency with the Crayfish Barrier Plan, which included a barrier location outside the Pit 1 Project area. The additional survey sites will be scheduled when there are monitoring funds available, for instance during years when regular monitoring surveys are not scheduled (e.g., 2008 through 2011 for Hat Creek; see Table 1).

Articles 411 and 412 of both the Hat Creek and Pit 1 licenses require PG&E to establish Shasta crayfish management funds to cover the cost of monitoring, non-native crayfish removal, and other TRC-approved Shasta crayfish activities. The annual amounts for crayfish surveys (Article 411) and non-native crayfish removal (Article 412) are adjusted annually from the original amounts stated in the licenses (2003 dollars for Hat and 2004 dollars for Pit 1) based on the Consumer Price Index as specified in the license. During years in which monitoring surveys are not scheduled (e.g., years 3 and 4 of the Hat Creek license), the annual management funds are used for other TRC-approved Shasta crayfish projects, such as the Sucker Springs Creek Restoration Project. Shasta crayfish management funds that are not spent during the year roll over to subsequent years. Beginning in 2008, barrier non-native crayfish control funding and implementation included the Spring Creek barrier project (i.e., Spring Creek Road Crossing

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Table 1 Schedule[a] of Shasta crayfish surveys included in the Hat Creek and Pit 1 Shasta crayfish management plans

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Hat license year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30											
Pit license year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Hat Surveys[b]	1	2			5					10					15					20					25					30											
Pit Surveys[c]		1			4		6				10					15					20					25					30					35				40	

[a] Schedule was revised because the initial Pit 1 Project surveys took 3 years. It was approved during the 3 May 2007 TRC meeting.
[b] Surveys for the Hat Creek Project are scheduled for years 1, 2, 5, 10, 15, 20, 25, and 30 of the license.
[c] Initial Pit 1 Project surveys took 3 years; future surveys will take 1-2 years each and are scheduled for years 4/5, 6/7, 10/11, 15/16, 20/21, 25/26, 30/31, 35/36, and 39/40 of the license.

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Cavity-Filling Project). Appendix B provides a summary of the Shasta crayfish management funds, including barrier non-native crayfish control, for both licenses through April 1, 2009.

This document includes the monitoring data for 2008 and early 2009 and a summary of all monitoring efforts since license implementation began in 2003. Activities performed in 2008 and the winter of 2009 include: (1) TRC/Recovery team meetings, (2) Rock Creek site visits with PG&E, USFWS, and other potential partners, (3) completion of the second Pit 1 crayfish monitoring survey, and (4) verification and correction of delineated crayfish habitat. This document reports and provides the multi-year summaries for all monitoring efforts under: (1) TRC actions, including crayfish monitoring, the Crayfish Barrier Plan (Pit 1 Article 413), and the investigation into the reintroduction of Shasta crayfish into Rock Creek (Hat Creek Article 412); and (2) Recovery Team actions, including the Sucker Springs Restoration Project and CDFG's temperature and genetics studies.

Technical Review Committee Activities

2008 Meetings

The Shasta crayfish TRC and Shasta crayfish Recovery Team held joint meetings on 9 April 2008 and 24 September 2008 (see Appendix C for Meeting Agenda and Summaries). On 22 July 2008, Spring Rivers personnel met with USFWS, Bureau of Land Management (BLM), and Ducks Unlimited (DU) personnel (Kathy Brown, the USFWS Conservation Partnerships Program Coordinator; Dominic Bachman, USFWS Partners for Fish and Wildlife Private Lands Biologist; John Ranlett, DU Regional Biologist-Intermountain West; and Harry McQuillen, BLM Cosumnes River Preserve Manager). In addition, Spring Rivers personnel met with PG&E personnel at Rock Creek on 6 October 2008 and 18 March 2009 to familiarize them with the site and issues related to potential habitat restoration.

Summary of Past Meetings

During the first Shasta crayfish TRC meeting, which was held on 16 April 2003, the draft TRC protocol, draft Hat Creek Shasta Crayfish Management Plan, and funding were discussed. It was decided that the TRC would handle Shasta Crayfish Management Plan issues for both the Hat

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Creek and Pit 1 projects. The revised TRC Protocol, describing the purpose, goals, objectives, and commitments of the TRC for both the Hat Creek and Pit 1 Projects, was filed with FERC on 26 May 2004. During a 7 October 2003 field meeting, the TRC visited Crystal Lake and Rock Creek and were given an overview of the status of Shasta crayfish in the Pit 1 Project area and the status of the Pit 1 Shasta Crayfish Management Plan.

There were two TRC meetings in 2004. During the 14 April 2004 TRC meeting, USFWS suggested that the TRC incorporate members into a recovery implementation team, which would allow recovery work to be performed outside of FERC project boundaries and also expedite USFWS funding of restoration projects. USFWS agreed to write a letter indicating that PG&E can use license monies allocated for Shasta crayfish anywhere within the species' range to best benefit Shasta crayfish, as opposed to only within project boundaries. During the 26 October 2004 TRC meeting, USFWS announced that a Shasta Crayfish Recovery Team had been formed that was comprised of eight members of the TRC. In addition, the TRC also conducted a site visit to Rock Creek on 9 June 2004, so that engineers from CDFG (George Heise) and the private sector (Chuck Schlumpberger), as well as other agency personnel, could review the proposed plan to move the intake structure for the Crystal Lake Hatchery approximately 600 feet downstream to restore potential Shasta crayfish habitat in the upper Rock Creek meadow.

In 2005, four joint meetings of the TRC and Recovery Team were held on 11 January, 12 April, 19 July, and 6 December. The TRC also conducted a site visit to potential barrier sites on 24 May 2005. Two additional field meetings were held at Sucker Springs Creek to discuss the Sucker Springs Restoration Project. CDFG and USFWS personnel toured Sucker Springs Creek on 13 April 2005. Construction managers, biologists, and habitat restoration specialists from PG&E and CDFG toured Sucker Springs on 7 September 2005.

In 2006, the TRC and Recovery Team met on 4 April, 3 August, and 2 November. The TRC also conducted site visits to potential barrier sites on 22 February 2006 and 21 March 2006. A Recovery Team meeting that included members Dan Strait of USFWS Partners for Fish and Wildlife and Maria Ellis and other Spring Rivers personnel was held at Sucker Springs Creek on 5 December 2006 to discuss the Sucker Springs Restoration Project.

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In 2007, the TRC and Recovery Team held meetings on 3 May and 25 September. During the May meeting, the TRC approved the inclusion of all known Shasta crayfish locations outside of Project areas (e.g., Rising River, Rainbow Spring, Lava Creek, Thousand Springs, etc.) in the study area for the surveys outlined in the Hat Creek and Pit 1 Shasta crayfish monitoring plans.

Agendas and meeting notes from all TRC and TRC/Recovery Team meetings and some of the site visits are included in Appendix C.

Crayfish Barriers

As required by the Pit 1 license, PG&E developed and implemented a Crayfish Barrier Plan to construct and maintain a minimum of two exclusion barriers to protect Shasta crayfish and their habitat from invasion by signal crayfish and other non-native crayfish species. Decisions about the locations, designs, construction methods, and materials of the proposed barriers were made based on the results of the Crayfish Barrier Flume Study (Spring Rivers 2005) and numerous field meetings and consultations with engineers, construction experts, landowners, federal and state agencies, the Shasta Crayfish TRC, and the Shasta Crayfish Recovery Team. The Crayfish Barrier Flume Study, which was funded by CDPR, USFWS, and Spring Rivers, was conducted at the J. Amorocho Hydraulics Laboratory and the Center for Aquatic Biology and Aquaculture at the University of California, Davis from January 2002 through July 2004 (Spring Rivers 2005). To determine the locations of potential barriers, highest priority was given to sites that would prevent the upstream migration of non-native crayfish into allopatric Shasta crayfish populations or sites where there was a possibility that allopatry could be restored upstream of a barrier. The upper Fall River at Thousand Springs and Spring Creek were considered the two highest priority barrier locations because of the relatively large size of the Shasta crayfish populations and the relatively few non-native signal crayfish found in the vicinity or upstream of the potential barrier locations in the 2006 surveys.

PG&E worked with the TRC and Recovery Team to develop a Crayfish Barrier Plan (PG&E 2006) that would provide the greatest benefit to the species. The Upper Fall River Crayfish Barrier Project benefits the Shasta crayfish in the upper Fall River at Thousand Springs by

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creating a barrier to upstream migration of the non-native signal crayfish. The Spring Creek Road Crossing Cavity-Filling Project protects Shasta crayfish by eliminating potential refugia for signal crayfish and by capturing signal crayfish, with the goal of reducing and controlling their numbers or eradicating them. Potential refuges for non-native crayfish were eliminated by filling the voids, gaps, and cavities in the upstream face of the Spring Creek Road Crossing. The capture efforts seek to either eradicate or control non-native crayfish populations in Spring Creek upstream of the Spring Creek Road Crossing. The Spring Creek Road Crossing Cavity-Filling Project is an extension of a project completed in 2000 that replaced the deteriorating culverts of the original road crossing at Spring Creek in order to create a barrier to the upstream movement of signal crayfish from Fall River.

PG&E requested four extensions (i.e., 31 December 2004, 31 December 2005, 31 August 2006, 10 December 2006) for filing the Crayfish Barrier Plan, which was originally due within one year of license issuance (i.e., March 19, 2004). Between 20 October 2004 and 31 January 2005, PG&E submitted two drafts of the Crayfish Barrier Plan and the final Crayfish Barrier Flume Study report to the TRC. Discussions on the plan, including the potential effects to rough sculpin, were held during the TRC meetings in October 2004, January 2005, and April 2005. Both USFWS and CDFG commented that the January 2005 draft of the Crayfish Barrier Plan lacked the detailed design drawings and map locations of the exclusion barriers and a schedule for construction and initial performance testing, as required by the license. USFWS emphasized the importance of having an engineer from PG&E work out the final details of barrier construction, materials, and installation. Both USFWS and CDFG reiterated the importance of extending the barrier onto the stream banks to prevent the overland travel of non-native crayfish and requested additional details as to the design and evaluation of overland barriers. CDFG stated that if genetic isolation of rough sculpin, a fully protected species, appears to be occurring, CDFG may relocate sculpin above the barriers.

During May 2005, engineers from PG&E and CDFG met with other USFWS, CDFG, PG&E, and Spring Rivers personnel, landowners, and managers to tour the potential barrier sites in the upper Fall River at Thousand Springs and in Spring Creek to determine and discuss the details of barrier construction, materials, and installation. Following the field tour, the TRC outlined the

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steps necessary to produce a barrier plan complete with barrier designs, location specifics, and engineering plans. During the July 2005 meeting, the TRC agreed to move forward on the two barrier locations. The TRC requested additional surveys of these areas to determine the current distribution of signal crayfish upstream of the potential barrier locations. The possibility of constructing a smaller, prototype barrier at Sucker Springs Creek was also discussed.

During the December 2005 meeting, the TRC voted in favor of pursuing the construction of a barrier across the channel of the upper Fall River at Thousand Springs, above the confluence of Bear Creek, utilizing the basic design criteria specified in the Barrier Flume Study (Spring Rivers 2005). The TRC requested that a streambed topography survey of the potential barrier location be done in late 2005. The TRC also voted in favor of the second barrier at Spring Creek, but that it would consist of refacing the existing barrier created by the Spring Creek Road crossing culverts. The TRC also included periodic surveys to remove and control, or eradicate, signal crayfish in Spring Creek upstream of the Spring Creek Road crossing. PG&E submitted a Crayfish Barrier Plan Update and Action Plan to the TRC and FERC in December 2005.

On 22 February 2006, a field meeting was held to familiarize the PG&E project manager and engineer and PG&E's consulting engineer with the proposed barrier locations in the upper Fall River at Thousand Springs and in Spring Creek and to meet with key ranch personnel at Thousand Springs Ranch. The site visits gave the engineers an opportunity to assess the overall site conditions and facilitate plan development. At the Spring Creek site, PG&E's engineer was able to determine that the key issues were related to construction, not engineering. He recommended an on-site meeting with a PG&E construction foremen to discuss the issues. The meeting with the construction foreman and Spring Rivers was carried out on 21 March 2006. At the April 2006 TRC meeting, one of the key action items identified for the upper Fall River barrier was for the engineers to produce a matrix that would list and evaluate the various barrier options. In order for this to be done, a detailed substrate mapping and depth-probing effort was done on 1–4 May 2006. The survey produced a data grid covering 210 linear feet of the Fall River channel from bank to bank at a 10-ft by 10-ft resolution. Data collected at the center of each square of the grid included water depth and the depth of the substrate overburden (i.e., sand, gravel, and cobble) covering the bedrock (Figure 2).

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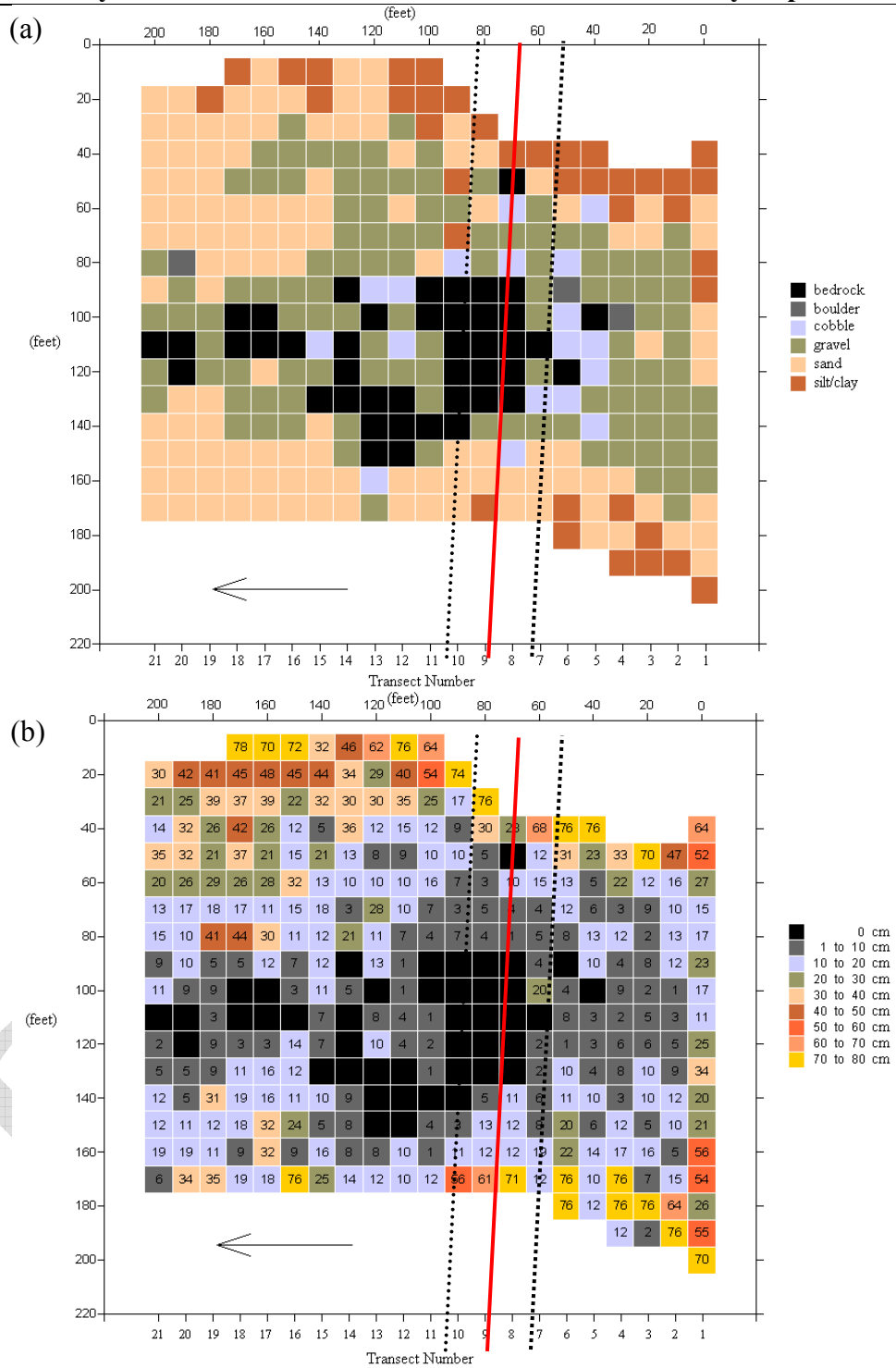

Figure 2 Substrate at the upper Fall River barrier location mapped in the center of each 10-foot square survey grid: (a) substrate type and (b) depth range (square color) and measured depth (number) of overburden on bedrock in centimeters. Red line indicates barrier allignment. Dashed lines delineate the 15-foot work area. Arrow indicates flow direction.

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Based on the substrate mapping, the following three barrier alternatives were devised. An evaluation matrix of these barrier alternatives is shown in Table 2.

Post-and-Plate Barrier. This barrier would be a stainless steel plate that would have its top edge 1 foot above the bottom of the river. The barrier would be supported by posts drilled and grouted into the bedrock bottom. The plate would be welded to the posts. Where the overburden is less than, or equal to, 1 foot deep, the bottom edge of the barrier would be sealed to the bedrock by a hydrophilic waterstop material, grout, or other filler material. Where the overburden is greater than 1 foot, the barrier plate would be buried a minimum of 1 foot into the overburden instead of being sealed to the bedrock.

Pre-cast, Anchor Blocks with Plate Barrier. This barrier would be a stainless steel plate with its top 1 foot above the bottom of the river. The plate would be held in place by bolts in pre-cast concrete blocks about 8 inches high, 12 inches deep, and 6 feet long. The bottom would be sealed by a hydrophilic waterstop material, grout, or other filler material.

Cast-in-place Concrete Anchor with Plate Barrier. This barrier would be a stainless steel plate that would have its top 1 foot above the bottom of the river. The plate would be attached with bolts to a concrete-filled tube. The concrete tube would be about 6 inches high and 14 inches wide and extend the entire width of the river. The tube would be placed in the water and then concrete would be pumped into it. Bolts would be drilled into the concrete after it is cured.

At the 3 August 2006 meeting, the TRC decided that the post-and-plate barrier was the preferred alternative, based on overall cost, ease of construction, installation, and removal, if necessary. The substrate survey data were then used to select the best possible alignment for the barrier (Figure 2). The alignment was selected to maximize the amount of exposed bedrock, while minimizing the length of the structure and the steepness of the bank at the barrier interface.

At the 3 August 2006 meeting, the TRC also agreed to a two-phase approach for implementation of the Crayfish Barrier Plan. The upper Fall River barrier would be constructed in 2007 and the Spring Creek barrier refacing would likely be completed in 2008. Non-native crayfish eradication would continue in both areas. PG&E agreed to initiate some of the permitting for the

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barriers once the plan was submitted to FERC for final approval. Significant funding of permitting or any other activity, however, would occur after FERC approval of the plan. The final Crayfish Barrier Plan was submitted to FERC and the agencies on 8 December 2006.

Table 2 Evaluation matrix of barrier design alternatives for the upper Fall River.

Barrier Type	Post-and-Plate	Pre-Cast Anchor Blocks	Concrete Footing in Fabric
Barrier Material(s)	Stainless Steel	Concrete, Stainless Steel	Concrete, Plastic Fabric, Stainless Steel
Ease of Installation	Small crew with minimum equipment and small material size.	Requires crane or barge and precise alignment of blocks.	Requires concrete truck, pump truck, and method to anchor tube.
Water Quality Concerns	Minimum impact while drilling post holes. Use non-toxic grout.	Minimum impacts during drilling bolts.	Potential impact from accident with concrete placement.
Sealing Bottom	Seal bottom of plate against rock with waterstop or grout.	More difficult than post-and-plate barrier due to block next to plate.	Depends on tube following bottom contour; may leave voids that need filling.
Removable	Cut plates from posts and cut posts at bottom.	Requires crane to lift out blocks.	Concrete in tube would have to be broken into small pieces and removed.
Cost	Probably lowest cost.	Higher than post-and-plate with crane or barge costs depending on alignment problems.	Higher than post-and-plate with concrete on site and pump truck.
Time to Construct	Probably 2 weeks.	Shortest time 1-2 weeks if able to align block easily.	Over 3 weeks total. Needs concrete cure for drilling.

FERC approved the Crayfish Barrier Plan on 8 March 2007, with the following modification. The Shasta Crayfish Technical Review Committee annual reports would provide: (1) updates on PG&E's efforts to secure funding, (2) a proposed schedule for accomplishing the Spring Creek Road culvert cavity filling, and (3) a proposed schedule for biannual eradication/control surveys of non-native crayfish in Spring Creek. The plan outlined the design and methods for the construction of a barrier in the upper Fall River at Thousand Springs (Upper Fall River Crayfish Barrier Project) and the repair of an existing barrier in Spring Creek (Spring Creek Road Crossing Cavity-Filling Project). All permitting and compliance issues related to the Endangered Species Act, National Historic Preservation Act, National Environmental Policy Act, California Environmental Quality Act, Clean Water Act, and the California Endangered Species Act, were addressed prior to construction.

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In 2007, the crayfish barrier in upper Fall River was constructed and the barrier in Spring Creek was refaced and the substrate in the vicinity of the upstream end of the culverts was moved. PG&E provided the USFWS with a post-construction report titled "Non-Native Crayfish Barrier Post-Construction Report Benefiting Shasta Crayfish" (Spring Rivers 2007b), which documented the results of the pre-construction surveys and project actions in fulfillment of the reporting requirements under the USFWS Biological Opinion and Incidental Take Statement (1-1-07-F-0333) for the Upper Fall River Crayfish Barrier Project.

Monitoring and maintenance surveys for the Upper Fall River barrier began immediately after the barrier was installed in August 2007 and will continue for the life of the barrier or until the landowner and/or TRC/Recovery Team decides that the barrier and/or its maintenance is no longer needed or functional. Snorkel surveys of the barrier were done to ensure the integrity of the barrier and to monitor for the presence of debris and/or algal growth that could compromise the barrier. In addition to snorkel surveys, Thousand Spring Ranch personnel also monitor for the presence of debris or any other disturbances to the barrier. Because no build-up of algae or debris was observed on the stainless steel surface of the barrier during the initial, more frequent monitoring, so a biannual monitoring schedule was adopted. Table 3 provides a summary of the upper Fall River barrier inspection, including dates, persons conducting the inspection, and details pertaining to cleaning, debris loading, algal growth, or other pertinent barrier information.

Table 3 Upper Fall River barrier inspection summary.

Date	Person(s) Conducting Inspection	Comments
August 27, 2007	Stalcup, Breedveld	Surface clean and free of debris
August 28, 2007	Stalcup, Breedveld	Surface clean and free of debris
September 27, 2007	Stalcup, Breedveld	Surface clean and free of debris
February 28, 2008	Stalcup, Breedveld	Surface clean and free of debris
July 24, 2008	Stalcup	Surface clean and free of debris
January 26, 2009	Stalcup, Breedveld	Surface clean and free of debris, snails

To streamline reporting, PG&E requested and USFWS agreed to a change in the deadline for reporting on post-construction monitoring, including the eradication surveys, from the 1st of January to the 31st of May each year (Appendix D). The extension allows the monitoring results

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to be included in the annual reports for the Shasta Crayfish TRC. The 2008 eradication survey data are reported in the Crayfish Monitoring, Non-Native Crayfish Eradication Surveys section.

Rock Creek Restoration

Pursuant to the Hat Creek Shasta Crayfish Monitoring and Management Plan, investigations to assess the feasibility of the restoration of Rock Creek and subsequent reintroduction of Shasta crayfish began in 2003. Reliable anecdotal evidence exists that Shasta crayfish inhabited Rock Creek up until 1950, when the majority of the flow was diverted near the upper end of its perennially wetted channel to supply CDFG's Crystal Lake Fish Hatchery and the stream was subsequently rotenoned in 1962 and 1963 (Schafer 1968).

Reintroduction of Shasta crayfish into Rock Creek would involve rewatering some portion of the channel to restore natural crayfish habitat, which still remains in the form of suitable cobble and boulder substrate. In order to do that, however, several concerns would have to be addressed, including: (1) insuring that CDFG's water needs for the Crystal Lake Fish Hatchery would continue to be met, and (2) a high level of confidence that a reintroduced Shasta crayfish population would be viable and protected from invasion by non-native crayfish.

In 2003, a longitudinal profile was surveyed along Rock Creek from the headwater springs above the hatchery intake to the mouth of Rock Creek at Baum Lake. Slope was surveyed following standard methods (e.g., Moffitt and Bouchard 1982). The locations and elevations of key features along the length of the channel were surveyed and noted, including the hatchery diversion intake structure and the drop-structure barrier near the lower end of the channel. Potential Shasta crayfish habitat was assessed, and a snorkel survey was done to verify that Rock Creek was free of any crayfish species. Channel widths in two areas of potential Shasta crayfish habitat in upper Rock Creek were measured to assess the amount of habitat that might be recreated with water released back into the channel.

The upper meadow section of the Rock Creek basin is a low-gradient reach that has good potential as a restoration site. In 2004, this upper meadow was mapped from the current hatchery diversion intake structure downstream to the location of a proposed replacement

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hatchery diversion intake structure. A total of 17 transects were established perpendicular to a 550-foot longitudinal transect approximately parallel to the Rock Creek channel but upslope of the channel on river right (Spring Rivers 2005). Twelve transects were established at 50-ft intervals along the longitudinal transect and four additional cross-sections were established at possible spillover areas. At the location of the proposed new hatchery diversion intake structure, one final transect was established perpendicular to the channel. Transects were surveyed following standard methods (e.g., Moffitt and Bouchard 1982). The locations and elevations of key features on each transect were surveyed and noted, including potential spillover areas and the hatchery water supply pipe. Elevations along all transects were tied to a common elevation datum to facilitate plotting the elevation data in a three-dimensional grid.

Figure 3 is a topographic map (contour interval = 6 inches) of the Rock Creek basin from the current hatchery intake structure to the downstream end of the low-gradient meadow. This map was generated from the topographic data collected in December 2004. Black dots represent transect data points, while white dots represent the current location of the hatchery water-supply pipe. All Rock Creek transects are included in the 2005 Annual Report (Spring Rivers 2005). In the upper 350 feet of the mapped area, Rock Creek is confined to its current channel with no possible spill-over areas. The hatchery water-supply pipe follows the old channel in the upper portion, but exits the channel between the 400-ft and 450-ft transects. In this area the natural historic bank of Rock Creek along its right-hand side (i.e., left side of Figure 3) was low, which made this the logical location for the pipeline to be diverted from the channel. In order to divert it, a notch was excavated through the natural bank berm to allow the pipeline to pass without any excessive elevation gain. This notch in the historic bank berm is the only location through which Rock Creek water could possibly spill out of the natural historic channel and be unavailable for diversion, if natural flows were to be returned to the channel. The notch in the berm is slightly wider than the width of the pipe, and, therefore, could be easily filled if spillover were to occur.

Based on the 2003 and 2004 topographical surveys of Rock Creek, TRC discussions of restoration and reintroduction of Shasta crayfish began to focus on the upper meadow of Rock Creek. The approximately 600-foot-long, low-gradient (0.5 % slope) meadow stretches from just below the present CDFG hatchery diversion structure to a substantial break in slope where

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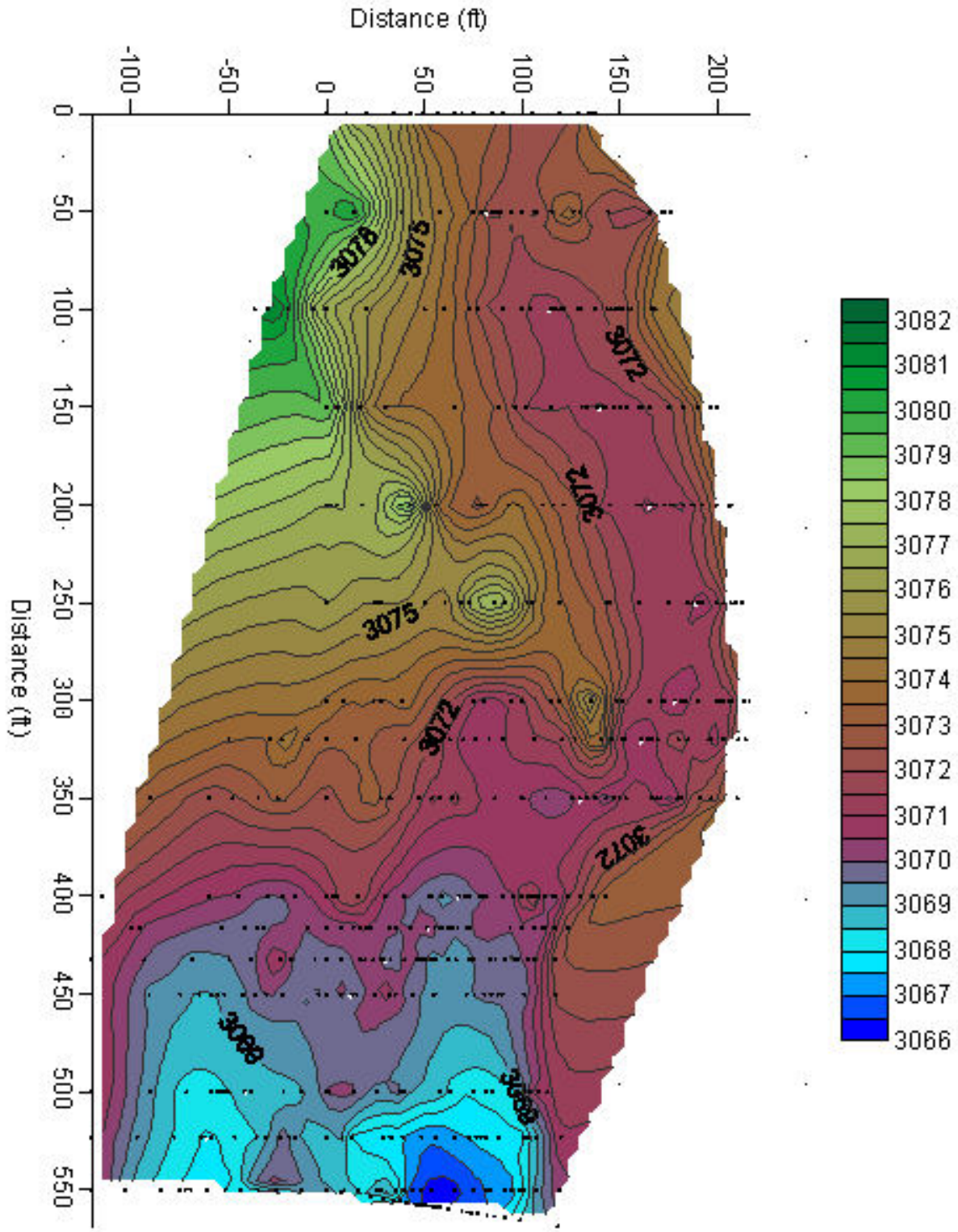

Figure 3 **Color-coded contour map of the upper Rock Creek basin, with transect data points (black dots) and hatchery water supply pipe (white dots). Each color represents a 6-inch elevation change.**

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Rock Creek enters a steep, cascading section. The average width of the remnant channel in the potential restoration section was about 23 feet. Restoration would involve relocating the diversion structure from its present location to one approximately 600 feet downstream and restoring flow to the channel through the upper meadow. This would create approximately 13,550 sq ft (1259 m^2) of Shasta crayfish habitat. Based on the calculated mean density of 0.83 Shasta crayfish per square meter observed in upper Spring Creek (Light et al. 1995), the restored Rock Creek meadow area potentially could support more than 1000 Shasta crayfish. This estimated carrying capacity could be conservative given that Daniels (1980) found densities as high as 6.89 Shasta crayfish per meter at Crystal Lake outflow and Ellis (1999) recorded as many as 25 Shasta crayfish under a single rock in the fish trap cove at Thousand Springs.

During a meeting in July 2005, CDFG voiced a major concern that the upper meadow of Rock Creek could be a losing reach (i.e., less water would exit the bottom of the reach than enters the top of the reach). If the reach is a losing reach then moving the diversion site downstream would result in less water for the Crystal Lake Fish Hatchery, which would be unacceptable to CDFG. CDFG engineer, George Heise, suggested that a sand bag test or a percolation test would indicate whether it was a losing reach (see Appendix E for the 15 July 2004 CDFG Memorandum prepared by George Heise on the proposal to relocate the Crystal Lake Hatchery water supply diversion point). During the December 2005 meeting, the TRC recommended that percolation testing be done in the upper meadow area of Rock Creek to determine whether moving the diversion downstream would result in less water available for diversion to the hatchery.

In early June 2006, the feasibility of conducting a standard percolation test in the Rock Creek reach targeted for restoration was assessed. Test holes were dug in the floodplain away from the Rock Creek channel to qualitatively assess soil moisture and percolation potential. These holes could only be dug approximately 6 to 12 inches into the soil before striking bedrock. Ground-water was encountered 4 to 6 inches below the soil surface and remained in the holes as standing water. By August, both holes remained moist, although standing water was no longer present.

In early August 2006, flow was measured at two locations in Rock Creek to assess whether any of the existing low flow (i.e., less than 1 cubic foot per second [cfs]) in the channel was being

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lost to the potential restoration channel. One location was in the upper half of the upper meadow, and the other was near the lower end. Several factors combined to make these measurements difficult and to create a worst-case scenario for assessing potential water loss within the reach. These factors included: (1) the very low discharge in the channel below the hatchery diversion; (2) the broad, shallow configuration of the current wetted channel and the coarseness of the substrate; (3) the split upper channel, which made it necessary to measure flow in both channels; (4) a small percentage of flow at the lower location that was seeping around the measurement transect; and (5) the time of year (August), when evapotranspiration losses would be relatively high.

The discharge at the upper end of the channel (i.e., the combined discharge of the two split channels) was 0.63 cfs. The discharge at the lower transect was 0.54 cfs. The specifications of the flow meter state an accuracy of ±2% of the measured value, plus or minus the zero stability of the sensor (0.05 ft/s). The difference between the upper and lower discharges was 0.09 cfs. Thus, although the flow measurement at the lower end of the reach was less than the upper measurement, the difference was less than the margin of error for the measurements and may not be real. Based on the measurements made under summer conditions in 2006 and the accuracy of those measurements, it cannot be concluded that the Rock Creek channel is a losing reach.

During TRC discussions in November 2006, it was suggested that a conference call between CDFG engineer George Heise, CDFG biologist Steve Baumgartner, and Spring Rivers biologists Maria Ellis and Jeff Cook would provide the opportunity for the following: (1) a discussion of site assessment methods (e.g., for hydrologic testing); (2) the establishment of criteria and thresholds for moving forward (e.g., acceptable percolation rates); and (3) a discussion of conceptual designs for a new diversion dam, intake structure, and other facilities that would be necessary for the project. This call has yet to be scheduled.

Shasta Crayfish Interpretive and Education Signs

In compliance with Article 413 of the Hat Creek license and Article 416 of the Pit 1 license, PG&E developed interpretive and education (I&E) signs to be installed at designated locations. The Hat Creek I&E sign was developed to educate the general public and protect Shasta crayfish

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from recreational activities (Figure 4). Copies of the sign were installed at the Hat Creek recreation sites, which include the Baum Lake parking lot and the Cassel Campground at Hat 1 Canal in 2008. The Pit 1 I&E sign was developed for educating the general public about the status of the Shasta crayfish and the bald eagle, including information on potential threats from recreational activities (Figure 5). Copies of the Pit 1 I&E sign were installed at the Pit recreation sites, which include the Rat Farm (Big Lake) Access, the Tule-Fall River Access, the Fall River Lake Day Use Area, the Fall River Pond Access, and the Pit River Access in 2008. In 2009, PG&E will be installing a sturdier version of CDFG's sign at the outflow of Crystal Lake, which needed to be replaced annually. The sign posts the CDFG regulation prohibiting fishing in the Crystal Lake outflow area from November 15th until the last Saturday in April.

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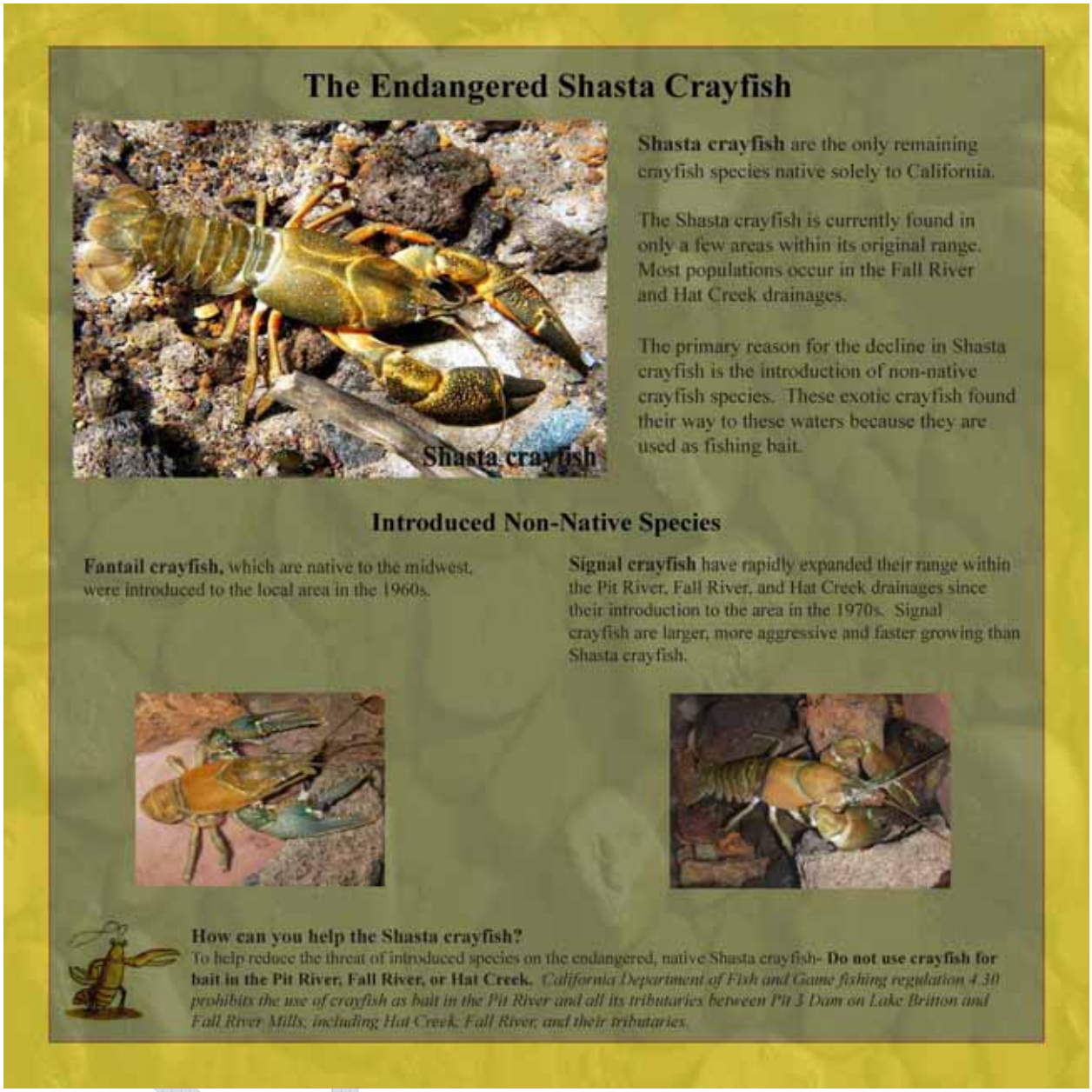

Figure 4 Hat Creek Shasta crayfish interpretive and education sign.

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Figure 5 Pit 1 Shasta crayfish and bald eagle interpretive and education sign.

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Crayfish Monitoring

Survey areas for monitoring crayfish in the vicinity of the projects were selected based on the findings of the comprehensive Shasta crayfish surveys done for PG&E in the early 1990s (Ellis and Hesseldenz 1993, Ellis 1996, 1999), as well as earlier surveys (Daniels 1980, Eng and Daniels 1982). Efforts focused on areas in which Shasta crayfish, or potentially suitable Shasta crayfish habitat, had been found during earlier surveys. For consistency, names for the Shasta crayfish populations and site locations designated in the Shasta Crayfish Recovery Plan (USFWS 1998) were also used in this report. Although the initial surveys for both projects focused on habitat and populations of Shasta crayfish within the Project boundaries, the TRC decided that subsequent surveys would include all known Shasta crayfish locations. Although Rising River was not surveyed during the first three Hat Creek monitoring surveys, it will be included in the future, if landowner permission is received. The second Pit 1 monitoring surveys added Rainbow Spring, Lava Creek, and Thousand Springs to the sites within the Pit 1 Project boundaries that were surveyed during the baseline surveys.

Habitat Mapping

Shasta crayfish habitat is typified by unembedded lava cobble and boulder substrate on gravel or a mixture of sand and gravel with minimal fine material. With less restrictive habitat requirements, non-native signal and fantail crayfish are also found in areas with more fine material or where lava substrate is sparse or absent in addition to Shasta crayfish habitat. To delineate existing Shasta crayfish habitat at each location, a site reconnaissance was done to map and measure habitat areas. Areas of habitat were identified, delineated, and measured by surveyors, snorkelers, and scuba divers using survey measuring tapes. Water depths and visibility in many of the headwater springs (e.g., parts of Crystal Lake, Ja She Creek, upper Big Lake, and Crystal Springs Cove) were such that habitat mapping and habitat quality assessments could be done looking through the water surface, using polarized glasses, from a boat or shore. Waters with greater depths and poorer visibility were surveyed using scuba or snorkeling equipment. Where water visibility was limited and depths were greater than approximately 2.5 ft, scuba gear was required to survey effectively and efficiently. Polygons representing individual habitat areas were drawn onto large-scale base maps. Smaller areas were measured by two divers; large areas, where divers would be out of visual range of each other, were measured

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on the surface by a diver and a person in a support boat or on shore. If additional habitat was found during crayfish surveys it was also mapped and added to the habitat calculations.

In Rock Creek, potential Shasta crayfish habitat locations were calculated from channel length measurements taken with a hip chain and an average of measured channel widths. Both the upper and lower meadows had low-gradient channel reaches that would provide potential Shasta crayfish habitat if re-watered. Because the proposed restoration would utilize the natural instream flow of Rock Creek, only the larger upper meadow site is being considered for restoration so that Rock Creek could remain as the Crystal Lake Hatchery water source.

It was not practical to map habitat in detail in the Pit River; however, Shasta crayfish were found from just above Pit River Falls to the coldwater spring (i.e., 13–14 °C) approximately 600 m upstream of the falls on river right. This section of river provided an estimated 750 m^2 of adequate habitat. Several springs with temperatures less than 15 ºC enter the Pit River within this section and provide coldwater areas with clean substrate. Warmer springs (i.e., 17–19 °C) enter the Pit River just upstream of this section.

Habitat was graded as prime, adequate, or marginal. The best quality habitat, designated "prime," consisted of mostly unembedded lava cobble and boulder on gravel that was mostly free of fine material (i.e., fine sand and silt). Prime habitat was generally associated with areas of spring inflow or upwelling or other flowing water that kept the substrate free of fines. Relatively unembedded lava cobble and boulder on gravel, or sand and gravel, that contained only minimal amounts of fine material was designated "adequate" habitat. Adequate habitat was usually located farther away from spring inflow or other water currents that minimized the accumulation of fine sediment. The lowest quality potential habitat was designated "marginal." Marginal habitat generally consisted of lava cobble and boulder embedded in gravel, sand, silt, or organic flocculants. Marginal habitat generally occurred in areas with little or no current. Spring inflow or upwelling areas that lacked larger cobble or boulder habitat were also designated as marginal. Within a location, Shasta crayfish were generally found in the higher quality (i.e., prime or adequate) habitat areas. Marginal habitat was mostly used by Shasta crayfish in locations that lacked better quality habitat.

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Shasta crayfish habitat mapping and the initial crayfish monitoring survey within the Hat Creek Project vicinity were completed in 2003 (Spring Rivers 2004). The second monitoring survey for the Hat Creek Project was completed in 2004 (Spring Rivers 2005), and the third survey was completed in 2007 (Spring Rivers 2008). Table 4 reports the locations, relative quality, and estimated areas of Shasta crayfish habitat in Crystal Lake and Baum Lake, and the estimated area of potential habitat that could be restored in the upper meadow of Rock Creek. Crystal Lake had a total of 3908 m^2 of potential habitat with a total of 663 m^2 of prime and 1115 m^2 of adequate habitat between Southwestern, Middle Cove, and the outflow area of Crystal Lake. A total of 1259 m^2 of potentially prime habitat would be available in the upper meadow this section of the Rock Creek channel were re-watered and restored. The low-gradient portion of the lower meadow (392 m^2) is not being considered for restoration.

Table 4 Size and quality of Shasta crayfish habitat in the Hat Creek Project vicinity as identified, mapped, and verified between 2003 and 2009.

		Habitat (m^2)			
Region	Location	Prime	Adequate	Marginal	Total Prime & Adequate
Crystal Lake	Southwest	401	529	2069	930
	Middle	24	586	1226	610
	Outflow	238	0	613	238
Baum Lake	Crystal Inflow	0	207	225	207
	West	0	195	175	195
	Turtle Pond	0	42	0	42
Rock Creek [a]	Rock Creek	1259	0	0	1259

[a] Potential habitat if the upper meadow were restored. Does not include the low-gradient portion of the lower meadow (392 m^2).

Shasta crayfish habitat mapping and the initial crayfish monitoring survey within the Pit 1 Project vicinity were done over an approximately three-year period from March 2004 to February 2007 (Spring Rivers 2004, 2005, 2006, 2007a). The second monitoring survey for the Pit 1 Project were conducted between 2007 and 2009 (this report). Table 5 presents the results of the habitat surveys in the Pit 1 Project vicinity. There was a total of approximately 34,987 m^2 of potential Shasta crayfish habitat identified, including 22,543 m^2 of prime and 10,477 m^2 of

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adequate habitat. Most of the habitat was associated with voluminous springs (e.g., Spring Creek, Ja She Creek headwaters, and North Big Lake), while little habitat was identified away from springs (e.g., Tule River Levee System). Spring areas generally had clean or slightly silty gravel and boulder habitat. Substrate along most of the levee system, however, was silty with only limited marginal habitat provided by boulders and earthen clumps on top of the compacted soil and roots on the levee face. The sparse substrate on the bottom of Big Lake and the Tule River was generally embedded in a 6–12 inch layer of silt and consequently did not provide Shasta crayfish habitat.

Table 5 Size and quality of Shasta crayfish habitat in the Pit 1 Project vicinity as identified, mapped, and verified between 2004 and 2009.

		Habitat (m^2)			
Region	Location	Prime	Adequate	Marginal	Total Prime & Adequate
Upper Fall River	1000 Springs Fish Trap Cove	836	0	0	836
	1000 Springs Old Property Line	480	6	0	486
	Fletcher's Bend	264	0	0	264
	Lennihan's Footbridge	216	0	0	216
Spring Creek	Upper coves	9083	470	37	9553
	Lower coves	1054	726	0	1780
Ja She Creek	Ja She Creek headwaters	3237	5270	463	8507
	Crystal Springs Cove	2610	1083	89	3693
	Tule Coves	118	93	20	211
Upper Big Lake	Big Lake Springs	177	0	0	177
	North Big Lake (excl. Springs)	363	955	8	1318
	Northeast Big Lake	138	138	0	276
	Northwest Big Lake	0	11	0	11
Tule River Levee System	South shore Big Lake	0	0	1265	0
	Northeast upper Tule River			0	0
	South shore upper Tule River	0	0	21	0
	East shore upper Tule River	0	0	0	0
	Horr Pond levees	0	75	0	75
Fall River at FRM	Fall River Pond	3967	900	64	4867
Pit 1 Bypass – Big Eddy to Powerhouse (PH)	Pit River Falls		750		750 [a]
	Canyon spring	ND	ND		ND
Pit River below PH	Pit River sand pits	ND	ND		ND

[a] Estimated value based on aerial photographs; ND = Not Determined

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Crayfish Surveys

During crayfish monitoring surveys, habitat areas were surveyed for crayfish by snorkelers and/or scuba divers who first inspected the undisturbed substrate before turning over individual cobbles and boulders. All crayfish encountered, regardless of species, were collected, except Shasta crayfish too small to be handled safely. To minimize possible injury, Shasta crayfish were kept separate from introduced crayfish species. Shasta crayfish were placed either in a rigid tube collector or directly into a bucket with water on board the support boat. After data collection, Shasta crayfish were released next to the rock where they were found and observed until they moved back underneath the rock. Non-native crayfish were collected and destroyed after data collection.

In addition to the crayfish monitoring surveys, one or more surveys to eradicate non-native crayfish were done at Spring Creek in 2003, 2005, 2006, and 2008 and at Thousand Springs annually between 2004 and 2009. These surveys focused solely on eradication of invasive crayfish. The Spring Creek surveys are part of the Spring Creek Road Crossing Cavity-Filling Project described in the Crayfish Barrier Plan. Shasta crayfish encountered during these surveys were not collected, although the number of Shasta crayfish observed was generally estimated and recorded. Non-native crayfish were collected and destroyed after data collection on individuals.

The following data were recorded for each collected crayfish: (1) species, (2) size measured as total carapace length (TCL) with vernier or dial calipers to the nearest tenth of a millimeter, (3) sex of crayfish greater than approximately 12 mm TCL, (4) general condition (e.g., reproductive state, missing appendages, and molt state), and (5) area or zone of capture. Crayfish less than 10 to 12 mm TCL cannot be reliably sexed and were therefore grouped as young of year (YOY). Shasta crayfish reach sexual maturity at approximately 27 mm TCL, whereas while signal crayfish reach sexual maturity at approximately 30 mm TCL (Ellis 1999). Fantail crayfish (*Orconectes virilis*) can be sexual mature at a size as small as 18.7 mm TCL (Spring Rivers unpublished data). Shasta crayfish between 10 and 27 mm TCL were categorized as juveniles, and those greater than 27 mm TCL were categorized as adults. Signal crayfish between 12 and 30 mm TCL were categorized as juveniles, and those greater than 30 mm TCL were categorized as adults. Fantail crayfish between 10 and 18.7 mm TCL were categorized as

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juveniles, and those greater than 18.7 mm TCL were categorized as adults. Crayfish densities were calculated based on the number of individuals found within each survey site. Because the vast majority of Shasta crayfish were found in areas classified as either prime or adequate habitat in most sites, the total area of prime and adequate habitat was used for density calculations. The Shasta crayfish sites along the Tule River Levee System, however, were the exception because only marginal habitat was present. Crayfish densities for all species found at South Shore Big Lake and South Shore Upper Tule River were calculated using the total area of marginal habitat present at each site.

Hat Creek Crayfish Surveys

The first three surveys for the Hat Creek Hydroelectric Project took place in the fall or early winter of 2003, 2004, and 2007. Surveys were done in areas of Crystal and Baum lakes where Shasta crayfish, or potentially suitable Shasta crayfish habitat, had been found during earlier surveys. Within Crystal Lake, the Southwest, Middle Cove, and Outflow areas were surveyed. In Baum Lake, the Crystal Inflow and the spring-fed area west of Crystal Inflow (i.e., West Baum Lake) were surveyed all three years. The springfed Turtle Pond was surveyed in 2003, but not in subsequent years because very little suitable habitat was found. Rock Creek was surveyed in 2003 to verify that no crayfish were present. The next survey is scheduled for 2012. Crayfish sex and age class composition for the three surveys are presented in Table 6.

Shasta crayfish were only found in Crystal Lake during the Hat Creek surveys (Table 6). A total of 162, 272, and 132 Shasta crayfish were found in 2003, 2004, and 2007, respectively. Within Crystal Lake, Shasta crayfish accounted for 13% of the crayfish captured in 2003 and 14% in 2004 and 2007. The sex ratio (male:female) among years varied somewhat: 54:46 in 2003, 52:48 in 2004, and 51:49 in 2007. The age-class distribution (adult:juvenile:YOY) showed an increased shift towards adults over the years: 49:47:4 in 2003, 59:36:6 in 2004, and 72:27:1 in 2007. Berried females (i.e., carrying eggs) were mainly found in Southwest Crystal Lake during all years; one female from Crystal Lake Outflow had a single egg in 2007. The percent of berried females increased over the years from 22% in 2003 to 50% in 2004, to 52% in 2007. Southwest Crystal Lake supported the majority of the Crystal Lake population (85 % in 2003, 97% in 2004, and 98% in 2007) and most of the berried females. The number of Shasta crayfish found at the Crystal Lake Outflow decreased from 23 to 7 to 2 over the years. Shasta crayfish

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were least abundant in Middle Cove with two crayfish found in 2003 and 2004, and none in 2007. The size distributions of Shasta crayfish found in Crystal Lake during the 2003, 2004, and 2007 surveys are presented in Figure 6.

Table 6 Crayfish species, sex [a], and age class [b] composition in the Hat Creek Study Area during the first three surveys (2003, 2004, and 2007).

Region		Shasta crayfish						Signal crayfish					
Location	Year	M	F [c]	Adult	Juv	YOY	Total	M	F	Adult	Juv	YOY	Total
Crystal Lake													
Southwest	2003	73	58 (13)	67	65	5	**137**	41	39	35	45	33	**113**
	2004	126	117 (59)	154	94	15	**263**	86	66	69	83	64	**216**
	2007	65	62 (32)	94	35	1	**130**	65	68	34	129	11	**174**
Middle Cove	2003	1	1 (0)	2	0	0	**2**	60	56	33	83	7	**123**
	2004	1	1 (0)	2	0	0	**2**	99	81	65	115	37	**217**
	2007	0	0 (0)	0	0	0	**0**	51	67	27	127	0	**154**
Outflow	2003	10	13 (0)	9	14	0	**23**	582	626	679	529	12	**1220**
	2004 [d]	3	4 (0)	7	0	0	**7**	570	715	718	569	40	**1327**
	2007	0	1 (1)	2	0	0	**2**	192	188	121	324	12	**457**
Baum Lake													
Crystal Inflow	2003	0	0	0	0	0	**0**	76	96	135	37	0	**172**
	2004	0	0	0	0	0	**0**	129	96	153	72	58	**283**
	2007	0	0	0	0	0	**0**	103	79	153	39	1	**193**
West	2003	0	0	0	0	0	**0**	98	95	166	27	0	**193**
	2004	0	0	0	0	0	**0**	631	406	981	56	4	**1041**
	2007	0	0	0	0	0	**0**	197	219	402	16	0	**418**
Turtle Pond	2003	0	0	0	0	0	**0**	1	5	3	3	0	**6**
	2004	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Rock Creek	2003	0	0	0	0	0	**0**	0	0	0	0	0	**0**

[a] M=male, F=female; [b] Juv=juvenile, YOY=young of year
[c] Number in parentheses indicates the number of females with eggs
NOTE: Totals by sex may differ from adult/juvenile totals, because sex was not determined for all crayfish.
[d] Combined data from UC Davis survey (20-22 Jul) and Spring Rivers survey (19 Nov, 1 & 3 Dec) at Crystal Lake Outflow.

Signal crayfish were found throughout the survey areas of Crystal and Baum lakes. A total of 6307 signal crayfish were captured and destroyed during the 2003, 2004, and 2007 surveys (Table 6). Signal crayfish accounted for 92% of all crayfish captured during the Hat surveys in 2003 and 2004 and 91% in 2007. The overall sex ratio was reasonably equal: 2981 males, 2902 females, and 279 of undetermined sex. Annual sex ratios were 48:52 in 2003, 53:47 in 2004, and 49:51 in 2007. The overall age class distribution was skewed towards adults: 3548 adults, 2071 juveniles, and 268 YOY. Annual age class distributions were 58:40:3 in 2003, 64:29:7 in 2004, and 53:45:2 in 2007. The size distribution of signal crayfish by location from the 2007 survey is

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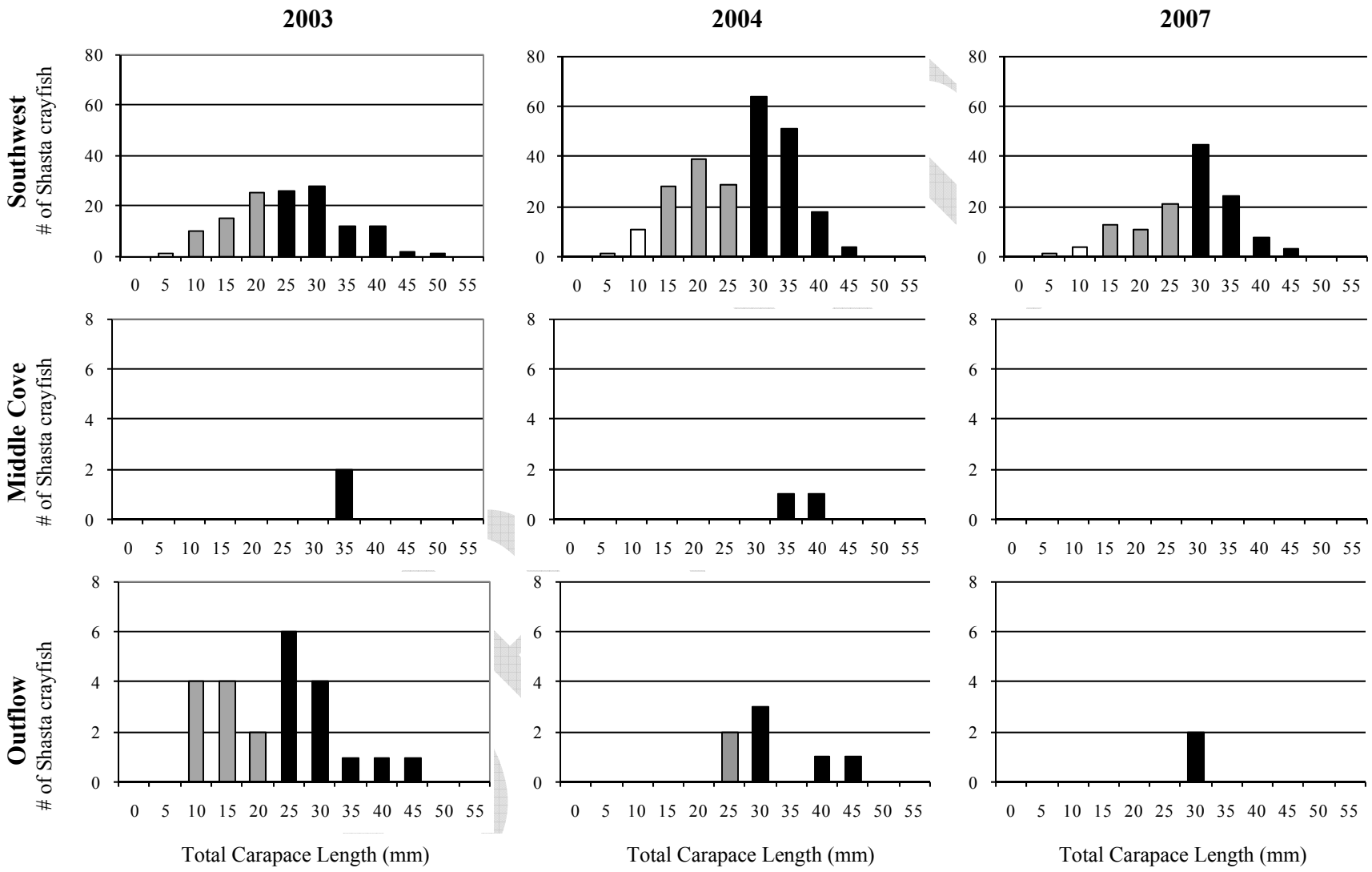

Figure 6 Size distribution of Shasta crayfish from Crystal Lake regions during the 2003, 2004, and 2007 surveys.

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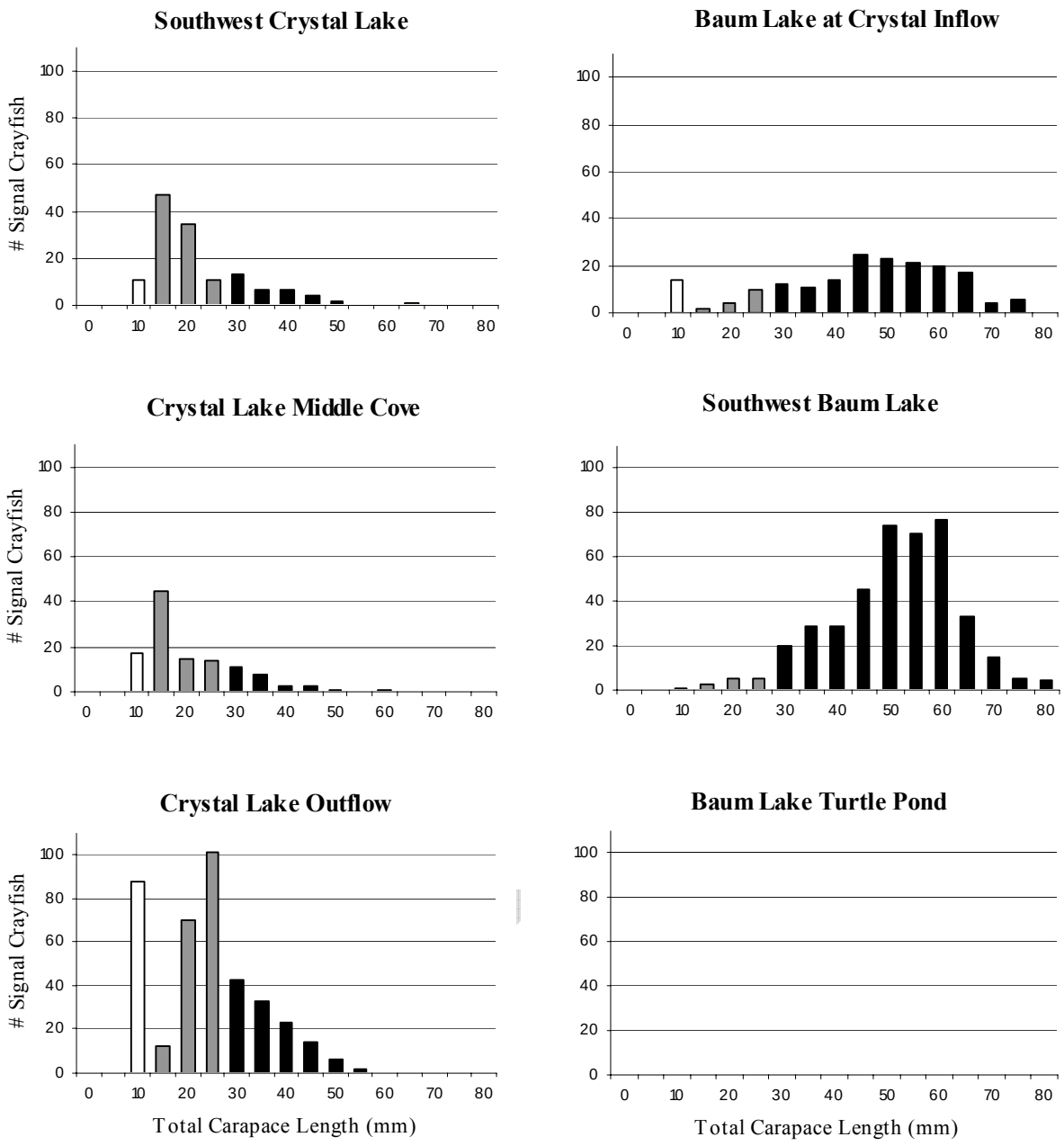

Figure 7 Size distribution of signal crayfish from Crystal Lake and Baum Lake during the 2007 survey.

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presented in Figure 7. The most signal crayfish were encountered at Crystal Lake Outflow (Table 6), but the highest density was observed at West Baum Lake.

No crayfish of any species were found in Rock Creek in 2003, during the only survey of that location.

Pit 1 Crayfish Surveys

The baseline monitoring survey for the Pit 1 Hydroelectric Project took place between 2004 and February 2007. The Pit 1 baseline survey area included the following sites in the Fall River drainage: Upper Fall River (i.e., Fletcher's Bend, Lennihan's Footbridge), Spring Creek, Ja She Creek (i.e., Ja She Creek headwaters, Crystal Springs Cove [including Crystal Springs, Crystal Cove, Crystal Inlet], Tule Coves), Upper Big Lake (i.e., Big Lake Springs, North Big Lake, Northeast Big Lake, Northwest Big Lake), Tule River Levee System (i.e., South shore Big Lake, Northeast upper Tule River, South shore upper Tule River, East shore upper Tule River, Horr Pond levees), and Fall River at Fall River Mills (i.e., Fall River Pond). In addition, the Pit 1 Bypass Reach of the mainstem Pit River from Big Eddy to the Pit 1 Powerhouse (i.e., Pit River Falls, Canyon spring) and the mainstem Pit River between the Pit 1 Powerhouse and Lake Britton (i.e., Pit River sand pits) were also surveyed in 2005, as part of the baseline surveys. The second monitoring survey took place between March 2007 and March 2009. The third survey is scheduled for 2009 and 2010. Crayfish sex and age class composition for the baseline and second monitoring surveys are presented in Tables 6 and 7, respectively.

During the Pit 1 baseline monitoring survey, 786 Shasta crayfish were collected, which accounted for 11.2% of all crayfish encountered (Table 7). The most Shasta crayfish were found in Spring Creek and at Thousand Springs in the upper Fall River drainage. Within the Fall River drainage (in order of numerical abundance), Shasta crayfish were also collected in Ja She Creek, Big Lake Springs, Rainbow Spring, North Big Lake, South Shore Big Lake near the Big Lake Levee Cove, Tule Coves, and Crystal Springs Cove. A single Shasta crayfish was also found at Northeast Big Lake and at Northwest Big Lake. In the mainstem Pit River, 21 Shasta crayfish were found upstream of the Pit River Falls. For all locations combined, more females (n = 342) were encountered than males (n = 303), for a sex ration of 53:47. There was a higher proportion

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of juveniles (n = 354) than adults (n = 348). In addition, 84 young-of-year were observed and left in place to avoid accidental harm.

During the second monitoring survey, 550 Shasta crayfish were collected, accounting for 8.1% of all crayfish encountered during surveys in the Pit 1 Study Area (Table 8). The most Shasta crayfish were found at Thousand Springs and Spring Creek in the upper Fall River drainage. Within the Fall River drainage (in order of abundance), Shasta crayfish were also collected in Ja She Creek, Lava Creek, Big Lake Springs, Rainbow Springs, North Big Lake, Crystal Springs Cove, Tule Coves, and Northwest Big Lake. Although Shasta crayfish were found at Northeast Big Lake or South Shore Big Lake during the baseline surveys, none were found at these sites during the second monitoring survey. In the mainstem Pit River upstream of the falls, only one dead Shasta crayfish was found. More females (n = 237) were encountered than males (n = 184) for a sex ration of 56:44. Juveniles (n = 270) outnumbered adults (n = 226). In addition, 54 young-of-year were observed and left in place to avoid accidental harm. The size distributions for Shasta crayfish are presented in Figure 8.

During the baseline monitoring survey, a total of 5903 signal crayfish were collected and exterminated at all survey locations combined (Table 7). Signal crayfish accounted for 83.9% of all crayfish collected. More females (n = 2865) were collected than males (n = 2370). There was a higher proportion of adults (n = 3799) than juveniles (n = 1686) or young-of-year (418).

During the second monitoring survey, a total of 6097 signal crayfish were collected and exterminated at all survey locations combined (Table 8). Signal crayfish accounted for 90.1% of all crayfish collected. More females (n = 2738) were collected than males (n = 2141). There was a higher proportion of adults (n = 3397) than juveniles (n = 2243) or young of year (n = 428). The size distributions for signal crayfish by location are presented in Figure 9.

During the baseline surveys, 350 fantail crayfish were collected and exterminated (Table 7). Fantail crayfish accounted for 5.0% of all crayfish collected. More males (n = 198) were collected than females (n = 149), and there was a higher proportion of adults (n = 330) than juveniles (n = 20). No young-of-year were found.

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Table 7 Number of crayfish, by species, sex[a], and age class[b], encountered in the Pit 1 Project vicinity during the baseline monitoring survey (2004–2007).

	Shasta crayfish						Signal crayfish						Fantail crayfish					
Region and Location	**M**	**F**	**Adult**	**Juv**	**YOY**	**Total**	**M**	**F**	**Adult**	**Juv**	**YOY**	**Total**	**M**	**F**	**Adult**	**Juv**	**YOY**	**Total**
Upper Fall River																		
Thousand Springs above barrier	129	128	152	117	11	280	9	9	8	6	10	24	0	0	0	0	0	0
Thousand Springs below barrier	0	0	0	2	0	2	605	673	770	678	70	1518	0	0	0	0	0	0
Rainbow Spring	4	12	3	14	2	19	8	15	9	14	0	23	0	0	0	0	0	0
Fletcher's Bend	0	0	0	0	0	0	152	210	91	270	89	450	0	0	0	0	0	0
Lennihan's Footbridge	0	0	0	0	0	0	41	44	43	42	27	112	0	0	0	0	0	0
Spring Creek																		
Upper coves	108	127	118	145	53	316	18	17	21	12	43	76	0	0	0	0	0	0
Lower coves	6	18	13	13	0	26	25	28	26	27	8	61	0	0	0	0	0	0
Ja She Creek																		
Ja She Creek headwaters	28	18	31	18	5	54	645	741	1218	168	0	1386	0	0	0	0	0	0
Crystal Springs Cove	3	1	2	2	0	4	670	896	1307	333	151	1791	0	0	0	0	0	0
Tule Coves	2	4	4	4	0	8	22	29	30	22	0	52	0	0	0	0	0	0
Upper Big Lake																		
Big Lake Springs	10	22	5	26	5	36	3	0	2	1	0	3	0	0	0	0	0	0
North Big Lake (excl. Springs)	5	2	4	5	0	9	146	181	247	88	20	355	0	0	0	0	0	0
Northeast Big Lake	0	1	1	0	0	1	1	2	1	2	0	3	0	0	0	0	0	0
Northwest Big Lake	1	0	1	0	0	1	2	0	1	1	0	2	0	0	0	0	0	0
Tule River Levee System																		
South shore Big Lake	3	6	8	1	0	9	2	1	2	1	0	3	3	6	9	0	0	9
Northeast upper Tule River	0	0	0	0	0	0	0	0	0	0	0	0	3	1	4	1	0	5
South shore upper Tule River	0	0	0	0	0	0	11	7	12	6	0	18	28	32	58	2	0	60
East shore upper Tule River	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0
Horr Pond levees	0	0	0	0	0	0	1	3	2	5	0	7	17	15	31	2	0	33
Fall River at FRM																		
Fall River Pond	0	0	0	0	0	0	2	6	5	3	0	8	143	87	216	14	0	230
Pit 1 - Big Eddy to PH																		
Pit River Falls	4	3	6	7	8	21	7	2	4	6	0	10	4	8	11	1	0	12
Canyon spring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pit 1 - below PH (sand pits)	0	0	0	0	0	0		M	A	N	Y		0	0	1	0	0	1
Totals	303	342	348	354	84	**786**	2370	2865	3799	1686	418	**5903**	198	149	330	20	0	**350**

[a] M=male, F=female [b] Juv=juvenile, YOY=young of year

NOTE: Sex totals may differ from adult and juvenile totals, because not all adults and juveniles were sexed.

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Table 8 Number of crayfish, by species, sex[a], and age class[b], encountered in the Pit 1 Project vicinity during the second monitoring survey (2007–2009).

	Shasta crayfish						Signal crayfish						Fantail crayfish					
Region and Location	**M**	**F**	**Adult**	**Juv.**	**YOY**	**Total**	**M**	**F**	**Adult**	**Juv.**	**YOY**	**Total**	**M**	**F**	**Adult**	**Juv.**	**YOY**	**Total**
Upper Fall River																		
Thousand Springs above barrier	99	115	102	132	16	250	23	17	16	24	62	102	0	0	0	0	0	0
Thousand Springs below barrier	0	0	0	0	0	0	20	12	9	20	9	38	0	0	0	0	0	0
Rainbow Spring	3	3	7	1	0	8	67	86	100	53	0	153	0	0	0	0	0	0
Fletcher's Bend	0	0	0	0	0	0	19	18	7	29	54	90	0	0	0	0	0	0
Lennihan's Footbridge	0	0	0	0	0	0	26	42	21	47	54	122	0	0	0	0	0	0
Lava Creek	12	23	33	12	0	45	155	200	174	181	113	468	0	0	0	0	0	0
Spring Creek																		
Upper coves	30	31	21	46	27	94	111	114	71	229	10	310	0	0	0	0	0	0
Lower coves	7	5	0	12	1	13	121	163	84	334	17	435	0	0	0	0	0	0
Ja She Creek																		
Ja She Creek headwaters	17	33	36	40	6	82	755	828	1229	550	4	1783	0	0	0	0	0	0
Crystal Springs Cove	1	2	3	1	0	4	591	889	1253	471	24	1748	0	0	0	0	0	0
Tule Coves	2	0	2	0	0	2	24	48	45	53	5	103	1	0	1	0	0	1
Upper Big Lake																		
Big Lake Springs	9	21	15	22	4	41	42	51	61	48	0	109	0	0	0	0	0	0
North Big Lake (excl. Springs)	2	3	4	4	0	8	180	260	319	195	76	590	0	0	0	0	0	0
Northeast Big Lake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Northwest Big Lake	1	1	2	0	0	2	3	5	6	2	0	8	0	0	0	0	0	0
Tule River Levee System																		
South shore Big Lake	0	0	0	0	0	0	1	2	2	1	0	3	24	35	59	0	0	59
Northeast upper Tule River	0	0	0	0	0	0	1	1	0	2	0	2	4	7	10	4	0	14
South shore upper Tule River	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
East shore upper Tule River	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Horr Pond levees	0	0	0	0	0	0	2	2	0	4	0	4	11	9	20	0	0	20
Fall River at FRM																		
Fall River Pond	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pit 1 - Big Eddy to PH																		
Pit River Falls	1	0	1	0	0	1	-	-	-	-	-	29	-	-	-	-	-	23
Canyon spring	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pit 1 - below PH (sand pits)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	184	237	226	270	54	**550**	2141	2738	3397	2243	428	**6097**	40	51	90	4	0	**117**

[a] M=male, F=female [b] Juv=juvenile, YOY=young of year

NOTE: Sex totals may differ from adult and juvenile totals, because not all adults and juveniles were sexed.

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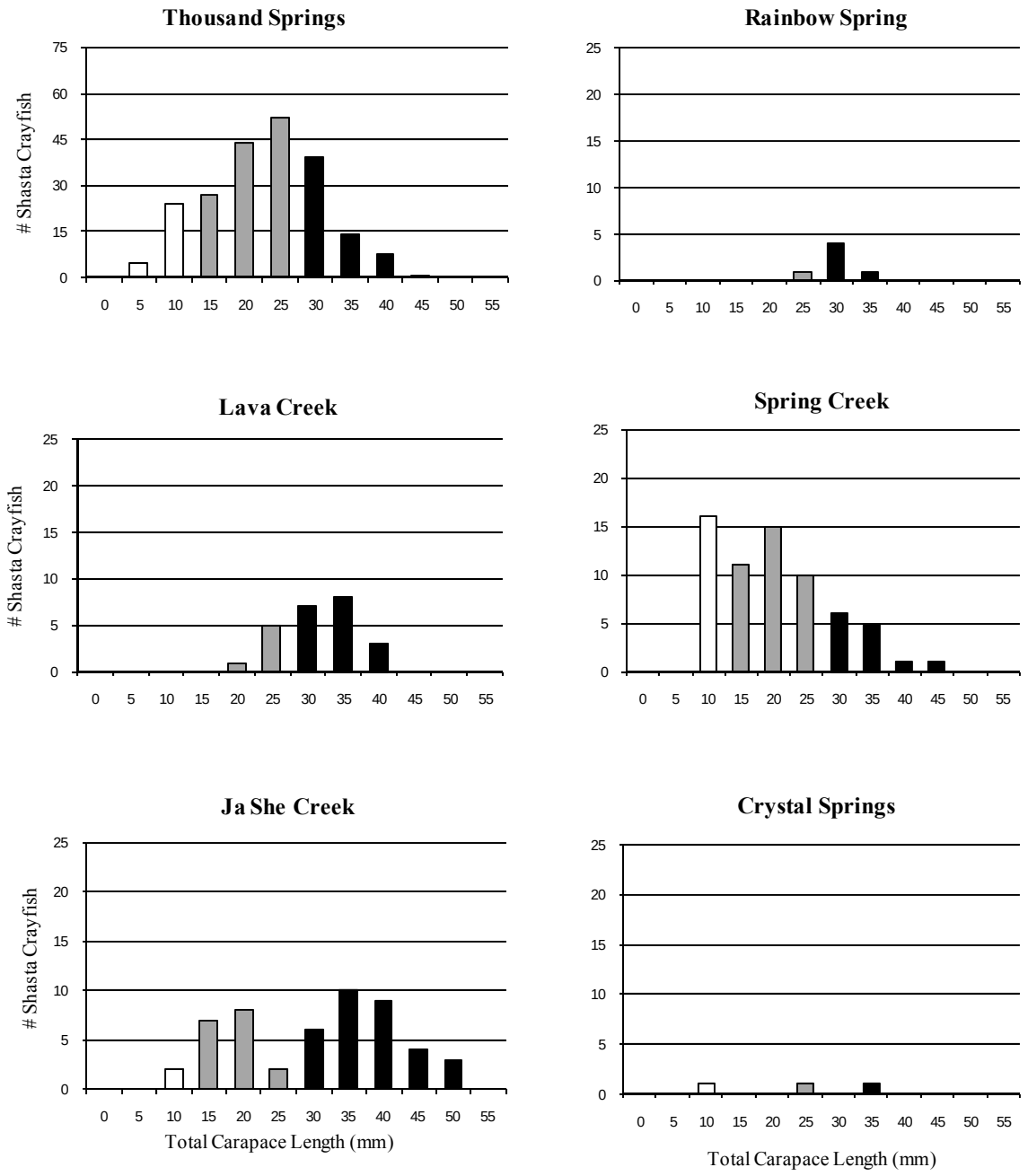

Figure 8 Shasta crayfish size-class distributions by location in the Pit 1 study area in 2007–2008. Bar shades represent age classes: young of year (white), juvenile (gray), and adult (black).

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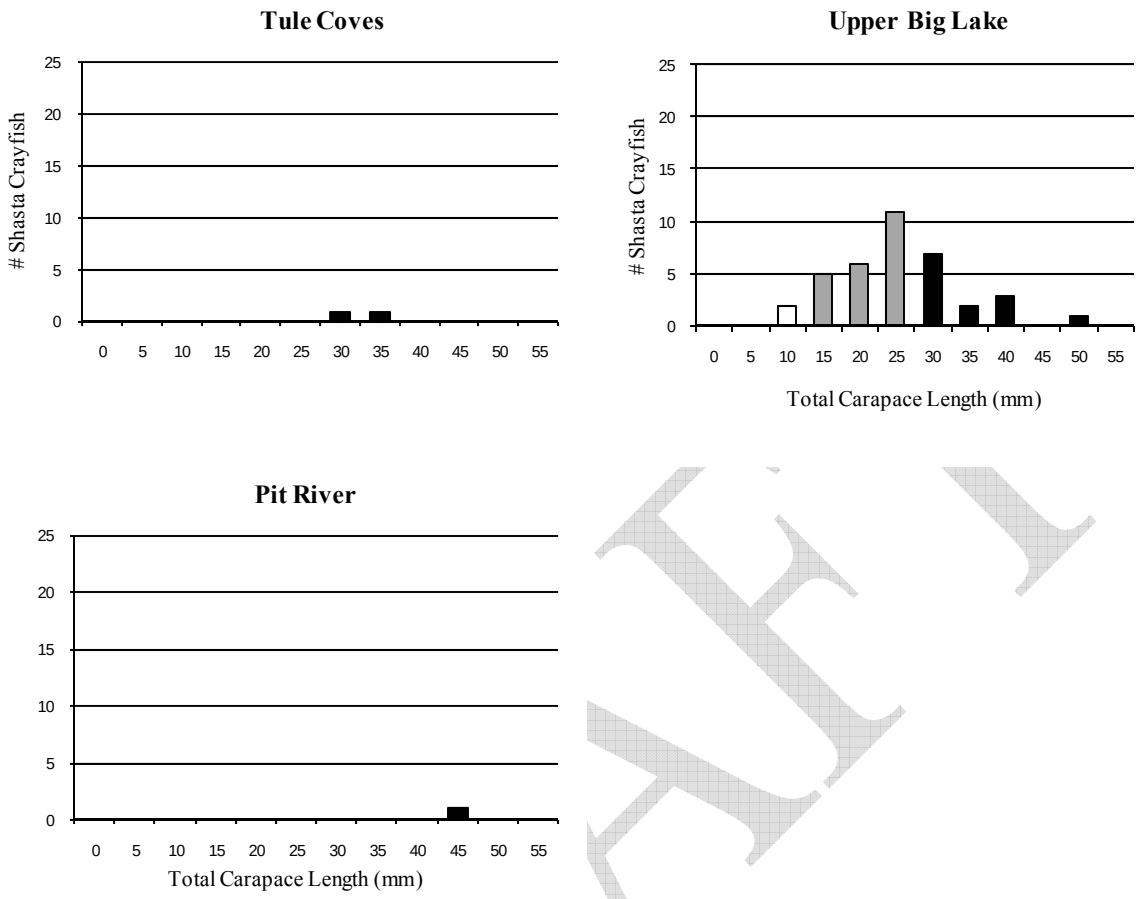

Figure 8 (continued) Shasta crayfish size-class distributions by location in the Pit 1 study area in 2007–2008. Bar shades represent age classes: young of year (white), juvenile (gray), and adult (black).

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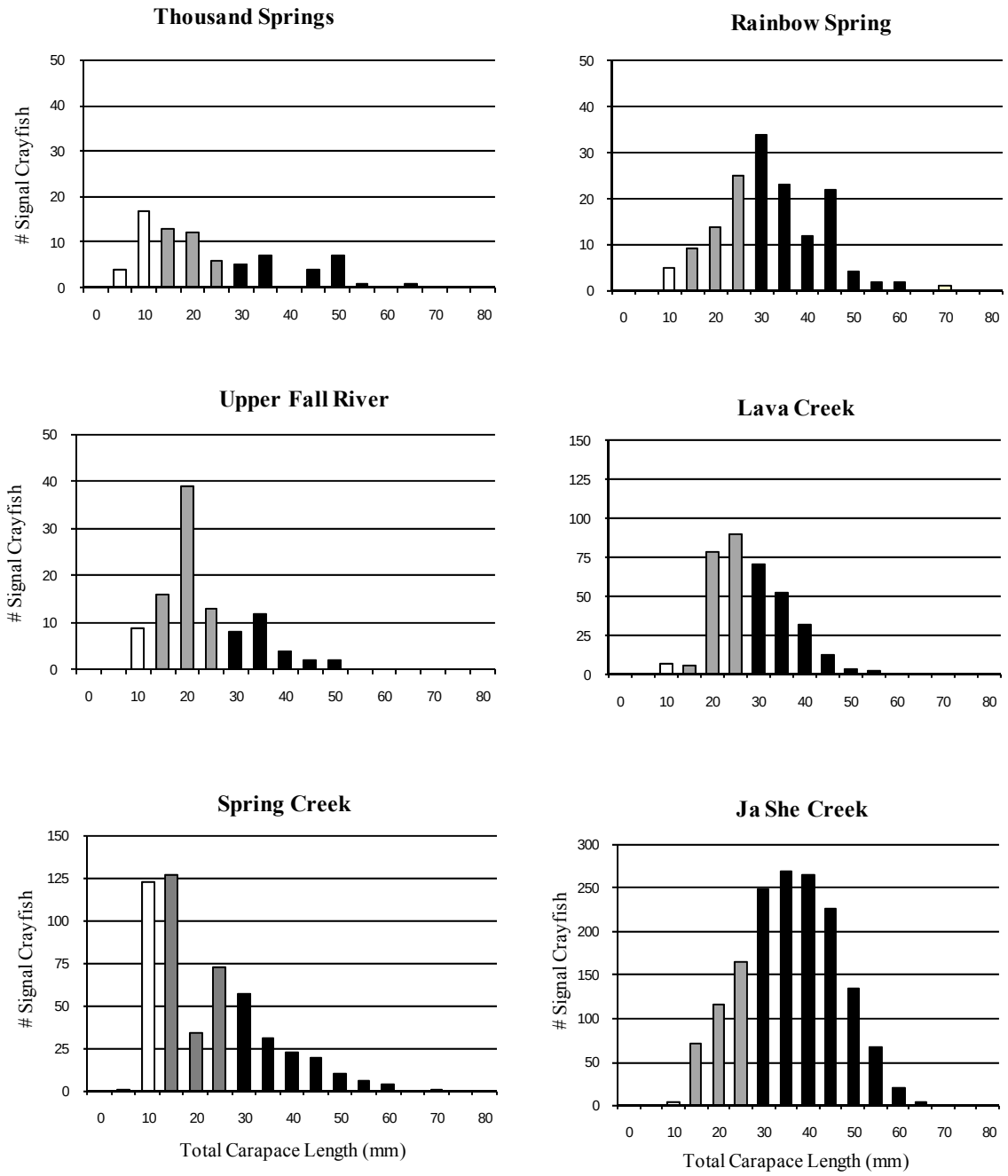

Figure 9 Signal crayfish size-class distributions by location in the Pit 1 study area in 2007–2008. Bar shades represent age classes: young of year (white), juvenile (gray), and adult (black).

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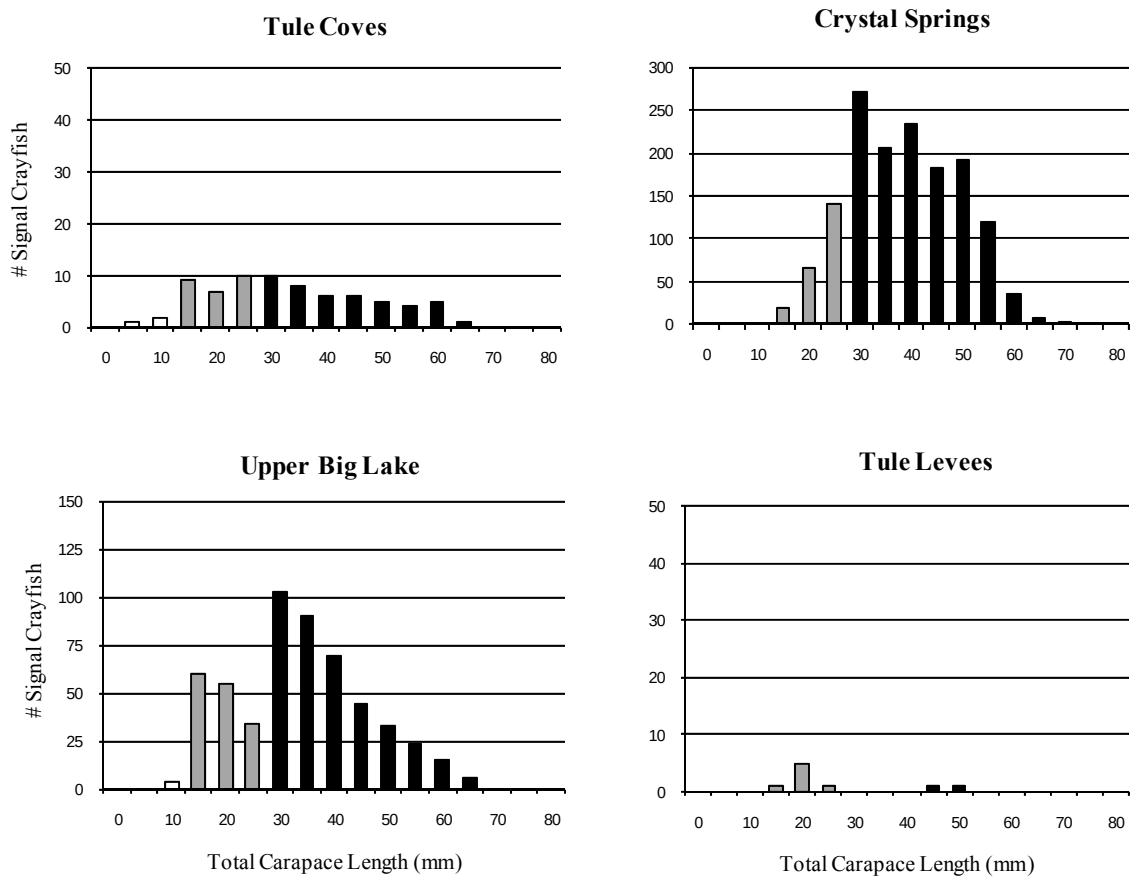

Figure 9 (continued) Signal crayfish size-class distributions by location in the Pit 1 study area in 2007–2008. Bar shades represent age classes: young of year (white), juvenile (gray), and adult (black).

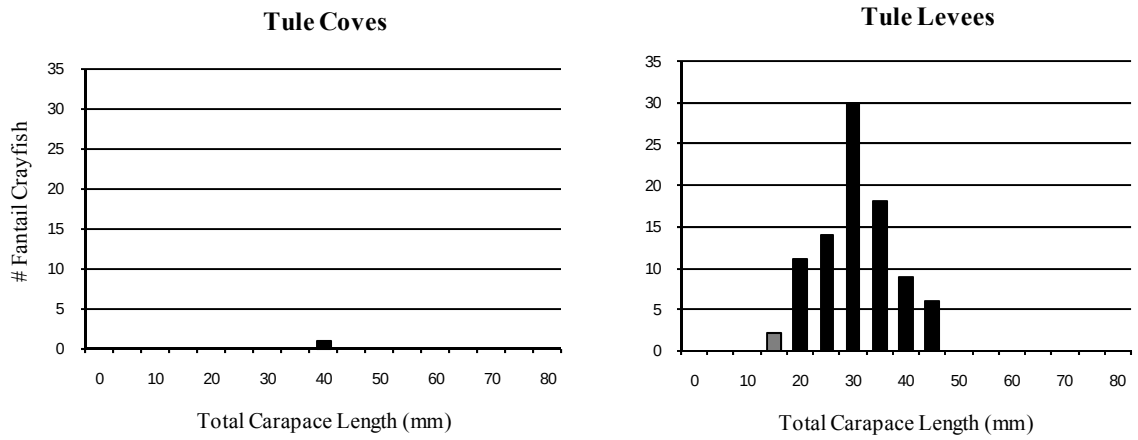

Figure 10 Fantail crayfish size-class distributions by location in the Pit 1 study area in 2007–2008. Bar shades represent age classes: young of year (white), juvenile (gray), and adult (black).

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During the second survey, 117 fantail crayfish were collected and exterminated (Table 8). Fantail crayfish accounted for 1.7% of all crayfish collected. More females (n = 51) were collected than males (n = 40), and there was a higher proportion of adults (n = 90) than juveniles (n = 4). No young of year were found. Size distributions for fantail crayfish are presented in Figure 10.

Some areas were omitted from the second monitoring survey because Shasta crayfish were not found during two consecutive surveys including the baseline survey. These areas included Fall River Pond and the Sand Pits site on the Pit River below the Pit 1 Powerhouse, where Shasta crayfish were last found in 1978. Both South Shore Upper Tule River and East Shore Upper Tule River were omitted, because only a few Shasta crayfish and/or molts were found during the 1990–1992 surveys and none were found in subsequent surveys. In comparison, several Shasta crayfish were found during the 1990–1992 surveys at Horr Pond Levee, Fletcher's Bend, and Lennihan's Footbridge so they were included in the second survey.

Non-Native Crayfish Eradication Surveys

Non-native crayfish eradication surveys were done at Spring Creek in 2003, 2005, 2006, and 2008 and in Thousand Springs annually from 2004 through 2009. These surveys, which focused solely on eradication of invasive crayfish, were in addition to the crayfish monitoring surveys done in Spring Creek (baseline and second survey) and Thousand Springs (second survey only). The Spring Creek non-native crayfish eradication surveys are part of the Crayfish Barrier Plan. The Thousand Springs surveys are part of the non-native crayfish removal, which is required by the Pit 1 License.

Figure 11 shows the number of signal crayfish captured and removed from Thousand Springs upstream of the current barrier location each year since 2003. Signal crayfish were first found in Thousand Springs upstream of the barrier location in 2005. The increase in the number of signal crayfish in early 2009 was due to 53 YOY, which were found in Fish Trap Cove. A total of 126 signal crayfish have been captured and removed from Thousand Springs upstream of the current barrier location since 2005.

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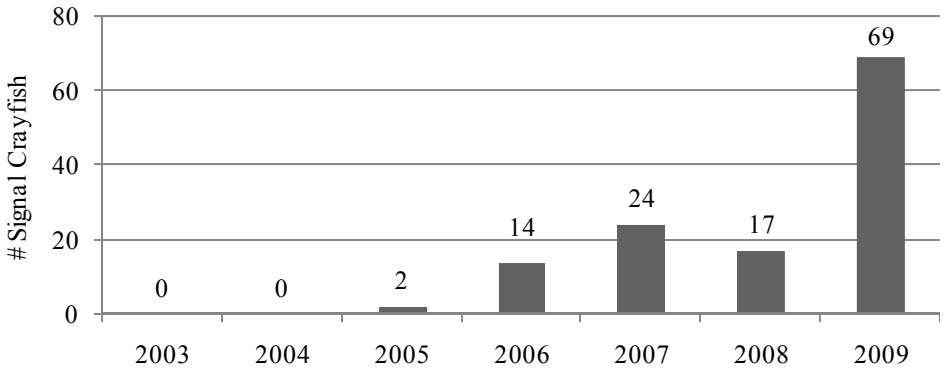

Figure 11 Number of signal crayfish found upstream of the Thousand Springs barrier location since 2003. Data for 2009 only includes January and February surveys.

Figure 12 shows the number of signal crayfish captured and removed from Spring Creek upstream of the Spring Creek Road crossing each year since 2003. Signal crayfish were first found upstream of the culverts in 1997, before the Spring Creek Road crossing was replaced in 2000 (Ellis and Cook 2001). Signal crayfish were first found in the upper coves of Spring Creek in 2003. A total of 897 signal crayfish have been captured and removed from Spring Creek upstream of the Spring Creek Road crossing since 2003.

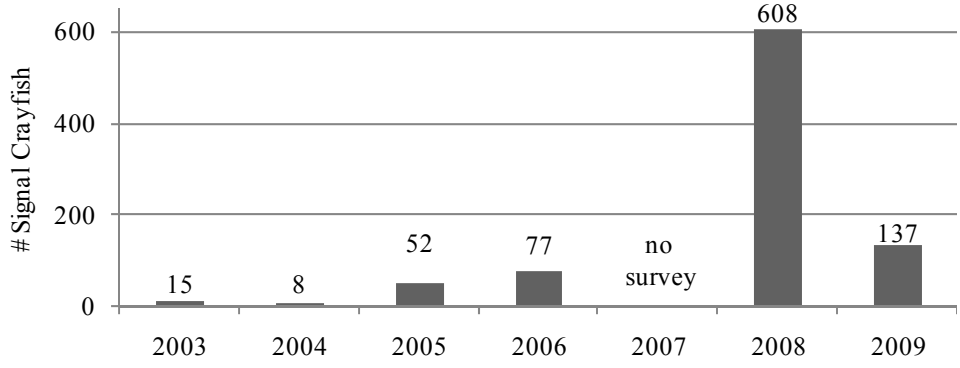

Figure 12 Number of signal crayfish found upstream of the Spring Creek Road crossing since 2003. Data for 2009 only includes surveys through February.

Shasta Crayfish Population Status

Table 9 summarizes all data on Shasta crayfish surveys in the Hat Creek Project vicinity between 1978 and 2007. Because survey objectives, methods, and effort intensity have differed from the earliest surveys to the present monitoring surveys, only general comparisons of past and present

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Table 9 Crayfish population characteristics (number, density, estimated population size, and percent composition) from previous and current surveys in the Hat Creek Project vicinity.

	Region and Location	1978 [a]	1990 [b]–1991 [c]	1993 [d]	2003 [e, h]	2004 [f, h]	2007 [g, h]
Crystal Lake	Southwest	**12 Shasta** (100%) 0.12 Shasta/m^2	Signals (no scuba)	**31 Shasta** (50%) 31 signal (50%)	**137 Shasta** (55%) 0.147 Shasta/m^2 113 signal (45%) 0.122 signal/m^2	**263 Shasta** (55%) 0.283 Shasta/m^2 216 signal (45%) 0.232 signal/m^2	**130 Shasta** (43%) 0.140 Shasta/m^2 174 signal (57%) 0.187 signal/m^2
	Middle Cove		**~2 Shasta** (33%) 4 signal (67%)	**5 Shasta** (33%) 10 signal (67%)	**2 Shasta** (2%) 0.003 Shasta/m^2 123 signal (98%) 0.202 signal/m^2	**2 Shasta** (1%) 0.003 Shasta/m^2 217 signal (99%) 0.356 signal/m^2	**0 Shasta (0%)** 154 signal (100%) 0.252 signal/m^2
	Outflow	**658 Shasta** (100%) 6.89 Shasta/m^2 Pop. size: 2000–3000 Shasta	**7 Shasta** (13%) population size: 369 ± 135 Shasta 45 signal (87%)		**23 Shasta** (2%) 0.097 Shasta/m^2 1220 signal (98%) 5.126 signal/m^2	**7 Shasta** (0.5%) 0.029 Shasta/m^2 1327 signal (99%) 5.576 signal/m^2	**2 Shasta** (0.4%) 0.008 Shasta/m^2 457 signal (99%) 1.920 signal/m^2
Baum Lake	Baum Lake at Crystal Inflow	**3 Shasta** (1%) 0.09 Shasta/m^2 230 signal (99%) 3.81 signal/m^2	19 signals (100%)	**1 Shasta** (10%) 9 signal (90%)	**0 Shasta (0%)** 172 signal (100%) 0.831 signal/m^2	**0 Shasta (0%)** 283 signal (100%) 1.367 signal/m^2	**0 Shasta (0%)** 193 signal (100%) 0.932 signal/m^2
Rising River	Rising River Road Bridge			**7 Shasta**			
	Rising River footbridge			**7 Shasta**			
	Rising River Lake outflow	**25 Shasta** 2 Shasta/m^2 Pop. size: 100 Shasta	**18 Shasta**	**18 Shasta**			
	Rising River Lake			**5 Shasta**			

[a] Daniels, 12 June – 7 November 1978 (unpublished data in letter dated 7/13/95, Daniels 1978, Daniels 1980, Eng and Daniels 1982)
[b] Clarke and Light, 19, 22, 27 June & 3 July 1990 (Light 1990 unpublished notes, Light 1991, Light et al. 1991, Erman et al. 1993)
[c] Light and Myrick—Summer 1991 (Light 1991 unpublished data, Erman et al. 1993)
[d] Ellis and Cook, 6 August and 21 & 27 October 1993 (Ellis 1994)
[e] PG&E Shasta crayfish monitoring September 2003 – February 2004 (Spring Rivers 2004)
[f] PG&E Shasta crayfish monitoring November 2004 – February 2005 (Spring Rivers 2005)
[g] PG&E Shasta crayfish monitoring January– April 2007 (Spring Rivers 2008)
[h] Habitat and crayfish data were verified and updated in 2009. Crayfish densities were calculated using the total area of prime and adequate habitat except at South shore Big Lake and South shore upper Tule River where the area of marginal habitat, which was the only habitat present, was used.

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Shasta crayfish populations are possible. It is apparent, however, that since the first surveys Shasta crayfish have generally decreased in their distribution and numbers, while signal crayfish have increased in their distribution and numbers. The increase in the number of Shasta crayfish encountered in Southwest Crystal Lake during the last three surveys, compared to earlier surveys, is due to the use of scuba in the surveys, which improved sampling. During the same period, Shasta crayfish have decreased in numbers in both the Middle Cove and the Crystal Lake outflow. In 1978, Daniels (1978, 1980) estimated the size of the Crystal Lake outflow Shasta crayfish population to be 2000 to 3000 individuals and described it as one of the largest, densest populations that he surveyed. In 2007, only two Shasta crayfish were found at the Crystal Lake outflow. The first signal crayfish was found at Crystal Lake outflow in November 1978 (Daniels 1980). In 1990–1991, 13% of the crayfish at Crystal Lake outflow were Shasta crayfish. By 2003 the percentage of Shasta crayfish at Crystal Lake outflow was less than 2% and by 2007 it was only 0.4%. In the absence of some reversal in the current trend, it seems likely that Shasta crayfish will be extirpated from all Crystal Lake locations except Southwest Crystal Lake by the next survey in 2012.

Table 10 summarizes all data on the Shasta crayfish surveys in the Pit 1 Project vicinity between 1978 and January 2009. Similar to the Hat Creek vicinity data, only general comparisons of past and present Shasta crayfish populations are possible. In 1978, Daniels found mainly Shasta crayfish in the Pit 1 Project vicinity, but fantail crayfish were found with Shasta crayfish at some sites in the mainstem Pit River (Table 10). During surveys in the early 1990s, fantail crayfish were only found in Fall River Pond and the Pit 1 Bypass Reach, until one fantail crayfish was found along the South Shore Big Lake levee in November 1993. Fantail crayfish are now found throughout much of the Tule River Levee System. In the 1990s, signal crayfish were present throughout most of the mainstem Pit River and in several areas of the Fall River drainage, but were absent from most of the headwaters of the Fall River drainage. Signal crayfish are now found throughout most of the Fall River drainage, including most of the headwater areas.

Shasta crayfish have been found at 25 locations (as listed in Tables 9 and 10) in the Hat and Pit 1 project vicinities since 1978. The most recent survey confirmed Shasta crayfish present at 15 locations with fewer than 10 Shasta crayfish at 8 of these locations, including the Pit River

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Table 10 Crayfish population characteristics (number, density, estimated population size, and percent composition) from previous and current surveys in the Pit 1 Project vicinity.

Region and Location		1978 [a]	1990, 1991, 1992 [b]	1993 [c] 1997 [d]	2001 [e]	2004–2007 [f,g]	2007–2009 [g, h]
Upper Fall River	Thousand Springs above barrier	**5–20 Shasta** 0.23–0.75 Shasta/m^2	**230 Shasta**			**280 Shasta (92%)** 0.212 Shasta/m^2 24 signal (8%) 0.018 signal/m^2	**250 Shasta (71%)** 0.189 Shasta/m^2 102 signal (29%) 0.077 signal/m^2
	Thousand Springs below barrier		**24 Shasta**			**2 Shasta (<1%)** 1518 signal (>99%)	**0 Shasta (0%)** 38 signal (100%)
	Rainbow Spring	**8 Shasta** **9 Shasta** (1985)	**45 Shasta (88%)** 6 signal (12%)			**19 Shasta (45%)** (*2003 survey*) 23 signal (55%)	**8 Shasta (5%)** 153 signal (95%)
	Fletcher's Bend		**4–11 Shasta (65%)** 0–6 signal (35%)	**4 Shasta (29%)** 0 Shasta (1995) 10 signal (71%)		**0 Shasta (0%)** 450 signal (100%) 1.705 signal/m^2	**0 Shasta (0%)** 90 signal (100%) 0.341 signal/m^2
	Lennihan's Footbridge		**11–13 Shasta (68%)** 0–6 signal (32%)	**1 Shasta (17%)** 5 signal (83%)		**0 Shasta** 112 signal (100%) 0.519 signal/m^2	**0 Shasta (0%)** 122 signal (100%) 0.565 signal/m^2
Spring Creek	Upper coves	**50 Shasta** Pop. size: 600–1000 0.79 Shasta/m^2	**466 Shasta** Population size: 4640 ± 627 0.83 Shasta/m^2			**316 Shasta (70%)** 0.033 Shasta/m^2 76 signal (30%) 0.008 signal/m^2	**94 Shasta (23%)** 0.010 Shasta/m^2 310 signal (77%) 0.032 signal/m^2
	Lower Coves	**8 Shasta** Pop. size: 10–50 0.50 Shasta/m^2	**17 Shasta**			**26 Shasta (30%)** 0.015 Shasta/m^2 61 signal (70%) 0.034 signal/m^2	**13 Shasta (3%)** 0.007 Shasta/m^2 435 signal (97%) 0.244 signal/m^2
Lava Creek	Lava Creek	**47 Shasta** 2.85 Shasta/m^2	**118 Shasta (98%)** 2 signal (1990) (2%)	**12–73 Shasta** (1993–1995) many signal			**45 Shasta (9%)** 468 signal (91%)
	Horr's Northern Pond	**12 Shasta** Pop. size: 50–100 0.12 Shasta/m^2		0 Shasta			

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Table 10 (continued)

Region and Location		1978 [a]	1990, 1991, 1992 [b]	1993 [c] 1997 [d]	2001 [e]	2004–2007 [f,g]	2007–2009[g, h]
Ja She Creek	Ja She Creek headwaters	0 Shasta (at bridge)	**33 Shasta** 1 signal (at bridge)		**62 Shasta** 364 signal	**54 Shasta (4%)** 0.006 Shasta/m^2 1386 signal (96%) 0.163 signal/m^2	**82 Shasta (4%)** 0.010 Shasta/m^2 1783 signal (96%) 0.210 signal/m^2
Ja She Creek	Crystal Springs Cove	1 Shasta molt 0.04 Shasta/m^2	**11 Shasta**		**17 Shasta** 315 signal	**4 Shasta (<1%)** 0.001 Shasta/m^2 1791 signal (>99%) 0.485 signal/m^2	**4 Shasta (<1%)** 0.001 Shasta/m^2 1748 signal (>99%) 0.473 signal/m^2
Ja She Creek	Tule Coves		**16 Shasta** 8 signal		**13 Shasta** 39 signal	**8 Shasta (13%)** 0.038 Shasta/m^2 52 signal (87%) 0.246 signal/m^2	**2 Shasta (2%)** 0.009 Shasta/m^2 103 signal (97%) 0.488 signal/m^2 1 fantail (1%) 0.005 fantail/m^2
Upper Big Lake	Big Lake Springs	**12 Shasta** 1.00 Shasta/m^2	**39 Shasta**		**61 Shasta**	**36 Shasta (92%)** 0.203 Shasta/m^2 3 signal (8%) 0.017 signal/m^2	**41 Shasta (27%)** 0.232 Shasta/m^2 109 signal (73%) 0.616 signal/m^2
Upper Big Lake	North Big Lake[f]		**32 Shasta**		**49 Shasta** 10 signal	**9 Shasta (2%)** 0.007 Shasta/m^2 355 signal (98%) 0.269 signal/m^2	**8 Shasta (1%)** 0.006 Shasta/m^2 590 signal (99%) 0.448 signal/m^2
Upper Big Lake	Northeast Big Lake	**10 Shasta** 1.11 Shasta/m^2 (East Shore)	**32 Shasta**		0 Shasta 6 signal	**1 Shasta (25%)** 0.004 Shasta/m^2 3 signal (75%) 0.011 signal/m^2	0 Shasta 0 signal
Upper Big Lake	Northwest Big Lake		**7 Shasta**		**3 Shasta** 12 signal	**1 Shasta (33%)** 0.091 Shasta/m^2 2 signal (67%) 0.182 signal/m^2	**2 Shasta (20%)** 0.182 Shasta/m^2 8 signal (80%) 0.727 signal/m^2

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Table 10 (continued)

Region and Location		1978 [a]	1990, 1991, 1992 [b]	1993 [c] 1997 [d]	2001 [e]	2004–2007 [f,g]	2007–2009 [g, h]
Tule River Levee System	South Shore Big Lake (only near Big Lake levee cove in 2004–2007)	**30 Shasta** 3.56 Shasta/m^2	**0–9 Shasta**	**2 Shasta (66%)** 1 fantail (33%)		**9 Shasta (43%)** 0.007 Shasta/m^2 3 signal (14%) 0.002 signal/m^2 9 fantail (43%) 0.007 fantail/m^2	**0 Shasta** 3 signal (5%) 0.002 signal/m^2 59 fantail (95%) 0.047 fantail/m^2
	Northeast upper Tule River	**30 Shasta** 1.20 Shasta/m^2	**5 Shasta (83%)** 1 signal (17%)		0 Shasta	**0 Shasta** 0 signal 5 fantail (100%) No habitat identified	**0 Shasta** 2 signal (13%) 14 fantail (88%)
	South shore upper Tule River		**4 Shasta (29%)** 10 signal (71%)	**0 Shasta** 1 signal YOY		**0 Shasta** 18 signal (23%) 0.857 signal/m^2 60 fantail (77%) 2.857 fantail/m^2	
	East shore upper Tule River		Shasta molts 11 signal			**0 Shasta** 1 signal (100%) No habitat identified	
	Horr Pond levee		**7 Shasta**		0 Shasta 26 signal 5 fantail	**0 Shasta** 7 signal (18%) 0.093 signal/m^2 33 fantail (82%) 0.440 fantail/m^2	**0 Shasta** 4 signal (17%) 0.053 signal/m^2 20 fantail (83%) 0.267fantail/m^2
Fall River Pond	Fall River Pond	**1 Shasta** 0.15 Shasta/m^2	0–many signal 0–most fantail			**0 Shasta** 8 signal (3%) 0.002 signal/m^2 230 fantail (97%) 0.047 fantail/m^2	

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Table 10 (continued)

Region and Location		1978 [a]	1990, 1991, 1992 [b]	1993 [c] 1997 [d]	2001 [e]	2004–2007 [f,,g]	2007–2009[g, h]
Mainstem Pit River	Pit River Falls (Pit 1 Bypass)		**4 Shasta** (1995) many fantail			**21 Shasta (49%)** 0.028 Shasta/m^2 10 signals (23%) 0.013 signals/m^2 12 fantail (28%) 0.016 fantail/m^2	**1 Shasta (dead; 2%)** 0.001 Shasta/m^2 29 signals (55%) 0.039 signals/m^2 23 fantail (43%) 0.031 fantail/m^2
	Canyon spring (Pit 1 Bypass)	1 Shasta (dead)	1 Shasta (dead) signal present 0 fantail				
	Sand Pits (below Pit 1 Power-house and 299 Bridge)	**8 Shasta (3%)** 0.44 Shasta/m^2 297 fantail (97%) 3.11 fantail/m^2	0 Shasta abundant signal 0 fantail			**0 Shasta** many signals 1 fantail	
Sucker Springs	Sucker Springs Creek (all ponds)	**10 Shasta** 0.2 Shasta/m^2	**4 Shasta (<< 1%)** 47 signal (>>99%) Pond 5	**27 Shasta** Pond 3	**53 Shasta**	**3 Shasta (<< 1%)** 2066 signal (>>99%)	**7 Shasta (1%)** 750 signal (99%)

[a] Daniels, June – October 1978 (unpublished data in letter dated 7/13/95, Daniels 1978, Daniels 1980, Eng and Daniels 1982)
[b] Light 1990 unpublished notes, Hesseldenz and Ellis 1991, Light et al. 1991, Erman et al. 1993, Ellis 1996
[c] PG&E Shasta crayfish monitoring along the South Shore Tule River levee on 6 March, 12 August, 31 October 2007 (Spring Rivers unpublished data)
[d] Ahjumawi Lava Springs State Park Survey (Spring Rivers 2001)
[e] PG&E Shasta crayfish monitoring March 2004 – February 2007 (Spring Rivers 2007a)
[f] Habitat and crayfish data were verified and updated in 2009. Crayfish densities were calculated using the total area of prime and adequate habitat except at South shore Big Lake and South shore upper Tule River where the area of marginal habitat, which was the only habitat present, was used.
[g] PG&E Shasta crayfish monitoring March 2007 – March 2009

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upstream of the Pit River Falls where only one dead Shasta crayfish was found in 2008. There has been a general decline in Shasta crayfish distribution and abundance. At the same time, introduced signal crayfish have continued to expand their range since the late 1970s and are now widespread and abundant throughout almost all Shasta crayfish habitat. Introduced fantail crayfish have expanded their range in the upper Tule River and Big Lake since 1993. In 1978 Shasta crayfish accounted for 100% of the crayfish encountered everywhere but the mainstem Pit River downstream of the Pit 1 Powerhouse. In 2009, Shasta crayfish, on average, account for less than 10% of the crayfish encountered (Figure 13).

Within the Hat and Pit 1 Project vicinities, Shasta crayfish have not been found in the Fall River at either Fletcher's Bend or Lennihan's Footbridge, Northeast Upper Tule River, South Shore Upper Tule River, East Shore Upper Tule River, and Horr Pond Levees since the mid-1990s. Although Shasta crayfish have not been found in Baum Lake since then either, the Shasta crayfish found in 1978 and 1993 may have represented wash downs from Crystal Lake rather than a self-sustaining population. The last Shasta crayfish found in Fall River Pond and at the Pit River Sand Pits was in 1978. These locations are all inhabited by either signal crayfish, fantail crayfish, or both non-native species. No Shasta crayfish have been found during at least the two previous surveys of these areas and Shasta crayfish are presumed extirpated from these locations. We propose to not survey these areas during future Shasta crayfish surveys.

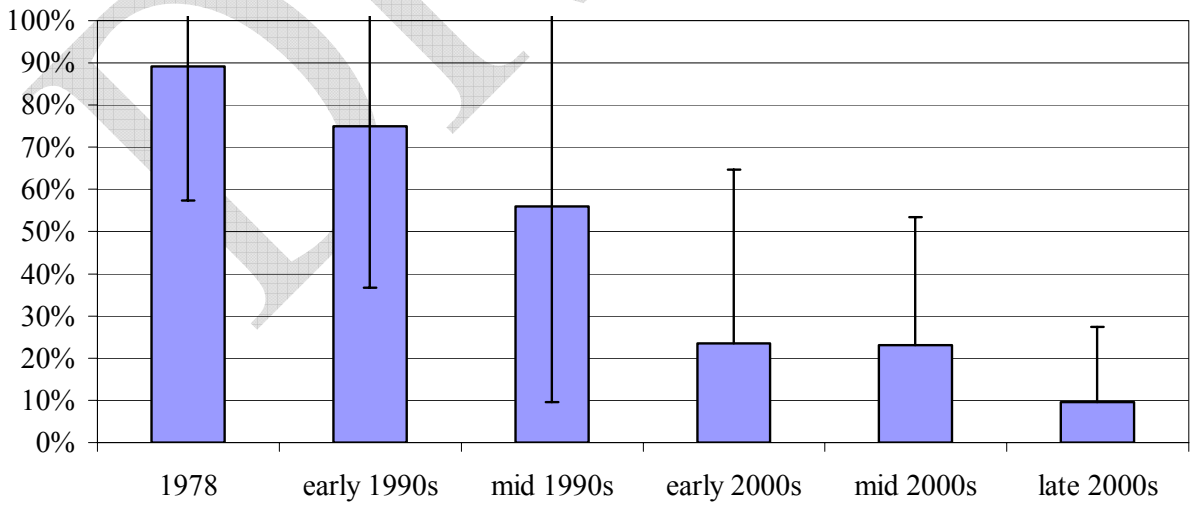

Figure 13 Mean (± standard deviation) percent crayfish species composition represented by Shasta crayfish encountered during crayfish surveys since 1978.

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Recovery Team Activities

Grant Funding

Spring Rivers Foundation worked together with the USFWS, CDFG, and CDPR to prepare a grant proposal for 2007 Preventing Extinction Funding, which was submitted to USFWS on 9 May 2007. The Shasta crayfish proposal was not funded in 2007. Spring Rivers Foundation submitted a grant proposal for 2008 Preventing Extinction Funding on 2 April 2008. Although this proposal did not receive Preventing Extinction Funding, it was awarded Director's Deferred Funds on 24 July 2008.

Sucker Springs Restoration Project

The Sucker Springs Creek Restoration Project is a multi-year, cooperative effort by the USFWS Endangered Species Recovery Program, the USFWS Partners for Fish and Wildlife, PG&E, and Spring Rivers Foundation, a non-profit 501(c) (3) corporation dedicated in part to working toward the recovery of Shasta crayfish. The goal of the restoration project is to improve habitat for Shasta crayfish by eliminating non-native signal crayfish and restoring geomorphic features to create more suitable physical habitat for Shasta crayfish. Spring Rivers Foundation is responsible for design and implementation of the restoration work.

In early 2006, all appropriate permits were acquired for stream restoration activities (i.e., CDFG 1600 Streambed Alteration Permit, Water Quality Certification from Regional Water Quality Control Board, Section 7 ESA consultation, Army Corps Nationwide 27 permit, and Section 106 programmatic agreement with the State Historic Preservation Officer). As part of the eradication efforts, two decrepit weirs, that provided habitat for signal crayfish and could not be adequately surveyed, were removed in September and October 2006. Before the upper of the two weirs was removed, an aluminum velocity barrier was constructed to halt any signal crayfish from migrating upstream (Spring Rivers 2007b).

The aluminum velocity barrier was originally constructed and installed on 25 and 26 October 2006 by Spring Rivers (Spring Rivers 2007b). It was rebuilt on 16 May 2007 after vandals had removed two stainless steel plates, which had been the integral bank contact points on both sides

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of the barrier. In addition, a rock V-weir was installed with the initial velocity barrier to stop slope adjustment and prevent destabilization of the velocity barrier. The V-weir was partially successful. When the barrier had to be rebuilt, an additional V-weir was constructed by placing large (~200 mm) cobble from onsite into the gravel bed between the original V-weir and the rebuilt velocity barrier. This additional measure has stopped slope adjustment and prevented destabilization of the velocity barrier.

Since 2006, Spring Rivers, under contract with Spring Rivers Foundation, has removed signal crayfish from Sucker Springs Creek by hand and with baited traps. These efforts continued the work of CDFG (1996–2000) and Spring Rivers (1996–2005), which have kept the number of signal crayfish in Sucker Springs Creek in check for the last 12 years. In 2006, in addition to snorkel surveys of Sucker Springs Creek to hand remove signal crayfish, enclosures were constructed around bank areas that were believed to harbor signal crayfish. These problem bank areas were isolated by constructing a wall of sandbags and thick construction plastic around each area to reduce water flow (Figure 14). The enclosures were left in place through early 2008. During that period, minnow traps baited with sardines were set out in the enclosures to capture signal crayfish. The traps were replenished and checked at least weekly. Trapped Pit sculpin, rough sculpin, and rainbow trout were released outside the enclosures. Once all rough sculpin (a fully protected, state-listed threatened species) were removed from the enclosures, CDFG-approved electrofishing techniques were employed inside the enclosures.

A backpack electrofishing unit (Smith-Root, model LR-24), set at standard fish-collection settings, was used to check for, and remove, any remaining fish inside the enclosures. After all fish were removed, settings were adjusted to more effectively agitate and draw signal crayfish from crevices within the banks. A method of intermittent shocking proved effective at enticing crayfish out of hiding places and into the open. Once in open water, crayfish were shocked to temporarily immobilize them for easy collection with dip nets.

Snorkel and electrofishing surveys showed that some signal crayfish remained in the bank habitat within the enclosures, so an additional method was devised to target them. In October 2007, PG&E provided personnel and a small excavator, to dig trenches into the bank on the

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upstream and downstream ends within each enclosure and along the front edge of the bank. Trenches were dug several feet into the bank and about one foot into the bottom substrate. A single section of plastic-coated, fine (i.e., 20-mesh) stainless-steel screen attached to 2 x 3-inch mesh, galvanized yard fencing was placed in each trench against the bank to entomb remaining signal crayfish. Screens were anchored to the substrate by back-filling the trenches with on-site substrate material. Gravel provided a good anchor medium with minimal interstitial areas for signal crayfish to crawl through. Cobble and boulder were added on top of the gravel, while rebar stakes were used to secure the top of the screens (Figure 15).

Figure 14 Several enclosures made with sandbags in Pond 4, with minnow traps deployed inside the walls.

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Figure 15 Small excavator back-filling the trenches after installation of the single section of screen at an enclosure in Pond 4.

The disturbance created during trench digging displaced many signal crayfish from their bank habitat into the enclosure, from which they were collected during subsequent electrofishing surveys and trapping. More signal crayfish, however, remained among the sandbags of the enclosure. In early 2008, before young-of-year signal crayfish would be free-living, one sandbag enclosure was removed to collect those remaining signal crayfish (Figure 16). Seventeen signal crayfish were collected during deconstruction of the enclosure, and an additional three crayfish in the immediate vicinity were removed during a follow-up snorkel survey. The sandbag enclosure was not reconstructed because the screen now prevented signal crayfish from entering the channel. Reconstruction likely would have provided more signal crayfish habitat that could not have been adequately surveyed. Other sandbag enclosures were deconstructed in early 2008.

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Figure 16 Screened bank section after removal of the sandbag enclosure.

In 2008, the various eradication methods used in ponds 2, 3, and 4 resulted in the removal of 192 signal crayfish: 88 adults, 78 juveniles, and 26 young-of-year. Snorkel surveys in the main channel turned up 153 signal crayfish, while 30 signal crayfish were collected from traps and 9 signal crayfish were shocked. After March 2008, all but one sandbag enclosure was left in place, which put a stop to effective electro-fishing. Traps remained in use in areas where crayfish were thought to be in the bank and produced crayfish throughout the year. The sex, size measured as total carapace length (TCL), and general condition (e.g., reproductive state, missing appendages, and molt state) were collected from all crayfish captured by all methods. All signal crayfish were exterminated. Figure 17 shows the number of signal crayfish collected annually during eradication efforts in ponds 2, 3, and 4 at Sucker Springs Creek since 2001.

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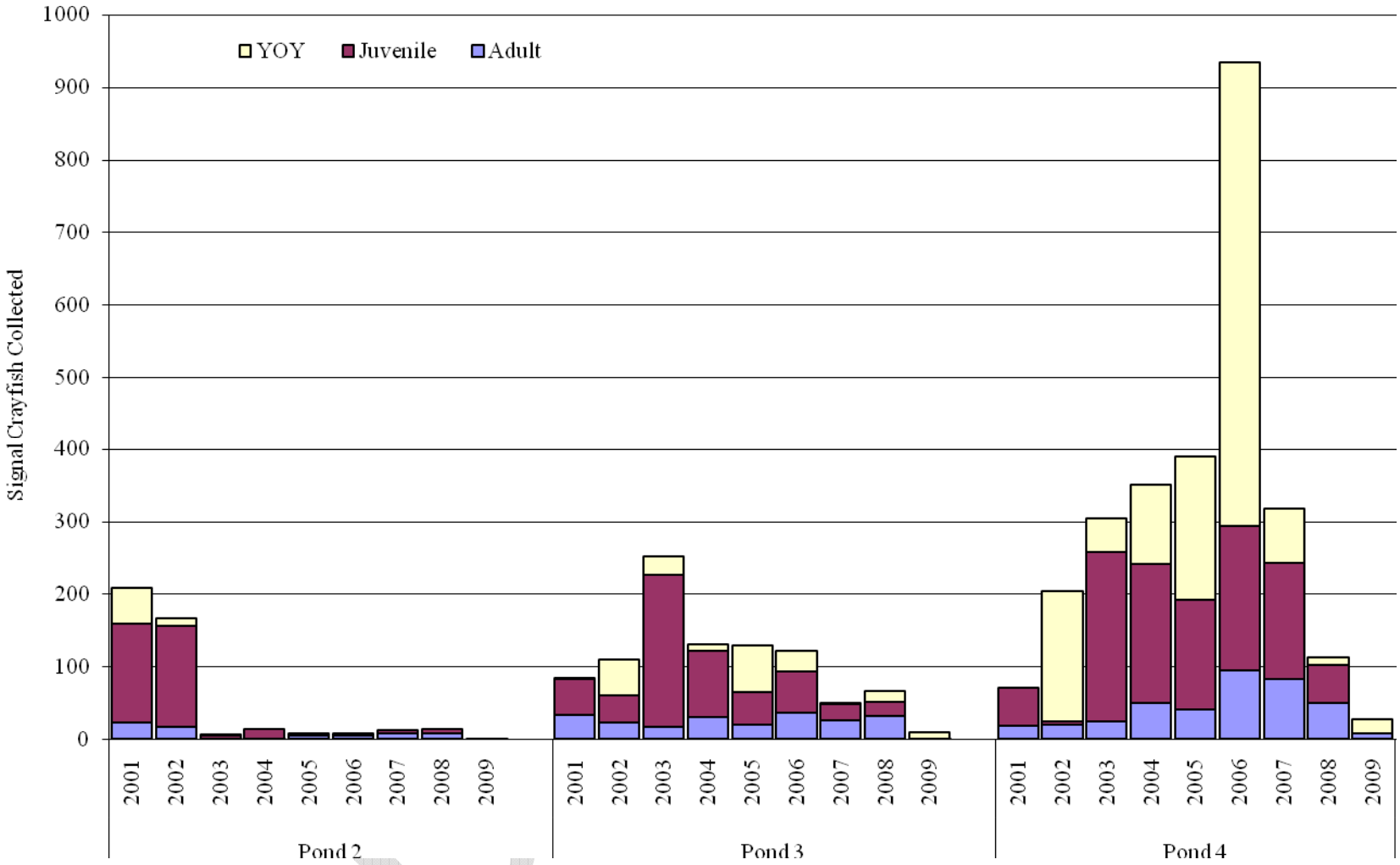

Figure 17 Signal crayfish collected during eradication efforts in ponds 2, 3, and 4 at Sucker Springs Creek since 2001.

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Sand bag exclusion barriers proved instrumental in drawing signal crayfish out of bank habitat by creating pond-like conditions in which baited traps and electro-fishing worked effectively. Unfortunately, the sand bags also created habitat that could not be surveyed until the barriers were taken down.

Signal crayfish eradication efforts will continue through 2009. To aid these efforts a secure barrier to halt any migration upstream from Pond 5 is needed. Structural deficiencies in the Pond 4 Weir (at the upstream end of Pond 5) have begun to appear, They include deteriorating concrete and water flowing visibly through the substrate and underneath the weir. Like the other weirs that were removed in 2006, the Pond 4 Weir creates habitat for signal crayfish at the upper end of Pond 5, and it is possible that some of the signal crayfish found recently in the lower end of Pond 4 moved up past the weir (e.g., through the gravel underneath the weir) from Pond 5. Restoration of the complete channel cannot begin until we can demonstrate that signal crayfish no longer inhabit the restoration area (i.e., no reproduction has occurred for at least one year, and no signal crayfish have been collected for at least one year). The Pond 4 Weir no longer appears to be a secure barrier to upstream migration from Pond 5 so it should be fortified or replaced as soon as possible.

CDFG Temperature Study

The objective of the CDFG Temperature Study at the Crystal Lake Fish Hatchery is to compare the growth of Shasta crayfish and signal crayfish at water temperatures of 50 °F and 56 °F. After the 2006 operating failure that resulted in only heated water entering the 56 °F treatment raceway and mortality of all the Shasta crayfish, CDFG continued their temperature study in 2007. On 15 June 2007, two female Shasta crayfish (1 berried and 1 with instars) were collected from Crystal Lake by Spring Rivers and handed over to CDFG biologist Steve Baumgartner. On 3 October 2007, after a failed brood in the hatchery raceway, Spring Rivers returned the two adult females and one surviving young-of-year to the area where they had been collected. On 7 May 2008, four berried Shasta crayfish were collected from Spring Creek by Spring Rivers and handed over to CDFG biologist Steve Baumgartner. On approximately 17 or 18 September 2008, all four female Shasta crayfish at Crystal Lake Fish Hatchery died. All crayfish were being held in 50 °C

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water. Specimens were frozen. As of the 24 September 2008 TRC/Recovery Team meeting, five YOY Shasta crayfish were still being held in 50 °C water at Crystal Lake Fish Hatchery.

In 2009, Spring Rivers personnel will install 18 temperature recorders at 10 locations presently inhabited by Shasta crayfish. The recorders will be installed at Thousand Springs, Spring Creek, Ja She creek, Big Lake Springs, Big lake Levee Cove, Pit River Falls, Sucker Springs Creek, Crystal lake, Rock Creek, and Rising River Lake (landowner permission pending). Recorders will be left in place for at least one year. Temperature will be recorded every hour. These data will document the range of water temperatures experienced by extant Shasta crayfish populations.

CDFG Genetics Study

CDFG has received two grants authorized under Section 6 of the Endangered Species Act to do a genetics study on Shasta crayfish. The study is being conducted at the Genomic Variation Laboratory of Bernie May, Ph.D. at the University of California, Davis. The goal is to document potential genetic variability within and among Shasta crayfish subpopulations that have experienced varying degrees of genetic isolation depending on their proximity to one another. After additional research by Spring Rivers and discussions with the TRC, it was determined that a single, second walking leg (i.e., pereopod 3), removed at the transverse fracture of the ischium, would provide sufficient genetic material while minimizing harm to the donor Shasta crayfish. Spring Rivers has primarily sampled Shasta crayfish during surveys required by the Hat Creek and Pit 1 licenses, although some additional surveys not covered under the licenses have also been conducted. Genetic sampling is only done on Shasta crayfish greater than, or equal to, 20-mm total carapace length. A maximum of 35 crayfish per subpopulation and/or location can be sampled during the study. Both field sampling and lab analysis are still ongoing and final results from the genetics study will not be known for a couple of years.

Genetic analyses are based upon genotyping of each individual crayfish sampled at nine microsatellite loci. Microsatellites are co-dominant (both maternal/paternal alleles can be observed), neutral markers that are employed to uncover population structure. Microsatellites can also be utilized to look for evidence of gene flow, hybridization, and inbreeding. The

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presence of population structure suggests that those populations found to be significantly different from one another are not randomly admixing, and may have accumulated local adaptations to their specific environment.

In 2007, DNA samples were taken from 24 Shasta crayfish in Lava Creek, five Shasta crayfish in Rainbow Spring, and two Shasta crayfish in Sucker Springs Creek. The small size of these Shasta crayfish populations limited the number of samples that could be obtained. An additional 17 Shasta crayfish from Big Lake were sampled to supplement the 18 samples collected in 2004. The Pit River upstream of Pit River Falls was surveyed on 11 May 2007 to obtain genetic samples from the Pit River Shasta crayfish, but no crayfish were found. On 16 November 2007, the second survey to obtain Shasta crayfish from the Pit River was aborted due to unfavorable survey conditions (i.e., high discharge and low visibility). Spring Rivers is awaiting approval from landowners to survey for Shasta crayfish in Rising River. Table 11 displays the genetics study working data set, which currently includes 235 individuals from nine sampling locations.

Table 11 Number of Shasta crayfish sampled for the genetics study by location, 2004-2007.

Population	Number	Date
Big Lake Springs	18	2004
	17	2007
Crystal Lake	35	2004
Thousand Springs – Fish Trap Cove	35	2005
Thousand Springs – Property Line	35	2005
Spring Creek	35	2005
JaShe Creek	35	2006
Lava Creek	24	2007
Sucker Springs	2	2007
Rainbow Springs	5	2007

Preliminary results indicate that there is a fair amount of variation among the subpopulations sampled to date and that the amount of genetic variability within subpopulations varied by location. Three different genetic clusters have been identified from the samples: 1) Crystal Lake, 2) Big Lake Springs/Ja She Creek/Lava Creek/Spring Creek, and 3) Thousand Springs. The two samples from Sucker Springs Creek fit with the Big Lake Springs/Ja She Creek/Lava Creek/Spring Creek cluster. The five samples from Rainbow Springs show the highest

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probability of assignment to the Big Lake Springs/Ja She Creek/Lava Creek/Spring Creek cluster, however, some probability is given that three of the five individuals may assign to the Thousand Springs group. The Rainbow Springs individuals may not be clearly assigning because: (1) we may not have a reference population remaining that is representative of the diversity that is found in Rainbow Springs, or (2) the results may be reflective of gene flow or perhaps a hybrid zone between the Big Lake Springs and Thousand Springs genetic types.

Crystal Lake had more genetic variation than any other cluster. Genotyping of signal crayfish from Crystal Lake indicated no genetic evidence of hybridization between the species. A summary of the genetics study data, presented at the 9 April 2008 TRC meeting by Jessica Peterson of the UC Davis Genomic Variability Laboratory, is included in Appendix F.

Genetics samples were collected (one each) from Pit River and Sucker Springs Creek during 2008 and winter 2009. Samples were sent to the UC Davis Genomic Variability Laboratory for inclusion in the data set.

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2009 Projected Activities

Technical Review Committee

The first 2009 meeting of the Shasta crayfish TRC and Shasta crayfish Recovery Team will be held on 22 April 2009 in Redding. The second Shasta crayfish TRC/Recovery Team meeting will be scheduled at the April meeting for Fall 2009.

The group will try to organize a meeting in 2009 with CDFG engineer George Heise, CDFG biologists Steve Baumgartner and Glenn Yoshioka, CDFG Senior Hatchery Supervisor Linda Radford, PG&E personnel (i.e., license manager, biologist, and groundwater hydrologist), and Spring Rivers' biologists Maria Ellis and Jeff Cook to discuss the potential Rock Creek restoration. Topics for discussion include site assessment methods (e.g., for hydrologic testing), establishment of criteria and thresholds for moving forward (e.g., acceptable percolation rates), and (3) discussions of conceptual designs for the necessary facilities (e.g., new diversion dam and intake structures).

The third Pit 1 monitoring survey will begin in 2009. The next scheduled survey of the Hat Creek Project vicinity, which will be the fourth survey, is in 2012. Efforts to obtain permission to survey Rising River will continue, and surveys will begin once permission is obtained. Eradication surveys related to the Upper Fall River Crayfish Barrier Project and the Spring Creek Road Crossing Cavity-Filling Project will continue in 2009. The 2009 survey data will be reported in the 2009 Shasta Crayfish Technical Review Committee Annual Report, which will be due to the agencies and FERC by 31 May 2010.

Recovery Team

Eradication efforts and repair/replacement of weirs in Sucker Springs Creek will continue in 2009 with the continued help of PG&E. Based on discussions at the April 2008 TRC meeting, the plan is to try to repair or replace the Pit 4 Weir, and possibly the Pit 5 Weir as well, in 2009. Work will continue on the design and installation of appropriate barriers adjacent to the Pond 4 and 5 weirs. Eradication methods will be reviewed and modified, as necessary, to improve effectiveness.

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CDFG plans to continue its temperature and genetics studies in 2009.

Efforts to obtain permission to survey Rising River will continue, and surveys will begin once permission is obtained. If permission can be obtained to survey and collect genetic samples, samples from Shasta crayfish in Rising River will be collected and sent to UC Davis Genomic Variability Laboratory.

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APPENDIX A—FERC License Articles pertaining to Shasta crayfish for the Hat Creek and Pit 1 Projects

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Hat 1 Project (FERC No. 2661) License Articles pertaining to Shasta Crayfish

Article 409. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, within six months of issuance of the license the licensee shall file with the Commission, for approval, an implementation plan to monitor the habitat and populations of Shasta crayfish in the Project Area. The plan shall include, but shall not be limited to, the following: (1) characterization of suitable Shasta crayfish habitat; (2) provisions to map and quantify amounts of existing (baseline) suitable habitat; (3) quantitative assessment of existing Shasta crayfish populations in the Project Area; (4) methodology for annual monitoring; and (5) annual reporting requirements including progress milestones.

The licensee shall include with the plan, documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the plan. The licensee shall allow a minimum of 60 days for U.S. Fish and Wildlife Service and California Department of Fish and Game to comment and to make recommendations before filing the plan with the Commission. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on site-specific conditions.

The Commission reserves the right to require changes to the plan. The plan shall not be implemented until the licensee is notified that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Article 410. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall within three months of license issuance, in coordination with the U.S. Fish and Wildlife Service, California Department of Fish and Game, Natural Resources Conservation Service, other resource agencies and interested stakeholders, establish a technical review committee (committee) for the purpose of assisting the licensee in the design and implementation of the terms and conditions required in the biological opinion (primarily focused on Shasta crayfish protection and recovery in the project area). The licensee in coordination with committee members shall establish rules of protocol for conduct of meetings, correspondence, and other communications necessary for committee activities. The licensee in coordination with committee members shall develop written guidance for the committee that describes the purpose, goals, and objectives of the committee. The purpose, goals, and objectives shall be consistent with the Shasta crayfish recovery plan and any new scientific information that may become available. The licensee shall provide to the Commission and the committee by May 31 of each year an annual report of the activities of the committee. The licensee shall provide notice to the Commission within 30 days (but prior to implementing change) of any decisions by the committee that result in changes to project operations that fall outside normal operations as described in the licensed project.

Article 411. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall within three months of license issuance establish an inflation indexed interest bearing account (Funding Account). Within 30 days of establishing the Funding Account, the licensee shall establish a separate interest deposit account

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(Interest Account). Funding Account interest payments shall accrue monthly to the Interest Account. The licensee shall be responsible for management of these accounts and all associated costs. Within 45 days following establishment of the Funding Account, the licensee shall deposit $500,000 in the Funding Account. The Funding Account and Interest Account shall be maintained for the term of the license. The licensee shall not withdraw funds from the Funding Account, and shall retain ownership of the asset value in the Funding Account, but all interest accrued shall be deposited into the Interest Account at the end of each month and shall be available for spending by the technical review committee for purposes of implementing the terms and conditions and conservation measures included in the license for protection and recovery of the Shasta crayfish, exclusive of Article 412. The licensee shall provide documentation of the establishment of these accounts to the Commission and the Service within 100 days of license issuance. In lieu of establishment of the Funding Account and Interest Account, the licensee can make available $30,000 annually, each year for the term of the license, adjusted annually for inflation using the Consumer Price Index, to be spent by the technical review committee for the same purposes as described above.

Article 412. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall file with the Commission within six months of the license issuance, for approval, a comprehensive Shasta crayfish management plan for the Project Area developed in coordination with the California Department of Fish and Game, Natural Resources Conservation Service, U.S. Fish and Wildlife Service and interested stakeholders within the Hat Creek drainage, and approved by the U.S. Fish and Wildlife Service. The plan will identify and examine action alternatives the licensee would implement to combat the rapid decline of Shasta crayfish in the Project Area. The plan shall include provisions to provide or maintain habitat refugia for Shasta crayfish isolated from populations of invasive non-native crayfish in the Project Area, and shall include but not be limited to the following: (1) provisions to fund signal crayfish removal on an annual basis in the amount of at least $10,000, and (2) annual reporting requirements including progress milestones. This plan shall include evaluation of known methods for reducing abundance such as hand removal and other methods that may require pilot testing or further research. Details of fish stocking in the Project Area developed in cooperation with the California Department of Fish and Game to protect and minimize the impacts on Shasta crayfish in the Project Area shall also be included in the Shasta crayfish management plan, and shall include but not be limited to the following: (1) written description and mapping of current locations being stocked and frequency of fish stocking on an annual basis, (2) record of historical stocking, and (3) a list of alternative planting locations. The Shasta crayfish management plan shall also include formulation of a plan to reintroduce Shasta crayfish to the Rock Creek springs area. At minimum this plan should include installation of a crayfish barrier, means to eradicate non-native crayfish above the barrier, and restoring historical Shasta crayfish habitat. This reintroduction plan should include methods to be implemented throughout the term of the license to protect and maintain this reintroduced population in stable condition.

The licensee shall include with the plan, documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the plan. The licensee shall allow a minimum of 60 days for U.S. Fish and Wildlife Service and California

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Department of Fish and Game to comment and to make recommendations before filing the plan with the Commission. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on site-specific conditions.

The Commission reserves the right to require changes to the plan. The plan shall not be implemented until the licensee is notified that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Article 413. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall file within six months of license issuance with the Commission, for approval, a recreational management plan (Shasta Crayfish). This plan shall include provisions for educating the general public about the status of the Shasta crayfish, information on potential threats from recreational activities, and protective measures to avoid take as part of the recreation planning for the project. The public outreach effort will serve to increase the public's awareness of the causes for species' endangerment. This information shall include an explanation of the fishing regulations restricting the use of crayfish as bait in the Project Area and distribution area of the Shasta crayfish.

The licensee shall include with the plan, documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the plan. The licensee shall allow a minimum of 60 days for U.S. Fish and Wildlife Service and California Department of Fish and Game to comment and to make recommendations before filing the plan with the Commission. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on site-specific conditions.

The Commission reserves the right to require changes to the plan. The plan shall not be implemented until the licensee is notified that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Pit 1 Project (FERC No. 2687) License Articles pertaining to Shasta Crayfish

Article 409. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall, within six months of license issuance, file for Commission approval, an implementation plan to monitor the habitat and populations of Shasta crayfish in the project area. The plan shall include, but shall not be limited to, the following: (1) characterization of suitable Shasta crayfish habitat; (2) provisions to map and quantify amounts of existing (baseline) suitable habitat; (3) quantitative assessment of existing Shasta crayfish populations in the project area; (4) methodology for annual monitoring; and (5) annual reporting requirements including progress milestones.

The licensee shall include with the plan, a schedule for implementing the plan, for consulting with the U.S. Fish and Wildlife Service and the California Department of Fish and Game, and for filing monitoring reports with the consulted agencies and the Commission, documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments

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are accommodated by the plan. The licensee shall allow a minimum of 60 days for the U.S. Fish and Wildlife Service and California Department of Fish and Game to comment and to make recommendations before filing the plan with the Commission. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on site-specific conditions.

The Commission reserves the right to require changes to the plan. The plan shall not be implemented until the licensee is notified by the Commission that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Article 410. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall within three months of license issuance, in coordination with the U.S. Fish and Wildlife Service, California Department of Fish and Game, California Department of Parks and Recreation, Bureau of Land Management, Natural Resources Conservation Service, other resource agencies and interested stakeholders, establish a technical review committee (committee) for the purpose of assisting the licensee in the design and implementation of the terms and conditions required in the U.S. Fish and Wildlife Service's biological opinion (primarily focused on Shasta crayfish protection and recovery in the project area). The licensee, in coordination with committee members, shall establish rules of protocol for conduct of meetings, correspondence, and other communications necessary for committee activities. The licensee, in coordination with committee members, shall develop written guidance for the committee that describes the purpose, goals, and objectives of the committee. The purpose, goals, and objectives shall be consistent with the Shasta crayfish recovery plan and any new scientific information that may become available. The licensee shall provide to the Commission and the committee, by May 31 of each year, an annual report of the activities of the committee. The licensee shall provide notice to the Commission within 30 days (but prior to implementing change) of any decisions by the committee that result in changes to project operations that fall outside normal operations, as described in the license.

Article 411. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall provide each year, beginning January 1, 2004, for the term of the license, $45,000, adjusted annually per the Consumer Price Index (CPI). These funds shall be for spending by the technical review committee, established pursuant to Article 410, for purposes of implementing the terms and conditions and conservation measures set forth in the biological opinion and incorporated in the license, for protection and recovery of the Shasta crayfish. These funds ($45,000) are distinct from funds required under Article 412 but may be used to supplement funds provided pursuant to Article 412, if approved by the technical review committee.

Article 412. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, within six months of license issuance, the licensee shall file for Commission approval a comprehensive Shasta crayfish management plan for project lands and waters developed in coordination with the U. S. Fish and Wildlife Service, California Department of Fish and Game, California Department of Parks and Recreation, and interested stakeholders within the Pit River drainage, and approved by the U.S. Fish and Wildlife Service. The plan shall identify and examine action alternatives the licensee would implement to combat

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the rapid decline of Shasta crayfish in the project area. The plan shall include provisions to provide or maintain habitat refugia for Shasta crayfish isolated from populations of invasive non-native crayfish in the project area, and shall include but not be limited to the following: (1) provisions to fund signal crayfish removal on an annual basis in the amount of at least $20,000, beginning January 1, 2004, and (2) annual reporting requirements including progress milestones. The funds required in this article for signal crayfish removal are distinct from those required in Article 411 above; however, should signal crayfish removal be deemed no longer necessary (as determined by the technical review committee, established pursuant to Article 410), these funds may be used for implementation of other terms and conditions, if approved by the technical review committee. This plan shall include evaluation of known methods for reducing abundance, such as hand removal and other methods that may require pilot testing or further research. Details of fish stocking in the project area developed in cooperation with the California Department of Fish and Game to protect and minimize the impacts on Shasta crayfish in the project area shall also be included in the Shasta crayfish management plan, and shall include but not be limited to the following: (1) written description and mapping of current locations being stocked and frequency of fish stocking on an annual basis; (2) record of historical stocking; and (3) a list of alternative planting locations.

The licensee shall include with the plan, a schedule for filing any proposed protection and management measures, or any proposed modifications to the project and project operations necessary to protect Shasta crayfish or its critical habitat, documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the plan. The licensee shall allow a minimum of 60 days for the consulted agencies to comment and to make recommendations before filing the plan with the Commission for approval. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on site-specific conditions.

The Commission reserves the right to require changes to the plan. The plan shall not be implemented until the licensee is notified by the Commission that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Article 413. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall within one year of license issuance file for Commission approval a plan to construct and maintain a minimum of two exclusion barriers to protect Shasta crayfish habitat from invasion by signal crayfish. The plan shall include, but not be limited to, the following: (1) provisions to fund the design and construction of two crayfish barriers, not to exceed $150,000 over 4 years; (2) detailed design drawings and map locations of the exclusion barriers; (3) a schedule for construction and initial performance testing; and (4) a monitoring and reporting schedule for long-term evaluation of barrier performance.

The licensee shall include with the plan, documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the plan. The licensee shall allow a minimum of 60 days for U.S. Fish and Wildlife Service and California

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Department of Fish and Game to comment and to make recommendations before filing the plan with the Commission. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on site-specific conditions.

The Commission reserves the right to require changes to the plan. The plan shall not be implemented until the licensee is notified by the Commission that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Article 416. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall, within six months of license issuance, file for Commission approval, a recreation management and public outreach plan. The plan shall include, but not be limited to the following: (1) information regarding the location, design, construction, maintenance, and use of the licensee's five proposed forebay recreational areas; (2) information regarding the location, design, construction, and maintenance of the proposed recreational access to the Pit River near Big Eddy, or a comparable site; (3) information regarding how the licensee would maintain the Rat Farm boat launching access area at Big Lake; (4) protective measures to avoid take as part of the recreation planning for the project; and (5) provisions for educating the general public about the status of the Shasta crayfish and the bald eagle, including information on potential threats from recreational activities. The public outreach effort will serve to increase the public's awareness of the causes for species' endangerment. The information provided to the general public shall include an explanation of the fishing regulations restricting the use of crayfish as bait in the project area and distribution area of the Shasta crayfish.

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APPENDIX B—Shasta Crayfish Management Plan Fund Summary

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Shasta Crayfish Management Plan Fund for the Hat Creek (FERC No. 2661) and Pit 1 (FERC No. 2687) Projects

License Article	Annual Fund $	SAP Order #
Hat Creek Survey Article 411	$ 30,000	10211203
Hat Creek Removal Article 412	$ 10,000	10211204
Pit 1 Survey Article 411	$ 45,000	10213521
Pit 1 Removal Article 412	$ 20,000	10213522

Hat Creek License was issued on November 4, 2002. Shasta Crayfish Plan was approved on August 21, 2003. Funding began on January 1, 2003.
Pit 1 License was issued on March 19, 2003. Shasta Crayfish Plan was approved on July 7, 2004. Funding began on January 1, 2004
Based on Article 413 of the Pit 1 License, the Crayfish Barrier Plan was approved on 8 March 2007.
As part of the Barrier Plan, the biannual (2 times per year) crayfish removal surveys for the Spring Creek Barrier project began in 2008 with an annual budget of $35 K.

	---------2003----------		---------2004----------		---------2005----------		---------2006----------		---------2007----------		---------2008----------	
Study/Task	**Principal**	**CPI**	**Principal**	**CPI**	**Principal**	**CPI**	**Principal**	**CPI**	**Principal**	**CPI**	**Principal**	**Estimated CPI**
Hat Surveys	$ 30,000	$ -	$ 30,000	$ 790	$ 30,000	$ 1,842	$ 30,000	$ 2,902	$ 30,000	$ 4,066	$ 30,000	$ 4,773
Hat Removal	$ 10,000	$ -	$ 10,000	$ 266	$ 10,000	$ 614	$ 10,000	$ 967	$ 10,000	$ 1,355	$ 10,000	$ 1,591
Pit 1 Surveys	$ -	$ -	$ 45,000	$ -	$ 45,000	$ 1,525	$ 45,000	$ 3,073	$ 45,000	$ 4,773	$ 45,000	$ 5,930
Pit 1 Removal	$ -	$ -	$ 20,000	$ -	$ 20,000	$ 678	$ 20,000	$ 1,366	$ 20,000	$ 2,121	$ 20,000	$ 2,635
Barrier Crayfish Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 35,000	$ -
Subtotal	$ 40,000	$ -	$ 105,000	$ 1,056	$ 105,000	$ 4,659	$ 105,000	$ 8,308	$ 105,000	$ 12,315	$ 140,000	$ 14,929
Total Annual Budget	$ 40,000		$ 106,056		$ 109,659		$ 113,308		$ 117,315		$ 154,929	
Spring Rivers Invoiced Amount	$ 40,000		$ 105,000		$ 98,310		$ 113,308		$ 117,315		$ -	
Allocated for Spring Creek Barrier	$ -		$ -		$ -		$ -		$ 12,405		$ -	
Balance/Year	$ -		$ 1,056		$ 11,349		$ -		$ (12,405)		$ 154,929	
Balance To Date (04/1/2008)												**$ 154,929**

The annual amounts for Crayfish surveys (Articles 411) and non-native crayfish removal (Articles 412) were adjusted annually from the original amounts stated in the licenses (2003 dollars for Hat and 2004 dollars for Pit 1) based on the CPI (rate of inflation from 2003 for Hat and 2004 for Pit 1 to 2006) as specified in the license. CPI was calculated based on the U.S. Department of Labor Bureau of Labor Statistics Consumer Price Index (CPI) inflation calculator (http://data.bls.gov/cgi-bin/cpicalc.pl).

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APPENDIX C—TRC Meeting Agendas and Summaries

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SHASTA CRAYFISH TECHNICAL REVIEW COMMITTEE
Hat Creek (FERC Project No. 2661) & Pit 1 (FERC Project No. 2687)
May 3, 2007 (Thursday) - 10:00 am to 4:00 pm
PG&E Shasta Hydro Bull Room ♦ 20818 Black Ranch Road, Burney, CA 96013 ♦ (530) 335–5634
Afternoon Field Trip to Sucker Springs Creek Restoration Project
PG&E Meeting Host: Jason Vann

AGENDA

Introductions (Jason Vann)

TRC Shasta Crayfish Project Updates

- Shasta crayfish Monitoring
  - 2006 TRC Annual Report (due by 31 May 2007)
  - Revised Monitoring Schedule (**Attachment A**)
  - Shasta Crayfish Management Plan Fund (**Attachment B**) (Jim Shang, PG&E)
  - Inclusion of all known Shasta crayfish locations (i.e., Rising River, Rainbow Spring, Lava Creek, Thousand Springs etc.) in study area for Shasta crayfish Monitoring Plans
- Shasta Crayfish Barrier Plan (Jason Vann)
  - FERC approved the Crayfish Barrier Plan on 8 March 2007
  - Plan approved with the modification that the Shasta Crayfish TRC Annual Reports provide updates on PG&E's efforts to secure funding and a proposed schedule for accomplishing the Spring Creek Road culvert cavity filling and biannual eradication/control surveys of non-native crayfish.
- Thousand Springs Crayfish Barrier
  - Cultural Resources Issues
    - Field visit with Lynn Compas (PG&E Cultural Resources Specialist), Spring Rivers, and the landowner at Thousand Springs on 19 April 2007
  - Project Description
    - Modified side-wall design (**Attachment C**)
  - Permitting and Timeline
- Spring Creek Road Culvert Cavity Filling Project and Biannual Non-native Crayfish Eradication/Control Surveys
  - Eradication surveys were done in June (upper coves) and July (lower coves) of 2006
  - Biannual Eradication surveys will start in 2007
    - Other potential avenues for signal crayfish access to upper Spring Creek will be explored
  - Potential Funding sources
- Rock Creek Restoration (Jeff Cook)
  - Discharges at the upstream and downstream end of the upper meadow reach, which has been proposed for habitat restoration and Shasta crayfish introduction (Hat Creek Article 412), were measured on 4 August 2006 and 6 March 2007 to assess the potential surface water loss within this reach.
  - Schedule conference call between CDFG (George Heise & Steve) and Spring Rivers

Recovery Team Shasta Crayfish Projects Updates

- CDFG Temperature Study (Steve Baumgartner)
- CDFG Genetic Study (Jessica Petersen, UC Davis Genomic Variation Lab)
- Sucker Springs Creek Restoration Project—**SITE VISIT**

Establish Action Items / Schedule Next Meeting

Jason Vann (jfv2@pge.com)
PG&E License Coordinator for the Hat Creek and Pit 1 projects (415) 973–6326

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Shasta Crayfish Technical Review Committee
May 2007 Meeting Summary

The following is a summary of the Shasta Crayfish Technical Review Committee and Recovery Team meeting held in Burney on May 3, 2007.

I. Recovery Team Activities (topic was moved ahead on the agenda so that Theo would be able to hear Jessica Peterson's presentation).
   A. Steve B. gave an update on the status of the CDFG Temperature Study
      1) USFWS' 23 May 2005 Biological Opinion for CDFG Section 6 Proposal needs to be revised to allow the capture of 4 additional gravid female Shasta crayfish from Crystal Lake so that the Temperature Study can be restarted in Spring 2007.
   B. Jessica Petersen gave a PowerPoint presentation on the results to-date of the UCD Population Genetics of Shasta Crayfish Study.
      1) Data indicate that there are 3 genetically distinct groups of Shasta crayfish:
         a) Crystal Lake
         b) Big Lake/Ja She Creek/Lava Creek/Spring Creek
         c) 1000 Springs
      2) Although private alleles (alleles unique to the population) were found within each cluster, Crystal Lake has more overall genetic variation than the other groups.
      3) Genotyping of signal crayfish from Crystal Lake showed no genetic evidence of hybridization between species.
      4) Genetic assignment tests place both individuals sampled from Suckers Springs with the Big Lake Springs, etc. cluster.
      5) Conservation should focus on maintaining representation of each of the three distinct genetic groups. Care should be taken to not translocate individuals between clusters.
   C. Craig Aubrey redirected the agenda to the topic of a grant RFP that he had just received a day or 2 prior ("Preventing Extinction/Showing Progress"), for which he thought Shasta crayfish related work could be very well suited, and which had a deadline of May 9th. A round-robin discussion ensued about the best strategies for successfully bidding for the available moneys. Topics included:
      1) What are the highest priorities for Shasta crayfish protection?
      2) Could/should the genetics study results be used to determine the most important Shasta crayfish stocks to protect?
      3) What are the most at-risk locations?
      4) What are the most defensible locations?
   D. After extended discussion, it was decided to table the topic and convene a teleconference of a subcommittee at 1:00 pm on Monday May 7th to put together a strategy for a successful proposal. Interested/designated subcommittee members were: Craig, Glenn, Steve B., Pat, Maria, and Jeff.
   E. Recent vandalism at Sucker Springs Creek Restoration. Jason will contact Mike Spainhour of Shasta Hydro about potential means of improving security, such as posting official PG&E no trespassing signs, replacing sections of fence, and changing the lock.

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II. Technical Review Committee Activities
   A. Shasta crayfish monitoring
      1) Maria talked about schedule and status of the TRC Annual Report and the revision of the Monitoring schedule.
      2) Jim Shang provided an update on PG&E's Shasta Crayfish Management Plan Funds.
      3) The TRC approved the inclusion of all known Shasta crayfish locations (e.g., Rising River, Rainbow Spring, Lava Creek, Thousand Springs etc.) in the study area for the surveys outlined in the Shasta crayfish Monitoring Plans. The expansion of study area will not result in additional monetary requirements.
   B. Jason reviewed the status of the Shasta Crayfish Barrier Plan
      1) FERC approved the Crayfish Barrier Plan on 8 March 2007
      2) Plan was approved with the modification that the Shasta Crayfish TRC Annual Reports provide updates on PG&E's efforts to secure funding and a proposed schedule for accomplishing the Spring Creek Road culvert cavity filling and biannual eradication/control surveys of non-native crayfish.
   C. Maria reviewed the status of the upper Fall River (Thousand Springs) Crayfish Barrier
      1) Cultural Resources Issues
         a) Field visit with Lynn Compas (PG&E Cultural Resources Specialist), Spring Rivers, and the landowner at Thousand Springs on 19 April 2007. Follow-up visit on 8 May. No cultural issues.
      2) Project Description
         a) Modified side-wall design
      3) Permitting and Timeline
         a) Formal consultation with the USFWS is required
         b) CDFG 1600 Office is fully staffed so turn around time is good
   D. Maria reviewed the status of the Spring Creek Road Culvert Cavity Filling Project and Biannual Non-native Crayfish Eradication/Control Surveys
      1) Eradication surveys done in June (upper coves) and July (lower coves) of 2006
      2) Biannual eradication surveys will start in 2007
         a) Other potential avenues for signal crayfish access to upper Spring Creek will be explored
      3) Potential funding sources are still being examined by PG&E.
   E. Jeff gave a PowerPoint presentation reviewing progress on the assessment of Rock Creek as a potential Shasta crayfish refugia
      1) Feasibility of conducting standard percolation test was assessed in June 2006.
      2) Flow measurements at the upstream end and downstream end of the upper meadow were taken to measure the potential water loss from the potential restoration channel.
         a) Calculated that less than 0.09 cubic foot per second (cfs) was being lost to the potential restoration channel.
      3) Flow measurements should be as accurate as possible to address this concern.
         a) Flow measurements may be more accurate if flow is measured inside a pipe, as opposed to measuring flow through a geometric shape.
      4) A conference call between CA Fish and Game (George Heise, Steve Baumgartner) and Spring Rivers Ecological Sciences (Jeff Cook, Maria Ellis) would help determine which method would be more accurate.

III. A subcommittee meeting to discuss potential Section 6 projects was scheduled for June 6 at 10:30 am in Redding. Interested/designated subcommittee members were: Craig, Amy,

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Glenn, Steve B., Pat, Maria, and Jeff. Jessica also said she would be happy to attend if it would be helpful.

IV. The next meeting will take place on Tuesday, September 25, 2007 at 10 am in Redding.

V. Attendees:

Jason Vann	925.866.5938	JFV2@pge.com	PG&E Hydro Licensing Management
Jim Shang	415.973.6759	JNS8@pge.com	PG&E Power Generation—Hydro Relicensing
Woody Elliott	530.538.2212	welli@parks.ca.gov	California Department of Parks and Recreation
Pat Gilbert	530.225.2065	pgilb@parks.ca.gov	California Department of Parks and Recreation
Craig Aubrey	916.414.6742	craig_aubrey@fws.gov	USFWS Recovery Branch Chief
Amy Fesnock	916.414.6678	amy_fesnock@fws.gov	USFWS Endangered Species Division
Steve Clay	530.233.3572	steve_clay@fws.gov	USFWS Modoc National Wildlife Refuge Manager
Steve Baumgartner	530.225.2370	sbaumgartner@dfg.ca.gov	CDFG Region 1 Fishery Biologist
Glenn Yoshioka	916.651.8764	gyoshioka@dfg.ca.gov	CDFG Species Conservation & Recovery
Theo Light	717.477.1093	TSLigh@ship.edu	Shippensburg University, Department of Biology
Jessica Petersen	530.752.6351	jlpetersen@ucdavis.edu	UC Davis Genomic Variation Lab
Maria Ellis	530.335.5446	maria@springrivers.com	Spring Rivers Ecological Sciences, LLC
Jeff Cook	530.335.5446	jeff@springrivers.com	Spring Rivers Ecological Sciences, LLC

Action Items:

Project	Task	Who	When
Funding	Preventing Extinction Grant Proposal conference call	Recovery Team subcommittee	7 May 2007
Funding	Prepare and submit Preventing Extinction Grant Proposal	Recovery Team subcommittee	9 May 2007
TRC	Shasta Crayfish Technical Review Committee (TRC) 2006 Annual Report	FERC TRC members	May 2007
Temp Study	Revise 23 May 2005 Biological Opinion for CDFG Section 6 Proposal	USFS	May 2007
Sucker Springs	Contact Shasta Hydro about Security Issues at Sucker Springs Creek Restoration Project	Jason Spring Rivers	May 2007
Temp Study	Restart Temperature Study	Spring Rivers CDFG	May/June 2007
Funding	Section 6 Funding meeting	Recovery Team subcommittee	6 June 2007
Genetics	Provide the rest of the genetic samples to Jessica	Spring Rivers	ASAP
Barrier	Upper Fall River barrier—permitting	PG&E	ASAP
Barrier	Upper Fall River barrier—construction	PG&E	August

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SHASTA CRAYFISH TECHNICAL REVIEW COMMITTEE
Hat Creek (FERC Project No. 2661) & Pit 1 (FERC Project No. 2687)

September 25, 2007 (Tuesday) - 10:00 am to 2:00 pm
California Department of Fish and Game Region 1 Office Conference Room
601 Locust Street, Redding, CA 96001
(530) 225–2370
CDFG Meeting Host: Steve Baumgartner

AGENDA

Introductions (Jason Vann)

I. **TRC Shasta Crayfish Project Updates**
   A. Crayfish Barrier Plan Implementation
      1) Upper Fall River Crayfish Barrier (Jason Vann)
         a) Completed in August
         b) Landowner Approval
         c) Continue surveys to remove/control signal crayfish upstream
            ⇒ Next survey September 27 or 28
      2) Spring Creek Road Culvert Cavity Filling Project and Biannual Non-native Crayfish Eradication/Control Surveys (Maria Ellis)
         a) Completed in August
         b) Biannual Eradication surveys in Fall 2007
      3) Crayfish Barrier PowerPoint Presentation (Maria Ellis)
   B. Big Lake Water Intake Structure PowerPoint Presentation (Steve Yonge, PG&E)
   C. Rock Creek Restoration (Maria Ellis)
      1) Schedule conference call between CDFG (George Heise & Steve) and Spring Rivers
   D. Shasta crayfish signs for the Hat Creek and Pit 1 projects (Maria Ellis)

II. **Recovery Team Shasta Crayfish Projects Updates**
   A. Preventing Extinctions Funding (Maria Ellis)
   B. Section 6 Funding (Glenn Yoshioka)
   C. CDFG Temperature Study (Steve Baumgartner)
   D. CDFG Genetic Study (Jessica Petersen, UC Davis Genomic Variation Lab)
   E. Sucker Springs Creek Restoration Project (Maria Ellis)

Establish Action Items / Schedule Next Meeting

Jason Vann (jfv2@pge.com)
PG&E License Coordinator for the Hat Creek and Pit 1 projects (415) 973–3727

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Shasta Crayfish Technical Review Committee
September 2007 Meeting Summary

The following is a summary of the Shasta Crayfish Technical Review Committee and Recovery Team meeting held in Redding on September 25, 2007.

I. **TRC Shasta Crayfish Project Updates (part 1)**

A. Both the Upper Fall River Crayfish Barrier and the Spring Creek Road Culvert Cavity Filling Project were completed in August.

1) Upper Fall River landowner was very pleased with the professionalism of the crew and the overall outcome.
2) Continue surveys to remove/control signal crayfish upstream of the Upper Fall River Barrier. Next survey September 27 or 28.
3) Need to begin biannual non-native crayfish eradication/control surveys upstream of the Spring Creek Road crossing. Start in Fall 2007/Winter 2008
4) Crayfish Barrier PowerPoint Presentation (Maria Ellis)
5) Amy Fesnock suggested that it would be good to give the barrier presentation at the Western Wildlife Society Meeting in Redding on February 7, 8, 9. Theo agreed that there are a lot of people interested in non-native crayfish control and eradication.

B. Big Lake Water Intake Structure PowerPoint Presentation (Steve Yonge, PG&E)—The purpose of the McArthur Swamp Waterfowl Restoration Project is to flood Hollenbeck field east of Rat Farm. The project involves the installation of an intake structure, a 24"-36" culvert, on the eastern levee approximately 100-150 feet north of the Rat Farm boat ramp. The intake structure would be used in September of each year to provide the initial flooding of Hollenbeck field. The intake would then be shut off until the following spring (March-May), when it would be opened again to augment the water in Hollenbeak field to maintain flooding.

1) Need 21 acre feet of water annually to flood Hollenbeak field
2) Construction costs and ongoing operations and maintenance difficulties make a groundwater well impractical.
3) Construct new levee so all construction is in the dry
4) No Shasta crayfish in the Rat Farm channel or near the Rat Farm channel. Water would be drafted off the top of Big Lake, probably 1-5' below the water surface.
5) PG&E believes that the project is "not likely to adversely effect" the Shasta crayfish and plans to request concurrence from the USFWS.

II. **Recovery Team Shasta Crayfish Projects Updates**

A. Preventing Extinctions Funding (Maria Ellis)

1) Delta smelt and Desert pupfish beat out the Shasta crayfish
2) Have the proposal so we can try again next year.

B. Section 6 Funding (Glenn Yoshioka)

1) Timeline for proposal next 5 weeks-submit internally within CDFG.
2) Need to have matching funds.
3) State Parks might have some funding in 2008-2009.
4) Could do more genetics work on existing samples and investigate refugia sites. Proposed 60K extension on genetics work for mictochondrial DNA (maternally passed) to show divergence between species/subspecies (phylogeny).

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5) Modular proposal depending on amount of matching funds

C. CDFG Genetic Study (Jessica Petersen, UC Davis Genomic Variation Lab)
   1) Developed nine microsatellite loci, which are neutral markers that can uncover population structure.
      a) Potential to develop additional marker microsatellites.
   2) Three different genetic clusters—Crystal Lake, Big Lake Springs/Ja She Creek/Lava Creek/Spring Creek, and Thousand Springs.
   3) Crystal Lake and the Big Lake Springs, etc. cluster contain more genetic variation than the Thousand Springs population.
   4) Genotyping of signal crayfish from Crystal Lake indicated no genetic evidence of hybridization between species.
   5) Genetic assignment tests place two individuals from Sucker Springs with the Big Lake Springs/Ja She Creek/Lava Creek/Spring Creek cluster

D. CDFG Temperature Study (Steve Baumgartner)
   1) Spring Rivers collected two females, one with eggs and one with instars, from Crystal Lake on June 15, 2007.
   2) Failed brood. Only one young-of-year Shasta crayfish was found. Plan to return the two females and one young-of-year to Crystal Lake this fall.
      a) Spring Rivers returned the three Shasta crayfish to Crystal Lake on October 3, 2007.

E. Update on the Sucker Springs Creek Restoration Project (Maria Ellis)
   1) Creative means of capturing signal crayfish using the streambanks.

III. **TRC Shasta Crayfish Project Updates (part 2)**

A. Rock Creek Restoration (Maria Ellis)
   1) Still need to schedule a conference call between CDFG (George Heise & Steve) and Spring Rivers

B. Update on the Shasta crayfish signs for the Hat Creek Project and the Shasta crayfish and Bald Eagle signs for the Pit 1 Project (Jason Vann)
   1) Opportunity for final review and comment before the signs go to the printers.

IV. The next meeting will take place on Wednesday, **April 9, 2008** at 10 am at the California Department of Fish and Game Region 1 Office Conference Room in Redding.

V. **Attendees:**

Jason Vann	415-973-3727	JFV2@pge.com	PG&E Hydro Licensing Management
Steve Yonge	925-866-5619	SRY1@pge.com	PG&E Wildlife Biologist
Woody Elliott	530.538.2212	welli@parks.ca.gov	California Department of Parks and Recreation
Pat Gilbert	530.225.2065	pgilb@parks.ca.gov	California Department of Parks and Recreation
Amy Fesnock	916.414.6678	amy_fesnock@fws.gov	USFWS Endangered Species Division
Steve Baumgartner	530.225.2370	sbaumgartner@dfg.ca.gov	CDFG Region 1 Fishery Biologist
Glenn Yoshioka	916.651.8764	gyoshioka@dfg.ca.gov	CDFG Species Conservation & Recovery
Theo Light	717.477.1093	TSLigh@ship.edu	Shippensburg University, Department of Biology
Jessica Petersen	530.752.6351	jlpetersen@ucdavis.edu	UC Davis Genomic Variation Lab
Maria Ellis	530.335.5446	maria@springrivers.com	Spring Rivers Ecological Sciences, LLC

Action Items:

Project	Task	Who	When

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Funding	Section 6 Proposal draft	CDFG/ Spring RIvers	Oct/Nov 2007
Temp Study	Return Shasta crayfish to Crystal Lake	Spring Rivers CDFG	Sept/Oct 2007
Genetics	Genetic samples from Pit River Falls and Rising River to Jessica	Spring Rivers	ASAP
Barrier	Barrier Presentation	Spring Rivers	February?
Barrier/ Crayfish Plan	Signal crayfish removal surveys upper Fall River and upper Spring Creek	Spring Rivers	ongoing
Crayfish Plan	Pit 1 and Hat Creek monitoring surveys	Spring Rivers	ongoing
Rock Creek	Schedule a conference call between CDFG (George Heise & Steve) and Spring Rivers	Steve Baumgartner	ASAP

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APPENDIX D—Correspondence with USFWS regarding Barrier Reporting Due Date

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From: Amy_Fesnock@fws.gov [mailto:Amy_Fesnock@fws.gov]
Sent: Monday, March 31, 2008 11:00 AM
To: Maria Ellis
Subject: RE: Shasta Crayfish Technical Review Committee September 2007 Meeting Summary

Hi Maria-

As follow-up to the email below and our phone call this morning -- yes you can make the Barrier report coincide with the other reports, thus pushing its deadline back to May 31 instead of January 1. I don't think we need to amend the BO -- this email should be sufficient.

Thanks-
A

Amy L. Fesnock
Senior Fish and Wildlife Biologist ♦ Forest and Foothills Ecosystems ♦ Endangered Species Division
2800 Cottage Way, Suite W-2605 ♦ Sacramento, CA 95825
916-414-6678 (v) ♦ 916-414-6713 (f) ♦ amy_fesnock@fws.gov

From: Maria Ellis" <Maria@springrivers.com>
Sent: Monday, March 31, 2008 09:20 AM
To: Amy_Fesnock@fws.gov [mailto:Amy_Fesnock@fws.gov]
Subject: RE: Shasta Crayfish Technical Review Committee September 2007 Meeting Summary

Hi Amy,

I hope you are doing well! Glad you will be able to make it either by phone or in person. It would be nice to see you in person, but I understand that your schedule may not allow it. Plus saving 6 hours of travel has a fair amount of appeal.

I have been meaning to get in touch with you for a while but have been swamped with Pit 345 stuff. Here is my download of questions / things I wanted to talk to you about:

When are the Preventing Extinction grant proposals due? Should we revamp our previous proposal to make it more competitive?

Has the Chief of the Recovery branch position been filled?

I want to change the reporting deadline on the Crayfish Barrier BO to coincide with the rest of the Shasta crayfish reporting deadlines (May 31). We already fulfilled the reporting requirements for 2007 so I am looking to change the reporting deadline for the 2008 survey year from January 1, 2009 to May 31, 2009. I should have requested this earlier before you did the last amendment—I apologize but at least there is no big hurry. How do I go about doing so now?

Thanks!
Maria

Maria J. Ellis, Ph.D.
Spring Rivers Ecological Sciences, LLC ♦ maria@springrivers.com ‖ www.springrivers.com
P.O. Box 153 ♦ 21451 Cassel Road ♦ Cassel, CA 96016 ♦ voice 530.335.5446 ‖ fax 530.335.4591

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APPENDIX E—15 July 2004 CDFG Memorandum —Proposal to relocate water supply Diversion Point for Crystal Lake Hatchery

DRAFT

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Department of Fish and Game
State of California

Memorandum

Date : July 15, 2004

To : Mr. Steve Baumgartner
Northern California North Coast Region

From : George Heise
Fisheries Engineering
NAFWB

Subject : **Proposal to Relocate Water Supply Diversion Point for Crystal Lake Hatchery**

At your request, on June 9, 2004, I attended a site meeting at the Crystal Lake hatchery diversion on Rock Springs Creek to evaluate the possibility of relocating the diversion structure approximately 700 feet downstream. The purpose for the proposed relocation of the diversion structure is to restore full stream flow through a meadow reach of the creek and establish or restore Shasta Crayfish habitat in Rock Springs Creek, in which crayfish currently do not exist. The meeting was attended by representatives of DFG Region 1 Redding office, Crystal Lake Hatchery staff, Marie Ellis and Jeff Cook of Spring Rivers Ecological Services, and their engineer, Charles Schlumpberger.

The primary issues to address are:

Can the diversion be moved to the lower end of the meadow and still be made to function hydraulically.

What are the risks to the hatchery water supply in terms of potential loss of water?

What are the constructability issues?

What are the maintenance issues?

This memo assumes that those who read it are familiar with the structure, the site, and proposal. The following are my observations of the site and opinions on the issues related to the relocation of the diversion.

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Existing Division Structure

The existing diversion structure is located approximately 100 feet upstream of the meadow on Rock Springs Creek. It is composed of a concrete weir with a crest length of approximately 25 feet traversing the stream channel, which spills through a grating/trashrack and into a wet well. I estimate the top of the weir to be approximately 4.5 to 5 feet above the stream thalweg. A four foot diameter culvert exits the wet well and transitions into a two foot diameter smooth steel pipe. The steel pipe traverses the meadow at a low gradient (0.5%) adjacent to the stream channel. At the end of the meadow, the pipeline increases in slope and continues on to the hatchery.

Hatchery personnel indicated that diversion to the hatchery is approximately 24 cfs at normal production levels, less when fish have been stocked for the year. On the day of the site visit, I estimated the flow depth at the weir to be about 5 inches, which equates to a flow of approximately 20 cfs across the 25 foot weir. A small amount of leakage, perhaps 2 cfs or so, was leaking past or though the diversion structure into the downstream channel. The rest of the flow was diverted into the four foot metal pipe.

Existing Diversion Structure & Pipeline

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Hydraulic Aspects of Diversion Dam Relocation

At the existing diversion dam, the upstream water elevation has been elevated approximately 4.5 to 5 feet above the invert (bottom) of the pipe in order to provide the necessary energy for diversion of the stream flow into the pipe. The increase in water depth is composed of the following components: 2 feet to fill the 2 foot diameter pipe; approximately 1 foot for velocity head (converting standing water to moving water); approximately 1 foot to account for minor losses (entrance, contraction, and friction losses); and 6 inches for flow depth across the upstream weir.

A similar increase in water elevation above the invert elevation of the pipeline would be needed to divert at the lower end of the meadow. This increase in water elevation for diversion is relative to the invert of the pipe near the new point of diversion, and not the stream bottom. If the stream bottom is lower than the pipe invert, then the water surface would have to be increased by a corresponding amount. If the stream bottom is higher, then the opposite would be true. It may be possible to reduce the increase in upstream water elevation needed for diversion by changing the intake design and improving the hydraulics of the structure. The reduction would probably not amount to more than about a foot of head, though.

The profile of the stream channel from the existing diversion structure to the proposed location shows a bed elevation change of only 3.1 feet. Therefore, if the water surface were raised by 4 feet at the proposed intake location, the backwater effect would be experienced all the way to the existing structure. One way to minimize the increase in water elevation at the proposed location would be to lower the conveyance pipe by burying it a trench through the meadow and connecting to the existing pipe farther down the slope.

Pipeline through the Meadow

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Proposed Diversion Site

Risk to the Hatchery Water Supply

There are three potential conditions that could result in a reduction of water for diversion to the hatchery.

The first risk is unintentional diversion of flow from the stream channel to alternate flow paths through the meadow. The topography of the meadow, relative to the stream channel, had not been documented as of the site visit. The relative elevation of the two seems minimal, perhaps only a few feet in places. If the water elevation in the stream needs to be raised by 3 feet or more to divert at the proposed location, then there will be a risk of loosing a portion of the flow through low points in the stream bank.

The second risk is due to increased infiltration. Relocation of the diversion would provide a greater wetted channel area and increase the depth of water in the channel. Both of these conditions could result in an increase in infiltration to the ground water or underflow, and therefore result reduction of water available for diversion to the hatchery. On the other hand, the water that is passing through the existing diversion could be captured at a new diversion at the end of the meadow. I can not speculate whether capturing the leakage at the existing diversion would be sufficient to offset an increase in infiltration resulting from relocation of the diversion.

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The third risk is an increase in evapotransporation resulting from an expanding riparian zone. Providing stream flow through the length of the meadow may encourage an expansion of the riparian plant community and its water usage.

A more significant aspect of an increase in riparian vegetation is the potential for the vegetation to block the channel and increase the depth of flow, possible causing diversion of flow to the meadow.

Constructability

Access for construction is available along the road to existing diversion. Construction would be of average difficulty and could probably be accomplished with typical construction equipment and techniques. Fish screening structures of average complexity range from $5,000 to $10,000 per cfs diverted. If $5,000/cfs is applied to this structure the cost would be around $100,000.

Maintenance

There could be an increase in the debris loading of a new diversion structure because of the increased channel length through the meadow. This may necessitate more frequent cleaning of the structure. There may be other maintenance and cleaning issues depending on how the structure is designed and how it fits into the existing channel. If the riparian vegetation along the channel becomes too thick and raises the water elevation to an unacceptable level, then some management and removal of vegetation would be needed.

Discussion and Recommendations

Meeting the hydraulic conditions needed for the diversion may be difficult at the proposed site at the lower end of the meadow. To raise the water elevation to the height needed for the diversion could cause lateral flow to the meadow, and/or backwater, velocity and depth conditions in the channel that are unsuitable for the crayfish. If the proposed diversion structure were recessed into the stream channel it would require the replacement of a longer section of the pipeline and tie in farther down slope. In this case, the pipeline would be below ground level and would have to be trenched in.

The potential for loss of water due to increased infiltration is a significant uncertainty. The more the water surface in the channel is raised, the greater the potential loss.

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These may be the primary reasons that the existing diversion was located in a well defined channel section upstream of the meadow. If further investigation of this proposal is to be made, I recommend that a topographic survey of the affected portion of the stream channel and meadow be conducted in sufficient detail to address the issue of flow from the stream channel to the meadow. I also recommend that an evaluation be made of the potential for increased infiltration losses. This could be evaluated by checking the ground permeability (similar to the test for septic leach fields) for areas that may be flooded from the proposed new structure.

cc: Department of Fish and Game
Don Koch, Reg. Manager R1

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APPENDIX F—Genetics Study Summary Prepared for 9 April 2008 TRC Meeting

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Shasta Crayfish – Conservation Genetics Study
April 2008 Update

Jessica Petersen and Bernie May
University of California Davis, Genomic Variation Laboratory

Progress: Since the Shasta Crayfish Technical Review Committee and Recovery Team meeting in September 2007, five samples have been added to the data set. The working data set now includes 235 individuals from nine sampling locations (Table 1).

Population	Number	Date
Big Lake Springs	18	2004
	17	2007
Crystal Lake	35	2004
Thousand Springs – Fish Trap Cove	35	2005
Thousand Springs – Property Line	35	2005
Spring Creek	35	2005
JaShe Creek	35	2006
Lava Creek	24	2007
Sucker Springs	2	2007
Rainbow Springs	5	2007

Table 1. Sampling effort for Shasta crayfish.

Results: Bayesian cluster analysis in STRUCTURE indentifies three major genetic clusters within the collection sites (Figure 1). These clusters represent 1) Big Lake Springs, Spring Creek, JaShe Creek, and Lava Creek (red), 2) Thousand Springs – Fish Trap Cove and Property Line, and 3) Crystal Lake.

Assignment testing of the Sucker Springs samples suggests that, of the genetic samples we have, they are most closely related to those within the Big Lake Springs, etc. cluster. However, assignment of the Rainbow Springs samples is more challenging. Using GeneClass2, all five samples show the highest probability of assignment to the Big Lake Springs, etc. cluster. However, some probability is given that three of the five individuals may assign to the Thousand Springs group. This is visually observed in the STRUCTURE output and also suggested in the likelihood based assignment program, Whichrun. Two potential reasons these individuals are not clearly assigning are: 1) we may not have a reference population remaining that is representative of the diversity that is found in Rainbow Springs, or 2) the results may be reflective of gene flow or perhaps a hybrid zone between the Big Lake Springs and Thousand Springs genetic types.

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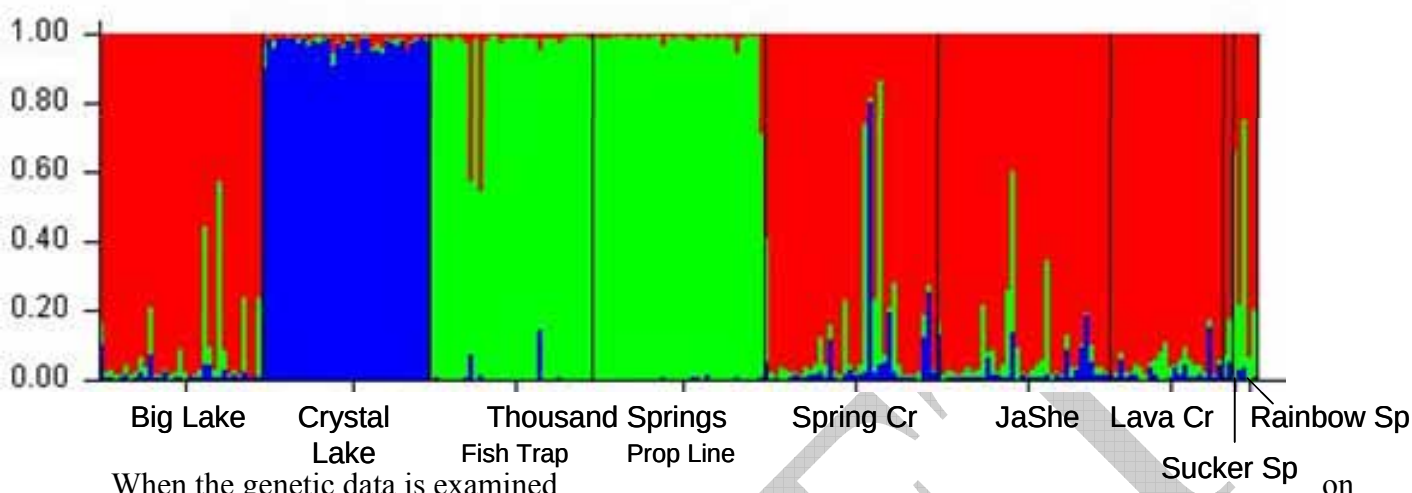
Figure 1. STRUCTURE clustering output illustrating the Big Lake Springs, etc. cluster (red), Crystal Lake (blue), and Thousand Springs (green).



When the genetic data is examined on a finer scale, it is of note that pairwise F_{ST} values show further genetic structuring (significance tested using Fisher's exact test) (Table 1). Based upon these data, each location should be treated as a distinct collection. The two samples from Big Lake Springs collected three years apart did not show any significant difference from one another.

	Big Lake Springs	Crystal Lake	1000 Sp - Fish Trap	1000 Sp - Prop Line	Spring Creek	JaShe Creek
Crystal Lake	0.13					
1000 Sp - Fish Trap	0.15	0.26				
1000 Sp - Prop Line	0.18	0.29	0.03			
Spring Creek	0.03	0.13	0.11	0.14		
JaShe Creek	0.02	0.13	0.15	0.17	0.02	
Lava Creek	0.02	0.13	0.16	0.17	0.02	0.02

Table 1. Pairwise F_{ST} values for each sampling location. F_{ST} values can range from zero (populations identical) to 1 (populations entirely different). A value of 0.25 is generally considered to show moderate to high population differentiation. All values reported indicate a significant difference between locations.

Genetic Management Recommendations: To conserve a maximum level of genetic diversity, it is essential to maintain collections of all three major genetic clusters. Because genetic structuring based upon sampling location is observed within the clusters, translocations between these sites should be avoided whenever possible. In the case where population supplementation or the establishment of a refuge is determined to be necessary to maintain viable collections, organisms should only be translocated between locations within the same major genetic cluster.

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Attachment 3

May 11, 2009 Agency Consultation Meeting

- 4/14/09 Lotus Notes invitation from Charles White to agencies - Pit 1 Project (FERC No. 2687) Water Quality Monitoring Results 5-year Summary Meeting
- May 11, 2009 meeting agenda
- May 7, 2009 email from Charles White to agencies - Pit 1 Project Water Quality Monitoring Results 5-year Summary Meeting - Supplemental Material
- Pdf of PowerPoint presentation for May 11, 2009 agency meeting
- Pit 1 Project: Potential Effects of Alternative Flow Releases on Selected Resources, May-09
- A Biological Evaluation of Thermal Effects from Summer Flushing/Whitewater Flows on Spring-influenced Aquatic Habitat in the Pit 1 Bypass Reach

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White, Charles

Subject:	Pit 1 Project (FERC No. 2687) Water Quality Monitoring Results 5-Year Summary Meeting
Location:	Sacramento
Start:	Mon 5/11/2009 10:00 AM
End:	Mon 5/11/2009 4:00 PM
Show Time As:	Out of Office
Recurrence:	(none)
Meeting Status:	Meeting organizer
Required Attendees:	White, Charles; Sundermeyer, Dagmar; Tu, Scott; Dennis Heiman (dheiman@waterboards.ca.gov); Kim Squires (Kim_Squires@fws.gov); Matt Myers (mmyers@dfg.ca.gov); Steve Baumgartner (sbaumgartner@dfg.ca.gov); TSagr@aol.com; Maria J. Ellis Ph. D. (maria@springrivers.com); Josh_Hull@fws.gov
Resources:	CR SAC RMC Room 1004

Meet at 7:30 @ 3401 Crow Canyon

This meeting is to discuss the Pit 1 Project (FERC No. 2687) Water Quality Monitoring Results 5-Ye Summary Report that I sent to your offices on March 12, 2009. In the *Order Modifying and Approvin Water Quality Monitoring Plan Under Article 401*, it states "the licensee and the Chief (or designatec staff) shall meet with 60 days of the summary submittal to review the results and determine if the beneficial uses of the Pit River described in the Board's 1998 Basin Plan are being reasonably protected".

Additionally, the *Order Modifying and Approving the Bald Eagle Compliance Monitoring Plan Pursua To Article 415* requires PG&E to consult with the California Department of Fish and Game, US Fish and Wildlife Service, and the SWRCB regarding any proposed changes in Project Operation.

Additionally, Dennis Heiman of the RWQCB has also requested to attend this meeting.

The meeting will be held at PG&E's West Sacramento RMC @ 850 Stillwater Road, W. Sacramento CA 95605.

Let me know if you have any questions.

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AGENDA

Pit 1 Project (FERC No. 2687)

Five-Year Water Quality Summary and Consultation

May 11, 2009
PG&E West Sacramento RMC
at 850 Stillwater Road, W. Sacramento, CA 95605
Call in: 866 234 4460 passcode:*9258665803*

10:00	Safety Procedures
10:05	Introductions
10:10	Purpose of the Meeting
10:20	Results of the Pit 1 Water Quality Sampling Program
11:45	Questions and Answers
12:00	Lunch
13:00	Discussion
	▪ Water Quality
	▪ Beneficial Uses
	▪ Fall River Pond flushing flow effectiveness
	▪ Affected Species
15:30	Summary and Recommendations
16:00	Adjourn

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White, Charles

From:	White, Charles
Sent:	Thursday, May 07, 2009 8:51 AM
To:	Russ Kanz (rkanz@waterboards.ca.gov); Kim Squires (Kim_Squires@fws.gov); Matt Myers (mmyers@dfg.ca.gov); Steve Baumgartner (sbaumgartner@dfg.ca.gov); 'Josh_Hull@fws.gov'; Dennis Heiman (dheiman@waterboards.ca.gov)
Subject:	Pit 1 Project (FERC No. 2687) Water Quality Monitoring Results 5-Year Summary Meeting - Supplemental Material
Attachments:	Pit1_5-yearPresentation_(05-06-09)Distributionversion.pdf; Pit 1 Summary of Flow Effects_May09.pdf; Pit 1 WW Biological Effects Summary 6May09.pdf

I am forwarding several supporting documents for meeting next Monday (We will also have hard copies of this material available at the meeting). Please find attached:

- ✓ A pdf of the PowerPoint presentation that PG&E is planning to use in the meeting
- ✓ a beneficial uses table outlining the possible improvements or impacts related to increase flows
- ✓ a copy of the report titled "*A Biological Evaluation of Thermal Effects from Summer Flushing/Whitewater Flows on Spring-influenced Aquatic Habitat in the Pit 1 Bypass Reach*" which the California Department of Fish and Game has requested. Since this report has not been previously been distributed to the agencies, I have included a short summary of the report below at the end of this e-mail.

If you have any questions or wish to discuss any of this information prior to next Monday, feel free to contact me.

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"A Biological Evaluation of Thermal Effects from Summer Flushing/Whitewater Flows on Spring-influenced Aquatic Habitat in the Pit 1 Bypass Reach"

Summary

Coldwater springs in the Pit 1 bypass reach cool the mainstem, create coldwater refugia, and

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support coldwater species, including fish, molluscs, and the endangered Shasta crayfish. The effects of a summer flushing flow on the temperature and size of thermal refugia was studied at a coldwater spring during and after the August 2004 flushing flow. The data from the thermal refugia study verified predictions made by application of jet/plume analytical theory. A summer flushing flow results in a rapid and substantial change in both the temperature and area of coldwater habitat adjacent to the spring. Furthermore, data from water quality monitoring indicate summer flushing flows can result in mainstem daily minimum temperatures that are 21 °C or higher.

This report evaluates potential biological effects of summer flushing flows. The elimination of cooler night-time temperatures (i.e., daily minimum temperatures) and coldwater areas in the vicinity of springs during summer flushing flows can result in stressful conditions for rainbow trout. Coldwater molluscs that have narrow temperature tolerances and prefer spring environments can be affected by the warmer temperatures and loss of thermal refugia during flushing flows. Freshwater mussels in the Pit River are particularly vulnerable to pulsed flows in the summer, when adults are reproducing and juveniles are falling off of their fish hosts to settle on the stream bottom.

Although its status in the Pit 1 bypass reach is not well known due to sampling difficulties created by the large substrate, there has been a significant decline in endangered Shasta crayfish numbers since the new license flow regime was implemented. In the approximately 600-meter-long reach of the mainstem Pit River that is influenced by colder temperature springs just above the Pit River Falls, 21 Shasta crayfish were found in 2005, but only one Shasta crayfish was found in 2008. During this same period, the numbers of non-native signal and fantail crayfish have almost tripled and doubled, respectively, in this reach. Non-native crayfish, which are more tolerant of a wider temperature range as well as temperature fluctuations, can be both competitors and predators of Shasta crayfish. The Shasta crayfish has a long evolutionary history of living in stable, cold, spring-fed environments and is not adapted to short-term fluctuations in temperature.

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Pit 1 Hydroelectric Project
FERC Project No. 2687

Five-Year Summary
Water Quality Monitoring

Pacific Gas and Electric Company

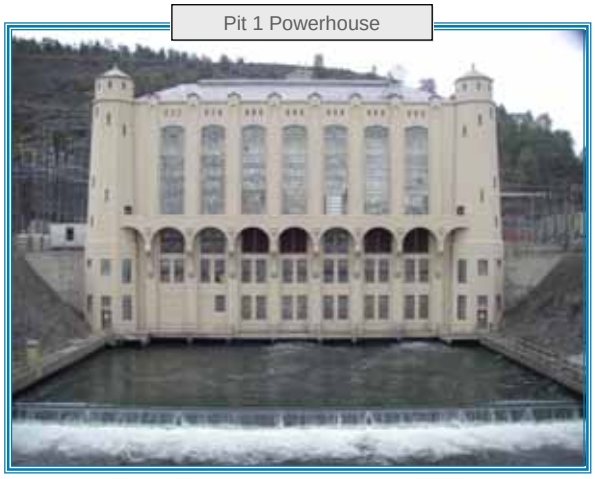
May 2009

FERC Project No. 2687

Agenda

1. Introduction
2. Emergency / Safety
3. 5-year Report Presentation
4. Discussion

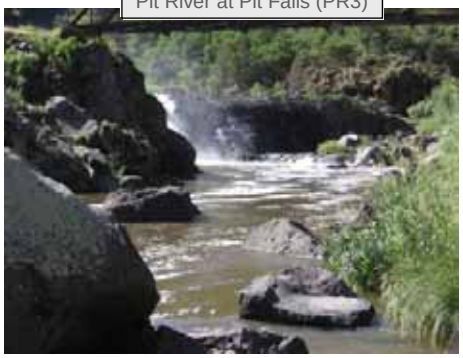
Pit 1 Powerhouse



5-Year Report Discussion Outline

1. Summarize 2004-2008 monitoring results
2. Compare 2004-2008 with 1990-1992 results
3. Discuss the impact of current Fall River minimum instream release on water quality
4. Discuss effect of increased minimum instream release on water quality
5. Suggested changes to monitoring program

Pit River at Pit Falls (PR3)



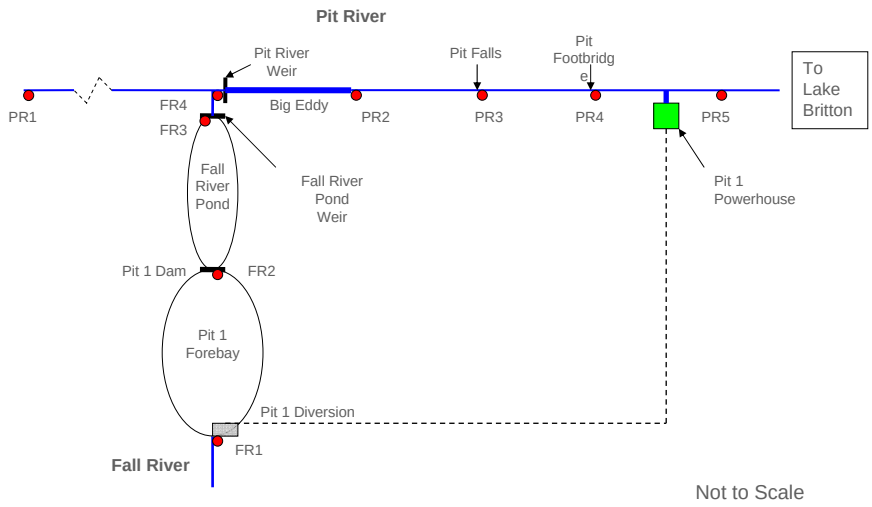
Monitoring Program

- Annual Monitoring
  - May 16 through October
  - Nine Monitoring Stations
  - Twice-a-month water quality sampling
  - Continuous Water Temperature
  - Three Supplemental Stream Flow Stations
  - Two Supplemental Meteorological Stations

Fall River above Diversion
Fall River at Pit 1 Forebay
Fall River at Fall River Pond Weir
Fall River near confluence

Pit River at Pittville
Pit River at Big Eddy
Pit River at Falls
Pit River at Footbridge
Pit River below Pit 1 Powerhouse

Pit 1 Project Monitoring Schematic



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Fall River Conditions

Fall River Pond Weir

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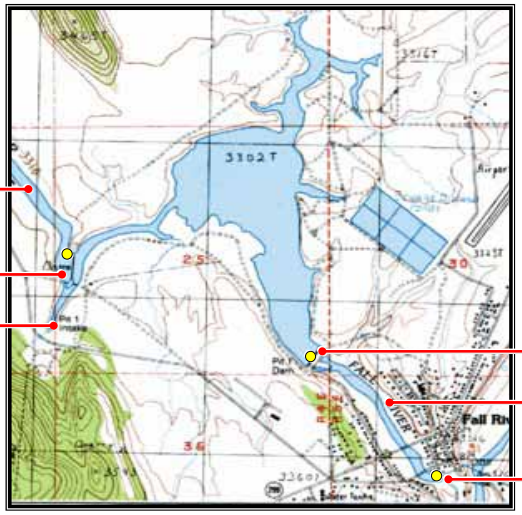
Pit 1 Forebay Configuration



Confluence Fall and Pit Rivers

Fall River Water Quality (2004-2008)

Comparative Range in *In situ* Parameters

Above Pit 1 Forebay	Below Pit 1 Forebay
DO: 8.2 to 11.5 (9.3) mg/L	DO: 6.1 to 12.4 (8.7) mg/L
DO Sat.: 81 to 140 (108) %	DO Sat: 71 to 157 (105) %
pH: 7.6 to 9.0 (8.4) units	pH: 7.7 to 9.5 (8.7) units
SpC: 129 to 163 (154) µS/cm	SpC: 121 to 163 (154) µS/cm
Turbidity: 0.4 to 16.4 (3.0) NTU	Turbidity: 0.2 to 16.4 (1.9) NTU

minimum to maximum (median)

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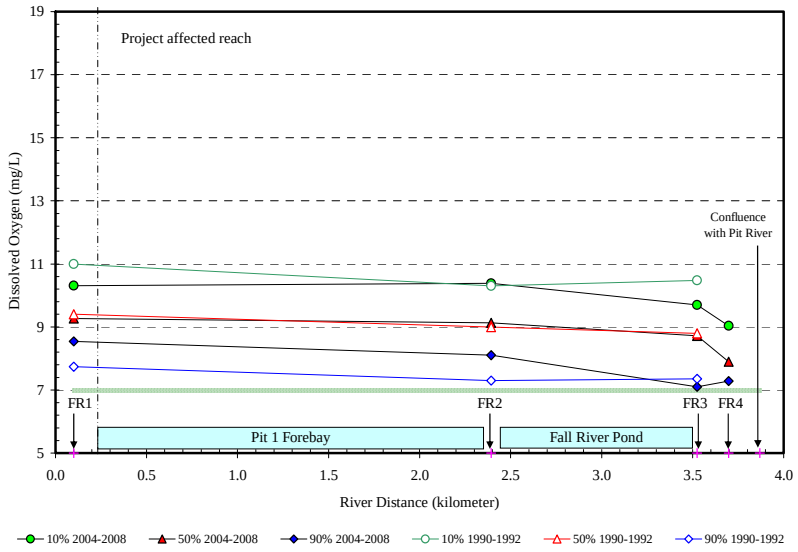
Fall River Dissolved Oxygen Frequency Distribution



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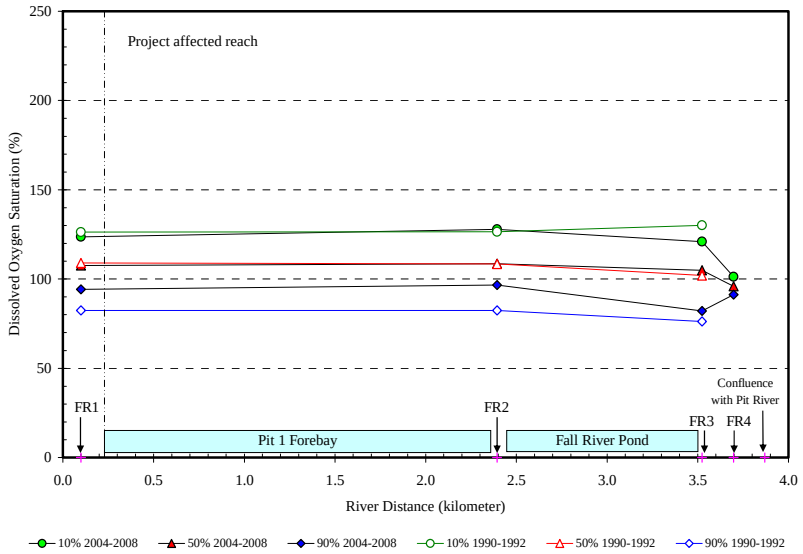
Fall River DO Saturation Frequency Distribution



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Fall River Evaluation of DO with Basin Plan Objectives

- *No samples less than the 5.0 mg/L WARM objective*
- *Six samples less than the 7.0 mg/L COLD objective*

Station	Value	Date	Time	Remarks
FR1	--	--	--	No occurrences
FR2	--	--	--	No occurrences
FR3	6.8	8-19-2004	10:44	Fall River Pond
FR3	6.1	9-15-2004	9:45	Fall River Pond
FR3	6.9	8-16-2005	10:07	Fall River Pond
FR3	6.7	9-07-2005	10:15	Fall River Pond
FR3	6.5	8-27-2008	9:08	Fall River Pond
FR4	6.8	7-12-2005	12:45	Sensor error*

* Sensor passed daily calibration adjustment for DO, and readings obtained in the morning were in the normal range. Suspect membrane failure or leak, replaced membrane at end of day and sensor recalibrated without issue.

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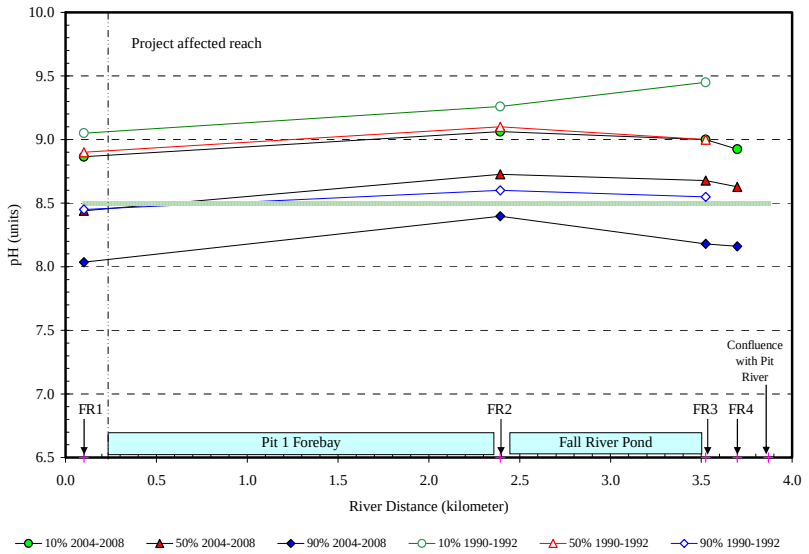
Fall River pH
Frequency Distribution



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Fall River
Evaluation of pH with Basin Plan Objectives

- ***No samples less than the 6.5 objective***
- ***Table highlights samples in the Fall River greater than the 8.5 objective***

	Maximum pH	Average pH	Samples Exceeding 8.5		Range of pH
Station	(units)	(units)	Total Occurrence[1]	Project Affect[2]	Change[3]
FR1	9.0	8.7	27 (47%)	--	--
FR2	9.1 [2]	8.7 [2]	45	18 [2]	-0.2 to1.0 (0.3)
FR3	8.9 [2]	8.7 [2]	38	14 [2]	-0.2 to 0.7(0.2)
FR4	8.8 [2]	8.7 [2]	36	13 [2]	-0.2 to 0.6(0.2)

1: For periods when pH exceeded 8.5 units.

2: Values calculated when pH at FR1 was less than 8.5 and greater than 8.5 at associated downstream station.

3: Change in pH calculated when pH was greater than 8.5 at the specified downstream station (Station pH – FR1pH).

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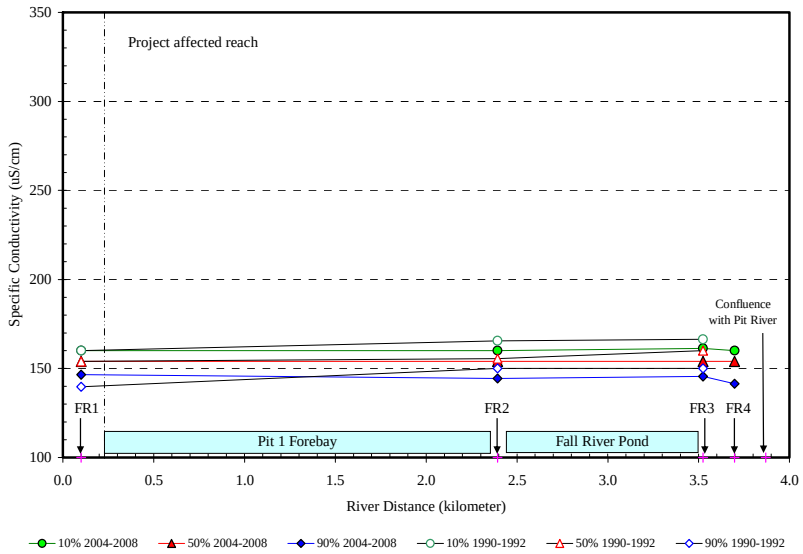
Fall River Conductivity Frequency Distribution



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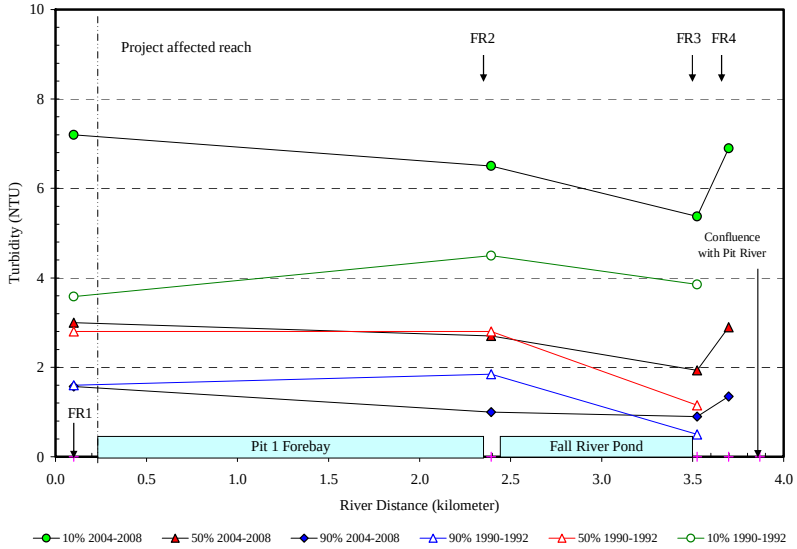
Fall River Turbidity Frequency Distribution



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Fall River
2004-2008 Daily Mean Water Temperature

Water Temperature – Frequency Distribution

Above Pit 1 Forebay (FR1)	At Fall River Pond Weir (FR3)
➢ 10% - 20.3	➢ 10% - 22.9
➢ 25% - 19.6	➢ 25% - 22.0
➢ 50% - 18.6	➢ 50% - 20.9
➢ 75% - 16.9	➢ 75% - 18.9
➢ 90% - 15.0	➢ 90% - 17.1
June through September exceedance	*June through September exceedance*

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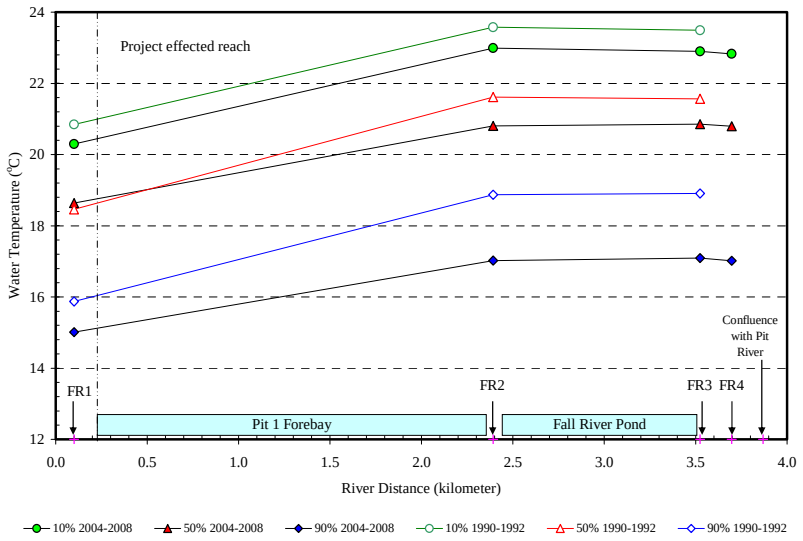
Fall River Daily Mean Water Temperature Frequency Distribution



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Comparison of Daily Mean Water Temperatures in Fall River

		Monthly Average (° C)				July-August Period	
Monitoring Year	Station	June	July	August	September	Maximum Daily Avg.	Average for period
1990-1992	FR1	18.1	20.1	18.9	16.4	21.9	19.5
	FR2	20.7	22.7	21.8	19.0	25.0	22.3
	FR3	20.8	22.7	21.8	19.4	25.7	22.2
2004-2008	FR1	18.0	20.0	18.8	15.7	21.8	19.4
	FR2	20.0	22.6	21.2	17.7	25.5	21.9
	FR3	19.9	22.5	21.2	17.7	24.4	21.9

* Monthly average calculated using the difference in the daily average values from each station.

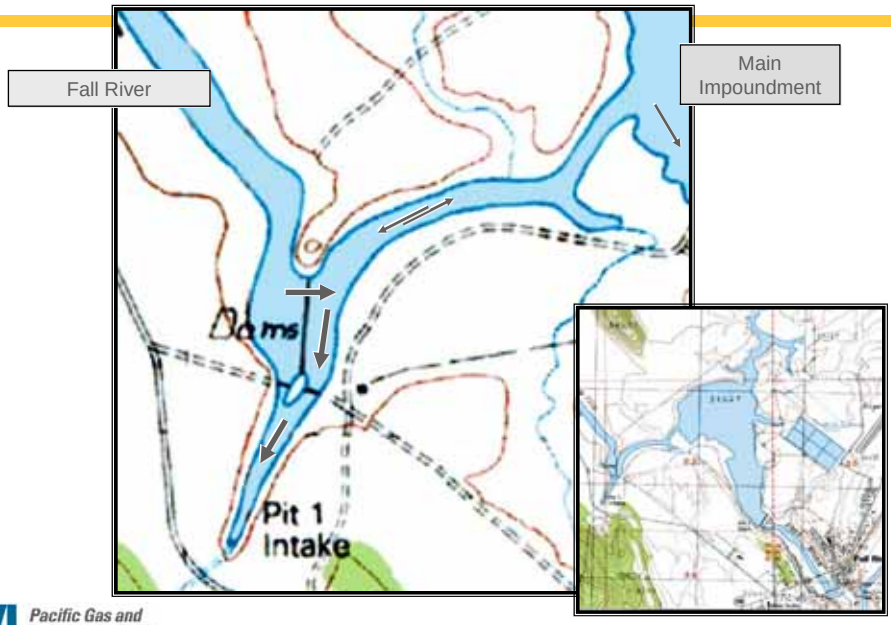
Comparison of Daily Mean Temperature Change through Pit 1 Forebay

Change in Water Temperature through Pit 1 Forebay Complex[1]

	Monthly Average Change (° C)				July-August Period	
Period	June	July	August	September	Maximum Change	Average Change
1990-1992	2.2	2.5	2.9	2.5	4.9	2.7
2004-2008	2.0	2.6	2.4	2.0	4.3	2.5

1. Defined as Pit 1 Forebay and Fall River Pond. Positive Δ-T value equals warming between upstream station and Fall River Weir (FR3-FR1)

Pit 1 Diversion Configuration



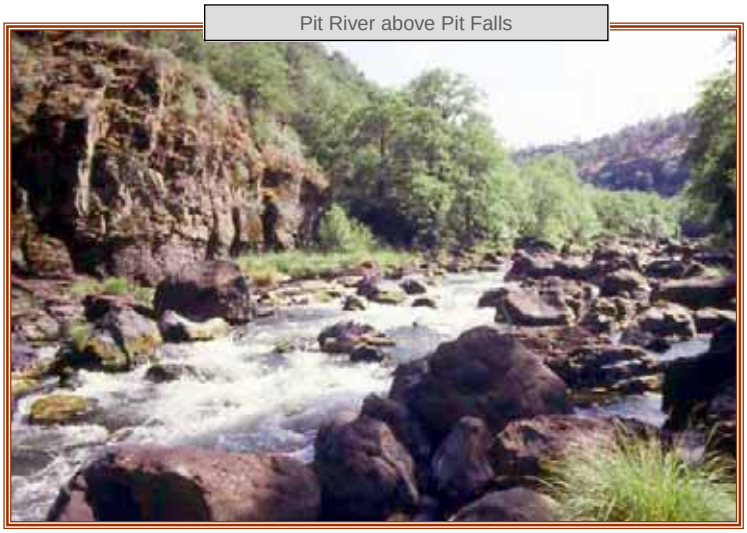
2004-2008 Monitoring Summary
Fall River

The current Pit 1 Forebay 150 cfs MIF has improved the following water quality parameters:

- DO in Pit 1 Forebay and Lower Fall River (Fall River Pond).
- pH in Pit 1 Forebay and Lower Fall River.
- Water temperature in Pit 1 Forebay and Lower Fall River.

Pit River Conditions

Pit River above Pit Falls



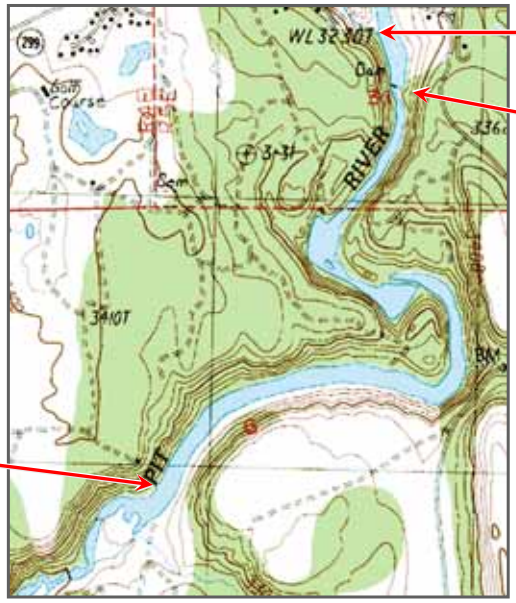
Pittville Station (PR1)

Pit River between Pittville and Fall River confluence

Pit River Weir

Pit River Weir during high flow

Big Eddy Section of the Pit 1 Reach



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Pit River at Big Eddy (PR2)

Pit River below Big Eddy Pool

Pit River at Big Eddy Pool

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Pit River Water Quality (2004-2008)
Low Gradient Section

Comparative Range in *In situ* Parameters

Pit River at Pittville	Pit River at Big Eddy
➢ DO: 5.6 to 12.7 (9.7) mg/L	➢ DO: 6.2 to 9.8 (7.9) mg/L
➢ DO Sat.: 61 to 171 (112) %	➢ DO Sat: 83 to 115 (95) %
➢ pH: 7.6 to 9.2 (8.4) units	➢ pH: 7.5 to 8.8 (8.2) units
➢ SpC: 130 to 333 (241) µS/cm	➢ SpC: 142 to 249 (185) µS/cm
➢ Turbidity: 2.4 to 192 (10.2) NTU	➢ Turbidity: 3.9 to 184 (8.7) NTU
PR1 all periods	*PR2 all periods*

minimum to maximum (median)

Pacific Gas and Electric Company.

Diagram of Pit River Gradient

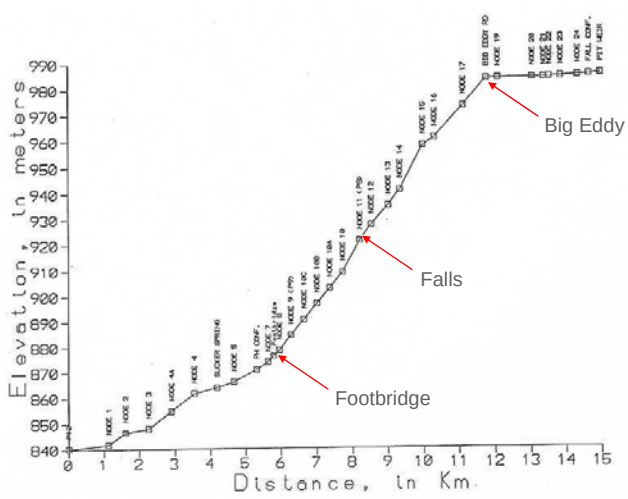

Figure 3-2. Elevation view of the study site.

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Pit River Water Quality (2004-2008)
High Gradient Section

Comparative Range in *In situ* Parameters

Pit River at Big Eddy	Pit River at Pit 1 Footbridge
➢ DO: 6.2 to 9.8 (7.9) mg/L	➢ DO: 6.9 to 9.9 (8.3) mg/L
➢ DO Sat.: 83 to 115 (95) %	➢ DO Sat: 87 to 114 (98) %
➢ pH: 7.5 to 8.8 (8.2) units	➢ pH: 7.8 to 8.8 (8.3) units
➢ SpC: 142 to 249 (185) µS/cm	➢ SpC: 146 to 233 (179) µS/cm
➢ Turbidity: 3.9 to 184 (8.7) NTU	➢ Turbidity: 2.2 to 209 (4.9) NTU
PR2 all periods	*PR4 all periods*

minimum to maximum (median)

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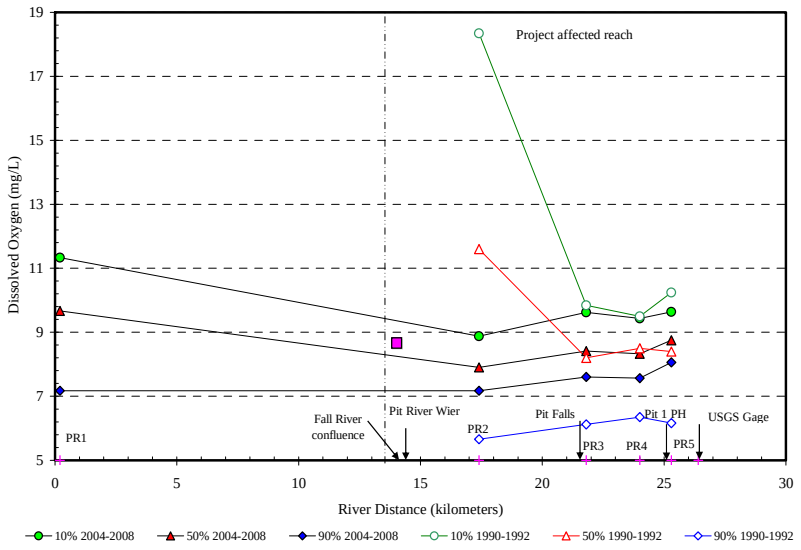
Pit River Dissolved Oxygen
Frequency Distribution



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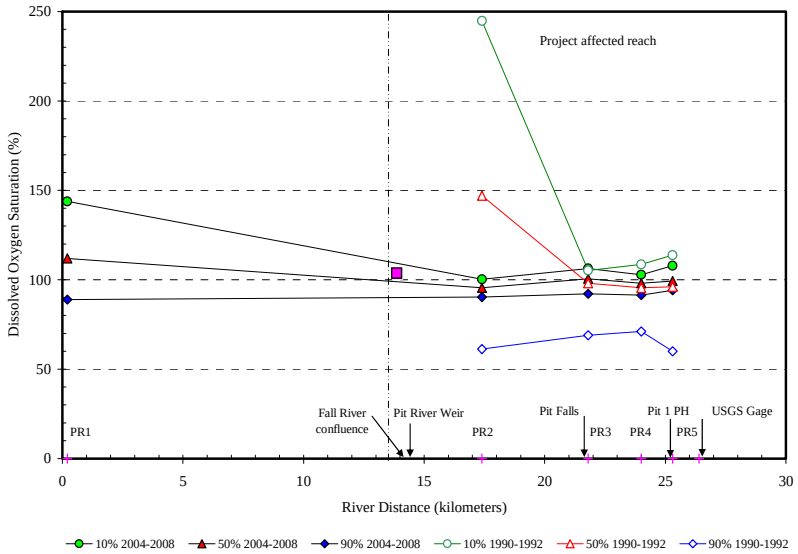
■ = Median Fall River value (FR3)

Pit River DO Saturation Frequency Distribution



Pacific Gas and Electric Company

■ = Median Fall River value (FR3)

Pit River Stations Evaluation of DO Results with Basin Plan Objectives

- *No samples less than the 5.0 mg/L WARM objective*
- *Eight samples less than the 7.0 mg/L COLD objective*

Station	Value	Date	Time	Remarks
PR1	6.5	8-18-2004	9:00	Entering Project
PR1	5.6	9-15-2004	8:00	Entering Project
PR1	6.7	8-10-2007	9:30	Entering Project
PR1	6.7	8-27-2008	10:09	Entering Project
PR2	6.2	7-12-2005	11:47	Sensor error*
PR2	6.8	9-07-2005	9:30	--
PR3	6.6	7-12-2005	15:15	Sensor error*
PR4	6.9	7-12-2005	14:18	Sensor error*

* Sensor passed daily calibration adjustment for DO, and readings obtained in the morning were in the normal range. Suspect membrane failure or leak, replaced membrane and sensor recalibrated without issue.

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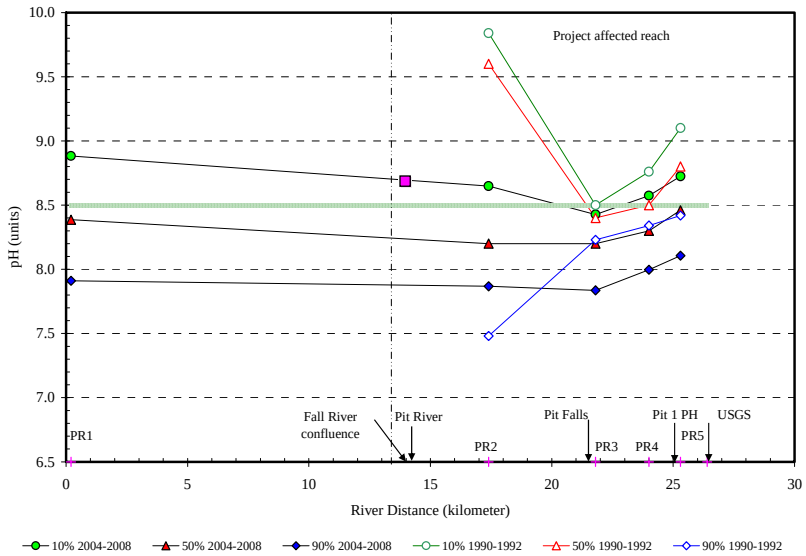
Pit River pH
Frequency Distribution



Pacific Gas and Electric Company

= Median Fall River value 2004-2008 (FR3)

Pit River Stations
Evaluation of pH Results with Basin Plan Objectives

- ***No samples less than the 6.5 objective***
- ***Table highlights samples in the Pit River greater than the 8.5 objective***

	Maximum pH	Average pH	Samples Exceeding 8.5		Range of pH
Station	(units)	(units)	Total Occurrence[1]	Project Affect[2]	Change[3]
PR1	9.2 [2]	8.8 [2]	22 (39%)		--
PR2	8.7 [3]	8.6 [3]	11	2	-0.5 to 0.5 (0.0)
PR3	8.6 [3]	8.6 [3]	3	2	-0.3 to 0.7 (0.3)
PR4	8.7 [3]	8.6 [3]	11	7	-0.3 to 0.9 (0.3)

1: For periods when pH exceeded 8.5 units.

2: Values calculated when pH at PR1 was less than 8.5 and greater than 8.5 at associated downstream station.

3: Change in pH calculated when pH was greater than 8.5 at the specified downstream station (Station pH – PR1pH) [minimum to maximum (average)]

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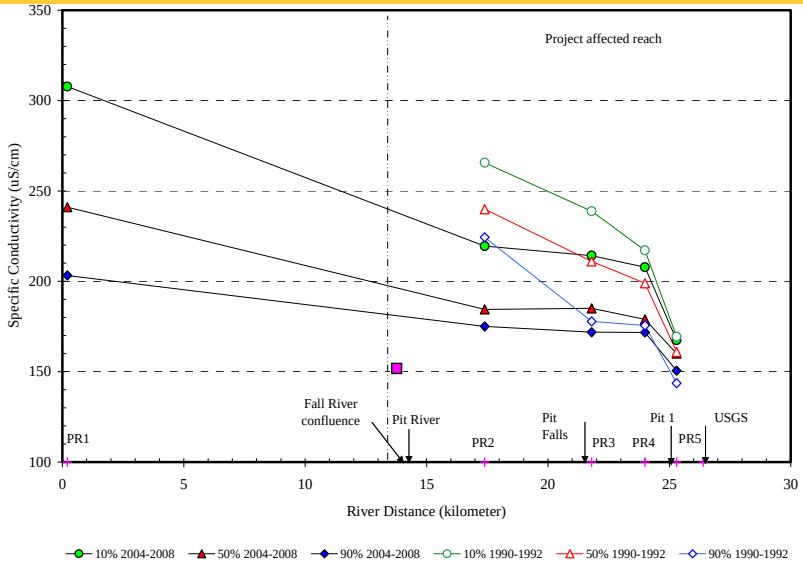
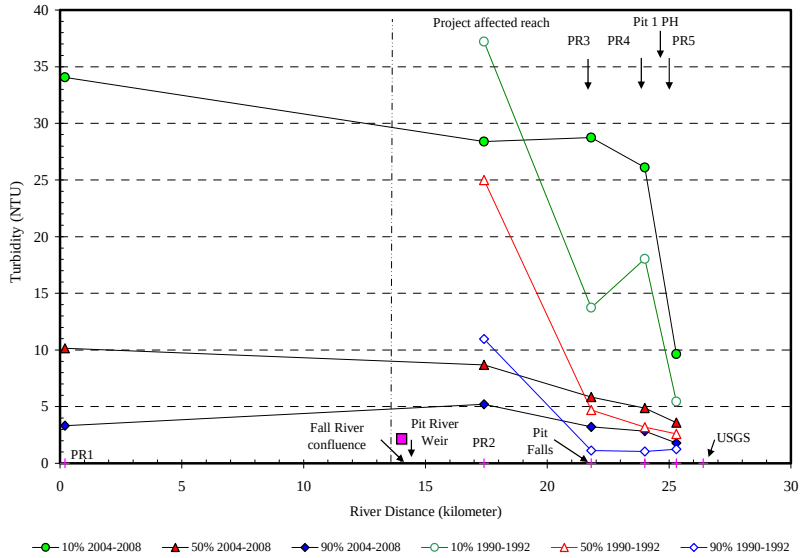
Pit River Conductivity Frequency Distribution



Pacific Gas and Electric Company

■ = Median Fall River value (FR3)

Pit River Turbidity Frequency Distribution



Pacific Gas and Electric Company

■ = Median Fall River value (FR3)

Pit River
2004-2008 Daily Mean Water Temperature

Pit River Water Temperature – Frequency Distribution

- At Pittville (PR1)
  - 10% - 23.4
  - 25% - 22.3
  - 50% - 20.8
  - 75% - 19.0
  - 90% - 16.6

June through September exceedance

- Big Eddy (PR2)
  - 10% - 23.3
  - 25% - 22.4
  - 50% - 21.1
  - 75% - 19.3
  - 90% - 17.2

June through September exceedance

- Pit 1 Footbridge (PR4)
  - 10% - 21.0
  - 25% - 20.4
  - 50% - 19.4
  - 75% - 18.2
  - 90% - 16.7

June through September exceedance

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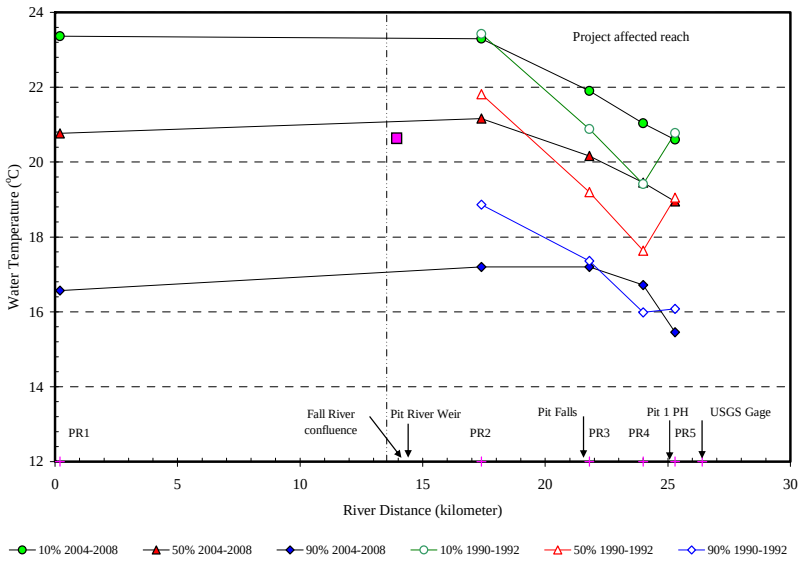
Pit River Daily Mean Water Temperature Frequency Distribution



Pacific Gas and Electric Company

■ = Median Fall River value (FR3)

Daily Mean Water Temperature in lower Pit 1 Reach Big Eddy to Pit River Falls

		Monthly Average (° C)				July-August Period	
Monitoring Year	Station	June	July	August	September	Maximum Daily Avg.	Average for period
1990-1992	PR2	21.9	22.4	21.9	19.1	24.6	22.1
	PR3	18.8	20.2	19.2	17.5	21.6	19.8
	PR4	17.4	19.1	17.8	16.3	21.9	18.4
2004-2008	PR2	20.2	22.9	21.6	18.0	25.0	22.3
	PR3	19.6	21.6	20.5	17.6	23.3	21.0
	PR4	19.1	20.8	19.7	17.1	23.0	20.3

* Monthly average calculated using the difference in the daily average values from each station.

Pacific Gas and Electric Company.

Evaluations of Daily Mean Water Temperature Change in Lower Pit 1 Reach

Change in Water Temperature between Big Eddy and Pit River Falls

	Monthly Average Change* (° C)				July-August Period	
Period	June	July	August	September	Maximum Change	Average Change
1990-1992	-3.2	-2.1	-2.8	-1.3	-4.3	-2.4
2004-2008	-0.6	-1.3	-1.1	-0.3	-2.4	-1.2

Change in Water Temperature between Big Eddy and Pit 1 Footbridge

	Monthly Average Change (° C)				July-August Period	
Period	June	July	August	September	Maximum Change	Average Change
1990-1992	-5.0	-3.1	-4.1	-3.0	-6.7	-3.7
2004-2008	-1.1	-2.1	-1.9	-0.9	-3.4	-2.0

* Monthly average calculated using the difference in the daily average values from each station.

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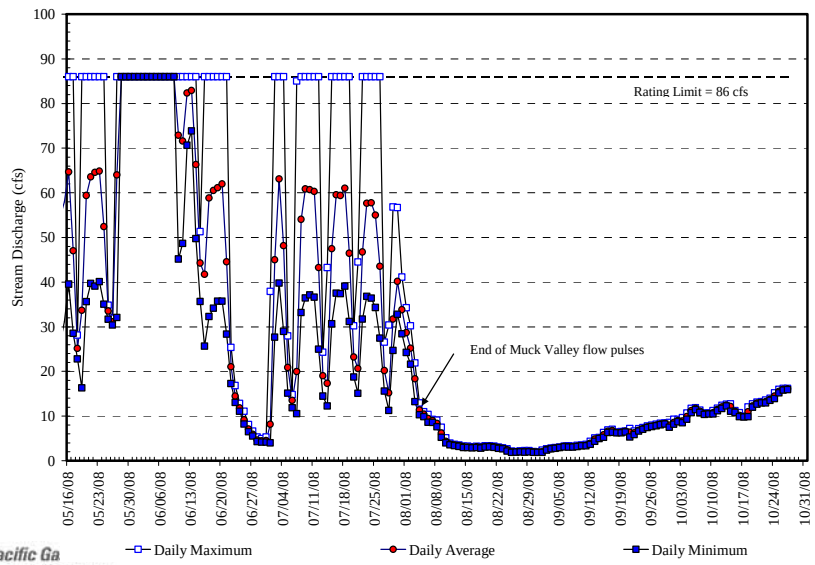
Factors Influencing Conditions in Pit 1 Reach

- Current Fall River minimum instream flow (MIF) release.
- Inflow from Pit River upstream of Fall River confluence.
  - Muck Valley Hydroelectric Operations.
  - Agricultural returns to up stream of Fall River confluence.

Muck Valley Operations

- Full operation in 1993, not operational during the 1990-1992 monitoring effort.
- Probably improved conditions in Big Eddy section prior to the implementation of the Fall River MIF.
  - Improvement is confined to early summer period. Operations are flow limited and typically end in June-July.
- Generates significant fluctuations in the Pit River flow regime.
  - 100-200 cfs above base flow during operation.
  - 5-day cycle (idle during weekends).

Effect of Muck Valley Operations on Flow Regime in Pit River - Pit River at Pittville (PR1)



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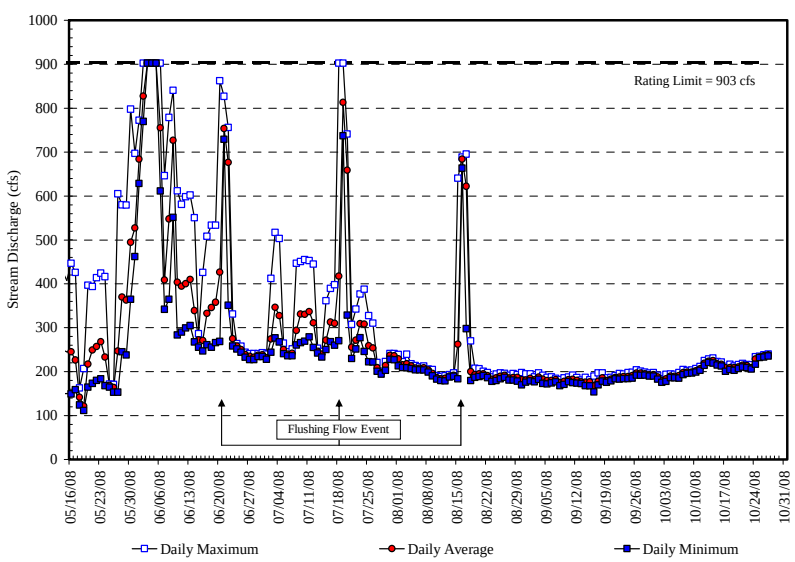
Effect of Muck Valley Operations on Flow Regime in Pit River - Pit River at Big Eddy (PR2)



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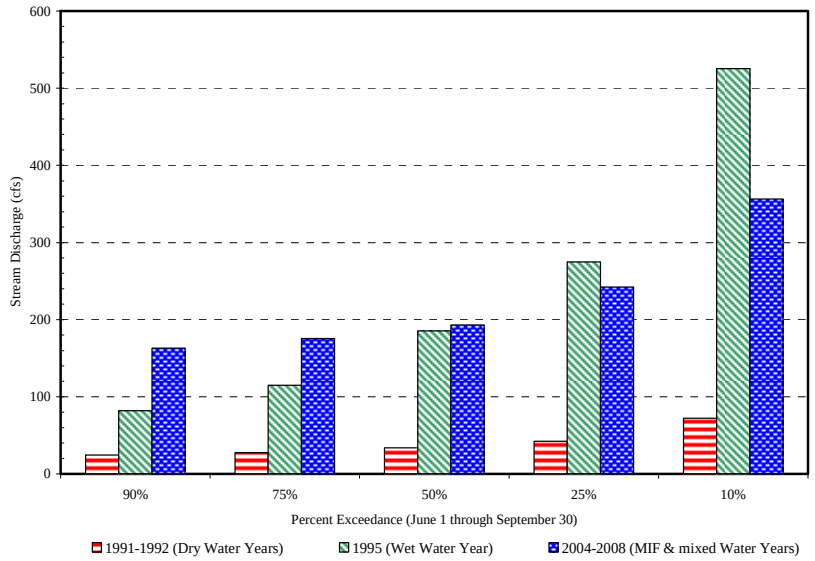
Comparison of Flow Regime in Pit River at Big Eddy



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2004-2008 Monitoring Summary
Pit River

The current Pit 1 Forebay 150 cfs MIF has improved the following water quality parameters:

- DO in Big Eddy section of the Pit 1 Reach.
- pH in Big Eddy section of the Pit 1 Reach.
- Conductivity in Big Eddy section of the Pit 1 Reach.
- Water temperature in Big Eddy section of the Pit 1 Reach.
  - Water temperature has been increased in the lower section (high gradient section) of the Pit 1 Reach.

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Pit 1 Project Water Resource Management

Pit River above Falls

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Adaptive Management - Flow Release Schedule

License Stipulated MIF Adjustments

Evaluation Period	Scheduled Release by Period [1] (cfs) Nov-1 to Nov-15	Nov-16 May-15	May-16 May-31	June-1 Oct-31
Current [2]	75	50	75	150
2nd 3-yr period	125	NC	125	200
3rd 3-yr period	150	NC	175	250
4th 3-yr period	NC	NC	200	300
5th 3-yr period	NC	NC	NC	350
6th 3-yr period	NC	NC	NC	400

1: The Licensee shall make continuous flow releases from the Pit 1 Forebay into the Lower Fall River thence the Pit River and maintain instantaneous flows downstream of the Fall River Pond as measured at the Fall River Weir.

2: First 5-year evaluation period (2004-2008).

3: NC = No change in schedule release.

Note: This table presents a release schedule that will be executed under the incremental adaptive water quality management periods as described in Condition 17 of the 401 Water Quality Certificate. The incremental flow schedule will be implemented if it is shown that the existing flow release is not able to reasonably protect beneficial uses. The adaptively implemented flow in increments of 50 cfs shall be limited to the period in which the beneficial uses are affected.

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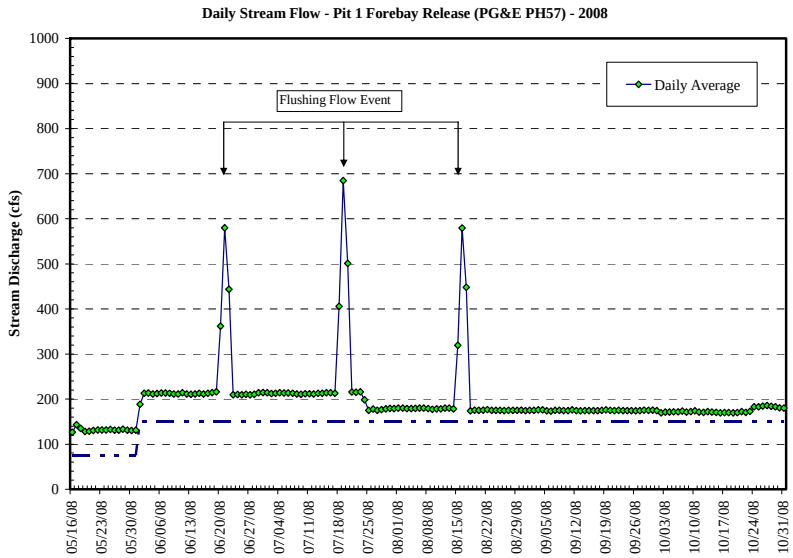
Flow Regime in Lower Fall River



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Speculated Effect of Increased MIF on Water Quality Lower Fall River

Water quality conditions are improved over Pre-MIF condition, but will probably not improve over current release.

- The change in water temperature occurring through Pit 1 Forebay under the current MIF is not appreciably different from the no release condition (increase of 150 cfs).
- Additional 50 cfs increase will likely not appreciably change residence time in Pit 1 Forebay.

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Summary of Temperature Change in Pit 1 Forebay and Lower Fall River

Change in Water Temperature through Pit 1 Forebay Complex

	Monthly Average Change (° C)				July-August Period	
Period	June	July	August	September	Maximum Change	Average Change
1990-1992	2.2	2.5	2.9	2.5	4.9	2.7
2004-2008	2.0	2.6	2.4	2.0	4.3	2.5

Positive Δ-T value equals warming (FR3-FR1)

Estimated Residence Time In Each Fall River Impoundment (Hours)

	Release from Pit 1 Forebay (cfs)					
Facility	30	150	200	250	600	900
Forebay	989 hrs	198 hrs	148 hrs	119 hrs	49 hrs	33 hrs
Fall River Pond	40 hrs	8.1 hrs	6.1 hrs	4.8 hrs	2.0 hrs	1.5 hrs

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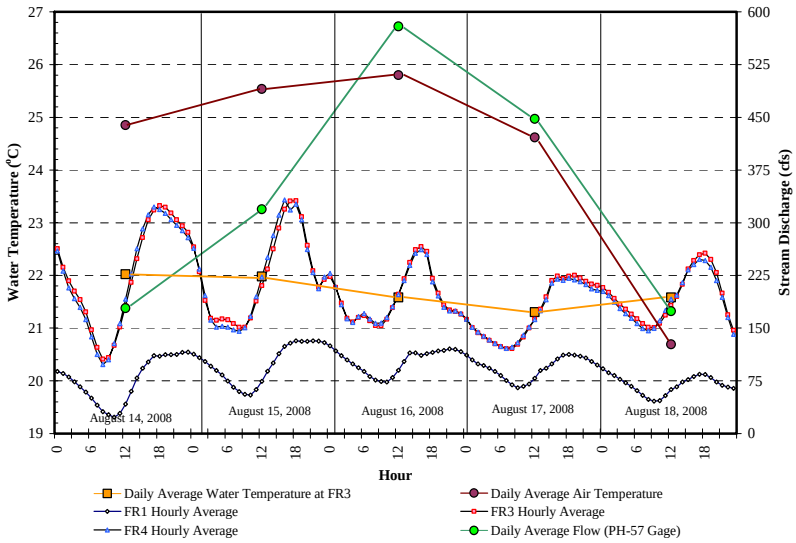
Effect of High Release Flows on Water Temperature in the Lower Fall River



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Water Temperature Changes in Lower Fall River During High Flow Events

Water Temperatures During August 2008 Flushing Flow Event

Period	8-14-08	8-15-08	8-16-08	8-17-08	8-18-08
FR1 (°C)	20.0	20.3	20.4	20.2	19.9
FR3 (°C)	22.0	22.0	21.6	21.3	21.6
Δ-T (°C)	-2.0	-1.7	-1.2	-1.1	-1.7
Release (cfs)	178	319	579	448	174

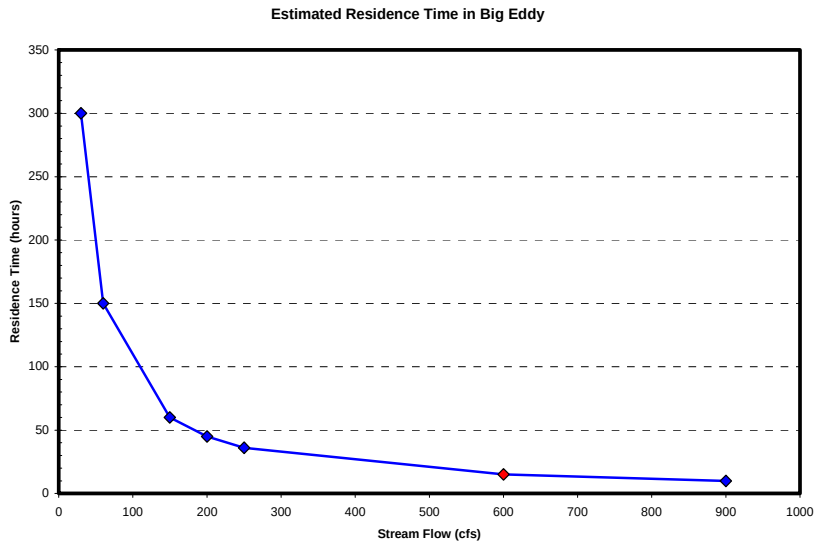
Using this data as an indicator of change, it is estimated that warming through the Forebay would be reduced by approximately 0.1°C with an additional 50 cfs above the current MIF.

Speculated Effect of Increased MIF on Water Quality Pit River

Water quality conditions are improved over no MIF condition, but will probably not improve over current release

- Current release is at or near the point where the calculated residence time curve for Big Eddy becomes asymptotic.
- Current release is at or near the point where model predictions of water temperature change with increasing flow becomes asymptotic.

Effect of Flow on Residence Time in Big Eddy



Release from Pit 1 Forebay

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Summary of Estimated Residence Time in Big Eddy Reach of Pit River

Estimated Residence Time In Pit River (Hours)

	Release from Pit 1 Forebay (cfs)					
Station	**+30**	**150**	**200**	**250**	**600**	**900**
Big Eddy	299 hrs	60 hrs	45 hrs	36 hrs	**15 hrs**	10 hrs
Pit 1 Footbridge	**5-13* hrs**	--	--	--	**2-6* hrs**	--

* Time is range from arrival to passing during 1992 dye test

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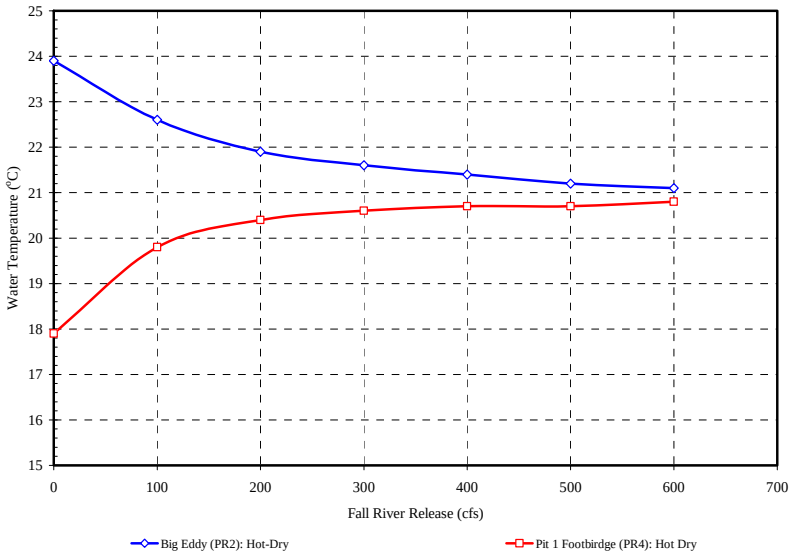
1992 Model Predicted Water Temperature in Pit 1 Reach with Increasing Pit 1 Forebay Release – July (Hot-Dry)



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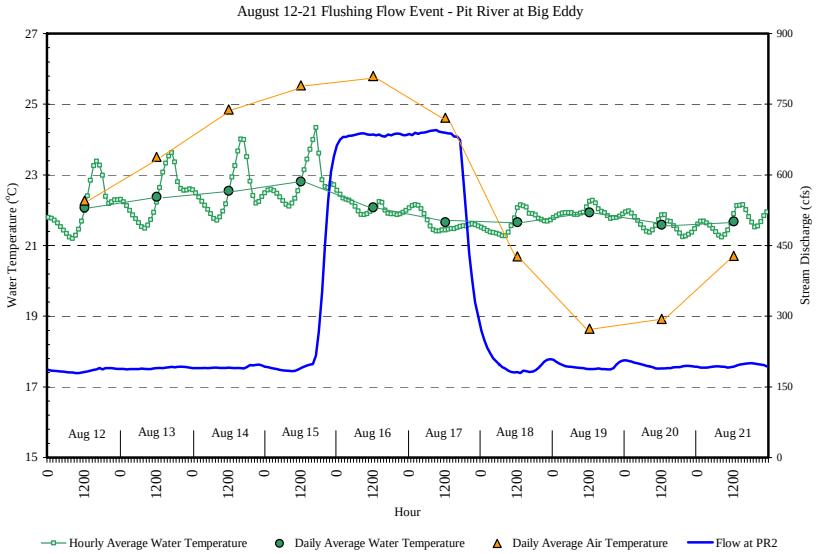
Effect of Elevated Flows on Water Temperature in the Low Gradient Section of the Pit 1 Reach (August 12-21, 2008)



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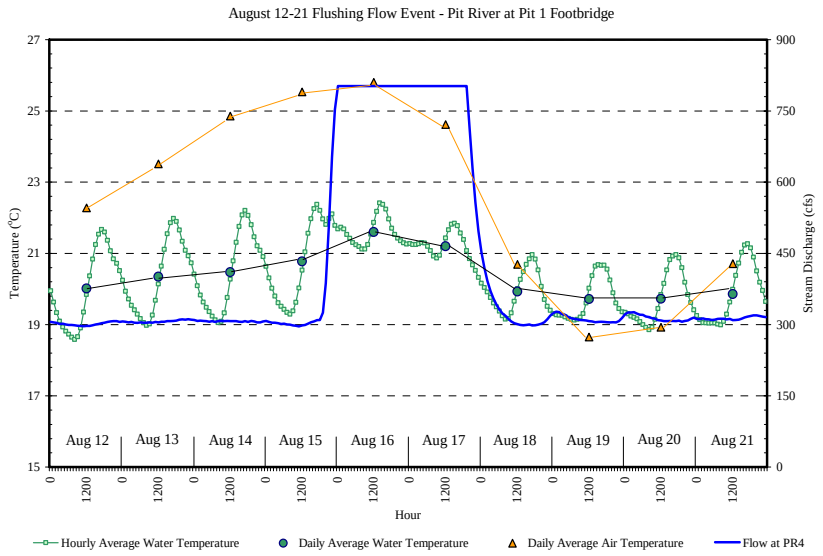
Effect of Elevated Flows on Water Temperature in the High Gradient Section of the Pit 1 Reach (August 12-21, 2008)



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PG&E's Proposed Operation

No change in current 150 cfs release at Pit 1 Forebay

- 2004-2008 water quality monitoring data indicates that the current 150 cfs MIF has improved DO, pH, Spc, and water temperature in the impacted reach of the Fall River and low gradient section of the Pit 1 Reach.
- Review of data from various studies conducted in 1990-1992 indicates that increasing the MIF by 50 cfs will not change the hydrologic regime in either Pit 1 Forebay or the low gradient section of the Pit 1 Reach sufficient to produce further improvements in water quality.

Continue water quality monitoring with modifications suggested in 5-year report

- Summarized in following slide

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Monitoring Program Modifications

Fall River

- Eliminate two (FR2, FR4) stations in Lower Fall River. Use current FR3 location at Fall River Pond Weir as primary compliance station.
- Reduce twice-a-month water quality sampling to once a month.

Pit River

- Move station PR1 from Pittville to above confluence with Fall River. Eliminate flow monitoring at Pittville.
- Eliminate PR3 station at Pit River Falls.
- Reduce twice-a-month water quality sampling to once a month.
- Implement diel monitoring at Big Eddy to define diel DO cycle under current MIF.

Questions - Discussion

Pit 1 Project: Potential Effects of Alternative Flow Releases on Selected Resources
May-09

Resource	Pre-license MIF	Current MIF	50 cfs Adaptive Increase to Summer MIF (from 150 to 200 cfs)	Comments & Recommendations
Beneficial Uses		Benefit - Beneficial uses supported include: MUN, AGR, POW, REC-1, REC-2, WARM, COLD, SPWN (warm)	Benefit - Beneficial uses supported include: MUN, AGR, POW, REC-1, REC-2, WARM, COLD, SPWN (warm)	Beneficial uses generally met.
		Risk: Beneficial uses potentially reduced : POW	Risk: Beneficial uses potentially reduced : POW	
		Fishing supported in Fall River. Wadeability in Pit River reduced.	Wadeability in Pit River would be reduced.	
Water Quality				
pH	Frequent exceedances.	Increases in Pit 1 Forebay, but quickly returns to stream levels.	No improvement over current MIF is expected with addition of 50 cfs.	
DO	Frequent exceedances. Significant diel fluctuation	Occasional exceedances for COLD in upper Pit 1 Reach (confluence to Big Eddy) and Fall River Pond. DO levels good in lower Pit 1 Reach (canyon section), significant improvement in diel variation in Big Eddy section.	No improvement over current MIF is expected with addition of 50 cfs.	Implement short-term study to investigate diel DO variation in Big Eddy section of Pit River.
Turbidity	No Project-related turbidity exceedances identified	Some reduction in turbidity is seen in the Fall River Pond, overall turbidity is passed through the system with very little change.	No change expected.	

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Pit 1 Project: Potential Effects of Alternative Flow Releases on Selected Resources
May-09

Temperature (upstream of Big Eddy)	Warm summer water temperatures in Pit 1 Forebay and Fall River Pond. No release to flow in lower Fall River. Water temperatures in Big Eddy section of Pit 1 Reach warm and driven by inflow from Pit River upstream of confluence.	Residence time has been decreased in Fall River Pond with current flows, thereby decreasing thermal load time. Approximately 2ºC warming through forebay, which is a slight improvement over 1990-1992 warming trends. Water temperatures in Big Eddy section of Pit 1 Reach are not significantly different from those observed in 1990-92.	Higher flow would not measurably decrease warming through Big Eddy. Temperature data obtained during flushing flow suggest releasing the next incremental 50-cfs in MIF would reduce summer water temperatures only by 0.1ºC.	Model predicts cooling effects at Big Eddy are greatest in first 100-150 MIF releases, benefits diminish at higher flows. Therefore no change recommended.
Temperature (downstream of Big Eddy)	Substantial cooling (colder by ~ 2 ºC) during summer due to spring flow accretion.	No water quality exceedances identified. Median temperatures at lower Pit 1 are approaching 20 ºC.	Risk - Potential to further increase water temperature (model predicted warming of additional 0.5-0.7 ºC) by diminishing the influence of the cool spring inflows.	Increased flow may negatively change temperature regime in reaches downstream of Big Eddy, therefore no change in flow recommended.
		Risk - Increase in flow decreases coldwater influence of springs.	Risk - Further decrease cold water spring habitat.	
Fall River Pond	Nuisance vegetation in Fall River Pond & related concern re. mosquito production.	Current MIF effectively controls vegetation in Fall River Pond.	No change expected.	If a series of drought years occurs, revisit potential need for flushing flows.

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Shasta Crayfish	Present in Pit River above the Falls. Probably occurred below the Falls, but deep water makes sampling difficult.	Risk - Population in Pit River Bypass Reach appears to have substantially decreased since license flow regime implemented. MIF or summer flushing flows may have contributed.	Risk - Increasing MIF would further increase water temperatures in the Pit River at the Pit Falls and footbridge.	To decrease risk of extirpation, do not increase flow at this time. Evaluate potential effects of summer flushing flows.
	The 1990-92 data showed that under the previous license, water temperature in the Pit River at the Pit Falls is 19.2° C 50% of the time from June thru Sept.	Under the MIF, water temperature at the Pit Falls has increased to over 20.2° C 50% of the time from June thru Sept.	The model shows that increasing MIF an additional 50 cfs will reduce cooling at the falls by 0.2° to 0.5° C (depending on month). The average July temperature of 21.6° C at the Falls from 2004-2008 would increase to over 22° C under a 200 cfs MIF based on the model estimated reduction in cooling. Water temperature at both the Pit River falls and the footbridge would be over 20° C in August.	

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Pit 1 Project: Potential Effects of Alternative Flow Releases on Selected Resources
May-09

Bald Eagle	Benefit - High eagle use and productivity.	Benefit - Forebay remains an important foraging site. Fall River is not important as foraging habitat	No change expected in Forebay or lower Fall River	Although bald eagle use of Pit River bypass reach declined, local populations are healthy. Continued monitoring recommended to identify future trends.
		Risk? - The bald eagle nesting in Pit 1 Forebay no longer utilizes the pool tail-out of Big Eddy, which may partly be due to residential development, partly to potential decrease in sucker population, or decrease in forage habitat.	Risk - Increased flow may further reduce shallow-water forage habitat.	
	Benefit - Model predicts highest foraging habitat under lowest flows.	Risk - Increased flow results in modest decline of foraging habitat.	Risk - Increased flow may further reduce shallow-water forage habitat.	Increased flow not likely to benefit forage habitat.
		Benefit - Increase in a forage species, hardhead, in Pit 1 bypass reach.	No change expected.	
		Risk - Potential for effects on an important forage species, Sacramento sucker.	Unknown impacts to Sacramento sucker. Spawning habitat, which is utilized by bald eagles for forage, is not likely to increase.	

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Pit 1 Project: Potential Effects of Alternative Flow Releases on Selected Resources
May-09

Fish				
Fall River Pond	Risk - Dominated by nonnative species.	Benefit - substantial decrease of bluegill, green sunfish, black crappie. Rainbow trout increased (CDFG stocking).	No change expected.	
		Risk - Tui chub decrease, largemouth bass increase.	No change expected.	
Fall River/ / Upper Pit River	For most adult species, WUA in Big Eddy would increase with higher flows.	Benefit - Improve fish habitat & temperature in lower Fall River.	WUA for adult fish species may increase in Big Eddy, but habitat is most suitable for adult largemouth bass. Deep water translates to very little habitat for early life stages of rainbow trout, Sacramento sucker, hardhead and Sacramento pikeminnow. Deep water preference of early life stages of LM bass translates to larger amounts of habitat.[1]	Increased flow may increase WUA for adult fish, but LM bass dominates the community.
		Risk - Increase in nonnative species (particularly largemouth bass) in lower Fall River and upper Pit River. Lower Fall River dominated by LM bass	Largemouth bass likely to continue to dominate Lower Fall River.	
		Water temperatures reach stressful levels for trout in the summer in Big Eddy.	Minimal change expected.	Increased flow would decrease summer temperature only slightly at Big Eddy.

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Pit 1 Project: Potential Effects of Alternative Flow Releases on Selected Resources
May-09

Canyon Reaches	Lower WUA for adult trout and Sacramento sucker.[1,2]	Increased % of maximum WUA for adult trout (~ 98% upper canyon, 73% lower canyon) and adult sucker (88% upper canyon, 54% lower canyon)[2]	Increased % of maximum WUA at 250 cfs (which would be 100 cfs greater than current MIF) for adult trout (100% upper canyon, 82% lower canyon) and adult sucker (98% & 62%).[2]	
		Maximum WUA for fry/juvenile trout and Sacramento sucker peak at releases at or below 100 cfs (both canyon reaches combined).[2]	Although higher releases would increase WUA for adult rainbow trout and Sacramento sucker, it would reduce habitat available to other life stages and oher native species.[2]	
Upper Canyon		Benefit - Bluegill & green sunfish decreased; native tule perch, hardhead increased.	No substantial change expected in native transition zone assemblage.	Habitat for native species assemblage currently good. No change in MIF recommended.
		Risk - Sacramento sucker decreased, LM bass increased (Note - sucker numbers due decreased sampling effectivness, i.e. deeper water, vs. actual population response?).	Impacts unknown.	
Lower Canyon		Benefit - Native fish dominated, hardhead comprised majority of fish collected.	No change expected	Habitat for native species assemblage currently good. No change in MIF recommended.

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		Risk - Sacramento sucker decreased (sampled effectively?)	Impacts unknown.	
		Rainbow trout have not increased, despite additional WUA, possibly due to higher summer water temperatures.	Reduction of coldwater influence of springs may reduce amount of cool-water habitat for trout during summer months.	Lower Canyon reach currently supports the best habitat for trout in the bypass reach, based on temperature.
Foothill yellow-legged frog	None documented	None documented	No change expected.	
Northwestern Pond Turtle		Current population appears to be healthy under current flows.	This species utilizes slow-moving water. Increase in flow may decrease the overall amount of available habitat.	Continue monitoring as outlined in plan, but add trapping component to collect age class data.

[1] Pit 1 License Application (PG&E 1993)

[2] FERC EA

License Required Releases (instantaneous releases measured at Fall River Weir)

Nov 1-15	75 cfs
Nov 16 - May 15	50 cfs
May 16 - 31	75 cfs
Jun 1 - Oct 31	150 cfs

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Pit 1 Hydroelectric Project, FERC No. 2687

A Biological Evaluation of Thermal Effects from Summer Flushing/Whitewater Flows on Spring-influenced Aquatic Habitat in the Pit 1 Bypass Reach

May 2009

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Pit 1 Project, FERC No. 2687

A Biological Evaluation of Thermal Effects from Summer Flushing/Whitewater Flows on Spring-influenced Aquatic Habitat in the Pit 1 Bypass Reach

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May 2009

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EXECUTIVE SUMMARY

This report provides a biological evaluation of the potential thermal impacts of summer flushing flows on spring-fed sections of the Pit River. In the lower Pit 1 bypass reach of the Pit River, coldwater species, including fish, molluscs, and the endangered Shasta crayfish, depend on the coldwater refugia created by the springs. The temperature data measured at a coldwater spring during and after the August 2004 flushing flow showed that the majority of the refugia area covered by coldwater habitat under base flow was reduced to zero during the flushing flow. A simple jet/plume analytical tool further supported the observation during the flushing flow, all the coldwater habitat disappeared and more than half the area's substrate was covered by water with temperatures of 19 ºC or greater.

Summer flushing flows introduced warmer ambient temperature to Pit 1 reach and has significantly reduced coldwater refugia. During the base flow, river bottom with temperatures in the range of 15-17 °C are mostly replaced with higher temperature of 17-19 °C during flushing flows. Additionally, diel temperature pattern changed dramatically. During the flushing flow, the cooler night-time temperatures (i.e., daily minimum temperatures) stayed above 21 ºC, thus eliminated thermal refugia that would otherwise provide trout with needed periods of metabolic recovery during critically warm periods.

Molluscs can be affected by the thermal changes or by the hydraulic changes caused by flushing flows. Coldwater molluscs that have narrow temperature tolerances and prefer spring environments, such as the U. S. Forest Service sensitive species *Fluminicola seminalis* (nugget pebblesnail) and *Juga occata* (scalloped juga [snail]) in the lower Pit 1 bypass reach, could be affected by the warmer temperatures and loss of thermal refugia during flushing flows.

Freshwater mussels in the Pit River are particularly vulnerable to pulsed flows in the summer, when adults are reproducing and juveniles are falling off of their fish hosts to settle on the stream bottom. The three critical reproductive events (spawning, glochidial release, and juvenile excystment) occur during June, July, and August for all three native mussels found in the Pit 1 bypass reach. Because all three reproductive processes occur in the water column, they are vulnerable to the high velocities of flushing flows. Newly excysted juveniles may be especially vulnerable to scouring flows. For the Pit River, the restriction of pulsed flows to mid September,

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or later, would allow newly excysted juvenile mussels more time to settle successfully and grow to a less-vulnerable size.

Shasta crayfish are known to occur in an approximately 600-meter-long reach of the mainstem Pit River that is influenced by colder temperature springs just above the Pit River Falls. Although its status in the Pit 1 bypass reach is not well known due to sampling difficulties created by the large substrate, there has been a significant decline in Shasta crayfish numbers in this 600-meter reach during recent years since the new license flow regime was implemented. In October 2005, a total of 21 Shasta crayfish were found in this 600-meter reach, but only one dying adult male Shasta crayfish was found in September 2008. During this same period, the numbers of the two non-native crayfish species: signal crayfish and fantail crayfish have almost tripled and doubled, respectively, in this reach. Non-native crayfish, which are more tolerant of a wider temperature range as well as temperature fluctuations, can be both competitors and predators of Shasta crayfish. The Shasta crayfish has a long evolutionary history of living in stable, cold, spring-fed environments and is not adapted to short-term fluctuations in temperature.

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Figure 1 Effects of the August 16-17, 2008 Flushing Flow Event on the hourly average and daily average water temperature in the Pit River at the Pit 1 Footbridge. 9

Figure A-1 Effect of base river flows on water temperatures in the Pit 1 bypass reach of the Pit River, at the confluence of the spring located just downstream of the Pit 1 Footbridge. Base flow data (30 August 2004 at 1520 hours) were obtained from temperature sensor arrays (black lines with black dots at sensor locations). The river bank during base flow (black) and flushing flow (red) is represented in the x-y plane (in meters). Graphical overhead orientation is looking downstream, with the spring flow entering from the left. Blue arrows indicate the general direction of the spring flow (5 cfs) and base river flow (277 cfs). A-5

Figure A-2 Effect of flushing flows on water temperatures in the Pit 1 bypass reach of the Pit River, at the confluence of the spring located just downstream of the Pit 1 Footbridge. Flushing flow data (28 August 2004 at 1520 hours) were obtained from temperature sensor arrays ((black lines with black dots at sensor locations). The river bank during base flow (black) and flushing flow (red) is represented in the x-y plane (in meters). Graphical overhead orientation is looking downstream, with the spring flow entering from the left. Blue arrows indicate the general direction of the spring flow (5 cfs) and flushing river flow (977 cfs). . A-6

Figure A-3 Amount of area in temperature isotherms at monitored spring inflow in the Pit River under base flow (blue) and flushing flow conditions (red). Areas are calculated based on Figures 1 and 2, and are therefore restricted to the total area confined within the perimeter of the temperature arrays. A-7

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INTRODUCTION

The Federal Energy Regulatory Commission (FERC) issued a license to Pacific Gas and Electric Company (PG&E) for the continued operation of the Pit 1 Hydroelectric Project (FERC Project No. 2687) (Project) on March 19, 2003. Article 401 of the license and Condition 13 and 14 of State Water Resources Control Board (SWRCB) 401 Water Quality Certification (Appendix A of the license) require PG&E to release flushing flows during late spring/summer months to control aquatic vegetation and mosquito production in Fall River Pond, and to implement a five-year program to monitor the effectiveness of these flushing flows. Condition 13 also requires advance public notice of these flushing flows. Article 424 of the license requires PG&E to implement a study plan to assess potential effects on fish, wildlife, cultural, and recreational resources within the Project area that may result from implementation of whitewater boating flows during the September 15 through October 30 period.

Upon review of the license, PG&E biologists were concerned about the potential thermal impacts of the summer flushing flows on spring-fed sections of the Pit River, which are important for the maintenance of coldwater habitat in the Project bypass reach. PG&E's consultant, Spring Rivers, conducted a thermal refugia study at a coldwater spring during and after the August 2004 flushing flow. The methods and results of the thermal refugia study are presented in this document. During subsequent consultation, PG&E discussed the results of the thermal refugia study and expressed concern about the potential impacts to coldwater species, including fish, molluscs, and the endangered Shasta crayfish (*Pacifastacus fortis*). As a result, the California Department of Fish and Game (CDFG) requested a written evaluation of the potential effects of the license-required flow regime, including the three summer pulse flows, on coldwater habitat near springs in the Project bypass reach in the Pit River. This report provides that evaluation of potential effects, as well as, the thermal refugia study conducted during and after the August 2004 flushing flow (Appendix A). In addition, the data from the thermal refugia study were used to verify predictions made by application of jet/plume analytical theory, the results of which are presented in Appendix B.

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BACKGROUND

During consultation for the Pit 1 Hydroelectric Project license in the 1990's, the resource agencies (i.e., CDFG and U.S. Fish and Wildlife Service [USFWS]) agreed to support an evaluation of whitewater boating flows requested by American Whitewater (AW), if they were limited to the period between September 15 and October 30. The rationale behind the timing of the potential whitewater flows was to minimize potential harm to young-of-year (YOY) fish in the affected river reaches. The reasoning was that by fall, most YOY fish would be large enough to avoid impacts such as stranding or being washed downstream.

FERC evidently agreed with the rationale for limiting whitewater flows to the fall, and, as a license condition (Article 424), ordered PG&E to prepare a plan to study the potential effects on various resources of whitewater boating flows made during the period between September 15 and October 30 (FERC 1999, 2003). The plan was prepared and implemented in two phases. The Phase 1 plan was prepared in consultation with CDFG, California Department of Parks and Recreation (CA Parks), California of Boating and Waterways, California State Historic Preservation Officer, USFWS, Fall River Wild Trout Foundation, AW, and Shasta Paddlers (PG&E 2004). Following subsequent agency consultation, the Phase 2 Study Plan (PG&E 2006) was filed with and approved by FERC in 2006. PG&E conducted the studies needed to complete the analysis of impacts, based on the designated September 15 – October 30 whitewater boating period.

Phase 1 of the plan included the compilation and review of existing resource information from the Project and from whitewater impact studies conducted elsewhere in California that would be useful for defining specific studies warranting implementation during Phase 2. The Phase 2 study included a whitewater boating study to refine the acceptable range of flows, and a fish stranding/trapping study. The literature review, study results, and impact analysis are presented in two reports prepared by R2 Resource Consultants, the Phase 1 Report: *Potential Impacts of Whitewater Boating Flows, Phase 1 Interim Report, Pit 1 Project, FERC Project No. 2687* (R2 Resource Consultants 2006) and the Phase 2 Report: *Potential Impacts of Whitewater Boating Flows, Phase 2 Report, Pit 1 Project, FERC Project No. 2687* (R2 Resource Consultants et al. 2008).

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The Phase 1 Report was filed with the FERC in 2006. On April 25, 2006, PG&E met with personnel from the CDFG, CA Parks, and AW to discuss report results and Phase 2 recommendations. Following implementation of the Phase 2 Study Plan, PG&E met with CDFG, SWRCB, and AW on October 31, 2007 to discuss the Phase 2 Report and develop recommendations. During this meeting, Spring Rivers discussed the results of a thermal refugia study (Appendix A) that found that the coldwater areas created by spring inflows in the Project bypass reach of the Pit River were reduced during the summer flushing flows. The potential impacts to coldwater-dependent fish, molluscs, and the endangered Shasta crayfish were also discussed. During the October 2007 meeting, CDFG asked for a written evaluation of the potential effects of the license-required flow regime, including the three summer pulse flows, on coldwater habitat near springs in the Project bypass reach in the Pit River. During additional consultation with SWRCB, AW, and CDFG, it was agreed that final recommendations regarding whitewater flows be developed following the conclusion of the five-year comprehensive monitoring studies (2004-2008/2009) of critical biological resources and their habitats within the Pit 1 Project. These monitoring studies include Shasta crayfish, bald eagle, fish, northwestern pond turtle, foothill yellow-legged frog, flushing flow effects on Fall River Pond vegetation, and water quality. The final Phase 2 Report was filed with FERC on March 26, 2008. PG&E expects to file a final recommendation regarding whitewater boating flows during the period between September 15 and October 30 with the resource agencies, stakeholders, and FERC by December 31, 2010.

During the pre-license first stage consultation in the early 1990s, excessive aquatic vegetation in Fall River Pond was identified as an issue. Studies were conducted in 1994 and 1995 to test the effectiveness of different flushing flow volumes at controlling nuisance surface aquatic vegetation in Fall River Pond, which at times covered as much as three-quarters of the pond's surface. These studies concluded that high volume, short duration flushing flows occurring two to three times a year were the most cost effective means of controlling vegetation on Fall River Pond (Ellis 1995, 1996a). Individual flushing flows in 1994 and 1995 reduced the amount of vegetation by 12% to 48% (Ellis 1995). Ground level photo-point monitoring before and after flushing flows from 1998 through 2004 showed that the amount of vegetation was not only reduced by flushing flows, but pre-flush vegetation generally decreased over this period as well (Spring Rivers 2006, 2007b, 2008, 2009a).

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The SWRCB Water Quality Certification in the Pit 1 license requires PG&E to control surface aquatic vegetation in Fall River Pond by providing flushing flows for two consecutive weekend days three times per year. Condition 13 sets the magnitude of the flushing flows at 1250 cubic feet per second (cfs) or the natural flow to the Pit 1 Forebay, whichever is less. The first flushing flow each year is to occur in either May or June, as warranted by vegetation growth in Fall River Pond. The second flushing flow is to occur in July and the third in late August, prior to Labor Day weekend. As required by the license, PG&E provides advance public notice of these flushing flows, which allows whitewater boaters to take advantage of them. PG&E has been making these required flushing flows every year since the license was issued in 2003. As required by the license, a Flushing Flow Effectiveness Monitoring Plan (PG&E 2005) was developed in compliance with Article 401 of the license and submitted to FERC in 2005 (approved in 2006). The fourth-year annual report was submitted in March 2009 (Spring Rivers 2009a). Following a five-year monitoring period, PG&E expects to file a final recommendation with FERC in 2010 regarding the effectiveness of the flushing flows in controlling aquatic vegetation in Fall River Pond.

Effects of Pulse Flows on Coldwater Refugia

One of the primary biological issues raised by the implementation of flushing flows during summer is the reduction of coldwater refugia provided by the numerous springs in the mid and lower portions of the canyon section of the Pit 1 bypass reach. A secondary issue is the physical hydraulic effect of the flushing flows on Pit River organisms. That secondary issue has been studied for fish and macroinvertebrates on the North Fork Feather River and elsewhere. Those studies were reviewed and discussed within the context of the Pit 1 bypass reach previously in the Phase 1 Report (R2 Resource Consultants 2006). Hydraulic effects will be discussed in this report primarily in terms of the potential effects on the reproduction of mussels (see *Potential Biological Effects*).

Temperature modeling conducted in the early 1990s predicted that flow releases in the range of the license-required base flows in the Pit 1 bypass reach would increase water temperatures by approximately 1–2 ºC in the lower canyon during the critically warm months of July and August in normal and dry years (PG&E 1993). This is because the temperature of any water released

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from the lower Fall River during those two months would be warmer than the temperatures of the spring inflows. The higher base flows stipulated in the license were implemented in 2003, and water quality monitoring was implemented in 2004. The warming trend predicted by the model was confirmed with a comparison of temperatures between 1990-1992 (pre-license flows) and 2004-2008 (current license flows) (PG&E 2009a). For example, the August daily mean temperatures near the lower end of the Pit 1 bypass reach at monitoring station PR4 (footbridge above powerhouse) averaged 19.8 ºC during 2004-2008, whereas the pre-license average was 17.8 ºC. Generally, the model predicts more pronounced temperature warming in the Pit 1 bypass reach for higher flow releases. The modeled temperature relationship with flow was documented in the Exhibit E of the Application for New License (PG&E 1993) and also in Appendix B of the Water Quality Monitoring Five-Year Summary Report (PG&E 2009a).

Because of the approximately 2 ºC increase in thoroughly mixed water (i.e., outside of spring influence) predicted and observed under the 150-cfs release, PG&E biologists were concerned about the potential effects of the annual July and August flushing flows on the temperature of the relatively cold pockets of water in the immediate vicinity of the springs. During these warmer months, flushing flows could reduce, or eliminate, important thermal refugia for aquatic organisms that are dependent upon coldwater habitat. To investigate this concern, two arrays of temperature sensors were set within the coldwater plume (~ 15 ºC) of a relatively large spring (~5 cfs) to record the effects of a flushing flow on the temperatures within the plume. The methods and results of this effort are presented in the *2004 Pit 1 Coldwater Refugia Study* (Refugia Study), which is included as Appendix A.

Refugia Study Results and Simple Plane Jet/Plume Analysis Predictions

The Refugia Study was conducted in late August 2004 during a 900-cfs flushing flow release (977 cfs at the study site) on August 28th and at the base flow (150-cfs Fall River release plus Pit River flow plus spring accretion, totaling 277 cfs) on August 30th. The river temperature in the mainstem (outside the coldwater refugia zone) was 21.5 ºC during the flushing flow and 19.8 ºC at the base flow. The main findings of the Refugia Study include:

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- At base flow, the spring created areas of coldwater (15–17 ºC) and marginally coldwater (17–19 ºC) habitat in the Pit River that extended beyond the area delineated by the array of temperature sensors.
- During the flushing flow, all the coldwater (15–17 ºC) habitat disappeared, and the marginally coldwater (17–19 ºC) habitat made up less than half the area delineated by the sensors. More than half the area's substrate was covered by water with temperatures of 19 ºC or greater.
- Water temperature at individual sensors increased by as much as 3.6 ºC.
- The sensor arrays were positioned along the river bottom to provide a thorough assessment of the coldest water available and to best characterize the thermal habitat available to substrate-dwelling organisms, including molluscs.

It is important to note that the flushing flow that was studied at the end of August 2004 during the Refugia Study did not represent a worst-case scenario. The August results represent a smaller increase in temperature than would be expected at spring-influenced areas during a typical flushing flow in July, when river temperatures are at their warmest levels of the year. For example, during the July 2005 flushing flow, the daily mean temperature of the river upstream of the springs (i.e., a mixture of Fall River water plus Pit River water) was 23–24 ºC, compared to the 20–21 ºC observed at the end of August 2004 in the Refugia Study (R2 Resource Consultants 2006). The warmer river water in July would result in greater changes in daily mean temperature (Figure 3-19 in PG&E 2009a) and higher peak temperatures in the otherwise coldwater-influenced areas. Also, the flushing flow release was approximately 900 cfs, which is smaller in magnitude than both the potential maximum prescribed flushing flow of 1250 cfs and the preferred boating flows of 1000 to 1200 cfs (R2 Resource Consultants et al. 2008). The larger the magnitude of the flushing or whitewater flows, the smaller and warmer the coldwater refugia would become.

The data from the Refugia Study were then used to verify predictions made by application of jet/plume analytical theory. A plane-jet formula was used as a conceptual analytical tool to characterize the physical habitat change under different flow scenarios (Appendix B). This analysis had the following findings:

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- There is a rapid and substantial change in both the temperature and area of coldwater habitat from the spring (or mixing with the receiving water) when summer flushing flows are implemented. The degree of temperature reduction and its spatial characteristics are greatly influenced by the temperature and volume of water from the spring and the temperature and volume of the main channel flow. Under the modeled base flow condition of 277 cfs (ambient temperature at 19.8 ºC), the plume bends rapidly in the downstream direction with the 18.5 °C isotherm contour extending about 100 feet from the mouth of the spring and spreading about 3 to 5 feet laterally from the jet centerline. Under the flushing flow condition (977 cfs), which brings in an ambient temperature at 21.5 ºC level, both the length and the width of the same isotherm contour are reduced by more than half from the base-flow case (Figure B-1 in Appendix B).
- The total area for different isotherms under the base flow is substantially reduced under flushing flow conditions, as shown in Figure B-2 in Appendix B. For instance, the 18.5 ºC isotherm area is reduced from more than 600 square feet to less than 100 square feet during the flushing event.
- The cold-jet from the spring bends rapidly with cross flow (mainstem flow) and evolves into a strong 'bending jet' region under all flow conditions. The coldwater refugia are expected to occur in narrow confined bands within 20 feet along the river edge downstream of the mouth of each spring.

This reduction in size and quality of refugia would be even more pronounced at springs smaller than the test spring, because the warmer river water would more thoroughly mix with, and dilute, the smaller coldwater plumes created by those springs.

A worst-case scenario could occur during an extended heat wave in July, or possibly early August, when Fall River and Pit River temperatures would rise above their usual seasonal peaks. A flushing flow at that time would be abnormally warm (i.e., daily mean temperature greater than 23 ºC [PG&E 2009a]) during a time when coldwater refugia would be most needed. As described above, the higher the magnitude of the flushing flow, the warmer the river temperature and the more the thermal refugia would be reduced or eliminated.

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POTENTIAL BIOLOGICAL EFFECTS

The potential effects of the reduction or elimination of coldwater refugia by flushing or whitewater flows on several groups of aquatic organisms are briefly discussed in this section. The discussion is based on a literature review and summarizes available information for the organisms, including their life history and habitat requirements.

The springs, and the coldwater habitat they provide, are the most important habitat feature in the lower canyon of the Pit 1 bypass reach for rainbow trout and other coldwater-dependent organisms. This was recognized during PG&E relicensing studies conducted in 1991 and 1992, when temperature studies showed significant cooling in the lower half of the canyon due to cold-water input from springs. Numerous coldwater springs, extending from approximately 800 meters above the Pit River Falls down through the lower canyon, were mapped and characterized (Ellis and Hesseldenz 1993, PG&E 1993, Spring Rivers July 2004 unpublished data). Fish surveys at the time found rainbow trout to be common in the lower canyon but absent from the warmer upper section of the canyon that lacks cold springs (PG&E 1993). In 1995, prior to the summertime 150-cfs base flow release required under the 2003 license, Shasta crayfish were discovered in spring-influenced habitat just above the Pit River Falls (USFWS 1998). Two coldwater-dependent mollusc species, *Fluminicola seminalis* (nugget pebblesnail) and *Juga occata* (scalloped juga [snail]), were also identified in the lower canyon, particularly in proximity to springs (Frest and Johannes 1995, Maria Ellis, personal observation).

Fish. The role of coldwater springs in both cooling the mainstem and creating coldwater refugia is a key factor in the ability of the lower canyon to support trout populations. Trout have not found in the upper canyon above the coldwater springs, where mean daily water temperature in the Pit River (Big Eddy) is greater than 21.1 °C fifty percent of the time during June through September (Table 3-9 of PG&E 2009a). Figure 1 shows that during the August 2008 flushing flow, water temperatures at the bottom of the Pit 1 Canyon (i.e., the coolest monitoring location with the most cumulative spring inflow) were 21 ºC or higher the entire period, as the usual nighttime cooling was eliminated. Summer flushing flows can both reduce or eliminate coldwater refugia, depending on size, and result in mainstem daily minimum temperatures that are 21 ºC or higher. This can result in stressful conditions for rainbow trout.

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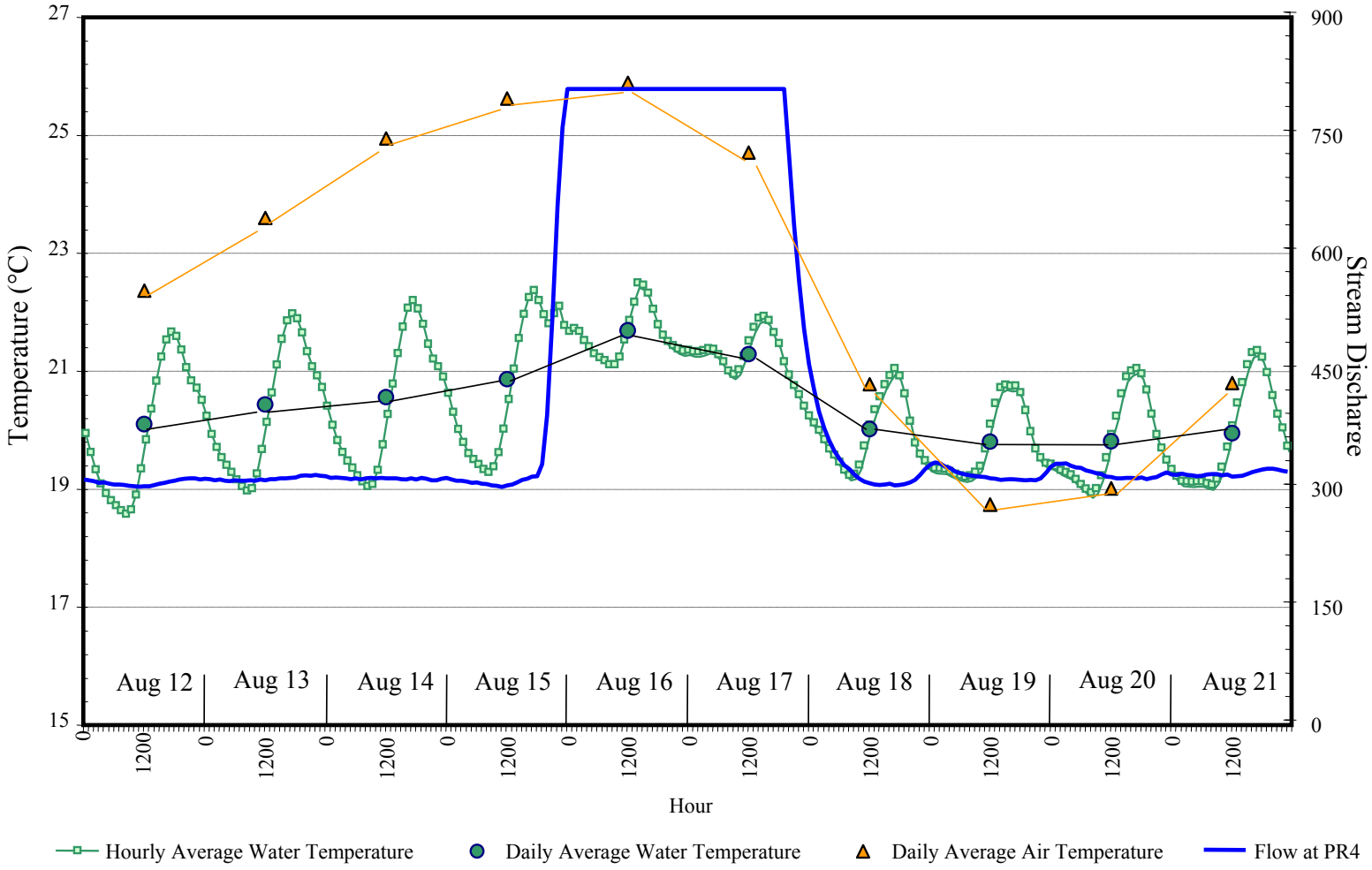

Figure 1 Effects of the August 16-17, 2008 Flushing Flow Event on the hourly average and daily average water temperature in the Pit River at the Pit 1 Footbridge.

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The native rainbow trout (*Onchorhynchus mykiss*) of the Pit River is the fish species that would likely be affected most by the reduction or loss of coldwater refugia. Brown trout (*Salmo trutta*), an introduced species that is much less abundant, would also be affected in a similar manner. Other native species (e.g., hardhead [*Mylopharodon conocephalus*], Sacramento sucker [*Catostomus occidentalis*], and Sacramento pikeminnow [*Ptychocheilus grandis*]) are more tolerant of, or prefer, warmer water than trout. The non-native centrarchid species (e.g., green sunfish [*Lepomis cyanellus*] and largemouth bass [*Micropterus salmoides*]) also prefer warmer temperatures in the Pit River. The springs in the Pit River bypass reach maintain generally suitable temperatures for rainbow trout during the summer. They also provide pockets of coldwater habitat when river temperatures climb above 20 ºC and become more stressful for trout. Trout have not been found upstream of the spring-influenced lower canyon section of the Pit 1 bypass reach during pre-license or post-license fish monitoring (PG&E 1993, 2009b). Regarding the status of the rainbow trout population in the lower canyon section, the following excerpt is taken from the discussion (Section 5.2.5) of the report on the five years of post-license fish monitoring (PG&E 2009b).

> Though individual species have shown year to year fluctuations in this reach, a general trend involving the decrease of the Rainbow Trout assemblage and an increase of the Pikeminnow-Hardhead-Sucker fish assemblage is notable. This shift is possibly due to the increase in water temperatures currently experienced in this reach due to the increase in base flows released from the Pit 1 Forebay. Temperature studies conducted by PG&E have determined that water temperatures within this reach are warmer during the summer months than in 1990-1992, likely due to the continual release of water through the bypass reach and the operation of the Muck Valley Project (PG&E 2008).

Studies in southern California (Matthews and Berg 1997) and northeastern Oregon (Ebersole et al. 2001, 2003) have shown the importance of small thermal refugia in maintaining rainbow trout populations in streams with marginal or lethal temperatures. Water temperature has been found to be an important determinant of trout distribution during periods when temperatures are stressfully high (Cech et al. 1990). Ebersole et al. (2001) observed rainbow trout using small (1-10 m²) thermal refugia during midday when stream temperatures were above 22 ºC in northeastern Oregon streams. They also found higher abundance of rainbow trout to be associated with inflows of cooler subsurface water into streams with complex channel morphologies (Ebersole et al. 2003). In a southern California stream, cold seeps in the bottom of

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a pool provided refuge from lethal temperatures, even though dissolved oxygen levels in the cold water were stressfully low (Matthews and Berg 1997).

A flushing flow in the Pit 1 bypass reach during the warm summer periods could eliminate critical refuge habitat for trout for approximately two days, particularly at the smaller spring inflows. Throughout the mainstem river, flushing flows also eliminate cooler night-time temperatures (i.e., daily minimum temperatures) that provide trout with needed periods of metabolic recovery during critically warm periods (Figure 1). With mean river temperatures reaching 22 ºC and maximum temperatures reaching 23 ºC or higher during heat waves, portions of the coldwater spring plume in the Refugia Study would experience temperature increases of 4–6 ºC, instead of the 2–4 ºC increases that occurred with 21 ºC river water in late August 2004. Also, the potential elimination of smaller refugia in the Pit 1 bypass reach would expose trout to the 23 ºC, or higher, temperatures of the main river flow during a July heat wave. Although such increases may not be directly lethal to trout (i.e., >25 ºC; see Hokanson et al. 1977), they would undoubtedly be stressful.

Molluscs. Molluscs, depending on type, could be affected by the thermal changes caused by flushing flows or by the hydraulic changes. Flushing flows would negatively affect coldwater molluscs (primarily snails) that are crenophilic (i.e., organisms that prefer spring environments) or stenothermic (i.e., organisms having narrow temperature tolerances) by reducing or eliminating coldwater refugia. Two such species that occur in the lower canyon of the Pit 1 bypass reach are *Fluminicola seminalis* (nugget pebblesnail) and *Juga occata* (scalloped juga [snail]) (Frest and Johannes 1995, Spring Rivers unpublished data). Both are U. S. Forest Service sensitive species considered to be extinct over much of their historic range (Taylor 1981, Frest and Johannes 1995, Hershler and Frest 1996, Hershler et. al 2007). On March 13, 2008, the Center for Biological Diversity and four other conservation groups petitioned the USFWS to protect *Fluminicola seminalis* as endangered under the Endangered Species Act. Frest and Johannes (1995) stated that *Fluminicola seminalis* and *Juga occata* merit classification as endangered under both the federal and California Endangered Species Acts. Being relatively immobile, both *Fluminicola seminalis* and *Juga occata* would be particularly vulnerable to the degradation of their coldwater habitat, as described previously for trout.

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The hydraulic changes, especially increased velocities, associated with summer flushing flows or whitewater flows could be detrimental to several species of mussels and peaclams (Spring Rivers 2007a). *Anodonta californiensis* (California floater [mussel]), a U. S. Forest Service sensitive species, *Gonidea angulata* (western ridged-shell [mussel]), and *Margaritifera falcata* (western pearlshell [mussel]) are found in the Pit 1 bypass reach (Spring Rivers 2007a). In addition, *Pisidium ultramontanum* (montane peaclam) is a U. S. Forest Service sensitive species that is also found in the Pit 1 bypass reach (Frest and Johannes 1995, Ellis 1996b). *Pisidium ultramontanum* has the most restricted distribution of any North American member of the family Sphaeriidae (Taylor 1960). *Anodonta californiensis, Gonidea angulata, Margaritifera falcata*, and *Pisidium ultramontanum* are all considered to be extinct over much of their historic range (Taylor 1981, Frest and Johannes 1995). Frest and Johannes (1995) suggest that *Anodonta californiensis* and *Pisidium ultramontanum* merit classification as threatened both federally and in California, and *Gonidea angulata* merits classification as threatened in California.

Freshwater mussels in the Pit River are particularly vulnerable to pulsed flows in the summer, when adults are reproducing and juveniles are falling off of their fish hosts to settle on the stream bottom (Spring Rivers 2007a). The three critical reproductive events—spawning (i.e., males expel sperm into the water column and females move eggs into portions of their gills), glochidial release (mature mussel larvae called glochidia are expelled into the water column in order to attach to suitable host fish), and juvenile excystment (glochidia that have successfully transformed into juvenile mussels drop off of host fish) occur during June, July, and August for all three native mussels found in the Pit 1 bypass reach (Spring Rivers 2007a). Because all three of these reproductive processes occur in the water column, they are vulnerable to the high velocities of flushing flows. Newly excysted juveniles may be especially vulnerable to scouring flows. The periods during which these reproductive events occur are quite restricted in some species, such as *Gonidea angulata* and *Margaritifera falcata*. For *Gonidea angulata*, peak glochidial release occurs during June and peak juvenile excystment occurs during late July. The glochidia of *Margaritifera falcata* mature in July in the Pit River, so juvenile excystment would likely occur in August. Flushing flows in August and early September would occur soon after juvenile excystment and could displace settling juveniles before they could burrow into, or attach to, the substratum (Holland-Bartels 1990). Hardison and Layzer (2001) concluded that recruitment of mussels in three regulated rivers in Kentucky was limited by unnaturally high

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discharges that occurred during periods of juvenile excystment. In the South Fork Eel River in California, a two-fold increase in river discharge caused a 60% decline in recruitment in populations of *Margaritifera falcata* (Howard and Cuffey 2006). For the Pit River, the restriction of pulsed flows to mid September, or later, would allow newly excysted juvenile mussels more time to settle successfully and grow to a less-vulnerable size (Spring Rivers 2007a).

Shasta crayfish. The Shasta crayfish, *Pacifastacus fortis*, is a state and federal endangered species. Shasta crayfish are known to occur in an approximately 600 meter-long reach of the mainstem Pit River that is influenced by colder temperature springs just above the Pit River Falls (Spring Rivers 2009b). Although its status in the Pit 1 bypass reach is not well known due to sampling difficulties created by the large substrate (USFWS 1998, Spring Rivers 2009b), there has been a significant decline in Shasta crayfish numbers in this 600-meter reach during recent years since the new license flow regime was implemented. In October 2005, a total of 21 Shasta crayfish (6 adults, 7 juveniles, and 8 YOY) were found in this 600-meter reach, but only one adult male Shasta crayfish was found in September 2008 (Spring Rivers 2009b). In addition, two non-native crayfish species: signal crayfish (*Pacifastacus leniusculus*) and fantail crayfish (*Orconectes virilis*) have invaded the Pit 1 bypass reach and are becoming more abundant. Between 2005 and 2008, the number of signal crayfish (10 in 2005, 29 in 2008) almost tripled and the number of fantail crayfish (12 in 2005, 23 in 2008) almost doubled in this reach (Spring Rivers 2009b). Non-native crayfish can be both competitors and predators of Shasta crayfish (Ellis 1999). Both non-native crayfish species are more tolerant of a wider temperature range as well as temperature fluctuations than Shasta crayfish. The Shasta crayfish has a long evolutionary history of living in stable, cold, spring-fed environments (Ellis 1999). It is not adapted to short-term fluctuations in temperature, as was shown by the high mortality of Shasta crayfish exposed to short-term increases in water temperature in an experimental setting at the University of California, Berkeley (Mojica et al. 1993). During unseasonably warm weather in the fall of 1992, Shasta crayfish mortalities occurred as water temperatures in the experimental ponds increased to 20 °C. In the final report of their study, Mojica et al. (1993) state that "we learned one very important fact about *P. fortis*: it is a temperature sensitive species." Because of its crenophilic nature and endangered status, the potentially harmful thermal effects of summer flushing flows discussed above should also be considered for the Shasta crayfish.

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CONCLUSIONS

The results of the Refugia Study conducted during August 2004 demonstrated the detrimental thermal effect of a 900-cfs flushing flow upon the coldwater refugia provided by the springs in the mid and lower section of the Pit 1 canyon. The observed thermal effect was smaller than would occur if the 1000-cfs to 1200-cfs preferred boating flows were to be made in the future. The observed thermal effect support the effects predicted by an analysis based on theoretical jet-plume formulae.

Although not studied directly, assessments of the potential impacts to organisms reliant upon coldwater habitat can be inferred from the results of the Refugia Study, combined with fish and water temperature studies from the Pit River (Baltz et al. 1987, PG&E 1985, 1993, 2001, 2009a, 2009b) and the literature cited in this document. Numerous biological studies on the Pit 1 bypass reach, as well as the Pit 3 and Pit 4 reaches downstream, have shown that these sections of the Pit River owe much of their high-level productivity, high species diversity (e.g., mollusc, fish), and high level of endemism (e.g., Shasta crayfish) to the stable, high quality, coldwater habitat that is provided by the numerous springs in each reach (PG&E 1993, Ellis 1996, Spring Rivers 2001).

The whitewater-effects evaluation conducted by R2 Resource Consultants (R2 Resource Consultants 2006) was limited to the period from mid September through October. During this period the Fall River and upper Pit River temperatures become comparable to those of the springs in the Pit 1 canyon. Therefore, the evaluation discounted the thermal impacts of summer flushing or whitewater flows in the Pit 1 bypass reach. Had the evaluation included the three flushing flows that are released annually during the summer, or any potential summer whitewater flows, conclusions regarding thermal effects would have been much different.

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Appendix A—2004 Pit 1 Coldwater Refugia Study

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2004 Pit 1 Coldwater Refugia Study

INTRODUCTION

Springs provide coldwater refugia for important aquatic species, such as certain crenophilic (i.e., organisms that prefer spring environments) or stenothermic (i.e., organisms having narrow temperature tolerances) coldwater molluscs. *Fluminicola seminalis* (nugget pebblesnail) and *Juga occata* (scalloped juga [snail]) are two U. S. Forest Service sensitive species associated with coldwater and spring-fed systems. The amount of coldwater refugia habitat available for coldwater molluscs could be reduced as a result of increased discharge overwhelming the localized cooling effects of spring inflows and washing out localized spring-fed pockets of cool water.

Pacific Gas and Electric Company (PG&E)'s license for the Pit No. 1 Hydroelectric Project (FERC No. 2687), which was issued by the Federal Energy Regulatory Commission (FERC) on March 19, 2003, requires flushing flows through the Pit 1 bypass reach during late spring and summer. This reach, which is located upstream of Pit 1 Powerhouse and downstream of the confluence with Fall River, has reduced flow because it is bypassed by the Pit 1 Hydroelectric Project. As of 2003, the Pit 1 bypass reach has a summer base flow release of 150 cfs with three two-day flushing/whitewater flow releases of 1,250 cfs or the natural flow of the Fall River, whichever is less. The objective of this study was to determine the effects of a flushing flow on water temperature in a coldwater spring-influenced area of the Pit River in the Pit 1 bypass reach.

METHODS

Two 100-foot arrays of continuously recording temperature sensors were deployed within the base flow "jet/plume" of the spring downstream of the Pit 1 Footbridge in the Pit 1 bypass reach to characterize the magnitude and area of coldwater influence from 26 August through 1 September 2004.

Discharge of this spring was estimated at approximately 5 cfs. The spring channel flows across a low, shaded terrace and cascades over the edge of the terrace into the Pit River. The width of the

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spring channel confluence with the Pit River was approximately 16 feet (5 meters), with an average water depth through the cascade of 1–2 inches. Based on the estimated width, depth, and discharge estimates, velocity at the cascade confluence would average about 2 to 3.5 feet per second. Under base flow conditions, the spring enters the mainstem in a sheltered, low-velocity bay. Just upstream of the spring, a low sedge-covered boulder bar protrudes perpendicularly into the river and keeps most of the mainstem flow away from the spring.

The Pit River at this location was approximately 70 feet wide (21.3 meters) at base flow, with an average depth of approximately 2.5 feet. Average velocity at base flow before and after the flushing flow evaluation was 1.5 to 2 feet per second. Under flushing flow conditions, width of the Pit River at this location increases by approximately 25–30 feet, as water flows directly over the low boulder bar.

Position of the two 10-sensor arrays was fixed during the entire test period (see the black lines in Figure 1). The extent of the coverage was such that both the lateral (i.e., from bank to bank) and longitudinal (i.e., along the direction of flow) dimensions of the refuge were characterized from the upstream limit of coldwater influence to the downstream end of the plume. The temperature from each sensor was recorded every 20 minutes.

Two headpins, one upstream and one downstream of the study site, were installed to facilitate mapping of the site on a Cartesian grid. A fiberglass measuring tape was stretched between the headpins to establish a measuring transect and a compass bearing was taken along the line. The shoreline and hydraulically significant features, such as near-shore boulders and outcroppings were mapped by (1) measuring distances from the upstream headpin, and (2) measuring out at 90 degrees from the transect line. The locations of the 10 individual temperature sensors along each array were mapped in the same way. The shoreline was mapped during base flow and flushing flow conditions.

The Cartesian grid data (x- and y-coordinates) for each sensor and the shoreline were analyzed using Graphis®, a 2D- and 3D- graphing program. Temperature data from 1520 hours on 28 August 2004 (i.e., flushing flow) and at 1520 hours on 30 August 2004 (i.e., base flow) provided a z-coordinate for each sensor. The extent of the plume was evaluated for base flow

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and flushing flow conditions to determine how increased discharge affected the area and temperatures within the coldwater refuge.

Pit River discharge data were obtained from Tim Sagraves, then with ATC Associates, who was conducting water quality monitoring for the Pit 1 Project. The Pit River discharge for 30 August 2004 was based on flow measurements at the Pit 1 Footbridge. Discharge on 28 August 2004, which was above the measurability of the flow meter (i.e., 750 cfs), was extrapolated from 1990 survey data.

RESULTS

Water temperature measured at the innermost temperature sensor on the arrays (which were affected only by spring inflow except at high flows) averaged 15.6 °C when data from the high flow dates were excluded. Mean daily water temperatures in the Pit River at a station approximately 200 feet upstream of the spring averaged 19.8 °C during base flow and 21.5 °C during the flushing flows.

Discharge was 277 cfs at 1500 and 1600 hours for an average of 277 cfs (Tim Sagraves, Sagraves Environmental, unpublished data). Discharge on 28 August 2004 was estimated to be 984 cfs at 1500 hours and 969 cfs at 1600 hours for an average of 977 cfs (Tim Sagraves, Sagraves Environmental, unpublished data) as reported in Figure 2.

Figures 1 and 2 provide a comparison of the plume temperatures during the approximately 277-cfs base flow (Figure 1) and the approximately 977-cfs flushing flow (Figure 2). Table 1 and Figure 3 summarize the base flow temperature conditions in the area encompassed by the temperature arrays and the effects of the flushing flow. Temperatures of the base flow plume of the spring ranged from 15.6 to 19.5 °C, with more than half of the plume within the 16 °C isotherm (Figure 1, Table 1). In contrast, the flushing flow plume temperatures ranged from 17 to 20.1 °C (Figure 2), and half of the plume was in the 19 °C isotherm (Table 1). The temperature increase for an individual sensor ranged from 0.7 to 3.6 °C, with an average increase (± standard deviation) of 2.1 ± 0.8 °C (Figure 3).

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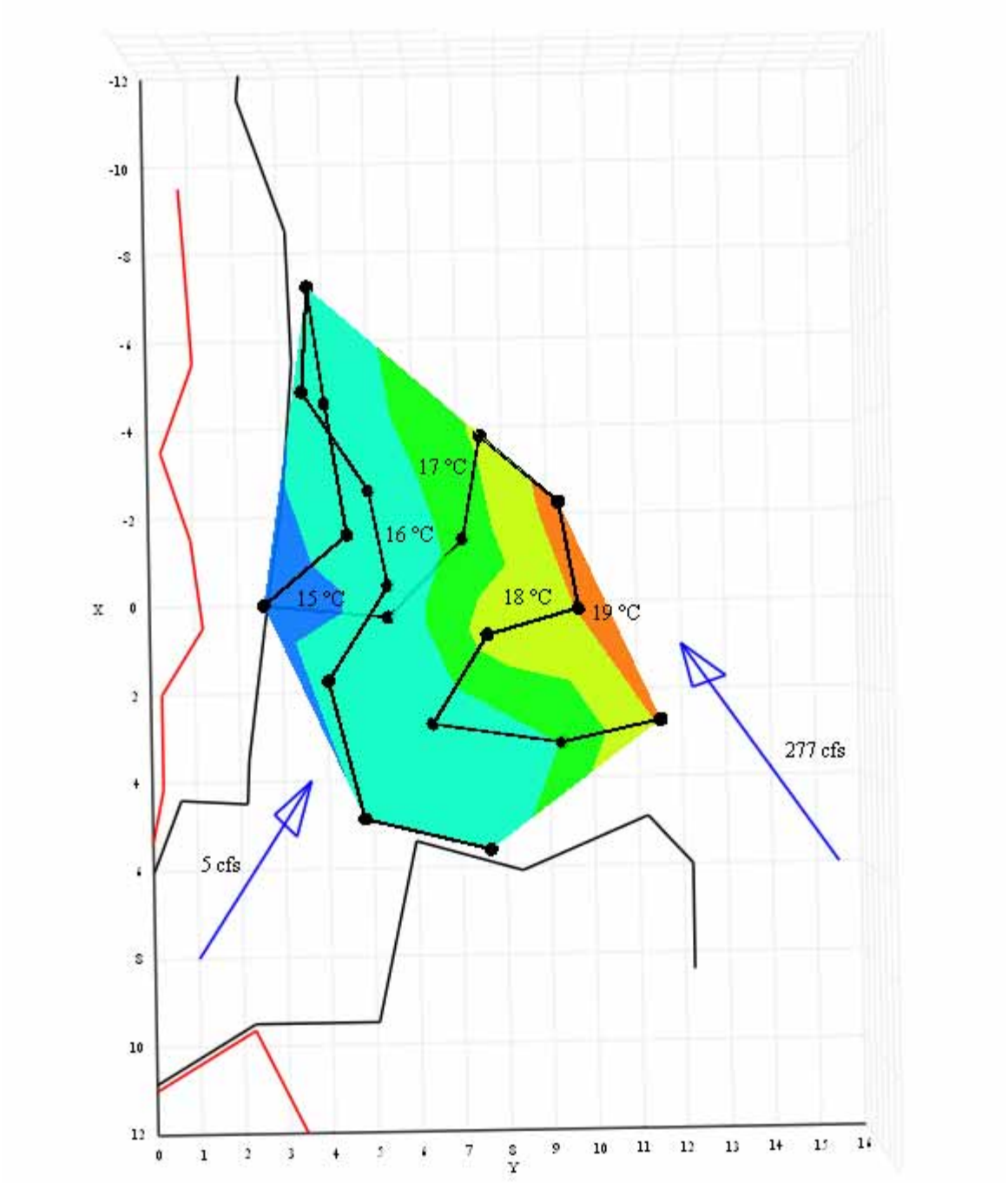

Figure A-1 Effect of base river flows on water temperatures in the Pit 1 bypass reach of the Pit River, at the confluence of the spring located just downstream of the Pit 1 Footbridge. Base flow data (30 August 2004 at 1520 hours) were obtained from temperature sensor arrays (black lines with black dots at sensor locations). The river bank during base flow (black) and flushing flow (red) is represented in the x-y plane (in meters). Graphical overhead orientation is looking downstream, with the spring flow entering from the left. Blue arrows indicate the general direction of the spring flow (5 cfs) and base river flow (277 cfs).

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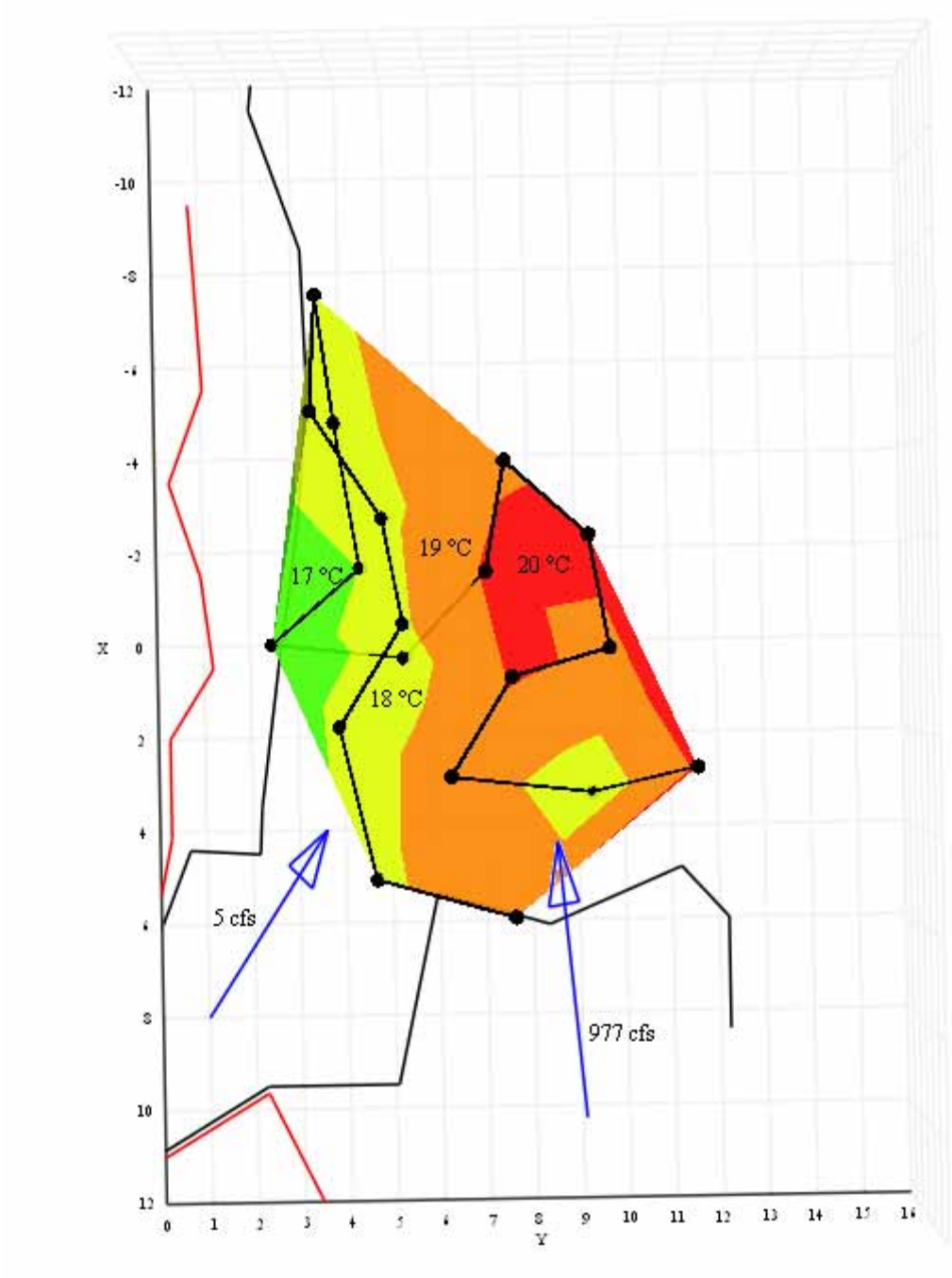

Figure A-2 Effect of flushing flows on water temperatures in the Pit 1 bypass reach of the Pit River, at the confluence of the spring located just downstream of the Pit 1 Footbridge. Flushing flow data (28 August 2004 at 1520 hours) were obtained from temperature sensor arrays ((black lines with black dots at sensor locations). The river bank during base flow (black) and flushing flow (red) is represented in the x-y plane (in meters). Graphical overhead orientation is looking downstream, with the spring flow entering from the left. Blue arrows indicate the general direction of the spring flow (5 cfs) and flushing river flow (977 cfs).

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Table A-1 Areas and percentages of total area within each isotherm mapped during base flow and flushing flow conditions, August 2004. Areas are calculated based on Figures 1 and 2, and are therefore restricted to the total area confined within the perimeter of the temperature arrays.

Water Temperature (°C)	Base Flow		Flushing Flow	
	Area (ft^2)	Percent Area	Area (ft^2)	Percent Area
15	43	6	0	0
16	388	55	0	0
17	129	18	56	8
18	118	17	213	30
19	32	4	256	50
20	0	0	87	12

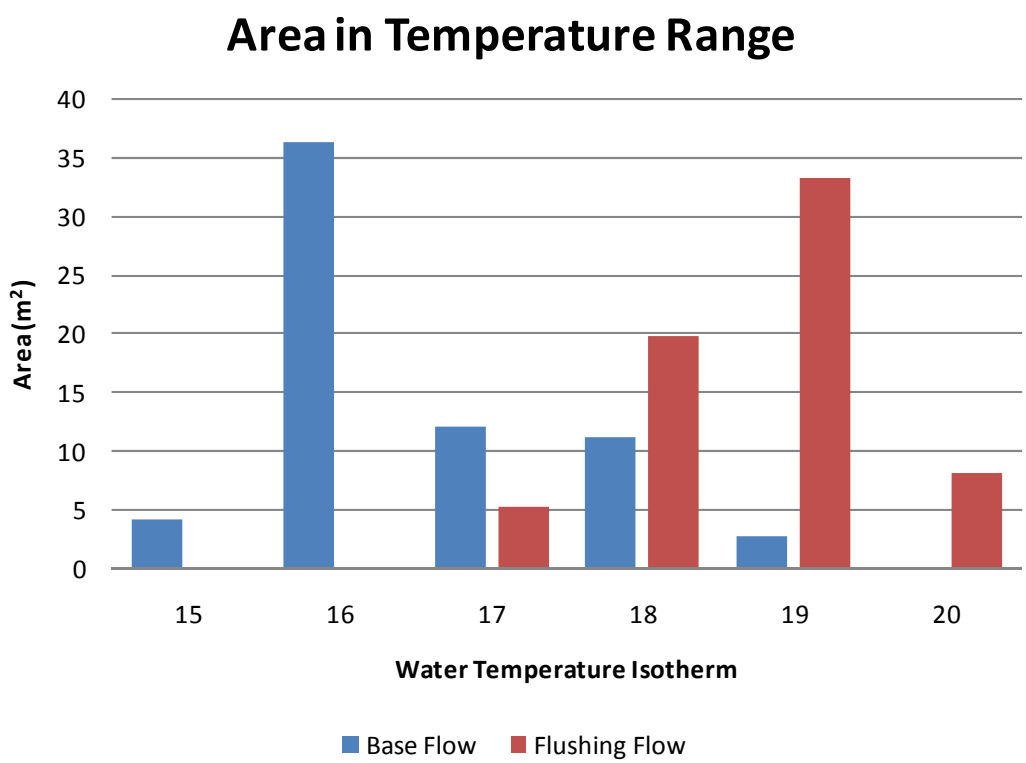

Figure A-3 Amount of area in temperature isotherms at monitored spring inflow in the Pit River under base flow (blue) and flushing flow conditions (red). Areas are calculated based on Figures 1 and 2, and are therefore restricted to the total area confined within the perimeter of the temperature arrays.

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Appendix B—2009 Simple Plane-Jet Analysis for Coldwater Refugia Study in the Pit 1 Bypass Reach

April 2009

Prepared by:

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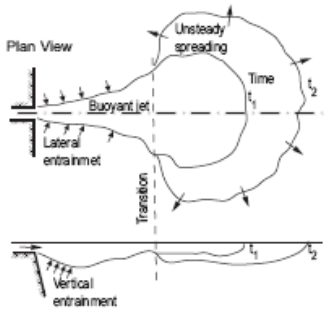
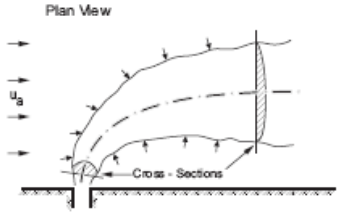
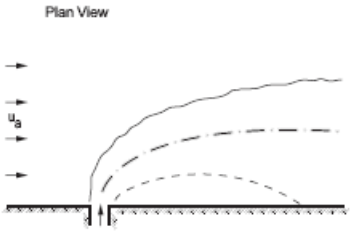
Simple Plane-Jet Analysis for Coldwater Refugia Study in the Pit 1 Bypass Reach







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Background

On March 2003, Pacific Gas and Electric Company (PG&E) received a new license for the continued operation of the Pit 1 Hydroelectric Project under Federal Energy Regulatory Commission (FERC) Project No. 2687. The new license incorporates the California State Water Resource Control Board (SWRCB) 401 Water Quality Certificate which contains flushing flow requirement (to control vegetation growth in the Fall River Pond during summer period) and a minimum flow release schedule (to improve water quality condition in the lower Fall River and Pit River). PG&E has provided summer flushing flows between May and Labor Day weekend since 1994. A separate study addressing the effectiveness of the flushing flow has been conducted annually since 2005 (Spring Rivers 2006, 2007, 2008, 2009).

In the past five years, advanced public notice has been issued to the boating community for whitewater boating use for all flushing flow events. FERC, recognizing the potential for whitewater flows to impact other resources, ordered PG&E to prepare a plan to study the potential effects of whitewater boating flows, with specific targeted timing between September 15 and October 30. The two-phased study plan was completed in 2008 (R2 Resource Consultants 2006, R2 Resource Consultants et al. 2008). The data and analysis cannot, however, provide any implication and/or linkage to relate to any impact (particularly the temperature impact) during the summer period on microhabitat, such as a coldwater spring area.

A field study was conducted in August 2004 (Appendix A), which acquired site-specific data and analyzed the temperature changes on a localized area in the Pit River influenced by a cold spring, before and during one of the flushing flow events. The data provide a good source of information on localized temperature changes associated with the summer flushing/boating flows.

This report presents the results of an analysis that applies jet/plume theoretical formulae (Fisher et al. 1979) to predict changes to coldwater habitat in spring-influenced areas of the Pit River bypass reach resulting from a flushing flow. Predicted effects are then compared to observed data.

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Purpose of the Study

In order to understand the temperature and mixing characteristics for the base flow and a pulse flow during summer time, this study uses an analytical tool for analysis to provide information for:

- Physical parameters and their changes associated with flow changes for the lower Pit 1 bypass reach. The parameters include the temperatures, trajectory, and areal spread.
- An analytical comparison for resource management consideration.
- Supplemental information to existing data of the 2004 field study.

Theoretical Approach

The study design utilizes the known formulae developed for a jet/plume that injects into a moving cross stream. Existing information and literature are widely available. A jet is a discharge of fluid from an orifice or slot into a large body of water. A plume is similar to a jet, but has a pronounced additional buoyancy force (either positive or negative) that comes into play in the mixing process.

Key assumptions and restrictions are used in deriving the following formulae (Fisher et al. 1979). Formulae applicable in the Zone of Established Flow (ZEF) are extracted for the present application to predict the temperature variation along its centerline (ΔT_c), its lateral temperature distribution (ΔT), the spread of jet width (b_T) and the trajectory with a crossing-flow velocity (U). Notice that all predictions are normalized to a temperature differential relative to an ambient level defined as the temperature in the receiving water (the mainstem). In the present application, the cold-jet entrains the warmer water in the mainstem, therefore, the jet is considered as a negative buoyant jet and the temperature increases as it enters into the river. Extracted formulae are summarized below.

<u>Simple Plane Jet/Plume in Weak Cross-flow</u>

$\Delta T_c/\Delta T_0 = a2\ (l_Q/Z)^{1/2}$ (1)

$l_Q = Q/M^{1/2}$ (2)

$\Delta T/\Delta T_c = \exp\ [-(x/b_T)^2)$, (3)

$b_T = a_1 Z$ (4)

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Where,

Q = discharge or volume flux

M = momentum of the jet = QW

W = average jet velocity

b_T = half width of the jet at which the concentration/temperature is 0.37 of the centerline

x = lateral distance from the centerline of the jet

Z = axial distance along the jet centerline across the transect

ΔT = temperature above the ambient water

ΔT_c = temperature at the centerline of the jet above the ambient water

ΔT_0 = jet discharge temperature above the ambient water

T_{amb} = ambient water temperature in the mainstem

a_1, a_2 = empirical constants

The above formulae apply to cases with weak cross current, referred to as a simple jet/plume condition. When a jet/plume enters into a mainstem with strong cross current, the jet/plume bends its trajectory. The degree of 'bending' varies depending on the degree of mixing between the jet and cross-flow. The curvature varies according to a power law. In general, the trajectory takes the form

<u>Jet Trajectory with Ambient Cross-flow</u>

$$Z/Z_L = C\,(X/Z_L)^{E} \qquad (5)$$

Where,

Z_L = a length scale either defined as Z_M for jet-like or Z_B for plume-like

Z_M = $M^{1/2} / U$ = a location at which the jet velocity has decayed to the order of the cross-flow velocity

Z_B = $M^{3/4} / B^{1/2}$ = a location at which the plume velocity has decayed to the order of cross-flow velocity

C = empirical constant

E = empirical power law, varies from ½ to $^{3/4}$

U = mainstem velocity

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Project Application

In the current application, the conditions at the study site during the August 2004 field study are considered (see Appendix A for more description). During the August 2004 field study, the test site was located in the lower Pit 1 bypass reach just downstream of the Pit 1 Footbridge near Pit 1 Powerhouse. The mainstem width varies from about 70 to 95 feet depending on the flow conditions in the river (277 cfs for the base-flow versus 977 cfs for flushing flow). The ambient water temperature in the mainstem was approximately 19.8 °C under the base-flow condition, and subsequently increased to 21.5 °C during the flushing flow period. Water from a 5-cfs, 15 °C cold spring enters the Pit River from the left bank (facing downstream). Where the spring enters the Pit River, it spills down a short shallow cascade. The total elevation drop is about 4 to 5 feet with an average water depth through the cascade of 1 to 2 inches. At the confluence, the width of the spring channel is approximately 16 feet with an angle of orientation about 40 to 50 degrees (Jeff Cook, personal communication). The following table summaries the specific configuration that is used in applying the formulae above.

Site Condition	Width (ft)	Depth (ft)	Velocity (fps)	Q (cfs)	T (°C)
Pit 1 Base flow	~70	2	1.5-2	277	19.8
Pit 1 flushing	~95	3	3-4	977	21.5
cold spring	~16	0.08-0.17	2-3.5	5	15

In the current application, several assumptions are used for simplification. These assumptions are: prediction applies in the zone of established flow (ZEF), the negative buoyancy effect is ignored, the jet angle is assumed perpendicular to the Pit 1 (at 90 degrees), and the receiving water depth is deep and unconfined.

Finding

Figure B-1 delineates half of the predicted jet/plume edges (relative to the centerline) for different temperature levels. At the base-flow (pre-flushing condition), which has an ambient water temperature of 19.8 °C, the cold spring rapidly mixes with the ambient water and expands to a 15.5 °C isotherm contour with a coverage area of 10 feet X 0.5 feet. The jet continues its expansion while mixing (warming up) with the mainstem. At 18.5 °C, the isotherm has a coverage area of about 100 feet X 5 feet. Under a flushing flow event of 977 cfs that brings in

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21.5 °C ambient water, the extent of the coldwater area is rapidly lost. For example, the 18.5 °C isotherm is substantially reduced to an area of 40 feet X 2 feet.

Figure B-2 provides graphical comparison of the predicted bottom area spread for various temperature levels under different flow scenarios. Under the base flow condition, 30 square feet of area is predicted to have temperatures less than 17 °C, but the area reduces to less than 16 square feet during the flushing flow. For the 18.5 °C isotherm, the predicted area is reduced from more than 600 square feet under the base-flow case to less than 100 square feet under the flushing flow event. At 19 °C, the coverage was about 1300 square feet under the base flow condition, but significantly reduced to 200 square feet by the flushing flow. This represents an 85% reduction in area for temperatures less than 19 °C level.

A comparison is made qualitatively with two isotherm levels, 17 °C and 19 °C, between the model prediction and data collected in 2004. During the 2004 August flushing event, the data indicated that

- At base flow, the spring created areas of coldwater (15–17 ºC) and marginally coldwater (17–19 ºC) habitat in the Pit River that extended beyond the area delineated by the array of temperature sensors.
- During the flushing flow, all the coldwater (15–17 ºC) habitat disappeared, and the marginally coldwater (17–19 ºC) habitat made up less than half the area delineated by the sensors. More than half the area's substrate was covered by water with temperatures of 19 ºC or greater.

For isotherms less than 17 °C, the complete loss of 15-17 °C habitat area during the flushing flow confirms the model prediction, but the coverage area for the base flow was somewhat under-predicted. The under-prediction by the model is likely caused by a lack of accounting for a core region where the shear layer is still "eating away" at the constant velocity core. This zone, termed the zone of flow establishment (ZFE), is often short and therefore is not considered in the present model application. Beyond the ZFE, say at 19 °C isotherm level, the field data suggest that about 60-70% of sensor coverage (about 7 meters by 14 meters, or 1050 square feet) was replaced with temperatures exceeding 19 °C. The field data qualitatively confirm the model's prediction.

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The predicted trajectory of the jet/plume under the influence of cross-flow is estimated using Equation 5. Jet or plume loses its momentum and buoyancy effect as mixing with receiving water occurs and eventually the jet velocity decays to the order of the cross-flow velocity. The form of the trajectory follows different power law depending on the degree of mixing. A length scale, Z_M or Z_B defined in Equation 5, is often used to determine the degree of mixing process and for which what power law is appropriate. In the Pit 1 application case, the 5-cfs spring behaves like a jet (as opposed to a plume). Calculation of Z_M indicates this length scale to be small, in the order of 1 to 2 feet. This means the jet quickly loses it momentum and is bent significantly by the cross-flow. The appropriate power law for a 'strong bending jet' is 1/3 (see Fisher et al 1979) with an empirical constant, C, between 1.6 and 2.3; an average value of 2 is used. Figure B-3 delineates the estimated jet trajectories for the 1/3 power law. Trajectories for the following three cross-flow conditions are simulated: (1) the pre-license condition with a cross-flow of 110 cfs, (2) the current license condition with a base flow at 260 cfs, and (3) a 1000-cfs flushing flow case. For all cases, the jet is bending downstream rapidly. Visual inspection of the jet trajectories observed in the 2004 field during the two flow conditions confirms this expectation. The coldwater habitat is expected and was observed to be confined within 20 feet from the bank. The significant bending, in combination with small jet spread (in the order of 1-5 feet) would constitute a narrow bandwidth of coldwater strip in the mainstem Pit River. For smaller springs, the bending is expected to be more confined to the bank and in some cases becomes shore-attached. Given the fact that various springs have been surveyed and in the Pit 1 Bypass reach downstream of Big Eddy Pool (Maria Ellis, personal communication), it is perceived that a series of small coldwater strips exist along the river bank associated with these springs throughout the lower Pit 1 bypass reach.

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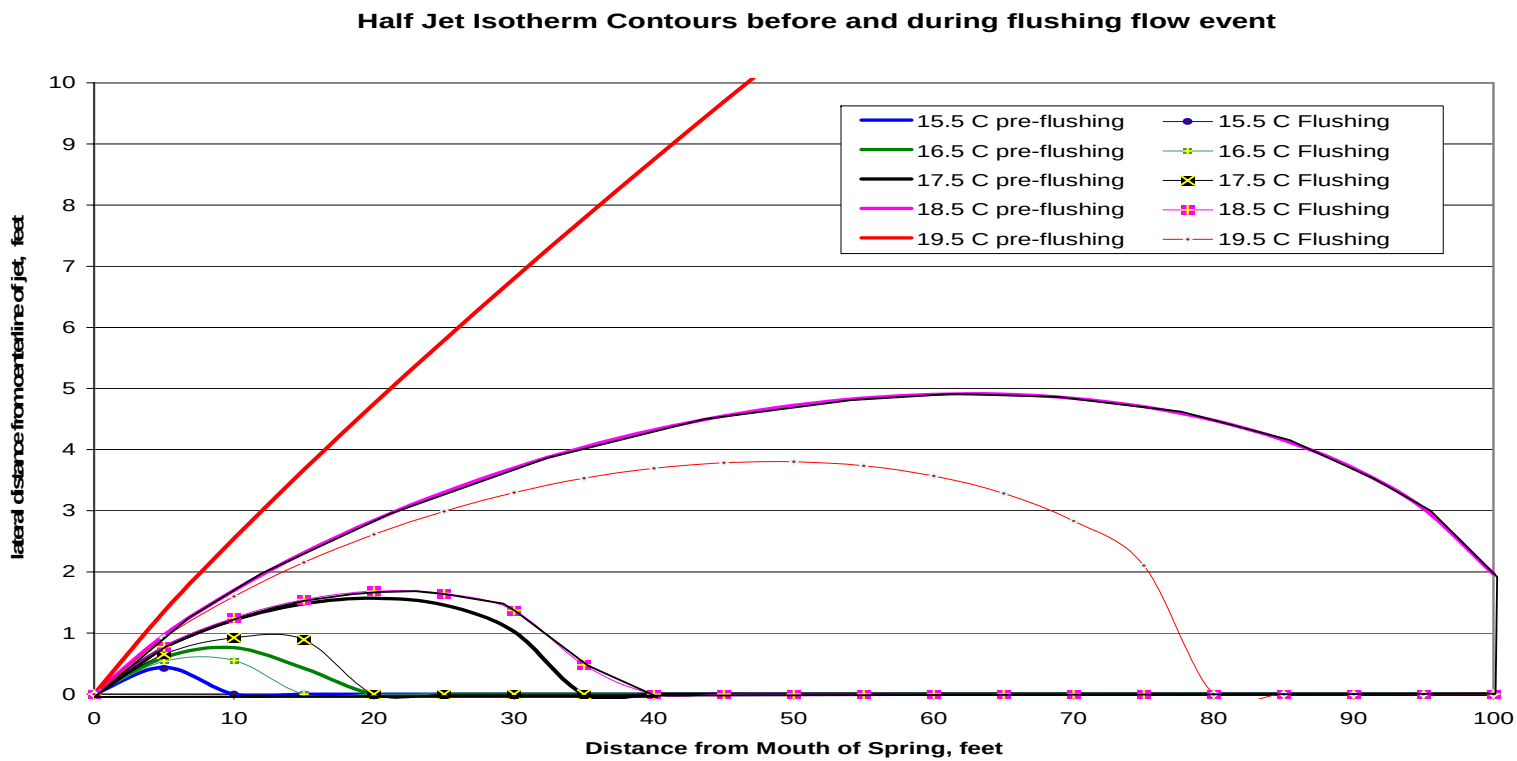

Figure B-1 Half Jet Width Predicted For Two Ambient Temperature Levels Representing the Base-flow (T_{amb}=19.8 °C) and Flushing-flow (T_{amb}=21.5 °C) Conditions.

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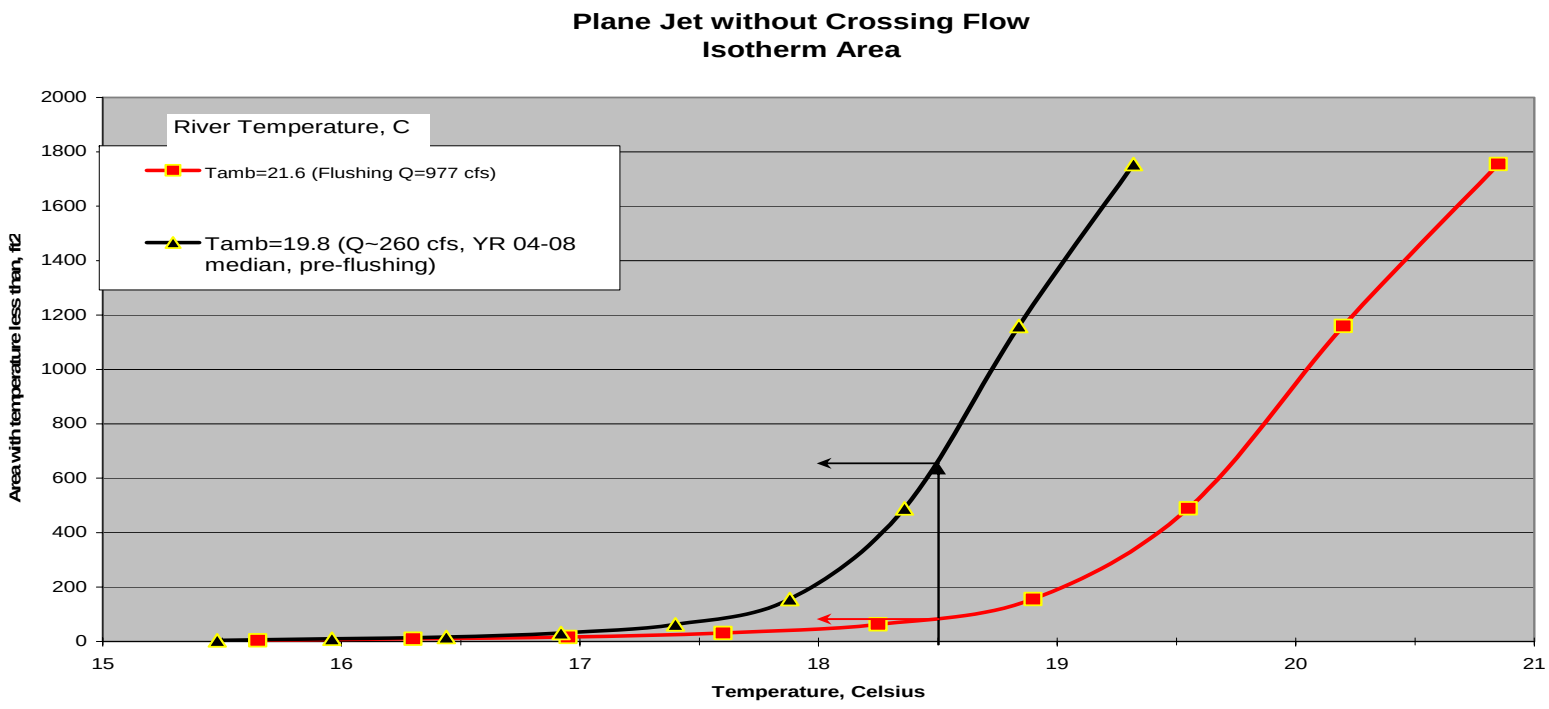

Figure B-2 Isotherm Areas Under Two Ambient Temperature Levels, Representing Base-flow and Flushing-flow Conditions

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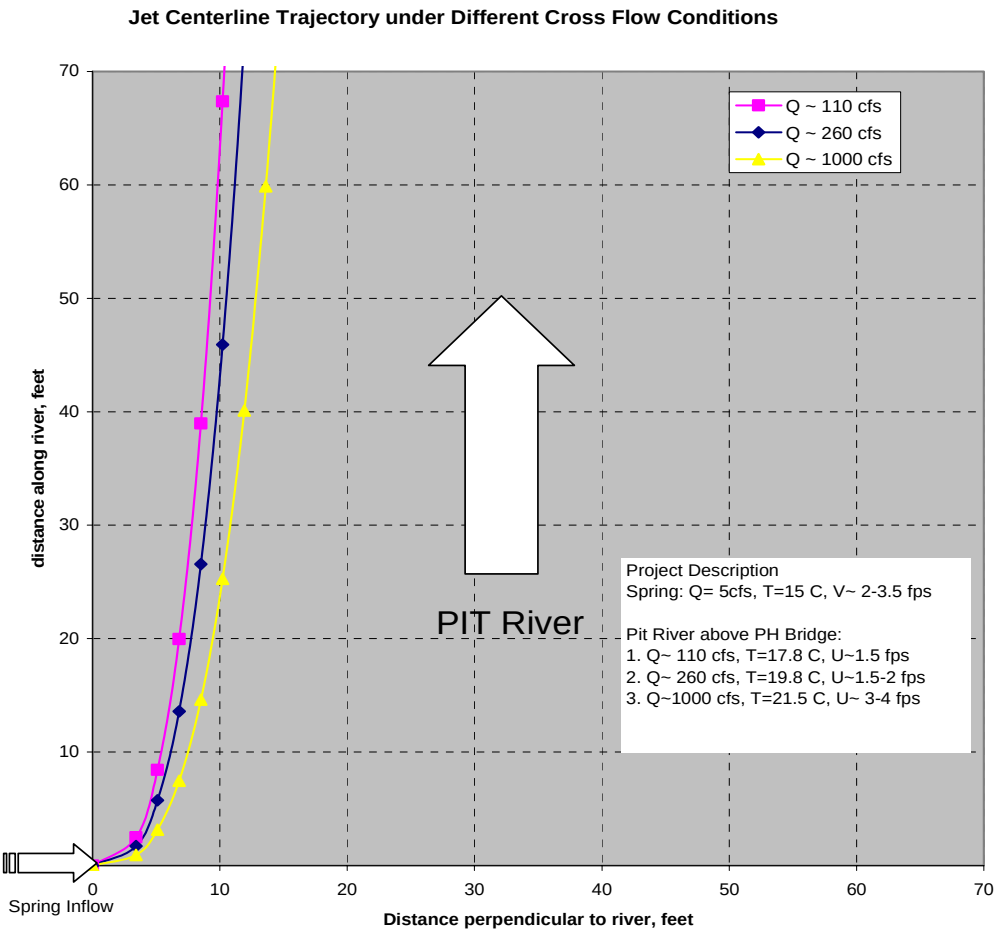

Figure B-3 Jet Trajectories Under Pre-license, Current Base-flow and Flushing-flow Conditions

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Attachment 4

Agency Meeting Follow-up

- June 22, 2009 email from Charles White to agencies – Pit 1 WQ meeting minutes and bulleted list for proposed changes
- Pit 1 Project (FERC No. 2687) PG&E recommendations for project operations and monitoring (2009)
- Final Meeting Notes, Pit 1 Project (FERC No. 2587) Five-Year Water Quality Summary and Consultation, May 11, 2009 (to be provided in a separate package)

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White, Charles

From: White, Charles
Sent: Monday, June 22, 2009 1:01 PM
To: 'Russ Kanz'; Dennis Heiman (dheiman@waterboards.ca.gov); 'Matt Myers'; 'Steve Baumgartner'; 'Kim_Squires@fws.gov'
Cc: Sundermeyer, Dagmar; Tu, Scott; 'TSagr@aol.com'
Subject: Pit 1 WQ meeting minutes and bulleted list for proposed changes
Attachments: Pit 1 Draft Meeting Notes_051109_ Agency Review Draft (2) (2).doc; Pit1Recommendations_9June09 (2).xls

Attached are the draft minutes to the May 11, 2009 water quality meeting and a list of the proposed changes to the water quality monitoring program and project flows.

The final 5-year summary report is due to FERC on July 1, 2009. We will be including the final meeting minutes and recommendations in the final report. If I could get any comments by the end of the week, I would appreciate it. Thanks you in advance.

Let me know if you have any questions. I will be on a FERC inspection on the Pit River the first part of this week, but available by phone. I will also be checking e-mails periodically during the day. Thanks again!

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Pit 1 Project (FERC No. 2687)
PG&E recommendations for project operations and monitoring (2009)

Article/Condition	Proposed Change	Rationale	Approval Authority	Consultation Requirement
Water Quality				
Condition 17	It is recommended that the State Water Resources Control Board (State Water Board) not adaptively increase flow releases by 50 cfs following the first five year water quality monitoring period.	Water quality in the Pit 1 reach has improved and is generally good. An increase is not needed to protect beneficial uses. An increase would increase summer water temperatures in the Canyon reach of the Pit 1 bypass reach, and negatively influence coldwater spring habitat that supports special-status species and species diversity.	State Water Board	
Article 401, Condition 16	Revise Condition 16 and the Water Quality Monitoring Plan for the Pit River to include the following components.	Proposed modifications to the Water Quality Monitoring Plan would be submitted to the State Water Board no later than September 30, 2009 for a 30-day review period and approval by November 1. Final proposal would be submitted to FERC no later than January 1, 2010. If FERC approval is received by March, 2010, the plan can be implemented effective May 16, 2010.	State Water Board	
	1. Reduce the number of monitoring stations in the Fall River. Consolidate three stations (FR2 [Fall River at Pit 1 Forebay Dam], FR3 [Fall River Pond at Weir] and FR4 [Lower Fall River near confluence with Pit River]) into one station (at FR3). Section 4.2.1 of Pit 1 Water Quality 5-year Report.	The current MIF release made to the Lower Fall River Reach has significantly altered the flow regime in this reach compared with pre-MIF conditions. As a result, water quality and water temperature conditions in the Lower Fall River Reach are essentially the same at each station and can be characterized using only one of the three currently active stations.		Modify Study Plan

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	2. Eliminate station PR3 (at Pit River Falls). Section 4.2.1 of Pit 1 Water Quality 5-year Report. 3. Reduce the frequency of monitoring from two times per month to one time per month. Section 4.2.2 of Pit 1 Water Quality 5-year Report. 4. Eliminate metrological Station at Pit 1 diversion dam. Section 4.2.1 of Pit 1 Water Quality 5-year Report.	The water quality conditions in the Pit 1 by-pass reach are captured by the upstream (PR2) and downstream station (PR4) while this station is the most difficult, unsafe and labor intensive station. 5-year data have suggested conductance and pH values are seasonally stable under current MIF. Monthly monitoring is adequate to characterize water quality condition Data from this station can be adequately characterized by an adjacent station at Pit 3 Dam (Lake Britton).		
Condition 16	Modify the Water Quality Management Plan to add the following monitoring components. 1. Move water quality monitoring station PR1 to a location downstream, closer to upstream of the confluence with Fall River. In 2009, monitor water quality and flow at both the current PR1 location at Pittville, and at the new location. Utilize 2009 data to assess the suitability of the new location. Collect data during a flushing flow to estimate the extent of backwater influence in the Pit River upstream of the confluence with the Fall River. Evaluate thermal stratification at the new monitoring location. After 2009, eliminate flow monitoring at Pittville. Section 4.2.1 of Pit 1 Water Quality 5-year Report.	No change to 401 conditions required. There are substantial agricultural diversions and return flows in the reach of Pit River between the current location of PR1 and the confluence with the Fall River. A monitoring station closer to the Project bypass reach would provide data that are more representative of water quality conditions of flows entering the Project bypass reach. RWQCB suggests the PR1 station has been monitored by DWR. PG&E will conduct a pilot test in 2009 to optimize sampling protocol for the new element in the proposed modification.	State Water Board	

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	2. Implement a short-term study to investigate continuous diel dissolved oxygen variation in the lower Fall River and Big Eddy section of the Pit River.	Dissolved oxygen fluctuates seasonally and exhibits diel cycles. This diel cycle is believed to cause few instaneous exceedances of DO value in the past. Diel monitoring would consist of short duration (3–5 days) effort during one or two critical periods (July or August 2010) using continuous recording DO meters (Hydrolab) to document diel DO cycle. The effort would include installing the instrument at two stations (Big Eddy and LFR) and allowing the instrument to record hourly average DO levels over the course of the monitoring period.		
Condition 17	Clarify in proposed modification to the Water Quality Management Plan the calendar years for each three-year adaptive management monitoring period and report due dates	Given the consultation period (60 days for State Water Board) and time needed for FERC approval operational changes and modifications of the monitoring plan can not be implemented until the year following reporting/consultation. For example, consultation for changes to operations and/monitoring plan that would occur in 2009 would be implemented in 2010 through 2012. The next summary report would be due in spring of 2013 with implementation year in 2014.	State Water Board	

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Condition 17	Revise Condition 17 and propose modifications to the Water Quality Monitoring Plan to change the annual report due dates to the State Water Board as follows. "*The Licensee will provide the Chief of the Division of Water Rights the results of the water quality monitoring program by ~~December 31~~ March 1 of the ~~each~~ following year.*"	Additional report preparation time is needed to 1) Analyze annual monitoring data and 2) compile equipment calibration information requested by the State Water Board.	State Water Board	
	Revise Condition 17 and propose modifications to the Water Quality Monitoring Plan to change the summary report due date to the State Water Board as follows. "The result of the additional three years of monitoring shall be summarized and submitted to the Chief of the Division of Water Rights by ~~December 31~~ March 1 of the following year in which the third year of monitoring is completed. Licensee will submit a water quality three-year summary report to State Water Board by March 1, 2013 for a 60-day review period. The report, and a record of consultation, will be filed with FERC by June 1, 2013.	Additional report preparation time is needed to 1) Analyze annual monitoring data and 2) compile equipment calibration information requested by the State Water Board.		
FERC Order Dec. 12/24/08 (B)	Revise the annual report due date to FERC as follows: "*The licensee shall file the annual water quality monitoring report required by Condition 17 of the Water Quality Certification with the Commission by ~~March 31~~ June 1 of each year.*"	Additional report preparation time is needed to 1) Analyze annual monitoring data and 2) compile equipment calibration information requested by the State Water Board.	FERC	

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No license requirement	Licensee will review 1991/92 BMI study methods and results: *Effects of Fluctuating Flows on Fish Food Resources Below Pit 1 Powerhouse* (McElravy 1993). Licensee will develop a one-year plan to implement a BMI study, consistent with the methods of the early study within the Pit 1 bypass reach.	A BMI study was requested by Regional Water Quality Control Board during meeting held May 11, 2009. The purpose of the study is to evaluate potential changes in invertebrate communities relative to baseline (pre-license) conditions. McElravy (1993) sample sites included Pit River near (and above) the Pit 1 Powerhouse and near the Highway 299 Pit River bridge downstream of the powerhouse.		Develop Study Plan
Article 401, 415, Condition 18	Implement recommendations for modifications of the Bald Eagle Compliance Monitoring Plan, as identified in *Pit 1 Project (FERC 2687) Bald Eagle Compliance Monitoring Five-year Comprehensive Report and Management Plan* (GANDA 2009).	No change to 401 conditions required.		USFWS, CDFG, State Water Board
Flushing Flows				
Condition 13	Temporarily hold off 2009 July 17-19/August 21-23 flushing flows in the Pit 1 bypass reach, but continue vegetation monitoring in Fall River Pond	Avoid potential negative impacts to resources within the bypass reach including Shasta crayfish. Current minimum instream flows (MIF) appear to adequately control aquatic vegetative in Fall River Pond. Final recommendation to be made in 2010 following the consultation of 5-year summary data.	State Water Board	USFWS
Condition 13	Modify Condition 13 to eliminate or modify summer flushing flows to avoid negative impacts to resources within the bypass reach.	Submit 5-year summary report with final recommendation. Current minimum instream flows appear to adequately control aquatic vegetation in Fall River Pond, and therefore flushing flows are not needed. Aseasonal pulse flows can negatively affect biological resources in the bypass reach and increase summer minimum water temperatures.	State Water Board	USFWS, CDFG

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Condition 13, 14	Modify the monitoring plan required under Condition 14. The modification will include a reasonable method to continue monitoring aquatic vegetation in Fall River Pond and consult with regulatory agencies if vegetation growth becomes excessive. Licensee will develop a Fall River Aquatic Vegetation Control Plan that identifies criteria (e.g. surface vegetation percent coverage) that trigger consultation. The plan will propose alternatives methods to control vegetation to summer flushing flows. The Licensee will develop the plan in consultation with the State Water Board and CDFD, and obtain written approval of the plan by the Chief of the Division of Water Rights.	Under pre-license conditions, excessive, nuisance vegetation was documented in Fall River Pond after a series of dry years. License-required minimum instream flows appear to be effective at controlling vegetation and associated mosquito production. The proposed measure would, however, ensure that if in the unlikely event, during a drought, vegetation becomes a nuisance; there will be a procedure in place to address it.	State Water Board	Modify Study Plan in consultation with CDFG, USFWS
Shasta Crayfish				
Article 410, Condition 17	Eliminate summer flushing flows in the Pit 1 bypass reach to reduce the potential for effects on Shasta crayfish.	Shasta crayfish numbers have plummeted in the Pit 1 bypass reach from 2005 to 2008. In a letter dated May 13, 2009 by Maria Ellis, PhD. of Spring Rivers Ecological Sciences LLC to Kim Squires of USFWS, the recommendation was made to discontinue the summer flushing flows required under the State Water Resources Control Board 401 Water Quality Certification Condition 13. This recommendation was included in the *Shasta Crayfish Technical Review Committee Summary Report* (PG&E 2009).	State Water Board & US Fish and Wildlife Service incidental take statement.	Shasta Crayfish Technical Review Committee

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Article 410, 417	Consult with U.S. Fish and Wildlife Service to assess any potential modifications to the terms and conditions of the incidental take statement in the Biological Opinion (USFWS 2004).	Five years of monitoring pursuant to Articles 411 and 412 of the license have provided new information on the status of Shasta crayfish. The USFWS biological opinion (pages 33-34) states "Due to the lack of sufficient information made available to the Service, the Service is unable to precisely quantify the number of Shasta crayfish that will be taken as a result of the proposed action. Incidental take is authorized for a three year interim period, and subsequent incidental take for the proposed action and associated activities will be authorized in subsequent tiered consultations, as adequate information becomes available."		USFWS
Fish Populations				
Article 401, Condition 18	Implement recommendations to discontinue summer flushing flows, as recommended in *Pit 1 Project Fish Monitoring FERC Project No. 2687 Final Report* (URS 2009).	The final report indicates that flushing flows are providing a mechanism to transport largemouth bass from Fall River Pond into the Big Eddy Pool, and increase water temperatures in spring-affected areas of the Upper Canyon and Lower Canyon during July and August. The report recommends flushing flows should be discontinued or used only when absolutely required for vegetation management in Fall River Pond, but not during July or August.		CDFG, USFWS

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