NATIVE AQUATIC SPECIES MANAGEMENT PLAN

2012 DATA COLLECTION AND BASELINE REPORT

DRAFT

Southern California Edison Company

Big Creek No. 4 Hydroelectric Project

FERC Project No. 2017

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LIST OF ACRONYMS/ABBREVIATIONS

°C	degrees Celsius
AMP	Adaptive Management Plan
ATS	Advanced Telemetry Systems Inc.
BC4	Big Creek No. 4
cfs	cubic feet per second
cm	centimeter(s)
cm/sec	centimeters per second
DO	dissolved oxygen
FERC	Federal Energy Regulatory Commission
FYLF	Foothill Yellow-Legged Frog
ft	foot
g	gram(s)
GPS	Global Positioning System
HSB	Horseshoe Bend
km	kilometer(s)
LWD	Large Woody Debris
m	meter(s)
mg/l	milligrams per liter
mm	millimeter(s)
msl	mean sea level
NASMP	Native Aquatic Species Management Plan
PG&E	Pacific Gas and Electric Company
PH3	Big Creek Powerhouse 3

PH4	Big Creek Powerhouse 4
SC	Specific Conductance
SCE	Southern California Edison Company
SJR	San Joaquin River
State Water Board	State Water Resources Control Board
TRG	Technical Review Group
USDA-FS	United States Department of Agriculture - Forest Service
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VES	Visual Encounter Surveys
WPT	Western Pond Turtle

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This report summarizes and compares the data collected in 2012 to previous year's data pursuant to the Native Aquatic Species Management Plan (NASMP). The management area includes Redinger Lake and the San Joaquin River (SJR) between Dam 7 and Big Creek Powerhouse 4 (PH4), also known as the Horseshoe Bend (HSB) reach. For the purpose of monitoring, Water Year 2012 was characterized as a non-spill year compared to Water Year 2011, which was characterized as a spill year. Monitoring in these two years completes the baseline data collection required in the NASMP. Key results of the 2012 monitoring are as follows:

Physical Data:

- Water Year 2012 in the San Joaquin Valley was classified as a dry water year (CDWR 2012).
- Water Year 2012 was considered to be a non-spill year for the purpose of monitoring with only a short duration, low magnitude spill that occurred in the HSB reach between April 22 and May 5.
- In contrast, Water Year 2011 was classified as a wet water year (CDWR 2012) with a prolonged spill occurring in the HSB reach between April 1 and August 19.
- Air temperatures in 2012 during the summer were some of the warmest on record and substantially higher than in 2011.
- Lower flows and warmer air temperatures in 2012 resulted in warmer water temperatures in the HSB reach compared to 2011.
- Redinger Lake was thermally stratified during the summer of 2012.
- No thermal stratification was observed in deep pools in the HSB reach in 2012.

Foothill Yellow-Legged Frog:

- No foothill yellow-legged frogs (FYLF) were detected in the HSB reach or associated tributary streams during Visual Encounter Surveys (VES) in 2012 or any previous year.

Western Pond Turtle:

- A total of 38 western pond turtles (WPT) were captured in 2012, with similar numbers of males and females captured. Willow Creek and the SJR Willow Creek confluence pool accounted for 25 of the 38 turtles captured.
- All the turtles appeared to be in good health.
- All suitable nesting habitat for WPTs was located above the potential inundation areas associated with proposed whitewater flow releases.

Mollusc:

- The mollusc populations in the HSB reach appear to be stable at most sites (Sites 5 and 6). Variation of numbers at Site 7 in 2012 compared to previous years may be a sampling artifact. Modification to the sampling strategy in future years is proposed to reduce this sampling variability.

Fish:

- Hardhead adult monitoring using radiotags did not reveal any substantial movement.
- Hardhead spawning was first observed in late May 2012 in the HSB reach.
- Sacramento suckers are the most abundance fish species present in the HSB reach (69.3 percent of the fish identified) followed by hardhead (11.7 percent), and Sacramento pikeminnow (7.3 percent). Rainbow trout, prickly sculpin, spotted bass and green sunfish were present in lower abundance.
- Multiple year classes of hardhead, Sacramento sucker, and Sacramento pikeminnow were observed.
- Age 0+ hardhead were much more abundant in 2012 (a non-spill year) compared to 2011 (a spill year).
- Overall, the native fish community is in good health and appears to be stable based on current and historical monitoring over a 26-year period.

1.0 INTRODUCTION

1.1 STUDY AREA DESCRIPTION

The Management Area addressed in the Native Aquatic Species Management Plan (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 (BC4) Hydroelectric Project owned and operated by Southern California Edison Company (SCE). The major components of the Project consist of Dam 7; a water conveyance system, which includes a tunnel, conduit and a penstock; and Big Creek Powerhouse 4 (PH4). The Management Area includes (1) Redinger Lake; (2) the San Joaquin River (SJR) downstream from Redinger Lake to the tailrace of PH4, also known as the Horseshoe Bend (HSB) reach; and (3) lower portions of tributary streams (Willow Creek and Backbone Creek flowing into the SJR). The Management Area is situated in an 11.55-mile (18.6-kilometer [km]) long, narrow canyon at elevations ranging between 985 feet (ft) above mean sea level (msl) at PH4 to 1,414 ft 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 ft (762 meters (m) and 914 m). Detailed descriptions of tributaries flowing into the SJR are provided in the NASMP.

1.2 2012 DATA COLLECTION OBJECTIVES

During 2012, data collection was completed consistent with the NASMP objectives. The monitoring objectives were identified in the Third Year Proposal Native Aquatic Species Management Plan (NASMP) and Adaptive Management Plan (AMP) (SCE 2012a), which was prepared in consultation with the Technical Review Group (TRG), approved by the United States Department of Agriculture - Forest Service (USDA-FS) and State Water Resources Control Board (State Water Board), and subsequently filed and approved by the Federal Energy Regulatory Commission (FERC).

1.2.1 PHYSICAL DATA

The objectives for physical data collection in 2012 included the following:

- Monitor water temperatures in the SJR between Dam 7 and PH4, as well as lower Willow Creek;
    - o Overwinter water temperatures will be recorded in the SJR between Dam 7 and PH4, and lower Willow Creek from November 2011 through April 2012 at four sites to characterize winter and spring water temperatures conditions;

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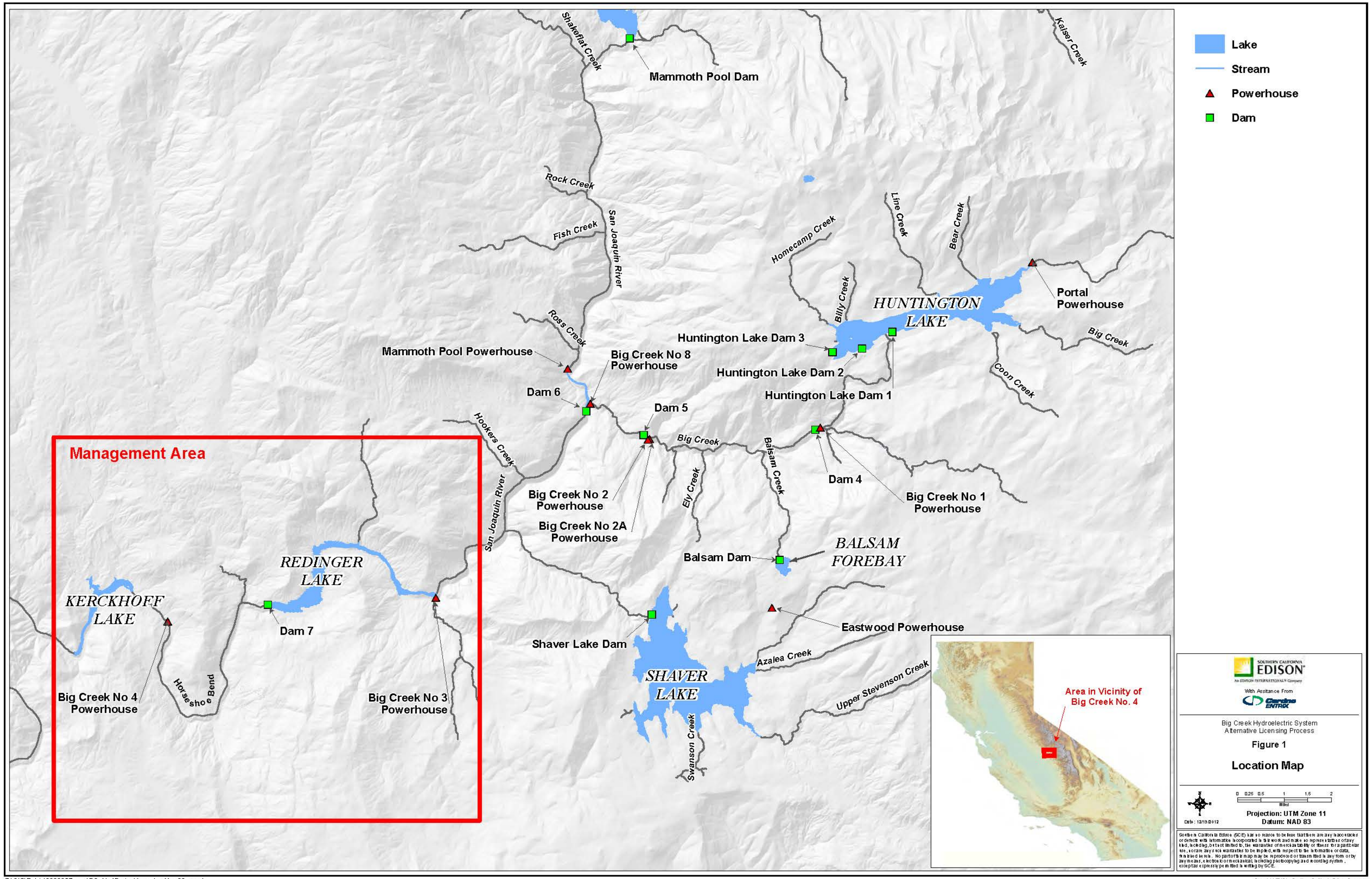

Figure 1. Location Map.

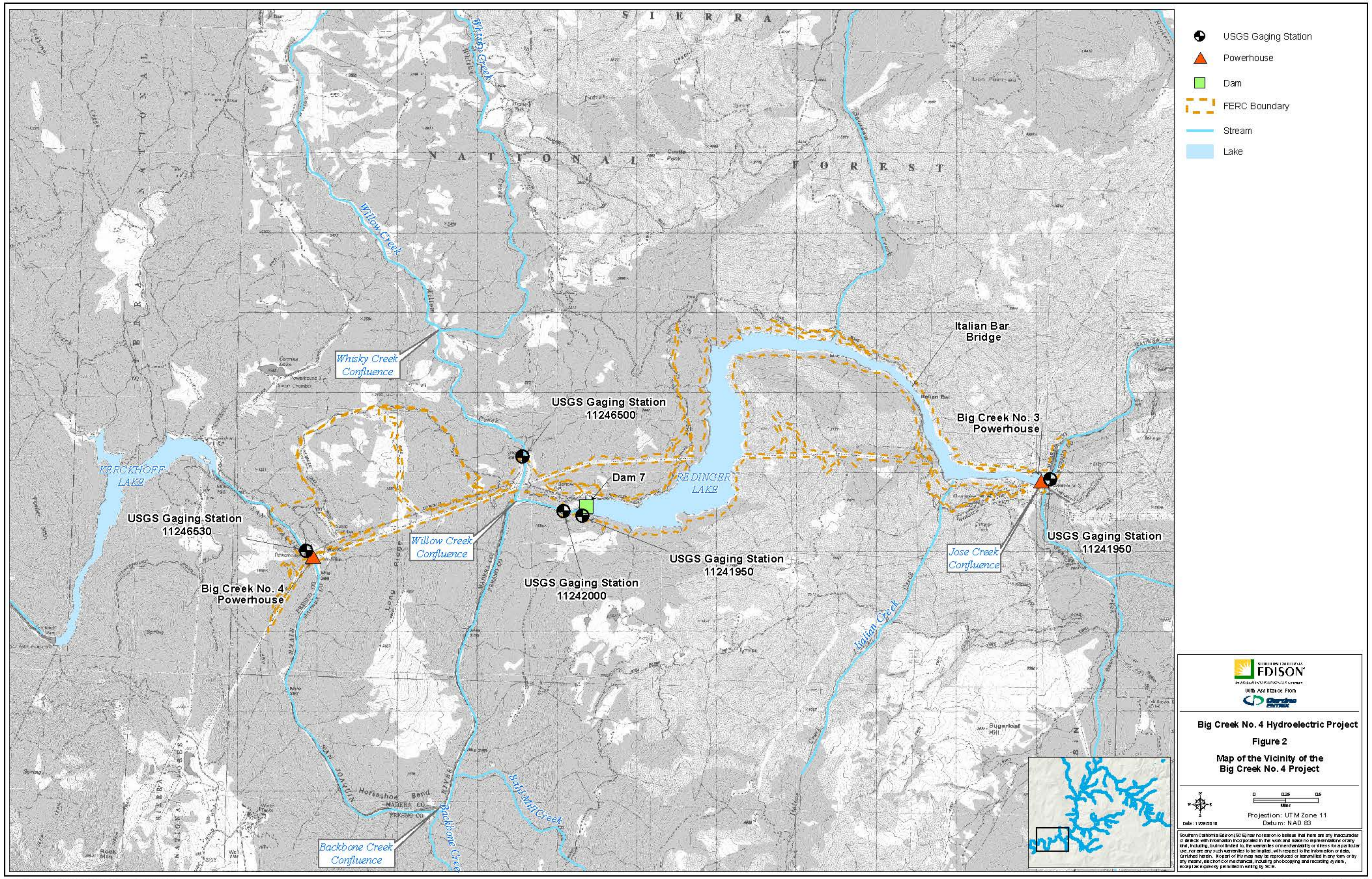

Figure 2. Map of the Vicinity of the Big Creek No. 4 Project.

  - o Summer-fall water temperatures will be recorded at six sites in the SJR between Dam 7 and PH4 and two sites in lower Willow Creek from May 1 to October 31, 2012;

- Monitor water temperature, dissolved oxygen (DO), and specific conductance (SC) profiles in Redinger Lake;

- Monitor water temperature profiles in three representative deep pools in the HSB reach to investigate the potential for thermal stratification;

- Monitor air temperature and relative humidity at Dam 7;

  - o Air temperature and relative humidity will be measured at Dam 7 for the summer-fall period. Air temperatures at a long-term historical site will be used to characterize the relative warmth (percent exceedance) of each summer month; and

- Characterize flow in the SJR and in lower Willow Creek.

Each of these objectives was met, except overwinter water temperature recorders were lost in the SJR downstream of Dam 7 and in Willow Creek; data were not available for these sites for most of the winter.

1.2.2 Amphibians and Reptiles

1.2.2.1 Foothill Yellow-Legged Frogs

For foothill yellow-legged frogs (FYLF), the 2012 objectives included the following:

- Establish presence/absence through visual encounter surveys (VES) for FYLF within the study area targeting all life history phases (i.e. egg masses, tadpoles, juveniles, and adults).

- Perform qualitative habitat characterizations for FYLF for the entire study area and collect qualitative and quantitative habitat data, if and where FYLF are found during the presence/absence surveys.

These objectives were met.

1.2.2.2 Western Pond Turtles

Western pond turtle (WPT) population size, demography, and status studies were conducted in the HSB based upon the following objectives:

- Collect additional information on the distribution of WPT in the HSB reach of the SJR;

- Estimate the age/size structure (i.e., juveniles and adults) of the WPT population;

- Monitor WPT population dynamics, particularly age/size structure, juvenile recruitment, and adult densities, to ascertain if the population is in good condition;

- Evaluate any external signs of disease and lesions for each individual and determine population health;

- Characterize habitat conditions in locations where WPT are found;

- Trap, mark, and tag adult female turtles with Global Positioning System (GPS) tags during spring for the primary purpose of locating nesting habitat sites and evaluating vulnerability of those sites to inundation during whitewater flow releases; and

- Determine if potential WPT nesting habitat exists at or below expected water level elevations during proposed whitewater flow releases at sites where WPT have been captured or observed in the HSB reach of the SJR. In addition, to locate and characterize potential WPT nesting habitat near these sites.

These objectives were met in 2012, except for tagging and tracking of female WPTs with GPS tags. This objective could not be met during 2012 because all females captured were deemed too small for the attachment of GPS tags. An alternative approach was used to meet this objective based on comparing the elevation of nesting habitat to the elevation of potential inundation by whitewater flows.

1.2.3 MOLLUSCS

For western pearlshell mussel in the HSB, the specific objective of the monitoring is:

- Provide a third year of baseline monitoring of western pearlshell mussels at the locations where mussel surveys were conducted in 2011.

This objective was met in 2012.

1.2.4 FISH

1.2.4.1 Hardhead Radiotracking

The hardhead radiotracking and spawning objective is:

- Confirm hardhead spawning areas and habitat use during 2012 by radiotracking 16 adult hardhead that were previously radiotagged in fall 2011.

This objective was met in 2012.

1.2.4.2 Larval Fish Sampling

The objective of this monitoring was to collect and identify fish larvae to confirm:

- Spawning success of hardhead and other native fish species;
- The timing of spawning; and
- Whether spawning takes place in the main stem of the SJR and/or Willow Creek.

This objective was met in 2012.

1.2.4.3 Fish Population Sampling

The objective of this monitoring is to:

- Describe fish population and community characteristics, including species abundance, distribution, population age structure, recruitment, growth, and condition using the methods of the NASMP (SCE 2008a) and as implemented in previous years.

This objective was met in 2012.

2.0 METHODS

2.1 PHYSICAL DATA

2.1.1 STREAM FLOW

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 (United States Geological Survey [USGS] Gage Nos. 11242000 and 11246500, respectively) operated by SCE. Provisional daily mean flow data for Water Year 2012 provided by SCE were used in this report. As shown in Figure 2, USGS Gage No. 11241950 records lake levels in Redinger Lake.

2.1.2 AIR TEMPERATURE

Air temperature and relative humidity were recorded between May 1 and September 30, 2012 adjacent to Dam 7. A HOBO air temperature and relative humidity recorder was installed at this location and functioned normally throughout the monitoring period.

2.1.3 WATER TEMPERATURE

2.1.3.1 Water Temperature Locations

Water temperature recorders were installed and operated at four locations in the SJR and one in Willow Creek from November 1, 2011 through April 30, 2012 to characterize overwinter water temperature conditions in the same locations as past studies (SCE 2008a). Water temperature monitoring locations are shown in Figure 3 for the overwinter data collection period.

Water temperatures were also monitored from May 1 to September 30, 2012 at all sites to characterize summer 2012 conditions. Figure 4 shows the locations monitored for the summer period. The water temperature monitoring sites (four overwinter / nine spring-summer) and serial numbers for the temperature loggers used are identified in Table 1.

In 2012, temperature profiles were measured in Redinger Lake during June and August at five locations and in October at three locations. Two locations were not accessible in October. Redinger Lake temperature profile stations are shown in Figure 4. Temperature profiles also were measured in three pools on the SJR within the HSB reach in August. River pool temperature profile sites also are shown on Figure 4.

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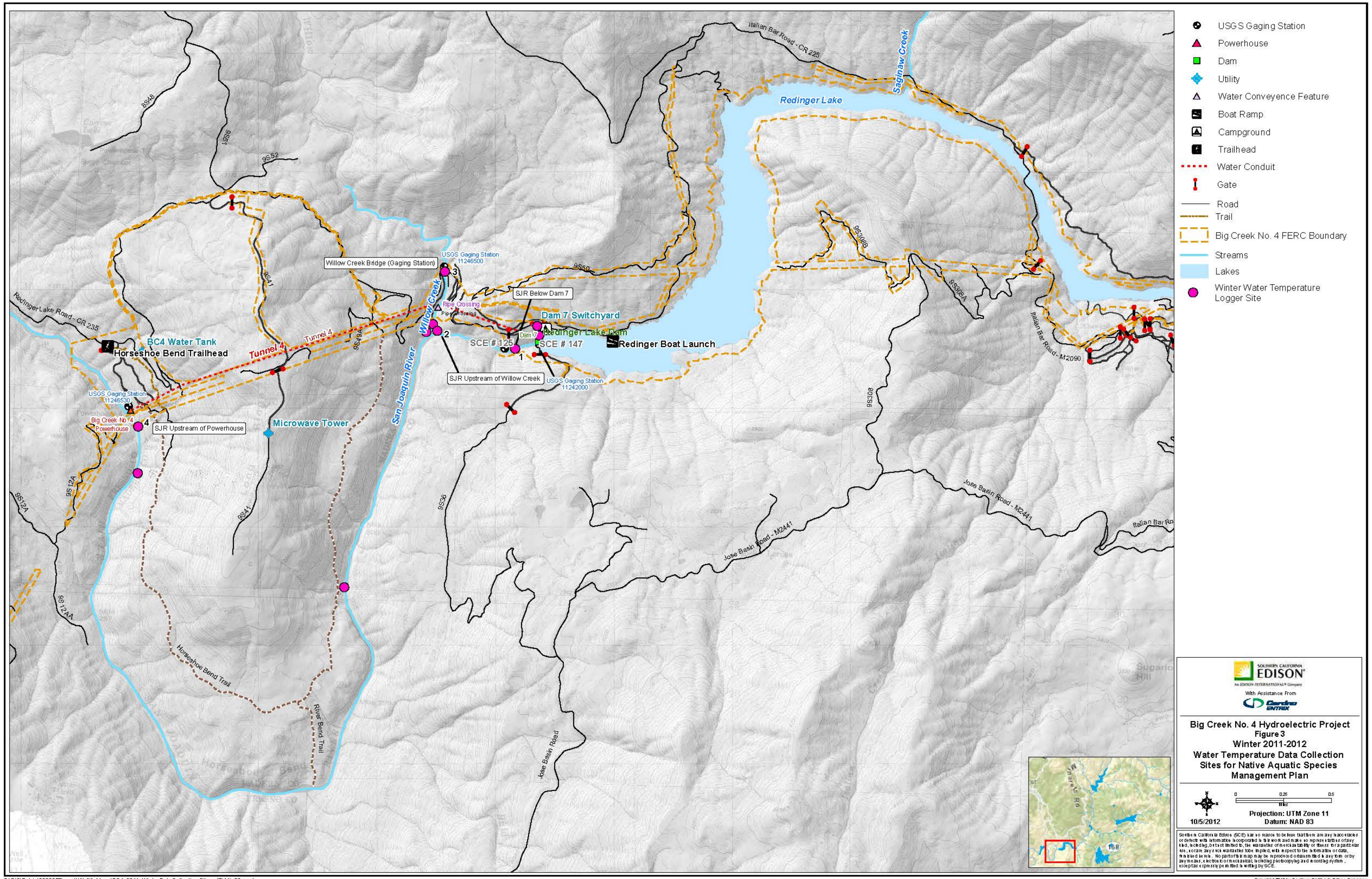

Figure 3. Winter 2011-2012 Water Temperature Data Collection Sites.

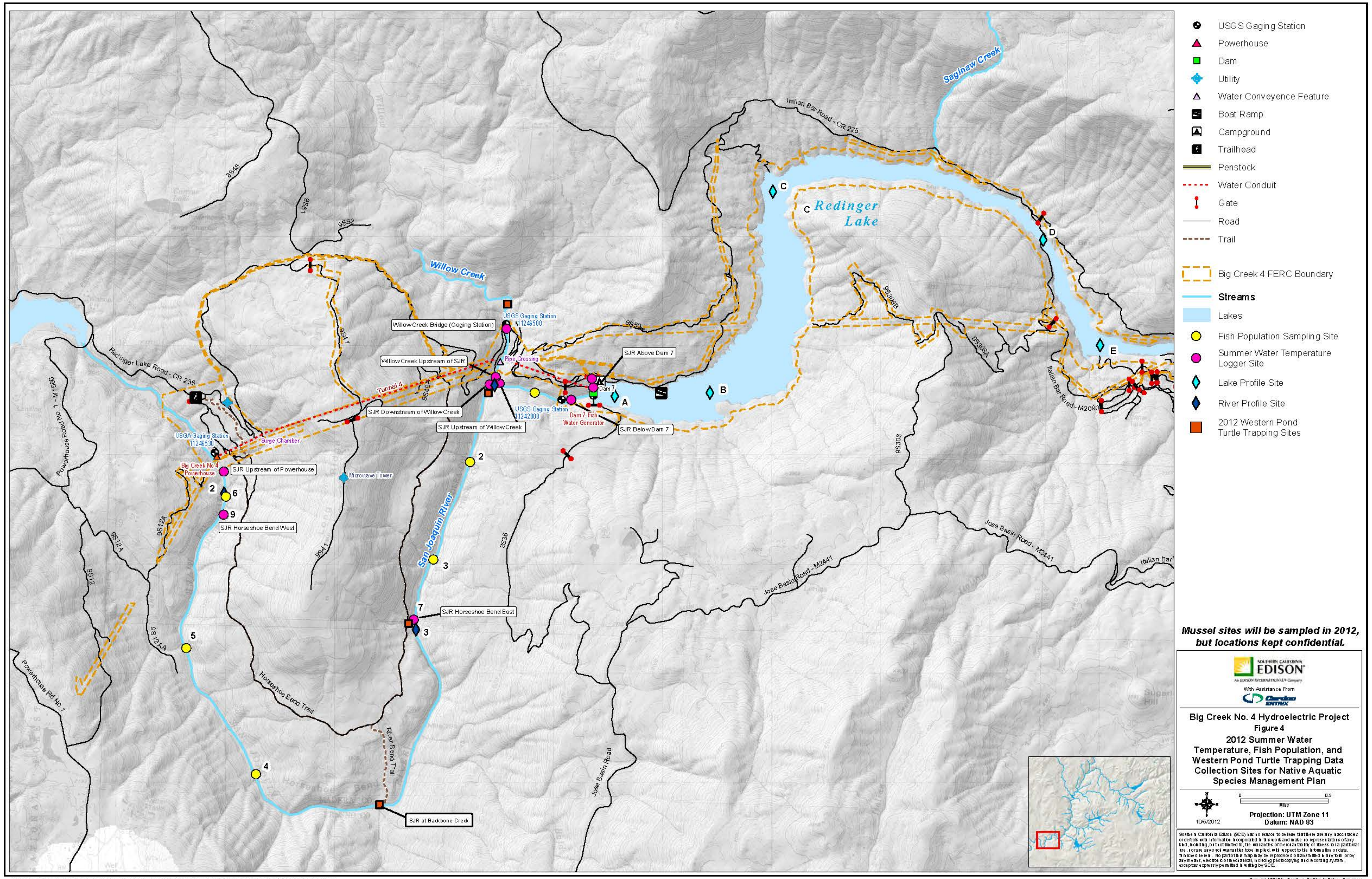

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Figure 4. 2012 Summer Water Temperature, Fish Population, and Western Pond Turtle Trapping Data Collection Sites.

Table 1. Water Temperature Monitoring Locations (2011-2012).

Overwinter Monitoring Locations Physical Location	GPS Coordinates (UTM Zone 11s NAD 83, Meters)	Unit A (Serial No.)	Unit B (Serial No.)
SJR Below Dam 7 / (USGS Gage site)[3]	0281956/4113704	9701212[1]/2306270[2]	2306276[2]
SJR Upstream of Willow Creek	0281429/4113858	2306273[1]/2306268	2306274[1]/2306267[2]
SJR Upstream of Powerhouse (approximately 0.1 miles upstream of PH4)	0278905/4113049	9701213[1]/10015851	2306278[1]/2306263
Willow Creek Bridge (Gauging Station)[3]	0281493/4114357	2306276[1]/2306278[2]	10015850[1]/2306271[2]
Spring-Summer Monitoring Locations Physical Location	**GPS Coordinates (UTM Zone 11s NAD 83, Meters)**	**Unit A (Serial No.)**	**Unit B (Serial No.)**
SJR Above Dam 7 (Redinger Lake)	0282287/4113819	2306274	10035071
SJR Below Dam 7 / (USGS Gage site)	0281956/4113704	2306276	10035067
SJR Upstream of Willow Creek	0281429/4113858	2306273	10127657
SJR Downstream of Willow Creek	0281337/4113847	9701213	10127658
SJR Horseshoe Bend East (approximately 1.5 miles downstream of Willow Creek confluence)	0280643/4111691	9701214	10127659
SJR Horseshoe Bend West (approximately 0.5 miles upstream of PH4)	0278902/4112654	10127656	10035070
SJR Upstream of Powerhouse (approximately 0.1 miles upstream of PH4)	0278905/4113049	2306272	10035072
Willow Creek Upstream of San Joaquin River	0281393/4113915	10015850	10127660
Willow Creek Bridge (Gauging Station)	0281493/4114357	2306278	2306271
Dam 7 Air (northern end of Dam 7 structure)	0282250/4113880	2317011	-

[1] Over summer temperature units from 2011 were used to supplement temperature data until overwinter loggers were installed on November 17, 2011.

[2] Over summer temperature units from 2012 were used to supplement data on temperature loggers that were lost during the 2012 overwinter monitoring period.

[3] Serial numbers provided for units that provided data only.

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2.1.3.2 Water Temperature Recorders

Stream water temperatures in the SJR were recorded at hourly intervals using Onset temperature recorders over the winter of 2011–2012 and at 10-minute intervals from May 1 to September 30, 2012. Redundant recorders were installed at all locations. Each recorder was checked for proper function within seven days of being placed in operation. A calibration check was made by measuring water temperature at the location of the instrument transducer with a calibrated thermometer. The date, time, and temperature were recorded at each location and compared to the corresponding temperature measured by the electronic recorder. Recorders were well hidden and examined for evidence of tampering during checks. Water temperature loggers and the meteorology station 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.

Temperature loggers operated normally at two sites during the 2011-2012 overwinter period. Temperature loggers at Willow Creek Bridge were inadvertently removed during construction of a new stream gage. Data at that site were unavailable during the overwinter period. Temperature data in the SJR downstream of the Dam 7 site are also unavailable from the middle of November to the middle of April. These units were lost over the winter.

During the May to September 2012 monitoring period, all temperature loggers operated normally. However, temperature data is unavailable for the HSB east site between May 10 and 15 due to exposure to the air as indicated by wide fluctuations in the daily temperature data for that period. Temperature data for Redinger Lake at Dam 7 also is unavailable between September 16 and 18 and September 28 and October 4 due to the loggers becoming exposed to air as reservoir water surface elevation dropped.

2.1.3.3 Redinger Lake Profiles

To characterize Redinger Lake conditions, temperature, DO, and SC vertical profile measurements were made in late spring (June 8), summer (August 16), and fall (October 16) by boat. One profile was taken near Dam 7 which is the deepest area of the lake (Figure 4, 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). Profile data were collected using a YSI 600-XLM DO/temperature meter and recorded at one m (3.3 ft) increments. Profile data were successfully collected at all five sites during June and August. In October, the two upstream profile sites, Site D and Site E, were not accessible by boat because of lowered reservoir water surface elevation. The depth was less than 1 m (3.3 ft) in October at Site D and Site E. Profile data at Sites A, B, and C was successfully collected in October 2012.

Water temperature profiles were measured in three deep pools in the SJR between Dam 7 and PH4 in August 2012. 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 deep pool temperature profiles were measured on August 17 using a YSI 600-XLM DO/temperature meter and a float tube to allow for measurements in the deepest part of each pool. Temperature measurements were recorded at 1 m increments.

2.2 AMPHIBIANS AND AQUATIC REPTILES

2.2.1 FOOTHILL YELLOW-LEGGED FROGS

2.2.1.1 Approach

The 2012 FYLF surveys were conducted in accordance with the methodology developed in consultation with the TRG and specified in the NASMP/AMP Study Plan (SCE 2008a) and NASMP/AMP Third Year Proposal (SCE 2012a). Field crews conducted VES in the HSB reach of the SJR and in three tributaries (Willow, Bald Mill, and Backbone creeks). Habitat characterizations were compiled for the entire Study Area during the surveys.

2.2.1.2 Visual Encounter Surveys

The entire HSB reach and the tributary confluences were surveyed three times in 2012. The tributaries were surveyed from their confluences with the SJR to at least 1,000 m (3,281 ft) upstream, or until the channel was dry, or impassible by the survey crew. Two surveys occurred in the spring/early summer (May 7-10 and May 21-24) for the detection of eggs, early tadpoles, and adults. The third survey occurred during summer (August 27-30) to detect older tadpoles, juveniles, and adults. The first survey was conducted as daily mean water temperatures reached 12 degrees Celsius (°C) in the lower portion of the HSB reach and high flows subsided after May 5 (see Section 3.1.3). High flows in late April and early May created conditions unsafe for surveyors at the time water temperatures reached 10°C. The second survey was conducted when average daily water temperatures ranged between 10-15°C (depending upon the location in the reach). The third survey focused on tadpoles, juvenile, and adult FYLF in potential breeding areas at daily average water temperatures of 18 to 22°C in the SJR.

The FYLF surveys were implemented using the USDA-FS VES protocol described in *Standard Operating Procedures for River and Creek Visual Encounter Surveys* (included in Attachment D of the NASMP [SCE 2008a]) with the modifications agreed to with the TRG and included in the 2012 Third Year Adaptive Management Proposal (SCE 2012a). VES was conducted from the shore, by wading and by snorkeling. Habitats were searched along a several meter wide transect parallel to the stream at the water's edge. Snorkeling was performed to help in detection of egg and tadpole life stages. Likely breeding areas were searched (e.g., under boulders) for egg masses, as appropriate. For adult and juvenile frogs, open water, potential mid-water basking sites (logs, rocks, etc.), and the shoreline were searched, sometimes with the assistance of binoculars, where appropriate.

2.2.1.3 Breeding Habitat Characterization

Breeding habitat characterization in the HSB reach of the SJR, Willow Creek, Bald Mill Creek, and Backbone Creek were performed during the FYLF VES. The surveyors focused on shallow areas near the shore with low velocities and cobble/small boulder attachment substrates. These areas with potential breeding habitat were located and described. Stream type (i.e. perennial, intermittent, or ephemeral) and the effects of water elevation of the SJR were taken into consideration when describing the tributaries potential breeding habitat suitability.

2.2.2 Western Pond Turtle

2.2.2.1 Abundance and Population Structure Surveys

The abundance and population structure of WPTs were assessed by trapping and marking WPTs on the HSB reach of the SJR in 2012. Trapping was initiated in spring as soon as ambient air and water temperatures were warm enough (>20°C and >12°C, respectively) for WPT activity. WPTs were captured and re-captured during two trapping events in spring and one in early summer. The trapping events were conducted at least two weeks apart to allow the population sufficient time to recover from investigator-caused disturbances. In addition, WPT visual encounter observations were recorded and opportunistic capture-recapture of WPTs took place on the HSB reach of the SJR during the FYLF VES in the spring and summer and during other studies in 2012.

Trapping was conducted at four study locations (Figure 4) in Willow Creek and SJR. These sites were trapped on May 15-17, May 30 to June 1, and July 17-19, 2012. WPTs were captured using floating tunnel traps, floated hoop net traps, and by hand. Traps were baited with a variety of baits, including canned sardines, cat food, fresh American shad, and canned tuna. Traps were placed in shaded areas under over hanging tree branches or brush and camouflaged with pieces of cut brush to disguise traps from humans and to keep captured WPTs shaded and cool prior to retrieval of the traps. The trapping locations were selected on this basis and were at or near the heads of pools where the scent of the bait would attract turtles from downstream portions of the pools. There was no large woody debris (LWD) present at the trap locations, as well as anywhere else in the study area, to focus trapping efforts.

All traps had floats to prevent turtles from drowning. Traps were usually set in the afternoon and checked the following morning (i.e. night trapping) and again in the afternoon the same day. Otherwise, they were set in the morning and checked later in the day. In addition, turtles were opportunistically captured by hand. Several WPTs were captured by hand during the FYLF VES conducted on May 22-24 and August 28-29. Snorkeling for WPTs also took place simultaneously with trapping events on May 30 to June 1 and July 17-19. WPTs captured by hand were processed and released immediately. GPS coordinates of their locations were recorded. The data collected included date, time, crew, location, general water and weather conditions, sex, weight, age, maximum carapace length, height, width, and external signs of disease and lesions. Photographs of each WPT captured or recaptured were taken. Age was estimated when possible by counting annuli on one or more scutes of the plastron and/or carapace (Bury and Germano 1998). Captured WPTs 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.

A female WPT that was previously tagged and tracked in 2010-2011, was trapped again on May 31, 2012 in Willow Creek near the confluence with SJR and fitted with a radiotag to assess movement and nesting habitat use. An Advanced Telemetry Systems Inc. (ATS) model number R1170 radiotag was attached to the carapace of the turtle using Ding Dough surfboard repair epoxy and darkened with black epoxy dye, sand, and dirt to camouflage the tag. The radiotag weighed approximately 4 grams (g), and measured 3.4 centimeters (cm) (1.33-inch) by 1.4 cm (0.55-inch) by 1.2 cm (0.47-inch) and had an internal helical antenna. The battery life was expected to last more than one year. Biologists located the turtle six times from June 27 to October 15 on the SJR with an ATS model 2000 receiver. GPS locations were recorded and distances moved were calculated.

2.2.2.2 Habitat Characterization

WPT habitat was characterized using methods previously reported (SCE 2009a) and based on descriptions by Abel (2010). Aquatic habitat for WPTs is addressed in this section and terrestrial habitat for nesting habitat is addressed in the following section.

Aquatic habitat for WPTs was characterized based on literature descriptions. The descriptions used are as follows: adult turtles require habitat with slow-moving water that is moderately deep (1 m (3.3 ft) to 1.5 m (4.9 ft)), secure basking sites (i.e., rocks, logs, etc. with immediate access to deep water, undercut banks, or other submerged refuges) and abundant aquatic invertebrate and plant forage. Basking generally increases in frequency throughout the spring and peaks in June, followed by a decline throughout the summer (Holland 1994). Hatchlings (individuals less than one year old) require shallow water, less than 0.3 m (1 ft) with adjacent dense submerged or emergent vegetation for refuge (Jennings and Hayes 1994), which are found in streams such as Willow Creek. Like many aquatic emydid turtles, WPTs can swallow food only under water, so they are restricted to aquatic habitat for all foraging.

2.2.2.3 Nesting Habitat Vulnerability

Initial Approach

The primary objective of the nesting habitat assessment in 2012 was to evaluate the extent of potential inundation of WPT nesting habitat on the HSB reach in the SJR by whitewater recreational releases. Data on the locations and elevations of WPT nests or nesting habitat was to be compared to the elevations of potential whitewater flow releases from stage (water surface elevation)-discharge (flow) relationships developed for the SJR near these nesting sites.

Nesting habitat was originally planned to be determined by tracking female turtles to nesting habitat using recording GPS tags that recorded locations when the turtle changed position. The initial trapping events were used to attempt to capture female WPTs for tagging with GPS tags. However, no female WPT of sufficient size was captured during the study large enough to attach a GPS tag without adverse effect.

Revised Approach

Since GPS tagging could not be conducted, a modification of this study element was initiated which focused on locating potential nesting habitat and comparing the elevation range in which this habitat occurred to the elevations that may be inundated by whitewater flow releases.

In 2011, stage-discharge data were collected at three sites, where WPT have been captured and observed during the past four years (SCE 2011a). Calculated water level elevations above minimum instream flow resulting from whitewater flows are shown in Table 2.

The water surface elevation (stage) discharge relationship as a function of flow was determined from field measurements at the three sites. During the initial survey at each site, benchmarks and reference pins were installed using pieces of rebar and wooden survey stakes. Water surface elevations relative to the bench marks were determined in the field with the use of a Topcon stadia rod and a Topcon 56210 autolevel. Water surface elevations were measured at no less than three flows ranging from the summer minimum instream flow to flows of more than 3,000 cubic feet per second (cfs) at each site. Flow data were obtained from SCE for each survey date. Flows at the confluence of Willow Creek and Big Creek and the locations downstream of the confluence were calculated by summing the flows from the SJR, upstream of Willow Creek and the flows from Willow Creek.

Non-linear regression was used to calculate the water surface elevation-discharge relationship at each site. This relationship was then used to calculate water surface elevation at 1,660 cfs based on the results of SCE’s 2005 navigability study (SCE 2006).

Identification of potential WPT nesting habitat was conducted near the three sites at which adult female WPTs had been previously found. The assessment was conducted July 18-19, 2012. The focus of the nesting habitat assessment was between the water level (elevation) at summer minimum instream flows and the calculated water surface elevation for the proposed recreational whitewater flows. The assessment survey elevation limits were extended approximately 20 percent above the expected water surface elevations of the proposed recreational whitewater flows to ensure that no vulnerable habitat would be omitted (upper limit elevation).

Table 2. Estimated Increase in Water Level Elevation Above Minimum Flow Level During Whitewater Flow Releases.

Survey Site	Estimated Water Level Elevation Above Minimum Flow Level During Whitewater Flow Releases (meters[ft])
SJR Willow Creek – Confluence Pool	1.1 m (3.7 ft)
SJR Horseshoe Bend East	2.1 m (7.0 ft)
SJR Backbone Creek Confluence Pool	2.5 m (8.3 ft)

The survey crew identified, located, and assessed the nearest potential WPT nesting habitat on both sides of the SJR at each site.

The entire elevation range between the summer minimum instream flow water surface elevation and the upper limit water surface elevation at each site was assessed for potential WPT nesting habitat. The criteria used to assess potential WPT nesting habitat suitability included vegetation cover, canopy cover, presence of LWD, substrate, substrate pliability, slope, aspect, accessibility for WPT, and other indicators, such as the presence of rodent burrows, etc., which indicates WPT nesting chamber resistance to collapse (Holte 1998). Observations made in these assessments were recorded, described, and the survey locations and nearest potential WPT nesting habitat were photographed on both sides of the river. The primary criteria for suitable nesting habitat were whether or not it was possible for WPT to excavate nesting chambers and if the substrate was cohesive enough to resist collapse. For example, the presence of loose sand with no rodent burrows indicated the substrate was not cohesive enough to resist collapse of nest chambers. Also, areas dominated by bedrock and/or large boulders are unsuitable for excavation.

After the areas were assessed, the surveyors then searched, located, assessed, and documented the nearest potentially suitable nesting habitat on both sides of the river, if present. The area surveyed at the SJR Willow Creek confluence pool was confined to the banks adjacent to the confluence pool and upstream into Willow Creek to the upper limit water surface elevation. The area surveyed at the HSB east site was confined to the banks of a small pool where trapping was conducted. The area surveyed at the SJR Backbone Creek confluence was confined to the confluence pool and 45.7 m (150 ft) upstream and downstream on the SJR, as well as the area on Backbone Creek at and below the upper limit water surface elevation.

2.3 MOLLUSCS

Mussel surveys were conducted in the HSB reach of the SJR during September 18–19, 2012. Two surveyors searched the three sites (Site 5, Site 6, and Site 7), where western pearlshell (*Margaritifera falcata*) mussels had been observed during the 2010 and 2011 mussel surveys. The sites were surveyed using the same methods employed during the 2010 and 2011 surveys, which are described in the NASMP (SCE 2008a). At Sites 5 and 6, surveyors performed a search of the river bed to count live mussels and shells and to document the locations of mussel clusters. The number of mussels observed in the stretch of river between the sandbar and Site 5 also was recorded.

The mussel bed at Site 7 was surveyed using a modification of the two-phase approach of Villella and Smith (2005). The downstream headpin that was established in 2010 was relocated, and a survey tape was stretched from that headpin to a willow tree located 50 m (164 ft) upstream. A reconnaissance snorkel survey was done to differentiate areas of high and low mussel density. The upstream and downstream extents of the high and low density areas were recorded, and that information was used to select randomly three survey transects within the high-density area and two survey transects within the low-density area. The wetted width of the river along each selected 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^2 (2.7 ft^2) quadrat. The 10^{th} location along each transect was drawn at random from the overall width. At each sampling location, the quadrat was placed with its nearshore 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. Site 7 was too deep (up to 2 m [6.6 ft]) for surveyors to systematically search for juvenile mussels (via sediment excavation), collect and measure adult mussels, or use a Marsh-McBirney flow meter to measure water velocities.

2.4 Fish

2.4.1 Hardhead Radiotracking

Following adult hardhead tagging in fall 2011, biologists returned in spring 2012 to locate and record movement of the tagged fish. An 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 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.

2.4.2 Hardhead Spawning

During WPT and FYLF VES, observations were made of hardhead spawning in HSB and, additionally, in Redinger Lake. The first of these observations was made on May 21, 2012. In each case, divers observed the spawning or pre-spawning activities, characterized habitat, cover, and water temperatures. Hardhead behaviors were noted and video was recorded, when feasible.

2.4.3 Larval Fish

Larval fish sampling was conducted at five areas on the HSB reach of the SJR in 2012, at locations sampled in 2007 through 2011, and at two locations on Lower Willow Creek (Figure 5, Table 3). During high flows in late April, backwaters and low velocity areas were sampled near the previous sampling locations. Larval fish sampling was conducted on eight occasions from late April to late July 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 an 11.4-cm (4.5-inch) diameter, 12.7-cm (5-inch) long cylinder that extended from the bottom

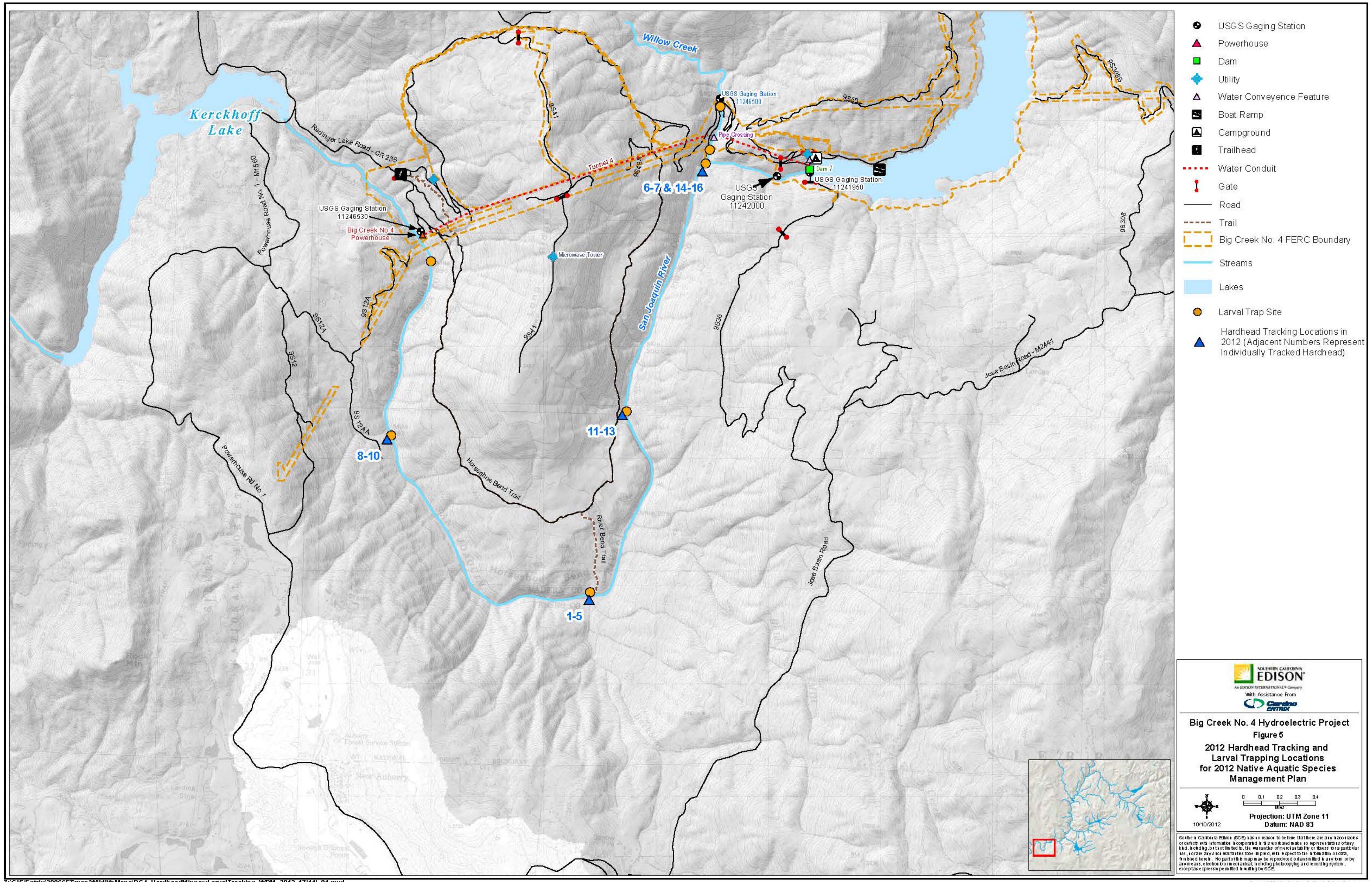

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Figure 5. 2012 Hardhead Tracking and Larval Trapping Locations.

Table 3. Larval Trapping Locations and Deployment Dates, 2012.

Trapping Site Location	Sample Dates	GPS Coordinates (UTM Zone 11S, NAD83, Meters)	Detailed Trapping Site Location
Powerhouse 4	April 24, May 1, May 16, June 8, June 12, June 26, July 11, and July 25	E278916, N4112953	BC4, Second Pool, Directly upstream of Powerhouse
Willow Creek Confluence	April 24, May 1, May 16, June 7, June 12, June 26, July 11, and July 25	E281362, N4113822	SJR at Willow Creek, Confluence Pool at bottom of Willow Creek
Willow Creek	April 24, May 1, May 17, June 7, June 12, June 26, July 11, and July 25	E281398, N4113946	Willow Creek, Second Pool upstream from Confluence SJR
Willow Creek near Redinger Lake Road bridge	April 24, May 1, May 17, June 8, June 12, June 26, and July 11	E281478, N4114285	Willow Creek just downstream of the bridge on Redinger Lake Road
Backbone Creek Confluence	May 1, May 15, June 6, June 12, June 26, July 11, and July 25	E281344, N4113788	SJR at Backbone Creek, Confluence Pool at bottom of Backbone Creek
Horseshoe Bend East	May 1, May 15, June 7, June 12, June 26, July 11, and July 25	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	May 1, May 16, June 6, June 12, June 26, July 11, and July 25	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

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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 therein reducing potential losses. Based on the work of Marchetti et al. (2004), 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. Dip nets also were used to capture and supplement larval samples, especially in shallow low velocity backwaters associated with submerged vegetation, woody debris, and large boulders. Typically, these areas were within 0.3 m (1 ft) of shore and at less than 0.6 m (2 ft) in depth.

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 identifying the date, time, location, and duration of sampling. Water temperature was measured before setting the light traps and after retrieving the traps. Larval fish were identified under a dissecting microscope to species. Total lengths were measured for at least 10 specimens of each species collected in each sample.

2.4.4 FISH POPULATIONS

2.4.4.1 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.

2.4.4.2 Site Selection

The NASMP identified six sampling locations within the HSB reach (Figure 4), corresponding to the 1985 BioSystems and 1995 Cardno ENTRIX sampling sites (BioSystems 1987, SCE 1997). At each of the fish sampling locations, an electrofishing site and a snorkel survey site were selected based on the earlier studies. Generally, electrofishing was conducted in sites shallower than about 1 m (3 ft) deep. Visual (snorkel) surveys were conducted in deeper water. In all, 24 percent of the study reach from Dam 7 to PH4 (2,247 of 9,557 m [7,372 of 31,355 feet]) was snorkeled. Sampling was conducted October 1-5, 2012. All six sampling locations were snorkeled; five sampling locations were electrofished. Electrofishing could not be conducted at one of the locations (Site 1) due to safety concerns caused by turbulence and depth.

2.4.4.3 Sampling Methodology

Electrofishing

Quantitative fish population surveys were conducted at sampling locations by electrofishing shallower riffle habitats. Multiple pass removal population estimates were made. All fish species present were identified to species and life stage 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, SCE 2011a, SCE 2012b).

Electrofishing was conducted using two Smith-Root Type LR24 backpack electrofishing units. The upstream and downstream ends of the site were blocked using 0.64 cm (0.25-inch) mesh block nets when possible. Sampling was conducted using multiple pass depletion in which fish were stunned and removed from the site in multiple sequential passes. 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, three net persons, and two net/livecar persons. Electrofishing was generally conducted as described by Reynolds (1996).

In this case, population estimates were based on the maximum likelihood technique of Zippin (1958) using the Microfish computer program (Deventer and Platts 1989).

Fish Measurement and Handling

All captured fish[1] were identified to species, measured for length to the nearest millimeter (mm) total length, and weighed to the nearest g. Each fish processed was examined for disease or injury and its condition noted on the field sheets. Scale samples were collected from native cyprinids larger than young-of-the-year for age and growth determinations.

Snorkeling

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 (snorkeling) provided lower resolution length information, since lengths were visually estimated in comparison to a target. Length bins for fish species observed during snorkeling were as follows: 0-3 inches (0-76 mm), 3-6 inches (76-152 mm), 6-9 inches (152-228 mm), and fish greater than nine inches (228 mm) in length. Water clarity was similar to conditions in 2011 and 2008. Visibility at Site 1 was six ft (1.8 m) and increased going downstream to 12 ft (3.7 m) at Sites 5 and 6. Methods generally were the same as those used in 2008 (SCE 2009b). The snorkeled habitat units were divided into one or more swimming lanes parallel to the direction of stream flow. 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

[1] Fish observed during snorkeling were not captured and so were not available for measurements and analyses described in this subsection.

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 diver's 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. Fish numbers and length by bin were recorded by each diver to a wrist slate. At the conclusion of each snorkeled transect, data were transferred to data sheets and verified for accuracy.

Small cyprinids in large schools that could not be adequately identified as either hardhead or Sacramento pikeminnow during snorkeling were classified as "unidentified minnows." 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."

3.0 RESULTS

3.1 PHYSICAL DATA

3.1.1 STREAM FLOW

Water Year 2012 in the San Joaquin Valley was classified as a dry water year (CDWR 2012). Daily mean overwinter flows in the SJR downstream of Dam 7 were between 34 cfs and 45 cfs from November 1, 2012 to April 21, 2012. A rapid period of warming occurred in late April 2012 (NCDC 2012), which resulted in rapid snow melt and filling of Mammoth Pool Reservoir and Redinger Lake. As a result, a short duration, low magnitude spill occurred at Dam 7 between April 22 and May 5. During the spill, the maximum daily flow was 1,790 cfs on April 27. Flows rapidly declined to 60 cfs following the spill. The monthly mean flow for the SJR downstream of Dam 7 ranged from 36 cfs to 48 cfs prior to the spill (Table 4). Monthly mean flows in Willow Creek ranged from 7 cfs in November up to 47 cfs in April (Table 4). Due to the short duration and low magnitude of the spill, Water Year 2012 was classified as a non-spill year for the purposes of the NASMP.

Daily mean summer flows in the SJR downstream of Dam 7 between May 1 and October 31 ranged from as much as 1,213 cfs on May 2 (Appendix A-7) to a minimum of 54 cfs recorded on several days during October (Appendix A-12). Flows at this location during September and October were generally below 60 cfs. Table 5 presents the monthly mean flows for summer 2012. The average monthly flow in the SJR upstream of Willow Creek after May 5 ranged from 55 to 60 cfs. The average monthly flow for Willow Creek during the monitoring period ranged from two to 19 cfs. Average monthly flows in the SJR downstream of Willow Creek ranged from 60 to 79 cfs, after May 5.

Water Year 2012 greatly differed from Water Year 2011. Water Year 2012 was a dry year and Water Year 2011 was a wet year. Flows during 2011 greatly exceeded those of 2012, with an extended spill lasting from April 1 until August 19, 2011. The peak daily flow during the 2011 spill period was 11,772 cfs (12,116 cfs downstream of Willow Creek).

3.1.2 AIR TEMPERATURE

A comparison of monthly mean air temperatures for May through October at Dam 7 and Fresno International Airport, with a percent exceedance based on 82 years of monthly mean air temperatures from Fresno International Airport (NCDC 2012) are presented in Table 6. Air temperatures for July, August and September were significantly warmer than average. August and September 2012 were the warmest on record, and July 2012

Table 4. Monthly Mean, Minimum, and Maximum Water Temperature and Average Monthly Flows from November 1, 2011 to April 30, 2012 (Overwinter).

Month	San Joaquin River Downstream of Dam 7[1]			San Joaquin River Upstream of Willow Creek Confluence			San Joaquin River Upstream of Powerhouse 4[2]			Willow Creek[3]			San Joaquin River Flow (cfs) at USGS Gauge No. 11242000	Willow Creek Flow (cfs) at USGS Gauge No. 11246500
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max		
November	12.9	11.7	15.0	11.8	9.7	14.7	11.6	9.2	14.9	-	-	-	36	7
December	-	-	-	7.7	6.1	10.0	6.7	5.1	9.5	-	-	-	38	7
January	-	-	-	6.2	5.8	7.2	6.5	4.8	8.1	-	-	-	40	6
February	-	-	-	6.4	6.0	7.4	7.7	6.5	9.3	-	-	-	48	12
March	-	-	-	7.2	6.2	8.9	9.1	6.4	11.6	-	-	-	43	28
April	10.1	7.3	15.1	9.3	7.0	15.1	11.3	7.9	16.4	12.1	6.7	19.7	328 (45)[4]	47

[1] **Temperature data unavailable for SJR Downstream of Dam 7 between November 17, 2011 - April 10, 2012 due to loggers being lost during winter months.**

[2] **Temperature data unavailable for SJR Upstream of Powerhouse 4 between April 19 and 20 due to loggers being out of water.**

[3] **Temperature data unavailable for Willow Creek between November 1, 2011 - April 10, 2012 due to loggers being lost during winter months.**

[4] **Average flow prior to spill.**

Table 5. Monthly Mean, Minimum, and Maximum Water Temperature and Average Monthly Flows during May 1 to October 31, 2012.

Month	Redinger Lake at Dam 7 Temperature (°C)			San Joaquin River Downstream of Dam 7 Temperature (°C)			San Joaquin River Upstream of Willow Creek Confluence Temperature (°C)			San Joaquin River Downstream of Willow Creek Confluence Temperature (°C)			San Joaquin River Horseshoe Bend East Temperature (°C)			San Joaquin River Horseshoe Bend West Temperature (°C)			San Joaquin River Upstream of Powerhouse 4 Temperature (°C)			Willow Creek Bridge Gauging Station Temperature (°C)			Willow Creek 200 m Upstream of SJR Confluence Temperature (°C)			San Joaquin River[1] Flow (cfs) at USGS Gauge No. 11242000	Willow Creek[1] Flow (cfs) at USGS Gauge No. 11246500
	Mean	Min	Max	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	11.9	9.4	16.8	9.9	8.6	16.0	10.1	8.7	15.3	10.5	9.0	14.1	12.2	10.1	14.1	13.9	10.8	16.2	14.4	10.9	17.9	16.2	11.5	20.3	16.3	11.5	20.5	160 (60)[1]	19
June	14.0	10.5	20.0	11.2	9.5	13.3	11.5	9.6	14.3	11.5	9.9	13.6	14.0	11.0	16.9	16.1	13.3	18.5	16.6	13.7	19.4	19.9	15.0	24.0	19.9	15.0	23.9	60	15
July	18.5	15.2	23.1	13.8	11.9	16.3	14.2	12.0	16.7	14.3	12.3	16.9	16.2	13.5	18.3	18.3	16.2	20.2	18.5	16.4	21.6	22.7	19.6	25.5	22.8	19.6	25.7	60	8
August	21.8	18.2	27.1	16.7	14.4	19.0	17.0	14.7	19.3	17.2	15.3	19.3	18.3	16.1	20.3	20.0	18.0	21.6	20.2	18.1	21.7	23.8	19.7	27.6	23.8	19.5	28.3	62	4
September	20.8	16.8	22.8	18.9	17.8	20.6	19.1	18.0	20.2	19.1	18.1	20.2	19.6	18.1	20.8	20.4	18.9	21.8	20.5	19.0	21.9	21.2	17.8	24.8	21.1	17.6	24.4	59	2
October	18.4	16.7	21.5	17.8	15.6	19.7	17.8	15.6	20.0	17.6	14.0	19.7	17.7	14.7	20.5	17.8	15.0	20.8	17.8	15.0	20.8	16.0	11.4	22.0	15.9	11.3	21.4	55	5

[1] Average flow after spill

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Table 6. 2012 Monthly Mean Temperatures at Fresno International Airport Compared with Percentage Exceedance for Historical Record (1931–2012) and Temperatures Measured at Dam 7.

Month	2012 Fresno Intl Airport Air Temperature (ºC)[1]	Fresno Intl Airport 2011 Percent Air Temperature Exceeded (1931-2011)	2012 Dam No.7 HOBO Air Temperature (ºC)
May	22.4	47.6%	20.2
June	25.5	39.0%	24.0
July	28.5	2.4%	27.9
August	30.3	0.0%	30.1
September	27.4	0.0%	26.9
October	20.6	67.1%	18.7

[1] Climate data obtained from NOAA from May to October 2012 is preliminary and subject to final review.

was the third warmest July on record. May and June were both slightly warmer than the 82-year average. October 2012 was slightly cooler than the 82-year average.

3.1.3 Water Temperature Results

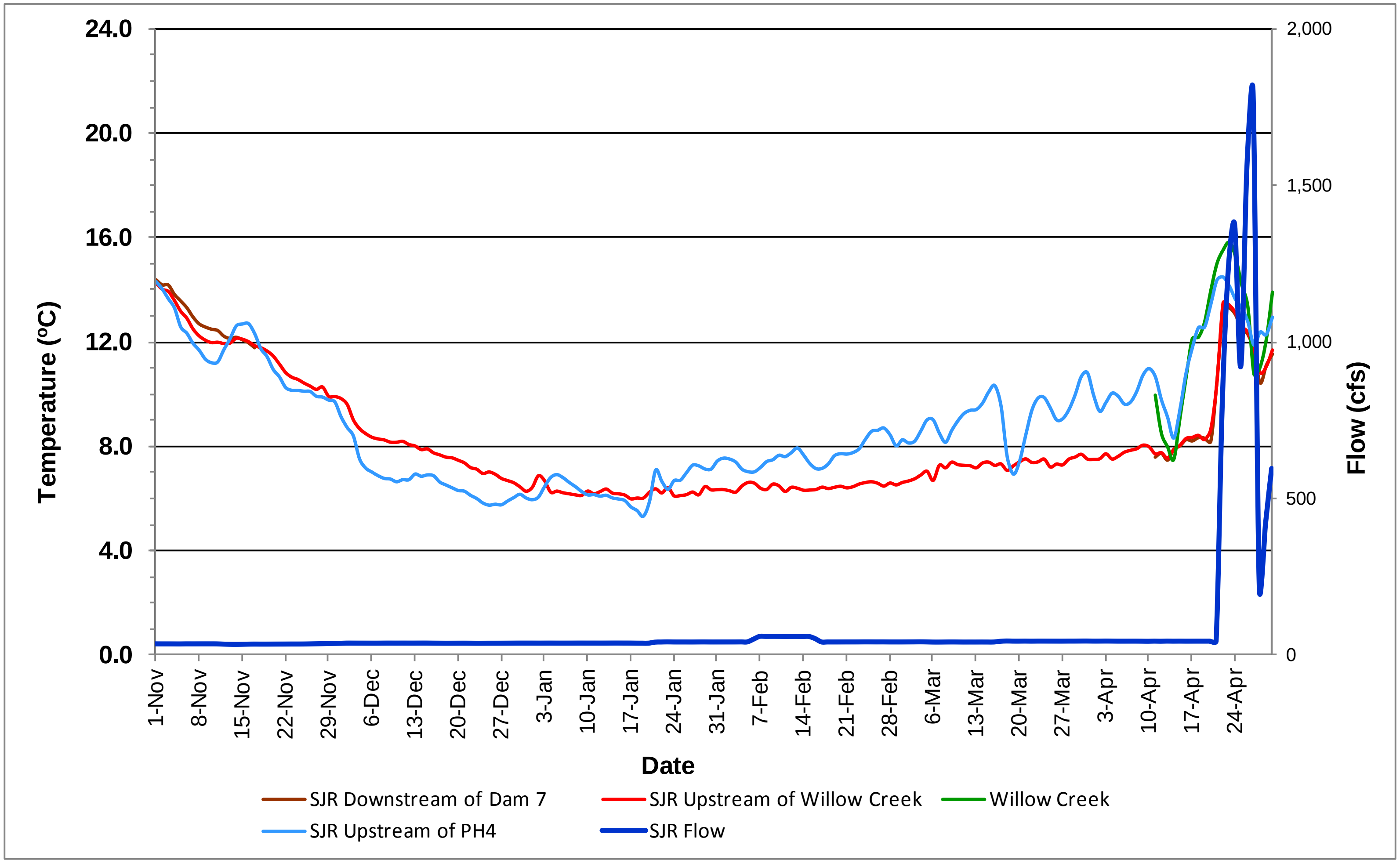
Average water temperatures for the four overwinter monitoring locations, along with flows in the SJR and Willow Creek, are reported by month in Table 4. Overwinter mean daily water temperatures and flows in the SJR and Willow Creek are plotted on Figures 6 and 7, respectively, for November 2011 through April 2012. Temperature data for SJR just downstream of Dam 7 are unavailable from the middle of November to the middle of April due to loss of recorders. Overwinter temperature data for Willow Creek is unavailable until the middle of April due to removal during a construction project. Spring-summer average water temperatures for the nine monitoring locations, along with flows in the SJR and Willow Creek, are reported by month, for May 2012 through October 2012, in Table 5. Daily mean water temperature and flows for the SJR during the spring-summer months are plotted on Figure 8. Daily mean water temperature and flows for Willow Creek for the summer months are plotted together on Figure 9.

3.1.3.1 Overwinter Water Temperatures, 2011–2012

Overwinter water temperatures in the SJR directly upstream of the Willow Creek Confluence decreased from a monthly mean of 11.8°C in November to 6.2°C in January, before gradually warming to 9.7°C in April (Table 4). Water temperature data in Willow Creek was not available until April 11. Mean daily temperatures ranged from 7.5°C to 15.8°C from April 12-30 in Willow Creek (Appendix A-6). Overwinter monthly mean water temperatures upstream of PH4 decreased from approximately 11.6°C in November to approximately 6.5°C in January, before gradually warming to 11.7°C in April (Table 4). Mean daily water temperatures increased quickly at the end of April, which was reflective of hot weather that also resulted in snow melt runoff and the short spill at the end of April to early May. Willow Creek mean daily water temperatures also increased quickly in late April (Appendix A-6).

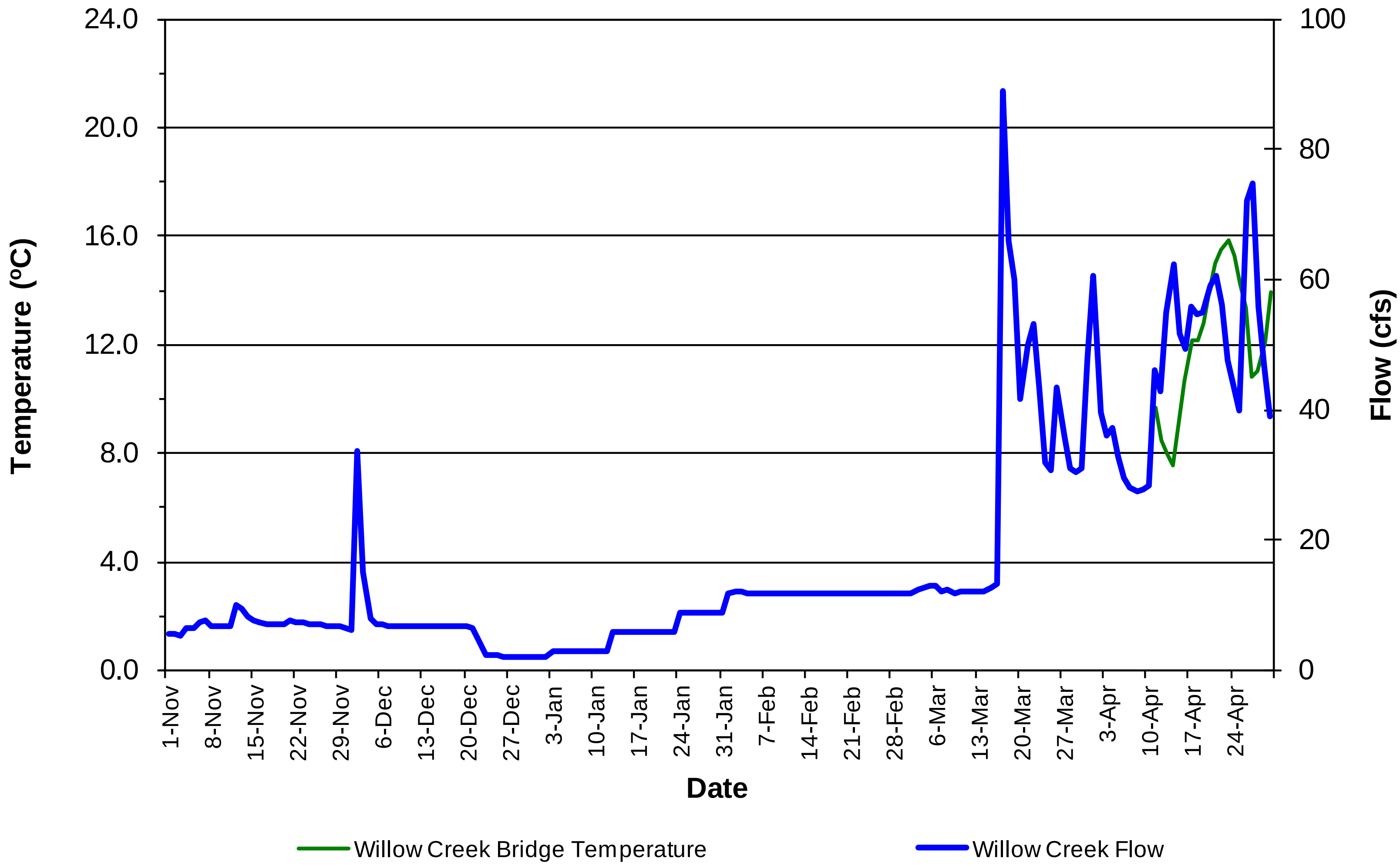
3.1.3.2 Spring-Summer 2012 Water Temperatures

Spring-summer water temperatures in the SJR ranged from a monthly minimum of 8.6°C directly downstream of Dam 7 in May up to a monthly maximum of 21.9°C just upstream of PH4 in September (Table 5). Monthly mean temperatures were generally coolest directly downstream of Dam 7 and gradually increased downstream. Monthly mean water temperatures from May to September directly downstream of Dam 7 showed a range of 9.0°C, increasing from May (9.9°C) to 18.9°C in September (Table 5). A similar warming pattern was observed at the other SJR sites, but with temperatures increasing to a lesser extent at SJR HSB east (7.4°C) and the two sites further downstream, SJR HSB west and SJR upstream of PH4, warming 6.5 and 6.1°C from May to September, respectively.



Note: Temperature data unavailable for SJR Downstream of Dam 7 November 17, 2011 - April 10, 2012 due to loggers being lost during winter months.
Temperature data unavailable for Willow Creek November 1, 2011 - April 10, 2012 due to loggers being lost during winter months.
Temperature data unavailable for SJR Upstream of Powerhouse 4 April 19 and 20 due to loggers being out of water.

Figure 6. Mean Daily Overwinter Temperatures and Flow in Willow Creek and the San Joaquin River Downstream of Dam 7, 2011 - 2012.



Note: Temperature data unavailable for Willow Creek November 1, 2011 - April 10, 2012 due to loggers being lost during winter months.

Figure 7. Mean Daily Overwinter Temperature and Flows in Willow Creek, 2011-2012.

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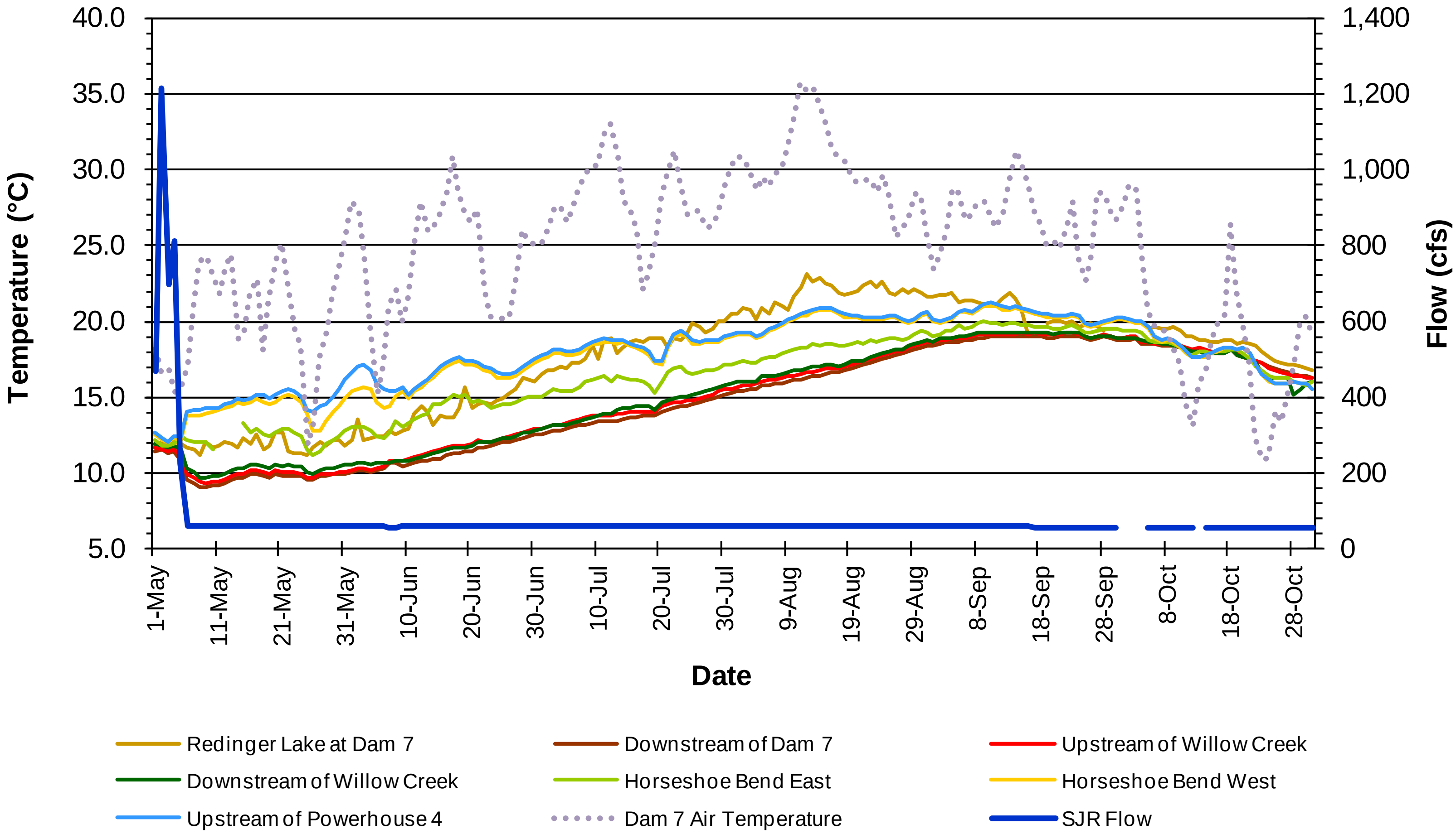
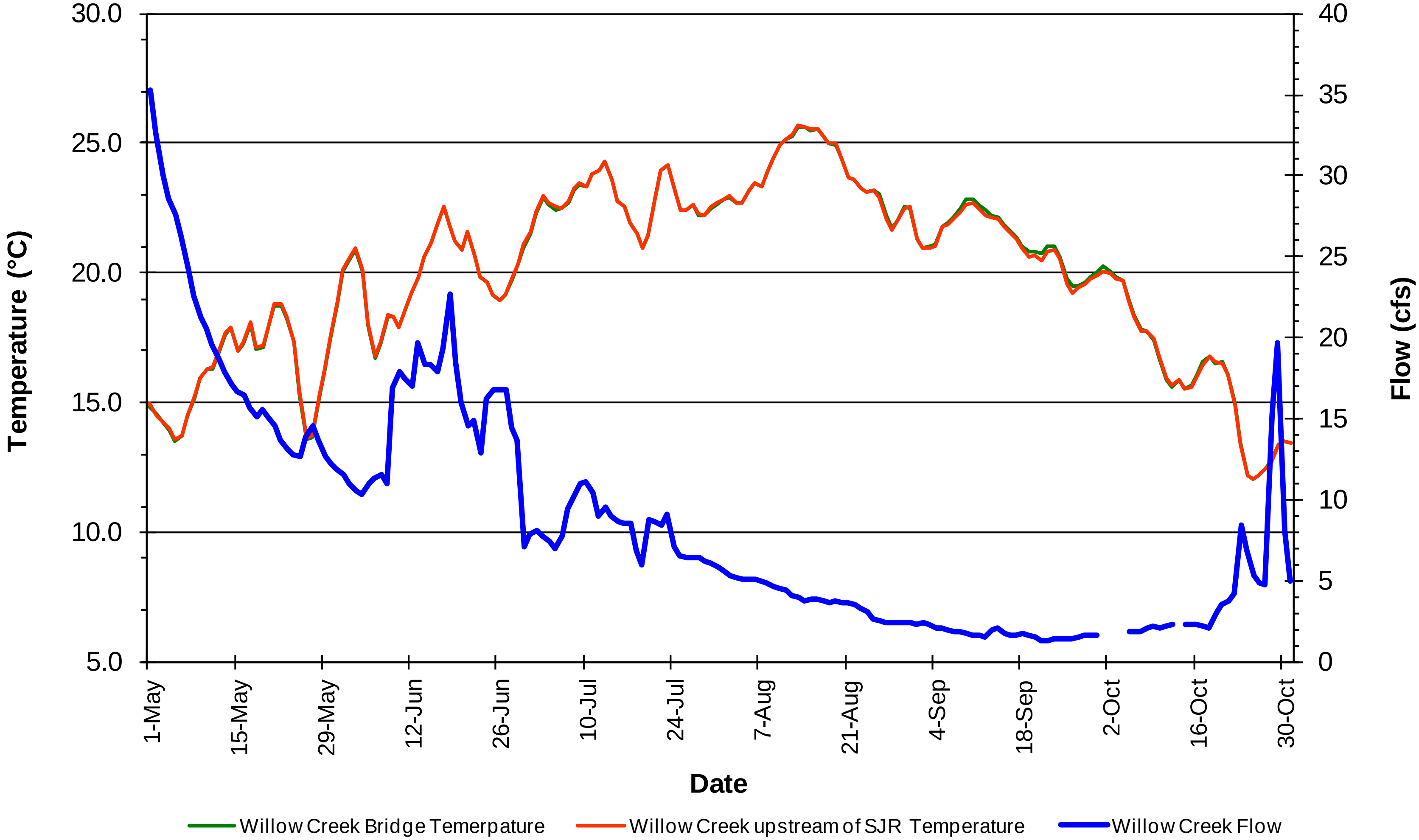


Note: San Joaquin River flow data unavailable from October 1-4 and October 13, 2012.

Temperature data unavailable for Horseshoe Bend East May 10-15, 2012 due to loggers out of water.

Temperature data unavailable for Redinger Lake at Dam 7 September 16-18, 2012 and September 28 - October 4, 2012 due to loggers out of water.

Figure 8. Mean Daily Flow and Temperatures in the Horseshoe Bend Reach of the San Joaquin River, May 1 – October 31, 2012.



Note: Willow Creek flow data unavailable from October 1-4 and October 13, 2012

Figure 9. Mean Daily Temperature and Flows in Willow Creek, May 1 – October 31, 2012.

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Mean monthly temperatures at all sites decreased from September to October. The warmest spring-summer water temperatures in the SJR were recorded at the furthest downstream station, directly upstream of PH4.

Monthly mean water temperatures in Willow Creek, upstream of the confluence with the SJR, showed a range of 7.5°C, increasing from 16.3°C during May to 23.8°C in August before gradually declining through September (21.1°C) into October, 15.9°C (Table 5).

Water flowing from Willow Creek from May through September was generally warmer than that of the SJR. The temperature differential increased from approximately 6.1°C in May up to 8.5°C in July before gradually decreasing down to approximately 2°C warmer in September (Table 5). The mean monthly temperature in October was 1.8°C cooler in the Willow Creek than in the SJR.

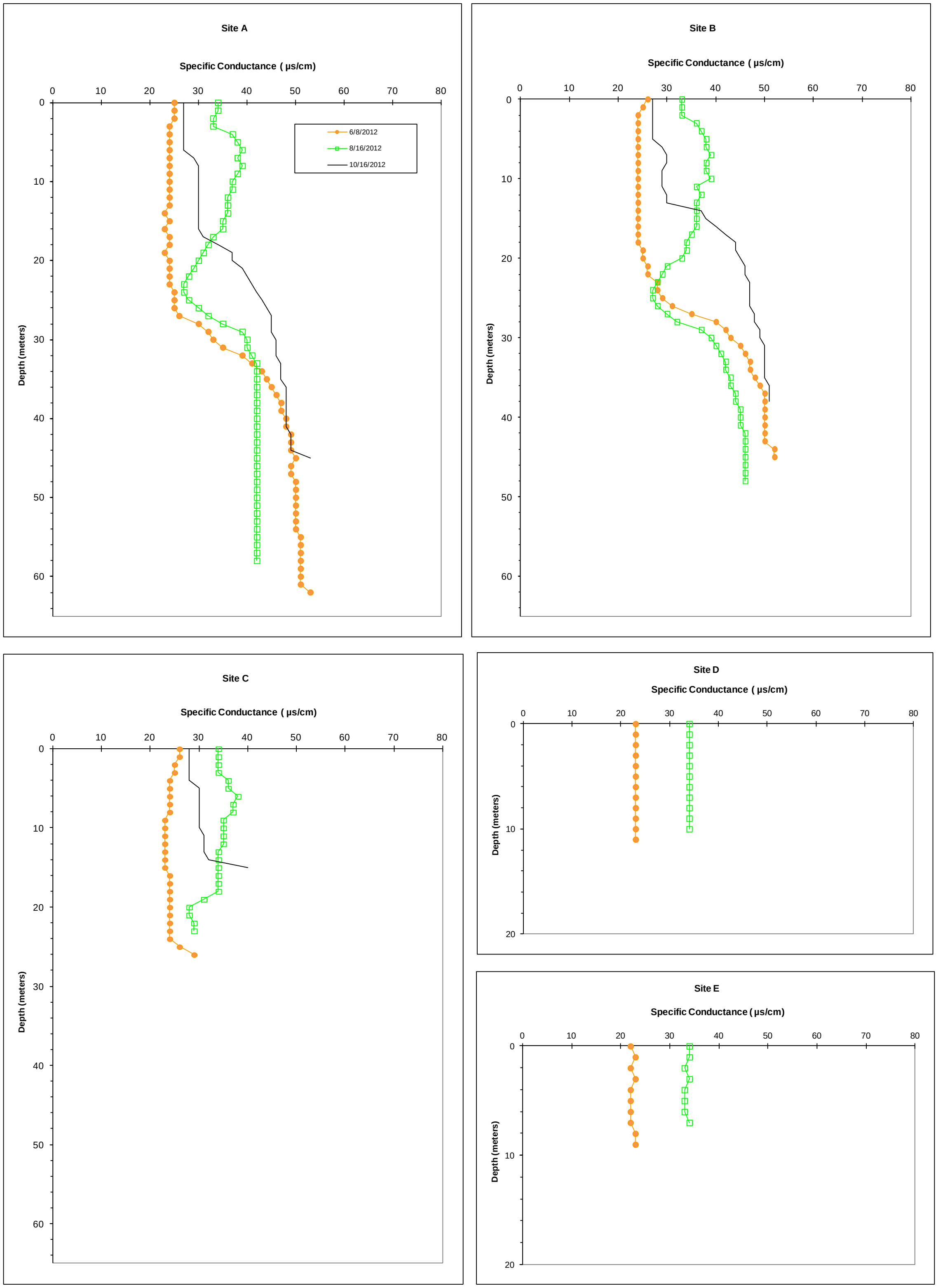
3.1.3.3 Redinger Lake Profiles

Cool inflows to Redinger Lake in spring 2012 resulted in storage of relatively cool temperatures in the deep portion of the lake. Cool water temperatures were generally present below 25 m (82 ft) depth, despite surface heating. Thermal stratification was observed at the three most downstream locations (Sites A, B, and C). DO levels remained high throughout most of the water column at all sites.

During June 2012, temperature, DO, and SC profiles were conducted at Sites A, B, C, and E (Figure 4). June water temperature profiles near Dam 7 (Site A), at Sites B and C indicated surficial warming with the warmest temperatures observed at the surface and quickly dropping 4 to 5°C within the first 4 m (13 ft) (Figure 10). Below that depth, Sites A, B, and C were essentially isothermal with a slight gradient deeper in the lake. Sites D and E were isothermal at approximately 10.5°C (Figure 10).

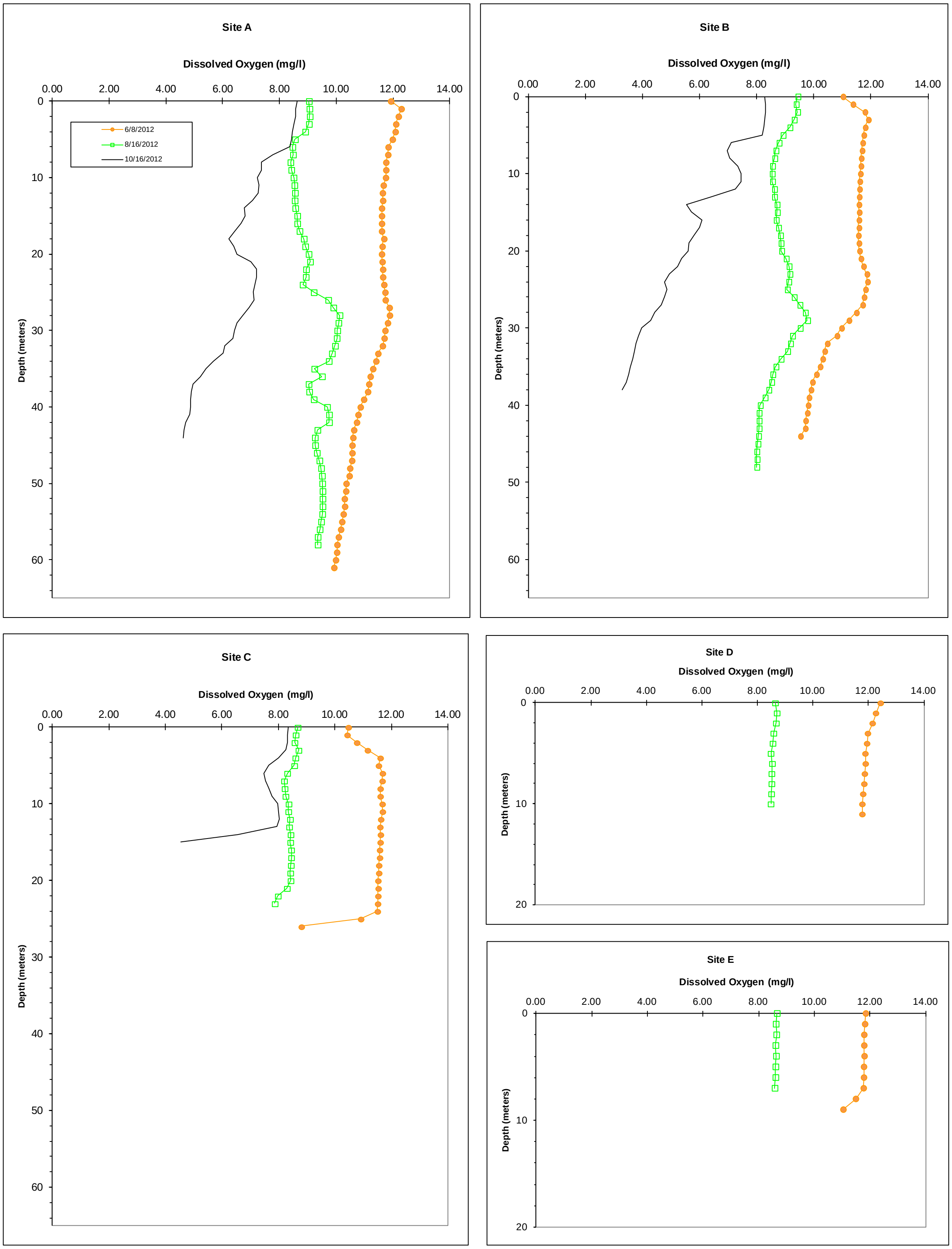
DO concentrations in June exceeded 10 milligrams per liter (mg/l) throughout the majority of the water column at all five sites. Concentrations dropped near the bottom at Sites A, B, and C. All sites reflected mixed conditions away from the bottom (Figures 11 and 12). SC increased from approximately 26 and 23 m (85 and 75 ft) to approximately 38 and 37 m (125 and 121 ft) at Sites A and B, respectively. SC at Sites C, D, and E remained relatively constant throughout the water column with only some variability observed towards the bottom of the profile at Site C.

During August, surface waters had warmed; exceeding 20°C at all sites (Figure 10). Additionally, a surface thermal gradient was present at all sites, except Site E down to depths of approximately 3 to 5 m (10 to 16 ft) (Figure 10). Thermal stratification was observed at Site A with the thermocline at 24 to 26 m (79 to 85 ft) depth and Site B at 25 to 28 m (82 to 92 ft) depth (Figure 10). A thermal gradient was observed at Site C near the bottom of the profile from 20 to 21 m (66 to 69 ft) near the bottom (Figure 10). Sites D and E were near isothermal with some surface heating at Site D (Figure 10).



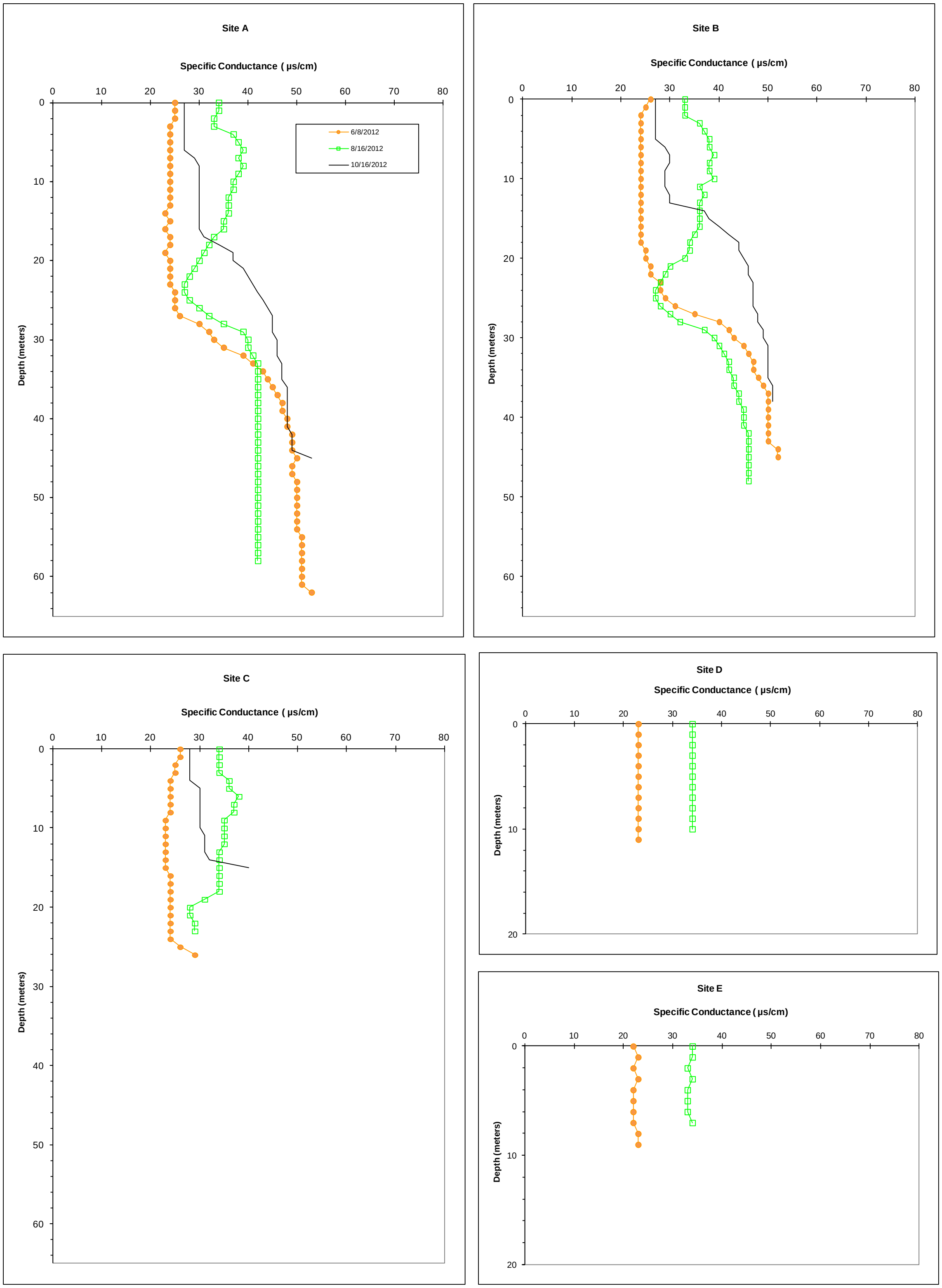
Note: Sites D and E were not accessible on 10/16/12

Figure 10. Redinger Lake Water Temperature Profiles for Sites A-E, 2012.



Note: Sites D and E were not accessible on 10/16/12

Figure 11. Redinger Lake Dissolved Oxygen Profiles for Sites A-E, 2012.



Note: Sites D and E were not accessible on 10/16/12

Figure 12. Redinger Lake Specific Conductance Profiles for Sites A-E, 2012.

DO concentrations in August decreased at all sites compared to June by as much as 3.5 mg/l (Figure 11). At Sites A and B, with the deepest profiles, concentration differences between August and June were less than 2 mg/l at depths 27 m (88.6 ft) and greater. SC was greater to depths of 20 to 25 m (66 to 82 ft) at Sites A-C in August when compared to the June data. At Sites A and B, SC was observed to have similar levels and follow a similar pattern to those seen in June at greater depths (Figure 12). SC remained relatively similar through the water column at Sites C, D, and E.

During October, water temperatures at the lake surface declined at Sites A, B, and C, to approximately 19°C. The surficial warming pattern observed in June and August was not observed in October. Thermal stratification remained present in October at Sites A and B, with well-defined epilimnion and hypolimnion layers, above and below the thermocline at depths of 17 to 21 m (56 to 69 ft) and 13 to 16 m (43 to 52 ft), at Sites A and B, respectively. Site C was isothermal for the upper portion of the water column, with a thermal gradient near the bottom. Sites D and E were not accessible because of the lowered reservoir water surface elevation.

DO profiles indicated that near surface DO concentrations in October were in excess of 8.0 mg/l at Sites A, B, and C. DO concentrations at all three sites were variable, but generally decreased with depth and were lower than in June and August throughout the water column (Figure 11). SC measurements were higher than those collected in June and were generally lower than those collected in August down to depths of 18 m and 14 m (59 to 46 ft) for Sites A and B, respectively, where conductivity began to increase more rapidly with depth (Figure 12). At Site C, SC had a small trend of increase with depth, but with a sharp increase near the bottom (Figure 12).

3.1.3.4 Deep Pool Temperature Profiles

Of the three pools monitored for summer water temperature stratification in the HSB reach of the SJR, none exhibited a distinct temperature decrease with increasing depth (Figure 13). This differed from measurements made in 2011.

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 (9 m [29.5 ft]). The temperature profile indicated that this pool was isothermal. This change from 2011 can be attributed to relatively low input of warm water from Willow Creek, only 9 cfs, compared to 59 cfs in the SJR, upstream of Willow Creek in 2012. The smaller flow from Willow Creek mixed with the SJR flow. When this pool was sampled in 2011, flows from Willow Creek and the SJR were 37 cfs and 33 cfs, respectively, and the density difference of the warmer Willow Creek water resulted in separation of the waters due to density.

The second pool sampled was located downstream of the HSB temperature logger site. The pool was relatively shallow (3 m [10 ft]) and, at the time of monitoring, was isothermal. The third pool sampled was located just upstream of PH4. The pool was relatively shallow (3 m [10 ft]) and, at the time of monitoring, was isothermal. These locations have been isothermal during previous years.

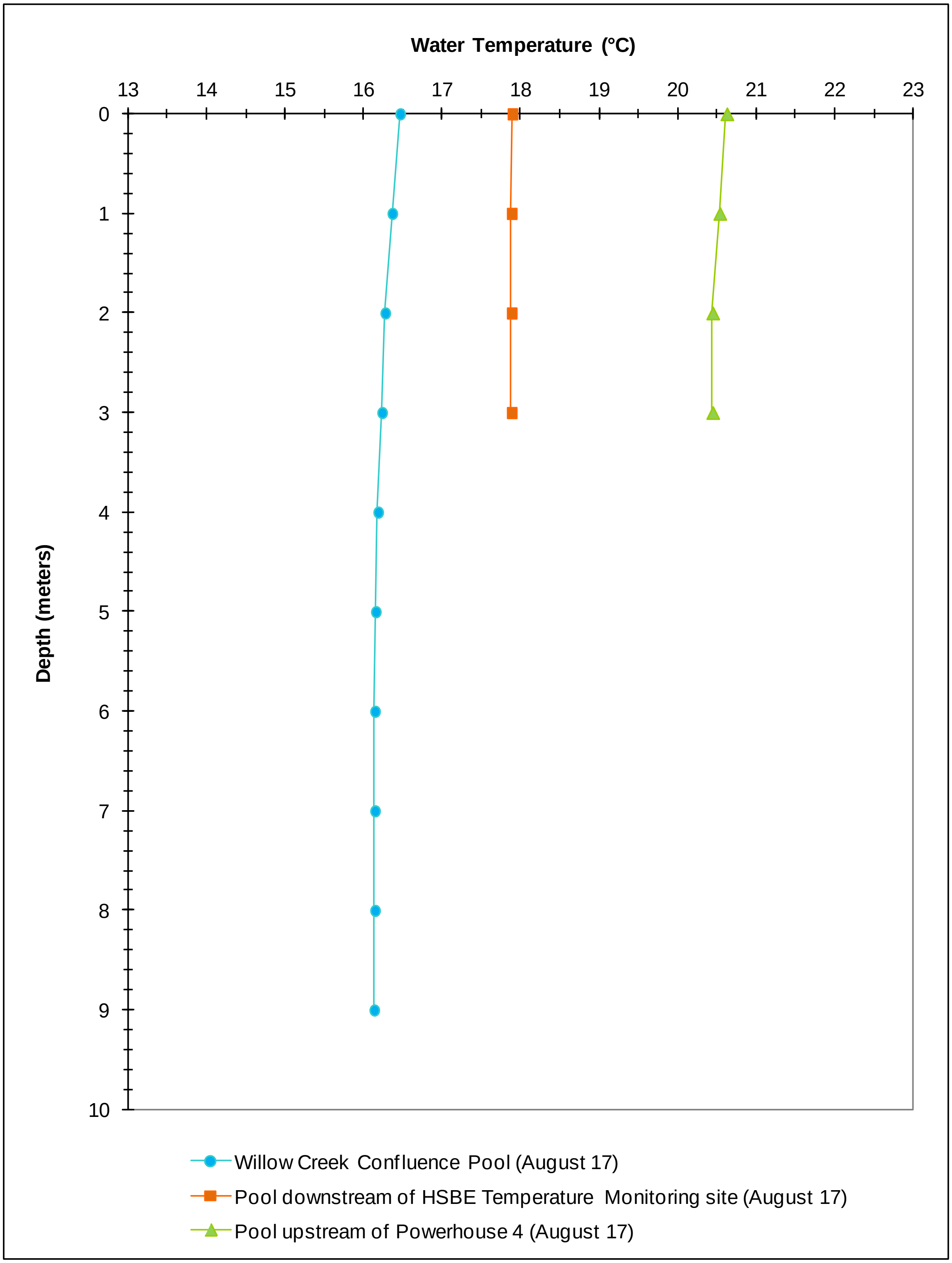


Figure 13. Pool Temperature Stratification Profile for Three Sites on the San Joaquin River - Horseshoe Bend Reach, August 17, 2012.

3.2 FOOTHILL YELLOW-LEGGED FROG

3.2.1 STATUS

No FYLF at any life history stage was detected during the three VES. Incidental observations of other amphibians included American bullfrog (*Rana catesbeiana*), pacific treefrog (*Pseudacris regilla*), and California newt (*Taricha torosa*). Additionally, several WPTs (*Actinemys marmorata*) and sierra garter snakes (*Thamnophis couchii*) were observed.

3.2.2 HABITAT

In general, most of the HSB reach lacked suitable breeding habitat for FYLF. The reach, particularly from the Backbone Creek confluence downstream, is dominated by steep bedrock and large boulder substrate, with deep margins. Lind et al. (1996) found that egg masses, in coastal streams, are laid along stream margins in shallow water that is usually <1.0 m (3.3 ft) deep and in flows less than 21 centimeters per second (cm/sec) (8.2-inch/sec). In the Sierra Nevada Mountains, studies have indicated that FYLFs typically deposit egg masses in shallow edgewater habitat <40 cm (15.6-inch) deep with velocities <10 cm/sec (3.9-inch/sec) (Pacific Gas and Electric Company [PG&E] 2001, 2002a, 2002b). This type of habitat was present only in occasional riffle head areas in the HSB reach of the SJR. There is a small area with potential breeding habitat downstream of Willow Creek near the pool tailout immediately upstream of the HSB east temperature monitoring site. Another location similar to the spot near HSB east is just downstream of the confluence with Bald Mill Creek.

Backbone and Bald Mill creeks had somewhat better habitat conditions (depths, velocities, and appropriate substrate), but both are ephemeral streams, going dry by midsummer (Backbone had only remnant isolated pools remaining by the August 29 survey, and Bald Mill was observed to be intermittent on August 28). Both Backbone and Bald Mill creeks have lower gradient habitat with appropriate velocities and substrate within the first 100 m (328 ft) from the confluence with the SJR, after runoff. However, the river has been observed to inundate most of this channel area in these creeks during spring high flows in each of the past four years. This is also the case with lower Willow Creek, which by contrast is a perennial stream. The surveyed length of Willow Creek lacked appropriate attachment substrates near the stream margins with low velocities. Cobbles and small boulders were embedded in sand in low velocity areas in the surveyed reach of Willow Creek.

3.3 WESTERN POND TURTLE

3.3.1 ABUNDANCE AND POPULATION STRUCTURE SURVEYS

In total, 38 turtles were captured in 2012 and one turtle was found dead from predation during the demography study (Table 7). Five of the 38 turtles captured were recaptures from previous years and another six were 2012 recaptures. There were 15 different adult/subadult females, 16 adult/subadult males, and two juvenile turtles of undetermined sex that were captured for a total of 33 different turtles.

Table 7. Western Pond Turtles Captured for Population Study on Horseshoe Bend in 2012.

Date	Site	Sex[1]	Age (years)[2]	Notch Location	Lifestage	Wt. (g)	Carapace Length (mm)	Recapture (yes/no)
5/16/2012	SJR at Backbone Creek	Female	11	210	adult	280	116	no
5/16/2012	SJR at Backbone Creek	Female	7	209	adult	175	98	no
5/16/2012	SJR at Backbone Creek	Male	11	208	adult	310	126	no
5/17/2012	SJR at Willow Creek	Male	n/a	309	adult	350	139	no
5/17/2012	SJR at Backbone Creek	Female	7	209	adult	175	98	yes
5/22/2012	SJR Main Channel*	Male	n/a	n/a	adult	n/a	150	no
5/23/2012	Willow Creek	Female	n/a	301	adult	n/a	140	yes
5/23/2012	Willow Creek	Male	n/a	none	adult	n/a	140	no
5/23/2012	Willow Creek	Male	n/a	none	adult	n/a	135	no
5/23/2012	Backbone Creek*	n/a	0+	n/a	juvenile	n/a	32.5	no
5/23/2012	SJR at Backbone Creek*	Male	n/a	9	adult	n/a	135	yes
5/24/2012	Willow Creek*	Male	n/a	n/a	adult	n/a	125	no
5/31/2012	Willow Creek	Male	n/a	none	adult	n/a	115	no
5/31/2012	Willow Creek	Female	n/a	50	adult	425	140	yes
5/31/2012	Willow Creek	Female	n/a	none	adult	n/a	130	no
6/1/2012	Willow Creek	Male	n/a	none	adult	n/a	155	no
6/1/2012	SJR at Willow Creek*	Female	n/a	none	adult	n/a	130	no
6/7/2012	SJR at Backbone Creek*	Male	n/a	none	adult	n/a	150	no
6/27/2012	SJR at Backbone Creek*	n/a	n/a	none	juvenile	n/a	90	no
7/18/2012	Willow Creek	Female	8	410	adult	175	115	no
7/18/2012	Willow Creek	Male	15+	411	adult	240	125	no

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Table 7. Western Pond Turtles Captured for Population Study on Horseshoe Bend in 2012 (continued).

Date	Site	Sex[1]	Age (years)[2]	Notch Location	Lifestage	Wt. (g)	Carapace Length (mm)	Recapture (yes/no)
7/18/2012	Willow Creek	Male	n/a	107	adult	n/a	129	yes
7/18/2012	Willow Creek	Female	n/a	419	adult	250	118	yes
7/18/2012	Willow Creek	Female	n/a	418	adult	275	121	no
7/18/2012	Willow Creek	Female	n/a	417	adult	200	114	no
7/18/2012	Willow Creek	Male	11	430	adult	200	121	no
7/18/2012	SJR at Backbone Creek	Male	n/a	208	adult	n/a	160	no
7/18/2012	SJR at Willow Creek	Female	8	50	adult	n/a	121	yes
7/18/2012	SJR at Willow Creek	Female	9	431	adult	n/a	122	no
7/18/2012	SJR at Willow Creek	Male	n/a	447	adult	375	139	yes
7/18/2012	SJR at Willow Creek	Female	n/a	40	adult	425	127	yes
7/18/2012	SJR at Willow Creek	Female	n/a	837	adult	450	136	yes
7/18/2012	SJR at Willow Creek	Female	n/a	412	adult	375	125	no
7/18/2012	SJR at Willow Creek	Male	n/a	448	adult	450	133	no
7/19/2012	SJR at Willow Creek	Female	n/a	50	adult	425	127	yes
8/28/2012	SJR Main Channel*	Male	n/a	n/a	adult	n/a	130	no
8/28/2012	Baldmill Creek*	n/a	1+	n/a	juvenile	n/a	n/a	no
8/29/2012	SJR at Backbone Creek*	Female	n/a	n/a	adult	n/a	132	no
8/29/2012	SJR Main Channel*	Female	n/a	n/a	adult	n/a	129	no

*Turtles that were opportunistically captured by hand.

[1]Turtles of undetermined sex were too young and did not show definitive sexual characteristics.

[2]Some turtles had so much wear on their scute rings and the edges beveled, that a specific age could not be determined.

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Turtles identified as females ranged in size from 98 to 140 mm. Identified males ranged in size from 115 to 155 mm. Gender was not discernible for two juvenile turtles with one hatchling measuring 31 mm and a yearling turtle measuring 90 mm. Fourteen turtles were notched in 2012. Most of the turtles were captured at study locations in Willow Creek, the SJR Willow Creek confluence pool, and SJR Backbone Creek confluence pool, but three were captured in the main channel SJR, and one was captured approximately 200 m (656 ft) up Backbone Creek. During the 19 encounters with 16 different female turtles, two were found to be gravid (notch numbers 418 and 412); both were encountered July 18, typically during the tail end of the nesting period. No gravid females were found in spring or early summer surveys. Neither gravid female was recaptured. One young-of-the-year 1+ year old was found during the demography study. The young-of-the-year turtle was found on Backbone Creek approximately 200 m (656 ft) upstream from the confluence with SJR and approximately 26 m (85 ft) in elevation above the water level of the SJR at base flows (Figure 14). The 1+ year old turtle was found on Baldmill Creek 700 m (2,296 ft) from its confluence with SJR and approximately 137 m (449 ft) above the elevation of the SJR at base flows. The 1+ year old turtle had been predated upon and only the posterior part of the shell remained.

All of the live turtles found appeared to be in good health, not having any active lesions or critical damage. Most all the turtles had scute chips in the carapaces and scrapes on their plastrons (Figure 15). Some turtles had linear grooves in their plastrons and carapaces to which the origin of is unknown (Figure 16). All external damage found looked to be healed or healing and not adversely affecting the turtles health.

There were five turtles recaptured in 2012 from 2010 and 2011. The carapace growth of the two female WPTs captured in 2010 and recaptured in 2012 was from 125 to 140 mm and 137 to 140 mm, 15 and 3 mm respectively. The ages of these female WPTs is unknown due to extensive scute wear. Another female captured at the SJR Backbone Creek confluence pool measured 82 mm in 2011, grew to 98 mm by summer 2012, and was seven years old. A male captured at the SJR Willow Creek confluence pool in 2010 measured 125 mm and grew to 135 mm by 2012, 10 mm growth. Another male captured at the same location in 2010 measured 130 mm, but showed no detectable growth when recaptured in 2012.

Growth appears to be variable among individuals on the HSB reach of the SJR for both male and female WPTs. The smallest recaptured turtle grew at the highest rate at over 15 mm/year from 2011 to 2012. One female turtle captured in 2010 averaged 7.5 mm/year growth from 2010 to 2012. Another grew much slower at the same location averaging 1.5 mm/year from 2010 to 2012 and was the larger of the two. Growth appears to slow dramatically for female WPTs once they reach 135 mm, based on the limited data available. Males show a similar pattern. The annual growth rate of one of the two males recaptured averaged 5 mm/year from 2010 to 2012. The other male did not appear to grow at all. The male that experienced growth was initially smaller than the other was, but surpassed it in size during 2010-2012. They were both captured and recaptured at the same times and location, yet exhibited different growth. This suggests a high variability in growth of individual WPTs, even at similar locations. The ages of both male turtles is unknown, due to extensive scute wear.

Figure 14. Young-of-the-Year WPT caught in Backbone Creek.

Figure 15. Example of Healed Over Shell Damage.

Figure 16. Example of Grooves Found on Turtles.

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Captured and observed WPTs seemed to favor habitats in and around incoming tributaries or at their confluences to the SJR. Only three of the 38 captures occurred on the main stem SJR away from an incoming tributary.

Willow Creek, near the confluence pool on the SJR, was the most populous site producing 15 of the 38 captures. The SJR Willow Creek confluence pool was the second most productive trapping site producing 10 of the 38 captures. The SJR Backbone Creek confluence pool yielded nine captures. The trapping site at SJR HSB east did not yield any turtles despite several trapping and snorkeling attempts.

The 2012 turtle demography study continues to show slight turtle movement for both sexes. A 140 mm female turtle notched #50 was captured and tagged in 2010 in the SJR Willow Creek confluence pool and again in 2012 slightly upstream from the confluence pool in Willow Creek but was tracked 265 m (869 ft) upstream near the flowline above Willow Creek in 2011. Male #447 and female #50 were both captured approximately 100 m (328 ft) downstream of the flowline and later found in the confluence pool, a distance of 165 m (541 ft) downstream.

3.3.2 Habitat Characterization

There are several pools within the study area that provide suitable forage habitat for WPTs. These pools include and are located between the confluence pools on the SJR with Willow and Backbone creeks. Characteristics include deep water, aquatic vegetation, undercut banks, open canopies, overhanging vegetation, algal growth, and basking locations near escape cover (SCE 2009a). LWD is often an important component of quality foraging and basking habitat for WPTs (Abel 2010). However, there is no LWD present in these pools, except for a large single log at a large pool upstream of the confluence pool on SJR at Backbone Creek.

There is suitable forage, basking, and escape habitat at all the WPT trapping locations sampled in 2012. These locations include; the SJR confluence pool at Willow Creek, Willow Creek upstream of the confluence pool, the SJR HSB east temperature monitoring and WPT trapping site, and the confluence pool on the SJR at Backbone Creek. All these sites have undercut banks with adventitious roots, steep banks adjacent to deep water (>1.2 m [4 ft]), and overhanging willows and/or alders for concealment and escape cover. The sites all have some algal growth and aquatic plants for forage and safe basking sites adjacent to escape cover. In addition, the adjacent terrestrial habitat has riparian ground cover and trees for additional concealment cover.

3.3.3 Nesting Habitat Vulnerability

As discussed in Section 2.2.2.1, female WPTs captured in spring 2012 were not large enough (>140 mm carapace length) to fit with the recording GPS tags. Therefore, potential WPT nesting vulnerability to whitewater flows was assessed based on the vulnerability of nesting habitat to inundation. However, an adult female WPT, previously collected in Willow Creek in 2010-2011, was tagged with a small radiotag. This WPT was found near potential nesting habitat on May 31, 2012 and had moved 189.9 m (623 ft) downstream to the Willow Creek confluence pool by June 27, 2012.

Efforts to identify potential vulnerable nesting habitat were focused on three locations where WPTs have been observed and captured; SJR Willow Creek confluence, SJR HSB East, and SJR Backbone Creek confluence (Figure 4). No potential nesting habitat was found in the elevation range between the water surface at minimum instream flow and the maximum water surface elevation estimated for whitewater release. Due to the lack of suitable nesting substrate in this elevation range, there is no potentially impacted WPT nesting habitat within the expected water levels that would result from whitewater flows in the HSB reach of the SJR. All of the potentially suitable turtle nesting habitat near the assessment sites was observed above the expected water levels for the proposed whitewater flows. A detailed description of the nesting habitat assessment is presented in Appendix B.

3.4 MOLLUSCS

The results of the 2012 mussel monitoring differed from previous years' results in estimated abundance, but not in spatial distribution. Mussel surveys were conducted at the three sites sampled in 2010 and 2011. These were Sites 5, 6, and 7.

3.4.1 SITE 5

At Site 5, in the stretch of river upstream of the sandbar and downstream of Site 5, 29 mussels were counted during 2012 (Table 8). Fewer mussels were found in this stretch of river in 2011 (six mussels) and 2010 (nine mussels). The additional mussels observed in 2012 were found in two locations—one that was thoroughly searched and one that was not thoroughly searched during previous years. The location that had been searched during previous years was a long, deep pool unit where 13 mussels were counted in 2012, four mussels were counted in 2011, and six mussels were counted in 2010. The location that had not been searched thoroughly in previous years was a crevice underneath a large (~8 m [26 ft] in diameter) boulder in a high-gradient riffle unit. A grouping of 11 live mussels and five shells was observed about 1 m (3.3 ft) underneath the boulder. Further inspection underneath the boulder was not possible. This mussel grouping was likely overlooked during previous years, because the location was difficult to access and water clarity was less than during the current survey.

Mussel counts within Site 5 were similar among survey years; nine mussels were counted in 2012, compared to 11 mussels in 2011 and 10 mussels in 2010 (Table 8). The mussels were found in the same general locations each year.

3.4.2 SITE 6

Within the pool tailout at Site 6, 14 live mussels and one shell were found in 2012 compared to 16 live mussels and two shells in 2011, and 17 live mussels and no shells in 2010 (Table 8). The mussels observed in 2012 were located in the same three locations (i.e., Sites A, B, and C) and were anchored in the same substrates as they were in 2011 and 2010 (Figure 17). The shell collected during 2012 was anchored in

Table 8. Summary of Mollusc Survey Data for Three Locations (Sandbar to Site 5, Site 5, and Site 6) Collected in 2010, 2011, and 2012.

Survey Location	Survey Year	Length of Survey Area (m)	Habitat Type(s)	Number of Shells	Number of Live Mussels
Sandbar to Site 5:					
	2010	430	Pools	0	9
	2011	430	Pools	2	6
	2012	430	Pools, High-Gradient Riffle	5	29
Site 5:					
	2010	100	Low-Gradient Riffle/Glide	0	10
	2011	100	Low-Gradient Riffle/Glide	0	11
	2012	100	Low-Gradient Riffle/Glide	0	9
Site 6:					
Location A	2010	15		0	12
Location B	2010	9		0	2
Location C	2010	10		0	3
All Locations:	**2010**	**34**	**Pool Tailout/Run**	**0**	**17**
Location A	2011	15		1	11
Location B	2011	9		0	3
Location C	2011	10		1	2
All Locations:	**2011**	**34**	**Pool Tailout/Run**	**2**	**16**
Location A	2012	15		0	9
Location B	2012	9		1	2
Location C	2012	10		0	3
All Locations:	**2012**	**34**	**Pool Tailout/Run**	**1**	**14**

a)

b)

Figure 17. Site 6 Mussel Cluster Locations: (a) Location A and (b) Locations B and C.

the same location where a live mussel was found in 2011. A subadult mussel that was observed during 2011 was not found during 2012.

3.4.3 Site 7

The mussel bed at Site 7 was located within a 438 m^2 (4,715 ft^2) area at the downstream end of a long, deep pool (Figure 18). The headpin (0 m [0 ft] mark) that was established in 2010 was located at the pool tail crest, along the river-left bank. The longitudinal distribution (from downstream to upstream) of mussels within the site did not appear to differ among survey years. In all years, the area of high density was located between 4 m (13 ft) and 17 m (56 ft) upstream from the headpin and the area of low density was located between 17 m (56 ft) and 34 m (112 ft) upstream from the headpin. The randomly selected high-density transects were located 5 m (16.4 ft), 9 m (30 ft), and 14 m (46 ft) upstream in 2012; 6 m (20 ft), 10 m (33 ft), and 14 m (46 ft) upstream in 2010; and 7 m (23 ft), 10 m (33 ft), and 12 m (39 ft) upstream in 2011. The mean wetted width for the high-density transects was 13.5 m (44.3 ft) in 2012, 15.3 m (50.2 ft) in 2010, and 15.6 m (51.2 ft) in 2011. The randomly selected low-density transects were located 21 m (69 ft) and 31 m (102 ft) upstream in 2012, 19 m (62 ft) and 23 m (75 ft) upstream in 2010, and 18 m (59 ft) and 24 m (79 ft) upstream in 2011.

The mean wetted width for the low-density transects was 13.5 m (44.3 ft) in 2012, 14.1 m (46.2 ft) in 2010, and 14.4 m (47.2 ft) in 2011.

Table 9 summarizes the results of the 2012 survey at Site 7. The results of the 2011 and 2010 surveys at Site 7 are also shown in Table 9 for comparison. Using the random survey technique described in the methods section, total mussel abundance was estimated at 398 in 2012 compared to 1,587 in 2011 and 1,033 in 2010. In all years, mussels were concentrated near the river-left bank; mussels located in the river-left stratum accounted for 71 percent of the mussels counted in 2012, 91 percent of the mussels counted in 2011, and 100 percent of the mussels counted in 2010. Of the 50 quadrats sampled per year, 15 were from the river-left stratum in 2012, 16 were from the river-left stratum in 2010, and 17 were from the river-left stratum in 2011.

At Site 7, the comparatively low population estimate (398 mussels) for the 2012 survey year likely reflects the random variability inherent in the sampling strategy. Since the mussels at Site 7 are distributed in small and large clusters with gaps between clusters, it is not surprising that the random sampling strategy resulted in high between-year variability. During the preliminary snorkel survey in 2012, surveyors counted over 300 mussels along the river-left bank alone. This indicates that the total population estimate of 398 mussels was likely low.

3.5 Fish

This section presents the results of fish monitoring. There are three monitoring elements discussed: hardhead radiotracking, larval fish sampling, and SJR fish population sampling.

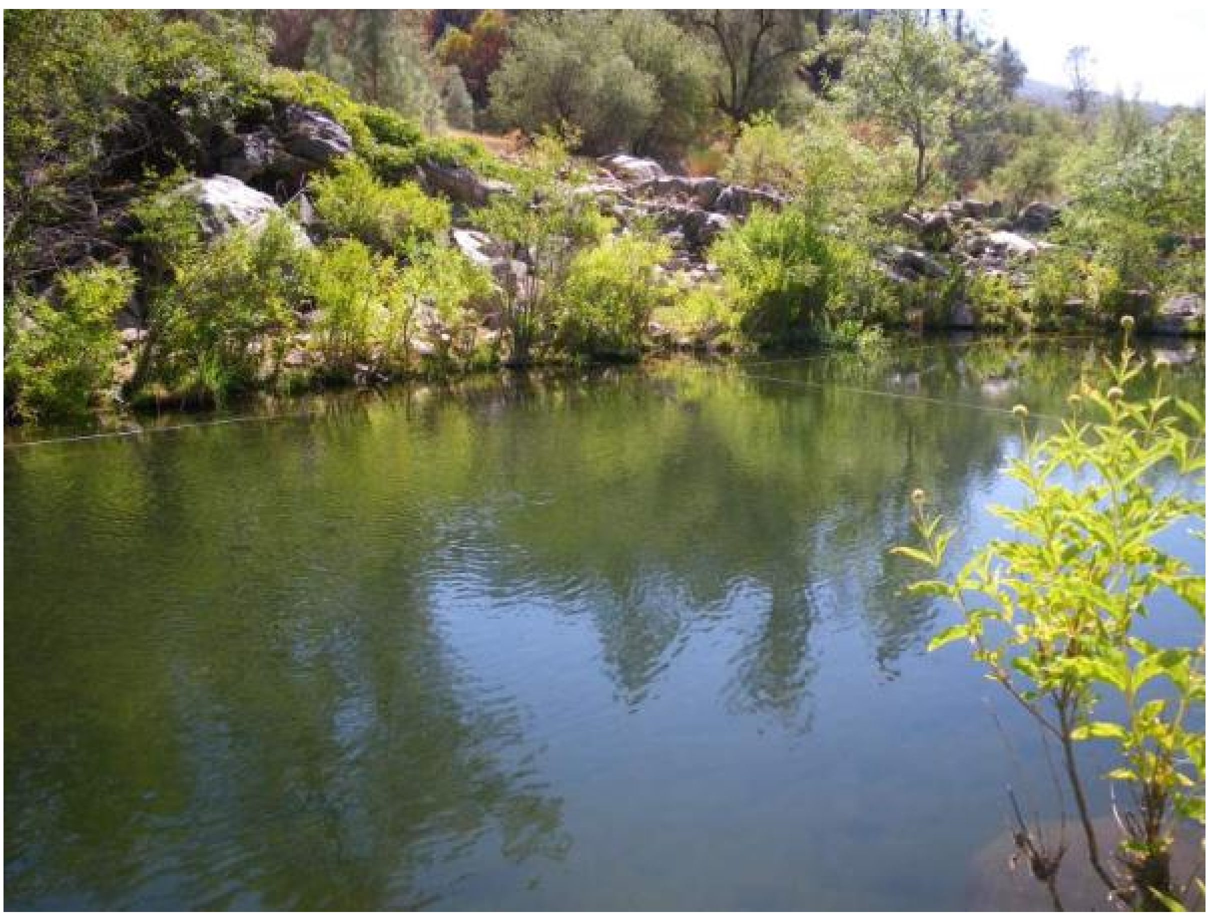

Figure 18. View of Site 7 Mussel Bed Looking at River-Left Bank.

Table 9. Summary of Mollusc Survey Data at Site 7 Collected in 2010, 2011 and 2012.

Transect Stratum	Survey Year	Width (m)	Length (m)	Area (m^2)	Mean Depth (m)	Total Number of Mussels	Number of Samples	Mean Density per Sample	Mean Density per m^2	Estimated Number of Mussels
HD River Left	2010	5.1	13.0	66.3	1.0	25	9	2.78	11.11	
HD River Left	2011	5.2	13.0	67.6	1.1	46	10	4.60	18.40	
HD River Left	2012	4.5	13.0	58.5	1.1	12	9	1.33	5.33	
HD Middle	2010	5.1	13.0	66.3	1.6	3	10	0.30	1.20	
HD Middle	2011	5.2	13.0	67.6	1.6	0	11	0.00	0.00	
HD Middle	2012	4.5	13.0	58.5	1.6	4	11	0.36	1.45	
HD River Right	2010	5.1	13.0	66.3	1.3	0	11	0.00	0.00	
HD River Right	2011	5.2	13.0	67.6	1.3	0	9	0.00	0.00	
HD River Right	2012	4.5	13.0	58.5	1.4	1	10	0.10	0.40	
2010 High Density:		15.4	13.0	200.2	1.3	28	30	0.93	3.73	747
2011 High Density:		15.6	13.0	202.8	1.3	46	30	1.53	6.13	1,244
2012 High Density:		**13.5**	**13.0**	**175.5**	**1.4**	**17**	**30**	**0.57**	**2.27**	**398**
LD River Left	2010	4.7	17.0	79.9	0.7	6	7	0.86	3.43	
LD River Left	2011	4.8	17.0	81.6	1.0	7	7	1.00	4.00	
LD River Left	2012	4.5	17.0	76.5	0.7	0	6	0	0	
LD Middle	2010	4.7	17.0	79.9	1.6	0	6	0.00	0.00	
LD Middle	2011	4.8	17.0	81.6	1.6	0	6	0.00	0.00	
LD Middle	2012	4.5	17.0	76.5	1.6	0	8	0	0	
LD River Right	2010	4.7	17.0	79.9	1.5	0	7	0.00	0.00	
LD River Right	2011	4.8	17.0	81.6	1.0	0	7	0.00	0.00	
LD River Right	2012	4.5	17.0	76.5	1.0	0	6	0	0	
2010 Low Density:		14.1	17.0	238.0	1.3	6	20	0.30	1.20	286
2011 Low Density:		14.4	17.0	244.8	1.2	7	20	0.35	1.40	343
2012 Low Density:		**13.5**	**17.0**	**229.5**	**1.3**	**0**	**20**	**0**	**0**	**0**
2010 Estimated Abundance:										**1,033**
2011 Estimated Abundance:										**1,587**
2012 Estimated Abundance:										**398**

3.5.1 HARDHEAD RADIOTRACKING

3.5.1.1 Hardhead Radiotracking

In general, no significant movements were detected in the majority of radiotagged hardheads. However, one fish moved downstream two miles from the SJR-Willow Creek confluence pool to a large pool about a quarter of a mile upstream of the SJR/Backbone Creek confluence sometime between mid-November 2011 and mid-May 2012. This was the smallest fish fit with a radiotag and made no other significant movements. Fourteen of sixteen fish were detected during the surveys.

Of the 16 fish tagged in 2011, two fish were never located. Tag failure is likely because the entire study area was searched during each survey. Two additional tags were recovered after being detached from the fish; these were likely due to mortalities. Five additional tags were suspected of having been detached over the course of the study.

3.5.1.2 Hardhead Spawning

Hardhead spawning activities were observed on May 21, 2012 during the second FYLF VES at the head of a large pool in the SJR, 0.52 miles downstream of Backbone Creek. Single females would lay their eggs above the rock and multiple males would fertilize the eggs simultaneously with egg deposition. The water temperature in the SJR near Backbone Creek was measured to be 15°C at one foot below the water surface. Hardhead were observed in large aggregates at six additional locations in between this location and PH4 on May 22 during the FYLF VES. Temperatures were slightly less than 15°C and the fish were not actively spawning. In all cases, hardhead were observed at the heads of pools and runs often under bedrock ledges. Also, there were patches of gravels and cobbles, as well as larger rock, present at these locations. In addition, the field crew observed a large aggregate of hardhead spawning on boulder riprap adjacent to the Redinger Lake boat ramp on the afternoon of May 21. The water temperature at this location was 15.5°C.

3.5.2 LARVAL FISH

Larval fish trapping results are shown in Table 10, by date and site. Larvae (age 0) and a few yearling (age 1) fish were collected in 2012. Larvae were collected at all sites between early May and late July except for the Willow Creek confluence site. Hardhead larvae were first observed on June 26 at the SJR-PH4 sampling site. Based on size and lifestage of the larvae, spawning would have been expected to have taken place one to two weeks earlier. Subsequent sampling captured hardhead through the July sampling period. Sacramento sucker was the most frequently collected species among all sites. Sacramento sucker larvae were captured on the main stem SJR on May 15 and were present at all sites through July. Sacramento pikeminnow larvae were not captured during the 2012 sampling. However, young-of-the-year fish were identified during the fish population sampling in October. Spotted Bass larvae were captured in Willow Creek and in the SJR-Willow Creek confluence pool.

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Table 10. Results of 2012 Larval Sampling (Numbers, Average Total Length, and Lifestage by Location and Date).

		Location	SJR - Powerhouse 4		SJR between PH4 and Backbone Creek		Backbone Creek		Horseshoe Bend Logger Site		SJR - Willow Creek Confluence		Willow Creek		Willow Creek Bridge	
Deployment Date	Life-Stage	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)
4/24 - 4/25/2012	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	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
		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
5/1 - 5/2/2012	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	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	-	-
		Unidentified	0	0.0	-	-	0	0.0	-	-	2	NA	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	-	-
5/15 - 5/17/2012	Larvae	Hardhead	0	0.0	0	0.0	0	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	0.0	0	0.0	0	0.0
		Sacramento Sucker	14	15.8	12	16.6	9	17.0	6	18.0	15	16.4	0	0.0	11	15.9
		Spotted Bass	0	0.0	0	0.0	0	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	0.0	0	0.0	0	0.0
	Age 1	Hardhead	0	0.0	0	0.0	0	0.0	1	34.0	0	0.0	0	0.0	0	0.0
		Sacramento Pikeminnow	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6/6 - 6/8/2012	Larvae	Hardhead	0	0.0	0	0.0	0	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	0.0	0	0.0	0	0.0
		Sacramento Sucker	20	17.0	27	16.6	17	17.4	2	15.5	0	0.0	5	15.4	18	17.7
		Spotted Bass	0	0.0	0	0.0	0	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	0.0	0	0.0	0	0.0
	Age 1	Hardhead	2	39.5	0	0.0	0	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	0.0	0	0.0	0	0.0

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Table 10. Results of 2012 Larval Sampling (Numbers, Average Total Length, and Lifestage by Location and Date) (continued).

Deployment Date	Life-Stage	Location / Species	SJR - Powerhouse 4 Total Number Collected	SJR - Powerhouse 4 Average Length (mm)	SJR between PH4 and Backbone Creek Total Number Collected	SJR between PH4 and Backbone Creek Average Length (mm)	Backbone Creek Total Number Collected	Backbone Creek Average Length (mm)	Horseshoe Bend Logger Site Total Number Collected	Horseshoe Bend Logger Site Average Length (mm)	SJR - Willow Creek Confluence Total Number Collected	SJR - Willow Creek Confluence Average Length (mm)	Willow Creek Total Number Collected	Willow Creek Average Length (mm)	Willow Creek Bridge Total Number Collected	Willow Creek Bridge Average Length (mm)
6/12 - 6/13/2012	Larvae	Hardhead	0	0.0	0	0.0	0	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	0.0	0	0.0	0	0.0
		Sacramento Sucker	34	16.0	15	15.8	11	15.9	11	16.5	31	16.0	26	17.0	12	15.3
		Spotted Bass	0	0.0	0	0.0	0	0.0	0	0.0	2	11.0	14	12.4	0	0.0
		Unidentified	0	0.0	0	0.0	0	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	0.0	0	0.0	0	0.0
		Sacramento Pikeminnow	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6/26 - 6/27/2012	Larvae	Hardhead	7	11.6	1	12.0	0	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	0.0	0	0.0	0	0.0
		Sacramento Sucker	10	18.2	16	15.9	52	15.3	11	17.7	32	15.9	5	17.4	12	17.8
		Spotted Bass	0	0.0	0	0.0	0	0.0	0	0.0	1	15.0	7	19.4	0	0.0
		Unidentified	0	0.0	0	0.0	0	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	0.0	0	0.0	0	0.0
		Sacramento Pikeminnow	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
7/11 - 7/12/2012	Larvae	Hardhead	5	16.4	9	13.0	6	12.8	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	0.0	0	0.0	0	0.0
		Sacramento Sucker	1	23.0	0	0.0	69	17.0	20	15.3	12	18.0	0	0.0	0	0.0
		Spotted Bass	0	0.0	0	0.0	0	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	0.0	0	0.0	0	0.0
	Age 1	Hardhead	0	0.0	0	0.0	0	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	6	34.0	0	0.0	0	0.0
		Sacramento Pikeminnow	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
7/25 - 7/26/2012	Larvae	Hardhead	0	0.0	2	22.0	27	15.0	6	12.0	0	0.0	0	0.0	-	-
		Sacramento Pikeminnow	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	-	-
		Sacramento Sucker	1	15.0	2	28.5	10	20.0	26	19.0	0	0.0	0	0.0	-	-
		Spotted Bass	0	0.0	0	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	0.0	0	0.0	-	-
	Age 1	Hardhead	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	-	-
		Spotted Bass	0	0.0	0	0.0	1	32.0	0	0.0	16	34.0	0	0.0	-	-
		Sacramento Pikeminnow	0	0.0	0	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.
NA = Data not available, captured fish escaped trap during collection.

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Hardhead larvae were first collected at the SJR-PH4 sampling site on June 26 and were again captured at that site on July 11 and July 25. Hardhead larvae were also captured at SJR between PH4 and Backbone Creek (June 26, July 11, and July 25), the Backbone Creek site on the SJR (July 11 and July 26), and the HSB logger site (July 25). There was no evidence of successful hardhead spawning in Willow Creek, which differs from what was observed in 2010 and 2011, but matches what was observe in 2008 and 2009.

The timing and size of hardhead larvae collected in the sampling period suggests hardhead spawning began in early to mid-June and continued through mid-July. However, observations of hardhead spawning occurred during the third week of May 0.52 miles downstream of SJR/Backbone Creek confluence. As the summer progressed, hardhead larvae became more abundant and the distribution extended in an upstream direction. The upstream succession of hardhead larvae observations may be a result of the general warming trend of HSB reach (i.e., the downstream end of the reach warms earlier than the upstream reaches). The onset of spawning for Sacramento sucker appears to have occurred by early May and continued throughout the summer. The timing and size of larval fish collections suggest that spawning occurred for hardhead and Sacramento sucker on multiple occasions and in multiple locations.

SJR monthly average water temperatures during the period of larval trapping ranged from 9.9-14.4°C for May, 11.2-16.6°C for June, 13.8-18.5°C for July and 16.7-20.2°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, July 26, daily mean water temperatures in the SJR downstream of Dam 7 and upstream of PH4 were 14.6 and 18.6°C, respectively. Average monthly water temperatures in Willow Creek ranged from 16.2°C in May to 23.8°C in August at the location sampled (Table 5). On the last day of sampling on July 26, daily mean water temperature at this site was 22.4°C.

3.5.3 Fish Populations

The results of the 2012 fish sampling (species composition, density, and population characteristics) are discussed below.

3.5.3.1 Species Composition and Density

There were 1,082 fish identified to species sampled through electrofishing and snorkeling combined. This does not include large numbers of unidentified age 0 cyprinids (discussed below). The fish community in the SJR between Dam 7 and PH4 consisted primarily of Sacramento suckers, which made up 69.3 percent of the fish identified. Hardhead made up 11.7 percent of the total; 7.3 percent consisted of Sacramento pikeminnow; rainbow trout made up 4.5 percent; 4.4 percent were prickly sculpin; 2.7 percent were spotted bass; and 0.1 percent were green sunfish (Figure 19). In addition, large numbers (approximately 12,239) of small (0 to 3 inches [76 mm] TL) cyprinids were found in the margins of the snorkeled pool habitat. These small fish

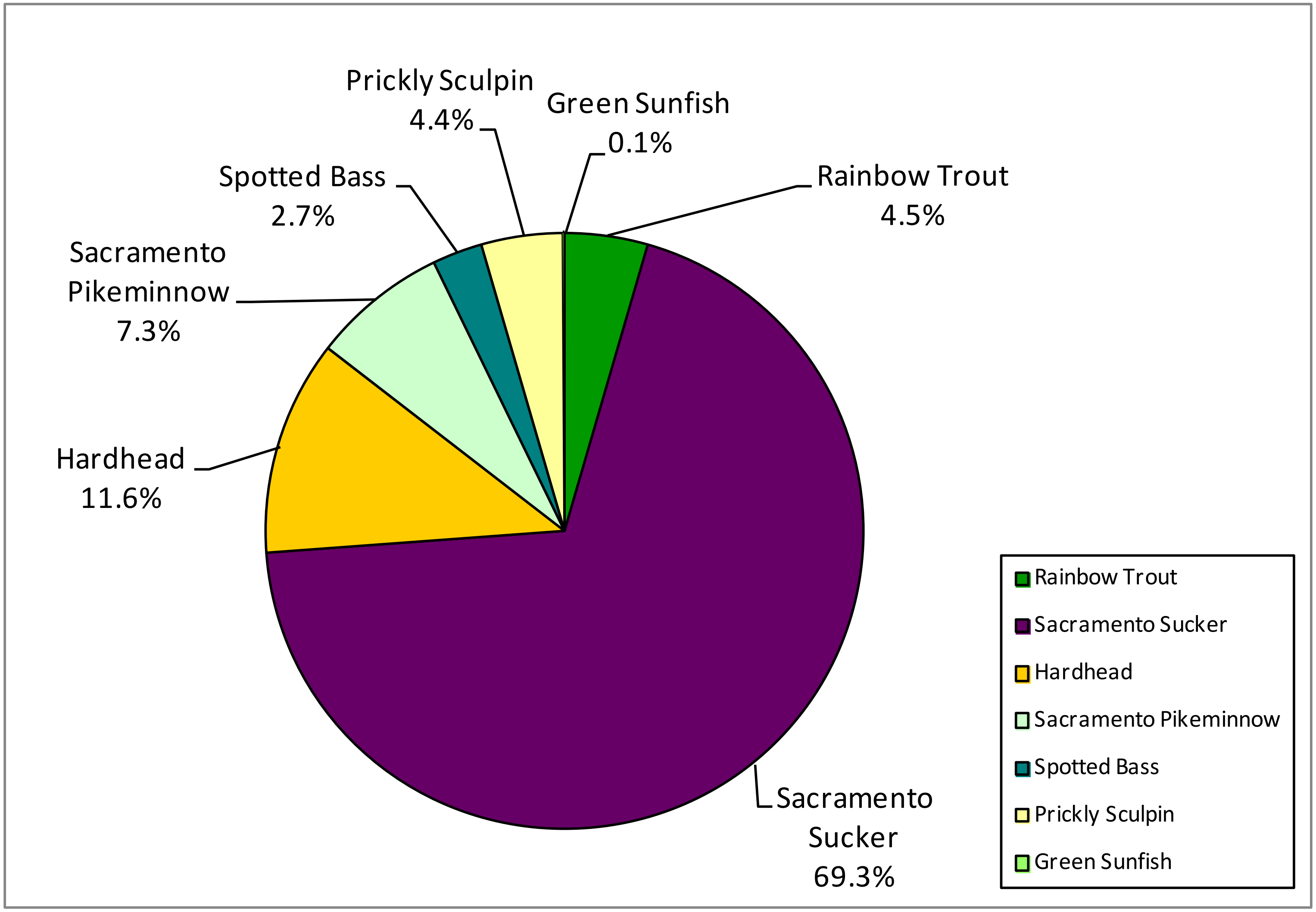

Figure 19. Species Composition – Electroshocking and Snorkel Data not including "Unidentified Cyprinids" in the San Joaquin River, 2012.

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 the “unidentified cyprinids” appear to consist mostly of hardhead with somewhat smaller numbers of Sacramento pikeminnow present. Based on the sizes observed, they were exclusively young-of-the-year (age 0) fish (Figures 20 and 21). The “unidentified cyprinids” outnumbered all other fish found.

Estimates for fish densities by site are provided 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 312.8 fish/km, Sacramento suckers 1,864.1 fish/km, Sacramento pikeminnow 30.9 fish/km, rainbow trout 19.0 fish/km, and “unidentified cyprinids” (age 0 and age 1 hardhead and Sacramento pikeminnow) 4,851.9 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 and reclusive behavior, which limited our ability to observe them. Although not abundant, spotted bass, a non-native species of the sunfish family (Centrarchidae), was present at many of the sites. One green sunfish, another non-native species of the sunfish family, also was observed. Estimates for biomass by species are based on weights measured from electrofishing only. Biomass estimates for each site are given in Table 13. Results for each site are discussed below. Species composition at each site is provided in Figures 22-23.

3.5.3.2 Population Characteristics

Length Frequency and Condition Factors

Length-frequency histograms for sampled fish are presented on Figure 21 and Figures 24 through 26. Multiple year classes of hardhead, Sacramento sucker and Sacramento pikeminnow were observed among the combined fish population sampling sites in 2012. “Unidentified cyprinids” were observed in one size range: 0-3 inches (0-76 mm) (Figure 21). These fish were a mixture of hardhead and Sacramento pikeminnow that were too small to distinguish from each other during snorkel surveys. There were far more “unidentified cyprinids” observed in 2012 than during 2011; the overall density in 2012 was about five times greater than that of 2011.

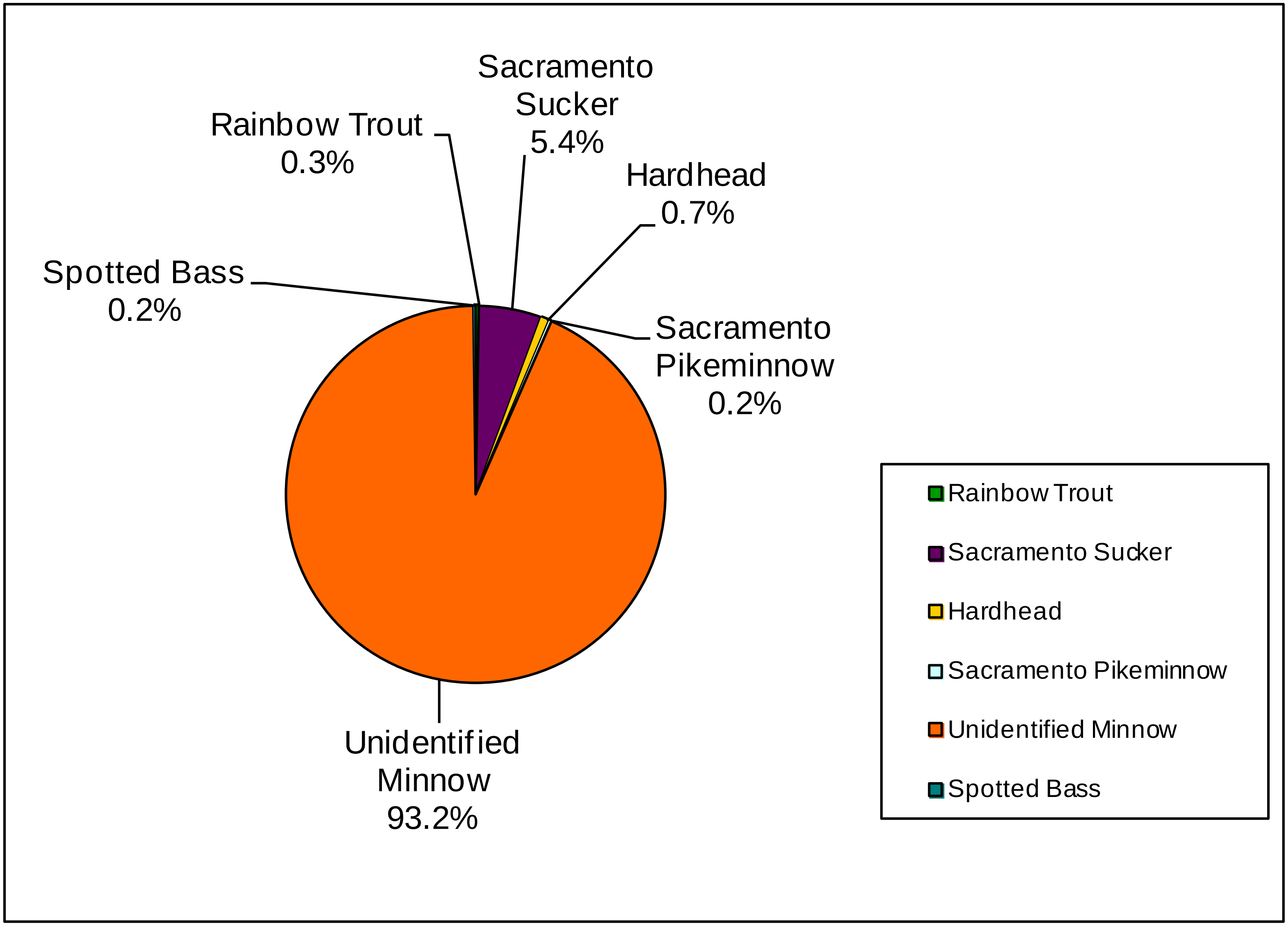

Figure 20. Species Composition for All Sites in 2012 based on Snorkeling.

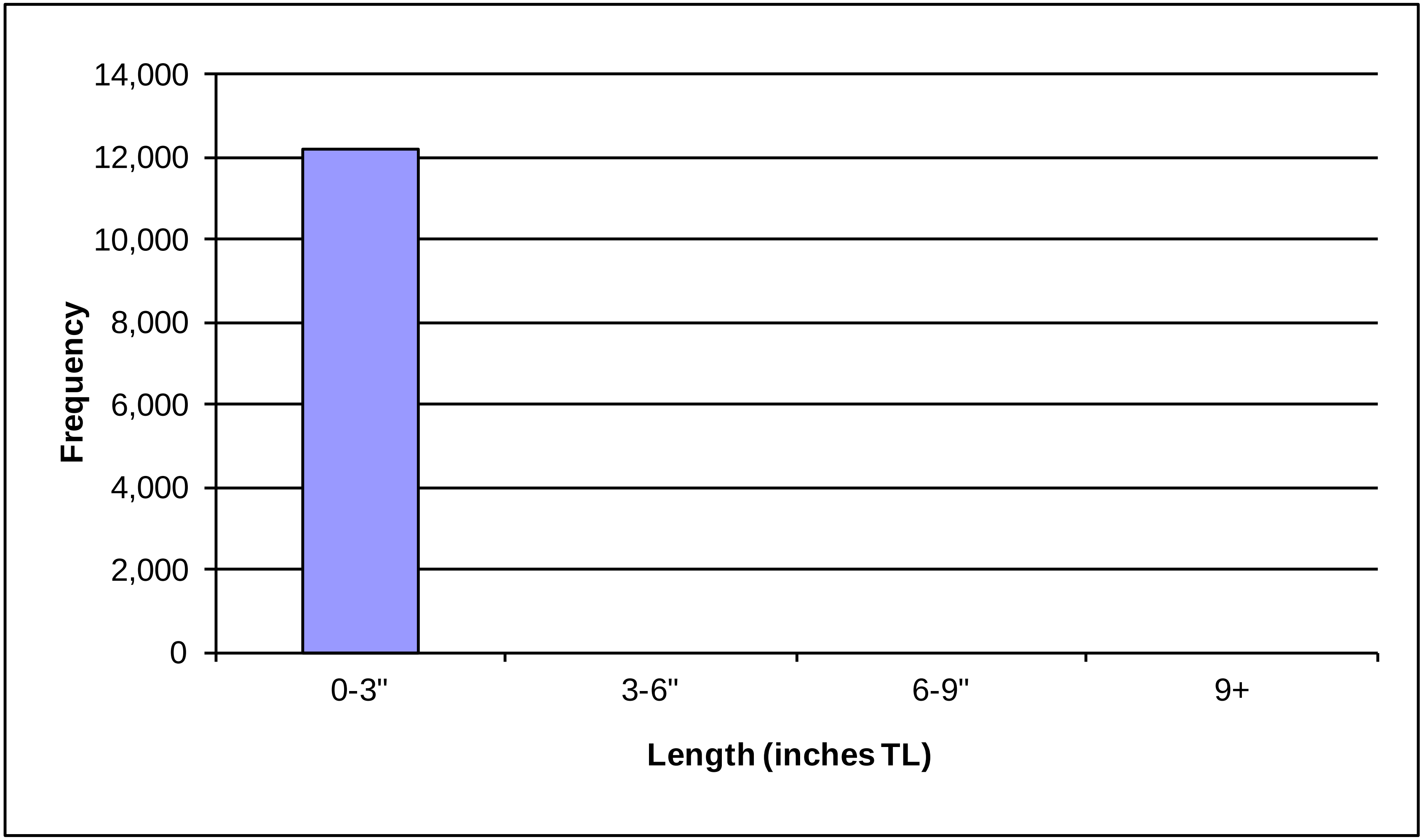

Figure 21. Length Frequency of "Unidentified Cyprinids" Observed by Snorkeling in the San Joaquin River, All Sites Combined, October 2012.

Table 11. Population and Density Estimates for Electrofishing and Snorkeling Sampling Sites in the San Joaquin River, October 2012.

Site	Unit[2]	Species	Estimated Fish Population					
			Size Range (millimeters)	Number of Fish Captured or Observed[3]	Population Estimate[4]	Lower 95 Percent Confidence Limit[5]	Upper 95 Percent Confidence Limit	Density Estimate Number per Kilometer
1[1]		Hardhead	>240	0(2)	2	2	-	4
		Sacramento Sucker	>240	0(12)	12	12	-	25
		Sacramento Pikeminnow	>240	0(2)	2	2	-	4
		Spotted Bass	160-240+	0(6)	6	6	-	13
		Rainbow Trout	>240	0(1)	1	1	-	2
2	15	Hardhead	>240	0(1)	1	1	-	2
		Sacramento Sucker	160-240+	0(8)	8	8	-	13
		Sacramento Pikeminnow	160-240	0(1)	1	1	-	9
		Rainbow Trout	70-240+	4(8)	12	12	-	19
		Prickly Sculpin	44-110	24(0)	24	24	-	39
		Spotted Bass	64-240+	2(14)	16	16	-	26
3		Hardhead	160-240+	0(2)	2	2	-	6
		Sacramento Sucker	52-240+	13(79)	95	92	107	304
		Sacramento Pikeminnow	47-240+	3(2)	5	5	-	16
		Rainbow Trout	80-240+	1(15)	16	16	-	51
		Prickly Sculpin	110-127	3	3	3	11	10
		Unidentified Cyprinids	<80	91	91	91	-	291
4	69	Hardhead	150-240+	4(53)	57	57	-	163
		Sacramento Sucker	37-371	26(284)	312	310	317	892
		Sacramento Pikeminnow	40-240+	8(13)	21	21	23	60
		Rainbow Trout	115-329	4(6)	10	10	350	29
		Prickly Sculpin	112-116	4	4	4	9	11
		Unidentified Cyprinids	<80	3,843	3,843	3,843	-	10,991

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Table 11. Population and Density Estimates for Electrofishing and Snorkeling Sampling Sites in the San Joaquin River, October 2012 (continued).

			Estimated Fish Population					
Site	Unit[2]	Species	Size Range (millimeters)	Number of Fish Captured or Observed[3]	Population Estimate[4]	Lower 95 Percent Confidence Limit[5]	Upper 95 Percent Confidence Limit	Density Estimate Number per Kilometer
5	81	Hardhead	42-240+	6(31)	49	37	183	102
		Sacramento Sucker	59-240+	5(292)	297	297	300	615
		Sacramento Pikeminnow	38-240+	8(6)	14	14	17	29
		Rainbow Trout	92-130	5(0)	5	5	7	10
		Prickly Sculpin	80-125	5	5	5	6	10
		Spotted Bass	>240	2	2	2	4.144	4
		Unidentified Cyprinids	<80	0(4,360)	4,360	4,360	-	9,034
6	109	Hardhead	33-160	19(6)	25	25	27	52
		Sacramento Pikeminnow	30-240	30(5)	35	35	37	72
		Sacramento Sucker	51-315	4(28)	32	32	37	66
		Rainbow Trout	23-253	4(0)	4	4	9	8
		Prickly Sculpin	64-107	11	11	11	11	23
		Spotted Bass	>240	1	1	1	-	2
		Green Sunfish	56	1	1	1	-	2
		Unidentified Cyprinids	<80	0(3,945)	3,945	3,945	-	8,166

1 Site was too swift and turbulent to block off and shock safely.

2 Unit numbers represent habitat units identified during 1997 habitat mapping by Cardno ENTRIX. These habitat units were electrofished.

3 Number of fish collected (number of fish enumerated from direct observation [snorkeling] in habitats too deep for electrofishing methods in parentheses).

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

5 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.

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Table 12. Density Estimates and Percentage Composition by Species for Combined Sites in the San Joaquin River, 2012.

Species	Density Estimate Number per Kilometer	Percentage of Total Fish Observed and Captured with Unidentified Cyprinids[1]	Percentage of Total Fish Observed and Captured without Unidentified Cyprinids[1]
Hardhead	312.8	0.9%	11.6%
Sacramento Sucker	1864.1	5.6%	69.3%
Sacramento Pikeminnow	30.9	0.6%	7.3%
Rainbow Trout	19.0	0.4%	4.5%
Prickly Sculpin	18.6	0.4%	4.4%
Spotted bass	11.5	0.2%	2.7%
Green Sunfish	0.4	0.01%	0.1%
Unidentified Cyprinids[1]	4,851.9	92.0%	-

[1] Unidentified cyprinids include hardhead (primarily) and Sacramento pikeminnow <75 mm TL.

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Table 13. Population and Biomass Estimates at Electrofishing Sampling Sites in the San Joaquin River, 2012.

Site	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[1]		-	-	-	-		-
2	Prickly Sculpin	44-110	24	24	0.164	10.550	8.050
	Rainbow Trout	70-100	4	n/a (4)	0.026	1.673	1.276
	Spotted Bass	64-271	2	n/a (2)	0.285	18.334	13.989
3	Prickly Sculpin	110-127	3	3 (3)	0.068	1.028	0.649
	Rainbow Trout	100	1	n/a (1)	0.01	0.151	0.095
	Sacramento Sucker	52-183	13	16	0.094	1.421	0.897
	Sacramento Pikeminnow	47	3	n/a (3)	0.003	0.045	0.029
4	Prickly Sculpin	112-116	4	4	0.088	1.283	1.316
	Rainbow Trout	115-329	4	10	0.507	7.393	7.580
	Sacramento Sucker	37-371	26	28	4.141	60.382	61.907
	Sacramento Pikeminnow	40-63	8	8	0.009	0.131	0.135
	Hardhead	56-61	4	4	0.007	0.102	0.105
5	Prickly Sculpin	80-125	5	5	0.079	2.592	1.575
	Rainbow Trout	92-130	5	5	0.084	2.756	1.674
	Sacramento Sucker	59-86	5	5	0.024	0.787	0.478
	Sacramento Pikeminnow	38-86	8	8	0.034	1.115	0.678
	Hardhead	42-55	6	18	0.008	0.262	0.159
6	Prickly Sculpin	64-117	11	n/a (11)	0.121	5.671	10.337
	Rainbow Trout	23-253	4	4	0.515	24.138	43.995
	Sacramento Sucker	51-315	4	4	0.549	25.731	46.900
	Sacramento Pikeminnow	30-75	30	30	0.04	1.875	3.417
	Hardhead	33-135	19	19	0.039	1.828	3.332
	Green Sunfish	56	1	n/a (1)	0.003	0.141	0.256

[1] Site was too deep and turbulent to electrofish safely
( ) Insufficient information for multiple pass population estimate, actual catch used for population estimate

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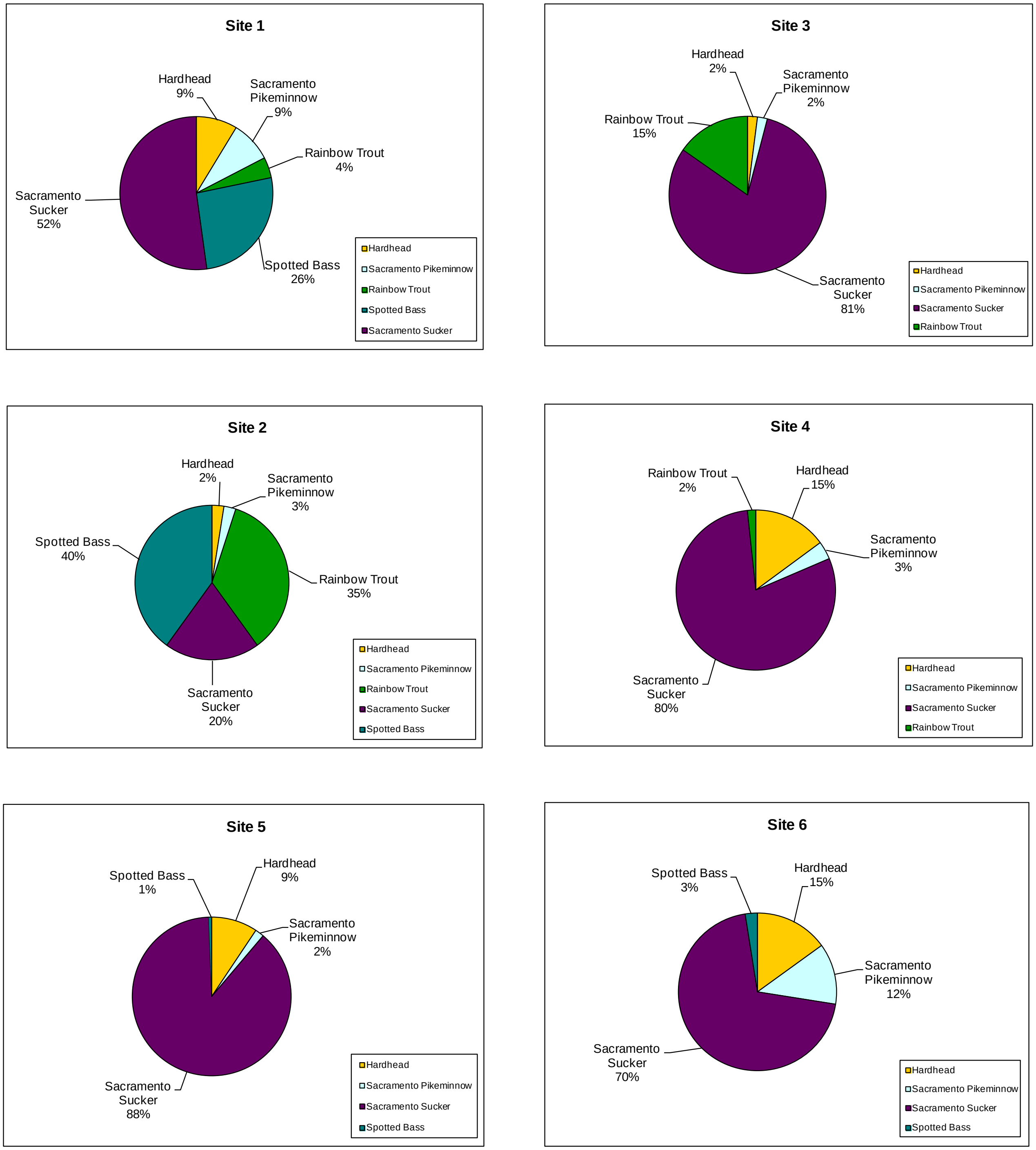

Figure 22. Species Composition by Site from Snorkeling Observations (not including "Unidentified Cyprinids") in the San Joaquin River, 2012.

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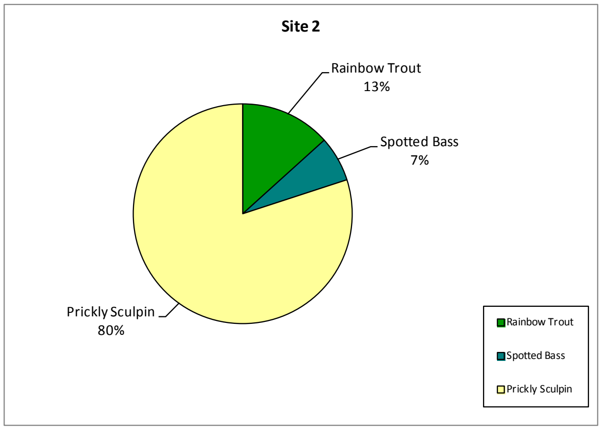

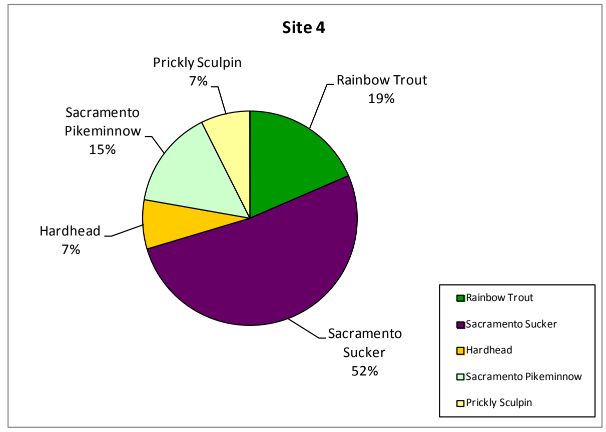

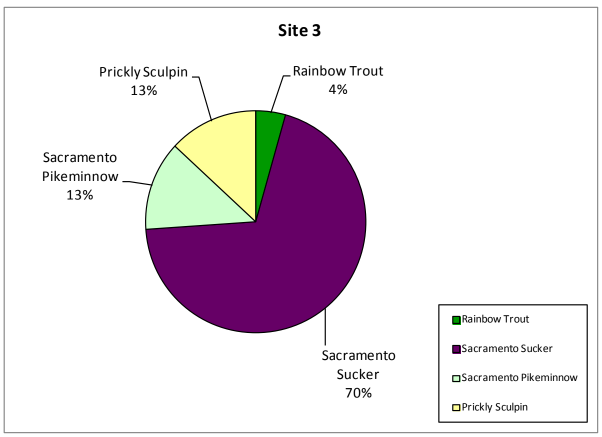

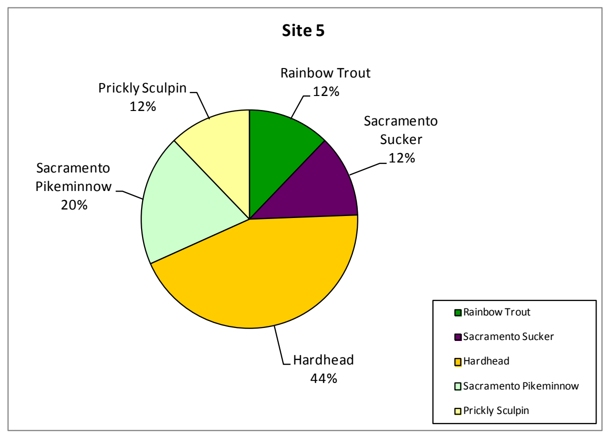

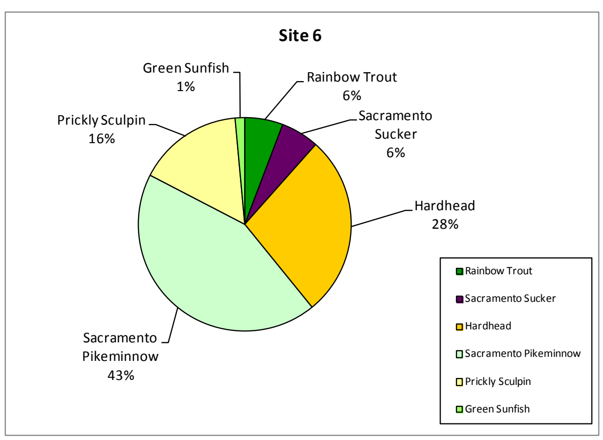

Figure 23. Species Composition based on Electrofishing Surveys in 2012.

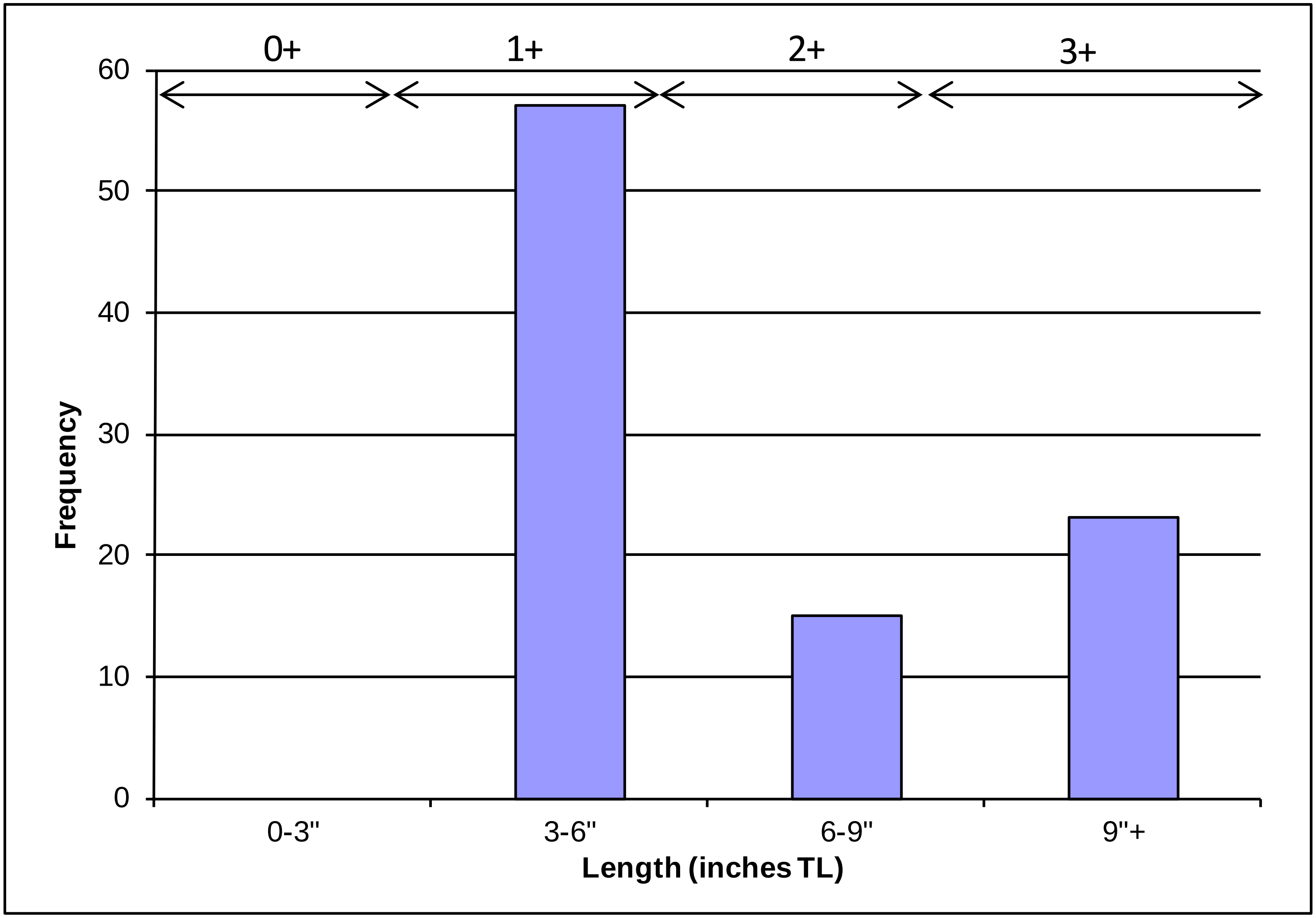

Figure 24. Length Frequency of Hardhead Observed by Snorkeling in the San Joaquin River, All Sites Combined, October 2012 (not including unidentified cyprinids).

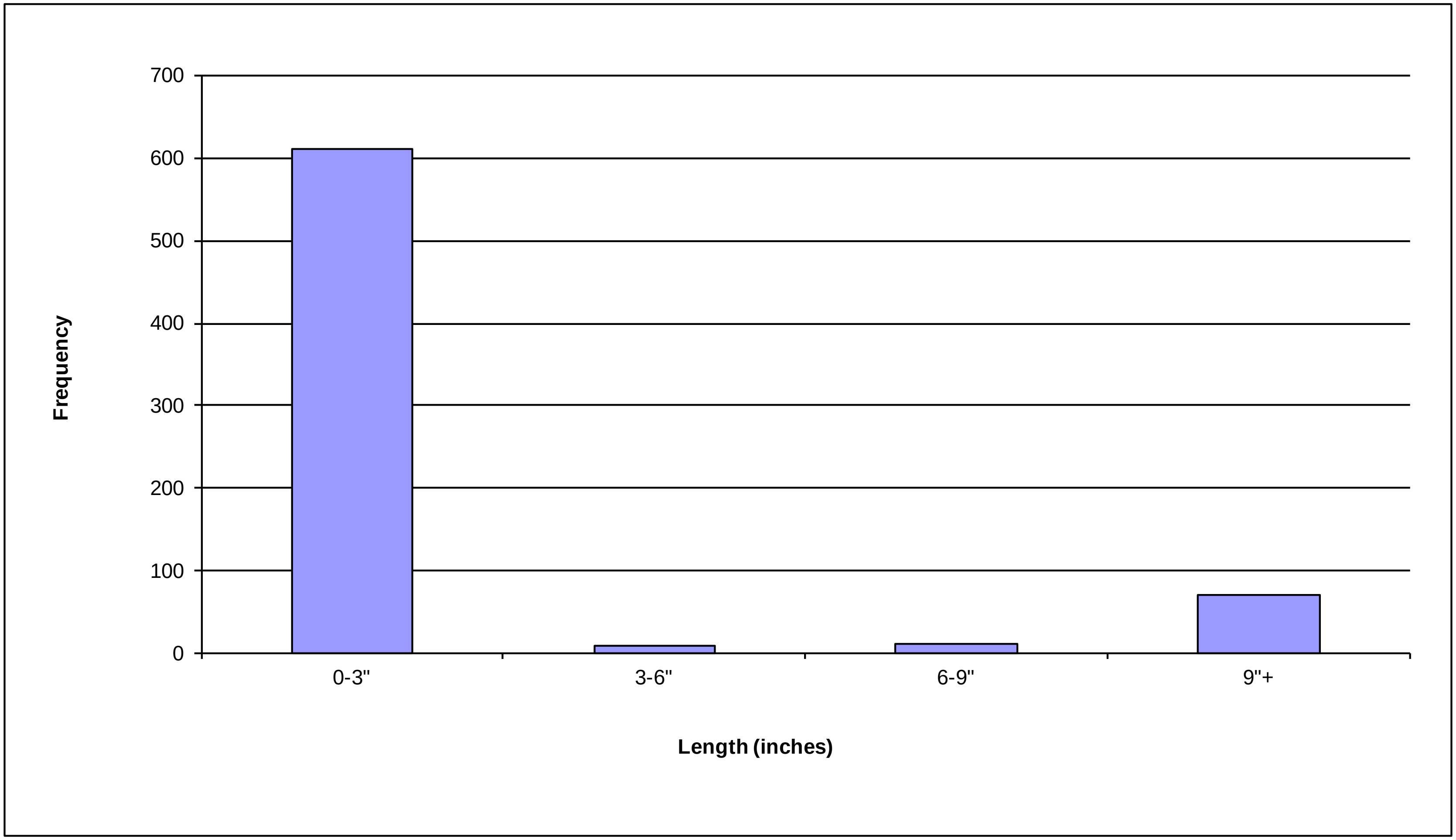

Figure 25. Length Frequency of Sacramento Sucker Observed by Snorkeling in the San Joaquin River, All Sites Combined, October 2012.

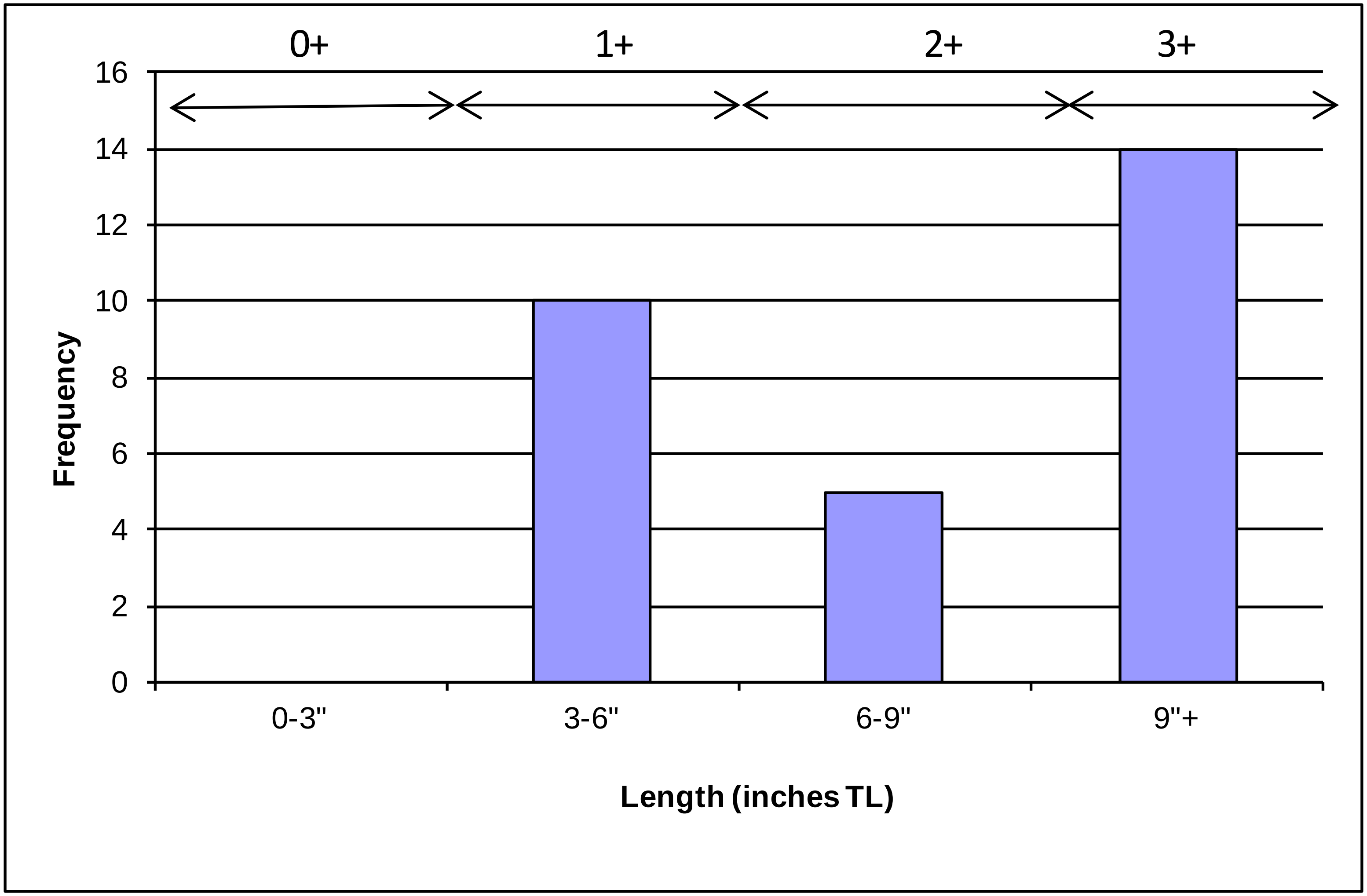

Figure 26. Length Frequency of Sacramento Pikeminnow Observed by Snorkeling in the San Joaquin River, All Sites Combined, October 2012.

The distribution of size classes of hardhead (Figure 24), Sacramento sucker (Figure 25) and Sacramento pikeminnow (Figure 26) suggest that multiple age classes are present. Age 1+ hardhead was more abundant than older age classes present, and relatively more abundant in comparison to older age classes than found during 2011. There were relatively large numbers of age 0+ for Sacramento suckers present. This age class was relatively more abundant compared to older age classes than in 2011. Age 1+ Sacramento pikeminnow were relatively more abundant than in 2011. However, older age classes were similar in relative abundance.

Condition factors by species are provided in Table 14.

Table 14. Condition Factors and 95 Percent Confidence Intervals by Species Collected by Electrofishing in the San Joaquin River in 2012.

Species	Average Condition Factor	Upper 95 Percent Confidence Interval	Lower 95 Percent Confidence Interval
Hardhead (0+)	0.89	1.10	0.69
Hardhead[1] (Juveniles)	0.73	-	-
Sacramento Sucker (0+)	1.04	1.14	0.94
Sacramento Sucker (Juveniles)	1.04	1.10	0.98
Sacramento Sucker (Adults)	1.05	1.12	0.99
Sacramento Pikeminnow (0+)	0.86	1.01	0.70
Rainbow Trout (Juveniles)	1.11	1.12	1.00
Rainbow Trout (Adults)	1.11	1.13	0.91
Prickly Sculpin	1.33	1.40	1.27

[1] Only one juvenile Hardhead captured

4.0 DISCUSSION

Water Year 2012 was classified as a dry water year, with a minor spill from Redinger Lake during April 22 through May 5. This is in contrast to Water Year 2011, which was classified as a wet water year (CDWR 2012) that had an extended spill with flows as high as 12,000 cfs past Dam 7. Flows in 2012 during late spring and summer were similar to post-spill late summer and fall flows in 2011. There were lower flows and warmer air temperatures in 2012, in contrast with the extended spill and lower air temperatures of 2011. Air temperatures for May through October were all warmer than the 81-year average, and August and September 2012 were the warmest of those months on record. July was the third warmest July on record.

4.1 FOOTHILL YELLOW-LEGGED FROG

No FYLF egg masses, tadpoles, juveniles, or adults were found during the three full reach surveys in HSB, Willow Creek, Bald Mill Creek, and Backbone Creek in 2012. In addition, no FYLF of any life history stage was found during the two full reach surveys conducted in HSB or Willow and Backbone creeks during 2008.

4.2 WESTERN POND TURTLE POPULATIONS

Both male and female WPT in the HSB reach of SJR have a diverse age structure and appear to be in good health. Recruitment of juvenile turtles was observed during both 2011 and 2012. Thirty-three different turtles were caught in 2012, which is over three times the number of turtles caught in 2011. A mix of females and males were captured during both years. Two different juvenile turtles were caught during 2012 and 2011. One juvenile turtle was found dead from predation in 2012. All live turtles caught in both years appeared to be healthy with no visible signs of disease or serious injuries. Almost all turtles caught in 2011-2012 were captured at or near the confluences of Backbone and Willow creeks. Two gravid females were captured in both 2011 and 2012. The WPT population appears to be in good condition.

A WPT nesting habitat assessment was conducted to ascertain if potential nesting habitat would be inundated by the proposed whitewater flows of 1,660 cfs. No potential WPT nesting habitat was found at an elevation at or below the area that would be inundated by the proposed whitewater flows.

4.2.1 INDIVIDUAL LEVEL

The WPTs captured in both 2011 and 2012 did not show any external signs of disease or parasites and appeared to be in good health. Growth of WPTs was slow and variable among individuals. Female WPTs captured appeared to have reduced growth after attaining 135 mm carapace size.

4.2.2 POPULATION LEVEL

WPTs were comprised of a mix of older and younger turtles in both 2011 and 2012. Ages varied from young-of-the-year to over twenty years old. There were no turtles aged 2, 3, 4, or 5 years old. There were several turtles aged 6, 7, 8, and 9 years old. The WPT population on the HSB of the SJR is not aged biased towards large old individuals as is observed in many populations below reservoirs (Reese 1986). Reese (1986) suggested that populations that are adult biased lack critical habitat components such as suitable nesting habitat upland and nursery habitat. Many of the populations in the nearby San Joaquin Valley are heavily biased towards older adults with little or no juvenile recruitment (Bury and Germano 2008).

WPT sex ratios were 60 percent females and forty percent males captured in 2011. There was a nearly one-to-one sex ratio observed in 2012. Abundances were much higher in 2012 compared with 2011. Nearly three times the numbers of turtles were captured in 2012, in comparison with 2011. This was due in part to ten WPTs that were opportunistically captured by hand during the FYLF visual encounter surveys. Also, conditions were much warmer in 2012 compared with 2011 and its extended spill; as a result, the turtles may have been more active in 2012 than 2011.

4.3 MUSSEL COMMUNITY

The abundance and distribution of western pearlshell (*Margaritifera falcata*) mussels at three sites were assessed. Abundances and spatial distribution were similar to those observed in 2010 and 2011 at areas of Sites 5 and 6. At Site 7, numbers of mussels differed substantially from 2010-2011. At Site 7, the comparatively low population estimate (398 mussels) for the 2012 survey year likely reflects the random variability inherent in the sampling strategy. Since the mussels at Site 7 are distributed in small and large clusters with gaps between clusters, it is not surprising for the results to be highly variable. The accuracy of the population estimates could be greatly increased in future years by surveying 10 rather than 5 transects at Site 7. This recommendation will be included in the 2013 AMP Proposal.

4.4 HARDHEAD SPAWNING AND LARVAL FISH SAMPLING

Visual observation of hardhead spawning occurred as early as May 21 in HSB downstream of Backbone Creek. Spawning occurred over rocky substrates near the heads of pools.

Larval hardhead were collected in the HSB starting in late June and continuing through late July. The size of larvae suggested that hardhead spawned through much of July. The distribution and timing of hardhead spawning appeared to progress upstream in the SJR as water temperatures increased. The timing and distribution of hardhead spawning in 2012 was similar to 2008 and 2009, which were critical and below normal water years, respectively. In contrast, hardhead spawning occurred much later in 2010 and 2011, which years experienced prolonged spills from Redinger Lake and cooler temperatures in spring and summer. No hardhead larvae was collected from Willow

Creek in 2012, as in 2008 and 2009, suggesting that spawning may not have occurred there or it may have produced few larvae. However, hardhead spawned in Willow Creek in spill years 2010 and 2011.

Sacramento sucker spawning appeared to have occurred first in the SJR in mid-May upstream of PH4 as temperatures approached 15°C in 2012. Larval Sacramento sucker were observed at all the sites in the SJR and continued present through July. Sacramento sucker spawning occurred in Willow Creek from early May and continued through June. As in past years, larval sampling suggests that spawning occurred at multiple sites during many occasions in 2012.

Larval Sacramento pikeminnow were not captured in 2012 or 2011. However, visual observations and electrofishing sampling of "unidentified cyprinids" identified that spawning had successfully occurred in the SJR downstream of Dam 7.

4.5 FISH COMMUNITY CHARACTERISTICS AND COMPARISONS

The NASMP (SCE 2008a) 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 previous studies conducted in 1985, 1995, 2008, 2010, and 2011 to assess the condition of the native fishes. In particular, the comparison between 2011 and 2012 baseline study years is emphasized. This comparison is based on the abundance, length-frequencies, condition factors, and recruitment of the fish community, with emphasis on hardhead. A 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 2012) found the fish community was composed primarily of native species (BioSystems 1987). In November 1995 (a wet year, CDWR 2012), resampling of these stations found the relative abundances of most species were similar (SCE 1997). These stations were resampled to gather initial data to contribute to baseline monitoring in 2008, 2010, and 2011, critical, above normal, and wet water years, respectively (SCE 2008a, 2011a, and 2012b).

Hardhead density increased substantially by more than a factor of two in 2012 from 2011 (not including "unidentified cyprinids", but their percentage of overall species composition slightly decreased (Table 15) due to increases in other species. Sacramento sucker and Sacramento pikeminnow increased in density and contribution to species composition in 2012 from 2011. Rainbow trout increased in density, but contributed a lower percentage to the overall species composition in 2012 compared to 2011. There was a substantial increase in the density of spotted bass in 2012 from 2011, but their percentage species composition increased by less than one percent.

Observed length frequencies in 2012 showed distinct age classes for all native species, as they did in 2008, 2010, and 2011. There was a dramatic increase in observed zero to three inch (76 mm) "unidentified cyprinids" in 2012 compared to 2011. This was about five times greater numerically than in 2011 and 25 percent greater than 2010.

Table 15. Comparison of Fish Density Estimates and Percentage Composition from the Horseshoe Bend Reach of the San Joaquin River.

Density Estimates and Percentage Composition by Species for Combined Sites in the San Joaquin River, 2012.

Species	Density Estimate Number per Kilometer	Percentage of Total Fish Observed and Captured with Unidentified Cyprinids (<75 mm)	Percentage of Total Fish Observed and Captured without Unidentified Cyprinids (<75 mm)
Hardhead	49.2	0.71%	8.95%
Sacramento Sucker	293	5.52%	69.11%
Sacramento Pikeminnow	30.9	0.59%	7.34%
Rainbow Trout	17.4	0.36%	4.52%
Prickly Sculpin	18.6	0.35%	4.43%
Spotted Bass	11.5	0.22%	2.73%
Green Sunfish	0.4	0.01%	0.09%
Unidentified Cyprinids <75 mm	4851.9	92.0%	-

Density Estimates and Percentage Composition by Species for Combined Sites in the San Joaquin River, 2011.

Species	Density Estimate Number per Kilometer	Percentage of Total Fish Observed and Captured with Unidentified Cyprinids (<75 mm)	Percentage of Total Fish Observed and Captured without Unidentified Cyprinids (<75 mm)
Hardhead	23	2%	15%
Sacramento Sucker	76	5.60%	47%
Sacramento Pikeminnow	6	0.04%	3%
Rainbow Trout	12	1.60%	14%
Spotted bass	2	0%	2%
Unidentified Cyprinids <75 mm	1,045	90.20%	-

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Table 15. Comparison of Fish Density Estimates and Percentage Composition from the Horseshoe Bend Reach of the San Joaquin River (continued).

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

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	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.

Species	Density Estimate Number per Kilometer	Percentage of Total Fish Observed and Captured with Unidentified Cyprinids (<75 mm)	Percentage of Total Fish Observed and Captured without Unidentified Cyprinids (<75 mm)
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%	-

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Table 15. Comparison of Fish Density Estimates and Percentage Composition from the Horseshoe Bend Reach of the San Joaquin River (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%	-

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Although there was no 3 to 6 inch (76 to 152 mm) "unidentified cyprinids" observed in 2012, hardhead and Sacramento pikeminnow of this size class were identified. The combined 3 to 6 inch (76 to 152 mm) "unidentified cyprinids," hardhead, and Sacramento pikeminnow for 2011 and 2012 were comparable, 66 and 60, respectively. These numbers were substantially less than those observed in 2010 (SCE 2011a) for this size class.

There were no signs of disease or other indications of poor health during the 2012 study, which suggests the fish are in good health. The following subsections compare and discuss 2012 results with those of earlier years.

4.5.1 INDIVIDUAL LEVEL

Condition Factors

Adult hardhead observed in 1985, 1995, 2008, 2010, 2011, and 2012 were generally characterized as healthy and robust. All native species in 2012 were characterized as healthy and robust and average condition factors for rainbow trout, prickly sculpin, and Sacramento sucker exceeded 1.0 (Table 14). Condition factors for hardhead and Sacramento pikeminnow were less than one, but they are based on small samples of young-of-the-year fish and one juvenile hardhead, whose field measured weight may be less certain than larger fish. In general, condition factors for 2012 were less that those measured in 2010 by species and lifestage.

Growth

Length frequency distributions from 2012 sampling (Figures 24 through 26) were compared with those of earlier years. Cyprinids less than 76 mm 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 not including fish of less than three inches (76 mm) (Figure 24). Hardhead length frequency distributions were similar to those for fish in 1985, 1995, 2008, 2010, and 2011. However, there were much greater numbers of 0 to 3 inch (0 to 76 mm) native cyprinids in 2012 than in 2010 and 2011, but similar to 2008. The length frequency distribution of hardhead in 2012 indicated an increase in age 1+ fish compared to 2011 and a decrease in age 3+ fish.

Young-of-the-year Sacramento sucker (0-3 inch [76 -152 mm]) were far more abundant in 2012 than previous years. Yearling Sacramento sucker (3-6 inch [76 -152 mm]) were less abundant than any other year surveyed since 1985, except 1995, when no yearling Sacramento sucker were observed. Six to nine inch (152 to 229 mm) Sacramento sucker were more abundant in 2012 than 2011, and of nearly the same abundance as 2010.

Sacramento pikeminnow length frequencies for 2012 indicated an increase in age 1+ fish and age 3+ fish in comparison to 2011. Age 2+ fish abundance was similar in between both years.

4.5.2 Population Level

Abundance

Densities of young-of-the-year Sacramento sucker and native cyprinids were much higher in 2012 than in 2011 or 2010. In addition, there was more 3 to 6 inch (76 to 152 mm) yearling Sacramento sucker observed in 2012 than in 2011. However, yearling Sacramento suckers were much more numerous in 2010 than in either 2011 or 2012.

Overall abundance of hardhead in 2012 was similar to those in 1985, greater than 2010 and 2011, and much less than 2008 and 1995 (Table 15). Densities of rainbow trout increased in 2012 from 2011. However, there were no rainbow trout juveniles captured in 2011. Densities of rainbow trout in 2012 were similar to 2010 and 1985, greater than 2008, but were less than in 1995, when the long spill period was believed to have transported fish from areas upstream of Redinger Lake and/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.

4.5.3 Community Level

Species Composition

Native fish clearly continue to dominate the fish community in 2012, between Dam 7 and PH4 as in all the past years surveyed since 1985. Spotted bass represented less than three percent of the fish community in 2012 compared with two percent in 2011 (Table 15). The percentage contribution of rainbow trout to the fish community in 2012 was similar to that of 2010 and less than half of that observed in 2011.

Resilience in Response to Stochastic Events

The native fish community was persistent and appeared to maintain itself successfully over the 26-year period represented by sampling events in 1985, 1995, 2008, 2010, 2011, and 2012. In 2012, recruitment of young-of-the-year native cyprinids and Sacramento sucker was the highest observed since 2008. These results suggest the native fish community was resilient to the major high flow event of 2011 and other past stochastic events (Moyle et al. 1998).

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Appendix A

Temperature, Meteorology, and Hydrology Data

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Table A-1. November 2011 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[1]			SJR Upstream of Willow Creek			Willow Creek[2]			SJR Upstream of Powerhouse 4			Flows (cfs)	
	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
11/1/11	14.4	14.0	14.9	14.3	14.0	14.7	-	-	-	14.3	13.7	14.9	36	6
11/2/11	14.2	14.0	14.7	14.0	13.8	14.4	-	-	-	14.1	13.4	14.6	36	6
11/3/11	14.2	13.8	15.0	14.0	13.6	14.4	-	-	-	13.7	13.0	14.2	36	5
11/4/11	13.8	13.5	14.4	13.6	13.4	13.9	-	-	-	13.3	12.9	13.8	36	7
11/5/11	13.6	13.4	14.0	13.2	13.0	13.4	-	-	-	12.6	12.1	13.0	36	7
11/6/11	13.3	12.9	13.7	12.9	12.6	13.1	-	-	-	12.4	12.0	12.7	36	7
11/7/11	13.0	12.7	13.3	12.5	12.3	12.7	-	-	-	12.0	11.3	12.6	36	8
11/8/11	12.7	12.5	13.0	12.2	12.1	12.5	-	-	-	11.7	11.1	12.2	36	7
11/9/11	12.6	12.3	12.9	12.1	11.8	12.3	-	-	-	11.4	10.6	12.0	36	7
11/10/11	12.5	12.2	13.1	12.0	11.7	12.3	-	-	-	11.2	10.6	11.7	36	7
11/11/11	12.4	12.1	12.7	12.0	11.8	12.2	-	-	-	11.3	11.0	11.5	36	7
11/12/11	12.2	12.0	12.4	11.9	11.8	12.1	-	-	-	11.7	11.4	12.1	35	10
11/13/11	12.1	12.0	12.5	12.0	11.8	12.2	-	-	-	12.1	11.7	12.6	35	9
11/14/11	12.2	12.0	12.5	12.1	12.0	12.4	-	-	-	12.6	12.3	12.9	34	8
11/15/11	12.1	11.9	12.4	12.1	11.9	12.3	-	-	-	12.7	12.2	13.0	35	8
11/16/11	12.0	11.8	12.2	12.0	11.8	12.2	-	-	-	12.7	12.2	13.1	35	7
11/17/11	11.8	11.7	12.1	11.9	11.6	12.1	-	-	-	12.3	11.9	12.7	35	7
11/18/11	-	-	-	11.8	11.6	11.9	-	-	-	11.8	11.5	12.1	35	7
11/19/11	-	-	-	11.7	11.5	11.8	-	-	-	11.5	11.1	11.8	35	7
11/20/11	-	-	-	11.5	11.3	11.6	-	-	-	11.0	10.8	11.2	35	7
11/21/11	-	-	-	11.2	11.0	11.3	-	-	-	10.7	10.2	11.1	35	8
11/22/11	-	-	-	10.8	10.7	11.0	-	-	-	10.3	9.7	10.7	35	7
11/23/11	-	-	-	10.7	10.5	10.9	-	-	-	10.2	9.6	10.6	35	7
11/24/11	-	-	-	10.6	10.4	10.8	-	-	-	10.2	9.5	10.6	35	7
11/25/11	-	-	-	10.4	10.2	10.7	-	-	-	10.1	9.5	10.5	35	7
11/26/11	-	-	-	10.3	10.1	10.5	-	-	-	10.1	9.5	10.5	36	7
11/27/11	-	-	-	10.2	9.9	10.6	-	-	-	9.9	9.4	10.3	36	7
11/28/11	-	-	-	10.3	9.9	10.8	-	-	-	9.9	9.5	10.3	36	7
11/29/11	-	-	-	9.9	9.7	10.1	-	-	-	9.8	9.2	10.2	37	7
11/30/11	-	-	-	9.9	9.8	10.1	-	-	-	9.7	9.4	10.0	37	6

[1] Temperature data unavailable for SJR downstream of Dam 7 November 18 to November 30 due to loggers being lost during winter months.
[2] Temperature data unavailable for Willow Creek Bridge November 1 to November 30 due to loggers being lost during winter months.

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Table A-2. December 2011 Water Temperatures (Daily Mean Temperatures Rounded to Nearest 0.1°C) and

	SJR Downstream of Dam 7[1]			SJR Upstream of Willow Creek			Willow Creek[1]			SJR Upstream of Powerhouse 4			Flows (cfs)	
	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
12/1/11	-	-	-	9.8	9.7	10.0	-	-	-	9.1	8.8	9.5	38	6
12/2/11	-	-	-	9.6	9.2	9.7	-	-	-	8.7	8.4	9.1	38	34
12/3/11	-	-	-	9.0	8.7	9.3	-	-	-	8.4	8.0	8.8	38	15
12/4/11	-	-	-	8.7	8.5	8.8	-	-	-	7.5	7.1	8.1	38	8
12/5/11	-	-	-	8.5	8.3	8.7	-	-	-	7.2	6.7	7.7	38	7
12/6/11	-	-	-	8.3	8.1	8.5	-	-	-	7.0	6.4	7.6	38	7
12/7/11	-	-	-	8.3	8.1	8.4	-	-	-	6.9	6.3	7.4	38	7
12/8/11	-	-	-	8.2	8.1	8.4	-	-	-	6.8	6.2	7.3	38	7
12/9/11	-	-	-	8.2	8.0	8.3	-	-	-	6.8	6.2	7.3	38	7
12/10/11	-	-	-	8.1	7.9	8.4	-	-	-	6.7	6.1	7.2	38	7
12/11/11	-	-	-	8.2	7.9	8.4	-	-	-	6.7	6.2	7.3	38	7
12/12/11	-	-	-	8.1	7.9	8.3	-	-	-	6.7	6.2	7.2	38	7
12/13/11	-	-	-	8.0	7.9	8.1	-	-	-	6.9	6.5	7.4	38	7
12/14/11	-	-	-	7.9	7.7	8.0	-	-	-	6.9	6.3	7.4	38	7
12/15/11	-	-	-	7.9	7.7	8.1	-	-	-	6.9	6.5	7.3	38	7
12/16/11	-	-	-	7.7	7.6	7.9	-	-	-	6.9	6.4	7.4	38	7
12/17/11	-	-	-	7.7	7.5	7.8	-	-	-	6.6	6.1	7.1	38	7
12/18/11	-	-	-	7.6	7.4	7.7	-	-	-	6.5	6.0	7.2	38	7
12/19/11	-	-	-	7.5	7.4	7.7	-	-	-	6.4	5.8	7.0	38	7
12/20/11	-	-	-	7.5	7.3	7.6	-	-	-	6.3	5.7	6.9	38	7
12/21/11	-	-	-	7.4	7.2	7.5	-	-	-	6.3	5.7	6.9	38	7
12/22/11	-	-	-	7.2	7.0	7.3	-	-	-	6.1	5.6	6.8	38	4
12/23/11	-	-	-	7.1	6.9	7.3	-	-	-	6.0	5.5	6.6	38	2
12/24/11	-	-	-	6.9	6.8	7.1	-	-	-	5.8	5.2	6.5	38	2
12/25/11	-	-	-	7.0	6.7	7.3	-	-	-	5.8	5.1	6.5	38	2
12/26/11	-	-	-	6.9	6.8	7.1	-	-	-	5.8	5.2	6.5	38	2
12/27/11	-	-	-	6.8	6.6	6.9	-	-	-	5.8	5.2	6.4	38	2
12/28/11	-	-	-	6.7	6.5	6.9	-	-	-	5.9	5.4	6.6	38	2
12/29/11	-	-	-	6.6	6.4	6.8	-	-	-	6.0	5.6	6.5	38	2
12/30/11	-	-	-	6.4	6.2	6.6	-	-	-	6.2	5.7	6.7	38	2
12/31/11	-	-	-	6.3	6.1	6.5	-	-	-	6.0	5.6	6.6	38	2

[1] Temperature data unavailable for December due to loggers being lost during winter months.

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Table A-3. January 2012 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[1]			SJR Upstream of Willow Creek			Willow Creek[1]			SJR Upstream of Powerhouse 4			Flows (cfs)	
	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
1/1/12	-	-	-	6.4	6.0	6.9	-	-	-	6.0	5.3	6.8	38	2
1/2/12	-	-	-	6.9	6.4	7.2	-	-	-	6.1	5.5	6.7	38	2
1/3/12	-	-	-	6.7	6.3	7.0	-	-	-	6.5	5.9	7.0	38	3
1/4/12	-	-	-	6.2	6.0	6.4	-	-	-	6.8	6.2	7.5	38	3
1/5/12	-	-	-	6.3	6.1	6.4	-	-	-	6.9	6.4	7.5	38	3
1/6/12	-	-	-	6.2	6.0	6.4	-	-	-	6.8	6.3	7.3	38	3
1/7/12	-	-	-	6.2	6.0	6.3	-	-	-	6.6	6.1	7.2	38	3
1/8/12	-	-	-	6.1	5.9	6.3	-	-	-	6.5	5.9	7.2	38	3
1/9/12	-	-	-	6.1	5.9	6.3	-	-	-	6.3	5.7	6.9	38	3
1/10/12	-	-	-	6.3	5.9	6.8	-	-	-	6.1	5.5	6.9	38	3
1/11/12	-	-	-	6.2	6.0	6.5	-	-	-	6.2	5.5	6.9	38	3
1/12/12	-	-	-	6.3	5.9	6.6	-	-	-	6.1	5.4	6.9	38	3
1/13/12	-	-	-	6.3	6.0	6.6	-	-	-	6.1	5.5	6.9	38	6
1/14/12	-	-	-	6.2	5.9	6.5	-	-	-	6.0	5.4	6.8	38	6
1/15/12	-	-	-	6.2	6.0	6.4	-	-	-	6.0	5.5	6.6	38	6
1/16/12	-	-	-	6.1	5.9	6.4	-	-	-	5.9	5.5	6.7	38	6
1/17/12	-	-	-	6.0	5.8	6.2	-	-	-	5.7	5.1	6.5	38	6
1/18/12	-	-	-	6.0	5.8	6.3	-	-	-	5.5	4.9	6.5	38	6
1/19/12	-	-	-	6.0	5.8	6.3	-	-	-	5.3	4.8	5.6	38	6
1/20/12	-	-	-	6.2	6.1	6.4	-	-	-	5.9	5.6	6.2	38	6
1/21/12	-	-	-	6.4	6.0	6.5	-	-	-	7.1	6.2	8.1	41	6
1/22/12	-	-	-	6.2	5.9	6.6	-	-	-	6.7	6.3	7.3	42	6
1/23/12	-	-	-	6.4	6.1	6.5	-	-	-	6.4	6.1	7.0	42	6
1/24/12	-	-	-	6.1	5.8	6.3	-	-	-	6.7	6.5	7.1	42	9
1/25/12	-	-	-	6.1	5.9	6.3	-	-	-	6.7	6.4	7.2	42	9
1/26/12	-	-	-	6.1	5.9	6.4	-	-	-	7.0	6.5	7.5	42	9
1/27/12	-	-	-	6.2	6.2	6.4	-	-	-	7.3	7.1	7.5	42	9
1/28/12	-	-	-	6.1	5.9	6.4	-	-	-	7.3	6.8	7.7	42	9
1/29/12	-	-	-	6.4	6.0	7.1	-	-	-	7.1	6.7	7.6	42	9
1/30/12	-	-	-	6.3	6.1	6.6	-	-	-	7.1	6.7	7.5	42	9
1/31/12	-	-	-	6.3	6.1	6.5	-	-	-	7.4	7.0	7.9	42	9

[1] Temperature data unavailable for January due to loggers being lost during winter months.

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Table A-4. February 2012 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[1]			SJR Upstream of Willow Creek			Willow Creek[1]			SJR Upstream of Powerhouse 4			Flows (cfs)	
	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
2/1/12	-	-	-	6.3	6.1	6.6	-	-	-	7.6	7.1	7.9	42	12
2/2/12	-	-	-	6.3	6.1	6.5	-	-	-	7.5	7.0	7.9	42	12
2/3/12	-	-	-	6.2	6.0	6.5	-	-	-	7.4	7.0	7.8	42	12
2/4/12	-	-	-	6.5	6.0	7.4	-	-	-	7.1	6.6	7.6	42	12
2/5/12	-	-	-	6.6	6.1	7.2	-	-	-	7.0	6.5	7.5	42	12
2/6/12	-	-	-	6.6	6.2	7.1	-	-	-	7.0	6.6	7.4	51	12
2/7/12	-	-	-	6.4	6.3	6.5	-	-	-	7.2	7.1	7.3	60	12
2/8/12	-	-	-	6.3	6.1	6.6	-	-	-	7.4	6.9	8.0	60	12
2/9/12	-	-	-	6.5	6.1	7.3	-	-	-	7.5	6.9	8.1	60	12
2/10/12	-	-	-	6.5	6.2	7.1	-	-	-	7.7	7.0	8.3	60	12
2/11/12	-	-	-	6.3	6.1	6.4	-	-	-	7.6	7.4	7.8	59	12
2/12/12	-	-	-	6.4	6.2	6.8	-	-	-	7.8	7.3	8.4	59	12
2/13/12	-	-	-	6.4	6.2	6.6	-	-	-	7.9	7.6	8.4	60	12
2/14/12	-	-	-	6.3	6.2	6.6	-	-	-	7.7	7.4	7.9	59	12
2/15/12	-	-	-	6.3	6.1	6.6	-	-	-	7.4	7.1	7.7	59	12
2/16/12	-	-	-	6.3	6.1	6.8	-	-	-	7.2	6.6	7.8	52	12
2/17/12	-	-	-	6.4	6.1	7.0	-	-	-	7.2	6.5	7.8	42	12
2/18/12	-	-	-	6.4	6.1	6.7	-	-	-	7.3	6.9	7.7	42	12
2/19/12	-	-	-	6.4	6.2	6.8	-	-	-	7.7	7.4	8.1	42	12
2/20/12	-	-	-	6.5	6.1	7.0	-	-	-	7.7	7.2	8.4	42	12
2/21/12	-	-	-	6.4	6.1	6.9	-	-	-	7.7	7.1	8.2	42	12
2/22/12	-	-	-	6.4	6.1	6.9	-	-	-	7.8	7.3	8.2	42	12
2/23/12	-	-	-	6.5	6.1	7.2	-	-	-	7.9	7.3	8.5	42	12
2/24/12	-	-	-	6.6	6.2	7.3	-	-	-	8.3	7.5	9.1	42	12
2/25/12	-	-	-	6.6	6.2	7.4	-	-	-	8.6	7.9	9.3	42	12
2/26/12	-	-	-	6.6	6.2	7.2	-	-	-	8.6	8.0	9.2	42	12
2/27/12	-	-	-	6.5	6.3	6.8	-	-	-	8.7	8.3	9.3	42	12
2/28/12	-	-	-	6.6	6.3	7.1	-	-	-	8.5	8.1	8.9	42	12
2/29/12	-	-	-	6.5	6.3	6.8	-	-	-	8.0	7.7	8.3	42	12

[1] Temperature data unavailable for February due to loggers being lost during winter months.

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Table A-5. March 2012 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[1]			SJR Upstream of Willow Creek			Willow Creek[1]			SJR Upstream of Powerhouse 4			Flows (cfs)	
	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
3/1/12	-	-	-	6.6	6.3	7.0	-	-	-	8.3	7.9	8.9	42	12
3/2/12	-	-	-	6.7	6.2	7.4	-	-	-	8.1	7.4	8.9	42	12
3/3/12	-	-	-	6.7	6.3	7.6	-	-	-	8.2	7.4	8.9	42	12
3/4/12	-	-	-	6.9	6.4	8.0	-	-	-	8.6	7.8	9.4	42	13
3/5/12	-	-	-	7.0	6.4	7.9	-	-	-	9.0	8.3	9.9	42	13
3/6/12	-	-	-	6.7	6.4	7.0	-	-	-	9.0	8.5	9.6	42	13
3/7/12	-	-	-	7.3	6.2	8.6	-	-	-	8.5	7.8	9.3	42	12
3/8/12	-	-	-	7.2	6.4	8.4	-	-	-	8.2	7.3	9.0	42	12
3/9/12	-	-	-	7.4	6.6	8.9	-	-	-	8.6	7.7	9.6	42	12
3/10/12	-	-	-	7.3	6.7	8.3	-	-	-	9.0	8.2	9.8	42	12
3/11/12	-	-	-	7.3	6.8	8.2	-	-	-	9.3	8.6	9.9	42	12
3/12/12	-	-	-	7.2	6.8	8.1	-	-	-	9.4	8.8	10.0	42	12
3/13/12	-	-	-	7.2	6.9	7.6	-	-	-	9.4	9.0	10.0	42	12
3/14/12	-	-	-	7.4	7.0	8.0	-	-	-	9.7	9.1	10.4	42	12
3/15/12	-	-	-	7.4	7.1	7.8	-	-	-	10.1	9.6	10.6	42	13
3/16/12	-	-	-	7.3	7.0	7.6	-	-	-	10.3	10.1	10.7	42	13
3/17/12	-	-	-	7.3	7.0	7.5	-	-	-	9.6	8.5	10.4	44	89
3/18/12	-	-	-	7.1	6.6	7.6	-	-	-	7.6	7.0	8.4	45	66
3/19/12	-	-	-	7.2	6.9	8.0	-	-	-	6.9	6.4	7.5	45	60
3/20/12	-	-	-	7.4	6.8	8.4	-	-	-	7.4	6.6	8.4	45	42
3/21/12	-	-	-	7.5	6.9	8.4	-	-	-	8.4	7.5	9.5	45	50
3/22/12	-	-	-	7.4	7.1	7.8	-	-	-	9.4	8.9	9.9	45	53
3/23/12	-	-	-	7.4	7.1	8.1	-	-	-	9.9	9.5	10.5	45	43
3/24/12	-	-	-	7.5	6.9	8.5	-	-	-	9.9	9.2	10.7	45	32
3/25/12	-	-	-	7.2	7.0	7.4	-	-	-	9.5	9.3	9.8	45	31
3/26/12	-	-	-	7.3	6.9	7.9	-	-	-	9.0	8.5	9.5	45	43
3/27/12	-	-	-	7.3	7.1	7.6	-	-	-	9.1	8.8	9.4	45	36
3/28/12	-	-	-	7.5	7.1	8.3	-	-	-	9.4	8.9	10.2	45	31
3/29/12	-	-	-	7.6	7.1	8.4	-	-	-	10.0	9.3	10.8	45	30
3/30/12	-	-	-	7.7	7.1	8.7	-	-	-	10.7	9.9	11.6	45	31
3/31/12	-	-	-	7.5	7.1	8.3	-	-	-	10.8	10.4	11.4	45	48

[1] Temperature data unavailable for March due to loggers being lost during winter months.

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Table A-6. April 2012 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[1]			SJR Upstream of Willow Creek			Willow Creek[1]			SJR Upstream of Powerhouse 4			Flows (cfs)	
	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
4/1/12	-	-	-	7.5	7.1	8.0	-	-	-	10.0	9.3	10.4	45	60
4/2/12	-	-	-	7.5	7.0	8.2	-	-	-	9.4	8.8	9.9	45	40
4/3/12	-	-	-	7.7	7.2	8.6	-	-	-	9.7	8.8	10.6	45	36
4/4/12	-	-	-	7.5	7.2	7.8	-	-	-	10.1	9.6	10.4	45	37
4/5/12	-	-	-	7.6	7.2	8.4	-	-	-	9.9	9.1	10.7	45	33
4/6/12	-	-	-	7.8	7.1	8.8	-	-	-	9.6	8.8	10.5	45	29
4/7/12	-	-	-	7.8	7.3	8.7	-	-	-	9.7	8.7	10.7	45	28
4/8/12	-	-	-	7.9	7.2	8.9	-	-	-	10.1	9.1	11.1	45	28
4/9/12	-	-	-	8.0	7.5	8.9	-	-	-	10.7	9.8	11.6	44	28
4/10/12	-	-	-	8.0	7.4	8.7	-	-	-	11.0	10.3	11.7	44	28
4/11/12	7.6	7.3	7.9	7.7	7.4	8.0	10.0	9.0	13.5	10.7	10.2	11.2	45	46
4/12/12	7.7	7.4	8.4	7.7	7.4	8.1	8.5	7.9	8.9	9.8	9.4	10.2	44	43
4/13/12	7.5	7.3	7.7	7.5	7.3	7.7	8.0	7.3	8.4	9.1	8.2	9.7	45	55
4/14/12	7.9	7.4	8.7	7.9	7.3	8.5	7.5	6.7	8.4	8.3	7.9	8.7	45	62
4/15/12	8.0	7.3	9.4	8.0	7.4	9.1	9.1	7.4	11.0	9.4	8.4	10.5	45	52
4/16/12	8.2	7.7	9.2	8.3	7.7	9.2	10.7	8.9	12.6	10.8	9.9	12.0	45	49
4/17/12	8.2	7.7	9.2	8.3	7.8	9.2	12.1	10.7	13.8	11.8	11.0	12.8	45	56
4/18/12	8.3	7.7	9.3	8.4	7.8	9.3	12.2	10.2	13.9	12.6	11.6	13.8	45	55
4/19/12	8.3	7.7	9.3	8.3	7.7	9.3	12.8	10.4	19.7	12.6	11.9	14.0	45	55
4/20/12	8.2	7.7	9.1	8.6	8.1	9.5	14.0	11.8	16.1	13.5	13.1	14.0	45	59
4/21/12	10.5	8.0	15.0	10.4	8.0	14.8	15.0	13.3	16.7	14.4	12.2	15.7	45	61
4/22/12	13.3	10.2	15.1	13.5	10.3	15.1	15.5	13.5	17.3	14.5	12.6	16.4	804	56
4/23/12	13.3	12.7	14.4	13.4	12.7	14.7	15.8	14.2	17.3	14.2	13.1	15.4	1238	47
4/24/12	13.1	12.7	13.4	13.1	12.7	13.5	15.3	14.5	16.0	13.7	13.0	14.2	1374	44
4/25/12	12.5	10.9	12.9	12.6	11.2	13.0	14.2	13.5	14.9	13.3	13.0	13.7	921	40
4/26/12	12.3	11.7	12.6	12.4	11.8	12.7	13.4	11.6	14.3	12.8	12.2	13.1	1560	72
4/27/12	11.7	11.3	12.0	11.7	11.4	12.1	10.8	10.1	11.3	11.9	11.7	12.1	1790	75
4/28/12	10.4	9.8	11.2	10.8	10.1	11.6	11.0	10.5	11.4	12.4	11.8	12.7	216	56
4/29/12	11.1	9.9	13.0	11.1	10.0	12.9	12.1	10.9	13.8	12.3	11.6	13.0	418	47
4/30/12	11.5	11.0	12.8	11.7	11.1	12.9	13.9	13.0	15.2	13.0	11.5	14.6	595	39

[1] Temperature data unavailable for April 1 to April 10 due to loggers being lost during winter months.

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Table A-7. May 2012 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.

	Redinger Lake at Dam 7 Temperature Recorder			SJR Downstream of Dam 7 Temperature Recorder			SJR Upstream of Willow Creek Temperature Recorder			Willow Creek Temperature Recorder			Willow Creek Bridge Temperature Recorder			SJR Downstream of Willow Creek Temperature Recorder		
Date	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum
5/1/12	11.8	10.6	13.4	11.5	10.7	11.9	11.6	10.8	12.2	15.0	13.4	16.6	14.8	13.7	16.1	11.9	11.1	12.6
5/2/12	12.1	11.1	13.3	11.5	10.9	12.0	11.6	10.9	12.0	14.5	13.1	15.8	14.6	13.3	15.8	11.8	11.1	12.2
5/3/12	12.0	11.0	13.6	11.3	10.6	11.8	11.5	10.8	11.9	14.3	12.8	15.9	14.3	12.8	15.9	11.7	11.1	12.2
5/4/12	12.1	11.0	13.9	11.5	10.6	12.1	11.6	10.7	12.1	14.0	12.2	15.5	13.9	12.2	15.7	11.8	10.9	12.7
5/5/12	11.9	10.4	13.4	10.8	9.5	11.7	11.2	9.9	12.0	13.6	11.7	15.1	13.5	11.7	15.2	11.6	10.6	12.4
5/6/12	11.6	10.7	13.3	9.6	9.1	10.5	9.9	9.2	10.9	13.8	11.7	15.6	13.7	11.7	15.7	10.3	9.7	11.2
5/7/12	11.6	10.1	14.0	9.4	8.9	10.1	9.7	9.1	10.6	14.5	12.3	16.4	14.5	12.3	16.5	10.0	9.4	11.0
5/8/12	11.2	9.4	12.3	9.1	8.7	9.8	9.4	8.9	10.3	15.2	12.9	17.2	15.2	13.0	17.3	9.8	9.1	10.7
5/9/12	12.1	10.4	13.9	9.1	8.6	9.7	9.4	8.7	10.3	16.0	13.7	17.8	15.9	13.7	18.0	9.7	9.0	10.7
5/10/12	11.7	10.5	13.1	9.1	8.8	9.7	9.4	8.9	10.3	16.3	14.1	18.1	16.3	14.1	18.2	9.8	9.1	10.7
5/11/12	11.8	10.5	12.7	9.2	8.8	9.7	9.5	8.9	10.2	16.3	14.1	18.0	16.3	14.1	18.1	9.8	9.1	10.7
5/12/12	12.0	10.6	13.4	9.3	8.8	9.7	9.6	9.0	10.4	16.9	14.7	18.7	16.9	14.7	18.9	9.9	9.2	10.8
5/13/12	11.9	10.4	14.5	9.6	9.1	10.2	9.8	9.2	10.7	17.7	15.6	19.2	17.6	15.5	19.4	10.1	9.4	11.1
5/14/12	11.6	10.5	13.0	9.7	9.3	10.5	10.0	9.4	11.0	17.9	16.2	19.1	17.9	16.2	19.2	10.3	9.6	11.4
5/15/12	12.2	10.9	14.3	9.7	9.3	10.3	10.0	9.5	10.8	17.0	15.1	18.2	17.0	15.0	18.4	10.3	9.6	11.2
5/16/12	12.0	10.5	13.8	9.9	9.5	10.8	10.2	9.6	11.3	17.3	15.2	19.0	17.3	15.1	19.2	10.5	9.8	11.6
5/17/12	12.5	10.1	16.1	9.9	9.6	10.7	10.2	9.7	11.1	18.1	16.4	19.5	18.0	16.3	19.4	10.5	9.9	11.5
5/18/12	11.6	10.2	13.6	9.8	9.3	10.6	10.0	9.4	11.0	17.1	15.2	18.3	17.1	15.2	18.3	10.4	9.7	11.3
5/19/12	11.8	10.4	14.5	9.7	9.2	10.5	10.0	9.3	10.9	17.2	15.2	18.7	17.2	15.1	18.8	10.3	9.6	11.3
5/20/12	12.7	10.2	16.4	9.9	9.4	10.9	10.2	9.6	11.2	18.0	15.8	19.6	18.0	15.8	19.7	10.5	9.8	11.6
5/21/12	12.7	9.9	16.8	9.8	9.3	10.8	10.1	9.5	11.1	18.8	16.8	20.1	18.7	16.7	20.2	10.5	9.7	11.5
5/22/12	11.5	10.0	14.0	9.9	9.4	10.7	10.1	9.5	11.1	18.8	16.9	20.1	18.7	16.8	20.0	10.5	9.8	11.6
5/23/12	11.4	10.1	13.8	9.9	9.3	10.9	10.1	9.4	11.1	18.3	16.5	19.6	18.2	16.5	19.3	10.5	9.7	11.5
5/24/12	11.3	9.8	14.2	9.8	9.3	10.8	10.0	9.3	11.1	17.4	15.5	18.6	17.3	15.5	18.4	10.4	9.6	11.4
5/25/12	11.1	9.8	13.9	9.6	9.2	10.4	9.7	9.3	10.6	15.4	14.5	17.5	15.4	14.4	17.6	10.1	9.5	10.9
5/26/12	11.7	10.1	13.0	9.6	9.3	10.4	9.7	9.4	10.4	13.7	12.8	14.5	13.6	12.7	14.6	10.0	9.6	10.8
5/27/12	12.1	10.1	13.9	9.8	9.2	10.7	9.9	9.2	10.9	13.7	11.5	15.4	13.7	11.5	15.6	10.3	9.5	11.3
5/28/12	11.8	9.9	13.8	9.8	9.3	10.8	10.0	9.4	15.3	15.2	13.2	16.8	15.2	13.1	16.9	10.3	9.6	11.3
5/29/12	12.2	9.9	14.6	9.9	9.3	10.9	10.0	9.4	10.9	16.3	14.2	17.7	16.2	14.1	17.8	10.4	9.6	11.4
5/30/12	12.2	10.2	15.0	10.0	9.4	11.1	10.0	9.5	11.0	17.5	15.4	19.0	17.4	15.4	19.0	10.5	9.7	11.5
5/31/12	11.8	10.4	13.6	10.0	9.4	11.1	10.1	9.5	11.2	18.9	16.8	20.5	18.8	16.8	20.3	10.5	9.8	11.5

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Table A-7. May 2012 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).

	SJR Horseshoe Bend (East)[1]			SJR Horseshoe Bend (West)			SJR Upstream of Powerhouse 4			Flows (cfs)		Dam 7			Dam 7			Redinger Lake
	Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek	Air Temperature Recorder			Relative Humidity			Surface Water Elevation
Date	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)
5/1/12	12.2	11.0	14.1	12.5	11.2	13.9	12.7	11.3	14.0	468	35	18.2	11.7	26.2	63.0	33.3	88.4	1399
5/2/12	11.8	11.1	12.3	12.2	11.4	13.6	12.3	11.5	13.6	1213	33	16.6	9.6	24.1	62.5	31.9	92.1	1399
5/3/12	11.8	11.0	12.4	12.0	11.1	13.2	12.1	11.2	13.3	700	30	16.8	10.2	24.2	59.1	22.2	89.8	1399
5/4/12	11.9	11.0	12.9	12.3	11.1	13.3	12.4	11.1	13.5	811	29	15.4	8.3	23.4	62.5	38.9	83.7	1398
5/5/12	12.4	10.8	14.1	12.2	10.8	13.4	12.4	10.9	13.7	227	28	15.5	8.6	23.1	59.0	35.7	85.2	1399
5/6/12	12.1	11.0	13.0	13.8	12.8	15.1	14.0	12.8	15.5	60	26	17.1	6.5	27.2	59.4	28.7	93.6	1398
5/7/12	12.0	10.9	13.0	13.8	12.7	14.7	14.2	12.9	15.4	60	24	21.0	11.3	29.3	37.3	19.1	82.1	1398
5/8/12	12.0	10.8	13.0	13.8	12.8	14.8	14.2	12.9	15.3	60	23	24.0	14.5	31.8	26.3	13.7	61.3	1398
5/9/12	12.1	10.9	13.2	13.9	12.9	15.0	14.2	13.1	15.4	61	21	24.3	16.7	33.5	31.5	14.7	54.1	1398
5/10/12	11.6	11.0	12.4	14.1	13.0	15.1	14.3	13.3	15.4	60	21	23.2	15.1	30.7	32.4	18.5	62.0	1399
5/11/12	-	-	-	14.1	13.0	15.2	14.4	13.2	15.5	60	20	21.8	14.2	30.5	39.7	21.4	63.1	1400
5/12/12	-	-	-	14.3	13.2	15.4	14.5	13.4	15.7	61	19	23.6	15.9	32.8	41.3	21.8	64.7	1400
5/13/12	-	-	-	14.5	13.4	15.5	14.7	13.7	15.8	61	18	24.5	16.9	34.2	42.3	19.9	75.0	1399
5/14/12	-	-	-	14.6	13.6	15.7	14.9	13.8	16.1	60	17	18.9	12.2	26.4	59.5	29.2	89.0	1399
5/15/12	13.3	12.8	13.6	14.6	13.6	15.6	14.8	13.8	15.9	59	17	19.3	11.8	28.1	50.3	28.3	71.9	1399
5/16/12	12.7	11.4	13.9	14.6	13.6	15.7	14.9	13.8	16.0	59	16	21.8	12.6	31.8	54.2	27.9	80.9	1399
5/17/12	12.9	11.8	14.0	14.9	13.9	15.9	15.1	14.1	16.3	59	16	22.9	13.5	31.1	40.9	10.8	72.4	1399
5/18/12	12.5	11.4	13.4	14.7	13.7	15.6	15.1	14.0	16.2	59	15	18.1	8.8	27.0	49.9	28.7	74.0	1398
5/19/12	12.5	11.3	13.6	14.6	13.5	15.6	14.9	13.9	16.0	59	16	21.5	12.9	31.1	48.3	22.0	73.3	1398
5/20/12	12.7	11.5	14.0	14.7	13.6	15.8	15.1	14.0	16.4	59	15	24.0	16.6	33.6	43.1	22.7	62.8	1399
5/21/12	12.9	11.7	14.1	15.0	13.9	16.1	15.4	14.2	16.6	59	15	25.2	17.1	33.5	37.1	20.4	60.3	1400
5/22/12	12.9	11.7	14.0	15.2	14.1	16.2	15.5	14.4	16.6	59	14	21.8	13.8	30.6	44.8	22.5	68.2	1399
5/23/12	12.7	11.5	13.7	15.0	14.0	16.0	15.4	14.3	16.4	59	13	19.4	11.2	28.6	47.3	17.7	76.6	1399
5/24/12	12.4	11.2	13.4	14.7	13.6	15.6	15.0	13.9	16.0	59	13	18.5	9.7	27.4	43.2	18.0	72.5	1399
5/25/12	11.6	10.8	12.6	13.9	13.2	14.8	14.2	13.5	14.9	59	13	11.8	6.5	17.3	53.1	28.6	78.3	1399
5/26/12	11.2	10.4	11.9	12.8	12.2	13.5	14.1	12.6	16.6	59	14	13.3	8.4	20.3	60.9	34.8	86.1	1399
5/27/12	11.4	10.1	12.7	12.8	11.7	13.9	14.5	12.1	17.0	59	15	17.6	10.1	25.4	45.9	28.8	74.8	1399
5/28/12	11.9	10.7	13.2	13.4	12.3	14.6	14.6	12.9	16.7	59	14	19.3	10.8	28.2	47.2	22.4	74.0	1399
5/29/12	12.1	10.9	13.4	14.0	12.8	15.1	15.1	13.4	17.1	60	13	21.8	14.2	29.8	38.4	22.9	60.4	1399
5/30/12	12.5	11.2	13.7	14.4	13.3	15.5	15.6	14.0	17.4	60	12	23.4	14.8	32.2	42.0	25.1	60.7	1399
5/31/12	12.8	11.4	14.1	14.9	13.8	16.0	16.1	14.3	17.9	60	12	25.6	15.9	36.0	43.7	21.0	70.0	1399

[1] SJR Horseshoe Bend (East) contains unrepresentative data between May 11 and 12 due to loggers out of water.

Table A-8. June 2012 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.

	Redinger Lake at Dam 7			SJR Downstream of Dam 7			SJR Upstream of Willow Creek			Willow Creek			Willow Creek Bridge			SJR Downstream of Willow Creek		
	Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder		
Date	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum
6/1/12	12.1	10.5	17.1	10.1	9.5	11.2	10.2	9.6	11.2	20.1	18.2	21.8	20.1	18.2	21.4	10.6	9.9	11.6
6/2/12	13.6	10.6	17.9	10.2	9.5	11.2	10.3	9.7	11.5	20.6	18.7	22.1	20.5	18.7	21.7	10.7	9.9	11.8
6/3/12	12.1	10.9	14.4	10.2	9.5	11.3	10.3	9.7	11.5	20.9	19.2	22.7	20.9	19.2	22.0	10.7	10.0	11.8
6/4/12	12.3	10.9	15.0	10.1	9.5	11.3	10.2	9.7	11.1	20.1	19.0	21.6	20.1	18.9	21.2	10.6	10.0	11.5
6/5/12	12.4	11.0	14.6	10.2	9.5	11.3	10.3	9.7	11.3	18.1	16.9	19.6	18.0	16.9	19.2	10.6	10.0	11.6
6/6/12	12.4	11.1	14.4	10.4	9.7	11.5	10.4	9.7	11.6	16.8	15.0	18.3	16.7	15.0	17.8	10.7	9.9	11.8
6/7/12	12.8	11.2	15.1	10.6	9.7	12.0	10.8	9.8	12.1	17.3	15.3	18.9	17.3	15.2	19.9	10.7	10.0	11.4
6/8/12	12.5	11.2	14.6	10.7	9.9	12.0	10.9	10.1	12.2	18.4	16.5	20.0	18.3	16.5	19.7	10.8	10.1	11.7
6/9/12	12.8	11.5	15.0	10.5	9.8	11.4	10.8	10.0	12.1	18.3	16.2	19.7	18.3	16.2	19.8	10.8	10.1	11.7
6/10/12	12.9	11.7	15.3	10.6	9.8	11.7	11.0	10.0	12.4	17.9	15.7	19.4	17.9	15.8	19.6	10.9	10.1	11.8
6/11/12	13.9	11.5	17.0	10.7	10.1	11.8	11.1	10.2	12.3	18.7	16.6	20.3	18.7	16.6	20.4	11.0	10.3	11.8
6/12/12	14.5	11.9	17.0	10.8	10.1	11.6	11.2	10.4	12.4	19.2	17.0	20.8	19.2	17.0	21.0	11.1	10.4	11.8
6/13/12	14.0	11.8	16.8	10.9	10.3	11.8	11.3	10.5	12.6	19.9	17.7	21.7	19.9	17.7	21.8	11.2	10.6	12.1
6/14/12	13.2	12.1	14.8	11.0	10.3	11.8	11.5	10.6	12.7	20.6	18.5	22.3	20.6	18.5	22.5	11.3	10.6	12.1
6/15/12	13.7	12.1	17.9	11.0	10.4	11.8	11.5	10.7	12.7	21.2	19.3	22.6	21.2	19.3	22.7	11.4	10.8	12.2
6/16/12	13.6	12.4	17.9	11.1	10.5	12.1	11.7	10.8	13.1	21.8	19.7	23.3	21.8	19.7	23.4	11.5	10.8	12.4
6/17/12	13.7	12.3	19.0	11.2	10.7	12.1	11.8	10.9	13.1	22.6	20.8	23.9	22.6	20.8	24.0	11.6	11.0	12.5
6/18/12	14.3	12.5	20.0	11.3	10.7	12.1	11.8	10.9	13.2	21.9	19.8	23.8	21.9	19.8	23.9	11.7	11.0	12.5
6/19/12	15.6	12.7	19.5	11.4	10.7	12.2	11.9	10.9	13.3	21.2	19.2	22.6	21.2	19.3	22.7	11.7	11.1	12.6
6/20/12	14.3	13.0	16.3	11.5	10.9	12.2	11.9	11.1	13.3	20.9	18.7	22.4	20.9	18.8	22.5	11.8	11.1	12.7
6/21/12	14.6	13.1	18.5	11.7	11.1	12.4	12.1	11.3	13.5	21.6	19.7	22.8	21.6	19.7	22.8	12.0	11.3	12.8
6/22/12	14.7	13.3	17.2	11.7	11.1	12.5	12.1	11.2	13.6	20.7	19.0	21.9	20.7	19.0	22.0	12.0	11.4	12.9
6/23/12	14.5	13.2	17.3	11.8	11.2	12.7	12.1	11.2	13.6	19.9	18.0	20.9	19.9	18.0	21.0	12.0	11.3	12.9
6/24/12	14.8	13.5	17.1	11.9	11.3	12.8	12.2	11.3	13.7	19.6	17.9	20.7	19.6	17.9	20.8	12.2	11.5	13.0
6/25/12	14.9	13.7	17.3	12.0	11.4	12.8	12.3	11.4	13.7	19.2	17.3	20.3	19.1	17.3	20.4	12.2	11.6	13.1
6/26/12	15.2	14.0	17.2	12.1	11.4	12.9	12.4	11.5	13.9	18.9	17.0	20.2	18.9	17.0	20.4	12.3	11.7	13.2
6/27/12	15.6	14.1	17.4	12.2	11.5	13.0	12.5	11.6	14.1	19.2	17.0	20.7	19.1	17.0	20.8	12.4	11.8	13.3
6/28/12	16.2	14.3	18.8	12.3	11.8	13.2	12.7	11.9	13.9	19.8	17.8	21.2	19.8	17.8	21.3	12.6	12.0	13.4
6/29/12	16.2	14.5	18.7	12.4	11.7	13.3	12.8	11.9	14.0	20.4	18.4	21.7	20.3	18.4	21.7	12.7	12.1	13.4
6/30/12	16.0	14.6	17.8	12.5	11.9	13.2	12.9	12.1	14.3	21.1	19.2	23.3	21.0	19.2	22.7	12.8	12.2	13.6

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Table A-8. June 2012 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).

	SJR Horseshoe Bend (East)			SJR Horseshoe Bend (West)			SJR Upstream of Powerhouse 4			Flows (cfs)		Dam 7			Dam 7			Redinger Lake
	Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek	Air Temperature Recorder			Relative Humidity			Surface Water Elevation
Date	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)
6/1/12	13.0	11.7	14.3	15.4	14.2	16.4	16.7	15.0	18.9	61	12	27.9	19.0	37.4	35.3	15.3	57.5	1,399
6/2/12	13.1	11.7	14.3	15.6	14.4	16.6	17.0	15.3	19.1	62	11	27.4	20.2	34.6	34.4	21.7	55.7	1,399
6/3/12	13.1	11.8	14.3	15.7	14.6	16.7	17.1	15.6	19.4	62	11	24.2	16.0	32.7	46.7	22.9	74.4	1,399
6/4/12	12.8	11.7	13.7	15.5	14.6	16.2	16.7	15.2	18.4	62	10	19.6	10.7	28.0	61.2	35.6	94.4	1,398
6/5/12	12.4	11.3	13.4	14.7	13.8	15.4	16.0	14.8	17.7	62	11	15.3	9.8	21.7	60.8	28.9	96.4	1,399
6/6/12	12.3	11.0	13.4	14.3	13.3	15.3	15.6	13.7	17.5	61	11	17.1	8.4	25.8	51.2	27.7	81.7	1,399
6/7/12	12.6	11.2	13.9	14.4	13.3	15.6	15.5	14.0	17.4	54	12	21.0	11.3	30.9	46.1	23.2	76.5	1,399
6/8/12	13.4	12.5	14.5	15.1	14.0	16.1	15.4	14.5	16.3	54	11	22.0	13.7	30.6	41.2	16.9	70.1	1,399
6/9/12	13.0	11.6	14.2	15.4	14.5	16.3	15.6	14.7	16.6	61	17	20.0	12.4	28.3	38.9	14.9	65.4	1,399
6/10/12	13.3	12.1	14.3	15.0	13.7	16.1	15.2	13.9	16.3	61	18	21.3	10.6	31.1	37.9	19.7	61.2	1,399
6/11/12	13.5	12.3	14.7	15.4	14.2	16.5	15.5	14.4	16.7	61	17	25.6	16.7	35.4	29.4	11.4	51.3	1,399
6/12/12	13.8	12.6	15.0	15.7	14.5	16.8	15.9	14.6	17.1	61	17	27.9	19.5	36.4	23.5	12.2	41.7	1,398
6/13/12	14.0	12.8	15.1	16.0	14.8	17.1	16.2	15.1	17.4	61	20	25.9	18.0	33.7	32.6	22.3	53.4	1,399
6/14/12	14.5	13.1	15.6	16.3	15.2	17.5	16.5	15.3	17.7	61	18	26.3	18.0	34.7	40.0	23.7	59.5	1,399
6/15/12	14.6	13.4	15.7	16.8	15.7	17.8	17.0	15.9	18.0	61	18	27.0	19.6	34.9	38.7	23.7	57.2	1,399
6/16/12	14.8	13.5	16.0	17.0	15.9	18.1	17.2	16.1	18.4	61	18	28.5	17.9	38.6	41.0	20.5	69.1	1,399
6/17/12	15.2	13.9	16.4	17.3	16.2	18.5	17.6	16.4	18.7	61	19	30.9	22.3	40.0	27.7	6.1	54.8	1,399
6/18/12	15.1	13.9	16.3	17.4	16.2	18.5	17.6	16.4	18.8	61	23	28.5	19.9	36.6	24.6	12.8	39.4	1,399
6/19/12	15.2	14.0	16.4	17.2	16.0	18.1	17.4	16.2	18.4	61	19	26.9	19.0	34.8	25.2	11.9	40.2	1,399
6/20/12	14.7	13.4	15.8	17.2	16.0	18.1	17.4	16.3	18.3	61	16	26.6	17.0	35.9	30.2	19.7	46.7	1,399
6/21/12	14.7	13.4	16.1	17.1	15.9	18.1	17.3	16.2	18.4	61	15	27.4	19.9	35.7	30.9	12.9	47.9	1,399
6/22/12	14.7	13.6	15.7	16.8	15.7	17.9	17.1	15.9	18.1	61	15	22.1	13.7	29.9	36.5	14.7	60.3	1,398
6/23/12	14.2	12.8	15.4	16.6	15.5	17.6	16.9	15.7	17.9	60	13	20.3	12.3	27.8	41.9	30.7	56.8	1,399
6/24/12	14.5	13.2	15.6	16.3	15.2	17.3	16.6	15.5	17.5	60	16	20.2	12.2	28.1	46.7	25.4	74.5	1,400
6/25/12	14.5	13.3	15.5	16.3	15.2	17.3	16.6	15.4	17.6	60	17	20.2	11.6	27.8	42.6	22.8	67.0	1,399
6/26/12	14.5	13.3	15.5	16.3	15.2	17.3	16.6	15.4	17.6	60	17	20.3	11.4	29.1	44.1	25.1	68.9	1,398
6/27/12	14.7	13.4	15.9	16.4	15.2	17.5	16.7	15.4	17.8	60	17	23.1	13.1	32.9	38.3	19.4	61.8	1,398
6/28/12	14.9	13.7	16.1	16.7	15.5	17.9	17.0	15.7	18.1	60	14	26.1	17.7	34.9	29.7	16.3	47.1	1,399
6/29/12	15.1	13.8	16.2	17.0	15.9	18.1	17.3	16.1	18.4	61	14	25.3	18.2	32.6	33.7	22.1	46.5	1,399
6/30/12	15.0	13.9	16.1	17.2	16.1	18.3	17.5	16.3	18.6	60	7	25.0	16.6	32.8	39.6	23.0	58.7	1,399

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Table A-9. July 2012 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.

	Redinger Lake at Dam 7 Temperature Recorder			SJR Downstream of Dam 7 Temperature Recorder			SJR Upstream of Willow Creek Temperature Recorder			Willow Creek Temperature Recorder			Willow Creek Bridge Temperature Recorder			SJR Downstream of Willow Creek Temperature Recorder		
Date	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum
7/1/12	16.6	15.2	18.4	12.6	11.9	13.2	13.0	12.0	14.3	21.6	20.1	23.5	21.5	20.1	22.9	12.9	12.3	13.7
7/2/12	16.8	15.7	19.0	12.7	12.1	13.4	13.1	12.2	14.3	22.3	20.8	24.1	22.3	20.8	23.6	13.0	12.3	13.8
7/3/12	16.7	15.3	19.2	12.8	12.2	13.5	13.2	12.4	14.4	23.0	21.6	24.8	22.9	21.5	24.3	13.1	12.5	13.9
7/4/12	17.0	15.3	21.0	12.8	12.1	13.8	13.2	12.4	14.3	22.7	21.2	24.5	22.6	21.2	24.0	13.2	12.5	13.9
7/5/12	16.9	15.7	19.9	13.0	12.2	13.7	13.3	12.4	14.6	22.5	21.0	24.4	22.4	20.7	24.8	13.2	12.6	14.0
7/6/12	17.3	15.5	21.2	13.0	12.4	14.2	13.4	12.5	14.9	22.5	21.0	24.2	22.5	20.9	24.2	13.3	12.6	14.2
7/7/12	17.3	15.9	21.0	13.2	12.4	14.1	13.5	12.5	15.0	22.8	21.2	24.2	22.7	21.2	23.9	13.4	12.7	14.2
7/8/12	17.5	15.8	21.7	13.2	12.5	14.2	13.7	12.8	15.0	23.2	21.6	24.8	23.2	21.5	24.4	13.6	13.0	14.3
7/9/12	18.3	15.7	21.9	13.3	12.6	14.1	13.7	12.9	15.0	23.4	21.7	24.9	23.4	21.7	24.6	13.7	13.1	14.4
7/10/12	17.5	16.8	19.2	13.4	12.8	14.2	13.8	13.0	15.0	23.4	21.5	24.8	23.3	21.4	24.5	13.7	13.1	14.5
7/11/12	18.7	15.9	22.9	13.5	13.0	14.1	13.8	13.2	15.1	23.8	22.1	25.4	23.9	22.1	25.5	13.9	13.3	15.7
7/12/12	18.9	16.1	23.1	13.4	13.1	14.1	13.7	13.3	14.7	24.0	22.8	25.0	23.9	22.8	24.8	14.0	13.5	14.9
7/13/12	18.0	17.0	20.8	13.5	13.2	14.0	13.9	13.4	14.6	24.3	23.1	25.6	24.3	23.1	25.4	14.2	13.5	15.1
7/14/12	18.2	16.9	20.6	13.6	13.2	14.2	14.0	13.4	14.8	23.6	22.1	25.2	23.6	22.1	24.7	14.3	13.6	15.2
7/15/12	18.7	16.8	22.1	13.7	13.3	14.2	14.0	13.4	14.9	22.8	21.2	24.3	22.8	21.2	23.9	14.3	13.6	15.3
7/16/12	18.7	17.4	20.9	13.7	13.1	14.4	14.1	13.2	15.1	22.6	21.1	24.1	22.6	21.1	23.7	14.4	13.6	15.4
7/17/12	18.6	17.4	21.5	13.8	13.2	14.6	14.1	13.3	15.1	21.9	20.5	23.4	21.9	20.5	23.0	14.4	13.6	15.4
7/18/12	18.9	17.4	21.2	13.8	13.4	14.3	14.1	13.5	14.8	21.5	20.2	22.8	21.5	20.2	22.4	14.4	13.6	15.2
7/19/12	18.8	16.6	21.6	13.8	13.4	14.4	14.0	13.6	14.5	21.0	20.4	21.6	21.0	20.5	21.5	14.2	13.8	14.7
7/20/12	18.8	17.1	21.2	14.1	13.4	14.9	14.4	13.6	15.5	21.4	19.6	23.4	21.4	19.6	23.1	14.7	13.9	15.7
7/21/12	18.3	17.5	20.0	14.1	13.3	14.9	14.5	13.5	15.5	22.9	21.2	24.7	22.9	21.2	24.3	14.8	14.0	15.8
7/22/12	18.9	17.8	20.5	14.2	13.4	14.8	14.6	13.8	15.4	23.9	22.3	25.7	23.9	22.3	25.3	14.9	14.3	15.8
7/23/12	18.8	18.0	21.4	14.4	13.9	14.9	14.7	14.1	15.4	24.2	22.9	25.5	24.1	23.0	25.2	15.0	14.4	15.8
7/24/12	19.1	18.1	21.6	14.4	13.7	15.2	14.7	13.8	15.7	23.4	21.9	25.3	23.4	22.0	24.7	15.1	14.2	16.0
7/25/12	19.9	17.9	22.4	14.5	13.8	15.3	14.8	13.9	15.8	22.5	20.8	24.3	22.4	20.8	23.7	15.2	14.3	16.2
7/26/12	19.7	18.0	22.1	14.6	13.8	15.6	15.0	14.1	16.0	22.4	20.8	24.4	22.4	20.9	23.8	15.3	14.5	16.4
7/27/12	19.3	18.0	21.8	14.8	14.0	15.7	15.1	14.1	16.0	22.7	21.2	24.7	22.7	21.3	24.1	15.4	14.5	16.5
7/28/12	19.5	18.0	21.9	14.9	14.3	15.9	15.2	14.5	16.3	22.3	20.7	24.3	22.2	20.7	23.7	15.5	14.8	16.5
7/29/12	20.0	18.0	22.0	15.1	14.4	16.0	15.4	14.5	16.5	22.2	20.6	24.3	22.2	20.7	23.7	15.7	14.8	16.7
7/30/12	20.0	18.2	22.1	15.2	14.6	16.3	15.5	14.7	16.7	22.6	20.9	24.8	22.5	21.0	24.2	15.8	15.0	16.8
7/31/12	20.5	18.0	22.1	15.3	14.3	16.1	15.6	14.7	16.7	22.7	21.0	24.9	22.6	21.1	24.2	15.9	15.1	16.9

Table A-9. July 2012 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).

	SJR Horseshoe Bend (East)			SJR Horseshoe Bend (West)			SJR Upstream of Powerhouse 4			Flows (cfs)		Dam 7			Dam 7			Redinger Lake
	Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek	Air Temperature Recorder			Relative Humidity			Surface Water Elevation
Date	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)
7/1/12	15.0	13.5	16.3	17.5	16.5	18.5	17.8	16.8	18.7	60	8	25.1	17.0	32.6	44.9	28.4	64.2	1,398
7/2/12	15.3	14.0	16.5	17.6	16.4	18.6	17.8	16.7	18.9	60	8	26.1	18.0	33.9	45.8	28.5	67.5	1,398
7/3/12	15.5	14.2	16.7	17.9	16.8	18.9	18.2	17.1	19.2	61	8	27.4	20.2	34.8	39.9	19.7	62.6	1,399
7/4/12	15.4	14.1	16.5	17.9	16.8	18.8	18.1	17.1	19.1	60	7	27.7	18.7	36.0	32.8	16.9	53.4	1,400
7/5/12	15.4	14.1	16.5	17.8	16.7	18.7	18.0	17.1	18.9	61	7	26.5	17.2	34.7	34.2	20.9	54.4	1,399
7/6/12	15.5	14.1	16.7	17.8	16.7	18.7	18.0	17.0	19.0	60	8	27.6	20.3	35.7	33.0	20.3	47.1	1,399
7/7/12	15.7	14.4	16.9	17.9	16.8	18.9	18.1	17.1	19.1	61	9	28.8	20.6	37.1	31.5	19.7	46.5	1,399
7/8/12	16.1	14.9	17.2	18.2	17.1	19.2	18.4	17.3	19.4	61	10	29.7	21.6	37.9	31.7	18.1	46.6	1,399
7/9/12	16.2	14.8	17.4	18.5	17.4	19.5	18.7	17.6	19.7	61	11	30.3	21.7	39.0	29.0	13.0	46.6	1,400
7/10/12	16.3	15.0	17.4	18.5	17.3	19.6	18.7	17.6	19.8	60	11	30.2	20.4	39.4	28.5	17.7	43.5	1,399
7/11/12	16.4	15.1	17.6	18.7	17.6	19.8	18.9	17.8	20.0	60	10	32.5	24.3	41.0	27.2	1.0	40.6	1,399
7/12/12	16.1	15.0	16.9	18.6	17.7	19.4	18.7	17.9	19.5	60	9	33.0	26.2	41.1	26.2	14.7	41.8	1,399
7/13/12	16.4	15.3	17.5	18.5	17.6	19.4	18.7	17.7	19.6	59	10	30.9	23.4	38.6	31.3	14.9	55.6	1,400
7/14/12	16.3	15.1	17.5	18.6	17.6	19.6	18.8	17.8	19.8	59	9	27.8	19.7	35.7	29.6	13.6	51.4	1,400
7/15/12	16.1	14.9	17.3	18.4	17.3	19.4	18.6	17.5	19.5	60	9	27.5	19.3	36.3	26.9	15.3	45.2	1,399
7/16/12	16.1	14.9	17.2	18.3	17.2	19.2	18.4	17.4	19.4	60	9	26.0	18.2	33.7	30.7	19.0	45.2	1,399
7/17/12	16.0	14.9	17.0	18.1	17.0	19.0	18.2	17.2	19.1	59	9	22.0	14.3	29.1	43.8	29.1	60.4	1,399
7/18/12	15.8	14.8	16.5	17.8	16.9	18.4	18.0	17.2	18.6	59	7	23.0	14.4	30.0	44.4	25.5	67.8	1,399
7/19/12	15.3	14.7	16.1	17.3	16.8	18.1	17.4	16.9	18.2	59	6	25.2	19.0	33.1	37.8	24.8	64.6	1,399
7/20/12	16.0	14.6	17.6	17.2	16.2	18.2	17.4	16.4	18.4	59	9	28.1	20.1	36.6	35.9	22.5	55.3	1,399
7/21/12	16.6	15.3	17.8	18.2	17.0	19.6	18.4	17.2	19.8	59	9	29.6	19.3	39.6	34.4	15.7	57.3	1,399
7/22/12	16.9	15.6	18.1	19.0	17.9	20.0	19.2	18.1	20.2	59	8	31.2	22.0	39.9	31.8	18.0	47.7	1,399
7/23/12	17.0	16.4	18.0	19.2	18.2	20.2	19.4	18.4	20.4	59	9	29.1	22.4	36.8	35.9	17.9	59.4	1,399
7/24/12	16.7	15.6	17.7	19.0	18.1	20.0	19.2	18.3	20.2	59	7	27.0	18.2	35.6	29.3	13.4	50.8	1,399
7/25/12	16.5	15.2	17.6	18.6	17.5	19.5	18.7	17.7	19.6	59	7	27.3	18.2	36.4	23.7	12.9	35.9	1,399
7/26/12	16.6	15.3	17.7	18.5	17.4	19.5	18.6	17.6	19.6	59	6	27.3	19.0	34.8	29.4	21.1	44.6	1,399
7/27/12	16.8	15.6	17.8	18.7	17.6	19.7	18.8	17.8	19.7	59	6	26.2	18.4	34.1	33.7	17.5	53.1	1,400
7/28/12	16.8	15.6	17.9	18.6	17.6	19.6	18.8	17.8	19.7	59	6	26.4	18.0	34.8	28.5	17.5	42.9	1,400
7/29/12	16.9	15.7	18.0	18.7	17.6	19.7	18.8	17.7	19.8	59	6	27.1	18.0	36.0	30.5	18.8	46.0	1,399
7/30/12	17.1	15.8	18.3	18.8	17.7	19.9	19.0	17.9	20.0	60	6	29.0	20.0	38.3	25.0	13.1	41.6	1,399
7/31/12	17.2	16.0	18.3	19.0	17.9	20.0	19.1	18.1	20.1	62	6	30.1	21.7	39.1	21.2	10.8	33.5	1,399

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Table A-10. August 2012 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.

	Redinger Lake at Dam 7			SJR Downstream of Dam 7			SJR Upstream of Willow Creek			Willow Creek			Willow Creek Bridge			SJR Downstream of Willow Creek		
	Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder		
Date	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum
8/1/12	20.5	18.2	22.1	15.4	14.4	16.2	15.7	14.7	16.7	22.9	21.2	25.1	22.8	21.3	24.5	16.0	15.3	17.0
8/2/12	20.8	18.2	22.0	15.5	14.6	16.3	15.8	15.0	16.7	23.0	21.3	25.3	22.9	21.4	24.7	16.1	15.4	16.9
8/3/12	20.7	18.2	22.0	15.5	14.9	16.4	15.8	15.3	16.5	22.7	21.3	24.5	22.7	21.4	24.0	16.1	15.6	16.7
8/4/12	20.2	18.7	21.6	15.6	14.8	16.3	15.9	15.4	16.5	22.7	21.6	24.1	22.7	21.7	23.7	16.1	15.7	16.7
8/5/12	20.9	18.6	22.1	15.8	15.2	16.7	16.1	15.5	17.1	23.2	21.5	25.6	23.2	21.7	25.0	16.4	15.7	17.3
8/6/12	20.5	19.0	21.8	15.8	15.0	16.7	16.1	15.3	17.1	23.4	21.8	25.8	23.4	22.0	25.2	16.4	15.7	17.4
8/7/12	21.3	19.2	22.4	15.9	15.0	16.7	16.1	15.4	17.3	23.3	21.6	25.7	23.3	21.7	25.1	16.5	15.8	17.5
8/8/12	21.0	19.5	22.8	15.9	15.3	16.7	16.3	15.5	17.2	23.9	22.1	26.4	23.9	22.3	25.8	16.6	15.8	17.6
8/9/12	20.8	19.7	22.7	16.0	15.4	16.7	16.4	15.6	17.2	24.4	22.6	26.9	24.4	22.8	26.3	16.6	15.9	17.6
8/10/12	21.7	19.6	24.0	16.1	15.5	16.8	16.4	15.7	17.4	24.9	23.2	27.4	24.9	23.4	26.8	16.7	15.9	17.7
8/11/12	22.2	19.6	24.5	16.1	15.1	17.0	16.5	15.5	17.5	25.2	23.3	27.6	25.1	23.5	27.0	16.8	15.9	17.8
8/12/12	23.1	20.1	24.4	16.3	15.7	17.1	16.7	16.0	17.5	25.4	23.9	27.4	25.3	24.0	26.9	16.9	16.2	17.8
8/13/12	22.6	20.0	24.0	16.4	15.6	17.1	16.7	15.9	17.6	25.7	23.9	28.0	25.6	24.1	27.6	17.0	16.2	18.0
8/14/12	22.9	20.2	23.9	16.4	15.4	17.2	16.8	16.1	17.5	25.6	24.3	27.4	25.6	24.5	27.1	17.0	16.3	17.9
8/15/12	22.5	20.2	23.5	16.6	15.5	17.5	16.9	15.9	18.4	25.5	23.7	27.9	25.5	23.9	27.5	17.2	16.3	18.7
8/16/12	22.4	20.4	23.3	16.6	15.7	17.5	16.9	15.9	18.1	25.6	23.9	28.0	25.6	24.1	27.5	17.1	16.2	18.1
8/17/12	21.8	20.7	23.0	16.7	15.9	17.5	16.9	16.1	17.9	25.2	23.7	27.1	25.3	23.9	26.8	17.1	16.2	18.0
8/18/12	21.8	20.7	22.7	16.8	16.2	17.4	17.0	16.4	17.7	25.0	23.7	26.6	25.0	23.9	26.4	17.1	16.5	17.8
8/19/12	21.8	20.5	22.7	16.9	16.4	17.7	17.2	16.6	18.2	25.0	23.5	27.3	25.0	23.6	26.8	17.3	16.7	18.2
8/20/12	22.0	20.5	23.7	17.0	16.5	17.8	17.3	16.6	18.2	24.4	22.7	26.9	24.4	22.9	26.4	17.4	16.7	18.3
8/21/12	22.4	20.4	23.9	17.1	16.6	18.0	17.3	16.6	18.3	23.7	21.9	26.0	23.7	22.1	25.4	17.5	16.7	18.4
8/22/12	22.6	20.8	23.7	17.3	16.2	18.3	17.5	16.6	18.6	23.6	22.1	26.1	23.6	22.2	25.6	17.7	17.0	18.6
8/23/12	22.2	20.6	23.1	17.4	16.5	18.2	17.6	16.8	18.4	23.3	21.5	25.6	23.3	21.7	25.2	17.7	17.1	18.5
8/24/12	22.6	20.7	23.1	17.6	16.6	18.3	17.8	16.7	18.8	23.1	21.3	25.5	23.1	21.4	25.1	17.9	17.0	18.7
8/25/12	21.9	20.7	23.1	17.7	16.6	18.6	17.9	16.8	18.8	23.2	21.4	25.5	23.2	21.6	25.2	18.1	17.1	18.7
8/26/12	21.7	20.5	23.1	17.8	17.1	18.6	18.0	17.2	18.8	22.9	21.1	25.1	23.0	21.4	25.1	18.2	17.4	18.8
8/27/12	22.1	20.6	22.7	17.9	17.0	18.8	18.1	17.1	19.1	22.1	20.0	24.2	22.2	20.3	24.3	18.2	17.3	19.1
8/28/12	21.9	20.7	22.4	18.1	17.3	19.0	18.2	17.3	19.2	21.6	19.5	23.8	21.7	19.7	24.0	18.3	17.5	19.2
8/29/12	22.1	20.7	22.4	18.1	17.4	18.7	18.3	17.7	19.1	22.0	20.0	24.1	22.0	20.1	24.2	18.5	17.8	19.2
8/30/12	21.8	20.8	22.8	18.3	17.2	19.0	18.5	17.6	19.3	22.5	20.6	24.5	22.6	20.8	24.7	18.6	18.1	19.3
8/31/12	21.6	20.4	22.8	18.4	18.0	18.8	18.6	18.1	19.2	22.5	21.2	24.5	22.5	21.3	24.2	18.7	18.3	19.2

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Table A-10. August 2012 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).

	SJR Horseshoe Bend (East)			SJR Horseshoe Bend (West)			SJR Upstream of Powerhouse 4			Flows (cfs)		Dam 7			Dam 7			Redinger Lake
	Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek	Air Temperature Recorder			Relative Humidity			Surface Water Elevation
Date	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)
8/1/12	17.3	16.1	18.5	19.1	18.0	20.1	19.2	18.2	20.2	62	6	30.9	23.3	39.3	19.9	10.0	32.1	1,399
8/2/12	17.4	16.2	18.5	19.2	18.1	20.2	19.3	18.3	20.3	62	5	30.7	22.6	39.7	19.8	8.9	30.3	1,399
8/3/12	17.2	16.2	18.2	19.1	18.2	19.9	19.2	18.4	20.0	62	5	29.9	22.8	38.1	21.6	13.7	39.9	1,399
8/4/12	17.2	16.3	18.1	18.9	18.2	19.5	19.1	18.4	19.6	62	5	28.6	22.3	35.2	28.3	18.6	42.8	1,399
8/5/12	17.5	16.3	18.7	19.0	18.0	20.1	19.2	18.1	20.3	62	5	29.5	21.8	38.1	31.8	18.4	48.3	1,399
8/6/12	17.7	16.5	18.7	19.4	18.4	20.5	19.5	18.5	20.6	62	5	28.9	20.1	37.8	28.7	12.3	47.0	1,399
8/7/12	17.7	16.5	18.8	19.5	18.5	20.5	19.7	18.7	20.6	62	5	29.8	21.3	38.1	26.1	15.2	37.6	1,399
8/8/12	17.9	16.7	18.9	19.7	18.7	20.7	19.8	18.9	20.8	62	5	30.0	21.1	39.1	32.4	17.5	51.5	1,399
8/9/12	18.0	16.8	19.1	20.0	19.0	20.9	20.1	19.2	21.1	62	5	31.4	21.7	40.6	31.2	16.0	49.8	1,399
8/10/12	18.1	17.0	19.2	20.2	19.2	21.1	20.3	19.4	21.3	62	5	33.6	25.3	42.2	25.2	12.7	38.6	1,399
8/11/12	18.2	17.1	19.2	20.3	19.3	21.2	20.5	19.5	21.4	62	4	35.8	28.1	43.2	20.9	12.7	28.6	1,399
8/12/12	18.2	17.3	19.1	20.4	19.6	21.2	20.6	19.8	21.3	62	4	35.1	28.0	41.2	24.8	15.1	33.2	1,399
8/13/12	18.5	17.5	19.5	20.6	19.7	21.5	20.7	19.9	21.6	62	4	35.4	27.3	41.9	25.6	16.3	38.5	1,399
8/14/12	18.4	17.6	19.1	20.8	20.0	21.5	20.9	20.2	21.6	62	4	34.4	30.6	40.9	27.2	16.4	39.6	1,399
8/15/12	18.5	17.5	19.5	20.7	19.8	21.6	20.8	20.0	21.7	62	4	33.1	27.0	39.7	29.3	20.1	41.2	1,399
8/16/12	18.5	17.5	19.4	20.7	19.8	21.6	20.8	20.0	21.7	62	4	31.3	24.9	38.6	30.9	16.4	43.5	1,399
8/17/12	18.4	17.5	19.0	20.6	19.8	21.1	20.7	20.0	21.2	62	4	30.9	23.3	38.3	29.2	13.0	50.4	1,399
8/18/12	18.4	17.7	18.8	20.3	19.8	20.8	20.4	20.0	20.9	62	4	30.5	24.2	37.3	31.5	21.1	49.9	1,399
8/19/12	18.5	17.7	19.5	20.3	19.6	21.1	20.4	19.7	21.2	62	4	29.7	23.1	37.9	34.3	15.9	55.6	1,399
8/20/12	18.6	17.6	19.5	20.3	19.4	21.2	20.4	19.6	21.2	62	4	29.2	20.7	38.7	27.9	10.0	48.0	1,399
8/21/12	18.5	17.4	19.4	20.1	19.2	20.9	20.3	19.4	21.0	62	4	29.3	21.6	37.9	22.4	11.9	36.7	1,399
8/22/12	18.7	17.7	19.7	20.2	19.3	21.0	20.3	19.5	21.1	62	4	29.4	23.0	36.2	28.1	13.5	43.9	1,399
8/23/12	18.7	17.6	19.5	20.2	19.3	21.0	20.3	19.4	21.1	62	3	28.5	20.7	37.0	25.3	14.2	37.1	1,399
8/24/12	18.8	17.9	19.7	20.2	19.3	21.0	20.3	19.4	21.1	62	3	29.6	23.0	37.3	25.1	15.5	38.2	1,399
8/25/12	19.0	18.1	19.8	20.3	19.4	21.2	20.4	19.6	21.3	61	3	28.4	20.8	36.5	29.4	17.8	42.5	1,399
8/26/12	18.9	18.1	19.7	20.3	19.5	21.1	20.4	19.7	21.2	61	3	25.5	18.1	33.5	33.5	16.9	58.6	1,398
8/27/12	18.8	17.8	19.6	20.0	19.1	20.8	20.1	19.2	20.9	61	2	26.1	17.8	35.6	24.9	10.8	40.1	1,398
8/28/12	18.9	17.8	19.8	19.9	18.9	20.7	20.0	19.1	20.8	61	2	26.5	15.4	36.8	23.9	12.5	39.2	1,399
8/29/12	19.2	18.2	20.1	20.0	19.1	20.9	20.2	19.2	21.0	62	2	28.4	21.0	37.2	26.5	15.4	47.6	1,399
8/30/12	19.4	18.4	20.3	20.4	19.6	21.2	20.5	19.7	21.3	61	2	28.3	19.4	37.9	32.5	15.4	52.1	1,399
8/31/12	19.3	18.6	20.0	20.5	19.9	21.2	20.6	20.0	21.2	61	2	25.9	19.2	33.9	29.3	11.8	47.7	1,398

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Table A-11. September 2012 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.

	Redinger Lake at Dam 7[1]			SJR Downstream of Dam 7			SJR Upstream of Willow Creek			Willow Creek			Willow Creek Bridge			SJR Downstream of Willow Creek		
	Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder		
Date	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum
9/1/12	21.6	20.6	22.3	18.4	17.8	19.1	18.6	18.0	19.4	21.3	19.5	23.2	21.3	19.7	23.2	18.7	18.1	19.4
9/2/12	21.7	20.8	22.2	18.6	17.9	19.3	18.7	18.0	19.5	20.9	19.0	23.0	21.0	19.2	23.1	18.9	18.1	19.5
9/3/12	21.7	20.6	22.1	18.6	18.0	19.3	18.8	18.0	19.5	20.9	18.9	23.1	21.0	19.2	23.2	18.9	18.1	19.5
9/4/12	21.8	21.1	22.1	18.7	18.2	19.2	18.8	18.2	19.6	21.0	19.1	22.9	21.1	19.3	23.1	18.9	18.3	19.6
9/5/12	21.3	20.2	21.8	18.7	18.2	19.0	18.9	18.3	19.6	21.8	20.1	23.8	21.8	20.1	23.7	19.0	18.5	19.6
9/6/12	21.3	20.5	22.3	18.7	18.2	19.1	18.9	18.4	19.4	21.9	20.7	23.1	22.0	20.8	23.3	19.0	18.6	19.4
9/7/12	21.4	20.2	22.3	18.8	18.4	19.4	19.0	18.4	19.8	22.0	20.3	23.9	22.1	20.5	24.1	19.2	18.6	19.8
9/8/12	21.3	20.4	22.5	18.9	18.4	19.3	19.1	18.5	19.8	22.4	20.7	24.0	22.5	20.9	24.3	19.2	18.6	19.9
9/9/12	21.1	20.2	22.3	18.9	18.5	19.4	19.2	18.7	19.9	22.7	20.9	24.4	22.8	21.1	24.8	19.3	18.8	19.9
9/10/12	21.1	20.1	22.7	19.0	18.7	19.4	19.2	18.7	20.0	22.7	20.9	24.3	22.9	21.2	24.7	19.3	18.8	20.0
9/11/12	21.2	20.2	22.8	19.0	18.7	19.4	19.2	18.8	19.8	22.5	20.7	24.1	22.7	21.1	24.4	19.3	18.9	19.8
9/12/12	21.5	20.0	22.8	19.0	18.6	19.5	19.2	18.7	19.9	22.2	20.5	23.8	22.4	20.7	24.2	19.3	18.8	19.9
9/13/12	21.9	20.2	22.7	19.0	18.6	19.4	19.2	18.6	20.0	22.2	20.3	23.9	22.2	20.6	24.1	19.3	18.7	20.1
9/14/12	21.5	20.3	22.3	19.0	18.8	19.3	19.2	18.8	19.8	22.1	20.4	23.9	22.2	20.6	24.0	19.3	18.8	19.9
9/15/12	20.9	19.9	21.5	19.0	18.7	19.2	19.2	18.9	19.8	21.8	20.0	23.4	21.9	20.2	23.7	19.3	18.9	19.9
9/16/12	-	-	-	19.0	18.8	19.3	19.2	18.9	19.9	21.6	19.9	23.1	21.7	20.1	23.4	19.3	18.9	20.0
9/17/12	-	-	-	19.1	18.9	19.4	19.2	18.9	20.0	21.3	19.5	22.8	21.3	19.8	23.0	19.3	18.9	20.2
9/18/12	-	-	-	19.0	18.8	19.3	19.2	18.8	19.9	21.0	19.2	22.5	21.0	19.4	22.8	19.3	18.8	20.0
9/19/12	-	-	-	19.0	18.6	19.3	19.1	18.7	19.9	20.6	18.8	22.1	20.8	19.1	22.7	19.2	18.8	20.0
9/20/12	20.0	19.3	20.6	19.0	18.8	19.3	19.1	18.7	19.7	20.7	19.1	22.0	20.8	19.3	22.4	19.2	18.7	19.8
9/21/12	20.0	19.4	20.6	19.0	18.9	19.3	19.2	18.9	19.7	20.5	18.9	21.7	20.7	19.1	22.3	19.3	18.8	19.8
9/22/12	19.9	19.4	20.6	19.1	18.9	19.4	19.2	18.9	19.8	20.9	19.4	21.9	21.0	19.6	22.6	19.3	18.9	19.9
9/23/12	20.0	19.1	20.5	19.1	18.8	19.4	19.2	18.9	19.9	20.9	19.2	22.2	21.0	19.4	22.7	19.3	18.9	20.0
9/24/12	19.6	19.0	20.3	19.1	18.8	20.6	19.2	18.8	20.2	20.6	18.9	22.2	20.6	19.2	22.3	19.3	18.8	20.0
9/25/12	19.8	19.1	20.1	18.9	18.7	19.3	19.0	18.7	19.6	19.5	17.9	20.7	19.7	18.1	21.3	19.1	18.7	19.5
9/26/12	19.8	19.1	20.1	18.8	18.6	19.1	18.9	18.7	19.6	19.3	17.6	20.6	19.5	17.8	21.3	18.9	18.6	19.4
9/27/12	19.7	19.0	20.0	18.8	18.6	19.4	19.0	18.6	19.7	19.4	17.8	20.7	19.5	17.8	21.3	19.0	18.6	19.6
9/28/12	-	-	-	19.0	18.5	19.4	19.2	18.5	19.9	19.6	18.0	21.0	19.7	18.0	21.4	19.1	18.5	19.8
9/29/12	-	-	-	18.9	18.5	19.4	19.1	18.5	19.8	19.8	18.2	21.2	19.8	18.3	21.5	19.0	18.6	19.7
9/30/12	-	-	-	18.7	18.4	19.0	18.9	18.5	19.5	19.9	18.4	21.3	20.1	18.5	21.8	19.0	18.6	19.5

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Table A-11. September 2012 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).

	SJR Horseshoe Bend (East)			SJR Horseshoe Bend (West)			SJR Upstream of Powerhouse 4			Flows (cfs)		Dam 7			Dam 7			Redinger Lake[1]
	Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR	Willow Creek	Air Temperature Recorder			Relative Humidity			Surface Water Elevation
Date	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)
9/1/12	19.0	18.1	20.0	20.0	19.2	20.7	20.1	19.3	20.8	61	2	23.4	16.5	31.7	30.1	19.0	42.1	1,399
9/2/12	19.2	18.2	20.1	19.8	18.9	20.7	20.0	19.1	20.8	61	2	24.3	15.6	34.2	32.8	17.3	49.8	1,399
9/3/12	19.4	18.4	20.2	20.0	19.1	20.9	20.1	19.2	21.0	61	2	26.0	16.7	36.4	26.6	12.7	45.5	1,399
9/4/12	19.4	18.5	20.3	20.1	19.2	21.0	20.3	19.4	21.0	61	2	28.8	21.5	37.6	19.9	11.2	38.3	1,399
9/5/12	19.7	18.8	20.5	20.6	19.8	21.3	20.7	19.9	21.4	62	2	28.5	21.4	36.3	27.6	15.8	47.2	1,399
9/6/12	19.5	18.9	20.0	20.6	20.1	21.1	20.7	20.2	21.2	62	2	26.7	20.8	34.5	34.8	16.8	50.0	1,400
9/7/12	19.6	18.7	20.6	20.5	19.6	21.2	20.6	19.8	21.3	61	2	27.0	19.6	35.1	36.7	21.2	50.8	1,400
9/8/12	19.9	19.0	20.7	20.7	19.9	21.5	20.8	20.1	21.6	61	2	27.8	20.0	36.5	37.0	20.9	59.0	1,399
9/9/12	20.0	19.0	20.8	21.0	20.2	21.8	21.1	20.3	21.9	61	2	27.9	20.2	37.3	37.8	17.5	60.3	1,399
9/10/12	19.9	19.0	20.8	21.1	20.2	21.8	21.2	20.4	21.9	61	2	27.0	18.7	35.9	37.9	20.7	61.2	-
9/11/12	19.8	18.9	20.7	20.9	20.2	21.6	21.1	20.3	21.8	62	2	26.2	19.4	34.3	37.3	20.2	53.1	-
9/12/12	19.8	18.8	20.7	20.8	19.9	21.5	21.0	20.1	21.7	61	2	27.1	19.4	35.8	33.1	18.8	49.0	-
9/13/12	19.9	18.9	20.8	20.8	19.9	21.5	20.9	20.1	21.6	61	2	29.2	21.1	37.7	26.5	16.4	43.6	1,399
9/14/12	19.9	18.9	20.8	20.8	20.0	21.6	21.0	20.2	21.7	61	2	31.2	24.7	39.0	20.5	7.4	33.2	1,398
9/15/12	19.8	18.7	20.8	20.7	19.8	21.5	20.9	20.0	21.5	60	2	30.3	23.8	38.2	20.8	11.1	38.3	1,392
9/16/12	19.8	18.8	20.7	20.6	19.8	21.3	20.8	20.0	21.4	59	2	29.1	22.8	36.6	23.1	14.2	34.2	1,390
9/17/12	19.7	18.7	20.7	20.5	19.7	21.1	20.6	19.8	21.2	58	2	27.1	20.0	35.0	25.4	15.1	42.8	1,390
9/18/12	19.7	18.7	20.6	20.4	19.5	21.0	20.5	19.7	21.2	58	2	26.4	19.6	34.7	29.4	18.2	53.3	1,379
9/19/12	19.6	18.5	20.6	20.3	19.5	21.0	20.5	19.7	21.1	57	2	25.0	16.5	35.2	33.6	19.8	50.1	1,377
9/20/12	19.6	18.6	20.4	20.3	19.6	20.9	20.4	19.8	20.9	57	2	25.3	17.4	35.2	35.5	21.1	54.3	1,375
9/21/12	19.6	18.6	20.4	20.2	19.5	20.7	20.4	19.7	20.8	57	1	24.8	15.7	34.5	38.8	22.2	56.6	1,374
9/22/12	19.7	18.8	20.5	20.3	19.6	20.8	20.4	19.8	21.0	57	1	26.3	18.9	36.3	34.8	18.0	50.3	1,372
9/23/12	19.7	18.8	20.6	20.3	19.6	21.0	20.5	19.7	21.1	57	1	28.0	20.2	36.0	27.1	16.6	40.7	1,373
9/24/12	19.6	18.7	20.3	20.2	19.6	20.9	20.4	19.7	21.0	56	1	24.2	17.0	32.9	30.5	11.8	54.5	1,372
9/25/12	19.3	18.3	20.1	19.8	19.1	20.3	19.9	19.2	20.4	57	1	22.7	14.1	32.1	31.2	16.5	47.1	1,369
9/26/12	19.3	18.3	20.2	19.6	18.9	20.2	19.7	19.0	20.4	57	1	24.4	15.6	34.7	30.7	14.9	48.8	1,371
9/27/12	19.3	18.3	20.3	19.7	19.0	20.4	19.8	19.1	20.5	57	1	28.5	22.8	36.5	21.9	13.0	41.9	1,371
9/28/12	19.5	18.4	20.5	19.9	19.2	20.5	20.0	19.3	20.6	56	2	28.5	22.2	35.9	24.9	15.8	41.2	-
9/29/12	19.5	18.5	20.4	20.0	19.3	20.6	20.1	19.5	20.7	55	2	27.3	21.0	35.1	28.4	19.2	43.2	-
9/30/12	19.5	18.5	20.3	20.1	19.5	20.7	20.2	19.6	20.8	55	2	26.7	19.2	36.7	32.9	18.2	49.6	-

[1] Redinger Lake at Dam 7 contains unrepresentative data between September 16 and 19 and September 28 and 30 due to loggers out of the water.

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Table A-12. October 2012 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.

	Redinger Lake at Dam 7[1]			SJR Downstream of Dam 7			SJR Upstream of Willow Creek			Willow Creek			Willow Creek Bridge			SJR Downstream of Willow Creek		
	Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder			Temperature Recorder		
Date	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum	Mean (°C)	Minimum	Maximum
10/1/12	-	-	-	18.7	18.3	19.0	18.9	18.5	19.5	20.1	18.5	21.4	20.2	18.6	22.0	18.9	18.6	19.4
10/2/12	-	-	-	18.8	18.3	19.7	19.0	18.4	19.4	20.0	18.4	21.4	20.1	18.5	21.8	19.0	18.5	19.5
10/3/12	-	-	-	18.8	18.4	19.6	19.0	18.4	20.0	19.8	18.2	21.2	19.8	18.3	21.4	18.9	18.4	19.7
10/4/12	-	-	-	18.6	18.3	18.8	18.7	18.4	19.2	19.7	18.4	21.1	19.7	18.5	21.2	18.8	18.5	19.2
10/5/12	-	-	-	18.5	18.2	18.8	18.6	18.3	18.8	19.0	17.8	19.9	19.0	18.0	20.0	18.7	18.5	18.9
10/6/12	19.6	19.1	19.8	18.5	18.2	18.9	18.6	18.3	19.0	18.3	16.8	19.6	18.4	17.0	19.8	18.6	18.3	19.0
10/7/12	19.6	19.1	19.8	18.5	18.2	18.8	18.6	18.3	19.0	17.8	16.2	19.2	17.8	16.4	19.3	18.6	18.3	19.0
10/8/12	19.5	18.9	19.8	18.4	18.2	18.7	18.5	18.3	19.0	17.8	16.4	19.2	17.8	16.5	19.2	18.5	18.2	19.0
10/9/12	19.6	19.5	19.7	18.4	18.1	18.7	18.5	18.2	18.7	17.5	16.4	18.8	17.4	16.5	18.8	18.5	18.2	18.8
10/10/12	19.4	18.7	19.6	18.3	18.2	18.6	18.4	18.2	18.8	16.8	15.5	18.2	16.7	15.6	18.0	18.4	18.1	18.8
10/11/12	19.1	18.6	19.4	18.2	18.0	18.5	18.2	18.1	18.4	15.9	15.2	16.7	15.9	15.2	16.4	18.1	18.0	18.4
10/12/12	19.0	18.9	19.0	18.2	18.0	18.5	18.2	18.1	18.4	15.7	15.4	16.0	15.6	15.4	15.9	18.1	17.9	18.2
10/13/12	18.8	18.7	18.9	18.2	18.0	18.4	18.3	18.0	18.6	15.9	15.1	17.1	15.9	15.1	16.9	18.1	17.9	18.3
10/14/12	18.7	18.6	18.9	18.0	17.8	18.2	18.1	17.8	18.6	15.5	14.1	17.1	15.5	14.3	17.1	17.9	17.7	18.2
10/15/12	18.6	18.5	18.8	17.9	17.7	18.1	18.0	17.7	18.4	15.6	14.3	17.2	15.7	14.4	17.3	17.8	17.5	18.5
10/16/12	18.7	18.6	18.8	17.9	17.7	18.1	17.9	17.7	18.4	16.0	14.7	17.7	16.1	14.9	17.7	17.9	17.5	18.4
10/17/12	18.8	18.4	19.0	17.9	17.6	18.3	17.9	17.7	18.2	16.4	15.1	18.0	16.6	15.3	18.2	17.9	17.6	18.3
10/18/12	18.7	18.2	19.0	18.1	17.5	19.3	18.2	17.6	19.4	16.8	15.5	18.3	16.8	15.6	18.3	18.1	17.5	19.2
10/19/12	18.5	18.0	18.7	17.8	17.5	18.3	17.8	17.5	18.6	16.6	15.4	18.1	16.5	15.5	17.8	17.8	17.3	18.5
10/20/12	18.6	18.3	18.7	17.6	17.3	18.0	17.7	17.4	18.0	16.5	15.4	18.2	16.6	15.7	17.9	17.7	17.4	18.1
10/21/12	18.5	18.1	18.7	17.5	17.3	17.8	17.6	17.3	17.9	16.1	15.2	17.7	16.1	15.4	17.2	17.5	17.2	18.0
10/22/12	18.4	18.2	18.6	17.4	17.1	17.9	17.4	17.1	17.8	14.9	14.3	15.5	14.9	14.3	15.5	17.3	17.0	17.6
10/23/12	18.0	17.9	18.2	17.3	17.0	17.8	17.2	16.9	17.6	13.4	12.8	14.2	13.4	12.8	14.3	16.7	16.0	17.3
10/24/12	17.7	17.5	17.8	17.0	16.7	17.6	16.9	16.5	17.3	12.2	11.6	13.2	12.2	11.6	12.8	16.3	16.1	16.6
10/25/12	17.4	17.3	17.5	16.9	16.3	17.6	16.8	16.3	17.4	12.1	11.3	13.4	12.0	11.4	12.9	16.3	16.0	16.7
10/26/12	17.3	17.2	17.4	16.7	16.3	17.4	16.6	16.3	17.3	12.2	11.3	13.8	12.2	11.5	13.3	16.2	15.8	16.7
10/27/12	17.1	17.0	17.2	16.6	16.2	17.3	16.6	16.2	17.2	12.5	11.5	14.1	12.5	11.7	13.6	16.2	15.8	16.7
10/28/12	17.1	17.0	17.2	16.6	16.2	17.0	16.4	16.1	16.7	12.7	11.7	13.7	12.8	11.8	13.7	15.2	14.0	16.0
10/29/12	17.0	16.9	17.2	16.5	16.0	17.4	16.4	16.0	17.1	13.4	12.4	14.2	13.4	12.4	14.3	15.5	14.9	15.9
10/30/12	16.9	16.8	17.2	16.4	15.9	17.2	16.3	15.9	17.1	13.5	12.7	14.7	13.5	12.7	14.3	15.9	15.1	16.6
10/31/12	16.8	16.7	17.0	16.2	15.6	17.1	16.3	15.6	17.0	13.4	12.8	14.4	13.4	12.9	14.1	16.0	15.5	16.8

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Table A-12. October 2012 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).

	SJR Horseshoe Bend (East)			SJR Horseshoe Bend (West)			SJR Upstream of Powerhouse 4			Flows (cfs)		Dam 7			Dam 7			Redinger Lake[1]
	Temperature Recorder			Temperature Recorder			Temperature Recorder			SJR[2]	Willow Creek[2]	Air Temperature Recorder			Relative Humidity			Surface Water Elevation
Date	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)
10/1/12	19.4	18.4	20.2	20.2	19.5	20.8	20.2	19.6	20.8	-	-	27.7	18.0	38.9	28.4	14.2	43.5	-
10/2/12	19.4	18.4	20.5	20.0	19.4	20.6	20.1	19.5	20.7	-	-	29.0	20.7	38.5	22.3	14.0	35.4	-
10/3/12	19.4	18.3	20.4	19.9	19.2	20.5	20.0	19.3	20.6	-	-	28.7	22.0	37.1	23.5	12.9	43.2	-
10/4/12	19.2	18.3	20.1	19.9	19.3	20.4	20.0	19.4	20.4	-	-	24.0	17.7	32.5	36.4	19.3	52.5	-
10/5/12	18.8	18.1	19.2	19.5	19.1	19.9	19.6	19.3	20.0	55	2	20.7	15.6	26.8	43.8	31.0	56.7	-
10/6/12	18.6	17.8	19.4	18.9	18.3	19.4	19.0	18.4	19.5	55	2	19.6	13.1	27.7	43.7	28.7	58.5	1,360
10/7/12	18.6	17.7	19.4	18.7	18.0	19.2	18.7	18.1	19.3	55	2	19.4	12.1	28.3	48.3	29.8	66.1	1,360
10/8/12	18.6	17.8	19.3	18.8	18.1	19.3	18.8	18.2	19.4	55	2	19.3	12.2	26.5	50.3	32.0	71.8	1,360
10/9/12	18.5	17.8	19.1	18.7	18.2	19.2	18.8	18.3	19.2	55	2	18.0	12.4	26.1	51.5	29.1	72.7	1,360
10/10/12	18.3	17.5	19.1	18.3	17.7	18.8	18.4	17.8	18.8	55	2	17.2	11.3	24.4	50.4	33.5	67.0	1,360
10/11/12	17.9	17.5	18.6	17.9	17.6	18.4	18.0	17.7	18.4	55	2	14.6	10.0	20.0	64.6	45.6	90.1	1,360
10/12/12	17.8	17.6	18.0	17.6	17.4	17.9	17.7	17.5	18.0	54	2	13.1	11.7	14.6	93.3	84.7	97.3	1,359
10/13/12	18.1	17.6	18.6	17.6	17.2	18.0	17.7	17.4	18.1	-	-	15.8	11.2	22.4	75.6	45.5	96.1	1,359
10/14/12	18.0	17.1	18.9	17.7	17.0	18.4	17.8	17.1	18.4	55	2	16.9	7.3	29.8	66.4	26.9	96.7	-
10/15/12	18.0	17.1	18.7	17.8	17.2	18.4	17.9	17.3	18.4	55	2	18.8	10.6	29.3	56.5	29.0	78.5	1,360
10/16/12	18.0	17.1	18.9	18.1	17.4	18.6	18.1	17.5	18.6	55	2	19.8	11.3	29.7	59.9	31.2	86.0	1,360
10/17/12	18.1	17.2	18.9	18.2	17.6	18.8	18.3	17.7	18.8	55	2	20.4	12.4	30.6	58.8	31.0	81.6	1,360
10/18/12	18.1	17.2	19.2	18.2	17.6	18.8	18.3	17.7	18.8	55	2	26.4	17.7	35.4	27.3	13.9	52.8	1,360
10/19/12	18.1	17.2	19.0	18.1	17.5	18.7	18.2	17.6	18.7	55	3	22.1	15.0	29.7	42.1	25.8	67.5	1,360
10/20/12	17.9	17.0	18.6	18.2	17.8	18.7	18.3	17.8	18.7	55	4	19.4	12.5	28.3	55.1	33.0	77.6	1,360
10/21/12	17.6	16.8	18.2	17.9	17.4	18.3	17.9	17.4	18.3	54	4	17.2	11.1	24.4	49.9	20.4	79.2	1,360
10/22/12	17.0	16.8	17.6	17.1	16.9	17.7	17.2	17.0	17.8	54	4	12.4	9.5	15.7	74.9	34.7	95.2	1,359
10/23/12	16.7	16.2	17.3	16.5	16.2	16.9	16.5	16.2	16.9	54	8	10.8	5.7	18.2	74.5	43.7	97.6	1,359
10/24/12	16.4	15.7	16.9	16.1	15.6	16.6	16.1	15.7	16.5	54	7	11.0	4.7	19.7	66.5	25.7	95.1	1,359
10/25/12	16.3	15.5	17.1	15.9	15.4	16.5	15.9	15.4	16.4	54	5	14.1	8.1	21.9	53.0	27.1	78.4	1,359
10/26/12	16.2	15.3	16.9	15.9	15.3	16.4	15.9	15.4	16.4	54	5	13.4	6.0	22.7	68.4	37.9	93.2	1,360
10/27/12	16.3	15.4	17.0	15.9	15.4	16.4	16.0	15.4	16.4	54	5	14.9	7.1	25.8	66.3	33.0	92.1	1,360
10/28/12	16.1	15.4	16.7	16.0	15.5	16.5	16.1	15.5	16.6	54	15	17.3	8.4	30.0	55.9	21.1	87.6	1,360
10/29/12	15.9	15.1	16.7	15.9	15.4	16.4	16.0	15.4	16.5	54	20	19.9	12.5	29.7	38.1	19.6	61.9	1,360
10/30/12	15.7	14.7	16.8	15.9	15.2	16.5	15.9	15.2	16.6	55	8	20.3	13.7	29.9	37.1	19.3	54.5	1,360
10/31/12	16.0	15.2	16.6	15.5	15.0	16.0	15.6	15.0	16.1	54	5	19.0	12.8	26.7	34.2	13.4	48.8	1,361

[1] Redinger Lake at Dam 7 contains unrepresentative data between October 1 and 5 due to loggers out of the water.

[2] Flow data for the SJR and Willow Creek is not yet available for October 1 to October 4, and October 13.

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Appendix B

Western Pond Turtle Nesting Habitat Vulnerability Assessment

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APPENDIX B - WESTERN POND TURTLE NESTING HABITAT VULNERABILITY ASSESSMENT

Approach

A western pond turtle (WPT) habitat assessment was conducted on July 18-19, 2012 to determine nesting habitat vulnerability in the range of elevations that potentially would be inundated by whitewater flow releases in the Horseshoe Bend (HSB) reach of the San Joaquin River (SJR). The resource concern is that nests established prior to whitewater releases could be inundated. Due to the unsuitable substrate (i.e. bedrock, boulders, steep banks, etc.) along most of the reach, survey efforts were focused on three locations with potentially suitable nesting habitat and where WPTs have been observed, including the SJR Willow Creek confluence, SJR HSB east, and SJR Backbone Creek confluence (Figure 4). During the surveys, the elevation range potentially inundated by whitewater flows was assessed for the presence of WPT nesting habitat. The objective was to determine the potential for inundation of nesting habitat by whitewater flows.

SJR Willow Creek Confluence

The pool at the confluence of SJR and Willow Creek is a large, deep pool with a substantial amount of riparian vegetation on the confluence side of the pool and tailout. In addition, there are large and partially submerged boulders that serve as basking locations located near escape cover. The area along the SJR portion consists of bedrock and boulders on the right bank (looking downstream) with limited stream edge vegetation and boulders with stream edge vegetation on the left bank, which are unsuitable for nest excavation (Figure B-1). The left bank has small pockets of sand deposits, these deposits are not deep and a restrictive layer (i.e. bed rock or boulders) are just two to three inches below the top of the sand (Figure B-2).

The upland habitat on the Willow Creek side of the confluence pool is characterized by bedrock and boulders on the left bank (looking downstream) and boulders and cobble on the right bank. There are small sandy terraces adjacent to the left bank. This sand is loose and lacks the cohesion necessary to resist collapse of nest chambers. There were no rodent or other animal burrows on these terraces. Boulders and bedrock are found between the survey elevation limits and the cismontane woodland (Figure B-3). The right bank is comprised mostly of medium size boulders with cobble and sand below the survey limits. The area upslope of the expected elevation of proposed recreational whitewater flows has an east aspect and thus might provide limited nesting potential due to lower solar exposure. It was in this area that one of the turtles radiotagged during 2011 was tracked to, but the turtle was not visually located.

Willow Creek offers some potential nesting habitat approximately 70 meters (m) (230 feet [ft]) upstream of the confluence along the left bank and over 6.1 m (20 ft) upslope of the survey elevation limit (Figure B-4). The area has a southwestern exposure and comprised of a mix of alluvium of various sizes that should have the cohesion necessary to resist nest chamber collapse and is pliable for exaction of the nest chambers. The river edge supports small stands of willows (*Salix* sp.),

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Figure B-1. Representative upland habitat along the SJR at the confluence with Willow Creek.

Figure B-2. Representative view of left bank as viewed from right bank at Willow Creek Confluence with SJR.

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Figure B-3. Typical view from shore of Willow Creek at SJR confluence looking east towards upland habitat along the left bank.

Figure B-4. Potentially suitable turtle nesting habitat along Willow Creek, upstream from confluence.

Oregon ash (*Fraxinus latifolia*), button willow (*Cephalanthus occidentalis var. californicus*), alder (*Alnus* sp.), horsetail (*Equisetum* sp.), clover (*Trifolium* sp.), and rush (*Juncus* sp.). The upland area supports horseweed (*Conyza canadensis*), Medusahead grass (*Taeniatherum caput-medusae*), wild oats (*Avena* sp.), silver hairgrass (*Aira caryophyllea*) and other forbs. Small mammal and California ground squirrel (*Otospermophilus beecheyi*) burrows were observed in the area, which indicates the substrate would resist nest chamber collapse and may be excavated by WPTs.

There is no suitable WPT nesting habitat available within the five foot stage elevation that the river is expected to rise to during the proposed whitewater flow releases. The primary reason is unsuitable substrate for nest excavation in the form of bedrock, boulders, cobbles and loose sand present within the inundation area. The potential suitable nesting habitat observed at the SJR Willow Creek confluence pool vicinity was located above the expected water level during the proposed whitewater flows. Therefore, proposed recreational whitewater flows do not have the potential to impact WPT nesting habitat.

SJR Horseshoe Bend East

This site supports a small pool and rapids. The area within the potential inundation zone is characterized by medium to small size boulders with a narrow riparian vegetation strip at the river's edge. Riparian vegetation include willow, button willow, Oregon ash, horse tail, broom (*Cytisus* sp.), and blackberry (*Rubus* sp.). Upland areas support wild oats, cheat grass (*Bromus tectorum*), doveweed (*Croton setigerus*), poison oak (*Toxicodendron diversilobum*), incense cedar (*Calocedrus decurrens*), foothill pine (*Pinus sabiniana*), California buckeye (*Aesculus californica*), and California black oak (*Quercus kelloggii*).

The right bank facing downstream contains a large sand bar that supports a cluster of willows and button willows. The area is littered by small boulders and medium size cobble. There is potentially suitable nesting ground located above the expected inundation area. No suitable nesting habitat was observed adjacent to the right bank further downstream due to the presence of steep boulders and bedrock below the expected elevation of recreational whitewater flows (Figure B-5). The left bank supports one large sand bar that would be under water at the proposed whitewater flows. This area has a west facing slope. Biologists observed WPT tracks that were heading out of the river and into the grassland areas within the cismontane woodland habitat upslope of the survey elevation limits (Figure B-7). All of the potentially suitable nesting habitat is greater than 7.6 m (25 ft) above the potential inundation area on both sides of the river at this site. Therefore, proposed recreational whitewater flows do not have the potential to impact WPT nesting habitat.

Figure B-5. Representative view of shore habitat on the right bank of the HSB east SJR site.

Figure B-6. Sand bar and boulder field on left bank of HSB east SJR site.

Figure B-7. Upland habitat with potentially suitable turtle nesting habitat that is outside of the expected water level during proposed whitewater flows at HSB east SJR site.

SJR Backbone Creek Confluence

This site consists of a deep pool at the confluence of the SJR and Backbone Creek with sand bars on both banks (Figure B-8). The habitat assessment was expanded 45.7 m (150 ft) upstream and downstream. However, these areas are characterized by large boulders and bedrock downstream of the pool and bedrock with large to medium size boulders upstream from the pool. There is no suitable nesting habitat upstream or downstream of the confluence pool within the potential inundation elevation of the proposed recreational whitewater flow releases. Further upslope from the sandbars there is suitable nesting habitat on both sides of the SJR. The suitable habitat on the right side of the SJR (facing downstream) starts at about 18.3 m (60 ft) above the potential inundation zone. The suitable nesting habitat on the left side of the SJR and Backbone Creek confluence starts at about 4.6 m (15 ft) above the potential inundation zone.

The potential nesting habitat upslope of the right bank offers the best available habitat due to the south facing slopes with low seasonal growing grasses and seasonal drainage. Several small mammal burrows were observed in this area, which indicates the substrate will resist nest chamber collapse and can be excavated by WPTs. The suitable nesting habitat area is well clear of the expected water level during whitewater flow releases (Figure B-9).

The potential nesting habitat upslope of the left bank offers suitable nesting habitat above the potential inundation zone of the whitewater flow releases (Figure B-10) and contains two seasonal channels that drain Backbone Creek. During one of the surveys conducted in 2012, a WPT hatchling was observed in the western channel. The left bank offers less suitable nesting habitat since it is a north facing slope; however, suitable nesting habitat was observed within the grassland at the edge of the cismontane woodland habitat. The substrate is a mixture of compacted gravels and coarse sand, which should resist nest chamber collapse and can be excavated by WPTs. This area was approximately 30 linear feet upslope from the expected water edge of the proposed whitewater flows.

Figure B-8. Sandbar on left bank of SJR at Backbone Creek confluence.

Figure B-9. Sandbar and cobble field on right bank of SJR at Backbone Creek confluence. Biologist is at water level expected during the proposed whitewater flows.

Figure B-10. Upland habitat on left bank of SJR at Backbone Creek confluence. Biologist is at expected water level during proposed whitewater flows.

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