

December 21, 2010

Dear Big Creek No. 4 Technical Review Group (TRG) Participant,

On September 30, 2009, the Federal Energy Regulatory Commission (FERC) approved the Adaptive Management Plan for River Flows (AMP) and the Native Aquatic Species Management Plan (NASMP) for the Big Creek No. 4 Project (FERC Project No. 2017). FERC approval initiated the formal implementation of these plans. The Technical Review Group (TRG) met on February 2, 2010 to review initial data collected and the proposed studies for 2010. The proposed studies were implemented. Please find attached, for your review and comment, the Draft 2010 Native Aquatic Species Management Plan Data Collection Report to support the implementation of the AMP and the NASMP. Please provide any comments or questions regarding this report to us by January 21, 2011 for discussion at the upcoming TRG meeting. On January 20, 2011, you will receive a copy of the Draft 2011 Study Proposal for AMP/NASMP studies to be implemented in 2011. This proposal will be reviewed at the TRG meeting.

On February 3, 2011, SCE will convene a formal TRG meeting from 10AM to 4PM at the Piccadilly Airport Hotel located at 5115 East McKinley Avenue, Fresno, CA 93727. At this meeting, SCE will review monitoring and survey methods, and summarize results of 2010 data collection activities and present the proposed biological baseline studies for 2011. Your comments and questions on the Draft 2010 Native Aquatic Species Management Plan Data Collection Report also will be discussed at this meeting.

Prior to the February 3, 2011 TRG meeting, you will receive a copy of the proposed biological baseline studies for 2011 (including monitoring and survey methods), for your review and discussion at the meeting.

We look forward to working with you as part of the TRG. Please RSVP your intent to attend the TRG meeting, along with any questions, comments, or concerns on the report by email to Eileen Dessaso at [edessaso@entrix.com](mailto:edessaso@entrix.com).

Sincerely,



Wayne Allen  
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**NATIVE AQUATIC SPECIES MANAGEMENT PLAN**  
**2010 DATA COLLECTION REPORT**

**Southern California Edison Company**  
**Big Creek No. 4 Hydroelectric Project**  
**FERC Project No. 2017**

**December 2010**

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**LIST OF ACRONYMS/ABBREVIATIONS**

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°C	degrees Celsius
ATS	Advanced Telemetry Systems Inc.
BBC	Backbone Creek
BC4	Big Creek No. 4
cfs	cubic feet per second
DO	dissolved oxygen
FERC	Federal Energy Regulatory Commission
g	gram(s)
GPS	Global Positioning System
HSB	Horseshoe Bend
HSBE	Horseshoe Bend East
km	kilometer(s)
m	meter(s)
mm	millimeter(s)
msl	mean sea level
NASMP	Native Aquatic Species Management Plan
PH3	Big Creek Powerhouse 3
PH4	Big Creek Powerhouse 4
QC	Quality Control
SCE	Southern California Edison Company
SJR	San Joaquin River
TL	total length
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WC	Willow Creek
WCB	Willow Creek Bridge
WCCP	Willow Creek Confluence Pool
WPT	Western Pond Turtle

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## EXECUTIVE SUMMARY

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### SUMMARY OF RESULTS FOR 2010

The Management Area covered by the Native Aquatic Species Management Plan (NASMP) includes the San Joaquin River (SJR) between Dam 7 and Big Creek Powerhouse 4 (PH4), as well as Redinger Lake. During 2010, data collection consistent with the NASMP was implemented on the SJR from downstream of Dam 7 to PH4 and in Redinger Lake. Southern California Edison Company (SCE) collected data during the first year of implementation after final approval of the NASMP/AMP Study Plan. These data were collected under cooler than average summer temperature conditions with wetter than normal runoff (above normal water year) conditions in Water Year 2010. There were high flows due to spill conditions at Dam 7 from mid-May into early July on SJR.

The following is a list of data collected during this study.

- Overwinter water temperatures were recorded in the SJR between Dam 7 and PH4, as well as lower Willow Creek from November, 2009, through April 2010 at four sites to characterize winter and spring water temperature conditions.
- Summer-fall water temperatures were recorded in the SJR between Dam 7 and PH4 and lower Willow Creek from May 2010 through October 2010, at all sites to characterize summer-fall water temperature conditions.
- Air temperature and relative humidity were measured concurrently at Dam 7 for the summer-fall period.
- Water temperature and dissolved oxygen (DO) profiles were measured at five sites in Redinger Lake on June 16, August 12 and October 7 to characterize temperature and DO conditions within the lake.
- Water temperature profiles were measured in three deep pools on August 11 to investigate potential thermal stratification in the Horseshoe Bend (HSB) reach of the SJR between Willow Creek confluence and PH4.
- Adult hardhead (*Mylopharodon conocephalus*) fitted with radio transmitters during fall, 2009 were tracked during spring and early summer, 2010.
- Larval fish traps were operated and larvae collected in locations in Willow Creek, Backbone Creek and the SJR from late April until August 20, 2009.
- Fish sampling by means of electrofishing and snorkel observations was conducted in six locations in the HSB during, October 2010.
- Adult western pond turtles (WPT) (*Emys marmorata*) were captured and marked at two sites for collection of population and demographic data. Two adult females had radiotags attached on them for tracking during 2011.

- Seven sites were evaluated for the presence of western pearlshell (*Margaritifera falcata*) mussels. Abundances were counted or estimated for the sites. The sites were surveyed on August 23-27 and on October 14-15.

### **Hardhead Radio Tracking and Larval Sampling**

In 2010 adult hardhead radio tagged during fall 2009 were tracked to identify when and where spawning might have taken place. Tracking indicated that tagged hardhead generally showed no significant movement. Light traps and dip nets for fish larvae were used in several locations close to where hardhead were found during 2010 and previous years. Larval sampling took place as water temperatures in the SJR approached 10°C. Larval Sacramento sucker (*Catostomus occidentalis*), hardhead, and Sacramento pikeminnow (*Ptychocheilus grandis*) and spotted bass (*Micropterus punctulatus*) were sampled in the SJR. Hardhead, Sacramento sucker and Sacramento Pikeminnow were collected from Willow Creek. Hardhead larvae were collected from mid-July through mid-August (with pre-juveniles observed as late as mid-August), Sacramento sucker larvae were collected during mid-May through late July at all locations.

### **MUSSEL SURVEYS**

The abundance and distribution of western pearlshell (*Margaritifera falcata*) mussels at seven sites were assessed. Concentrations of mussels were observed at only two sites, 6 and 7.

### **FISH POPULATION MONITORING**

Fish sampling took place in October 2010 at the locations previously sampled and identified in the NASMP. Snorkeling was used to identify and enumerate fish in deeper habitats such as pools. Electrofishing was confined to shallower habitats that could be safely accessed and electrofished. Fish abundance was much greater in the deeper habitats, which included high densities of hardhead. Native fish appeared to be healthy without signs of disease. Large numbers of schools of young of the year native cyprinids (unidentified cyprinids) were observed visually. They were the most abundant group of fish observed during both 2010 and 2008. Relatively greater percentages of Sacramento sucker occurred compared to previous data. Sacramento pikeminnow were less numerous in 2010 compared with all other years except 1995. Condition factors were calculated for fish collected from electrofishing. Average condition factors for hardhead, Sacramento pikeminnow and Sacramento sucker were greater than one, including the “unidentified cyprinids”. The percentage of native fish species present in 2010 was similar to 2008.

## **1.0 INTRODUCTION**

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### **1.1 STUDY AREA DESCRIPTION**

The Management Area addressed in the NASMP is located in the foothills on the western slope of the Sierra Nevada Mountains, approximately 26 miles northeast of the City of Fresno, California (Figure 1). A dominant feature of the Management Area is the Big Creek No. 4 Hydroelectric Project owned and operated by SCE. The Project's major components consist of Dam 7; a water conveyance system, including a tunnel, conduit and a penstock; and PH4. The Management Area, including Redinger Lake and the HSB, is situated in an 11.55-mile (18.6-kilometer [km])-long narrow canyon containing the SJR at elevations ranging between 985 feet above mean sea level (msl) at PH4 to 1,414 feet above msl at Redinger Lake (Figure 2). The surrounding hillsides and canyon walls rise quickly from the river canyon to an elevation between approximately 2,500 and 3,000 feet. The Management Area includes (1) Redinger Lake, (2) the SJR downstream from Redinger Lake to the tailrace of PH4, and (3) lower portions of tributary streams (Willow Creek and Backbone Creek flowing into the SJR). Detailed descriptions of tributaries flowing into the SJR are provided in the NASMP.

### **1.2 2010 DATA COLLECTION**

During 2010, data collection consistent with the NASMP was implemented on the SJR from downstream of Dam 7 to PH4 and in Redinger Lake. The data collected included water temperature, air temperature, temperature profiles in Redinger Lake, and the HSB reach of the SJR, stream discharge, hardhead radio tracking, larval fish sampling, fish population monitoring, and western pond turtle (WPT) radio tagging.

### **1.3 HARDHEAD**

The primary objective for the hardhead study in 2010 was to track adults radio-tagged during fall 2009, to identify when and where spawning may have taken place. Tracking indicated that most hardhead showed no signs of movement. The second objective was to identify where and when larval fish, particularly hardhead, were found. Light traps for fish larvae and dipnetting were used in six locations close to where hardhead were found in the past. Larval sampling took place as water temperatures in the SJR approached 10°C.

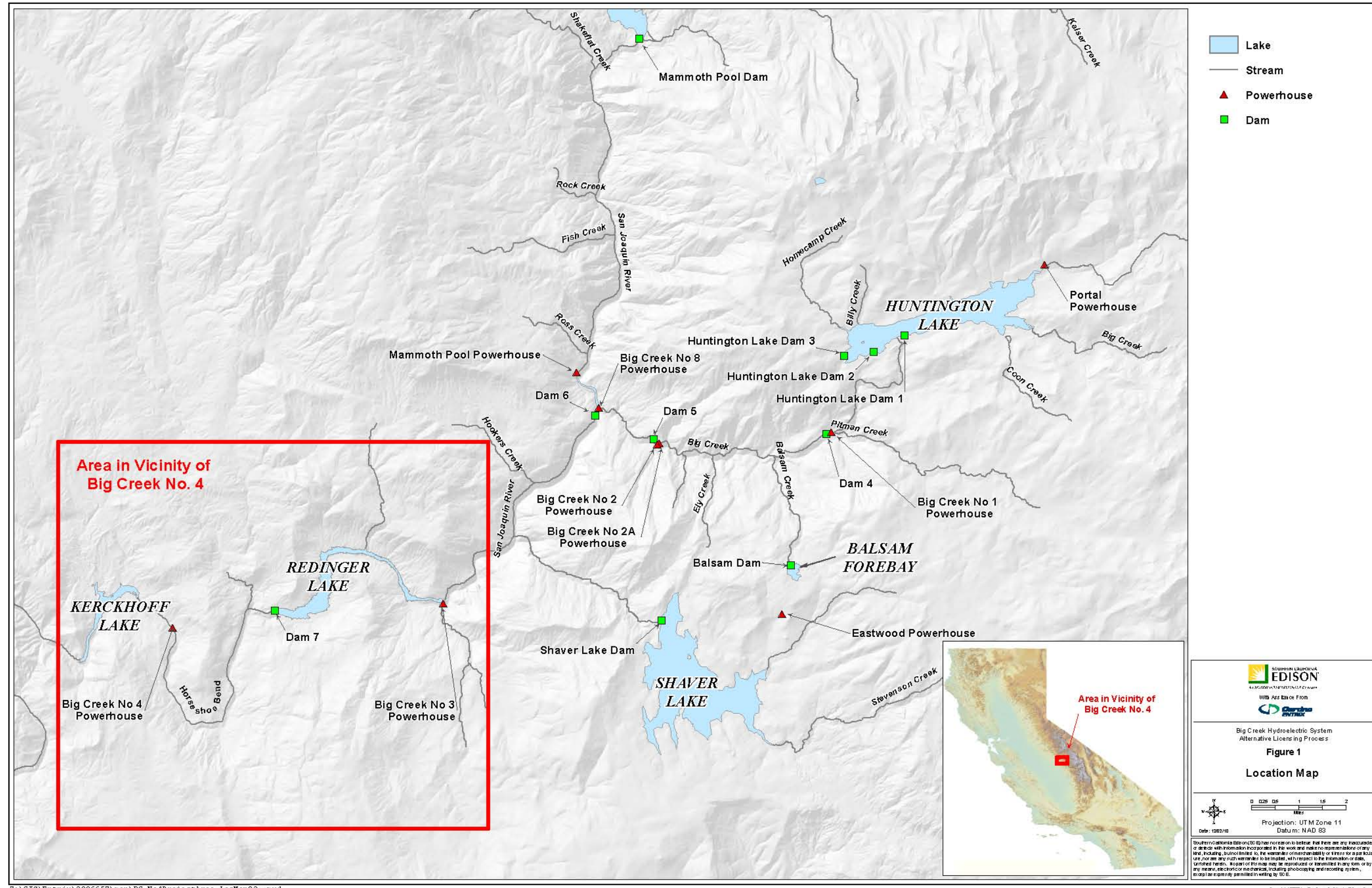


Figure 1. Location Map.



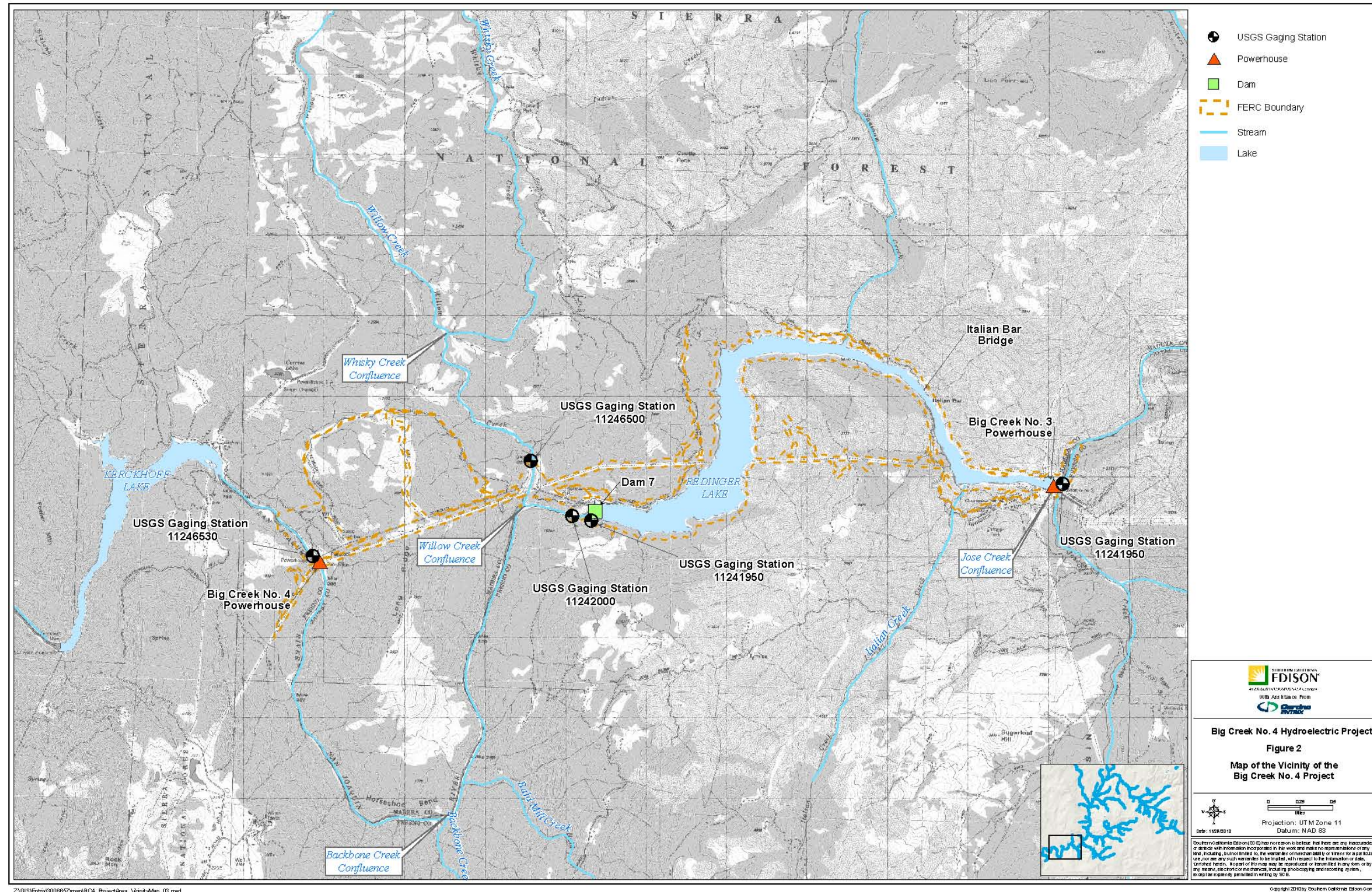


Figure 2. Map of the Vicinity of the Big Creek No. 4 Project.

## 2.0 METHODS

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### 2.1 ABIOTIC PARAMETERS

#### 2.1.1 STREAM DISCHARGE

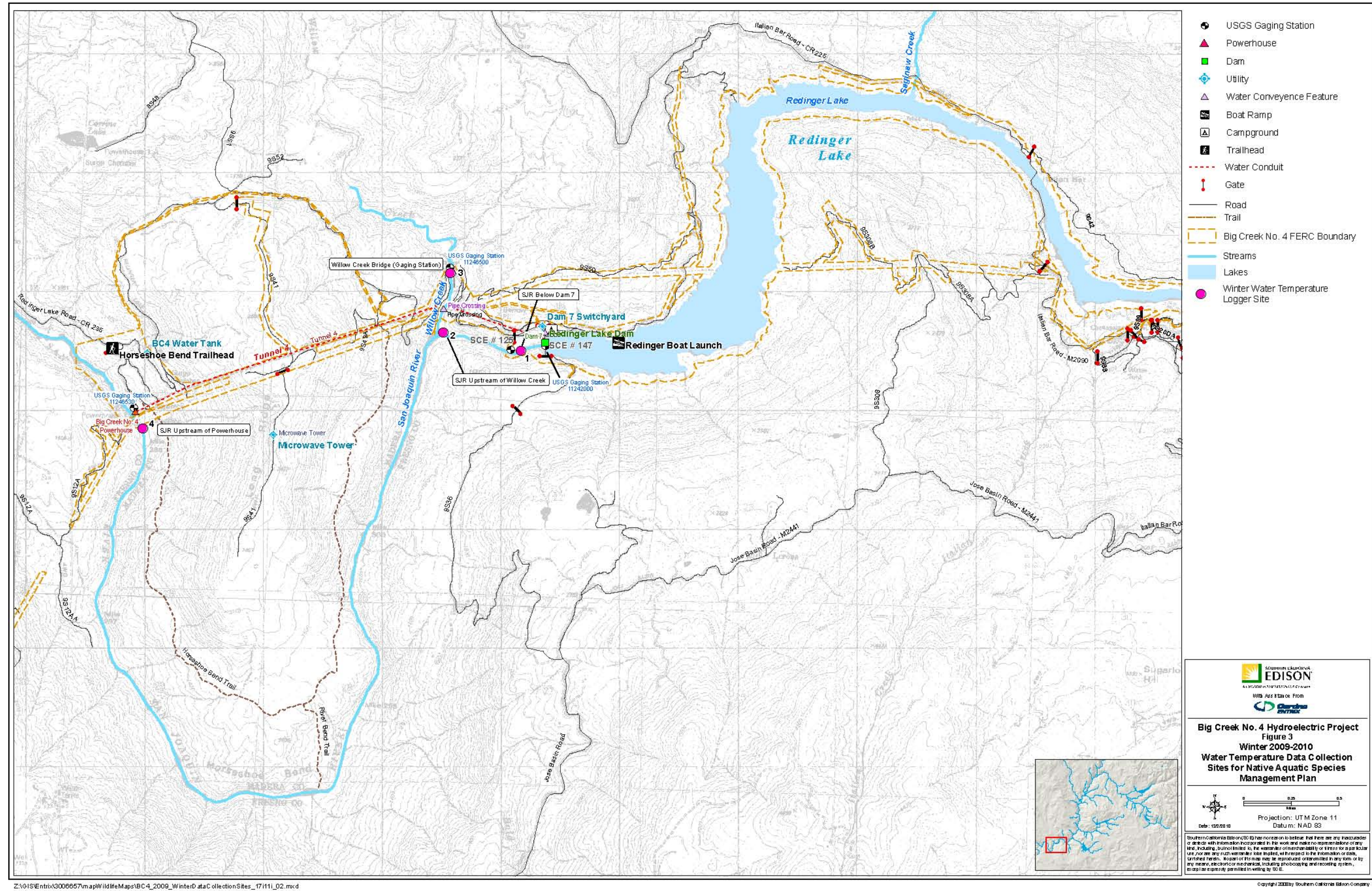
The BC4 Project diverts water from an approximately 6.3-mile stretch of the SJR between Redinger Lake and PH4. Instream flows are monitored downstream of Dam 7 and in Willow Creek near the mouth by stream gages (U.S. Geological Survey (USGS) Gage Nos. 11242000 and 11246500, respectively) operated by SCE. Provisional daily mean flow data for Water Year 2010 provided by SCE were used in this report. As shown in Figure 2, USGS Gage No. 11241950 records lake level in Redinger Lake.

#### 2.1.2 WATER TEMPERATURE MONITORING

Water temperature monitoring locations are shown in Figure 3 for the winter data collection period and in Figure 4 for the summer period. These locations are summarized in Table 1. Water temperatures were recorded at four locations in the SJR from November 2009 through April 2010 to characterize overwinter water temperature conditions (SCE 2009a). Water temperatures were monitored from May 1 to October 31, at all sites. They included all locations monitored during the previous three years (2007, 2008 and 2009 (SCE 2009b; 2009c). Water temperatures were recorded at one location in Redinger Lake, six locations in the SJR between Dam 7 and PH4, and two locations in Willow Creek. In 2010, temperature profiles were measured in Redinger Lake during June, August, and October at five locations. Redinger Lake temperature profile stations are shown on Figure 4. Temperature profile measurements were taken to characterize thermal and water quality stratification conditions. Temperature profiles also were conducted in three pools on the SJR within the HSB in August. River pool temperature profile sites are shown on Figure 4. Air temperature and relative humidity were measured concurrently at Dam 7. Beginning in November 2010, four pairs of temperature recorders were set to run over the winter, similar to those operated during winter 2009–2010.

##### 2.1.2.1 Water Temperature Recorders

Stream water temperatures in the SJR were recorded at hourly intervals using Onset temperature recorders installed *in situ* over the winter of 2009 and at 10-minute intervals for May 1 to October 31, 2010. After October 31, 2010, overwinter period, temperature recorders were reset to record at hourly intervals. Water temperature monitoring locations were selected to have well-mixed flows, to avoid groundwater influence, and to deter tampering of the recorders, to the extent feasible (Figure 4). Redundant recorders were installed at all locations. Each recorder was checked for proper function within seven days of being placed in operation. A calibration hack (check) was made upon resetting recorders. The calibration hacks consist of measuring water temperature at the location of the instrument transducer with a calibrated thermometer whose calibration is traceable to a recognized standard; the date, time, and temperature



**Figure 3. Winter 2009-2010 Water Temperature Data Collection Sites for the Native Aquatic Species Management Plan.**

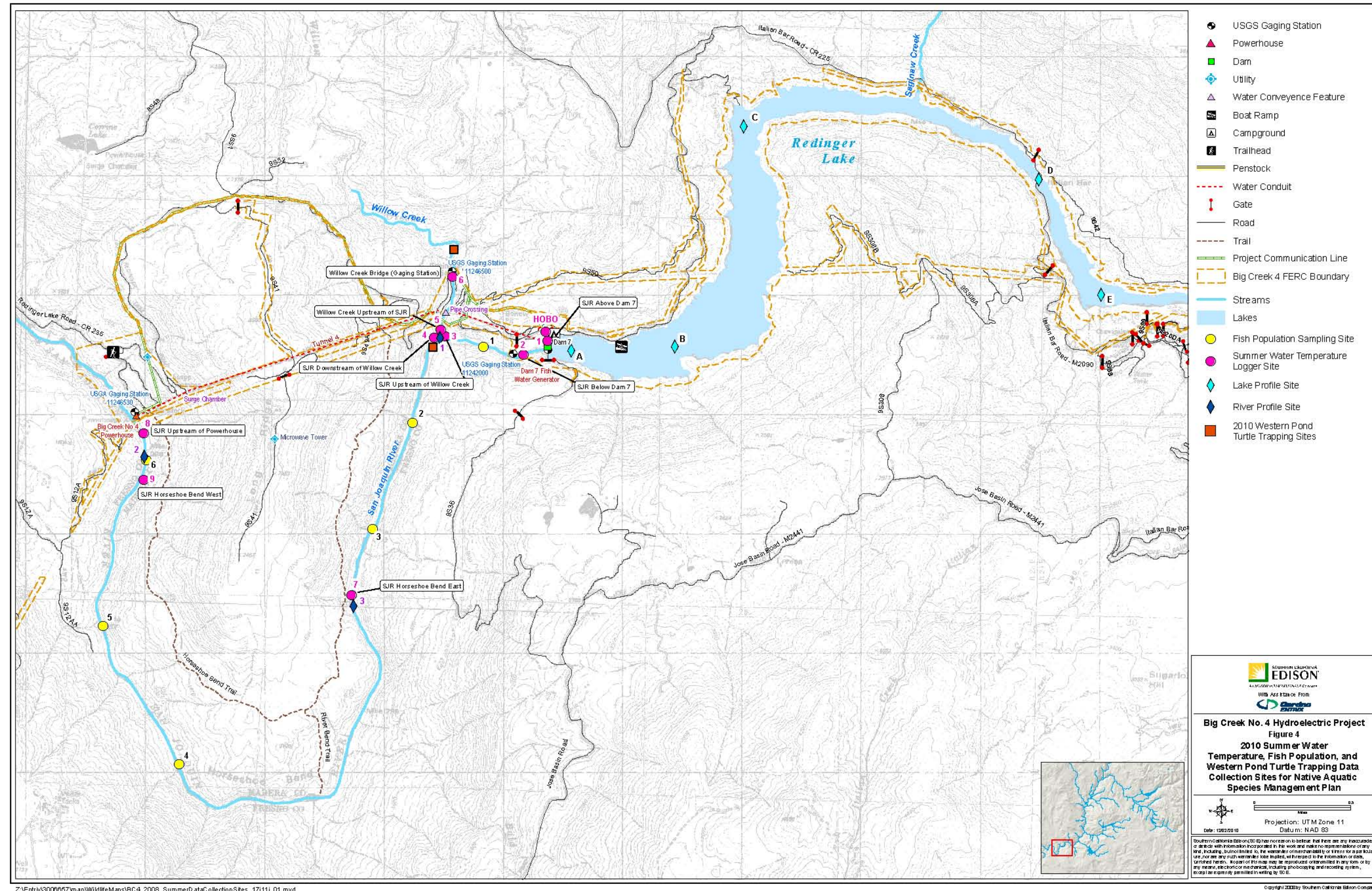


Figure 4. 2010 Summer Water Temperature, Fish Population, and Western Pond Turtle Trapping Data Collection Sites for the Native Aquatic Species Management Plan.

**Table 1. Water Temperature Monitoring Locations and Unit Serial Numbers.**

Physical Location	GPS Coordinates (UTM Zone 11S NAD 83, Meters)	Unit A (Serial No.)	Unit B (Serial No.)	Winter Monitoring Sites (X) <sup>2</sup>
SJR Upstream of Dam 7 (Redinger Lake) <sup>1</sup>	0282287/4113819	2306265	2306266	
SJR Downstream of Dam 7 / (USGS Gage site) <sup>2</sup>	0282085/4113706 / (0281956/4113704) <sup>2</sup>	2306264	2306280	X
SJR Upstream of Willow Creek	0281429/4113858	2306267	2306268	X
SJR Downstream of Willow Creek <sup>1</sup>	0281337/4113847	2306273	2306274	
SJR Horseshoe Bend East (approximately 1.5 miles downstream of Willow Creek confluence) <sup>1</sup>	0280643/4111691	2306275	2306276	
SJR Horseshoe Bend West (approximately 0.5 miles upstream of PH4) <sup>1</sup>	0278902/4112654	1888887	360407	
SJR Upstream of Powerhouse (approximately 0.1 miles upstream of PH4) <sup>3</sup>	0278905/4113049	9701212	9701213	X
Willow Creek Upstream of San Joaquin River	0281393/4113915	2306269	2306270	
Willow Creek Bridge (Gauging Station)	0281493/4114357	2306271	2306272	X

<sup>1</sup> A software problem prevented operation of the dataloggers and resulted in a data loss for the period between August, 12 2010 and October 31, 2010.

<sup>2</sup> Summer loggers downstream of Dam 7 were repositioned slightly downstream to USGS gauge site to avoid spill effects. High flows and spill downstream of Dam 7 resulted in the loss of both overwinter loggers at Dam 7 (Serial No. 360453 & 360485). Missing data were between March 19, 2010 and July 13, 2010.

<sup>3</sup> Overwinter water temperature loggers were exposed to air and resulted in data loss from October 6, 2009 to February 24, 2010.

were recorded in each case and compared to the corresponding temperature measured by the electronic recorder. Recorders were well hidden and examined for tampering during checks. Water temperature loggers and meteorology stations were checked periodically to reduce potential data loss from equipment malfunction and tampering. The data were downloaded onto a laptop computer and exported to spreadsheets for analysis. Daily mean temperature, maximum daily temperature, and minimum daily temperature were calculated. All data calculations were subject to Quality Control (QC) verification. The four temperature recorders set to run over the winter were programmed to record hourly temperature data, to assure that the recorders had sufficient memory to collect data over the winter period. The nine water temperature monitoring sites used are identified in Table 1.

### **2.1.2.2 Water Temperature Profiles**

To characterize Redinger Lake conditions, vertical profile measurements of temperature, DO, and specific conductance were made in late spring (June), summer (August), and fall (October). Measurements, to characterize stratification were collected at five sites (A through E) shown on Figure 4. One profile was taken near Dam 7 near the downstream end of the reservoir, which is the deepest area of the lake (Site A). Two additional profiles were measured near the middle and upstream end of the deep portion of the reservoir (Sites B and C, respectively). A fourth profile was taken near the Italian Bar Bridge (Site D) and a fifth profile was taken upstream of the bridge near Big Creek Powerhouse 3 (PH3) (Site E). Depths were greatest in the downstream portion of the lake and shallowest near Italian Bar Bridge and near PH3. Dissolved oxygen, temperature, and specific conductance were measured using an YSI 600-XLM DO/Temperature meter and recorded at 1-meter increments.

Water temperature profiles were measured in three deep pools in the SJR between Dam 7 and PH4. The purpose was to characterize water temperatures and the potential for temperature stratification that may affect habitat available for fish. These locations are shown on Figure 4. Summer temperature profiles were measured during August using an YSI 600-XLM DO/temperature meter and a float tube to allow for measurements throughout the deepest part of each pool. Temperature measurements were recorded at 0.5-meter increments.

### **2.1.3 AIR TEMPERATURE AND RELATIVE HUMIDITY RECORDING**

Air temperature and relative humidity were recorded between May 1 and October 31, 2010, adjacent to Dam 7. A HOBO air temperature and relative humidity recorder (Unit Serial No. 2317011) was installed at this location and functioned normally throughout the full period.

## **2.2 HARDHEAD**

The primary objective for the hardhead study in 2010 was to track adults radio-tagged during fall 2009, to identify when and where spawning may have taken place. Tracking indicated that most hardhead showed little to no signs of movement. The second objective was to identify where and when larval fish, particularly hardhead, were found. Light traps, cone nets, and dip nets for fish larvae were used in several locations close to where hardhead were found. Larval sampling took place as water temperatures in the SJR approached 10°C.

### **2.2.1 SAMPLING SITES FOR HARDHEAD**

During fall 2009, three areas in the SJR were sampled to obtain adult hardhead for tagging and future tracking in 2010. Twelve adult hardhead were tagged at these sites (Figure 5). The first site was near the confluence of Backbone Creek, where two fish were captured and tagged from the confluence pool on September 29<sup>th</sup>. The second site was between Willow Creek and Backbone Creek on the SJR, where five fish were captured and tagged on September 30 from the pool where the temperature logger station is located downstream of Willow Creek and the adjacent pool downstream. The third site was located between the Backbone Creek confluence with SJR and PH4 and is the second fish population monitoring site upstream of PH4. Five hardhead were tagged in a large pool in the middle of the fish population monitoring site and the large pool immediately downstream of the site on October 1<sup>st</sup>. The capture information is provided in detail in the 2009 progress report (SCE 2009c) and is reproduced in Table 2.

During September 2010, inclement weather and high flows in the SJR resulted in turbid conditions in the SJR and restricted hardhead tagging activities. The remote sites sampled in 2009 could not be accessed in 2010. As a result no suitable-sized adult hardhead were captured or tagged to conduct radio tagging of fish for tracking in 2011.

### **2.2.2 TRACKING METHODOLOGY**

Following the hardhead capture and tagging in fall 2009, a crew of biologists returned in spring 2010 to locate and record movement of the tagged fish. An Advanced Telemetry Systems Inc. (ATS) Model R2100 radio telemetry device was used to detect and locate individual fish based on their tag's unique radio frequency. Searches were conducted on foot from the bank, in areas thought to be used by adult hardhead such as large pools, runs, and along the shoreline of Kerckhoff Reservoir. The original capture locations at the Willow Creek/SJR confluence pool, HSB east temperature monitoring site, the Backbone Creek/SJR confluence pool, fish population Site 5, and upstream of Big Creek Powerhouse 4 also were searched extensively. To allow for greater coverage of the HSB reach and upstream reaches of Willow Creek, radio tag location searches also were conducted from a helicopter on several occasions throughout the spring.

### **2.2.3 LARVAL FISH SAMPLING**

Larval fish sampling and collection was conducted at five areas on the HSB reach of the SJR in 2010, at locations where radio tracking indicated the presence of hardhead tagged in fall 2007 through 2009 and at two locations on Lower Willow Creek (Figure 5, Table 3). During high flows in June, nearby backwaters and low velocity areas were sampled near the previous sampling locations. Larval fish sampling was conducted 11 times from late April to early August after water temperatures approached 10°C. The locations and dates sampled are shown in Table 3. Light traps were operated overnight to check for the presence of larval fish. Light traps were constructed following the general design of Kissick (1993) with modifications similar to those described by Marchetti et al. (2004). Additional modifications included a 4.5-inch-diameter, 5-inch-long cylinder that extended from the bottom plate of the trap. This cylinder was used to attach a plankton net with a dolphin bucket, so larval samples could be caught in the net while the trap operated and reduce potential losses. Based on the work of Marchetti et al. (2004),

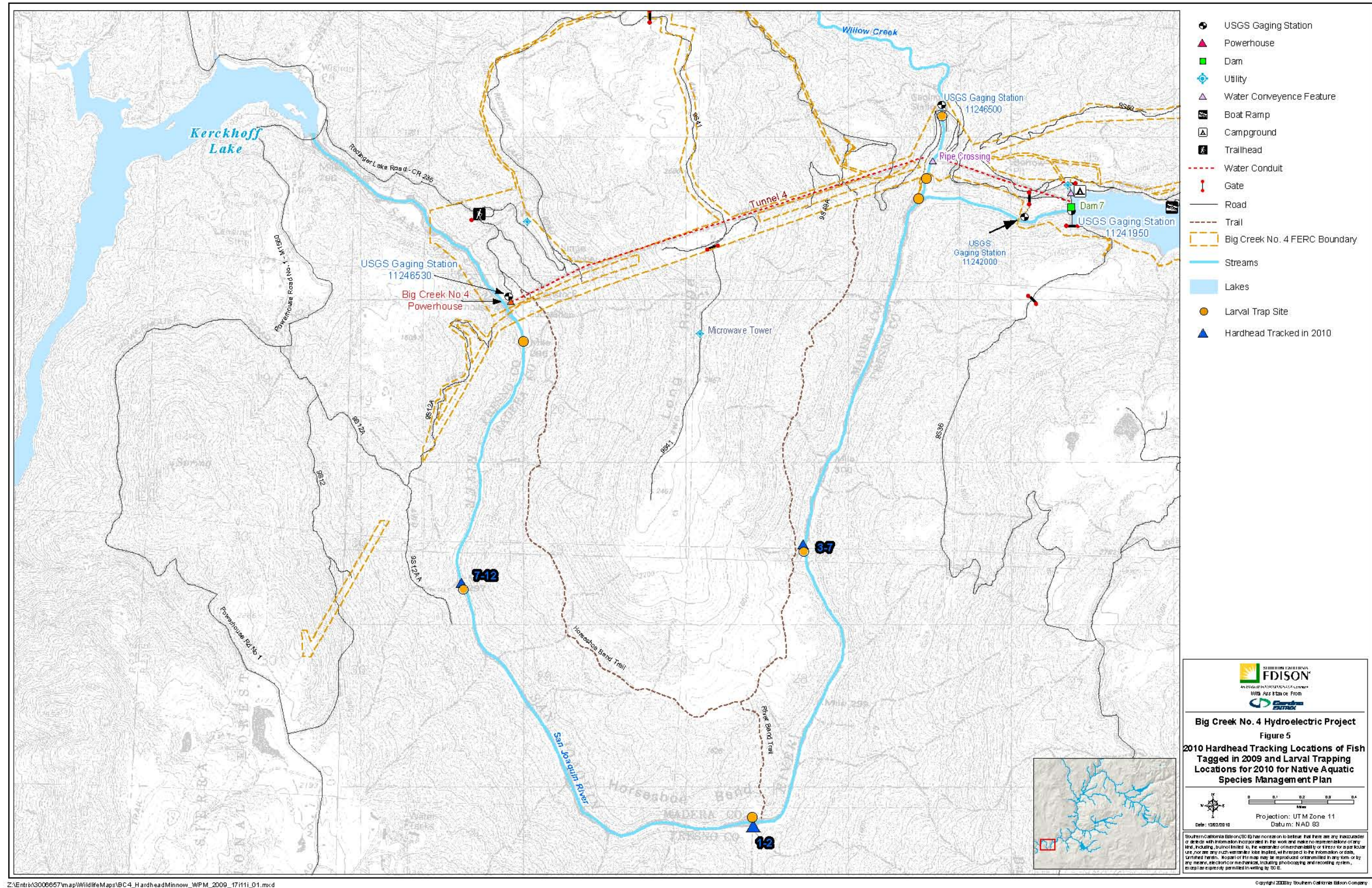


Figure 5. 2010 Hardhead Tracking Locations of Fish Tagged in 2009 and Larval Trapping Locations for 2010 for the Native Aquatic Species Management Plan.



**Table 2. Hardhead Radio Tagged in 2009 and Tracked during Spring and Summer 2010.**

Sample No.	Date	Site	No.	Weight (g)	Fork Length (mm)
1	9/29/2009	Backbone Creek	8.322	451	329
2	9/29/2009	Backbone Creek	8.303	318	270
3	9/30/2009	HSB Logger Site	8.081	569	366
4	9/30/2009	HSB Logger Site	8.242	282	298
5	9/30/2009	HSB Logger Site	8.282	246	300
6	9/30/2009	HSB Logger Site	8.121	352	282
7	9/30/2009	HSB Logger Site	8.262	161	246
8	10/1/2009	Between BBC and PH4	8.061	418	352
9	10/1/2009	Between BBC and PH4	8.221	329	308
10	10/1/2009	Between BBC and PH4	8.022	305	293
11	10/1/2009	Between BBC and PH4	8.202	266	296
12	10/1/2009	Between BBC and PH4	8.042	150	235

HSB = Horseshoe Bend between Willow Creek and Backbone Creek confluences

BBC = Backbone Creek Confluence on San Joaquin River

PH4 = Upstream of Big Creek Powerhouse 4

**Table 3. Larval Trapping Locations and Sampling Dates, 2010.**

<b>Trapping Site Location</b>	<b>Deployment Dates</b>	<b>GPS Coordinates (UTM Zone 11S, NAD83, Meters)</b>	<b>Detailed Trapping Site Location</b>
Powerhouse 4	April 6, 29, May 6, 19, June 3, 16, 29, July 14, 28, 30 and August 10, 2010	E278916, N4112953	BC-4, Second Pool, Directly upstream of Powerhouse
Willow Creek Confluence	April 6, 29, May 6, 19, June 3, 16, 29, July 14, 28, 30 and August 10, 2010	E281362, N4113822	SJR at Willow Creek, Confluence Pool at bottom of Willow Creek
Willow Creek	April 6, 29, May 6, 19, June 3, 16, 29, July 14, 28, 30 and August 10, 2010	E281398, N4113946	Willow Creek, Second Pool upstream from Confluence SJR
Willow Creek near Redinger Lake Road bridge	June 16 and 28	E281478, N4114285	Willow Creek just downstream of the bridge on Redinger Lake Road
Backbone Creek Confluence	April 6, 29, May 6, 19, June 3, 16, 29, July 14, 28, 30 and August 10, 2010	E281344, N4113788	SJR at Backbone Creek, Confluence Pool at bottom of Backbone Creek
Horseshoe Bend East	April 6, 29, May 6, 19, June 3, 16, 29, July 14, 28, 30 and August 10, 2010	E280643, N4111691	SJR at the Horseshoe Bend water temperature monitoring station just downstream of fish population Site 3.
Fish Population Site # 5 on SJR Horseshoe Bend West	April 6, 29, May 6, 19, June 3, 16, 29, July 14, 28, 30 and August 10, 2010	E278533, N4111626	SJR on the west side of Horseshoe Bend at the middle of fish population site # 5.

SJR = San Joaquin River

UTM = Universal Transverse Mercator

green chemical light sticks (8-inch glow sticks) were used to attract larval fish. One trap was operated at each location overnight. Collections were initiated before sunset and operated until after sunrise.

After retrieval of the traps, the contents were transferred to a sample jar and preserved in 95 percent ethanol. Labels were placed in and on the sample jar. Labels identified the date, time, location, and duration of sampling. Water temperature, turbidity, and DO were measured before setting the light traps and after retrieving the traps. Larval fish were identified under a dissecting microscope to species, except where specimens were too damaged to identify. Total lengths were measured for at least 10 specimens of each species collected in each sample.

Due to high flows associated with spills from Dam 7 during the late spring – early summer, there were limitations in the operation of the larval traps due to current velocities. Trapping locations were adjusted to take advantage of local backwaters. In addition, conical nets and dip nets were used to supplement larval trapping, especially in shallow low velocity backwaters associated with submerged vegetation and woody debris.

## **2.3 SJR FISH SURVEY**

### **2.3.1 SURVEY REACHES**

Fish sampling was carried out in the HSB Reach at sampling locations used in previous studies (BioSystems 1987; SCE 1997) and identified in the NASMP to characterize the native transition-zone fish community.

#### Site Selection

The NASMP identified six sampling sites within the HSB reach (Figure 3), corresponding to the 1985 BioSystems and 1995 Cardno ENTRIX sampling sites (BioSystems 1987 and SCE 1997, respectively). Sampling sites were selected to provide adequate coverage of the area to be sampled. At each of the fish sampling locations selected for the HSB, both an electrofishing site and a snorkel survey site were selected based on the earlier studies. Generally, electrofishing was conducted in sites shallower than three feet deep. Visual (snorkel) surveys were conducted in deeper water. Deep water (pools and deep runs) were visually surveyed at a similar length or to the end of the habitat unit being surveyed. In all, 24 percent of the study reach from Dam 7 to PH4 (7,372 of 31,355 feet) was snorkeled. Sampling was conducted in the fall, consistent with earlier surveys. Sampling was conducted October 10-15, 2010. All six sites were snorkeled and four sites were electrofished. Electrofishing could not be conducted at two of the sites due to safety concerns caused by turbulence and depth.

#### Sampling Methodology

##### ***Electrofishing***

Quantitative fish population surveys were conducted at Sites 3, 4, 5, and 6. Electrofishing surveys were conducted in shallower habitats. Multiple removal population estimates were made. All fish species present were identified to species and lifestage and abundance was estimated.

Electrofishing sampling enabled the collection of data on fish length, weight, and scales. From these, information on standing crop, and condition factors were analyzed. Observation of collected fish provided information on disease or injury, if present. The data provided the information necessary to address whether aquatic species were in good condition as defined by Moyle et al. (1998). These data and visual observations allowed comparing current populations and trends with those of previous studies (BioSystems 1987, SCE 1997, SCE 2009b).

Electrofishing was conducted using two Smith-Root Type 12B backpack electrofishing units. This sampling technique was used in habitats sufficiently shallow to allow adequate sampling. The upstream and downstream ends of the site were blocked using 0.25-inch mesh block nets. Sampling was conducted using multiple pass depletion, in which fish were stunned and removed from the site in multiple sequential passes.

In this case, population estimates were based on the maximum likelihood technique of Zippin (1958) using the Microfish computer program (Deventer and Platts 1989). Sampling was performed in an upstream direction beginning at the downstream block net and finishing at the upstream block net. A typical electrofishing team consisted of two backpack electrofishers, two net persons, and one net/livecar person for habitats smaller than 20 feet wide. Electrofishing was generally conducted as described by Reynolds (1996).

### ***Fish Measurement and Handling***

All captured fish<sup>1</sup> were identified to species, measured for length to the nearest millimeter (mm) fork length, and weighed to the nearest 0.1 gram (g) for fish up to two kilograms (kg), or to the nearest gram for fish over two kg.

Each fish processed was examined for disease or injury and its condition noted on the field sheets. Scale samples were collected from native cyprinids and catostomids for age and growth determinations. Scales were collected from the backs of the fish above the lateral line and below and slightly behind the dorsal fin. Scales were stored in envelopes and the date, stream, site, species, length, weight and a data sheet reference code recorded on the envelope.

Scale analyses were conducted to determine the age of sampled fish and to assess the age structure of sampled populations. To determine the age of the fish, scales were mounted on standard glass microscope slides and either directly viewed through a microscope or imaged with a microscope-mounted digital camera. Images of scales were digitally recorded for analysis. The digital images of the scales were manipulated to make the annuli appear distinct from the rest of the circuli (scale rings).

### ***Snorkeling***

Direct observation of fish by snorkel surveys were conducted in habitats that were too deep (pools and deep runs) for effective sampling by electrofishing. Both techniques provided information on fish abundance and length. However, direct observation provided lower

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<sup>1</sup> Fish observed during snorkeling were not captured and so were not available for measurements and analyses described in this subsection.

resolution length information, since lengths were visually estimated in comparison to a target. Turbidity was higher during the 2010 sampling than 2008, due to intense thunderstorms the previous week. As a consequence, the bottoms of the deepest parts of most pools snorkeled were not visible.

The snorkeled habitat units were divided into one or more swimming lanes parallel to the direction of stream flow. Methods generally were the same as those used in 2008.

Divers entered the water slightly below the downstream end of the sample unit (Hankin and Reeves 1988) and moved directly across and slightly below the lowermost boundary of the sample unit into their designated swimming lane. When in position, the divers moved upstream to the lowermost boundary of the sample unit. From a fixed position and prior to moving upstream, the divers looked upstream to locate fish on the fringe of vision (Platts et al. 1983). Divers then identified and counted fish species in their lane, while moving slowly upstream at a uniform, even, pace with no abrupt movements. Fish were counted as they passed below or to the side of an observer. Cover for fish such as interstitial spaces between substrate particles, woody debris, bubble screens, crannies in bedrock, and along stream margins were inspected closely for concealed fish to the best of the divers abilities (Fausch and White 1981; Hicks and Watson 1985). A bank-side observer was stationed to monitor and verbally direct diver distribution and sampling rate, when possible the diving effort was constrained to standardized time spans determined by individual habitat/site extent and structure.

### **2.3.2 DETAILED METHODS FOR WESTERN POND TURTLE**

The methodologies used are based on standard survey techniques. Five traps were installed at one of the three proposed study locations (Table 4) on SJR at the confluence with Willow Creek and two additional sites (not originally proposed) near the Willow Creek bridge and in the vicinity of Big Creek Powerhouse 4. These sites were sampled from October 5 to October 8, 2010. Two other proposed sites were not sampled because the field crew could not access the sites due to inclement weather.

Four days of trapping were conducted. Three collapsible nylon hoop net traps were staked or tied in water of sufficient depth to submerge the entries. These traps were checked every two hours from early morning to late afternoon to prevent captured turtles from drowning. Two floating traps were employed simultaneously and were checked on the same schedule as the hoop traps. In addition, the floating traps were left overnight to increase sampling time. Unlike the hoop net traps, the floating traps can be operated unattended, since the design prevents turtles from drowning. The floating turtle traps were baited with sardines and either set in the morning and checked in the afternoon of the same day (i.e. trapping day) or set in the afternoon and checked the following morning (i.e. trapping night). Trapping data included date, time, crew, location, general water and weather conditions, sex, weight, age, and maximum carapace length, height, width, external signs of disease and lesions and photographs of each individual turtle captured or recaptured. Age was estimated when possible by counting annuli on one or more scutes of the plastron and/or carapace (Bury and Germano 1998). Captured turtles were individually marked with a numerical identification code, notched into the marginal scutes, before being released at the point of capture (adapted from Holland 1994) as a means to document movement of individuals. Three adult females and two adult males were captured at

**Table 4. Western Pond Turtles Captured during October 2010.**

Sample #	Date Captured	Site	Sex	Age	Radiotagged (Yes/No)	Notch Location	Weight (g)	Carapace Length (in.)
1	10/5/2010	Willow Creek	Female	? <sup>1</sup>	Yes	101	235	5
2	10/5/2010	Willow Creek	Female	7	No	300	226	4.7
3	10/6/2010	Willow Creek	Female	7	No	106	161	4.2
4	10/6/2010	Willow Creek	Male	? <sup>1</sup>	No	107	282	5.2
5	10/6/2010	Willow Creek	Male	5	No	108	295	5.2
6	10/7/2010	WCCP <sup>2</sup>	Male	? <sup>1</sup>	No	109	327	5
7	10/7/2010	WCCP	Female	? <sup>1</sup>	Yes	301	388	5.5

<sup>1</sup>Turtles Scutes were too worn to age.

<sup>2</sup>Willow Creek/SJR Confluence Pool. This is one of the proposed sites.

the Willow Creek site and one adult male and female were captured at the SJR/Willow Creek confluence pool (Table 4).

Radio tagging was initiated of WPT in 2010. External transmitters were attached to two adult female WPT captured with a carapace of length >14 cm. One adult female was tagged at the Willow Creek site and another adult female at the SJR/Willow Creek confluence pool site. The radio tags weighed approximately 4g and measured 3.4 cm by 1.4 cm by 1.2 cm and had internal helical antennae. The battery life is guaranteed for 220 days but may be expected to last 441 days. This should provide enough coverage to determine both overwintering and nesting habitat locations. Radio tags were glued onto the front of the carapace of adult WPT with Devcon 5 minute epoxy and molded to the shell with dental acrylic colored black with copy machine toner (Rathbun et al. 2002).

## 2.4 MUSSEL SURVEYS

Baseline monitoring surveys for native freshwater mussels were conducted within the Horseshoe Bend Reach of the San Joaquin River during August 23-26, 2010 by Cardno ENTRIX and Spring Rivers personnel. Initially, three surveyors searched five of the seven locations where western pearlshell (*Margaritifera falcata*) mussels had been historically or recently reported to occur. In October, Cardno ENTRIX crew members snorkeled the remaining two sites and found no mussel beds suitable for long term monitoring. Only scattered clusters of three or less mussels were observed at these sites. The numbers of live mussels or shells within or between these sites were not recorded. At the request of the Native Americans who consulted on this study, the specific sites studied have been kept confidential. The site designations do not correspond to any map or other site description provided. Of the seven sites included, only one site contained a large mussel bed that was deemed suitable for long-term monitoring using the methods outlined in the Adaptive Management Plan (SCE 2008).

To estimate the mean density and number of mussels at Site 7, surveyors used a modification of the two-phase approach of Vilella and Smith (2005). A reconnaissance snorkel survey was done to differentiate areas of high and low mussel density. A permanent marker was selected at the downstream end of the site to serve as the reference point for the high and low density areas and for all sampling locations. The site marker was photographed and GPS coordinates were recorded. A survey tape was strung from the site marker and attached to a willow branch located 50 meters upstream. The locations of the high and low density areas along the site were noted by starting and ending distances referenced to the site marker. Three transects were randomly selected within the high density area and two transects were randomly selected within the low density area. No transect was sampled within 3 meters of another transect. The width of the river along each transect was then divided into three strata (river-left stratum, middle stratum, and river-right stratum), each of which represented one third of the transect width. Distances along each transect from the shore were selected by use of a random number table and three locations were selected within each stratum for sampling with a 0.25-m<sup>2</sup> quadrat. The 10<sup>th</sup> location along each transect was drawn at random from the overall width. At each sampling location, the quadrat was placed with its near shore corner at the specified distance. The numbers and species of mussels observed within each quadrat were recorded. Substrate conditions, the presence of algae, and other pertinent physical characteristics were also recorded for each quadrat. Parts of Site 7 was too deep (up to 3 meters) for surveyors to systematically

search for juvenile mussels (via sediment excavation), collect and measure adult mussels, or use a Marsh-McBirney flow meter to calculate water velocities.



## 3.0 RESULTS

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### 3.1 ABIOTIC PARAMETERS

#### 3.1.1 STREAM DISCHARGE

Water year 2010 was classified as an above normal water year (CDWR 2010). Daily mean flows in the SJR downstream of Willow Creek between May 1 and October 31 ranged from as much as 11,011 cfs to a minimum below 35 cfs<sup>2</sup>. Dam 7 spilled between May 23 and May 25, throughout June, for the first week of July and again during the first two weeks of September. Flows during August and October were generally below 45 cfs in the SJR downstream of Willow Creek. Table 5 presents the monthly mean flows for summer 2010. The average daily flow for the SJR during the monitoring period was just over 1,120 cfs due to the prolonged spills. The average daily flow for Willow Creek during the monitoring period was approximately 73 cfs due to spring and early summer high flows.

#### 3.1.2 WATER TEMPERATURE RESULTS

Average water temperatures for the four overwinter monitoring locations, along with flows in the SJR and Willow Creek, are reported by month for the winter in Table 6. Average water temperatures for the nine monitoring locations are reported by month in Table 5. Daily mean water temperature and flows for the SJR during the summer months are plotted on Figure 6. Daily mean water temperature and flows for Willow Creek for the summer months are plotted together on Figure 7. Water temperatures were affected by periods of high flows that occurred during the 2010 monitoring period.

##### 3.1.2.1 Overwinter Water Temperatures, 2009–2010

Overwinter mean daily water temperatures and flows in the SJR and Willow Creek are plotted on Figures 8 and 9, respectively, for November 2009 through April 2010. Overwinter water temperatures in the SJR, directly downstream of Dam 7 decreased from a high monthly mean of 14.4°C in November to a low of approximately 5.7°C in February, before slowly warming through March. The mean November water temperature was warmest at the site downstream of Dam 7, while mean temperatures were warmest at the PH4 site in December, March, and April. The Willow Creek site recorded the highest mean water temperature for February. Overwinter monthly mean water temperature upstream of PH4 decreased from approximately 12.8°C in November to a low of approximately 7.0°C in February before slowly warming to over 9°C in April. High flows during late February to early March and late March through April kept water

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<sup>2</sup> All flow data is considered provisional until reviewed by USGS

**Table 5. Monthly Mean, Maximum, and Minimum Water Temperature and Average Monthly Flows during May 1 to October 31, 2010.**

Month	San Joaquin River Downstream of Dam 7 <sup>1</sup> Temperature °C			San Joaquin River Upstream of Willow Creek Confluence Temperature °C			San Joaquin River Downstream of Willow Creek Confluence <sup>2,3</sup> Temperature °C			San Joaquin River Horseshoe Bend East <sup>2,3</sup> Temperature °C			San Joaquin River Horseshoe Bend West <sup>2,3</sup> Temperature °C			San Joaquin River Upstream of Powerhouse 4 Temperature °C			Willow Creek Bridge Gauging Station Temperature °C			Willow Creek 200m Upstream of Confluence Temperature °C			Willow Creek <sup>4</sup> Flow (cfs) at USGS Gauge No. 11246500	San Joaquin River <sup>4</sup> Flow (cfs) at USGS Gauge No. 11242000
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max		
May	-	-	-	8.9	7.4	11.9	10.4	6.6	13.5	10.6	7.0	13.6	11.1	7.5	13.5	11.3	7.5	14.2	10.6	6.4	14.5	10.8	6.5	27.3	161	141
June	-	-	-	12.0	10.1	14.6	12.3	10.4	14.6	12.3	10.2	14.6	12.4	10.1	14.6	12.4	10.2	14.7	16.2	12.4	22.9	16.6	11.9	22.4	200	5320
July	13.3	12.8	15.2	14.6	13.0	17.1	15.2	13.4	18.2	18.1	13.4	22.2	18.9	13.5	23.4	19.0	13.5	23.5	21.7	16.7	26.2	21.8	16.9	26.2	37	626
August	14.8	13.2	16.3	15.6	13.5	17.5	15.3	14.2	16.5	18.6	17.7	19.5	20.6	19.5	22.1	20.7	18.4	22.9	20.8	17.0	24.1	21.9	18.7	26.2	21	34
September	16.7	15.5	19.3	17.0	15.7	19.2	-	-	-	-	-	-	-	-	-	18.9	17.1	21.3	19.0	16.2	22.5	20.7	17.2	24.4	3	700
October	16.1	13.0	17.3	16.1	12.9	18.1	-	-	-	-	-	-	-	-	-	18.9	16.7	20.4	18.9	14.6	21.7	19.0	16.3	22.4	15	32

<sup>1</sup> Loggers Downstream of Dam 7 were lost due to high flow conditions snapping attachment cable.

<sup>2</sup> Onset Firmware issue resulted in loss of data for the period August 10th to October 31st at several sites: SJR DWC, SJR HSBE, SJR HSBW

<sup>3</sup> August means for the following months are based on August 1 through August 9 data: SJR DWC, SJR HSBE, SJR HSBW

<sup>4</sup> All flow data is considered provisional until reviewed by USGS.

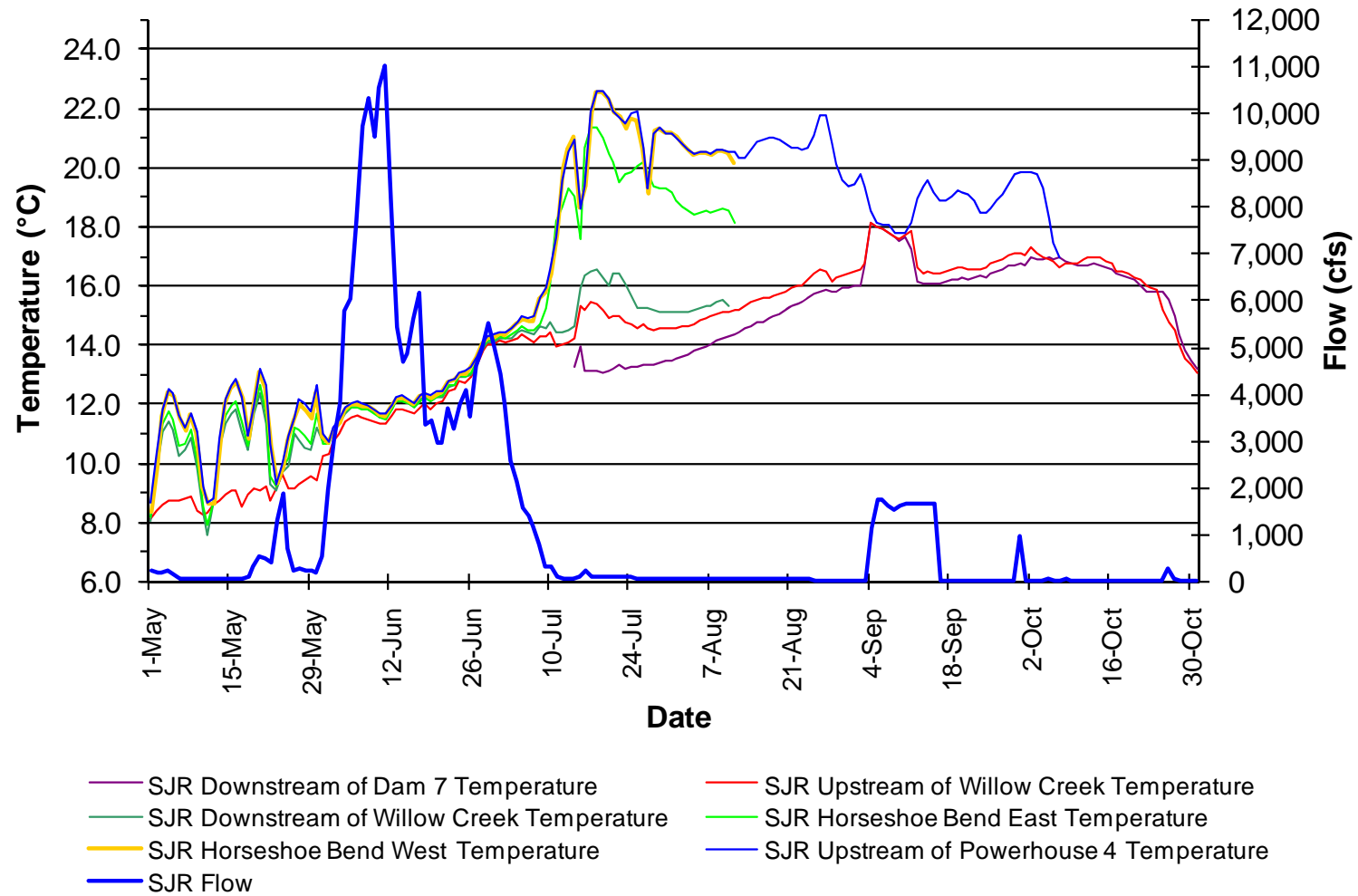
**Table 6. Monthly Mean, Minimum, and Maximum Water Temperature and Average Monthly Flows from November 1, 2009, to April 30, 2010 (Overwinter).**

Month	San Joaquin River Downstream of Dam 7 <sup>1</sup> Temperature °C			San Joaquin River Upstream of Willow Creek Confluence Temperature °C			San Joaquin River Upstream of Powerhouse 4 <sup>2</sup> Temperature °C			Willow Creek Bridge Temperature °C			Willow Creek <sup>3</sup> Flow (cfs) at USGS Gauge No. 11246500	San Joaquin River <sup>3</sup> Flow (cfs) at USGS Gauge No. 11242000
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max		
November	14.4	12.3	15.4	13.6	11.5	14.9	12.8	9.8	14.4	10.1	6.1	12.2	9.7	31.5
December	9.6	7.2	12.4	9.3	7.4	11.7	9.8	9	10.6	5.5	3	7.4	13.3	32.2
January	6.7	5.6	7.9	6.9	5.7	7.8	-	-	-	6.4	4.1	9.2	34.4	33.2
February	5.7	5.3	6.7	6	5.3	7.2	7	6.1	9.8	7.5	5.2	9.5	77	150.5
March	6.2	5.9	7.6	7.2	6	9.7	8.6	6.7	11.7	8.5	4.6	11.9	101.5	359.6
April	-	-	-	7.9	6.9	10.2	9.3	6.9	13.1	9	4.9	13.3	187.1	812.6

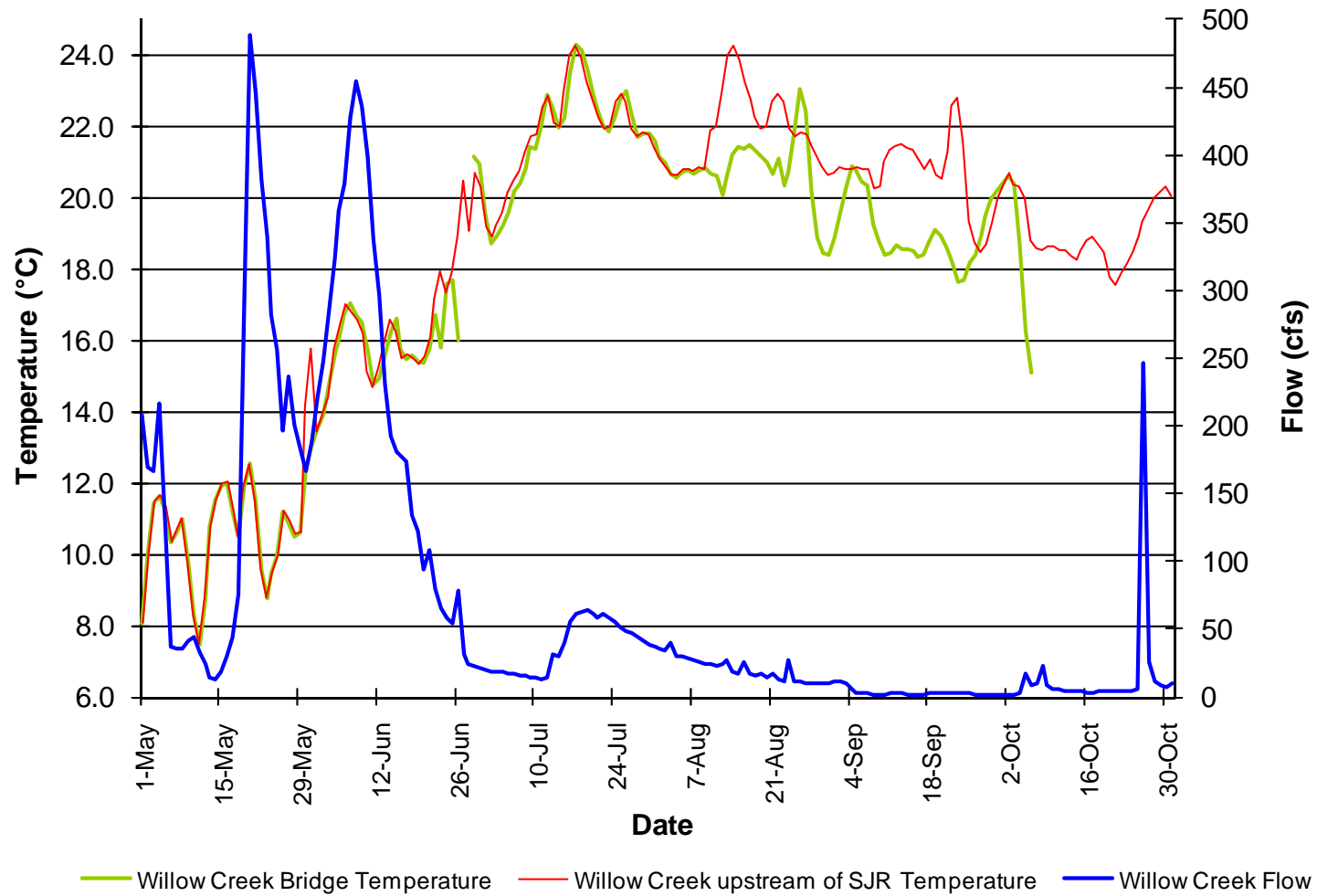
<sup>1</sup> March temperature averages for SJR Downstream of Dam 7 are calculated from the period March 1- March 18 due to unit loss.

<sup>2</sup> January temperature averages for PH4 are unavailable due to the units being exposed to air following unauthorized removal.

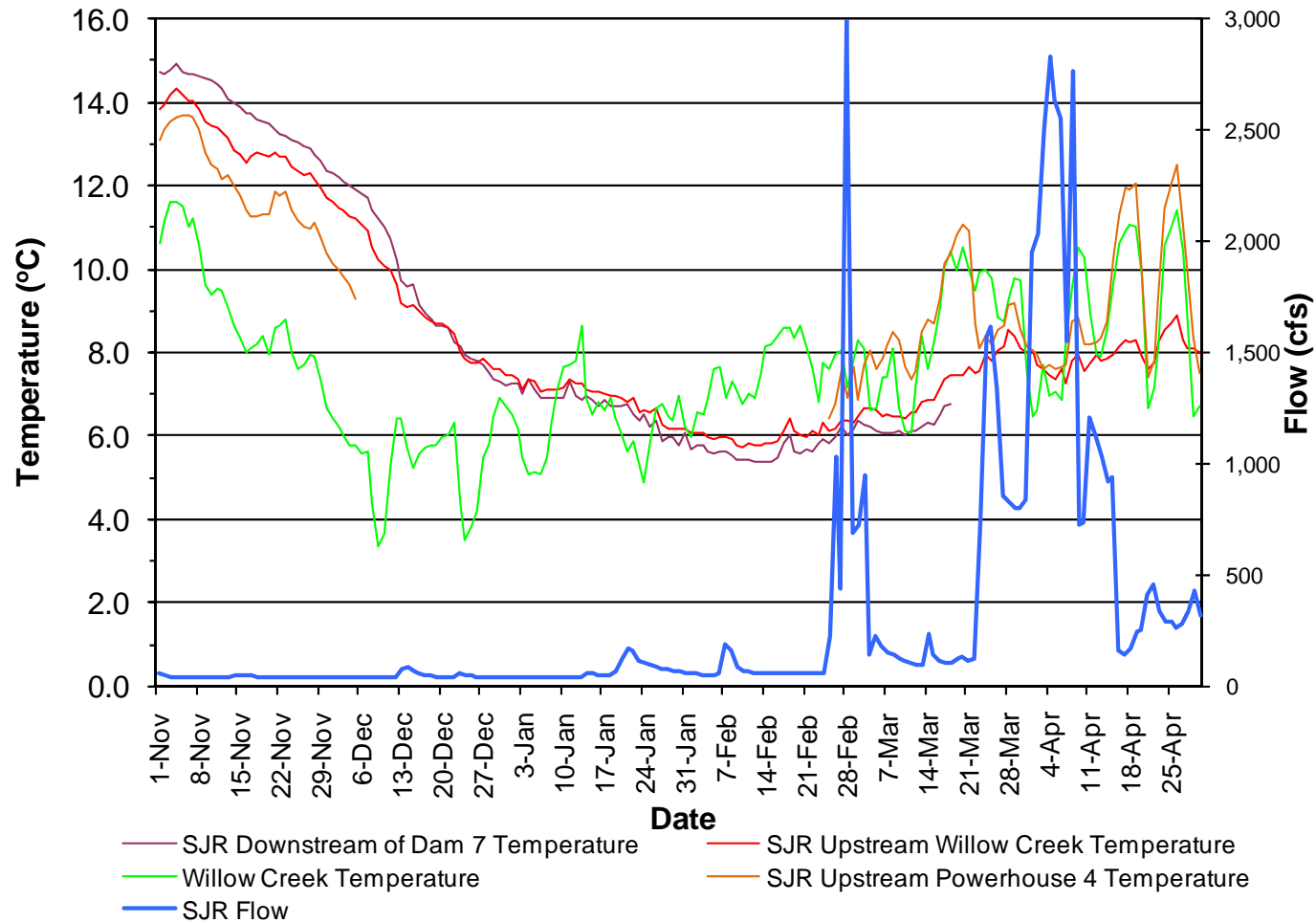
<sup>3</sup> All flow data is considered provisional until reviewed by USGS.



**Figure 6. Mean Daily Flow and Water Temperatures in the Horseshoe Bend Reach of the San Joaquin River, May 1–October 31, 2010 .**

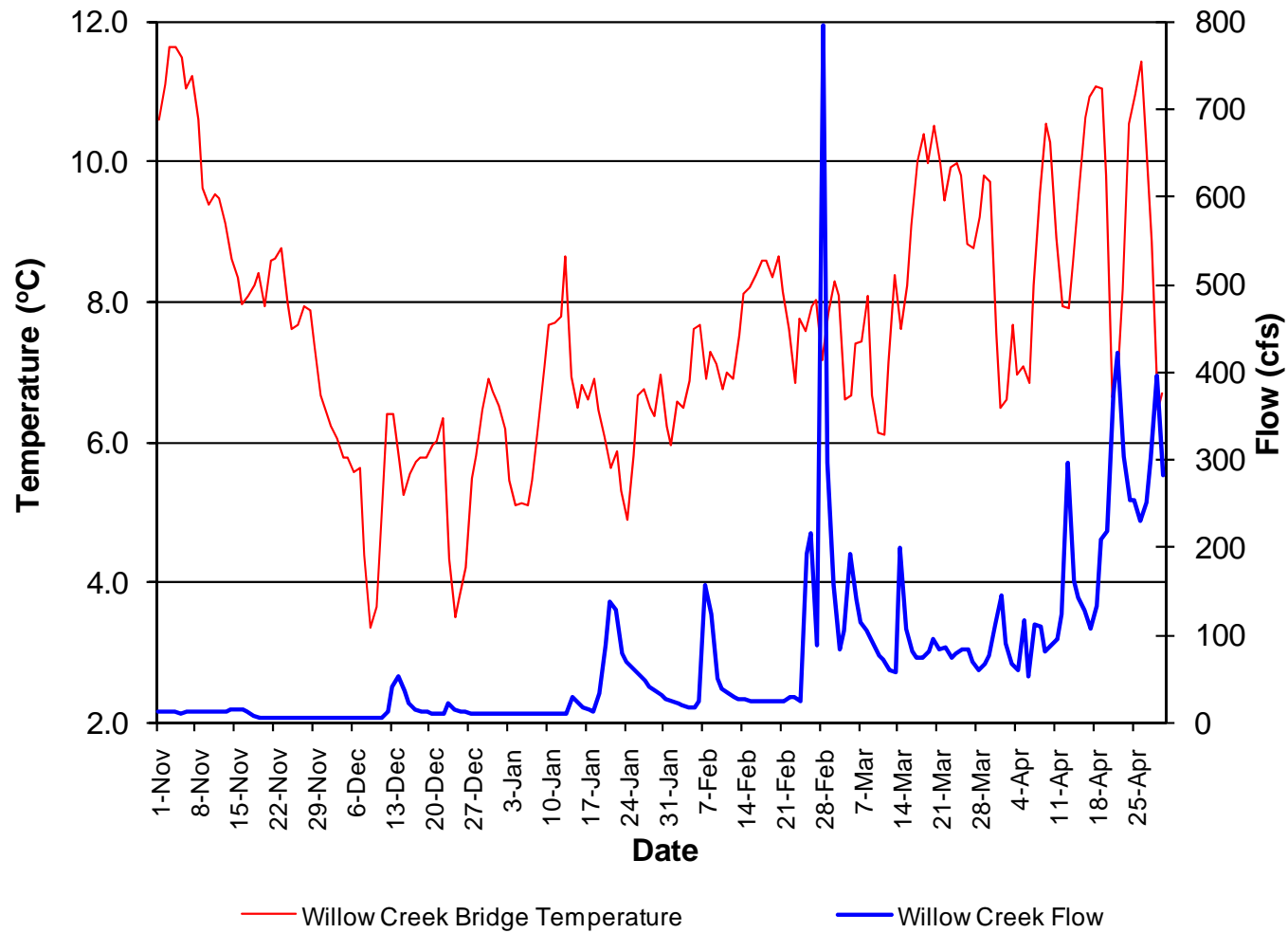


**Figure 7. Mean Daily Water Temperature and Flows<sup>1</sup> in Willow Creek, May 1–October 31, 2010.**  
<sup>1</sup> Flow data from USGS Gage No. 11246500.



\* Temperature data unavailable for SJR Downstream of Dam 7 from March 19 - April 30 due to loss of temperature loggers. Temperature data unavailable for SJR Upstream Powerhouse 4 between December 6, 2009 and February 24, 2010 due to the unofficial removal of units from water.

**Figure 8. Overwinter Mean Daily Water Temperatures and Flow in the San Joaquin River and Willow Creek Downstream of Dam 7, 2009–2010.**



**Figure 9. Mean Daily Overwinter Water Temperature and Flows in Willow Creek, 2009–2010.**

temperatures cooler on average than recent years in the SJR. Mean monthly water temperatures for the overwinter period in Willow Creek decreased from just over 10°C in November to a low of 5.5°C in December, before slowly warming through the remainder of the winter and spring. Water temperatures in Willow Creek were cooler than the SJR in December and January only.

### 3.1.2.2 Summer 2010 Water Temperatures

Water temperatures in the SJR ranged from a monthly minimum of 8.9°C in May, up to a monthly maximum of 23.5°C in July, depending on location, and are listed in Table 7. For this monitoring, temperatures were coolest among all sites at the site directly downstream of Dam 7. Monthly mean water temperatures directly downstream of Dam 7 (between July and October) ranged approximately 3.4°C, increasing from 13.3°C during July to just under 17°C in September, before beginning to decrease into the fall. Monthly mean water temperatures at the adjacent site (SJR upstream of Willow Creek) had a range of just over 8°C, increasing from 8.9°C in May to 17°C in September, before decreasing in the fall.

Monthly maximum water temperatures directly downstream of Dam 7 increased from 15.2°C in July to 19.3°C in September, before dropping in October. Monthly maximum water temperatures just upstream of the Willow Creek confluence increased from 11.9°C in May to just over 19°C in September, before dropping in October.

Water temperatures in the SJR near Willow Creek confluence were generally warmer than those directly downstream of Dam 7. Warm water inflows from Willow Creek between May and October affected SJR temperatures downstream of the confluence.

The warmest summer water temperatures in the SJR were recorded on the west side of the HSB, directly upstream of PH4. Monthly mean water temperatures directly upstream of PH4 increased from a monthly mean of 11.3°C during May to almost 21°C in August before beginning to decrease in September. Monthly maximum water temperatures directly upstream of PH4 showed increased from 14.2°C in May to 23.5°C in July, before gradually decreasing through the late summer and fall.

High flows during late May to mid July in the SJR kept water temperatures cooler, on average, than previous study years. In addition, a high flow event in September resulted in temperatures being relatively uniform throughout the SJR for the duration of the event with temperatures at PH4 dropping by approximately 2°C while temperatures directly downstream of Dam 7 having increased by approximately 2°C.

Willow Creek generally contained warmer water temperatures over the summer months than the SJR. Monthly mean water temperatures in Willow Creek, upstream of the confluence with the SJR, increased from 10.6°C during May up to 21.7°C in July before beginning to decline from August onwards (Table 7). Monthly maximum water temperatures in Willow Creek, upstream of the confluence with the SJR, increased from 14.5°C during May up to 26.2°C in July before beginning to decline from August onwards.



**Table 7. 2010 Monthly Mean Temperatures at Fresno International Airport Compared with Percentage Exceedance for Historical Record (1931–2010) and Temperatures Measured at Dam 7.**

<b>Month</b>	<b>2010 Fresno Intl Airport Air Temperature (°C)</b>	<b>Fresno Intl Airport 2010 Percent Air Temperature Exceeded (1931-2009)</b>	<b>2010 Dam No.7 HOBO Air Temperature (°C)</b>
May	18.4	98.8%	15.4
June	25.3	51.3%	23.6
July	28.3	3.8%	28.3
August	26.6	18.8%	27.1
September	24.9	57.5%	24.7
October	20.0	87.5%	18.3

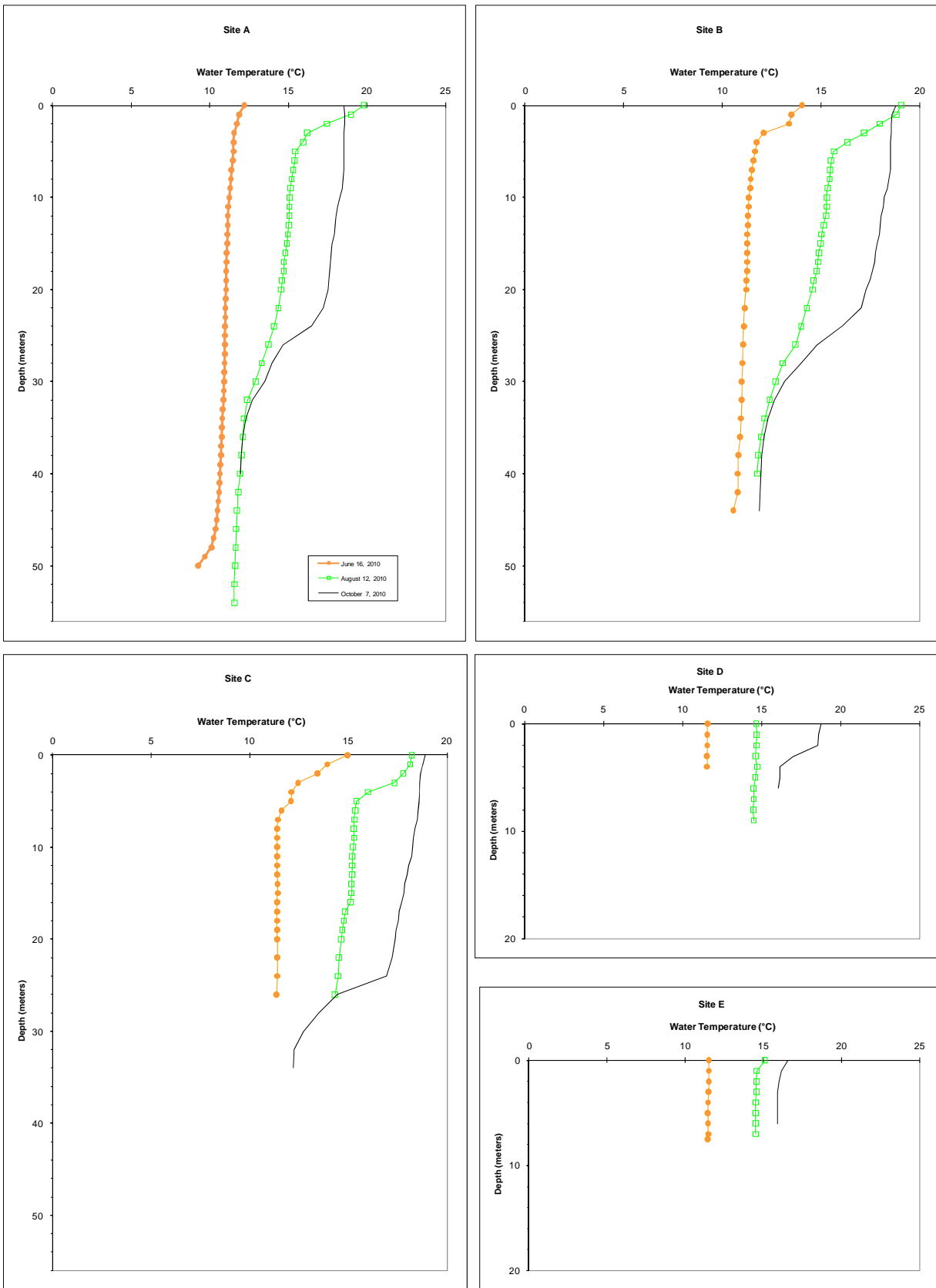
### *Redinger Lake Temperature and Physical Profile Results*

The measurements made during June, 2010 occurred during an extended spill with high flows in excess of 10,000 cfs present from downstream of Mammoth Pool Dam and downstream past Dam 6, Redinger Lake, and the HSB reach of the SJR (CDWR 2010). These flows influenced water temperatures and other physical properties in Redinger Lake. During June, water temperatures near Dam 7 (Site A) (Figure 4) were approximately 12°C at the surface ranging to approximately 9°C at the bottom (Figure 10). Site C had the warmest surface temperatures (15°C) ranging down to just above 11°C, while Site B was approximately 14°C at the surface and decreased to 10.5 at the bottom (Figure 10). Water temperatures upstream at Sites D and E were cooler near the surface with temperatures of about 11.5°C throughout the water column. Strong currents at Site D due to flows in excess of 10,000 cfs meant that only the upper few meters of water could be effectively sampled. June temperature profiles (Figure 10) indicated the presence of a thermal discontinuity of >1°C/m to depths of 1 to 3m below the surface depending upon the site, at Sites B and C. Due to the high flow conditions, the two upstream sites (Sites D and E) were essentially isothermal with slight warming at the surface at Site E. DO profiles (Figure 11) indicated a slight decrease in DO concentration with depth. During the June profile survey DO levels were determined to be supersaturated at the surface, especially at the upper Sites (D and E). This was attributed to the high flow conditions and was confirmed by visual evidence of air entrainment, at the waters surface. DO concentrations were about 12 mg/l (110 percent of saturation) at the surface decreasing to 11 mg/l with depth at Sites A and B and E, about 14 mg/l (135 percent of saturation) at the surface decreasing down to 11 mg/l at Site C, and about 14-15 mg/l (140 percent of saturation) at the surface of Site D. Specific conductance was relatively constant through the water column at all Sites (Figure 12).

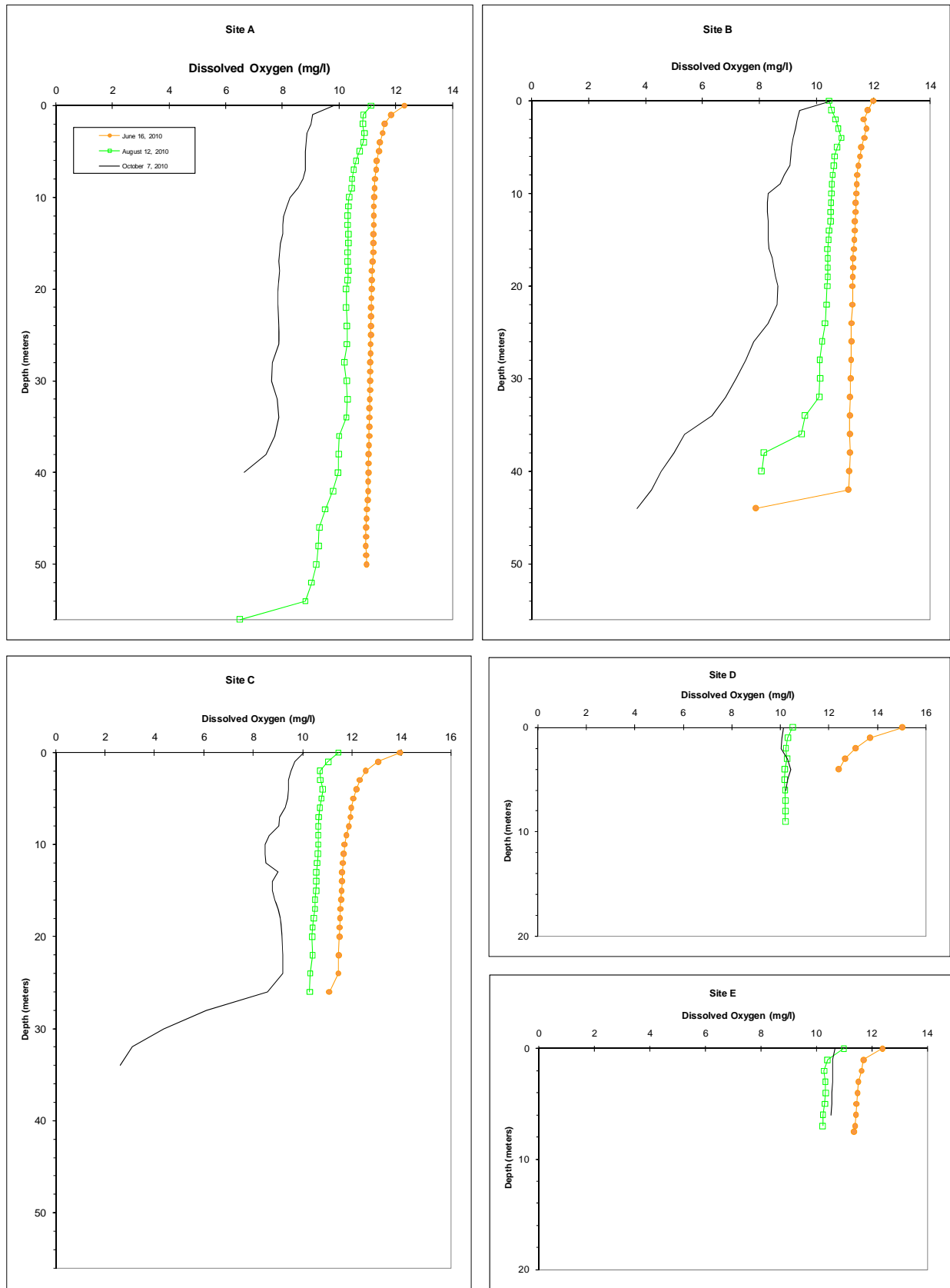
During August, surface waters had warmed and exceeded 18°C at Sites A, B and C with cooler water temperatures measured below. A thermal gradient extending from the surface downward with cooler waters below was observed at Sites A, B and C. Water temperatures generally showed a gradual decrease to less than 12°C near the bottom at sites A and B while temperatures at Site C decreased to approximately 14°C (Figure 10). Sites D and E were near isothermal over depth with water temperatures close to 15°C.

DO profiles (Figure 11) indicated DO concentrations in excess of 8 mg/l throughout the water column at Sites A through C. At Sites D and E, DO concentrations exceeded 10 mg/l throughout the water column. Specific conductance was relatively constant through the water column at all Sites, with A and B demonstrating a slight increase at depth. Sites C, D and E, demonstrated little change in specific conductance with depth (Figure 12).

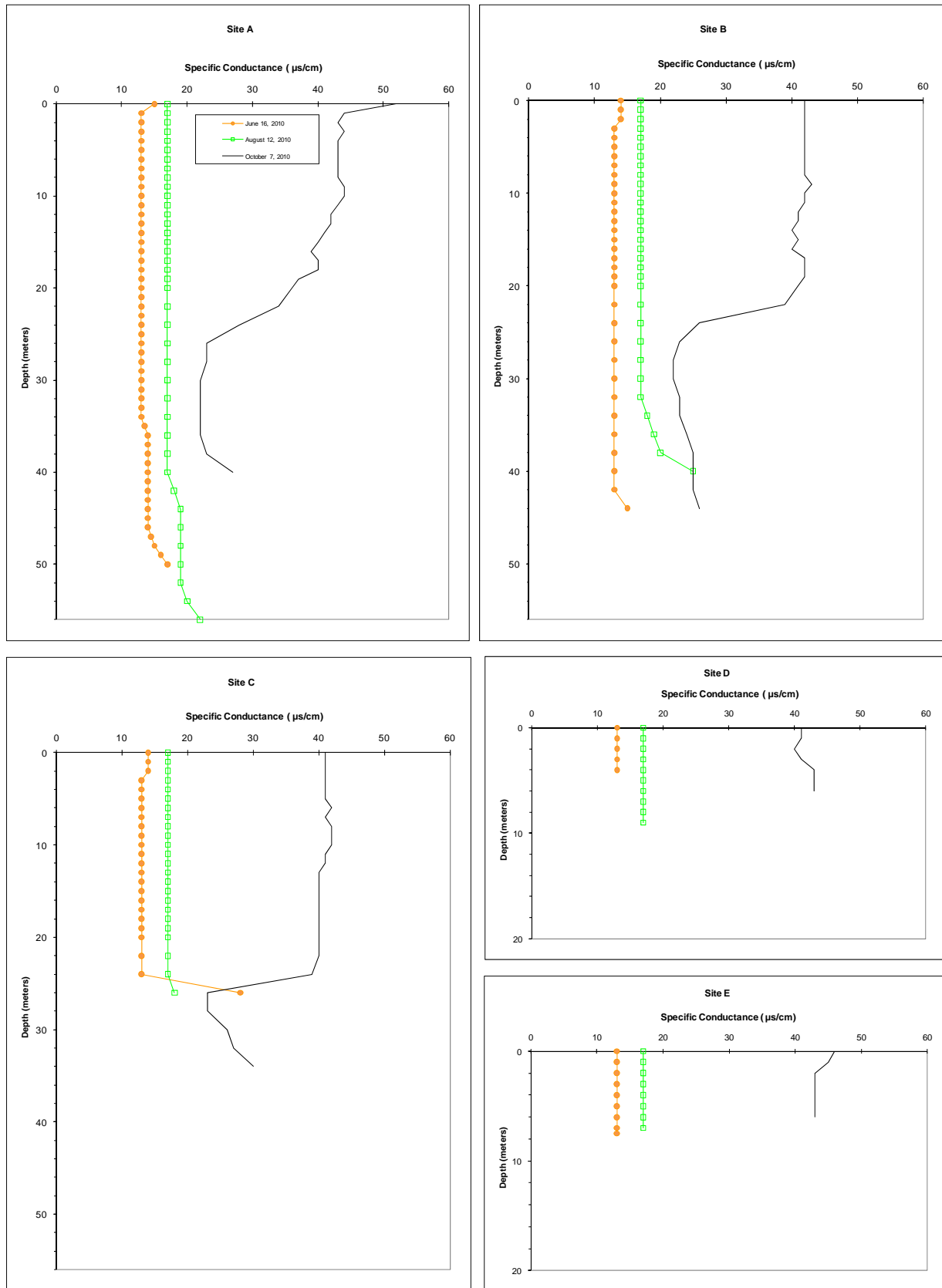
By October, water temperatures near the lake surface had declined at Sites A and B. Surface water temperatures were warmer at Sites C, D, and E (Figure 10). At Sites A, B and C thermal gradients were located at depths of approximately 26m. Site D demonstrated a thermal gradient at 3m while Site E had a shallow thermal gradient just below the surface.



**Figure 10. Redinger Lake Water Temperature Profiles for Sites A-E, 2010.**



**Figure 11. Redinger Lake Dissolved Oxygen Profiles for Sites A-E, 2010.**



**Figure 12. Redinger Lake Specific Conductance Profiles for Sites A-E, 2010.**

DO profiles (Figure 11) indicated that near surface DO concentrations were approximately 100 percent of saturation with values in excess of 10 mg/l at all five sites. A decrease in DO occurred with depth at Sites A, B and C. However, Site A had reasonably high (>6 mg/l) DO levels throughout the water column. At Site B, DO levels dropped considerably between 34 and 36m, while Site C contained a steep decrease in DO between 26 and 32m. Sites D and E were both relatively shallow (<7 m), and both exhibited high DO concentrations (>10 mg/l) throughout the water column.

During October, all sites demonstrated significantly higher levels of specific conductance than those noted in June and August. All sites demonstrated levels in excess of 40  $\mu\text{S}/\text{cm}$  in the upper water column (Figure 12). However, this was similar to previous years of monitoring. The three deepest sites exhibited a steep decline in specific conductance approximately below 22m. However, given their relatively shallow nature, sites D and E had little change in specific conductance with depth.

### *SJR Deep Pool Temperature Profile results*

Of the three pools monitored for summer water temperature stratification in the HSB Reach of the SJR, only one exhibited a distinct temperature decrease with increasing depth (Figure 13).

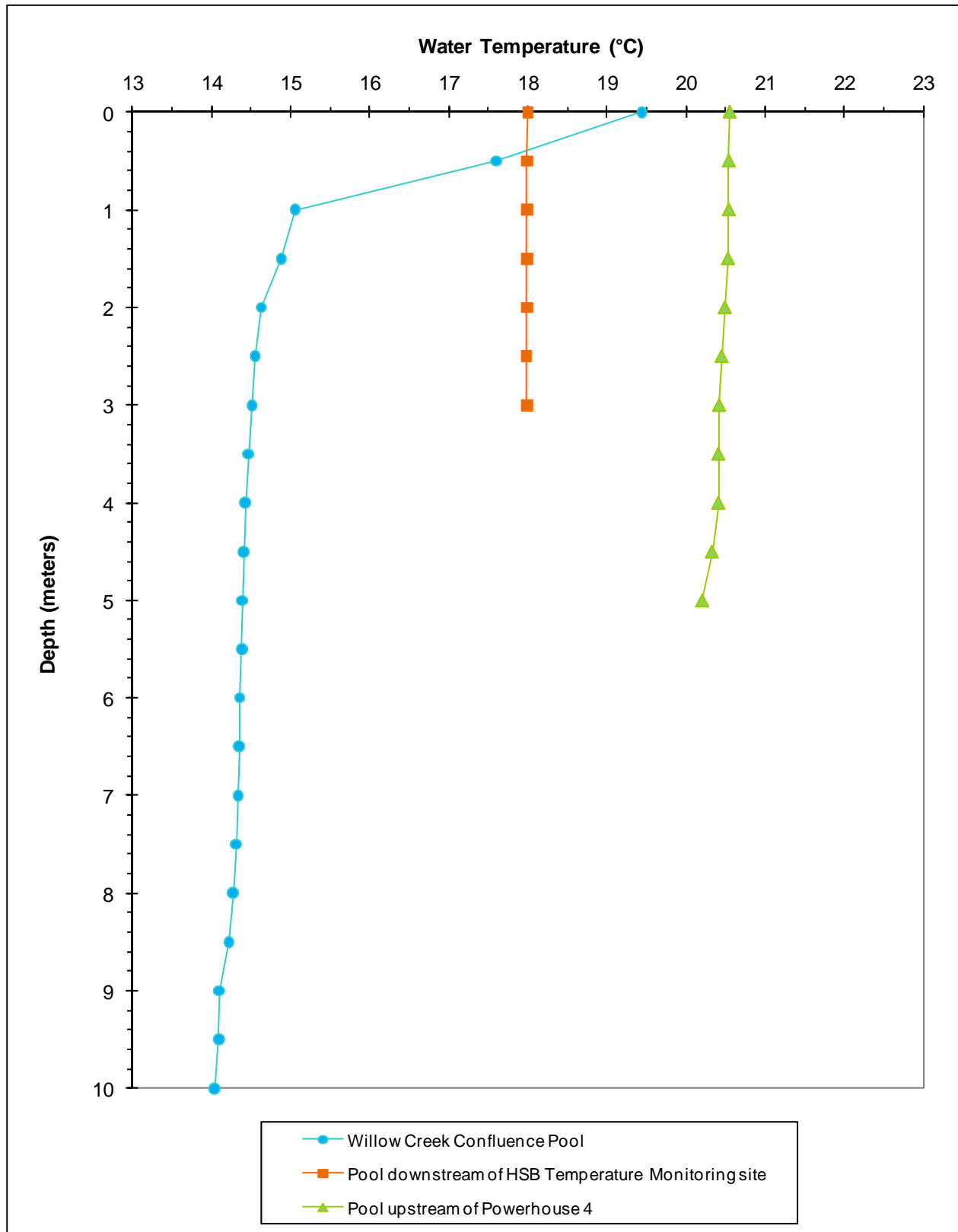
The upstream site sampled was in a deep pool in the SJR downstream of the Willow Creek confluence (confluence pool). This site also was the deepest pool monitored (10m). The temperature profile indicated the presence of a steep thermal gradient below the surface. Flows in the SJR are released from deep within Redinger Lake at Dam 7. In this pool, the cool SJR waters receive outflow from Willow Creek, which accounts for the warm surface water. On the date of pool monitoring (August 11), approximately 34 cfs of 14.4°C water was being released downstream of Dam 7, while Willow Creek was discharging approximately 23 cfs of 22°C water. The thermal gradient observed in the confluence pool resulted from the inflow of the warmer, less dense Willow Creek water floating over the cooler denser water of the mainstem SJR. The second pool sampled was located downstream of the HSB temperature logger site. The pool was relatively shallow (3m) and, at the time of monitoring, was isothermal. The third pool sampled was located just upstream of PH4. The pool was relatively shallow (5m) and, at the time of monitoring, was isothermal.

### **3.1.3 AIR TEMPERATURES**

Table 7 presents a comparison of monthly mean air temperatures for May through October at Dam 7 and Fresno International Airport, with a percent exceedance based on 80 years of monthly mean air temperatures from Fresno International Airport (National Climatic Data Center 2010). Air temperatures for July and August were significantly warmer than average while June and September were very close to the 80-year average. May 2010 was the coolest May on record, while July 2010 was one of the warmest of the months of July.

### **3.2 HARDHEAD SPAWNING**

To identify the timing and location of hardhead spawning, radio tracking of adult hardhead and sampling of larval fish at locations along the SJR were used. The approach to obtaining this



**Figure 13. Pool Temperature Stratification Profiles for Three Sites in the San Joaquin River – Horseshoe Bend Reach, August 2010.**

information was to use radio tracking of adult hardheads to determine where spawning was likely to take place and to trap larval fish near the location of adult hardhead to determine when and whether spawning had occurred. This work was performed during spring-summer 2010.

### **3.2.1 HARDHEAD FISH TAGGING AND MOVEMENT**

Cardno ENTRIX field crews initiated the third year of adult hardhead tracking starting in September 2009. A total of twelve adult hardhead were captured and fitted with radio transmitters at three mainstem locations within the HSB. Biologists returned during spring 2010 and utilized a radio telemetry receiver to detect and locate individual fish based on their tag's unique radio frequency. All tags were detected by the receiver both from the bank and from the air. No movements were detected out of the habitats within which the fish were tagged (Table 8). Eleven of twelve fish were detected during all surveys. One fish within fish population Site 5 on the east side of HSB was not detected anywhere after June 3. Tag failure is likely because the entire study area was searched during every survey by foot and helicopter.

### **3.2.2 LARVAL FISH COLLECTION**

Larval fish trapping results are shown in Table 9, by date and site. Larvae (age 0) and a few yearling (age 1) fish were collected in 2010. Sacramento sucker was the most frequently collected species among all sites. Larvae were collected at all sites between mid-May and mid-July. Larvae were not collected at any sites during the last sampling period in mid-August. Hardhead larvae were collected at all sites including Willow Creek, in contrast to previous years. However, they were found only between July 13 and August 10. All hardhead larvae were captured after spills had subsided on the SJR and high flows on Willow Creek. Sacramento pikeminnow larvae were captured at both sites on Willow Creek and at all sites on the SJR except the SJR Willow Creek confluence pool area. Spotted Bass larvae and post larvae were captured at the SJR/Willow Creek confluence pool.

No larval fish were captured during the first three trapping periods on April 6, April 29, and May 5. Sacramento sucker larvae were captured on the mainstem of SJR by May 21 and were present at all sites through June. Sacramento pikeminnow larvae were collected in the SJR at the Backbone Creek confluence, fish population Site 5 and the Willow Creek site, starting on July 27. However, no Sacramento pikeminnow larvae was found in Willow Creek during any other sampling. Sacramento pikeminnow larvae were found at all sites on the SJR except the SJR/Willow Creek confluence area.

Hardhead larvae were collected on Willow Creek starting on July 13 and were captured again on July 27. Hardhead larvae were collected in the SJR starting on July 13; they were captured at all sites in the SJR during at least one sampling between July 13 and August 10. However, they were only captured near Powerhouse 4 at Fish population Site 5 on August 10. The timing and size of hardhead larvae collected in the sampling period suggests hardhead spawning



**Table 8. Adult Hardhead Tracking in 2010 by Location, Showing Distances Moved Between Samplings.**

Sample #	Date	Site	Trans. #	Frequency	Zone	Coordinates (Easting)	Coordinates <sup>1</sup> (Northing)	Change <sup>2</sup> (Miles)	Temp °C
1*	9/29/2009	Backbone Creek	322	8.322	11S	281344	4113788	-	20
1	12/3/2009	Backbone Creek	322	8.322	11S	281344	4113788	0.0	-
1	4/8/2010	Backbone Creek	322	8.322	11S	281344	4113788	0.0	9
1	4/28/2010	Backbone Creek	322	8.322	11S	281344	4113788	0.0	9.1
1	5/6/2010	Backbone Creek	322	8.322	11S	281344	4113788	0.0	11.2
1	5/18/2010	Backbone Creek	322	8.322	11S	281344	4113788	0.0	11.2
1	6/3/2010	Backbone Creek	322	8.322	11S	281344	4113788	0.0	11.2
1	6/15/2010	Backbone Creek	322	8.322	11S	281344	4113788	0.0	12.7
1	6/28/2010	Backbone Creek	322	8.322	11S	281344	4113788	0.0	15.2
1	7/10/2010	Backbone Creek	322	8.322	11S	281344	4113788	0.0	20.5
1	7/27/2010	Backbone Creek	322	8.322	11S	281344	4113788	0.0	21
1	8/10/2010	Backbone Creek	322	8.322	11S	281344	4113788	0.0	19
2*	9/29/2009	Backbone Creek	303	8.303	11S	281344	4113788	-	20
2	12/3/2009	Backbone Creek	303	8.303	11S	281344	4113788	0.0	-
2	4/8/2010	Backbone Creek	303	8.303	11S	281344	4113788	0.0	9
2	4/28/2010	Backbone Creek	303	8.303	11S	281344	4113788	0.0	9.1
2	5/6/2010	Backbone Creek	303	8.303	11S	281344	4113788	0.0	11.2
2	5/18/2010	Backbone Creek	303	8.303	11S	281344	4113788	0.0	11.2
2	6/3/2010	Backbone Creek	303	8.303	11S	281344	4113788	0.0	11.2
2	6/15/2010	Backbone Creek	303	8.303	11S	281344	4113788	0.0	12.7
2	6/28/2010	Backbone Creek	303	8.303	11S	281344	4113788	0.0	15.2
2	7/10/2010	Backbone Creek	303	8.303	11S	281344	4113788	0.0	20.5

**Table 8. Adult Hardhead Tracking in 2010 by Location, Showing Distances Moved Between Samplings (continued).**

Sample #	Date	Site	Trans. #	Frequency	Zone	Coordinates (Easting)	Coordinates <sup>1</sup> (Northing)	Change <sup>2</sup> (Miles)	Temp °C
2	7/27/2010	Backbone Creek	303	8.303	11S	281344	4113788	0.0	21
2	8/10/2010	Backbone Creek	303	8.303	11S	281344	4113788	0.0	19
3*	9/30/2009	HSB Logger Site	081	8.081	11S	280643	4111691	-	18.5
3	12/3/2009	HSB Logger Site	081	8.081	11S	280643	4111691	0.0	-
3	4/8/2010	HSB Logger Site	081	8.081	11S	280643	4111691	0.0	8.7
3	4/28/2010	HSB Logger Site	081	8.081	11S	280643	4111691	0.0	8.8
3	5/6/20010	HSB Logger Site	081	8.081	11S	280643	4111691	0.0	11.2
3	5/18/2010	HSB Logger Site	081	8.081	11S	280643	4111691	0.0	11.2
3	6/3/2010	HSB Logger Site	081	8.081	11S	280643	4111691	0.0	11.1
3	6/15/2010	HSB Logger Site	081	8.081	11S	280643	4111691	0.0	12
3	6/28/2010	HSB Logger Site	081	8.081	11S	280643	4111691	0.0	14
3	7/10/2010	HSB Logger Site	081	8.081	11S	280643	4111691	0.0	18.9
3	7/27/2010	HSB Logger Site	081	8.081	11S	280643	4111691	0.0	18
3	8/10/2010	HSB Logger Site	081	8.081	11S	280643	4111691	0.0	18
4*	9/30/2009	HSB Logger Site	242	8.242	11S	280643	4111691	-	18.5
4	12/3/2009	HSB Logger Site	242	8.242	11S	280643	4111691	0.0	-
4	4/8/2010	HSB Logger Site	242	8.242	11S	280643	4111691	0.0	8.7
4	4/28/2010	HSB Logger Site	242	8.242	11S	280643	4111691	0.0	8.8
4	5/6/20010	HSB Logger Site	242	8.242	11S	280643	4111691	0.0	11.2
4	5/18/2010	HSB Logger Site	242	8.242	11S	280643	4111691	0.0	11.2
4	6/3/2010	HSB Logger Site	242	8.242	11S	280643	4111691	0.0	11.1
4	6/15/2010	HSB Logger Site	242	8.242	11S	280643	4111691	0.0	12
4	6/28/2010	HSB Logger Site	242	8.242	11S	280643	4111691	0.0	14

**Table 8. Adult Hardhead Tracking in 2010 by Location, Showing Distances Moved Between Samplings (continued).**

Sample #	Date	Site	Trans. #	Frequency	Zone	Coordinates (Easting)	Coordinates <sup>1</sup> (Northing)	Change <sup>2</sup> (Miles)	Temp °C
4	7/10/2010	HSB Logger Site	242	8.242	11S	280643	4111691	0.0	18.9
4	7/27/2010	HSB Logger Site	242	8.242	11S	280643	4111691	0.0	18
4	8/10/2010	HSB Logger Site	242	8.242	11S	280643	4111691	0.0	18
5*	9/30/2009	HSB Logger Site	282	8.282	11S	280643	4111691	-	18.5
5	12/3/2009	HSB Logger Site	282	8.282	11S	280643	4111691	0.0	-
5	4/8/2010	HSB Logger Site	282	8.282	11S	280643	4111691	0.0	8.7
5	4/28/2010	HSB Logger Site	282	8.282	11S	280643	4111691	0.0	8.8
5	5/6/2010	HSB Logger Site	282	8.282	11S	280643	4111691	0.0	11.2
5	5/18/2010	HSB Logger Site	282	8.282	11S	280643	4111691	0.0	11.2
5	6/3/2010	HSB Logger Site	282	8.282	11S	280643	4111691	0.0	11.1
5	6/15/2010	HSB Logger Site	282	8.282	11S	280643	4111691	0.0	12
5	6/28/2010	HSB Logger Site	282	8.282	11S	280643	4111691	0.0	14
5	7/10/2010	HSB Logger Site	282	8.282	11S	280643	4111691	0.0	18.9
5	7/27/2010	HSB Logger Site	282	8.282	11S	280643	4111691	0.0	18
5	8/10/2010	HSB Logger Site	282	8.282	11S	280643	4111691	0.0	18
6*	9/30/2009	HSB Logger Site	121	8.121	11S	280643	4111691	-	18.5
6	12/3/2009	HSB Logger Site	121	8.121	11S	280643	4111691	0.0	-
6	4/8/2010	HSB Logger Site	121	8.121	11S	280643	4111691	0.0	8.7
6	4/28/2010	HSB Logger Site	121	8.121	11S	280643	4111691	0.0	8.8
6	5/6/2010	HSB Logger Site	121	8.121	11S	280643	4111691	0.0	11.2
6	5/18/2010	HSB Logger Site	121	8.121	11S	280643	4111691	0.0	11.2
6	6/3/2010	HSB Logger Site	121	8.121	11S	280643	4111691	0.0	11.1
6	6/15/2010	HSB Logger Site	121	8.121	11S	280643	4111691	0.0	12

**Table 8. Adult Hardhead Tracking in 2010 by Location, Showing Distances Moved Between Samplings (continued).**

Sample #	Date	Site	Trans. #	Frequency	Zone	Coordinates (Easting)	Coordinates <sup>1</sup> (Northing)	Change <sup>2</sup> (Miles)	Temp °C
6	6/28/2010	HSB Logger Site	121	8.121	11S	280643	4111691	0.0	14
6	7/10/2010	HSB Logger Site	121	8.121	11S	280643	4111691	0.0	18.9
6	7/27/2010	HSB Logger Site	121	8.121	11S	280643	4111691	0.0	18
6	8/10/2010	HSB Logger Site	121	8.121	11S	280643	4111691	0.0	18
7*	9/30/2009	HSB Logger Site	262	8.262	11S	280643	4111691	-	18.5
7	12/3/2009	HSB Logger Site	262	8.262	11S	280643	4111691	0.0	-
7	4/8/2010	HSB Logger Site	262	8.262	11S	280643	4111691	0.0	8.7
7	4/28/2010	HSB Logger Site	262	8.262	11S	280643	4111691	0.0	8.8
7	5/6/20010	HSB Logger Site	262	8.262	11S	280643	4111691	0.0	11.2
7	5/18/2010	HSB Logger Site	262	8.262	11S	280643	4111691	0.0	11.2
7	6/3/2010	HSB Logger Site	262	8.262	11S	280643	4111691	0.0	11.1
7	6/15/2010	HSB Logger Site	262	8.262	11S	280643	4111691	0.0	12
7	6/28/2010	HSB Logger Site	262	8.262	11S	280643	4111691	0.0	14
7	7/10/2010	HSB Logger Site	262	8.262	11S	280643	4111691	0.0	18.9
7	7/27/2010	HSB Logger Site	262	8.262	11S	280643	4111691	0.0	18
7	8/10/2010	HSB Logger Site	262	8.262	11S	280643	4111691	0.0	18
8*	10/1/2009	Between BBC and PH4	061	8.061	11S	278533	4111626	-	18.1
8	12/3/2009	Between BBC and PH4	061	8.061	11S	278533	4111626	0.0	-
8	4/8/2010	Between BBC and PH4	061	8.061	11S	278533	4111626	0.0	9.2
8	4/28/2010	Between BBC and PH4	061	8.061	11S	278533	4111626	0.0	9.3
8	5/6/20010	Between BBC and PH4	061	8.061	11S	278533	4111626	0.0	11.7
8	5/18/2010	Between BBC and PH4	061	8.061	11S	278533	4111626	0.0	11.7
8	6/3/2010	Between BBC and PH4	061	8.061	11S	278533	4111626	0.0	11.4

**Table 8. Adult Hardhead Tracking in 2010 by Location, Showing Distances Moved Between Samplings (continued).**

Sample #	Date	Site	Trans. #	Frequency	Zone	Coordinates (Easting)	Coordinates <sup>1</sup> (Northing)	Change <sup>2</sup> (Miles)	Temp °C
8	6/15/2010	Between BBC and PH4	061	8.061	11S	278533	4111626	no signal	12.2
8	6/28/2010	Between BBC and PH4	061	8.061	11S	278533	4111626	no signal	14.2
8	7/10/2010	Between BBC and PH4	061	8.061	11S	278533	4111626	no signal	21.2
8	7/27/2010	Between BBC and PH4	061	8.061	11S	278533	4111626	no signal	22.5
8	8/10/2010	Between BBC and PH4	061	8.061	11S	278533	4111626	no signal	21
9*	10/1/2009	Between BBC and PH4	221	8.221	11S	278533	4111626	-	18.1
9	12/3/2009	Between BBC and PH4	221	8.221	11S	278533	4111626	0.0	-
9	4/8/2010	Between BBC and PH4	221	8.221	11S	278533	4111626	0.0	9.2
9	4/28/2010	Between BBC and PH4	221	8.221	11S	278533	4111626	0.0	9.3
9	5/6/2010	Between BBC and PH4	221	8.221	11S	278533	4111626	0.0	11.7
9	5/18/2010	Between BBC and PH4	221	8.221	11S	278533	4111626	0.0	11.7
9	6/3/2010	Between BBC and PH4	221	8.221	11S	278533	4111626	0.0	11.4
9	6/15/2010	Between BBC and PH4	221	8.221	11S	278533	4111626	0.0	12.2
9	6/28/2010	Between BBC and PH4	221	8.221	11S	278533	4111626	0.0	14.2
9	7/10/2010	Between BBC and PH4	221	8.221	11S	278533	4111626	0.0	21.2
9	7/27/2010	Between BBC and PH4	221	8.221	11S	278533	4111626	0.0	22.5
9	8/10/2010	Between BBC and PH4	221	8.221	11S	278533	4111626	0.0	21
10*	10/1/2009	Between BBC and PH4	022	8.022	11S	278533	4111626	-	18.1
10	12/3/2009	Between BBC and PH4	022	8.022	11S	278533	4111626	0.0	-
10	4/8/2010	Between BBC and PH4	022	8.022	11S	278533	4111626	0.0	9.2
10	4/28/2010	Between BBC and PH4	022	8.022	11S	278533	4111626	0.0	9.3
10	5/6/2010	Between BBC and PH4	022	8.022	11S	278533	4111626	0.0	11.7
10	5/18/2010	Between BBC and PH4	022	8.022	11S	278533	4111626	0.0	11.7

**Table 8. Adult Hardhead Tracking in 2010 by Location, Showing Distances Moved Between Samplings (continued).**

Sample #	Date	Site	Trans. #	Frequency	Zone	Coordinates (Easting)	Coordinates <sup>1</sup> (Northing)	Change <sup>2</sup> (Miles)	Temp °C
10	6/3/2010	Between BBC and PH4	022	8.022	11S	278533	4111626	0.0	11.4
10	6/15/2010	Between BBC and PH4	022	8.022	11S	278533	4111626	0.0	12.2
10	6/28/2010	Between BBC and PH4	022	8.022	11S	278533	4111626	0.0	14.2
10	7/10/2010	Between BBC and PH4	022	8.022	11S	278533	4111626	0.0	21.2
10	7/27/2010	Between BBC and PH4	022	8.022	11S	278533	4111626	0.0	22.5
10	8/10/2010	Between BBC and PH4	022	8.022	11S	278533	4111626	0.0	21
11*	10/1/2009	Between BBC and PH4	202	8.202	11S	278533	4111626	-	18.1
11	12/3/2009	Between BBC and PH4	202	8.202	11S	278533	4111626	0.0	-
11	4/8/2010	Between BBC and PH4	202	8.202	11S	278533	4111626	0.0	9.2
11	4/28/2010	Between BBC and PH4	202	8.202	11S	278533	4111626	0.0	9.3
11	5/6/2010	Between BBC and PH4	202	8.202	11S	278533	4111626	0.0	11.7
11	5/18/2010	Between BBC and PH4	202	8.202	11S	278533	4111626	0.0	11.7
11	6/3/2010	Between BBC and PH4	202	8.202	11S	278533	4111626	0.0	11.4
11	6/15/2010	Between BBC and PH4	202	8.202	11S	278533	4111626	0.0	12.2
11	6/28/2010	Between BBC and PH4	202	8.202	11S	278533	4111626	0.0	14.2
11	7/10/2010	Between BBC and PH4	202	8.202	11S	278533	4111626	0.0	21.2
11	7/27/2010	Between BBC and PH4	202	8.202	11S	278533	4111626	0.0	22.5
11	8/10/2010	Between BBC and PH4	202	8.202	11S	278533	4111626	0.0	21
12*	10/1/2009	Between BBC and PH4	042	8.042	11S	278533	4111626	-	18.1
12	12/3/2009	Between BBC and PH4	042	8.042	11S	278533	4111626	0.0	-
12	4/8/2010	Between BBC and PH4	042	8.042	11S	278533	4111626	0.0	9.2
12	4/28/2010	Between BBC and PH4	042	8.042	11S	278533	4111626	0.0	9.3
12	5/6/2010	Between BBC and PH4	042	8.042	11S	278533	4111626	0.0	11.7

**Table 8. Adult Hardhead Tracking in 2010 by Location, Showing Distances Moved Between Samplings (continued).**

Sample #	Date	Site	Trans. #	Frequency	Zone	Coordinates (Easting)	Coordinates <sup>1</sup> (Northing)	Change <sup>2</sup> (Miles)	Temp °C
12	5/18/2010	Between BBC and PH4	042	8.042	11S	278533	4111626	0.0	11.7
12	6/3/2010	Between BBC and PH4	042	8.042	11S	278533	4111626	0.0	11.4
12	6/15/2010	Between BBC and PH4	042	8.042	11S	278533	4111626	0.0	12.2
12	6/28/2010	Between BBC and PH4	042	8.042	11S	278533	4111626	0.0	14.2
12	7/10/2010	Between BBC and PH4	042	8.042	11S	278533	4111626	0.0	21.2
12	7/27/2010	Between BBC and PH4	042	8.042	11S	278533	4111626	0.0	22.5
12	8/10/2010	Between BBC and PH4	042	8.042	11S	278533	4111626	0.0	21

<sup>1</sup> Coordinates of habitat unit.

<sup>2</sup> The change in position is the distance from the last encounter.

\* Initial Capture in 2008.

**Table 9. Results of Larval Sampling (Numbers, Average Total Length, and Lifestage by Location and Date), 2010.**

Sampling Date	Life-Stage	Location	SJR - Powerhouse 4		SJR between PH4 and BBC		Backbone Creek		Horseshoe Bend Logger Site		SJR - Willow Creek Confluence		Willow Creek		Willow Creek Bridge		
			Species	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)
4/6/2010	Larvae	Hardhead	0	0	-*	-	-	-	-	-	0	0	0	0	-	-	
		Sacramento Pikeminnow	0	0	-	-	-	-	-	-	0	0	0	0	-	-	
		Sacramento Sucker	0	0	-	-	-	-	-	-	0	0	0	0	-	-	
		Spotted Bass	0	0	-	-	-	-	-	-	0	0	0	0	-	-	
		Unidentified	0	0	-	-	-	-	-	-	0	0	0	0	-	-	
	Age 1	Hardhead	0	0	-	-	-	-	-	-	0	0	0	0	-	-	
		Sacramento Pikeminnow	0	0	-	-	-	-	-	-	0	0	0	0	-	-	
4/29/2010	Larvae	Hardhead	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Sacramento Pikeminnow	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Sacramento Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Spotted Bass	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Unidentified	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Age 1	Hardhead	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Sacramento Pikeminnow	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
5/6/2010	Larvae	Hardhead	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Sacramento Pikeminnow	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Sacramento Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Spotted Bass	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Unidentified	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Age 1	Hardhead	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Sacramento Pikeminnow	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
5/16/2010	Larvae	Hardhead	-	-	-	-	-	-	-	-	-	-	0	0	-	-	
		Sacramento Pikeminnow	-	-	-	-	-	-	-	-	-	-	0	0	-	-	
		Sacramento Sucker	-	-	-	-	-	-	-	-	-	-	0	0	-	-	
		Spotted Bass	-	-	-	-	-	-	-	-	-	-	0	0	-	-	
		Unidentified	-	-	-	-	-	-	-	-	-	-	0	0	-	-	
	Age 1	Hardhead	-	-	-	-	-	-	-	-	-	-	0	0	-	-	
		Sacramento Pikeminnow	-	-	-	-	-	-	-	-	-	-	0	0	-	-	



**Table 9. Results of Larval Sampling (Numbers, Average Total Length, and Lifestage by Location and Date), 2010 (continued).**

Sampling Date	Life-Stage	Location	SJR - Powerhouse 4		SJR between PH4 and BBC		Backbone Creek		Horseshoe Bend Logger Site		SJR - Willow Creek Confluence		Willow Creek		Willow Creek Bridge	
			Species	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected
5/18/2010	Larvae	Hardhead	-	-	-	-	-	-	-	-	0	0	-	-	-	-
		Sacramento Pikeminnow	-	-	-	-	-	-	-	-	0	0	-	-	-	-
		Sacramento Sucker	-	-	-	-	-	-	-	-	52	16	-	-	-	-
		Spotted Bass	-	-	-	-	-	-	-	-	0	0	-	-	-	-
		Unidentified	-	-	-	-	-	-	-	-	0	0	-	-	-	-
	Age 1	Hardhead	-	-	-	-	-	-	-	-	0	0	-	-	-	-
		Sacramento Pikeminnow	-	-	-	-	-	-	-	-	0	0	-	-	-	-
5/19/2010	Larvae	Hardhead	-	-	-	-	0	0	-	-	-	-	-	-	-	-
		Sacramento Pikeminnow	0	0	-	-	0	0	-	-	-	-	-	-	-	-
		Sacramento Sucker	4	15.75	-	-	11	15.9	-	-	-	-	-	-	-	-
		Spotted Bass	0	0	-	-	0	0	-	-	-	-	-	-	-	-
		Unidentified	0	0	-	-	0	0	-	-	-	-	-	-	-	-
	Age 1	Hardhead	1	33	-	-	0	0	-	-	-	-	-	-	-	-
		Sacramento Pikeminnow	0	0	-	-	0	0	-	-	-	-	-	-	-	-
5/20/2010	Larvae	Hardhead	-	-	0	0	-	-	0	0	-	-	-	-	-	-
		Sacramento Pikeminnow	-	-	0	0	-	-	0	0	-	-	-	-	-	-
		Sacramento Sucker	-	-	7	15	-	-	1	15	-	-	-	-	-	-
		Spotted Bass	-	-	0	0	-	-	0	0	-	-	-	-	-	-
		Unidentified	-	-	0	0	-	-	0	0	-	-	-	-	-	-
	Age 1	Hardhead	-	-	0	0	-	-	0	0	-	-	-	-	-	-
		Sacramento Pikeminnow	-	-	0	0	-	-	0	0	-	-	-	-	-	-
6/3/2010	Larvae	Hardhead	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Sacramento Pikeminnow	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Sacramento Sucker	15	16.5	10	16.4	23	17.7	5	16.6	37	15.5	122	16.1	-	-
		Spotted Bass	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Unidentified	0	0	0	0	0	0	0	0	0	0	0	0	-	-
	Age 1	Hardhead	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Sacramento Pikeminnow	0	0	0	0	0	0	0	0	0	0	0	0	-	-

**Table 9. Results of Larval Sampling (Numbers, Average Total Length, and Lifestage by Location and Date), 2010 (continued).**

Sampling Date	Life-Stage	Species	Location		SJR - Powerhouse 4		SJR between PH4 and BBC		Backbone Creek		Horseshoe Bend Logger Site		SJR - Willow Creek Confluence		Willow Creek		Willow Creek Bridge	
			Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)
6/15/2010	Larvae	Hardhead	-	-	0	0	0	0	-	-	0	0	0	0	-	-		
		Sacramento Pikeminnow	-	-	0	0	0	0	-	-	0	0	0	0	-	-		
		Sacramento Sucker	-	-	3	15.3	62	19.8	-	-	21	16.5	43	15.3	-	-		
		Spotted Bass	-	-	0	0	0	0	-	-	0	0	0	0	-	-		
		Unidentified	-	-	0	0	0	0	-	-	0	0	0	0	-	-		
	Age 1	Hardhead	-	-	0	0	0	0	-	-	0	0	0	0	-	-		
6/16/2010	Larvae	Hardhead	0	0	-	-	-	-	0	0	-	-	-	-	0	0		
		Sacramento Pikeminnow	0	0	-	-	-	-	0	0	-	-	-	-	0	0		
		Sacramento Sucker	39	15.8	-	-	-	-	7	16	-	-	-	-	61	13.5		
		Spotted Bass	0	0	-	-	-	-	0	0	-	-	-	-	0	0		
		Unidentified	0	0	-	-	-	-	0	0	-	-	-	-	0	0		
	Age 1	Hardhead	0	0	-	-	-	-	0	0	-	-	-	-	0	0		
6/27/2010	Larvae	Hardhead	-	-	-	-	-	-	-	-	-	-	-	0	0			
		Sacramento Pikeminnow	-	-	-	-	-	-	-	-	-	-	-	0	0			
		Sacramento Sucker	-	-	-	-	-	-	-	-	-	-	-	26	20.2			
		Spotted Bass	-	-	-	-	-	-	-	-	-	-	-	0	0			
		Unidentified	-	-	-	-	-	-	-	-	-	-	-	0	0			
	Age 1	Hardhead	-	-	-	-	-	-	-	-	-	-	-	0	0			
6/28/2010	Larvae	Hardhead	-	-	-	-	0	0	-	-	0	0	0	0	0	0		
		Sacramento Pikeminnow	-	-	-	-	0	0	-	-	0	0	0	0	0	0		
		Sacramento Sucker	-	-	-	-	20	17.5	-	-	17	19.9	0	0	86	17.3		
		Spotted Bass	-	-	-	-	0	0	-	-	0	0	0	0	0	0		
		Unidentified	-	-	-	-	0	0	-	-	0	0	0	0	0	0		
	Age 1	Hardhead	-	-	-	-	1	48	-	-	0	0	0	0	0	0		
6/28/2010	Age 1	Sacramento Pikeminnow	-	-	-	-	0	0	-	-	0	0	0	0	0	0		

**Table 9. Results of Larval Sampling (Numbers, Average Total Length, and Lifestage by Location and Date), 2010 (continued).**

Sampling Date	Life-Stage	Species	SJR - Powerhouse 4		SJR between PH4 and BBC		Backbone Creek		Horseshoe Bend Logger Site		SJR - Willow Creek Confluence		Willow Creek		Willow Creek Bridge	
			Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)
6/29/2010	Larvae	Hardhead	0	0	0	0	-	-	0	0	-	-	-	-	-	-
		Sacramento Pikeminnow	0	0	0	0	-	-	0	0	-	-	-	-	-	-
		Sacramento Sucker	12	16.9	6	16.5	-	-	10	18.2	-	-	-	-	-	-
		Spotted Bass	0	0	0	0	-	-	0	0	-	-	-	-	-	-
		Unidentified	0	0	0	0	-	-	0	0	-	-	-	-	-	-
	Age 1	Hardhead	0	0	0	0	-	-	1	48	-	-	-	-	-	-
		Sacramento Pikeminnow	0	0	0	0	-	-	0	0	-	-	-	-	-	-
7/13/2010	Larvae	Hardhead	-	-	0	0	0	0	-	-	4	11.3	1	11	3	12.7
		Sacramento Pikeminnow	-	-	0	0	0	0	-	-	0	0	0	0	0	0
		Sacramento Sucker	-	-	3	17.6	81	17.5	-	-	15	18.2	3	18	24	18.4
		Spotted Bass	-	-	0	0	0	0	-	-	4	14.5	0	0	0	0
		Unidentified	-	-	0	0	0	0	-	-	0	0	0	0	0	0
	Age 1	Hardhead	-	-	0	0	0	0	-	-	0	0	0	0	0	0
		Sacramento Pikeminnow	-	-	0	0	0	0	-	-	0	0	0	0	0	0
7/14/2010	Larvae	Hardhead	0	0	-	-	-	-	0	0	-	-	-	-	-	-
		Sacramento Pikeminnow	0	0	-	-	-	-	0	0	-	-	-	-	-	-
		Sacramento Sucker	48	17.5	-	-	-	-	0	0	-	-	-	-	-	-
		Spotted Bass	0	0	-	-	-	-	0	0	-	-	-	-	-	-
		Unidentified	0	0	-	-	-	-	0	0	-	-	-	-	-	-
	Age 1	Hardhead	0	0	-	-	-	-	0	0	-	-	-	-	-	-
		Sacramento Pikeminnow	0	0	-	-	-	-	0	0	-	-	-	-	-	-
7/27/2010	Larvae	Hardhead	-	-	17	12.3	7	12.1	-	-	0	0	0	0	5	17
		Sacramento Pikeminnow	-	-	1	12	4	13	-	-	0	0	3	15.3	7	17.3
		Sacramento Sucker	-	-	1	15	4	16.25	-	-	0	0	3	28.7	0	0
		Spotted Bass	-	-	0	0	0	0	-	-	1	20	0	0	0	0
		Unidentified	-	-	0	0	0	0	-	-	0	0	0	0	0	0
	Age 1	Hardhead	-	-	0	0	0	0	-	-	0	0	0	0	0	0
		Sacramento Pikeminnow	-	-	0	0	0	0	-	-	0	0	0	0	1	27

**Table 9. Results of Larval Sampling (Numbers, Average Total Length, and Lifestage by Location and Date), 2010 (continued).**

Sampling Date	Life-Stage	Species	SJR - Powerhouse 4		SJR between PH4 and BBC		Backbone Creek		Horseshoe Bend Logger Site		SJR - Willow Creek Confluence		Willow Creek		Willow Creek Bridge	
			Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)	Total Number Collected	Average Length (mm)
7/28/2010	Larvae	Hardhead	19	12.7	-	-	-	-	0	0	0	0	-	-	-	-
		Sacramento Pikeminnow	0	0	-	-	-	-	0	0	0	0	-	-	-	-
		Sacramento Sucker	1	23	-	-	-	-	23	16	0	0	-	-	-	-
		Spotted Bass	0	0	-	-	-	-	0	0	0	0	-	-	-	-
		Unidentified	0	0	-	-	-	-	0	0	0	0	-	-	-	-
	Age 1	Hardhead	0	0	-	-	-	-	0	0	0	0	-	-	-	-
		Sacramento Pikeminnow	0	0	-	-	-	-	0	0	0	0	-	-	-	-
8/10/2010	Larvae	Hardhead	29	16.5	14	14.8	0	0	4	16.25	0	0	0	0	0	0
		Sacramento Pikeminnow	10	18.1	4	15.5	13	16.6	6	18	0	0	0	0	0	0
		Sacramento Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Spotted Bass	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Unidentified	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Age 1	Hardhead	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sacramento Pikeminnow	0	0	0	0	0	0	0	0	0	0	0	0	0	0

\* Shaded areas indicate locations not sampled on that date. Typically, two or three days were required for one visit. Not all sites were sampled on every day of a sampling trip.

likely occurred from early July through mid- July.

The timing of larval fish collections and sizes of larvae collected suggest that spawning occurred for Sacramento sucker, Sacramento pikeminnow, and hardhead on more than one occasion and in more than one location. However, the duration of successful spawning may have been shorter for Sacramento pikeminnow than hardhead and Sacramento suckers. Spawning was delayed or not in evidence until early July, which was much later than previous years. Also, hardhead successfully spawned in Willow Creek in contrast to the previous two years. SJR monthly average water temperatures during the period of larval trapping ranged from 8.9-11.3°C for May, 12.0-12.4°C for June, 13.3-19.0°C for July and 14.8-20.7°C for August, with the coolest water temperatures occurring downstream of Dam 7 and the warmest temperatures upstream of PH4 (Table 5). On the last day of sampling, August 10, daily mean water temperatures in the SJR downstream of Dam 7 and upstream of PH4 were 14.3 and 20.6°C, respectively. Water Temperatures in Willow Creek ranged from 10.6°C in May to 21.9°C in August at the location sampled (Table 5). On the last day of sampling on August 10, daily mean water temperature at this site was 20.1°C.

### 3.3 TURTLES

Three adult females and two adult males were captured at the Willow Creek site and one adult male and female were captured at the SJR/Willow Creek confluence pool (Table 4). External transmitters were attached to two adult female WPT captured with a carapace of length >14 cm (one female at the Willow Creek site and another adult female at the SJR/Willow Creek confluence pool site). No turtles were captured or tagged in the pools upstream of Big Creek Powerhouse 4.

### 3.4 MUSSEL SURVEYS

No live mussels were found at Site 1, but two fresh *M. falcata* shell fragments were found in an eddy habitat downstream.

Sites 2, 3 and 4 had scattered live mussels (usually single), but in clusters up to three within pockets behind large boulders protected by high flows. These pockets were typically located near the heads of pools. A few mussels were observed at other protected locations within deep runs or in the middle or tailouts of pools.

At Site 5, a total of 7 live *M. falcata* were found scattered in relatively shallow (1- to 2- m deep) areas of a long pool, where small gravel substrate had accumulated. Two more live *M. falcata* were also found in the pool at the downstream end of Site 5.

At Site 6, 17 live *M. falcata* were found within a 110-m<sup>2</sup> area at the tailout of a long, deep pool. The width of the channel at the tailout was narrow (5.8 m) relative to the average pool width, which was estimated at 18 meters. Boulder and bedrock were the dominant and subdominant substrates. One group of 12 mussels was located 13 meters upstream from the pool tail crest, one group of two mussels was located 22 meters upstream from the pool tail crest, and one group of three mussels was located 32 meters upstream from the pool tail crest. The three groupings were located in water that was 1.1 m, 1.2 m, and > 2.0 m deep, respectively. All of the mussels

were wedged beneath or between large boulders in cracks containing root material or small gravel substrate and were oriented downstream (Figure 14). Ten more mussels were found in the riffle and glide habitats downstream of Site 6, and one isolated mussel was found in the pool approximately 200 meters upstream from the pool tail crest. The majority of mussels found downstream of Site 6 were anchored in deposits of small and large gravel substrate (Figure 14). Results for Site 6 are reported in Table 10.

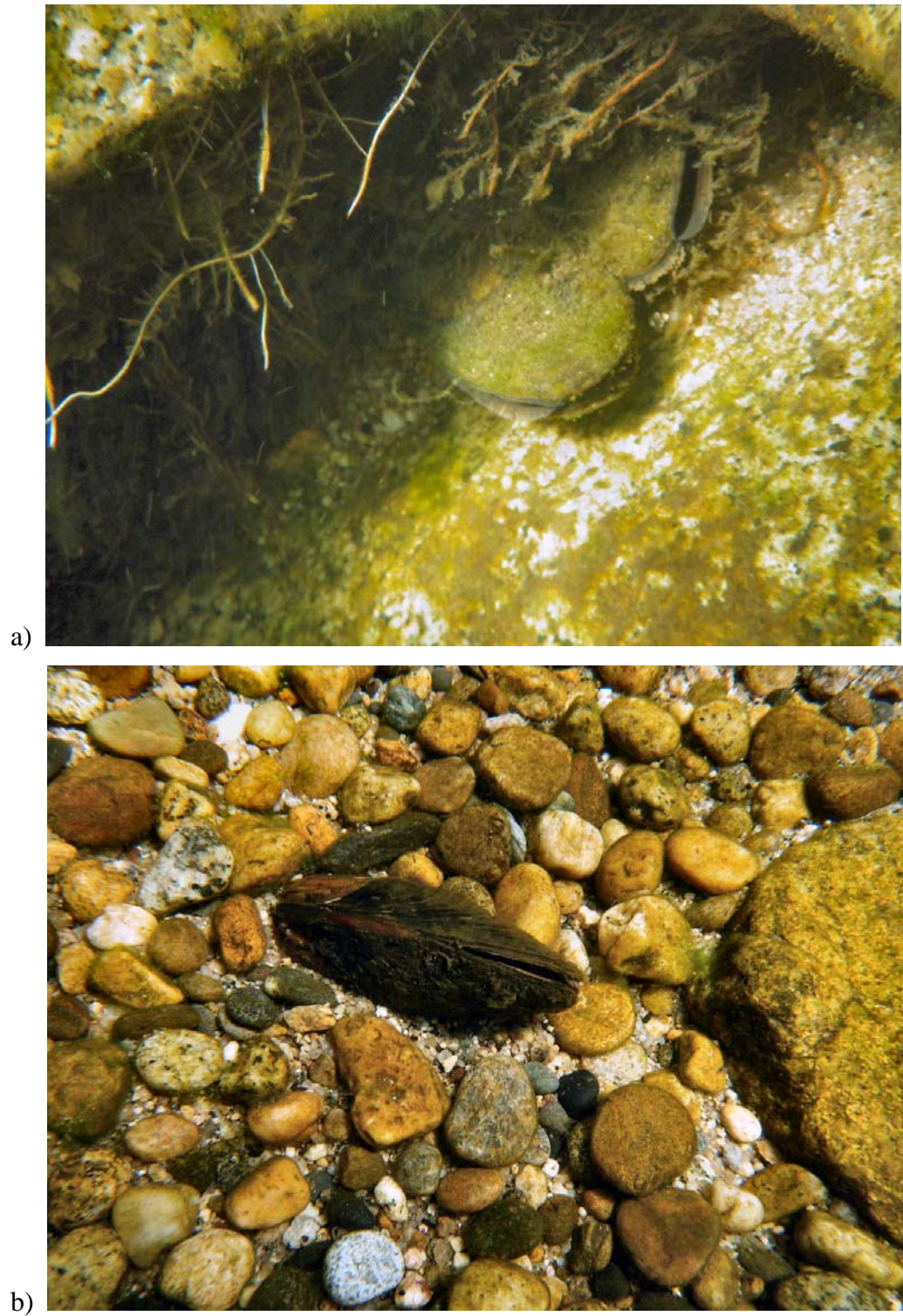
The mussel bed at Site 7 was located within a 438-m<sup>2</sup> area at the downstream end of a long, deep pool (Figure 15). The end (0 meter mark) of the longitudinal survey tape was attached to a metal pipe anchored on the river-left bank at the approximate location of the pool tail crest. Mussels were found between 4 and 34 meters upstream from the pool tail crest, where the stream width ranged from 14 to 16 meters. Substrate within this area was estimated at 75 percent boulder, 15 percent cobble, and 10 percent smaller substrates. Algae coverage was between 85 percent and 100 percent; *Cladophora* was the only genus of algae observed. Mussel densities averaged 3.73 mussels/m<sup>2</sup> between the 4 and 17 meter marks (high density area) and 1.20 mussels/m<sup>2</sup> between the 17 and 34 meter marks (low density area) (Table 10). In both areas, mussel densities were highest in the river-left stratum and lowest in the river-right stratum. Although water velocities were not measured at the time of the survey, velocities were estimated to be lower near the river-left bank, which was on the outside of a slight bend in the river. During the initial site reconnaissance, surveyors estimated that the site contained fewer than 400 mussels. Based on the calculated densities, however, the surface abundance estimate at Site 7 was 1,033 mussels (747 in the high density area and 286 in the low density area).

### 3.5 SJR FISH SAMPLING

The results of the 2010 fish sampling (species composition, density, and population characteristics) are discussed in the following sections.

#### 3.5.1 SPECIES COMPOSITION AND DENSITY

There were 506 fish identified to species sampled through electrofishing and snorkeling combined. This does not include unidentified age 0 cyprinids, which are discussed below. The fish community in the SJR between Dam 7 and PH 4 consisted primarily of Sacramento sucker, which made up 75 percent of the fish identified, hardhead at 14 percent, seven percent rainbow trout, three percent Sacramento pikeminnow and 1 percent spotted bass. Smaller numbers of prickly sculpin, and largemouth bass combined for less than one percent of the total (Figure 16). In addition, large numbers (approximately 9,100) of small (0 to 3 inches Total Length [TL]) cyprinids were found in the margins of the snorkeled pool habitat. These small fish were designated as “unidentified cyprinids,” and were largely hardhead with some Sacramento pikeminnow, based on their morphological features and qualitative sampling. While distinctive features (e.g., body plan, scales) make it relatively easy to differentiate the native species of minnow from many of the possible introduced minnows (e.g., carp [*Cyprinus carpio*], goldfish [*Carassius auratus*], golden shiner [*Notemigonus crysoleucas*], etc.) during snorkeling surveys, it is more difficult to distinguish between small Sacramento pikeminnow and hardhead without capturing them for close observation. Captures made using qualitative electrofishing were used to examine the composition of portions of these “unidentified cyprinids.” Captures indicated that



**Figure 14. Site 6 habitat photos: (a) mussels wedged between boulders at Site 6 and (b) mussel burrowed in gravel substrate downstream of Site 6.**



a)



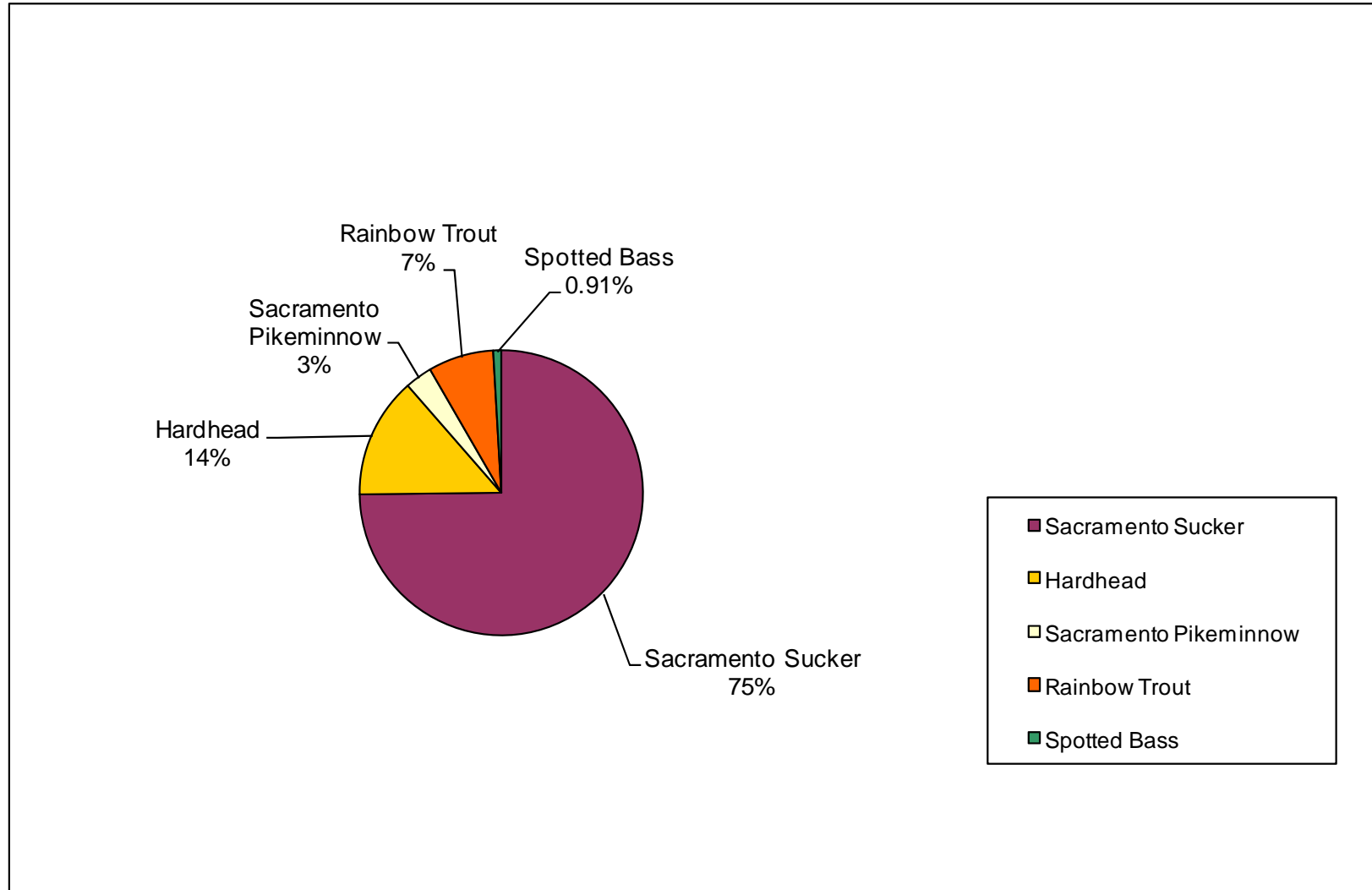
b)

**Figure 15. Site 7 habitat photos: (a) view of site looking upstream and (b) view of mussels covered in silt and algae.**



**Table 10. Summary of mussel survey data collected during August, 2010 at Sites 6 and 7.**

Transect Stratum	Width (m)	Length (m)	Area (m <sup>2</sup> )	Total Number of Mussels	Number of Samples	Mean Density per Sample	Mean Density per m <sup>2</sup>	Estimated Number of Mussels
6	5.8	19.0	110	17	N/A	N/A	0.15	17
<b>Estimated Number of Mussels at Site 6:</b>								<b>17</b>
<u>High Density Survey Area</u>								
River Left	5.13	13.0	67	25	9	2.78	11.11	
Middle	5.13	13.0	67	3	10	0.30	1.20	
River Right	5.13	13.0	67	0	11	0.00	0.00	
All	15.40	13.0	200	28	30	0.93	3.73	747
<u>Low Density Survey Area</u>								
River Left	4.67	17.0	79	6	7	0.86	3.43	
Middle	4.67	17.0	79	0	6	0.00	0.00	
River Right	4.67	17.0	79	0	7	0.00	0.00	
All	14.00	17.0	238	6	20	0.30	1.20	286
<b>Estimated Number of Mussels per Site:</b>								<b>1,033</b>



**Figure 16. Species Composition – Electroshocking and Snorkel Data not including “Unidentified Cyprinids” in the San Joaquin River, 2010.**

they appeared to consist of hardhead with somewhat smaller numbers of Sacramento pikeminnow. Based on the sizes observed, they included both young of the year (age 0) and age 1 fish (Figures 17 and 18). These “unidentified cyprinids” outnumbered all other identified fish groups combined.

Estimates for fish densities by site are given in Table 11. These densities are based on the combined densities for both electrofishing and snorkeling. Fish species densities for all sites combined were as follows: hardheads 30 fish/km, Sacramento suckers 164 fish/km, Sacramento pikeminnow 7 fish/km, rainbow trout 16 fish/km, and “unidentified cyprinids” (age 0 and age 1 hardhead and Sacramento pikeminnow) 3,592 fish/km (Table 12). Total numbers and densities for larger adult fish, particularly hardhead, were likely underestimated, due to their use of deep water habitats, reclusive behavior, and turbid conditions at the time of sampling, which limited the ability to observe them. Estimates for biomass by species are based on weights measured from electrofishing only. Biomass estimates for all sites are given in Table 13.

### **3.5.1.1 Site 1**

There were 19 fish identified to species at this site during the snorkeling survey. The Site 1 fish community identified to species consisted primarily of Sacramento sucker and hardhead, which comprised 47 and 32 percent of the total, respectively (Figure 19). In addition, spotted bass comprised twenty one percent of the fish identified. Electrofishing was not conducted on Site 1 because physical conditions were incompatible with backpack electrofishing and would have presented a safety hazard to the field crew. Total fish densities at Site 1 (Table 11) were 19 fish/km for Sacramento sucker, 13 fish/km for hardhead, and 8 fish/km for spotted bass.

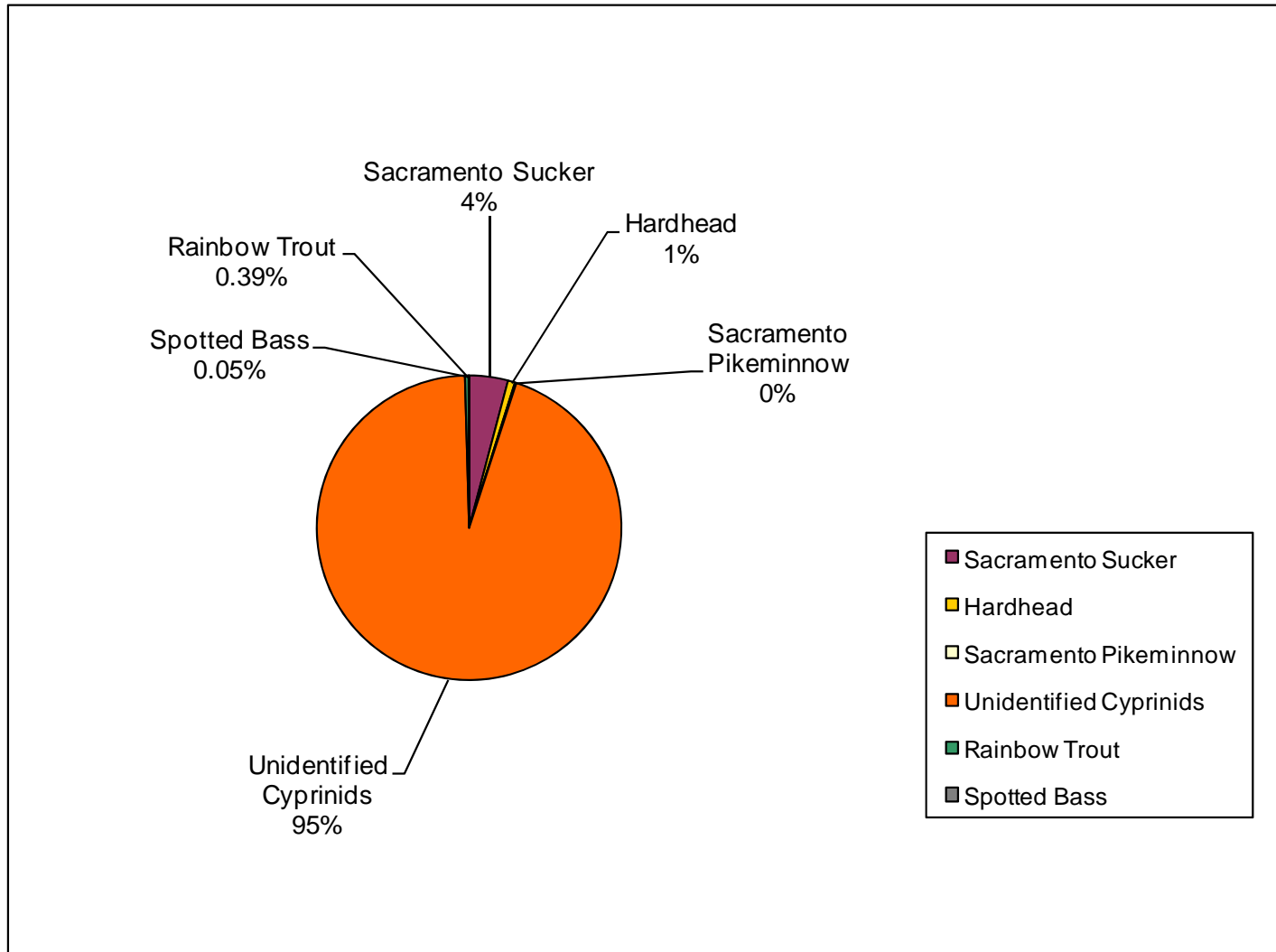
### **3.5.1.2 Site 2**

There were 27 fish identified to species during the snorkeling survey. The Site 2 fish community in the snorkeled habitats consisted of 37 percent Sacramento sucker, 40 percent rainbow trout, 11 percent Sacramento pikeminnow and four percent largemouth bass (Figure 19). Total fish densities at Site 2 were; 16 fish/km for Sacramento sucker, 21 fish/km for rainbow trout, 5 fish/km for Sacramento pikeminnow and 3 fish/km for spotted bass (Table 11). Electrofishing was not conducted at Site 2 due to logistical time constraints.

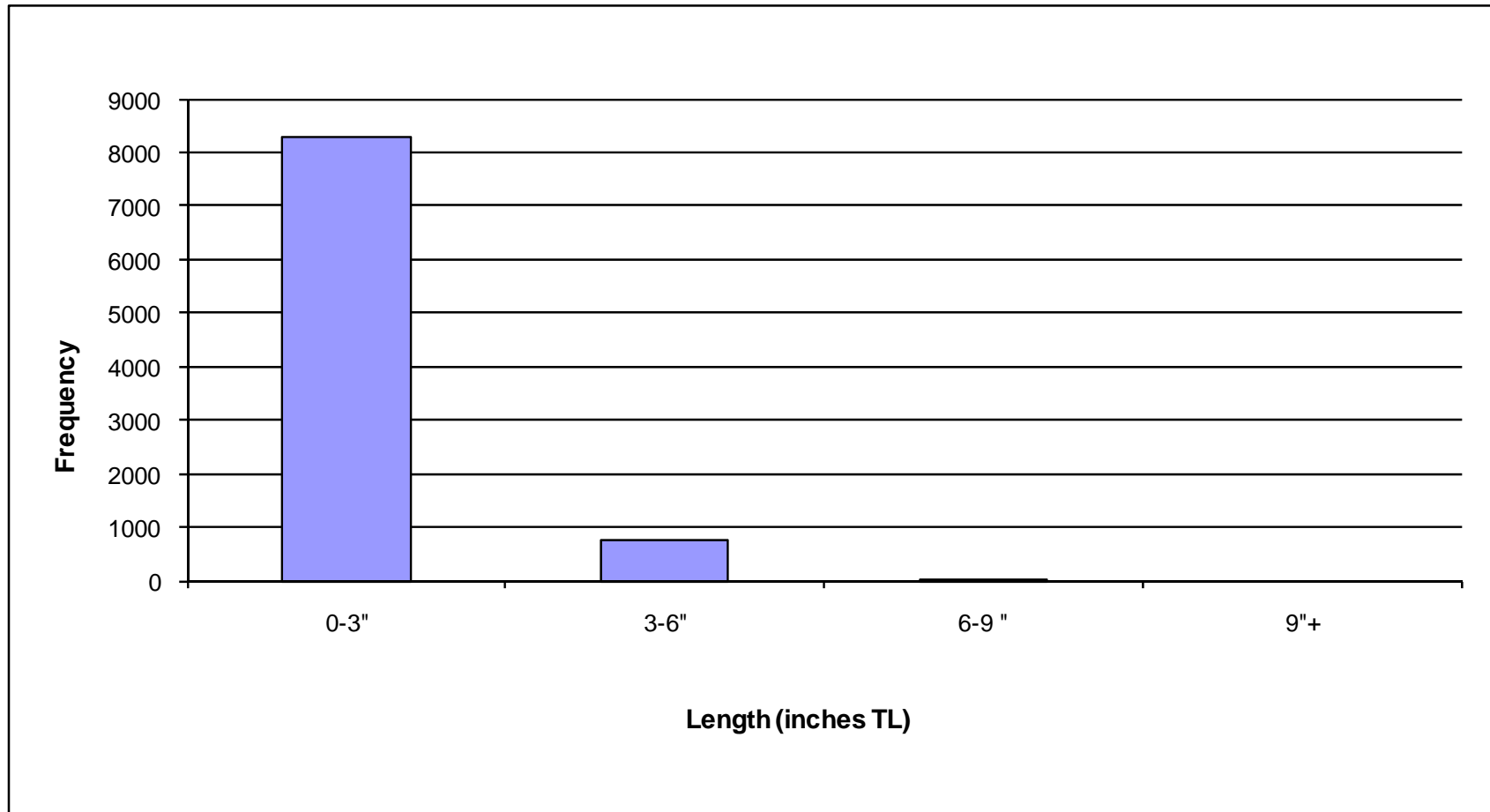
### **3.5.1.3 Site 3**

There were 87 fish identified to species during the snorkeling survey at this site. The Site 3 fish community identified to species in the snorkeled habitats consisted of five percent hardhead, 83 percent Sacramento sucker, two percent Sacramento pikeminnow and 10 percent rainbow trout, respectively (Figure 19). There were 627 "unidentified cyprinids" counted during snorkeling.

Total fish densities at Site 3 were 13 fish/km for hardhead, 247 fish/km for Sacramento sucker, 6 fish/km for Sacramento pikeminnow, 38 fish/km for rainbow trout and 2,028 fish/km for “unidentified cyprinids” (Table 11).



**Figure 17. Species Composition for All Sites in 2010 based on Snorkeling.**



**Figure 18. Length Frequency of “Unidentified Cyprinids” Observed by snorkeling in the San Joaquin River, All Sites Combined, October 2010 (\*Young of the Year hardhead and Sacramento Pikeminnow. \*\*Yearling hardhead and pikeminnow).**

**Table 11. Population and Density Estimates for Sampling Sites in the San Joaquin River, October 2010.**

Site	Unit <sup>3</sup>	Species	Estimated Fish Population					
			Size Range (millimeters)	Number of Fish Captured or Observed <sup>4</sup>	Population Estimate <sup>5</sup>	Lower 95 Percent Confidence Limit <sup>6</sup>	Upper 95 Percent Confidence Limit	Density Estimate Number per Kilometer
1'		Hardhead	75-350	0(6)	6	6	-	13
		Sacramento Sucker	40-350	0(9)	9	9	-	19
		Spotted Bass	>300	0(4)	4	4	-	8
2 <sup>2</sup>	15	Sacramento Sucker	40-350	0(10)	10	10	-	16
		Sacramento Pikeminnow	75-400	0(3)	3	3	-	5
		Rainbow Trout	150-300	0(13)	13	13	-	21
		Spotted Bass	>300	0(1)	1	1	-	2
3		Hardhead	75-350	0(4)	4	4	-	13
		Sacramento Sucker	40-350	5(72)	77	77	83	247
		Sacramento Pikeminnow	75-400	0(2)	2	2	-	6
		Rainbow Trout	150-300+	3(9)	12	12	-	38
		Unidentified Cyprinids	25-75	6(627)	633	633	-	2028
4	69	Hardhead	43-350	0(15)	15	15	26	43
		Sacramento Sucker	40-350	6(51)	57	57	-	163
		Sacramento Pikeminnow	33-400	0(8)	8	8	-	23
		Rainbow Trout	75-300+	0(5)	5	5	-	14
		Unidentified Cyprinids	25-75	5(901)	906	906	-	2596

**Table 11. Population and Density Estimates for Sampling Sites in the San Joaquin River, October 2010 (continued).**

Site	Unit <sup>3</sup>	Species	Estimated Fish Population					
			Size Range (millimeters)	Number of Fish Captured or Observed <sup>4</sup>	Population Estimate <sup>5</sup>	Lower 95 Percent Confidence Limit <sup>6</sup>	Upper 95 Percent Confidence Limit	Density Estimate Number per Kilometer
5	81	Hardhead	42-350	0(23)	23	23	-	48
		Sacramento Sucker	40-350	1(36)	37	37	-	77
		Sacramento Pikeminnow	75-400	0(2)	2	2	-	4
		Rainbow Trout	150-300	1(4)	5	5	-	10
		Unidentified Cyprinids	25-75	13(3317)	3319	3319	-	6879
6	109	Hardhead	35-350	4(24)	28	28	-	58
		Sacramento Sucker	40-350	7(216)	223	223	-	462
		Sacramento Pikeminnow	75-400	2(0)	2	2	-	4
		Rainbow Trout	278	0(6)	6	6	-	12
		Unidentified Cyprinids	25-75	9(4222)	4231	4222	4222	8769

<sup>1</sup> Site was too swift and turbulent to block off and shock safely.

<sup>2</sup> Changes at bottom of the electrofishing habitat (widening of braided channel) created conditions too difficult to insert lower block net.

<sup>3</sup> Unit numbers represent habitat units identified during 1997 habitat mapping by Cardno ENTRIX. These habitat units were electrofished.

<sup>4</sup> Number of fish collected (number of fish enumerated from direct observation [snorkeling] in habitats too deep for electrofishing methods in parentheses).

<sup>5</sup> Fish population estimates were calculated from electrofishing data, and the number of fish observed by direct observation were added to the population estimate (since, at a minimum, at least that many more fish were at the sampling site).

<sup>6</sup> The calculated lower confidence interval for the population was lower than the number of fish captured/observed; the lower confidence interval was therefore set equal to the total number of fish captured plus the number of fish observed.

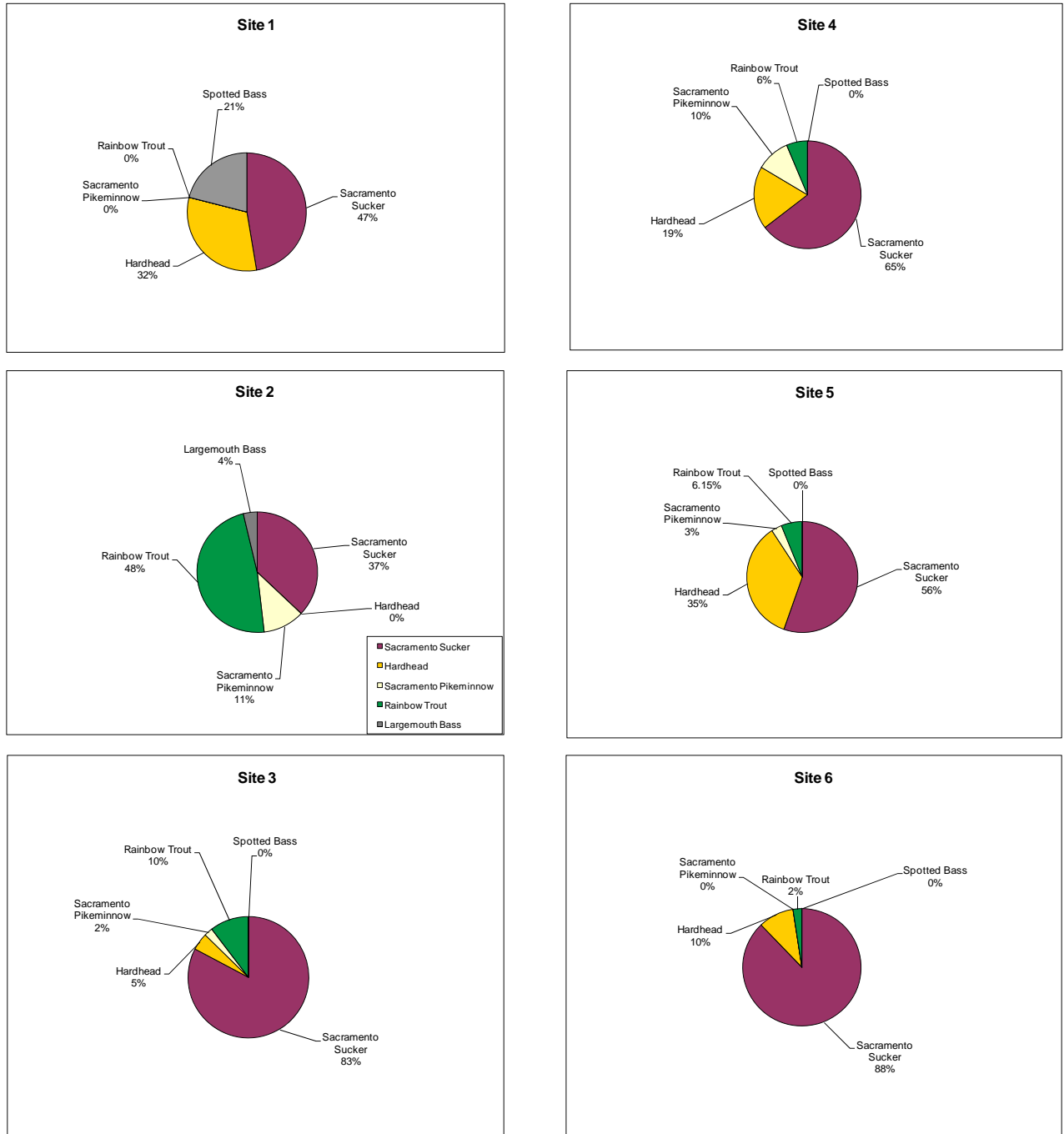
**Table 12. Density Estimates and Percentage Composition by Species for Combined Sites in the San Joaquin River, 2010.**

<b>Species</b>	<b>Density Estimate Number per Kilometer</b>	<b>Percentage of Total Fish Observed and Captured with Unidentified Cyprinids</b>	<b>Percentage of Total Fish Observed and Captured without Unidentified Cyprinids</b>
Hardhead	30	0.6%	15.1%
Sacramento Sucker	164	3.1%	72.9%
Sacramento Pikeminnow	7	0.2%	3.6%
Rainbow Trout	16	0.4%	8.4%
Unidentified Cyprinids	3,592	95.7%	-



**Table 13. Estimates from Electrofishing Sampling Sites in the San Joaquin River, 2010.**

Site	Unit	Species	Size Range (mm)	Number of Fish Captured	Population Estimate	Biomass		
						Biomass per Site (kg)	Biomass per Kilometer (kg/km)	Biomass per Hectare (kg/ha)
1 <sup>1</sup>	10		-	0	-	-	-	-
2 <sup>2</sup>			-	0	-	-	-	-
3		Rainbow Trout	94-283	3	3	0.248	3.75	2.37
		Sacramento Sucker	44-90	5	5	0.013	0.20	0.12
		Prickly Sculpin	53-123	22	22	0.208	3.14	1.98
		Unidentified Cyprinid	35-46	6	6	-	-	-
4	69	Sacramento Sucker	83-288	6	6	0.470	6.85	7.03
		Unidentified Cyprinid	26-32	5	5	-	-	-
5	81	Rainbow Trout	102	1	1	0.013	0.427	0.259
		Sacramento Sucker	49	1	1	0.001	0.033	0.020
		Prickly Sculpin	56-117	5	5	0.072	2.362	1.435
		Unidentified Cyprinid	-	13	13	-	-	-
6	109	Hardhead	32-38	4	4	0.001	0.05	0.09
		Sacramento Pikeminnow	43-47	2	2	0.001	0.05	0.09
		Sacramento Sucker	35-53	7	7	0.007	0.33	0.60
		Prickly Sculpin	100	1	1	0.016	0.75	1.37
		Unidentified Cyprinid	22-32	9	9	-	-	-



**Figure 19. Species Composition by Site from Snorkeling Observations (not including “Unidentified Cyprinids”) in the San Joaquin River, 2010.**

#### **3.5.1.4 Site 4**

There were 79 fish identified to species during the snorkeling survey. The Site 4 fish community in the snorkeled habitats that were identified to species consisted of 65 percent Sacramento sucker, 19 percent hardhead and six percent rainbow trout, respectively (Figure 19). There was a total of 901 "unidentified cyprinids" counted during snorkeling.

Eleven fish were captured during the electrofishing survey at Site 4. Sacramento sucker and young of the year unidentified cyprinids were the only species captured, contributing 55 and 45 percent of the total, respectively (Figure 19).

Total fish densities at Site 4 were 163 fish/km for Sacramento sucker, 43 fish/km for hardhead, 23 fish/km for Sacramento pikeminnow, 14 fish/km for rainbow trout and 2,596 fish/km for "unidentified cyprinids" (Table 11).

#### **3.5.1.5 Site 5**

There were 65 fish identified to species during the snorkeling survey at Site 5. These fish consisted of 56 percent Sacramento sucker, 35 percent hardhead, 6 percent rainbow trout and three percent Sacramento pikeminnow, respectively (Figure 19). There was a total of 3,317 "unidentified cyprinids" counted during snorkeling.

There was a total of two fish captured during the electrofishing survey at Site 5. Sacramento sucker comprised 50 percent and rainbow trout 50 percent of the fish captured, respectively (Figure 20).

Total fish densities at Site 5 were 48 fish/km for hardhead, 4 fish/km for Sacramento pikeminnow, 77 fish/km for Sacramento sucker, 10 fish/km for rainbow trout and 6,879 fish/km for "unidentified cyprinids" (Table 11).

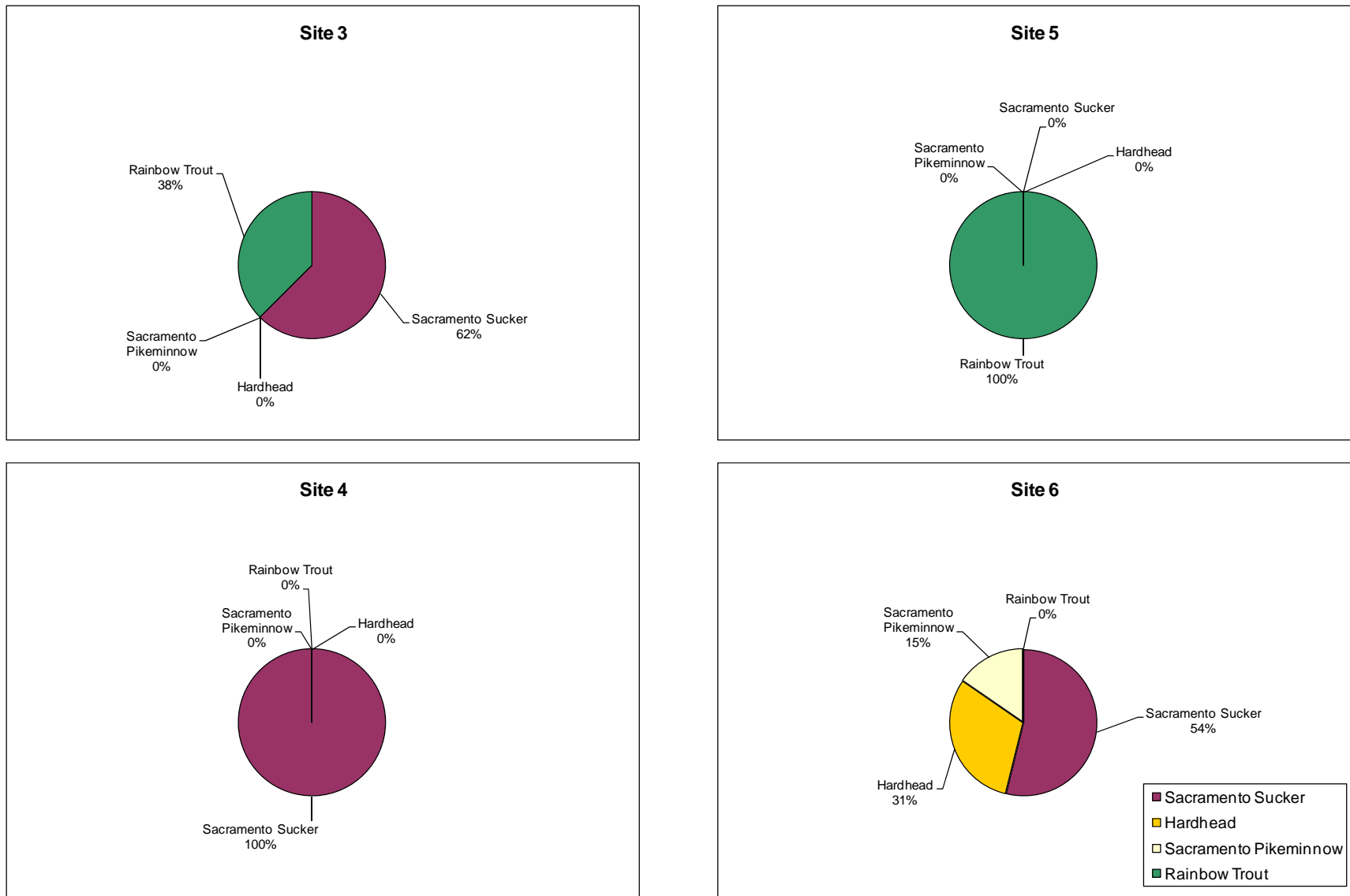
#### **3.5.1.6 Site 6**

There were 246 fish identified to species during the snorkeling survey at Site 6. These were comprised of 10 percent hardhead, 87 percent Sacramento sucker, and two percent rainbow trout, respectively (Figure 19). In addition, 3,793 "unidentified cyprinids" were counted at this site.

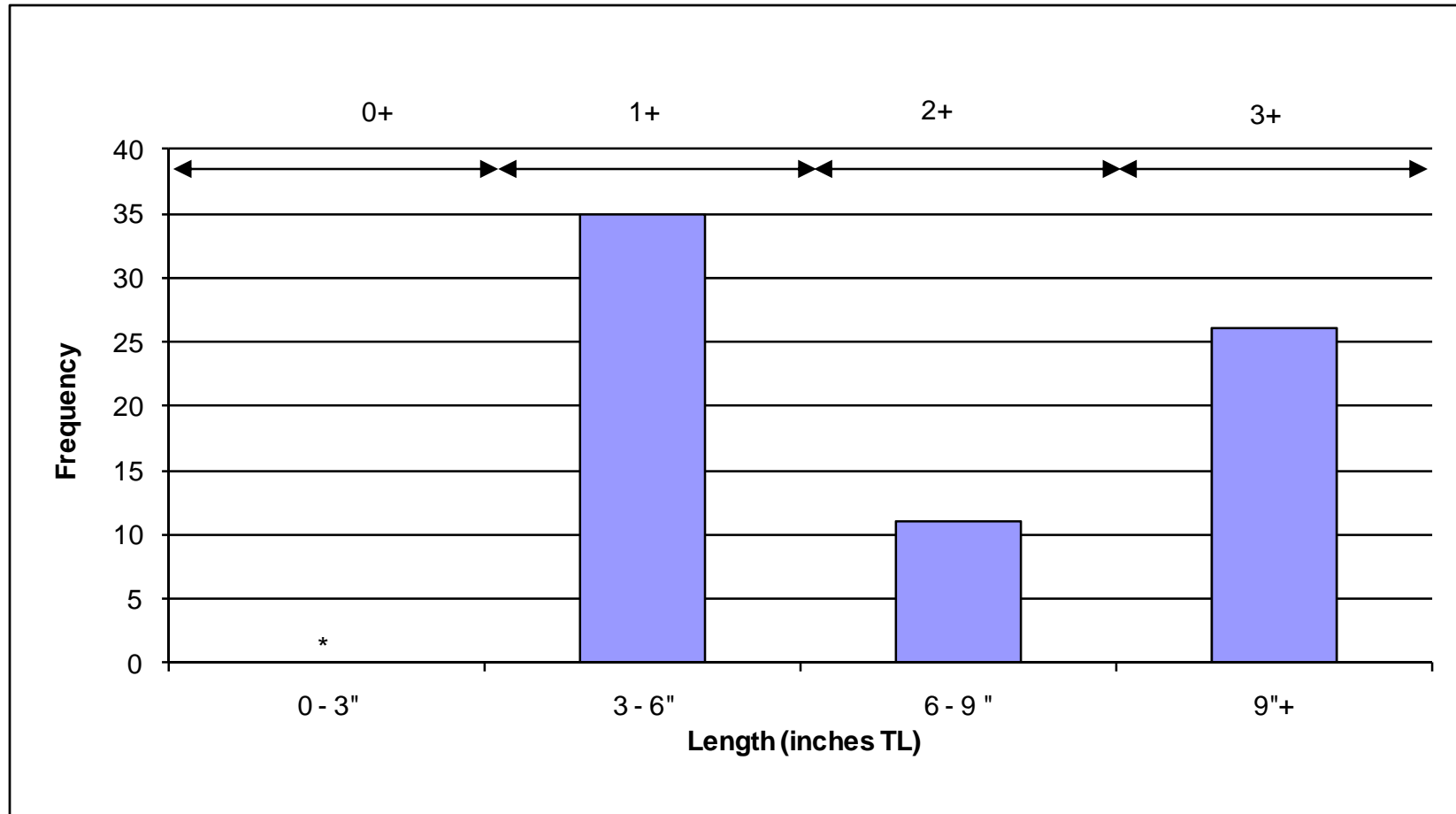
Electrofishing surveys identified 13 fish of four species. Sacramento sucker was the most abundant at 54 percent of the total, followed by hardhead at 31 percent and Sacramento pikeminnow at 18 percent (Figure 20). Total fish densities at Site 6 were 58 fish/km for hardhead, 462 fish/km for Sacramento sucker, 4 fish/km for Sacramento pikeminnow, 12 fish/km for rainbow trout, and 8,769 fish/km for "unidentified cyprinids" (Table 11).

### **3.5.2 POPULATION CHARACTERISTICS**

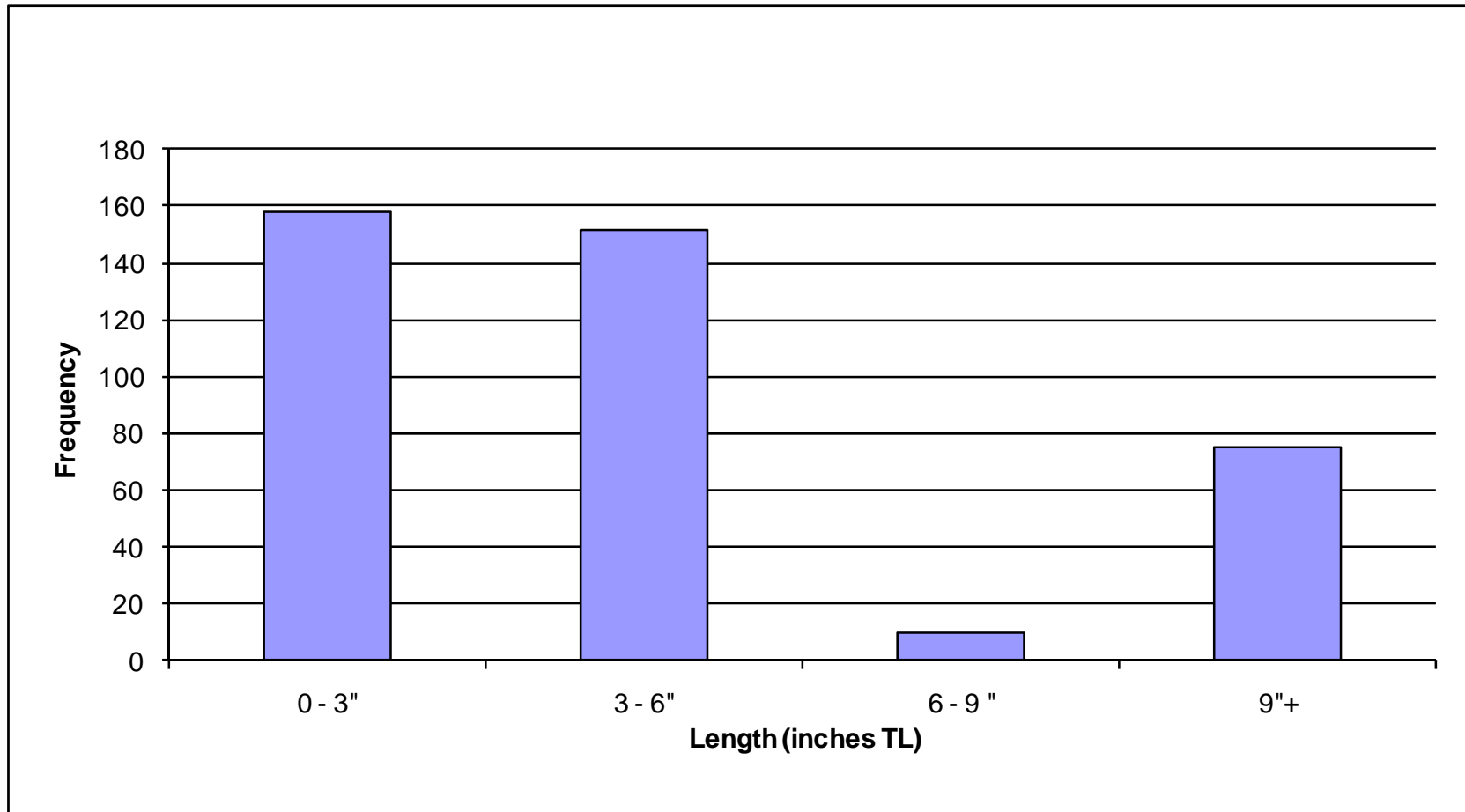
Length-frequency histograms for sampled fish are presented on Figure 18 and Figures 21 through 23. Multiple year classes for Hardhead, Sacramento sucker and Sacramento



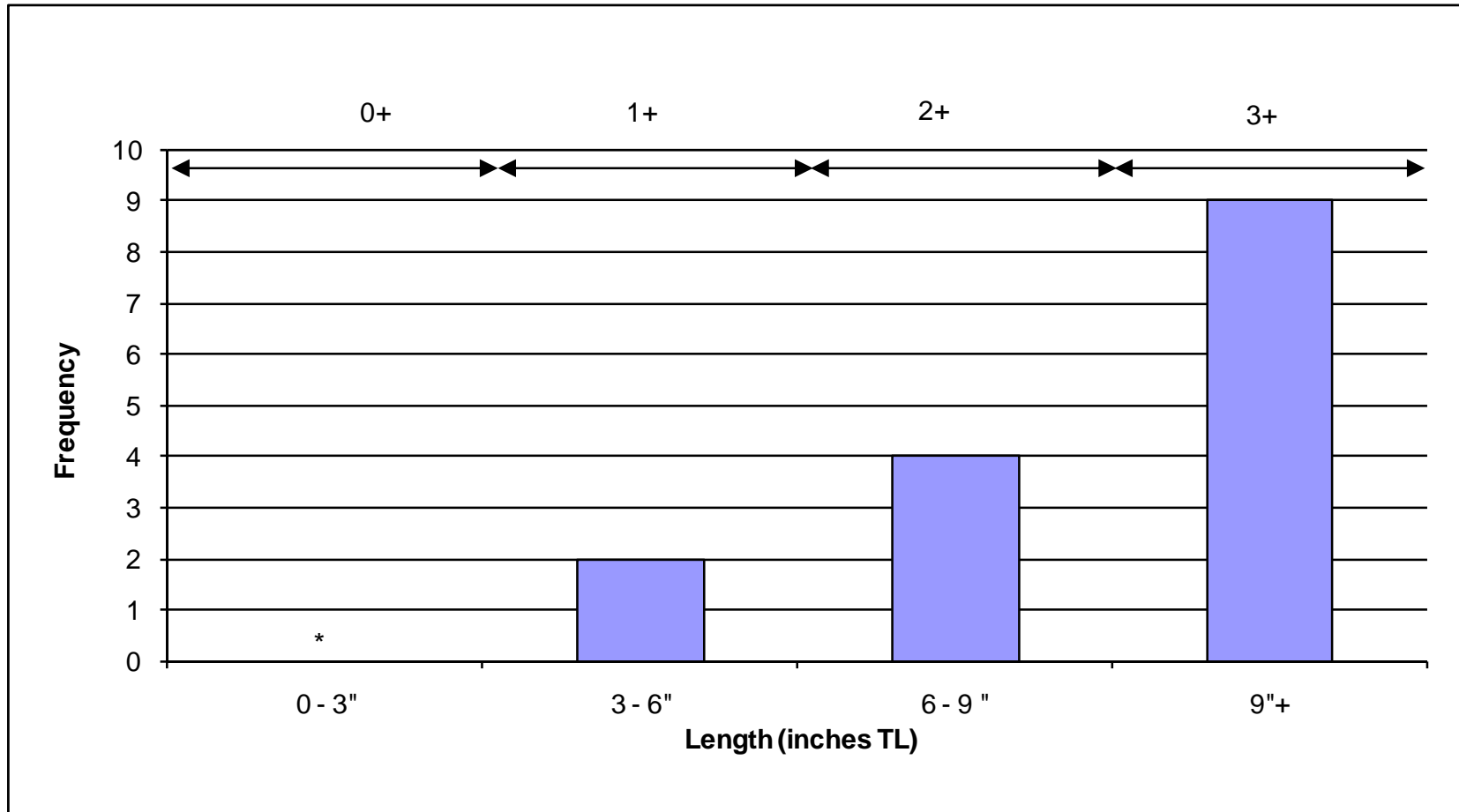
**Figure 20. Species Composition based on Electrofishing Surveys 2010.**



**Figure 21. Length Frequency of Hardhead Observed by Snorkeling in the San Joaquin River, All Sites Combined, October 2010 (not showing unidentified cyprinids) (\*Hardhead in this age category are included in the Unidentified Cyprinid data).**



**Figure 22. Length Frequency of Sacramento Sucker Observed by Snorkeling in the San Joaquin River, All Sites Combined, October 2010.**



**Figure 23. Length Frequency of Sacramento Pikeminnow Observed by snorkeling in the San Joaquin River, All Sites Combined, October 2010 (\*Sacramento Pikeminnow in this age category are included in the Unidentified Cyprinid data).**

pikeminnow were observed among the fish population sampling sites combined in 2010. "Unidentified cyprinids" were observed in two size ranges (0-3 inches (0-75 mm) and 3-8 inches (75-200 mm) (Figure 18). These fish were a mixture of hardhead and Sacramento pikeminnow and were of too small a size to distinguish from each other during snorkel surveys.

The distribution of size classes of hardhead (Figure 21), Sacramento sucker (Figure 22) and Sacramento pikeminnow (Figure 23) suggest that multiple age classes are present, including age 0+ for Sacramento suckers. In addition, large numbers of small (0 to 3 inches Total Length [TL]) "unidentified cyprinids," which included both hardhead and Sacramento pikeminnow were observed in the reach.

Condition factors for hardhead averaged 2.50 (Table 14); Sacramento sucker condition factors averaged 1.34; and Sacramento pikeminnow condition factors averaged 1.11. The condition factors for both hardhead and Sacramento pikeminnow were calculated entirely from young of the year and one year old fish. Condition factors are greatly influenced by age class. As a consequence, valid comparisons with future data sets will need to be made between similar age fish.



**Table 14. Condition Factors and 95 Percent Confidence Intervals by Species Collected by Electrofishing in the San Joaquin River in 2010.**

<b>Species</b>	<b>Average Condition Factor</b>	<b>Upper 95 Percent Confidence Interval</b>	<b>Lower 95 Percent Confidence Interval</b>
Hardhead Minnow (0+)	2.50	2.77	2.23
Sacramento Pikeminnow (0+)	1.11	1.32	0.90
Sacramento Sucker (0+)	1.34	1.41	1.21
Sacramento Sucker (Juveniles)	1.35	1.40	1.30
Sacramento Sucker (Adults)	1.36*	-	-

All hardhead and Sacramento Pikeminnow were age 0+

\*Only one adult captured

## 4.0 DISCUSSION

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Water year 2010 was above normal, with spills of greater than 1,000 cfs for more than 40 days from late May to early July. By contrast, spill during 2009 lasted about 30 days from mid-April to early June. Summer base flows were much greater during early summer but similar between the two years after the first week in July 2010. Water temperatures remained cooler further into spring and summer during 2010 than in 2009 on the entire HSB.

### 4.1 HARDHEAD SPAWNING

Little movement of adult hardhead was observed during either 2008 or 2009 and little movement was detected in 2010. This strongly suggests hardhead in the HSB do not make significant movements to spawn.

All captures of hardhead larvae occurred only after Redinger Lake spills had subsided. In addition, spawning initiation appears to have occurred in Willow Creek at the same time as SJR, despite the fact that high flows had subsided on Willow Creek about two weeks prior to those on SJR. Successful spawning by hardhead was not detected until mid-July during 2010, in contrast to early July during 2009 and mid-May during 2008. The extended spill duration in 2010 resulted in cooler than normal water temperatures in the spring and early summer. The lengths of hardhead larvae, collected in late July, suggest that spawning may have continued through mid-July.

Sacramento suckers bred successfully throughout late spring and summer during all three years and were the most prolific breeders within the study area. However, successful breeding was also delayed for this species. Larval suckers were captured on May 1, 2008, but were not captured until May 21 during 2009 and May 18 during 2010. The capture of larval suckers suggests that spawning may have occurred through late July during 2008 and 2009, but probably ended in mid-July during 2010.

Sacramento pikeminnow larvae were first captured in early July with the last capture occurring at the end of the month during 2010. Sacramento pikeminnow appeared to have spawned later in the summer in 2010 than in 2008 and 2009. Sacramento pikeminnow appear to have had a shorter spawning period in 2010 than the previous two years.

### 4.2 MUSSEL COMMUNITY

The abundance and distribution of western pearlshell (*Margaritifera falcata*) mussels at seven sites were assessed. The results indicate that there were few mussels present at several sites at which mussels had been common to abundant in previous years. Two sites, 6 and 7, were the only sites with an appreciable concentration of mussels. Site 7 was the only site, in which there were sufficient mussels to constitute a monitoring site for future comparisons.

### 4.3 FISH COMMUNITY CHARACTERISTICS AND COMPARISONS

As described in the NASMP (SCE 2008), a major objective of this study is to determine whether the native aquatic species are in “good condition” (Moyle et al. 1998) under existing Project operations for comparison against future conditions.

The NASMP (SCE 2008) describes using baseline data to evaluate whether the native aquatic community is in good condition. Baseline data collected as part of the NASMP are to be compared to data from studies conducted in 1985, 1995 and 2008 to perform an initial evaluation of the condition of the native fishes. This comparison is to be based on the abundance, length-frequencies, condition factors, and recruitment of the fish community, with an emphasis on hardhead. An initial comparison to the criteria discussed in Section 4 of the NASMP is discussed below.

Quantitative electrofishing surveys of the fish community in the HSB Reach conducted in the fall of 1985 (a dry year, CDWR 2008) found the fish community was composed primarily of native species (BioSystems 1987). In November 1995 (a wet year, CDWR 2008), Cardno ENTRIX resampled many of these stations, performed qualitative electrofishing and snorkel surveys in deep pool habitat, and found the relative abundances of most species were similar (SCE 1997). In 2010, Cardno ENTRIX resampled the same six sites by electrofishing and snorkel surveys to gather initial data to contribute to baseline monitoring (SCE 2008). Observed species abundances showed decreases from 2008. This is in part due to increased turbidity compared to 2008, which decreased snorkel counts in deeper water. The Cardno ENTRIX divers could not distinguish species from one another at depths greater than 20 feet. Larger fish were observed moving close to the bottom but were not counted, because of the uncertainty of the numbers and identification of individuals dimly observed. Length frequencies in 2010 showed distinct age classes for all native species as they did in 2008. However, numbers of 0- to 3-inch (young of the year) native cyprinids and 3- to 6-inch yearling hardhead were lower than 2008. Average condition factors for all native fish were over one. Disease and other signs of poor health were not observed during the 2010 study, which suggests the fish are in good health. The following subsections compare and discuss 1985, 1995, 2008, and 2010 data.

#### 4.3.1 INDIVIDUAL LEVEL

##### *Disease*

No diseases were observed in any of the fish captured or observed during the 2010 study.

##### *Condition Factors*

Adult hardhead observed in 1985–1986, 1995, 2008, and 2010 were generally characterized as healthy and robust. All native species in 2010 were characterized as healthy and robust and average condition factors for hardhead, Sacramento pikeminnow, and Sacramento sucker exceeded 1.1 (Table 14). Changes in condition factors in subsequent years will be evaluated relative to condition factors found during the current initial monitoring period.

## *Growth*

Length frequency distributions from 2010 sampling were compared with those in 2008, 1985–1986 and 1995 (Figures 21 through 23). Cyprinids less than 75mm length were excluded from species comparisons, since these fish were not identified to species in 2008 and 2010 (included in the category "unidentified cyprinids"). A separate comparison was made, for hardhead including fish of less than 75mm in Figure 21. Hardhead length frequency distributions were similar to those for fish in 1985–1986 and 1995, but 2008 and 2010 data included greater numbers of substantially younger fish. Length frequency distributions in 2010 of Sacramento suckers were similar to those in 2008 and 1995, but showed decreased numbers of young fish (0-3") compared to 2008. This may be related to the earlier spawning of Sacramento suckers during high flows in 2010.

### **4.3.2 POPULATION LEVEL**

#### *Age Structure*

Comparisons of age structure for native species between 2010, 2008, 1995 data showed no negative changes of length at age (Figures 21 through 23). However, the relative abundance of size 0- to 3-inch cyprinids in 2010 is much greater than that of 1985–1986 and 1995, but less than in 2008 (Figure 18). This abundance indicates decreased spawning and rearing success for young-of-the-year fish in 2010 in comparison to 2008. The relative abundance of the 3-6 in size classes for hardhead, Sacramento sucker, and Sacramento pikeminnow suggests a decrease in recruitment success from the 2009 age class (age 1 fish) relative to the 2008 study. No age classes were missing as in 2008. However, relative abundance appears to have decreased from 2008. Inability to count all fish due to elevated turbidity may account for some of the difference. In addition, spills during spring-summer and September may have washed fish downstream from the reach.

#### *Abundance*

Densities were lower in 2010, for Sacramento pikeminnow in comparison with 2008 densities (Table 15). Hardhead densities were much lower based on observations, but inability to enumerate larger fish in deep water, due to turbidity influenced the results. Sacramento pikeminnow were proportionately less abundant than in 1985, which also was the case in 1995. Rainbow trout densities were higher than in 2008, but lower compared to 1995 and 1985. Rainbow trout densities were highest in 1995, when the long spill period was believed to have transported fish from areas upstream of Redinger Lake or Willow Creek. As pointed out in the NASMP, the rainbow trout assemblage can overlap with the pikeminnow-hardhead-sucker assemblage, although water temperatures are likely to be too warm to support rainbow trout during some or all of the summer months.

### **4.3.3 COMMUNITY LEVEL**

#### *Species Composition*

The fish community between Dam 7 and PH4 was clearly dominated by native species as in 2008, 1997 and 1985. Less than one percent non-native fish were present in 2010, as in 2008

**Table 15. Comparison of Density Estimates and Percentage Composition from the Horseshoe Bend Reach of the San Joaquin River, 1985, 1995, 2008 and 2010.**

**Density Estimates and Percentage Composition by Species for Combined Sites in the San Joaquin River, 2010.**

<b>Species</b>	<b>Density Estimate Number per Kilometer</b>	<b>Percentage of Total Fish Observed and Captured with Cyprinids (&lt;75 mm)</b>	<b>Percentage of Total Fish Observed and Captured without Cyprinids (&lt;75 mm)</b>
Hardhead	30	1%	14%
Sacramento Sucker	164	4.5%	75%
Sacramento Pikeminnow	7	0.1%	3%
Rainbow Trout	16	0.4%	7%
Spotted bass	2	0%	-
Unidentified Cyprinids <75 mm	3,592	94%	-

**Density Estimates and Percentage Composition by Species for Combined Sites in the San Joaquin River, 2008.**

<b>Species</b>	<b>Density Estimate Number per Kilometer</b>	<b>Percentage of Total Fish Observed and Captured with Unidentified Cyprinids (&lt;75 mm)</b>	<b>Percentage of Total Fish Observed and Captured without Unidentified Cyprinids (&lt;75 mm)</b>
Hardhead	189	4%	47%
Sacramento Sucker	157	3%	39%
Sacramento Pikeminnow	48	1%	12%
Rainbow Trout	5	0%	1%
Unidentified Cyprinids <75 mm	4,532	92%	-

**Table 15. Comparison of Density Estimates and Percentage Composition from the Horseshoe Bend Reach of the San Joaquin River, 1985, 1995, 2008 and 2010 (continued).**

**Density Estimates and Percentage Composition by Species for Combined Sites in the San Joaquin River, 1995 (SCE 1997).**

Species	Density Estimate Number per Kilometer	Percentage of Total Fish Observed and Captured with Cyprinids (<75 mm)	Percentage of Total Fish Observed and Captured without Cyprinids (<75 mm)
Hardhead	87	14%	55%
Sacramento Sucker	26	4%	16%
Sacramento Pikeminnow	3	0.50%	2%
Rainbow Trout	43	7%	27%
Cyprinids <75 mm	448	74%	-

**Density Estimates and Percentage Composition by Species for Combined Sites in the San Joaquin River, 1985 (BioSystems 1987).**

Species	Density Estimate Number per Kilometer	Percentage of Total Fish Observed and Captured with Cyprinids (<75 mm)	Percentage of Total Fish Observed and Captured without Cyprinids (<75 mm)
Hardhead	54	6%	27%
Sacramento Sucker	66	7%	33%
Sacramento Pikeminnow	58	6.40%	29%
Rainbow Trout	22	2%	11%
Cyprinids <75 mm	708	78%	-

(Figure 16). The percentage of native species present in 2010 (not including “unidentified cyprinids”) was the same as in 2008 and 1995 and greater than 1985. The presence of the non-native spotted bass will need to be followed in subsequent years.

#### **4.3.4 COMMUNITY LEVEL**

##### *Species Composition*

The fish community between Dam 7 and PH4 was clearly dominated by native species as in 2008, 1997 and 1985. Less than one percent non-native fish were present in 2010, as in 2008 (Figure 16). The percentage of native species present in 2010 (not including “unidentified cyprinids”) was the same as in 2008 and 1995 and greater than 1985. The presence of the non-native spotted bass will need to be followed in subsequent years.

##### *Resilience in Response to Stochastic Events*

The native fish community was persistent and appeared to successfully maintain itself over the 25-year period represented by sampling events in 1985, 1995, 2008, and 2010. These results suggest the native fish community was resilient to stochastic events that occurred over this period (Moyle et al. 1998).

## 5.0

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**Appendix A**  
**Temperature, Meteorology, and Hydrology Data**

**Table A-1. November 2009 Water Temperatures (Daily Mean Temperatures Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek.**

Date	SJR Downstream of Dam 7			SJR Upstream of Willow Creek			Willow Creek			SJR Upstream of Powerhouse 4			Flows (cfs) <sup>1</sup>	
	Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	D/S Dam 7	WC Bridge
11/1/09	14.7	14.6	14.9	13.8	13.5	14.1	10.6	9.7	11.3	13.1	12.3	13.8	31	14
11/2/09	14.7	14.6	14.9	13.9	13.6	14.3	11.1	10.2	11.9	13.3	12.5	14.0	31	14
11/3/09	14.8	14.5	15.3	14.2	13.8	14.6	11.6	10.8	12.2	13.5	12.8	14.3	31	13
11/4/09	14.9	14.4	15.4	14.3	13.8	14.9	11.6	10.8	12.2	13.7	12.9	14.4	31	13
11/5/09	14.7	14.6	15.0	14.2	13.9	14.5	11.5	10.9	12.0	13.7	13.0	14.3	31	10
11/6/09	14.7	14.5	14.9	14.0	13.8	14.4	11.0	10.3	11.6	13.7	13.0	14.4	31	12
11/7/09	14.6	14.4	14.9	14.0	13.7	14.3	11.2	10.6	11.7	13.7	13.0	14.2	31	12
11/8/09	14.6	14.4	14.9	13.9	13.6	14.1	10.6	10.2	11.4	13.3	12.8	13.9	31	12
11/9/09	14.6	14.4	14.7	13.5	13.3	13.7	9.6	8.8	10.3	12.8	12.2	13.3	31	13
11/10/09	14.5	14.4	14.7	13.4	13.2	13.6	9.4	8.8	9.8	12.5	12.0	12.9	31	13
11/11/09	14.4	14.3	14.5	13.4	13.2	13.6	9.5	9.0	10.0	12.4	12.0	12.9	31	12
11/12/09	14.3	14.3	14.4	13.3	13.2	13.4	9.5	9.2	9.9	12.2	12.0	12.4	31	12
11/13/09	14.1	14.0	14.3	13.1	12.9	13.2	9.1	8.4	9.5	12.2	11.8	12.7	31	13
11/14/09	14.0	13.8	14.1	12.9	12.6	12.9	8.6	7.8	9.1	12.0	11.3	12.4	32	15
11/15/09	13.9	13.8	14.0	12.8	12.6	12.9	8.4	7.7	8.8	11.8	11.2	12.3	32	15
11/16/09	13.7	13.7	13.8	12.5	12.3	12.8	8.0	7.2	8.4	11.4	10.7	12.0	31	14
11/17/09	13.7	13.5	13.8	12.7	12.3	13.1	8.1	7.5	8.8	11.2	10.6	11.8	31	14
11/18/09	13.6	13.5	13.7	12.8	12.5	12.9	8.2	7.7	8.8	11.3	10.7	11.7	32	7
11/19/09	13.5	13.5	13.7	12.7	12.5	12.9	8.4	8.0	9.1	11.3	10.7	11.8	32	6
11/20/09	13.5	13.3	13.7	12.7	12.5	12.9	7.9	7.4	8.4	11.3	10.6	11.7	31	6
11/21/09	13.3	13.3	13.3	12.8	12.5	12.9	8.6	8.1	9.2	11.8	11.3	12.3	31	6
11/22/09	13.2	13.2	13.3	12.7	12.5	12.8	8.6	8.1	9.1	11.7	11.2	12.1	31	5
11/23/09	13.2	13.0	13.3	12.7	12.6	12.8	8.8	8.4	9.4	11.8	11.5	12.3	31	5
11/24/09	13.1	13.0	13.2	12.4	12.3	12.6	8.0	7.5	8.6	11.4	10.7	12.0	31	5
11/25/09	13.0	13.0	13.0	12.3	12.2	12.5	7.6	7.1	8.3	11.1	10.6	11.7	32	5
11/26/09	12.9	12.9	13.0	12.2	12.0	12.5	7.7	7.2	8.4	11.0	10.4	11.5	32	5
11/27/09	12.9	12.7	13.0	12.3	12.2	12.5	7.9	7.5	8.3	11.0	10.4	11.3	32	5
11/28/09	12.8	12.6	12.9	12.2	12.0	12.3	7.9	7.5	8.3	11.1	10.9	11.5	32	5
11/29/09	12.6	12.4	12.7	12.0	11.9	12.2	7.4	6.9	8.0	10.8	10.3	11.3	32	5
11/30/09	12.4	12.3	12.4	11.7	11.5	11.9	6.7	6.1	7.4	10.4	9.8	10.9	32	5

<sup>1</sup> All flow data is considered provisional until reviewed by USGS

**Table A-2. December 2009 Water Temperatures (Daily Mean Temperatures Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek.**

	SJR Downstream of Dam 7			SJR Upstream of Willow Creek			Willow Creek			SJR Upstream of Powerhouse 4 <sup>1</sup>			Flows (cfs) <sup>2</sup>	
	Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek
Date	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	D/S Dam 7	WC Bridge
12/1/09	12.3	12.3	12.4	11.6	11.4	11.7	6.4	6.0	7.1	10.1	9.5	10.6	32	5
12/2/09	12.2	12.1	12.3	11.5	11.4	11.5	6.2	5.8	6.9	10.0	9.5	10.4	32	5
12/3/09	12.1	12.1	12.3	11.4	11.2	11.5	6.0	5.6	6.7	9.8	9.3	10.3	31	5
12/4/09	12.0	12.0	12.1	11.3	11.1	11.4	5.8	5.3	6.4	9.6	9.0	10.3	32	5
12/5/09	11.9	11.8	12.0	11.2	11.1	11.4	5.8	5.3	6.4	9.3	9.2	9.5	32	5
12/6/09	11.8	11.8	11.8	11.1	10.9	11.2	5.6	5.2	6.1	-	-	-	32	5
12/7/09	11.7	11.6	11.8	10.9	10.6	11.1	5.6	5.3	5.8	-	-	-	32	5
12/8/09	11.4	11.3	11.5	10.5	10.3	10.6	4.4	3.9	5.2	-	-	-	32	6
12/9/09	11.2	11.0	11.3	10.2	10.0	10.5	3.4	3.0	3.9	-	-	-	32	6
12/10/09	11.0	10.7	11.2	10.1	10.0	10.3	3.7	3.1	4.2	-	-	-	32	6
12/11/09	10.7	10.4	11.0	10.0	9.8	10.0	5.3	4.4	6.0	-	-	-	32	6
12/12/09	10.2	9.9	10.3	9.6	8.1	9.8	6.4	6.0	7.2	-	-	-	32	12
12/13/09	9.8	9.5	9.9	9.2	8.1	9.4	6.4	6.1	6.9	-	-	-	32	41
12/14/09	9.6	9.3	10.3	9.1	8.9	9.4	5.7	5.2	6.1	-	-	-	32	53
12/15/09	9.6	9.2	10.3	9.1	8.9	9.5	5.3	4.6	5.8	-	-	-	32	36
12/16/09	9.1	8.9	9.5	9.0	8.9	9.2	5.6	5.0	6.0	-	-	-	32	23
12/17/09	8.9	8.7	9.0	8.8	8.8	8.9	5.7	5.2	6.1	-	-	-	32	15
12/18/09	8.8	8.7	8.9	8.8	8.8	8.8	5.8	5.5	6.0	-	-	-	32	13
12/19/09	8.6	8.5	8.9	8.7	8.6	8.8	5.8	5.3	6.1	-	-	-	32	12
12/20/09	8.6	8.2	9.0	8.7	8.4	8.8	6.0	5.6	6.3	-	-	-	33	11
12/21/09	8.6	8.2	9.2	8.6	8.3	9.1	6.0	5.5	6.7	-	-	-	33	11
12/22/09	8.3	8.2	8.4	8.4	8.1	8.6	6.3	5.3	6.7	-	-	-	33	11
12/23/09	8.1	7.9	8.4	8.0	7.8	8.1	4.3	3.9	5.2	-	-	-	33	22
12/24/09	7.9	7.8	8.1	7.8	7.8	8.0	3.5	3.0	3.9	-	-	-	33	15
12/25/09	7.8	7.8	8.1	7.8	7.7	7.8	3.8	3.3	4.2	-	-	-	33	13
12/26/09	7.8	7.5	8.2	7.8	7.5	8.0	4.2	3.8	4.9	-	-	-	33	12
12/27/09	7.7	7.5	8.2	7.9	7.7	8.3	5.5	4.9	6.1	-	-	-	33	11
12/28/09	7.5	7.3	7.9	7.7	7.5	8.0	5.8	5.3	6.1	-	-	-	33	11
12/29/09	7.4	7.3	7.5	7.6	7.5	7.7	6.5	6.0	6.9	-	-	-	33	11
12/30/09	7.3	7.2	7.5	7.6	7.5	7.8	6.9	6.7	7.4	-	-	-	33	11
12/31/09	7.2	7.2	7.3	7.4	7.4	7.7	6.7	6.3	7.1	-	-	-	33	11

<sup>1</sup> Temperature data unavailable for Upstream of PH4 from 12/6 due to loggers being out of water<sup>2</sup> All flow data is considered provisional until reviewed by USGS

**Table A-3. January 2010 Water Temperatures (Daily Mean Temperatures Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek.**

	SJR Downstream of Dam 7			SJR Upstream of Willow Creek			Willow Creek			SJR Upstream of Powerhouse 4 <sup>1</sup>			Flows (cfs) <sup>2</sup>	
	Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek
Date	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	D/S Dam 7	WC Bridge
1/1/10	7.3	7.0	7.8	7.4	7.2	7.8	6.5	6.1	6.7	-	-	-	33	11
1/2/10	7.3	7.0	7.9	7.4	7.1	7.8	6.2	5.8	6.6	-	-	-	33	10
1/3/10	7.0	6.9	7.2	7.1	6.9	7.4	5.5	5.0	6.1	-	-	-	33	10
1/4/10	7.3	7.0	7.8	7.4	6.9	7.7	5.1	4.6	5.3	-	-	-	33	10
1/5/10	7.1	6.9	7.3	7.3	6.9	7.5	5.1	4.6	5.5	-	-	-	33	10
1/6/10	6.9	6.9	7.0	7.1	6.9	7.2	5.1	4.6	5.3	-	-	-	33	9
1/7/10	6.9	6.9	7.0	7.1	6.9	7.4	5.5	4.9	5.8	-	-	-	33	9
1/8/10	6.9	6.9	7.0	7.1	6.9	7.4	6.3	5.6	7.1	-	-	-	33	9
1/9/10	6.9	6.7	7.2	7.1	6.9	7.4	7.1	6.6	7.7	-	-	-	33	10
1/10/10	6.9	6.7	7.3	7.2	6.9	7.4	7.7	7.2	8.0	-	-	-	33	10
1/11/10	7.3	6.9	7.6	7.4	6.9	7.8	7.7	7.2	8.0	-	-	-	33	10
1/12/10	7.0	6.9	7.2	7.3	7.1	7.5	7.8	7.4	8.3	-	-	-	33	11
1/13/10	6.9	6.9	6.9	7.3	7.1	7.5	8.6	8.1	9.2	-	-	-	33	11
1/14/10	6.9	6.7	7.5	7.1	6.7	7.5	6.9	6.3	8.0	-	-	-	34	29
1/15/10	6.9	6.7	7.3	7.0	6.7	7.2	6.5	5.8	7.1	-	-	-	33	25
1/16/10	6.7	6.7	6.9	7.1	6.9	7.4	6.8	6.3	7.2	-	-	-	33	17
1/17/10	6.8	6.7	7.2	7.0	6.7	7.4	6.6	6.1	6.9	-	-	-	33	14
1/18/10	6.7	6.7	6.9	7.0	6.9	7.1	6.9	6.4	7.4	-	-	-	34	14
1/19/10	6.7	6.5	7.0	7.0	6.9	7.1	6.5	6.1	6.7	-	-	-	34	33
1/20/10	6.7	6.5	7.2	6.9	6.7	7.2	6.1	5.8	6.4	-	-	-	33	88
1/21/10	6.7	6.5	6.9	6.8	6.6	7.1	5.6	5.3	6.1	-	-	-	34	138
1/22/10	6.5	6.2	6.7	6.9	6.7	7.1	5.9	5.5	6.1	-	-	-	33	128
1/23/10	6.3	6.1	6.7	6.6	6.4	6.7	5.3	4.6	5.8	-	-	-	33	78
1/24/10	6.5	6.1	6.7	6.6	6.1	6.9	4.9	4.1	5.5	-	-	-	33	70
1/25/10	6.2	6.1	6.5	6.6	6.4	6.7	5.8	5.3	6.4	-	-	-	33	62
1/26/10	6.4	5.9	6.5	6.7	6.4	7.1	6.7	6.1	7.4	-	-	-	33	55
1/27/10	5.9	5.8	6.1	6.3	6.1	6.6	6.8	6.1	7.2	-	-	-	33	48
1/28/10	6.0	5.9	6.1	6.2	6.0	6.4	6.5	5.6	6.9	-	-	-	33	42
1/29/10	6.0	5.9	6.1	6.2	6.0	6.4	6.4	5.6	6.9	-	-	-	33	37
1/30/10	5.8	5.6	5.9	6.2	6.0	6.4	7.0	6.3	7.8	-	-	-	33	32
1/31/10	6.1	5.6	6.5	6.2	5.7	6.9	6.2	5.5	6.9	-	-	-	33	28

<sup>1</sup>Temperature data unavailable for Upstream of PH4 from 12/6 due to loggers being out of water

**Table A-4. February 2010 Water Temperatures (Daily Mean Temperatures Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek.**

Date	SJR Downstream of Dam 7			SJR Upstream of Willow Creek			Willow Creek			SJR Upstream of Powerhouse 4 <sup>1</sup>			Flows (cfs) <sup>2</sup>	
	Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	D/S Dam 7	WC Bridge
2/1/10	5.7	5.6	5.8	6.1	5.8	6.3	6.0	5.2	6.7	-	-	-	33	24
2/2/10	5.8	5.6	6.4	6.1	5.8	6.4	6.6	5.8	7.2	-	-	-	33	22
2/3/10	5.8	5.6	6.4	6.1	5.7	6.4	6.5	5.6	7.2	-	-	-	33	20
2/4/10	5.6	5.6	5.8	6.0	5.8	6.1	6.9	6.3	7.5	-	-	-	33	18
2/5/10	5.6	5.5	5.8	5.9	5.8	6.1	7.6	7.2	8.1	-	-	-	33	17
2/6/10	5.6	5.6	5.6	6.0	5.8	6.0	7.7	6.9	8.0	-	-	-	33	25
2/7/10	5.6	5.6	5.8	6.0	5.8	6.3	6.9	6.6	7.2	-	-	-	34	157
2/8/10	5.5	5.5	5.6	5.9	5.8	6.1	7.3	6.6	8.0	-	-	-	34	123
2/9/10	5.5	5.5	5.5	5.8	5.7	6.0	7.1	6.7	7.4	-	-	-	34	51
2/10/10	5.4	5.3	5.5	5.7	5.5	6.0	6.8	6.1	7.2	-	-	-	34	38
2/11/10	5.4	5.3	5.6	5.8	5.7	6.1	7.0	6.3	7.8	-	-	-	34	33
2/12/10	5.4	5.3	5.6	5.8	5.3	6.4	6.9	5.8	7.8	-	-	-	34	29
2/13/10	5.4	5.3	5.6	5.8	5.3	6.3	7.5	6.3	8.6	-	-	-	34	27
2/14/10	5.4	5.3	5.6	5.8	5.5	6.4	8.1	6.9	9.1	-	-	-	34	26
2/15/10	5.4	5.3	5.6	5.8	5.5	6.3	8.2	7.1	9.1	-	-	-	34	25
2/16/10	5.5	5.3	5.8	5.9	5.5	6.4	8.4	7.2	9.4	-	-	-	34	25
2/17/10	5.8	5.3	6.5	6.1	5.5	6.9	8.6	7.4	9.5	-	-	-	34	25
2/18/10	6.0	5.5	6.5	6.4	5.8	7.2	8.6	7.4	9.5	-	-	-	34	24
2/19/10	5.6	5.5	6.1	6.1	5.8	6.4	8.4	7.5	8.9	-	-	-	34	25
2/20/10	5.6	5.5	5.8	6.0	5.8	6.3	8.6	8.1	9.2	-	-	-	34	24
2/21/10	5.7	5.6	5.8	6.0	5.8	6.1	8.1	7.7	8.6	-	-	-	34	25
2/22/10	5.6	5.5	5.9	6.1	5.8	6.7	7.6	6.7	8.4	-	-	-	34	29
2/23/10	5.8	5.5	6.5	6.0	5.7	6.6	6.8	6.1	7.5	-	-	-	34	29
2/24/10	5.9	5.6	6.5	6.3	6.0	6.7	7.7	6.9	8.6	-	-	-	34	25
2/25/10	5.8	5.6	6.4	6.1	5.8	6.7	7.6	6.3	8.6	6.4	6.2	6.7	34	192
2/26/10	5.9	5.8	6.1	6.2	6.0	6.4	8.0	7.4	8.9	6.8	6.1	8.3	816	217
2/27/10	6.2	6.1	6.7	6.4	6.3	6.4	8.0	7.4	8.9	7.5	6.7	9.8	356	87
2/28/10	6.0	5.9	6.1	6.4	6.1	6.6	7.2	6.0	8.0	6.9	6.2	7.6	2200	795

<sup>1</sup>Temperature data unavailable for Upstream of PH4 from 12/6 due to loggers being out of water<sup>2</sup>All flow data is considered provisional until reviewed by USGS

**Table A-5. March 2010 Water Temperatures (Daily Mean Temperatures Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek.**

Date	SJR Downstream of Dam 7 <sup>1</sup>			SJR Upstream of Willow Creek			Willow Creek			SJR Upstream of Powerhouse 4			Flows (cfs) <sup>2</sup>	
	Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	D/S Dam 7	WC Bridge
3/1/10	6.2	5.9	6.4	6.3	6.1	6.6	7.8	6.7	8.9	7.7	7.0	8.3	393	297
3/2/10	6.4	6.1	6.5	6.5	6.3	6.6	8.3	8.0	8.6	6.9	6.7	7.2	570	158
3/3/10	6.3	6.2	6.4	6.7	6.4	6.9	8.1	7.4	8.8	7.7	6.9	8.6	862	84
3/4/10	6.2	6.1	6.4	6.7	6.3	7.1	6.6	5.6	7.2	8.1	7.6	8.7	34	105
3/5/10	6.1	5.9	6.4	6.6	6.3	6.9	6.7	5.3	7.8	7.6	7.2	8.3	34	191
3/6/10	6.1	5.9	6.2	6.5	6.3	6.7	7.4	6.7	8.1	7.9	7.5	8.3	34	141
3/7/10	6.1	5.9	6.4	6.5	6.1	6.9	7.4	6.1	8.3	8.1	7.6	8.7	34	115
3/8/10	6.1	5.9	6.2	6.5	6.3	6.6	8.1	7.5	8.4	8.5	8.3	8.7	34	106
3/9/10	6.1	5.9	6.4	6.5	6.1	6.7	6.7	6.0	7.4	8.3	7.9	8.7	34	91
3/10/10	6.0	5.9	6.2	6.4	6.3	6.6	6.1	5.6	6.4	7.6	7.3	7.9	34	77
3/11/10	6.1	5.9	6.5	6.6	6.0	7.4	6.1	4.6	7.7	7.3	6.7	7.9	34	72
3/12/10	6.1	5.9	6.4	6.5	6.1	7.1	7.2	6.0	8.1	7.5	6.9	8.3	34	61
3/13/10	6.2	6.1	6.5	6.8	6.4	7.4	8.4	7.5	9.4	8.5	7.9	9.2	34	58
3/14/10	6.3	6.1	6.7	6.8	6.1	7.7	7.6	6.1	9.1	8.8	8.3	10.0	34	200
3/15/10	6.3	5.9	6.7	6.9	6.3	7.5	8.2	6.7	9.7	8.7	7.9	9.5	34	107
3/16/10	6.5	6.2	7.0	7.1	6.4	8.0	9.1	7.4	10.6	9.4	8.4	10.3	34	82
3/17/10	6.7	6.2	7.3	7.3	6.6	8.3	10.0	8.6	11.4	10.1	9.3	10.9	34	75
3/18/10	6.7	6.4	7.6	7.5	6.7	8.6	10.4	9.1	11.9	10.4	10.0	11.7	34	74
3/19/10	-	-	-	7.5	6.7	8.3	10.0	8.1	11.4	10.8	10.2	11.7	39	82
3/20/10	-	-	-	7.4	6.7	8.3	10.5	9.2	11.7	11.1	10.4	11.6	34	96
3/21/10	-	-	-	7.7	6.9	8.4	10.0	8.6	10.8	10.9	10.1	11.6	34	84
3/22/10	-	-	-	7.5	6.9	8.1	9.5	8.0	10.8	8.7	7.6	11.3	34	86
3/23/10	-	-	-	7.6	7.4	8.0	9.9	8.4	11.2	8.1	7.7	8.8	665	74
3/24/10	-	-	-	8.0	7.5	8.8	10.0	8.8	11.1	8.4	7.9	9.6	1493	78
3/25/10	-	-	-	7.8	7.7	8.0	9.8	8.8	10.6	8.2	7.7	8.9	1530	84
3/26/10	-	-	-	8.1	7.7	8.4	8.8	7.4	10.0	8.5	7.7	9.6	1252	84
3/27/10	-	-	-	8.1	7.7	8.8	8.8	7.2	10.1	8.7	7.7	9.8	788	69
3/28/10	-	-	-	8.5	7.7	9.7	9.2	7.5	10.8	9.2	7.9	10.8	766	61
3/29/10	-	-	-	8.4	7.7	8.9	9.8	8.1	11.1	9.2	8.5	10.2	735	66
3/30/10	-	-	-	8.1	7.8	8.4	9.7	8.9	10.6	8.6	8.3	9.0	726	77
3/31/10	-	-	-	8.0	7.8	8.1	7.6	6.7	8.8	8.2	7.7	8.6	722	111

<sup>1</sup> Temperature data downstream of Dam 7 is unavailable from 3/19 due to loss of units in high flows<sup>2</sup> All flow data is considered provisional until reviewed by USGS

**Table A-6. April 2010 Water Temperatures (Daily Mean Temperatures Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek.**

Date	SJR Downstream of Dam 7 <sup>1</sup>			SJR Upstream of Willow Creek			Willow Creek			SJR Upstream of Powerhouse 4			Flows (cfs) <sup>2</sup>	
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	SJR	Willow Creek
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	D/S Dam 7	WC Bridge
4/1/10	-	-	-	8.0	7.5	8.4	6.5	4.9	8.1	8.1	7.4	9.2	1808	145
4/2/10	-	-	-	7.7	7.4	8.1	6.6	5.5	7.4	7.9	7.6	8.5	1942	90
4/3/10	-	-	-	7.6	7.4	7.8	7.7	6.9	8.6	7.6	7.3	8.1	2436	66
4/4/10	-	-	-	7.5	7.2	7.8	7.0	6.4	7.7	7.7	7.4	8.0	2766	60
4/5/10	-	-	-	7.4	7.2	7.5	7.1	6.6	7.7	7.6	7.4	8.1	2631	117
4/6/10	-	-	-	7.6	7.1	8.0	6.8	5.0	8.8	7.7	6.9	8.8	2496	54
4/7/10	-	-	-	7.2	6.9	7.7	8.2	6.3	10.3	7.7	7.0	8.4	1440	113
4/8/10	-	-	-	7.8	6.9	8.8	9.5	7.7	11.4	8.8	7.8	10.0	2658	110
4/9/10	-	-	-	7.9	7.1	8.8	10.5	8.9	12.2	8.9	7.5	10.2	643	80
4/10/10	-	-	-	7.6	7.1	8.3	10.3	9.4	11.1	8.2	7.5	9.3	643	87
4/11/10	-	-	-	7.7	7.2	8.0	8.9	8.4	9.7	8.2	7.8	8.5	1116	95
4/12/10	-	-	-	8.0	7.5	8.8	7.9	7.5	8.4	8.2	7.4	9.3	996	125
4/13/10	-	-	-	7.8	7.4	8.4	7.9	6.1	9.5	8.3	7.4	9.3	733	296
4/14/10	-	-	-	7.8	7.4	8.6	8.6	6.6	10.5	8.7	8.1	9.6	762	162
4/15/10	-	-	-	7.9	7.2	8.8	9.6	8.0	11.2	10.2	9.7	10.6	794	142
4/16/10	-	-	-	8.1	7.2	9.2	10.6	8.9	12.5	11.3	10.7	12.1	34	129
4/17/10	-	-	-	8.3	7.4	9.5	10.9	9.1	12.6	12.0	11.2	13.1	34	108
4/18/10	-	-	-	8.3	7.4	9.2	11.1	9.7	12.3	11.9	11.4	12.9	34	134
4/19/10	-	-	-	8.3	7.5	9.2	11.0	9.5	12.3	12.1	11.6	12.8	34	209
4/20/10	-	-	-	7.9	7.7	8.3	9.8	7.5	11.4	9.9	7.7	11.5	34	218
4/21/10	-	-	-	7.6	7.4	7.8	6.6	6.0	7.4	7.4	7.2	7.7	34	376
4/22/10	-	-	-	7.7	7.4	8.1	7.2	6.7	7.5	7.8	7.6	8.1	34	422
4/23/10	-	-	-	8.3	7.5	9.2	8.2	6.1	10.1	9.4	8.4	10.7	34	305
4/24/10	-	-	-	8.6	7.8	9.5	10.6	9.2	11.9	11.5	11.0	11.7	34	254
4/25/10	-	-	-	8.7	7.8	9.8	11.0	9.4	12.6	12.0	11.7	12.5	34	254
4/26/10	-	-	-	8.9	8.0	10.2	11.4	9.7	13.3	12.5	12.2	13.0	34	230
4/27/10	-	-	-	8.3	8.1	8.8	10.4	9.7	12.2	11.0	10.1	12.2	34	251
4/28/10	-	-	-	8.1	8.0	8.8	8.9	8.3	9.7	10.0	9.3	10.5	34	301
4/29/10	-	-	-	8.1	7.7	8.8	6.5	5.6	7.4	8.3	7.6	9.2	35	396
4/30/10	-	-	-	8.0	7.5	8.7	6.7	5.3	7.9	7.5	7.1	7.8	34	283

<sup>1</sup> Temperature data downstream of Dam 7 is unavailable from 3/19 due to loss of units in high flows<sup>2</sup> All flow data is considered provisional until reviewed by USGS



**Table A-7. May 2010 Air Temperature and Relative Humidity, Water Temperatures (Daily Mean are Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek.**

Date	Redinger Lake at Dam 7			SJR Downstream of Dam 7 <sup>1</sup>			SJR Upstream of Willow Creek			Willow Creek			Willow Creek Bridge			SJR Downstream of Willow Creek		
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum
5/1/10	8.8	7.9	10.1	-	-	-	8.2	7.4	9.1	8.1	6.5	9.6	8.1	6.4	9.6	8.1	6.6	9.4
5/2/10	8.6	7.8	10.0	-	-	-	8.4	7.5	9.5	10.0	8.0	12.1	10.0	8.0	12.1	9.8	8.0	11.6
5/3/10	9.5	7.8	11.9	-	-	-	8.6	7.6	9.8	11.5	9.6	13.3	11.4	9.6	13.3	11.1	9.5	12.6
5/4/10	9.5	8.0	11.6	-	-	-	8.7	7.8	10.0	11.7	10.0	13.1	11.6	10.0	13.1	11.4	9.9	12.7
5/5/10	8.9	8.0	10.6	-	-	-	8.7	7.8	9.9	11.3	9.9	12.6	11.3	9.9	12.6	11.1	9.8	12.3
5/6/10	9.3	8.3	11.3	-	-	-	8.7	7.8	9.9	10.3	8.8	11.6	10.3	8.8	11.6	10.2	8.9	11.4
5/7/10	9.4	8.3	10.9	-	-	-	8.8	7.8	10.0	10.6	9.0	12.2	10.6	8.9	12.1	10.5	8.9	12.0
5/8/10	9.9	8.2	12.5	-	-	-	8.9	7.9	10.0	11.0	9.6	12.2	11.0	9.6	12.2	10.9	9.6	12.0
5/9/10	9.4	8.3	11.5	-	-	-	8.4	8.0	8.9	9.8	8.9	11.2	9.8	8.9	11.2	9.8	9.0	11.2
5/10/10	8.7	8.0	10.0	-	-	-	8.3	7.8	8.8	8.3	7.3	8.9	8.3	7.3	8.9	8.4	7.5	9.0
5/11/10	8.6	8.0	9.8	-	-	-	8.3	7.8	9.0	7.5	6.6	8.0	7.4	6.6	8.0	7.6	6.8	8.1
5/12/10	9.0	8.0	10.1	-	-	-	8.6	7.7	9.9	8.8	6.8	11.0	8.7	6.8	10.9	8.7	7.0	10.7
5/13/10	9.4	8.2	11.3	-	-	-	8.8	7.8	9.8	10.8	9.0	12.7	10.8	9.0	12.7	10.5	9.0	12.2
5/14/10	9.2	8.1	10.0	-	-	-	9.0	8.0	10.2	11.6	10.0	13.1	11.5	9.9	13.1	11.3	9.9	12.8
5/15/10	9.4	8.4	9.9	-	-	-	9.1	8.1	10.3	12.0	10.4	13.4	11.9	10.4	13.4	11.7	10.3	13.1
5/16/10	9.6	8.3	10.5	-	-	-	9.1	8.2	10.1	12.0	10.7	12.9	12.0	10.7	12.9	11.8	10.6	12.7
5/17/10	10.1	8.5	10.9	-	-	-	8.5	8.3	8.8	11.2	10.0	12.5	11.2	10.0	12.5	11.1	10.2	12.2
5/18/10	9.3	8.1	11.0	-	-	-	9.0	8.1	9.9	10.5	9.2	11.7	10.5	9.1	11.7	10.4	9.1	11.5
5/19/10	10.0	8.2	11.8	-	-	-	9.1	8.3	10.2	11.9	10.4	13.3	11.9	10.4	13.3	11.7	10.3	13.1
5/20/10	9.7	8.3	12.3	-	-	-	9.1	8.2	10.2	12.5	11.4	13.8	12.5	11.4	13.8	12.4	11.2	13.4
5/21/10	9.6	8.4	11.4	-	-	-	9.2	8.3	10.3	11.5	10.4	12.5	11.4	10.3	12.4	11.4	10.3	12.3
5/22/10	9.5	8.3	10.9	-	-	-	8.7	8.0	9.6	9.6	8.7	10.8	9.6	8.6	10.8	9.3	8.6	10.9
5/23/10	10.1	8.7	11.5	-	-	-	9.1	8.5	9.3	8.8	8.0	9.6	8.7	7.9	9.6	9.1	8.6	9.3
5/24/10	9.7	8.7	11.2	-	-	-	9.6	9.0	10.5	9.5	8.1	11.2	9.4	8.0	11.2	9.7	8.5	11.1
5/25/10	9.8	8.7	11.1	-	-	-	9.2	8.4	10.1	10.0	8.5	11.2	10.0	8.4	11.2	9.9	8.5	11.1
5/26/10	9.6	8.7	11.1	-	-	-	9.2	8.5	10.1	11.2	10.6	12.3	11.2	10.5	12.2	11.0	10.3	12.1
5/27/10	9.3	8.5	11.0	-	-	-	9.3	8.6	10.1	10.9	10.1	12.1	10.9	10.0	12.0	10.8	9.9	11.8
5/28/10	9.4	8.5	10.3	-	-	-	9.5	8.6	10.6	10.5	9.5	11.6	10.5	9.5	11.5	10.5	9.6	11.4
5/29/10	9.9	8.7	11.1	-	-	-	9.6	8.5	11.0	10.6	8.5	12.8	10.6	8.5	12.8	10.5	8.6	12.4
5/30/10	10.2	8.8	12.4	-	-	-	9.4	8.7	10.8	14.1	10.7	24.8	12.4	10.7	14.2	11.2	9.9	13.5
5/31/10	10.8	8.8	12.9	-	-	-	10.3	9.0	11.9	15.8	12.1	27.3	13.0	11.6	14.5	10.8	9.7	12.0

<sup>1</sup> Temperature Data unavailable for SJR Downstream of Dam 7 from 5/1 to 7/13 due to loss of units in high flow conditions

**Table A-7. May 2010 Air Temperature and Relative Humidity, Water Temperatures (Daily Means are Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek (continued).**

Date	SJR Horseshoe Bend (East)			SJR Horseshoe Bend (West)			SJR Upstream of Powerhouse 4			Flows (cfs) <sup>1</sup>		Dam 7			Dam 7			Redinger Lake
	Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek	Air Temperature Recorder			Relative Humidity			Surface Water Elevation
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	D/S Dam 7	WC Bridge	Mean (°C)	Minimum	Maximum	Mean	Minimum	Maximum	(Feet)
5/1/10	8.2	7.0	9.4	8.4	7.5	9.2	8.7	7.5	9.8	35	208	10.0	3.5	18.2	76.1	45.4	98.3	1,400
5/2/10	9.8	8.5	11.4	10.0	9.0	11.0	10.3	9.1	12.0	35	169	13.8	6.7	21.6	71.0	41.4	94.0	1,401
5/3/10	11.3	10.1	12.5	11.6	10.7	12.6	11.8	10.7	13.1	35	167	17.4	11.3	24.1	62.7	38.0	93.0	1,400
5/4/10	11.8	10.6	12.7	12.4	12.0	12.9	12.5	12.0	13.3	36	217	20.5	14.1	27.6	48.5	32.1	80.8	1,399
5/5/10	11.5	10.5	12.3	12.3	12.0	12.6	12.4	12.1	12.9	35	129	17.2	9.5	26.2	65.7	38.2	92.3	1,399
5/6/10	10.6	9.4	11.6	11.5	11.0	12.0	11.6	11.2	12.0	35	37	14.7	6.9	24.1	61.9	26.7	92.5	1,399
5/7/10	10.7	9.4	11.9	11.1	10.6	11.5	11.2	10.6	11.7	35	36	14.4	7.6	22.0	61.1	34.0	88.8	1,399
5/8/10	11.1	10.1	12.0	11.6	11.2	12.0	11.7	11.2	12.2	35	36	17.0	9.5	25.4	53.0	26.3	76.7	1,399
5/9/10	10.1	9.4	11.5	11.0	10.1	11.8	11.1	10.1	11.8	35	41	15.3	9.3	24.6	59.9	26.8	83.0	1,399
5/10/10	8.6	7.8	9.4	9.2	8.7	10.0	9.3	8.8	10.0	35	44	9.8	3.5	16.3	74.9	46.4	94.5	1,399
5/11/10	7.9	7.3	8.6	8.6	8.4	8.9	8.7	8.4	9.1	35	32	7.7	1.5	15.4	81.8	49.9	99.9	1,399
5/12/10	8.7	7.1	10.6	8.6	7.8	9.3	8.8	7.8	9.9	35	25	9.7	3.7	18.2	76.7	44.5	98.7	1,398
5/13/10	10.6	9.4	12.1	10.7	9.5	11.5	10.9	9.5	12.1	35	14	15.2	8.6	22.9	64.9	36.3	89.1	1,398
5/14/10	11.6	10.4	12.7	12.0	11.3	12.7	12.1	11.3	13.1	35	13	20.2	13.6	26.3	40.0	24.2	70.5	1,397
5/15/10	12.0	10.8	13.1	12.5	12.1	12.9	12.6	12.2	13.2	35	18	21.7	15.1	28.3	38.2	21.3	65.8	1,397
5/16/10	12.1	11.2	12.8	12.7	12.3	12.9	12.8	12.4	13.2	34	29	22.8	15.9	30.2	39.8	22.6	71.1	1,396
5/17/10	11.4	10.5	12.4	12.2	10.7	12.9	12.2	10.9	12.9	34	44	20.8	14.5	29.8	52.4	23.2	82.9	1,395
5/18/10	10.6	9.4	11.7	10.9	10.1	11.7	11.0	10.2	11.7	35	76	12.0	7.8	19.4	90.0	55.1	99.7	1,395
5/19/10	11.8	10.5	13.2	11.9	11.2	13.1	12.0	11.2	13.0	35	287	16.2	10.4	23.2	68.2	41.0	90.9	1,395
5/20/10	12.6	11.6	13.5	13.1	12.6	13.4	13.2	12.7	13.5	35	489	18.1	9.9	26.4	63.0	29.6	94.0	1,394
5/21/10	11.7	10.8	12.5	12.6	12.0	13.4	12.6	12.0	13.3	35	446	15.9	8.2	24.1	64.1	35.2	91.6	1,394
5/22/10	9.6	8.6	11.4	10.6	8.9	12.3	10.6	8.8	12.3	35	382	11.9	3.9	21.6	60.6	21.3	92.7	1,394
5/23/10	9.2	8.6	9.5	9.3	8.6	9.8	9.3	8.6	9.8	999	339	11.3	6.5	17.0	54.1	26.1	80.7	1,395
5/24/10	9.8	9.0	11.0	9.9	9.0	10.7	9.9	9.1	11.1	1,615	282	11.6	6.7	17.3	64.5	37.6	88.5	1,395
5/25/10	10.2	9.0	11.1	10.8	10.4	11.2	10.9	10.4	11.8	475	257	14.2	7.2	21.4	49.9	27.9	75.6	1,395
5/26/10	11.2	10.4	12.1	11.4	10.7	12.1	11.5	10.8	12.3	34	196	15.5	10.7	22.5	70.4	29.6	97.1	1,395
5/27/10	11.1	10.2	11.8	12.0	11.7	12.3	12.2	11.8	12.9	34	237	15.4	10.1	21.6	59.8	34.0	87.6	1,394
5/28/10	10.9	10.1	11.5	11.8	11.5	12.4	12.0	11.5	12.9	34	201	13.9	6.9	20.9	64.4	26.5	95.3	1,394
5/29/10	10.6	9.2	12.2	11.5	11.0	12.1	11.8	11.0	12.6	34	184	12.6	4.6	21.3	66.6	34.8	95.8	1,397
5/30/10	11.7	9.8	13.6	12.4	11.3	13.5	12.6	11.3	14.2	35	167	18.4	11.3	26.1	52.1	30.0	75.9	1,399
5/31/10	10.7	9.6	11.9	10.9	9.8	12.1	11.0	9.8	12.3	335	188	22.7	14.8	31.0	37.4	18.7	61.8	1,399

<sup>1</sup> All flow data is considered provisional until reviewed by USGS

**Table A-8. June 2010 Air Temperature and Relative Humidity, Water Temperatures (Daily Means are Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek.**

Date	Redinger Lake at Dam 7			SJR Downstream of Dam 7 <sup>1</sup>			SJR Upstream of Willow Creek			Willow Creek			Willow Creek Bridge <sup>2</sup>			SJR Downstream of Willow Creek		
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum
6/1/10	10.8	10.0	11.7	-	-	-	10.3	10.1	10.7	13.5	11.9	15.2	13.5	12.4	15.0	10.8	10.4	11.3
6/2/10	11.2	10.2	12.1	-	-	-	10.7	10.4	11.1	13.9	12.6	15.2	13.9	12.6	16.0	11.1	10.9	11.5
6/3/10	11.7	10.5	13.4	-	-	-	11.0	10.7	11.3	14.4	13.5	15.5	14.8	13.5	16.2	11.3	11.0	11.7
6/4/10	11.9	11.0	13.0	-	-	-	11.4	11.2	11.7	15.8	14.6	16.8	15.6	14.4	16.8	11.7	11.4	12.1
6/5/10	12.0	11.2	13.5	-	-	-	11.6	11.4	11.9	16.4	15.6	17.3	16.0	14.6	17.2	11.9	11.7	12.3
6/6/10	12.0	11.1	13.1	-	-	-	11.6	11.4	12.0	17.0	15.9	18.0	16.8	15.5	18.0	11.9	11.7	12.4
6/7/10	11.7	11.1	13.0	-	-	-	11.5	11.2	12.0	16.8	15.3	18.0	17.0	15.9	18.0	11.9	11.6	12.3
6/8/10	11.7	11.2	12.8	-	-	-	11.5	11.3	11.9	16.6	15.3	17.8	16.7	15.3	17.8	11.8	11.6	12.3
6/9/10	11.7	11.1	12.8	-	-	-	11.4	11.2	11.8	16.2	14.6	17.7	16.5	15.3	17.7	11.7	11.3	12.3
6/10/10	11.6	11.1	12.3	-	-	-	11.4	11.2	11.7	15.1	13.4	16.7	15.7	14.6	16.7	11.6	11.4	12.0
6/11/10	11.6	11.0	12.4	-	-	-	11.3	11.1	11.7	14.7	13.4	16.0	14.8	13.4	16.0	11.5	11.4	11.9
6/12/10	12.1	11.1	13.0	-	-	-	11.6	11.3	11.9	15.3	14.0	16.7	14.9	13.4	16.7	11.8	11.6	12.2
6/13/10	12.0	11.2	12.8	-	-	-	11.8	11.3	12.5	15.9	14.6	17.4	15.6	14.0	17.4	12.1	11.6	12.8
6/14/10	12.1	11.4	13.3	-	-	-	11.8	11.4	12.7	16.6	15.2	18.2	16.3	14.6	18.2	12.1	11.7	12.8
6/15/10	12.1	11.2	13.5	-	-	-	11.8	11.3	12.6	16.2	14.3	18.4	16.6	15.2	18.4	12.0	11.5	12.7
6/16/10	12.0	11.2	12.7	-	-	-	11.7	11.4	12.0	15.5	13.9	17.4	15.7	14.3	17.4	11.9	11.6	12.2
6/17/10	12.4	11.4	13.4	-	-	-	11.9	11.3	12.5	15.6	14.0	17.4	15.5	13.9	17.4	12.1	11.7	12.7
6/18/10	12.4	11.2	14.1	-	-	-	12.0	11.3	13.0	15.5	13.7	17.4	15.6	14.0	17.4	12.2	11.5	13.1
6/19/10	12.1	11.2	12.8	-	-	-	11.9	11.4	12.2	15.4	13.5	17.3	15.4	13.7	17.2	12.1	11.7	12.5
6/20/10	12.4	11.2	13.3	-	-	-	12.0	11.4	12.4	15.5	13.8	17.3	15.4	13.5	17.3	12.2	11.7	12.6
6/21/10	12.7	11.4	13.7	-	-	-	12.1	11.6	12.5	16.1	14.5	17.7	15.7	13.8	17.8	12.3	11.8	12.6
6/22/10	13.1	11.5	14.8	-	-	-	12.4	11.8	13.3	17.2	15.8	18.7	16.7	14.5	19.7	12.6	12.0	13.4
6/23/10	12.9	11.9	15.2	-	-	-	12.5	12.1	13.0	17.9	16.2	19.6	15.8	14.9	17.8	12.7	12.2	13.1
6/24/10	13.4	12.0	15.3	-	-	-	12.8	12.2	13.5	17.3	16.1	18.4	17.6	16.1	19.0	12.9	12.3	13.6
6/25/10	13.0	12.4	13.7	-	-	-	12.7	12.4	13.1	17.9	16.3	19.6	17.7	16.1	19.6	12.9	12.7	13.4
6/26/10	13.3	12.3	14.6	-	-	-	12.9	12.6	13.4	18.9	17.6	20.0	16.0	14.8	17.7	13.0	12.7	13.5
6/27/10	13.5	12.6	14.8	-	-	-	13.3	13.0	13.8	20.5	18.9	21.8	-	-	-	13.4	13.0	13.8
6/28/10	14.3	13.2	16.4	-	-	-	13.8	13.4	14.5	19.1	17.7	20.4	-	-	-	13.9	13.5	14.6
6/29/10	14.4	13.4	15.7	-	-	-	14.0	13.7	14.6	20.7	19.2	22.3	21.2	19.1	22.9	14.1	13.7	14.6
6/30/10	14.3	13.5	15.3	-	-	-	14.0	13.6	14.4	20.3	17.7	22.4	20.9	19.2	22.4	14.1	13.7	14.5

<sup>1</sup> Temperature Data unavailable for SJR Downstream of Dam 7 from 5/1 to 7/13 due to loss of units in high flow conditions<sup>2</sup> Temperature data for WCB affected by exposure to air on 6/26 & 6/27.

**Table A-8. June 2010 Air Temperature and Relative Humidity, Water Temperatures (Daily Means are Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek (continued).**

Date	SJR Horseshoe Bend (East)			SJR Horseshoe Bend (West)			SJR Upstream of Powerhouse 4			Flows (cfs) <sup>1</sup>		Dam 7			Dam 7			Redinger Lake
	Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek	Air Temperature Recorder			Relative Humidity			Surface Water Elevation <sup>3</sup>
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	D/S Dam 7	WC Bridge	Mean (°C)	Minimum	Maximum	Mean	Minimum	Maximum	(Feet)
6/1/10	10.7	10.2	11.0	10.7	10.1	11.0	10.8	10.2	11.0	1,745	221	21.0	14.0	31.1	47.0	18.2	74.7	1,400
6/2/10	11.1	10.8	11.3	11.2	10.7	11.7	11.2	10.7	11.7	2,819	247	20.0	12.3	27.8	58.0	32.2	87.2	1,400
6/3/10	11.3	11.1	11.5	11.4	11.0	11.7	11.5	11.2	11.8	3,536	285	22.1	14.3	29.2	57.1	34.6	83.6	1,400
6/4/10	11.7	11.6	12.0	11.8	11.5	12.1	11.9	11.6	12.1	5,441	323	23.0	14.6	31.6	60.5	32.8	90.8	1,400
6/5/10	11.9	11.7	12.1	12.0	11.8	12.1	12.0	11.9	12.2	5,667	359	24.4	17.3	33.1	52.1	28.7	74.8	1,399
6/6/10	11.9	11.7	12.2	12.0	11.8	12.3	12.1	11.8	12.3	7,348	379	25.6	16.7	34.3	53.2	28.5	81.1	1,399
6/7/10	11.8	11.6	12.2	11.9	11.7	12.3	12.0	11.7	12.3	9,280	428	25.3	16.2	34.8	53.3	28.5	82.3	1,399
6/8/10	11.8	11.6	12.2	11.9	11.7	12.1	12.0	11.7	12.2	9,878	455	23.6	15.5	32.6	50.0	24.5	79.1	1,398
6/9/10	11.7	11.5	12.1	11.8	11.7	12.1	11.9	11.6	12.2	9,068	436	22.7	14.2	32.6	48.5	21.8	79.7	1,399
6/10/10	11.6	11.4	11.9	11.7	11.5	12.0	11.7	11.5	12.0	10,131	399	19.7	10.9	30.3	56.8	31.0	90.8	1,400
6/11/10	11.5	11.3	11.8	11.6	11.3	11.8	11.7	11.4	11.8	10,674	337	17.4	9.4	25.8	53.2	28.7	82.1	1,400
6/12/10	11.8	11.5	12.1	11.9	11.3	12.3	12.0	11.5	12.4	7,811	296	21.9	15.1	26.9	32.0	17.9	46.8	1,397
6/13/10	12.1	11.6	12.7	12.2	11.7	12.6	12.3	11.7	12.7	5,213	230	24.2	15.2	30.6	33.3	17.0	63.3	1,397
6/14/10	12.1	11.7	12.8	12.2	11.7	12.7	12.3	11.7	12.8	4,522	193	26.7	19.2	33.2	28.2	16.7	48.0	1,399
6/15/10	12.0	11.6	12.7	12.1	11.7	12.7	12.2	11.7	12.8	4,672	181	27.2	19.2	35.9	30.5	15.1	50.9	1,399
6/16/10	11.9	11.7	12.1	12.0	11.7	12.1	12.0	11.8	12.3	5,423	178	21.8	12.0	32.6	37.4	12.5	67.3	1,399
6/17/10	12.1	11.6	12.7	12.3	11.7	12.9	12.3	11.7	13.0	5,994	174	21.3	13.5	29.0	37.6	20.9	68.8	1,399
6/18/10	12.2	11.5	13.1	12.4	11.5	13.4	12.4	11.6	13.4	3,231	135	23.3	15.3	30.8	32.0	16.4	58.6	1,399
6/19/10	12.1	11.6	12.3	12.2	11.7	12.7	12.3	11.7	12.8	3,322	123	20.2	10.7	30.5	44.2	14.9	78.4	1,400
6/20/10	12.2	11.6	12.5	12.3	11.7	12.9	12.4	11.7	12.9	2,856	94	19.4	11.0	27.6	46.5	25.6	80.5	-
6/21/10	12.3	11.8	12.6	12.4	11.8	12.9	12.5	11.9	13.0	2,848	108	20.4	12.5	28.2	45.0	23.6	78.9	1,399
6/22/10	12.6	12.0	13.4	12.7	12.1	13.5	12.8	12.1	13.7	3,642	79	22.8	15.0	30.3	40.5	23.5	70.0	1,399
6/23/10	12.7	12.2	13.2	12.8	12.3	13.5	12.9	12.4	13.6	3,223	65	25.4	16.9	34.0	37.8	18.8	61.1	1,399
6/24/10	13.0	12.4	13.7	13.0	12.4	13.8	13.1	12.6	14.0	3,721	59	25.9	17.4	35.3	35.3	17.4	60.0	1,399
6/25/10	12.9	12.6	13.2	13.0	12.7	13.5	13.1	12.7	13.6	4,045	54	24.0	17.1	31.4	40.5	18.6	64.0	1,399
6/26/10	13.1	12.8	13.5	13.2	12.9	13.5	13.3	12.9	13.6	3,430	78	23.8	15.7	31.7	45.7	24.0	71.6	1,401
6/27/10	13.4	13.2	13.8	13.6	13.2	14.0	13.6	13.4	14.0	4,574	31	26.3	18.7	34.4	48.4	28.9	72.6	1,401
6/28/10	13.9	13.6	14.6	14.0	13.5	14.6	14.1	13.7	14.6	4,989	25	30.5	22.3	37.9	36.7	21.8	60.8	1,400
6/29/10	14.2	13.9	14.6	14.2	13.8	14.6	14.3	13.9	14.6	5,493	22	30.5	20.0	41.1	33.1	16.2	56.7	1,399
6/30/10	14.1	13.8	14.5	14.3	13.8	14.6	14.3	13.9	14.7	4,992	21	27.7	18.6	37.0	42.2	22.7	69.1	1,399

<sup>1</sup> All flow data is considered provisional until reviewed by USGS

<sup>2</sup>Redinger Lake Surface Elevation unavailable for 6/20

**Table A-9. July 2010 Air Temperature and Relative Humidity, Water Temperatures (Daily Means are Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek.**

Date	Redinger Lake at Dam 7			SJR Downstream of Dam 7 <sup>1</sup>			SJR Upstream of Willow Creek			Willow Creek			Willow Creek Bridge			SJR Downstream of Willow Creek		
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum
7/1/10	14.8	13.5	16.2	-	-	-	14.1	13.6	14.8	19.2	16.9	21.0	19.5	17.6	20.9	14.2	13.6	14.9
7/2/10	14.6	13.7	16.2	-	-	-	14.1	13.5	14.7	18.9	17.1	20.4	18.7	16.7	20.3	14.2	13.6	14.8
7/3/10	14.6	13.2	16.8	-	-	-	14.2	13.5	15.1	19.2	17.3	20.7	19.0	16.9	20.7	14.3	13.6	15.2
7/4/10	14.7	13.4	16.5	-	-	-	14.2	13.4	15.2	19.5	17.7	21.1	19.2	17.2	20.9	14.4	13.5	15.2
7/5/10	14.8	13.1	16.6	-	-	-	14.4	13.2	15.4	20.1	18.5	21.5	19.6	17.5	21.3	14.5	13.4	15.5
7/6/10	14.7	13.0	16.8	-	-	-	14.2	13.2	15.1	20.5	18.7	21.9	20.2	18.3	21.7	14.4	13.4	15.2
7/7/10	14.1	13.0	15.7	-	-	-	14.1	13.2	14.6	20.7	19.1	22.1	20.4	18.6	21.9	14.4	13.5	14.9
7/8/10	14.2	13.0	16.4	-	-	-	14.3	13.4	15.4	21.3	19.7	22.6	20.8	18.9	22.3	14.6	13.7	15.7
7/9/10	14.3	13.1	17.1	-	-	-	14.3	13.5	14.8	21.7	19.9	23.3	21.4	19.5	22.8	14.6	13.7	15.3
7/10/10	14.4	13.3	16.4	-	-	-	14.4	13.5	15.3	21.8	20.7	23.0	21.4	19.6	22.5	14.8	13.7	15.7
7/11/10	15.1	13.2	18.2	-	-	-	13.9	13.0	15.3	22.5	21.6	23.9	22.0	20.4	23.2	14.5	13.6	15.5
7/12/10	14.5	13.2	17.2	-	-	-	14.0	13.0	15.4	22.9	21.1	24.4	22.9	21.5	24.3	14.5	13.5	15.5
7/13/10	14.5	13.4	17.2	-	-	-	14.1	13.1	16.3	22.1	20.1	23.7	22.5	21.0	23.8	14.5	13.6	16.0
7/14/10	14.5	13.3	16.7	13.3	12.9	14.4	14.2	13.1	15.8	22.0	20.2	23.7	22.0	20.1	23.8	14.6	13.6	15.9
7/15/10	15.1	13.3	19.1	14.0	12.9	15.2	15.3	13.5	17.1	23.0	21.8	24.4	22.3	20.2	24.4	15.9	14.0	17.6
7/16/10	14.9	13.2	19.5	13.1	12.9	13.7	15.2	14.0	16.5	24.0	22.5	25.5	23.5	21.8	25.5	16.4	15.4	17.6
7/17/10	14.6	13.2	17.6	13.1	12.8	13.6	15.5	14.2	16.7	24.3	22.4	26.2	24.3	22.5	26.2	16.5	15.6	17.4
7/18/10	14.4	13.6	16.7	13.1	12.8	13.7	15.4	14.1	16.8	23.9	21.7	26.0	24.2	22.4	26.0	16.6	15.7	18.2
7/19/10	14.8	13.8	17.2	13.1	12.8	13.6	15.2	14.0	16.6	23.2	21.1	25.4	23.6	21.8	25.4	16.3	15.4	17.5
7/20/10	15.6	13.7	19.7	13.1	12.9	13.6	14.9	13.7	16.4	22.7	20.7	24.6	22.9	21.1	24.7	16.0	15.1	17.0
7/21/10	15.4	13.6	19.5	13.2	12.9	13.7	15.0	13.6	16.6	22.3	20.2	24.1	22.5	20.7	24.2	16.4	15.0	17.9
7/22/10	15.3	13.6	19.4	13.3	12.9	14.4	15.0	13.6	17.0	21.9	19.9	23.8	22.0	20.2	23.8	16.5	14.7	17.8
7/23/10	15.5	13.7	19.6	13.2	12.8	13.7	14.7	13.5	16.2	22.0	20.3	23.7	21.9	19.9	23.8	16.1	15.4	16.8
7/24/10	15.1	13.9	16.9	13.2	12.9	13.7	14.7	13.5	16.2	22.7	21.2	24.1	22.2	20.3	24.2	15.7	14.9	16.6
7/25/10	14.9	13.8	17.8	13.3	13.0	13.7	14.6	13.5	15.9	22.9	21.6	24.2	22.8	21.2	24.3	15.3	14.6	16.0
7/26/10	15.0	14.1	17.4	13.3	13.0	13.8	14.7	13.5	16.2	22.7	20.7	24.4	23.0	21.6	24.5	15.3	14.5	16.2
7/27/10	15.1	14.0	17.3	13.3	13.0	13.8	14.6	13.4	16.2	21.9	19.9	23.7	22.3	20.7	23.8	15.3	14.4	16.2
7/28/10	15.4	14.0	17.8	13.3	13.0	13.8	14.5	13.4	16.1	21.7	20.1	23.3	21.7	19.9	23.4	15.2	14.3	16.1
7/29/10	15.4	14.1	17.7	13.4	13.1	13.9	14.6	13.4	16.1	21.8	20.0	23.4	21.8	20.1	23.5	15.1	14.2	16.2
7/30/10	15.5	14.3	17.5	13.5	13.2	13.9	14.6	13.5	16.1	21.8	19.9	23.3	21.8	20.0	23.5	15.1	14.2	16.2
7/31/10	15.8	14.4	19.9	13.5	13.1	13.9	14.6	13.6	16.1	21.4	19.4	23.0	21.6	19.8	23.2	15.1	14.2	16.1

<sup>1</sup> Temperature Data unavailable for SJR Downstream of Dam 7 from 5/1 to 7/13 due to loss of units in high flow conditions

**Table A-9. July 2010 Air Temperature and Relative Humidity, Water Temperatures (Daily Means are Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek (continued).**

Date	SJR Horseshoe Bend (East)			SJR Horseshoe Bend (West)			SJR Upstream of Powerhouse 4			Flows (cfs) <sup>1</sup>		Dam 7			Dam 7			Redinger Lake
	Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek	Air Temperature Recorder			Relative Humidity			Surface Water Elevation <sup>2</sup>
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	D/S Dam 7	WC Bridge	Mean (°C)	Minimum	Maximum	Mean	Minimum	Maximum	(Feet)
7/1/10	14.3	13.8	14.9	14.4	13.8	15.1	14.5	13.9	15.2	4,409	21	25.5	16.9	35.3	32.5	13.6	58.4	1,400
7/2/10	14.3	13.7	14.9	14.4	13.8	15.2	14.4	13.9	15.3	3,800	19	24.3	15.7	33.3	35.5	17.0	64.0	1,399
7/3/10	14.3	13.6	15.4	14.5	13.7	15.9	14.6	13.7	16.0	2,566	19	24.6	16.2	32.7	40.7	20.5	71.1	1,399
7/4/10	14.5	13.5	15.4	14.7	13.7	16.2	14.8	13.7	16.4	2,107	18	25.2	16.7	33.5	39.0	21.1	72.8	1,399
7/5/10	14.6	13.4	15.6	14.9	13.7	16.3	15.0	13.8	16.4	1,564	17	27.7	20.2	35.0	30.5	17.1	51.5	1,399
7/6/10	14.5	13.4	15.2	14.8	13.5	16.0	14.9	13.5	16.3	1,402	16	27.9	19.0	37.5	35.4	17.6	59.9	1,399
7/7/10	14.5	13.5	15.2	14.8	13.5	16.2	15.0	13.5	16.4	1,181	16	26.6	18.6	35.0	38.7	20.1	61.2	1,399
7/8/10	14.7	13.5	16.8	15.5	13.7	17.9	15.6	13.7	17.9	798	15	26.8	19.1	34.6	41.0	25.0	62.4	1,399
7/9/10	15.2	13.8	16.5	15.8	14.0	17.1	16.0	14.1	17.5	328	15	28.4	19.5	37.6	38.9	20.0	60.3	1,399
7/10/10	16.1	14.1	18.3	16.4	15.2	17.1	16.5	15.6	17.3	325	14	28.7	20.3	37.8	33.5	21.3	46.5	1,399
7/11/10	18.2	17.2	19.1	17.8	16.7	19.2	17.7	16.6	19.0	77	13	30.8	23.9	38.9	31.8	18.2	46.7	1,399
7/12/10	18.7	17.2	20.1	20.0	18.9	21.3	19.6	18.4	21.1	34	14	29.2	21.7	36.6	42.6	24.2	62.9	1,399
7/13/10	19.3	18.7	19.9	20.6	19.7	21.5	20.5	19.7	21.5	34	31	27.8	19.3	35.9	43.7	22.4	71.7	1,399
7/14/10	19.0	18.2	19.7	21.0	20.4	21.8	21.0	20.2	21.8	34	30	27.4	19.8	34.7	37.2	22.0	57.9	1,400
7/15/10	17.6	14.9	20.6	18.6	16.5	21.2	18.6	16.4	21.3	57	39	29.3	21.3	37.2	35.0	19.5	54.3	1,400
7/16/10	20.7	19.7	21.5	19.4	18.0	21.4	19.4	18.1	21.4	184	55	31.7	24.3	40.3	37.5	20.0	56.9	1,400
7/17/10	21.4	20.4	22.2	21.9	20.9	23.1	21.9	20.9	23.2	34	61	32.5	25.2	39.9	36.7	22.3	53.0	1,399
7/18/10	21.4	20.5	22.0	22.5	21.4	23.4	22.6	21.5	23.5	34	63	31.4	22.7	40.3	36.0	16.6	58.4	1,400
7/19/10	21.0	20.2	21.7	22.6	21.7	23.3	22.6	21.7	23.4	34	63	30.9	22.4	40.5	31.0	14.3	45.6	1,401
7/20/10	20.5	19.6	21.1	22.3	21.4	23.1	22.3	21.4	23.1	34	61	30.1	21.9	39.4	27.5	12.2	42.1	1,400
7/21/10	20.2	19.2	20.8	21.9	21.0	22.6	21.9	21.0	22.6	34	58	29.0	21.0	38.1	30.6	15.0	45.4	1,399
7/22/10	19.5	18.5	20.5	21.7	20.6	22.6	21.7	20.6	22.6	34	61	28.2	20.5	36.6	32.6	17.3	48.7	1,399
7/23/10	19.8	19.0	20.3	21.3	20.3	22.1	21.5	20.3	22.4	36	59	28.3	20.7	36.3	32.3	20.5	48.3	1,399
7/24/10	19.8	19.0	20.5	21.7	20.3	23.3	21.8	20.3	23.5	34	55	29.7	21.9	37.8	30.8	16.4	46.0	1,399
7/25/10	20.1	19.4	20.5	21.6	21.0	22.7	21.9	21.1	23.3	34	52	30.5	22.9	38.8	35.3	20.8	55.3	1,399
7/26/10	20.2	19.4	20.9	20.6	19.1	22.8	20.7	19.2	23.1	34	49	29.4	21.9	37.6	40.1	22.5	66.0	1,399
7/27/10	19.8	19.2	20.3	19.1	17.1	21.6	19.3	17.1	21.9	34	47	26.6	18.1	35.8	42.0	21.7	64.9	1,399
7/28/10	19.4	18.7	19.9	20.9	18.5	22.5	20.8	16.9	22.4	34	44	25.7	17.3	34.4	40.3	22.8	63.4	1,399
7/29/10	19.3	18.6	19.9	21.3	20.4	22.2	21.3	20.4	22.2	34	42	26.3	18.4	34.6	42.7	23.6	66.7	1,399
7/30/10	19.3	18.6	19.9	21.2	20.3	22.2	21.2	20.3	22.1	34	39	27.0	19.1	35.6	38.5	22.8	56.9	-
7/31/10	19.2	18.5	19.8	21.1	20.2	22.2	21.2	20.2	22.3	34	37	28.3	20.7	36.6	31.9	17.5	47.3	-

<sup>1</sup> All flow data is considered provisional until reviewed by USGS

<sup>2</sup> Redinger Lake Surface Elevation unavailable for 7/30-7/31

**Table A-10. August 2010 Air Temperature and Relative Humidity, Water Temperatures (Daily Means are Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek.**

Date	Redinger Lake at Dam 7 <sup>1</sup>			SJR Downstream of Dam 7			SJR Upstream of Willow Creek			Willow Creek			Willow Creek Bridge			SJR Downstream of Willow Creek <sup>1</sup>		
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum
8/1/10	16.8	14.5	20.1	13.5	13.2	14.1	14.6	13.5	16.0	21.1	19.2	22.6	21.2	19.3	22.7	15.1	14.3	16.0
8/2/10	16.6	14.6	19.6	13.6	13.3	14.1	14.6	13.6	16.1	20.9	18.9	22.4	21.0	19.2	22.6	15.1	14.2	16.1
8/3/10	17.1	14.8	19.4	13.7	13.4	14.1	14.7	13.6	16.2	20.6	18.8	22.0	20.7	18.8	22.3	15.1	14.2	16.1
8/4/10	16.9	14.6	18.9	13.8	13.5	14.2	14.7	13.7	16.1	20.7	19.0	21.9	20.6	18.6	22.2	15.2	14.2	16.3
8/5/10	16.7	14.7	18.5	13.9	13.6	14.3	14.9	13.8	16.3	20.8	19.1	22.1	20.7	18.8	22.3	15.3	14.3	16.3
8/6/10	16.5	14.8	18.3	14.0	13.6	14.4	14.9	13.9	16.3	20.8	19.1	22.1	20.8	19.0	22.3	15.3	14.4	16.3
8/7/10	16.7	14.9	18.5	14.0	13.7	14.5	14.9	14.0	16.4	20.8	19.2	21.9	20.7	18.9	22.1	15.3	14.5	16.3
8/8/10	16.7	15.0	18.6	14.1	13.9	14.6	15.0	14.1	16.4	20.8	19.3	21.9	20.8	19.1	22.1	15.5	14.6	16.4
8/9/10	17.0	15.1	18.8	14.2	14.0	14.6	15.1	14.2	16.5	20.8	19.1	21.9	20.8	19.2	22.2	15.5	14.6	16.5
8/10/10	16.7	15.3	18.7	14.3	14.0	14.7	15.1	14.2	16.8	21.9	20.1	23.7	20.7	18.9	22.1	15.3	14.7	16.4
8/11/10	17.4	15.6	18.8	14.4	14.1	14.8	15.2	14.3	16.2	22.0	20.2	23.7	20.6	19.1	21.7	-	-	-
8/12/10	-	-	-	14.4	14.1	14.9	15.2	14.3	16.2	23.0	21.8	24.3	20.1	18.3	21.5	-	-	-
8/13/10	-	-	-	14.6	14.3	15.0	15.3	14.5	16.4	24.0	22.5	25.4	20.6	18.7	22.1	-	-	-
8/14/10	-	-	-	14.6	14.4	15.0	15.4	14.6	16.6	24.3	22.3	26.2	21.2	19.6	22.4	-	-	-
8/15/10	-	-	-	14.8	14.5	15.2	15.5	14.7	16.6	23.9	21.7	26.0	21.4	19.8	22.6	-	-	-
8/16/10	-	-	-	14.8	14.3	15.2	15.6	14.7	16.7	23.2	21.0	25.4	21.4	19.7	22.6	-	-	-
8/17/10	-	-	-	14.9	14.6	15.3	15.6	14.8	16.6	22.7	20.7	24.6	21.5	19.9	22.5	-	-	-
8/18/10	-	-	-	15.0	14.6	15.4	15.7	14.9	16.8	22.2	20.2	24.1	21.3	19.8	22.5	-	-	-
8/19/10	-	-	-	15.1	14.8	15.4	15.7	14.9	16.8	21.9	19.9	23.7	21.2	19.6	22.1	-	-	-
8/20/10	-	-	-	15.2	15.0	15.5	15.8	15.1	16.9	22.0	20.3	23.7	21.0	19.5	22.0	-	-	-
8/21/10	-	-	-	15.3	15.1	15.5	15.9	15.3	16.9	22.7	21.2	24.1	20.6	19.2	21.7	-	-	-
8/22/10	-	-	-	15.4	15.1	15.7	16.0	15.2	17.1	22.9	21.6	24.2	21.1	20.0	22.0	-	-	-
8/23/10	-	-	-	15.4	15.1	15.8	16.0	15.2	17.1	22.7	20.7	24.4	20.3	18.7	21.3	-	-	-
8/24/10	-	-	-	15.6	15.3	16.0	16.2	15.3	17.3	21.9	19.9	23.7	20.7	19.0	21.9	-	-	-
8/25/10	-	-	-	15.7	15.4	16.0	16.4	15.7	17.5	21.7	20.1	23.3	21.8	20.2	23.0	-	-	-
8/26/10	-	-	-	15.8	15.4	16.1	16.6	16.0	17.5	21.8	20.0	23.4	23.0	21.8	24.1	-	-	-
8/27/10	-	-	-	15.9	15.6	16.1	16.5	15.9	17.4	21.8	19.9	23.4	22.5	21.3	23.4	-	-	-
8/28/10	-	-	-	15.8	15.5	15.9	16.1	15.7	16.8	21.4	19.3	23.1	20.2	19.2	21.9	-	-	-
8/29/10	-	-	-	15.8	15.6	16.0	16.3	15.8	17.2	21.1	19.2	22.6	18.9	17.9	19.7	-	-	-
8/30/10	-	-	-	15.9	15.7	16.2	16.3	15.6	17.4	20.9	18.8	22.4	18.4	17.1	19.2	-	-	-
8/31/10	-	-	-	15.9	15.6	16.3	16.4	15.6	17.5	20.6	18.7	22.1	18.4	17.0	19.4	-	-	-

<sup>1</sup>Data from temperature recorders located at Redinger Lake, SJR Downstream of Willow Creek, Horseshoe Bend East and Horseshoe Bend West lost due to Onset Shuttle firmware problem.

**Table A-10. August 2010 Air Temperature and Relative Humidity, Water Temperatures (Daily Means are Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek (continued).**

Date	SJR Horseshoe Bend (East) <sup>1</sup>			SJR Horseshoe Bend (West)*			SJR Upstream of Powerhouse 4			Flows (cfs) <sup>2</sup>		Dam 7			Dam 7			Redinger Lake
	Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek	Air Temperature Recorder			Relative Humidity			Surface Water Elevation <sup>3</sup>
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	D/S Dam 7	WC Bridge	Mean (°C)	Minimum	Maximum	Mean	Minimum	Maximum	(Feet)
8/1/10	18.9	18.2	19.5	21.0	20.1	22.1	21.0	20.0	22.0	34	36	28.2	20.6	36.7	27.9	15.2	42.0	-
8/2/10	18.7	18.0	19.4	20.8	19.9	21.6	20.8	19.9	21.7	34	34	27.8	20.6	35.8	29.2	16.4	41.9	-
8/3/10	18.5	17.8	19.2	20.6	19.6	21.4	20.6	19.6	21.6	34	41	28.5	21.5	36.8	23.5	12.9	35.2	1,399
8/4/10	18.4	17.7	19.1	20.4	19.5	21.3	20.5	19.5	21.5	34	30	28.9	21.8	36.7	22.6	12.4	35.9	1,400
8/5/10	18.5	17.7	19.2	20.5	19.6	21.3	20.5	19.6	21.5	34	29	29.1	21.9	37.5	24.2	12.8	38.0	1,400
8/6/10	18.5	17.8	19.2	20.5	19.6	21.3	20.5	19.6	21.5	34	28	27.7	19.9	36.4	29.5	18.4	48.5	1,400
8/7/10	18.5	17.8	19.2	20.5	19.7	21.2	20.5	19.7	21.4	34	27	27.2	19.8	35.1	30.9	19.0	44.7	1,400
8/8/10	18.5	17.8	19.2	20.5	19.7	21.4	20.6	19.7	21.5	34	26	26.7	20.2	34.5	33.4	19.8	47.0	1,400
8/9/10	18.6	17.9	19.3	20.5	19.7	21.4	20.6	19.8	21.5	34	25	26.9	19.7	33.8	33.9	21.2	50.2	-
8/10/10	18.5	17.8	19.2	20.5	19.6	21.4	20.6	19.7	21.5	33	24	26.4	19.0	34.2	33.8	19.6	47.0	-
8/11/10	18.2	17.8	18.6	20.2	19.7	20.7	20.5	19.7	21.4	34	23	25.9	17.9	34.0	38.3	22.6	57.0	-
8/12/10	-	-	-	-	-	-	20.3	19.5	21.3	33	24	24.7	17.4	32.8	34.2	17.6	48.9	-
8/13/10	-	-	-	-	-	-	20.3	19.5	21.2	33	28	25.2	17.7	33.0	40.3	23.8	60.0	-
8/14/10	-	-	-	-	-	-	20.6	19.7	21.7	34	18	27.0	19.4	35.3	38.6	22.3	56.8	-
8/15/10	-	-	-	-	-	-	20.9	20.1	22.0	33	17	27.2	20.4	34.7	38.7	25.6	56.9	-
8/16/10	-	-	-	-	-	-	21.0	20.1	21.9	34	26	27.3	19.5	35.3	35.7	23.1	55.8	1,399
8/17/10	-	-	-	-	-	-	21.0	20.2	22.0	34	18	28.5	21.0	37.0	33.6	17.4	54.2	1,400
8/18/10	-	-	-	-	-	-	21.0	20.3	21.9	34	16	29.8	21.2	38.8	24.3	11.9	37.8	1,400
8/19/10	-	-	-	-	-	-	20.9	20.2	21.8	34	16	28.1	20.7	36.9	27.6	16.7	44.5	1,399
8/20/10	-	-	-	-	-	-	20.8	19.8	21.7	34	15	27.9	20.5	36.6	29.2	16.1	42.2	1,399
8/21/10	-	-	-	-	-	-	20.6	19.9	21.3	34	17	28.5	20.5	37.3	25.9	13.7	40.3	1,399
8/22/10	-	-	-	-	-	-	20.7	19.9	21.7	33	13	27.0	19.7	35.0	28.5	11.4	52.7	-
8/23/10	-	-	-	-	-	-	20.6	19.7	21.6	34	12	24.1	15.7	33.1	32.4	15.7	50.6	-
8/24/10	-	-	-	-	-	-	20.6	19.6	21.8	34	28	29.7	22.0	40.1	23.7	9.0	43.3	1,400
8/25/10	-	-	-	-	-	-	21.1	20.1	22.1	33	11	35.3	28.7	42.8	18.6	9.6	29.7	1,399
8/26/10	-	-	-	-	-	-	21.7	20.9	22.9	33	11	34.3	27.2	43.6	26.7	12.3	39.7	1,399
8/27/10	-	-	-	-	-	-	21.8	20.8	22.8	33	11	29.8	20.5	40.8	29.6	14.0	49.2	1,399
8/28/10	-	-	-	-	-	-	20.8	20.1	21.6	33	10	23.7	13.2	36.3	29.0	11.5	46.4	1,399
8/29/10	-	-	-	-	-	-	20.1	19.3	21.1	33	10	19.7	14.8	26.6	37.8	20.4	51.3	1,400
8/30/10	-	-	-	-	-	-	19.5	18.6	20.4	34	10	19.0	12.3	25.7	45.7	26.6	66.2	1,401
8/31/10	-	-	-	-	-	-	19.4	18.4	20.4	34	10	20.4	13.1	28.0	43.0	25.9	64.7	1,400

<sup>1</sup>Data from temperature recorders located at Redinger Lake, SJR Downstream of Willow Creek, Horseshoe Bend East and Horseshoe Bend West lost due to Onset Shuttle firmware problem.

<sup>2</sup> All flow data is considered provisional until reviewed by USGS

<sup>3</sup>Redinger Lake Surface Elevation data unavailable for the following dates: 8/1-8/2; 8/9-8/15; 8/22-8/23.



**Table A-11. September 2010 Air Temperature and Relative Humidity, Water Temperatures (Daily Mean Temperatures Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek.**

Date	Redinger Lake at Dam 7 <sup>1</sup>			SJR Downstream of Dam 7			SJR Upstream of Willow Creek			Willow Creek			Willow Creek Bridge			SJR Downstream of Willow Creek <sup>1</sup>		
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum
9/1/10	-	-	-	16.0	15.6	16.4	16.5	15.7	17.6	20.7	18.8	22.0	18.9	17.3	19.9	-	-	-
9/2/10	-	-	-	16.0	15.8	16.3	16.6	15.9	17.6	20.8	19.0	22.2	19.6	18.1	20.7	-	-	-
9/3/10	-	-	-	16.7	15.8	17.8	16.8	15.9	18.0	20.8	19.0	22.2	20.3	18.8	21.6	-	-	-
9/4/10	-	-	-	18.1	17.2	19.3	18.1	17.3	19.1	20.8	19.1	22.0	20.9	19.4	22.5	-	-	-
9/5/10	-	-	-	18.0	17.3	19.0	18.0	17.4	18.8	20.9	19.2	22.0	20.8	19.3	22.5	-	-	-
9/6/10	-	-	-	17.9	17.5	18.6	17.9	17.6	18.5	20.8	18.9	22.1	20.5	19.0	22.0	-	-	-
9/7/10	-	-	-	17.8	17.5	18.2	17.8	17.5	18.3	20.8	19.1	21.9	20.4	18.9	22.1	-	-	-
9/8/10	-	-	-	17.6	17.5	17.8	17.7	17.5	17.9	20.3	18.3	21.8	19.3	18.3	19.9	-	-	-
9/9/10	-	-	-	17.5	17.4	17.7	17.6	17.4	17.9	20.3	18.8	21.4	18.8	17.5	20.2	-	-	-
9/10/10	-	-	-	17.7	17.3	18.0	17.7	17.3	18.1	21.0	19.6	21.9	18.4	17.1	19.8	-	-	-
9/11/10	-	-	-	17.2	16.2	18.1	17.9	16.6	19.2	21.4	19.9	22.3	18.5	17.1	20.1	-	-	-
9/12/10	-	-	-	16.1	15.7	16.5	16.6	16.1	17.4	21.4	19.7	22.6	18.7	17.2	20.3	-	-	-
9/13/10	-	-	-	16.1	15.5	16.3	16.4	15.9	17.2	21.5	20.0	22.5	18.5	17.1	20.1	-	-	-
9/14/10	-	-	-	16.1	15.7	16.4	16.5	16.0	17.2	21.4	19.9	22.7	18.5	17.1	20.2	-	-	-
9/15/10	-	-	-	16.1	15.6	16.4	16.4	16.0	17.1	21.4	19.7	22.5	18.5	17.1	20.2	-	-	-
9/16/10	-	-	-	16.1	15.8	16.3	16.4	15.9	17.2	21.1	19.7	22.3	18.3	16.9	20.0	-	-	-
9/17/10	-	-	-	16.1	15.8	16.4	16.5	16.0	17.2	20.8	19.2	22.2	18.4	17.0	20.0	-	-	-
9/18/10	-	-	-	16.2	15.7	16.6	16.6	16.0	17.2	21.0	20.0	21.9	18.8	17.4	20.3	-	-	-
9/19/10	-	-	-	16.2	15.9	16.6	16.6	16.1	17.4	20.6	18.8	22.4	19.1	17.8	20.7	-	-	-
9/20/10	-	-	-	16.3	15.8	16.6	16.6	16.0	17.3	20.5	19.1	21.6	18.9	17.7	20.5	-	-	-
9/21/10	-	-	-	16.2	15.7	16.6	16.6	16.1	17.2	21.3	20.2	22.2	18.6	17.4	20.2	-	-	-
9/22/10	-	-	-	16.2	15.8	16.6	16.5	16.2	17.1	22.6	21.8	23.4	18.2	17.2	19.5	-	-	-
9/23/10	-	-	-	16.3	15.9	16.7	16.6	16.0	17.2	22.8	21.3	24.4	17.6	16.2	19.2	-	-	-
9/24/10	-	-	-	16.3	15.8	16.6	16.6	16.0	17.4	21.6	19.5	23.8	17.7	16.2	19.3	-	-	-
9/25/10	-	-	-	16.4	15.9	16.9	16.7	16.1	17.5	19.3	18.2	20.9	18.2	16.7	20.0	-	-	-
9/26/10	-	-	-	16.5	16.0	16.7	16.8	16.2	17.6	18.8	17.4	20.3	18.4	17.0	20.2	-	-	-
9/27/10	-	-	-	16.6	16.0	17.1	16.9	16.4	17.7	18.5	17.2	19.8	18.9	17.4	20.7	-	-	-
9/28/10	-	-	-	16.7	16.2	17.0	17.1	16.6	17.7	18.7	17.6	19.8	19.5	18.0	21.0	-	-	-
9/29/10	-	-	-	16.7	16.3	17.0	17.1	16.8	17.8	19.3	18.3	20.3	20.0	18.6	21.6	-	-	-
9/30/10	-	-	-	16.8	16.3	17.1	17.1	16.8	17.6	20.0	19.0	21.1	20.2	19.2	21.2	-	-	-

<sup>1</sup>Data from temperature recorders located at Redinger Lake, SJR Downstream of Willow Creek, Horseshoe Bend East and Horseshoe Bend West lost due to Onset Shuttle firmware problem.

**Table A-11. September 2010 Air Temperature and Relative Humidity, Water Temperatures (Daily Mean Temperatures Rounded to Nearest 0.1 °C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek (continued).**

Date	SJR Horseshoe Bend (East) <sup>1</sup>			SJR Horseshoe Bend (West)*			SJR Upstream of Powerhouse 4			Flows (cfs) <sup>2</sup>		Dam 7			Dam 7			Redinger Lake
	Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek	Air Temperature Recorder			Relative Humidity			Surface Water Elevation <sup>3</sup>
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	D/S Dam 7	WC Bridge	Mean (°C)	Minimum	Maximum	Mean	Minimum	Maximum	(Feet)
9/1/10	-	-	-	-	-	-	19.4	18.5	20.3	34	11	22.8	15.3	32.3	40.6	21.2	58.4	1,400
9/2/10	-	-	-	-	-	-	19.8	18.8	21.0	34	11	27.2	19.8	36.9	29.4	14.1	42.6	1,400
9/3/10	-	-	-	-	-	-	19.4	17.5	21.3	33	10	31.1	24.3	39.7	20.8	10.4	36.7	1,399
9/4/10	-	-	-	-	-	-	18.5	17.5	20.1	1,137	6	30.8	22.9	39.2	24.4	13.9	42.5	1,399
9/5/10	-	-	-	-	-	-	18.2	17.4	19.4	1,733	3	29.3	22.3	38.5	24.6	12.5	41.5	1,399
9/6/10	-	-	-	-	-	-	18.1	17.5	18.9	1,764	3	26.5	18.3	36.3	28.3	12.5	48.9	1,399
9/7/10	-	-	-	-	-	-	18.1	17.5	19.1	1,610	2	26.5	19.1	35.2	30.9	18.4	52.0	1,399
9/8/10	-	-	-	-	-	-	17.8	17.4	18.2	1,545	2	22.1	13.2	35.2	39.2	14.7	61.1	1,400
9/9/10	-	-	-	-	-	-	17.8	17.3	18.5	1,619	2	17.3	10.1	23.6	63.0	39.8	88.4	1,400
9/10/10	-	-	-	-	-	-	17.8	17.1	18.9	1,677	2	18.6	11.8	28.0	53.5	29.6	79.9	1,399
9/11/10	-	-	-	-	-	-	18.1	17.3	19.2	1,677	3	22.5	15.2	33.2	39.9	15.9	59.4	1,400
9/12/10	-	-	-	-	-	-	19.0	17.8	20.2	1,677	3	24.5	16.3	33.8	29.6	15.9	42.5	1,399
9/13/10	-	-	-	-	-	-	19.4	18.2	20.4	1,677	2	26.1	19.7	34.2	21.9	12.4	37.0	1,399
9/14/10	-	-	-	-	-	-	19.6	18.7	20.6	1,677	2	24.9	17.7	33.7	26.6	13.5	42.9	1,399
9/15/10	-	-	-	-	-	-	19.2	18.2	20.1	1,677	2	23.5	17.0	32.2	31.3	18.8	49.3	1,399
9/16/10	-	-	-	-	-	-	18.9	17.9	19.7	33	2	22.7	14.4	32.5	29.9	15.0	46.2	-
9/17/10	-	-	-	-	-	-	18.9	17.9	19.8	33	2	22.5	13.8	32.7	37.1	18.7	54.7	-
9/18/10	-	-	-	-	-	-	19.0	17.9	20.0	34	2	24.0	17.1	32.9	36.8	19.9	54.2	-
9/19/10	-	-	-	-	-	-	19.2	18.3	20.2	34	2	23.5	17.2	32.2	43.7	27.6	62.9	-
9/20/10	-	-	-	-	-	-	19.1	18.2	20.0	34	2	21.8	15.3	30.5	44.3	27.4	60.8	-
9/21/10	-	-	-	-	-	-	19.1	18.2	20.0	34	2	20.9	13.7	29.2	48.2	29.6	67.5	-
9/22/10	-	-	-	-	-	-	18.9	18.1	19.8	34	2	19.9	13.1	29.4	44.6	27.0	63.5	-
9/23/10	-	-	-	-	-	-	18.5	17.6	19.5	34	2	17.3	9.5	28.4	51.9	27.8	79.0	-
9/24/10	-	-	-	-	-	-	18.5	17.5	19.4	33	2	20.6	11.3	32.3	47.2	22.4	70.6	-
9/25/10	-	-	-	-	-	-	18.6	17.6	19.6	34	2	26.6	18.9	36.5	27.7	11.8	53.0	-
9/26/10	-	-	-	-	-	-	18.9	17.8	19.9	34	2	29.1	20.4	37.3	21.6	13.1	38.1	-
9/27/10	-	-	-	-	-	-	19.1	18.2	19.8	34	2	29.5	22.1	39.9	22.4	11.3	42.9	-
9/28/10	-	-	-	-	-	-	19.4	18.4	20.3	33	2	32.3	26.7	40.6	18.2	11.5	34.2	-
9/29/10	-	-	-	-	-	-	19.8	19.0	20.4	33	2	28.3	20.2	40.6	31.8	12.6	51.9	-
9/30/10	-	-	-	-	-	-	19.9	19.2	20.3	964	2	28.6	21.1	39.2	30.7	15.8	46.3	1,399

<sup>1</sup>Data from temperature recorders located at Redinger Lake, SJR Downstream of Willow Creek, Horseshoe Bend East and Horseshoe Bend West lost due to Onset Shuttle firmware problem.

<sup>2</sup> All flow data is considered provisional until reviewed by USGS

<sup>3</sup>Redinger Lake Surface Elevation data unavailable for the following dates: 9/16-9/29.

**Table A-12. October 2010 Air Temperature and Relative Humidity, Water Temperatures (Daily Means are Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek.**

Date	Redinger Lake at Dam 7 <sup>1</sup>			SJR Downstream of Dam 7			SJR Upstream of Willow Creek			Willow Creek			Willow Creek Bridge <sup>1</sup>			SJR Downstream of Willow Creek <sup>1</sup>		
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum
10/1/10	-	-	-	16.7	16.4	17.0	17.0	16.8	17.5	20.4	19.4	22.1	20.4	19.6	21.1	-	-	-
10/2/10	-	-	-	17.0	16.6	17.3	17.3	16.9	18.1	20.7	19.4	22.4	20.6	19.7	21.7	-	-	-
10/3/10	-	-	-	16.9	16.6	17.3	17.1	16.9	17.7	20.4	19.1	21.7	20.4	20.0	21.1	-	-	-
10/4/10	-	-	-	16.9	16.6	17.3	17.0	16.8	17.3	20.3	19.0	21.9	18.7	17.0	19.9	-	-	-
10/5/10	-	-	-	16.9	16.7	17.1	16.9	16.8	17.2	20.0	18.3	21.7	16.3	15.8	17.0	-	-	-
10/6/10	-	-	-	16.9	16.8	17.2	16.8	16.6	17.2	18.8	17.5	19.8	15.1	14.6	15.7	-	-	-
10/7/10	-	-	-	17.0	16.7	17.2	16.6	16.2	17.0	18.6	17.2	20.5	-	-	-	-	-	-
10/8/10	-	-	-	16.8	16.6	17.0	16.8	16.4	17.2	18.5	17.2	20.5	-	-	-	-	-	-
10/9/10	-	-	-	16.8	16.6	16.9	16.7	16.4	17.3	18.6	17.4	20.5	-	-	-	-	-	-
10/10/10	-	-	-	16.7	16.6	16.9	16.8	16.4	17.4	18.6	17.3	20.6	-	-	-	-	-	-
10/11/10	-	-	-	16.7	16.6	17.0	16.9	16.5	17.6	18.5	17.2	20.3	-	-	-	-	-	-
10/12/10	-	-	-	16.7	16.5	16.9	16.9	16.5	17.6	18.5	17.3	20.2	-	-	-	-	-	-
10/13/10	-	-	-	16.8	16.5	17.0	17.0	16.6	17.7	18.4	17.0	20.2	-	-	-	-	-	-
10/14/10	-	-	-	16.7	16.5	16.8	17.0	16.6	17.7	18.3	17.0	19.7	-	-	-	-	-	-
10/15/10	-	-	-	16.6	16.5	16.7	16.8	16.5	17.5	18.5	17.5	19.9	-	-	-	-	-	-
10/16/10	-	-	-	16.5	16.4	16.7	16.7	16.4	17.4	18.8	17.9	20.1	-	-	-	-	-	-
10/17/10	-	-	-	16.4	16.2	16.6	16.5	16.4	16.8	18.9	17.7	20.5	-	-	-	-	-	-
10/18/10	-	-	-	16.3	16.3	16.4	16.5	16.2	16.9	18.7	17.4	20.4	-	-	-	-	-	-
10/19/10	-	-	-	16.3	16.2	16.5	16.4	16.0	16.9	18.5	17.3	20.1	-	-	-	-	-	-
10/20/10	-	-	-	16.2	16.1	16.4	16.3	16.0	16.8	17.8	16.3	19.7	-	-	-	-	-	-
10/21/10	-	-	-	16.0	15.7	16.2	16.2	15.9	16.7	17.6	16.3	19.1	-	-	-	-	-	-
10/22/10	-	-	-	15.8	15.7	16.0	16.0	15.7	16.6	17.9	16.9	19.0	-	-	-	-	-	-
10/23/10	-	-	-	15.8	15.7	15.9	15.9	15.7	16.3	18.2	17.1	19.2	-	-	-	-	-	-
10/24/10	-	-	-	15.8	15.7	16.0	15.9	15.7	16.1	18.5	17.5	19.4	-	-	-	-	-	-
10/25/10	-	-	-	15.8	15.6	16.0	15.2	14.7	15.8	18.9	18.0	19.7	-	-	-	-	-	-
10/26/10	-	-	-	15.5	15.2	15.7	14.8	14.4	15.2	19.4	18.5	20.0	-	-	-	-	-	-
10/27/10	-	-	-	15.0	14.4	15.2	14.5	14.0	14.9	19.7	18.9	20.3	-	-	-	-	-	-
10/28/10	-	-	-	14.4	13.7	15.0	14.0	13.5	14.8	20.0	19.5	20.3	-	-	-	-	-	-
10/29/10	-	-	-	13.8	13.4	14.1	13.5	13.2	14.1	20.1	19.6	20.5	-	-	-	-	-	-
10/30/10	-	-	-	13.5	13.3	13.6	13.3	13.2	13.6	20.3	19.9	20.7	-	-	-	-	-	-
10/31/10	-	-	-	13.2	13.0	13.4	13.1	12.9	13.4	20.1	19.1	20.8	-	-	-	-	-	-

<sup>1</sup>Data from temperature recorders located at Redinger Lake, SJR Downstream of Willow Creek, Horseshoe Bend East and Horseshoe Bend West lost due to Onset Shuttle firmware problem.

**Table A-12. October 2010 Air Temperature and Relative Humidity, Water Temperatures (Daily Means are Rounded to Nearest 0.1°C) and Flows for the Horseshoe Bend Reach of the San Joaquin River and Willow Creek (continued).**

Date	SJR Horseshoe Bend (East) <sup>1</sup>			SJR Horseshoe Bend (West) <sup>1</sup>			SJR Upstream of Powerhouse 4 <sup>2</sup>			Flows (cfs) <sup>3</sup>		Dam 7			Dam 7			Redinger Lake
	Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek	Air Temperature Recorder			Relative Humidity			Surface Water Elevation <sup>4</sup>
	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	D/S Dam 7	WC Bridge	Mean (°C)	Minimum	Maximum	Mean	Minimum	Maximum	(Feet)
10/1/10	-	-	-	-	-	-	19.9	19.3	20.4	33	2	28.0	21.8	37.0	33.8	19.4	48.8	1,399
10/2/10	-	-	-	-	-	-	19.9	19.2	20.4	33	2	27.6	21.7	34.9	36.1	21.9	46.6	1,397
10/3/10	-	-	-	-	-	-	19.7	19.5	20.3	33	2	23.3	18.7	34.5	60.5	23.8	86.0	1,394
10/4/10	-	-	-	-	-	-	19.3	18.7	19.6	33	2	20.1	15.0	25.8	74.0	46.8	96.7	1,394
10/5/10	-	-	-	-	-	-	18.3	17.7	18.7	34	17	14.4	12.7	16.5	93.0	82.4	99.1	-
10/6/10	-	-	-	-	-	-	17.5	17.1	18.0	33	8	13.8	9.3	20.0	80.8	48.7	95.7	1,394
10/7/10	-	-	-	-	-	-	17.0	16.7	17.5	33	10	13.5	9.9	20.6	86.3	52.4	99.6	1,394
10/8/10	-	-	-	-	-	-	-	-	-	33	23	15.9	10.3	24.0	72.4	41.1	92.2	1,394
10/9/10	-	-	-	-	-	-	-	-	-	33	8	17.0	10.6	25.8	70.2	38.1	92.8	1,393
10/10/10	-	-	-	-	-	-	-	-	-	33	6	18.4	11.2	28.5	69.2	35.6	94.9	1,393
10/11/10	-	-	-	-	-	-	-	-	-	33	6	20.5	13.5	30.3	62.7	32.5	86.2	1,392
10/12/10	-	-	-	-	-	-	-	-	-	33	5	21.1	13.2	31.6	64.8	32.0	92.5	1,392
10/13/10	-	-	-	-	-	-	-	-	-	33	4	25.1	18.2	33.7	42.3	21.7	68.6	1,390
10/14/10	-	-	-	-	-	-	-	-	-	33	4	25.9	20.3	34.9	40.6	18.3	68.9	1,389
10/15/10	-	-	-	-	-	-	-	-	-	33	4	26.4	21.1	35.5	29.1	14.3	48.5	1,383
10/16/10	-	-	-	-	-	-	-	-	-	33	3	25.8	20.9	34.6	29.5	17.6	49.6	-
10/17/10	-	-	-	-	-	-	-	-	-	33	3	21.9	17.1	32.7	49.4	21.0	73.7	-
10/18/10	-	-	-	-	-	-	-	-	-	33	4	15.2	13.1	18.9	83.6	57.9	94.8	1,382
10/19/10	-	-	-	-	-	-	-	-	-	33	4	14.1	8.3	22.6	78.7	52.4	97.9	1,378
10/20/10	-	-	-	-	-	-	-	-	-	33	4	15.9	10.0	26.2	75.7	34.0	97.4	1,377
10/21/10	-	-	-	-	-	-	-	-	-	33	4	18.7	13.4	27.2	62.5	31.3	81.6	1,378
10/22/10	-	-	-	-	-	-	-	-	-	33	4	16.0	10.1	24.4	70.1	44.4	93.2	1,377
10/23/10	-	-	-	-	-	-	-	-	-	33	4	16.6	13.5	22.8	67.4	41.9	85.2	1,377
10/24/10	-	-	-	-	-	-	-	-	-	33	4	15.6	13.3	20.0	85.6	56.4	98.9	1,377
10/25/10	-	-	-	-	-	-	-	-	-	33	6	14.3	10.2	19.2	93.0	52.0	100.0	1,375
10/26/10	-	-	-	-	-	-	-	-	-	33	247	11.8	6.2	20.1	81.9	49.1	99.6	1,375
10/27/10	-	-	-	-	-	-	-	-	-	33	26	11.4	4.7	20.6	67.7	29.6	91.9	1,375
10/28/10	-	-	-	-	-	-	-	-	-	32	11	15.2	9.7	25.2	48.2	21.5	77.1	1,374
10/29/10	-	-	-	-	-	-	-	-	-	31	9	17.9	12.8	25.8	27.1	10.0	48.8	1,373
10/30/10	-	-	-	-	-	-	-	-	-	31	7	14.8	9.4	26.5	65.8	15.9	96.4	1,373
10/31/10	-	-	-	-	-	-	-	-	-	31	10	10.9	6.4	20.4	86.8	45.7	98.1	1,372

<sup>1</sup> Data from temperature recorders located at Redinger Lake, SJR Downstream of Willow Creek, Horseshoe Bend East and Horseshoe Bend West lost due to Onset Shuttle firmware problem.

<sup>2</sup> Data unavailable from loggers located at SJR Upstream of Powerhouse 4 from 10/8 is unavailable due to loggers being removed from the water.

<sup>3</sup> All flow data is considered provisional until reviewed by USGS <sup>4</sup> Redinger Lake Surface Elevation data unavailable for the following dates: 10/5; 10/16-10/17.