TECHNICAL MEMORANDUM 3-11

Entrainment

Yuba River Development Project
FERC Project No. 2246

November 2013

TECHNICAL MEMORANDUM 3-11

EXECUTIVE SUMMARY

In 2012, Yuba County Water Agency (YCWA) began an entrainment assessment at the Yuba River Development Project's (Project) four intake structures: 1) the Lohman Ridge Diversion Tunnel, which diverts up to 860 cubic feet per second (cfs) of water from the Middle Yuba River to Oregon Creek; 2) the Camptonville Diversion Tunnel, which diverts up to 1,100 cfs of water from Oregon Creek to New Bullards Bar Reservoir on the North Yuba River; 3) New Colgate Power Tunnel, which diverts up to 3,500 cfs of water from New Bullards Bar Reservoir to the New Colgate Powerhouse on the Yuba River; and 4) the Narrows 2 Power Tunnel, which diverts up to 3,400 cfs of water from the United States Army Corps of Engineers' Englebright Reservoir to the Narrows 2 Powerhouse on the Yuba River.

The assessment at the two diversion tunnels utilized passive integrated transponder (PIT) antennas installed immediately downstream from the entrance of each tunnel to detect rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*) and western pond turtles (*Actinemys marmorata*) that had been collected upstream of the diversions and PIT-tagged between September 24 and October 18, 2012. Tags used were either 23 millimeters (mm) or 12 mm depending mostly on fish size. In the Middle Yuba River above the Lohman Ridge Diversion Tunnel, 159 rainbow trout and two brown trout were tagged. In Oregon Creek above the Camptonville Diversion Tunnel, 379 rainbow trout and two western pond turtles were tagged.[1]

The assessment at the power tunnel intakes in New Bullards Bar and Englebright reservoirs used gill net information developed as part of YCWA's Study 3.7, *Reservoir Fish Populations* (YCWA 2012a). Nets were set as near as possible to the tunnel intakes.

The PIT antenna arrays were operable at each diversion tunnel from October 22, 2012 through November 7, 2013, coinciding with diversions into each tunnel. Tunnel maintenance and antenna repair led to occasional removal of the arrays. Over the entire monitoring period, the Lohman Ridge and Camptonville diversion tunnel antennas operated 98.9 percent and 97.8 percent of the time, respectively. Tag detection efficiency ranged from 98 percent to 100 percent during 19 tests at the Lohman Ridge Diversion Tunnel antenna array, with most tests indicating 100 percent efficiency for all antenna sections and for both sizes of PIT tags. Mean detection efficiency during 17 tests at the Camptonville Diversion Tunnel antenna array ranged from 95 percent to 100 percent for 23-mm tags. Efficiency ranged from 90 percent to 95 percent for 12-mm tags, except for the middle section of the array, for which mean efficiency was only 55 percent. Overall efficiency of the Camptonville Diversion Tunnel array was not substantially affected because the middle antenna was above the water line for most of the study period.

In the Lohman Ridge Diversion Tunnel, 65 detections occurred, representing 49 individual tagged fish. All but one of the detected fish originated from the Middle Yuba River. Based on

[1] WPT was not observed in the Middle Yuba River upstream of Our House Diversion Dam, and brown trout were not observed in Oregon Creek upstream of Log Cabin Diversion Dam.

the results of the tagging and population estimates in the Middle Yuba River, the rainbow trout entrainment rate into the Lohman Ridge Diversion Tunnel is 0.56 fish per day.

In the Camptonville Diversion Tunnel, 155 detections occurred, representing 39 individual fish. No western pond turtles were detected. Most detected fish (n=30) originated from the Middle Yuba River. Based on the results of the tagging and population estimates in Oregon Creek, the rainbow trout entrainment rate into the Camptonville Diversion Tunnel is 0.03 fish per day.

Because discharges were less than 200 cfs into the Lohman Ridge tunnel and less than 250 cfs into the Camptonville tunnel about 79 percent of the time, velocities were low enough that most rainbow trout in the study area were capable of burst speeds to avoid involuntary entrainment. Observations of fish of various sizes maintaining position or swimming upstream in diversion tunnels provided further evidence that many detected fish were likely not involuntarily entrained. Movement through either of the tunnels was unlikely to result in injury or death due to the lack of turbines at the downstream ends of the tunnels.

Few fish were captured near the two reservoir power tunnel intakes. In New Bullards Bar Reservoir, gillnets set 100-feet (ft) deep near the intake collected one kokanee (*Oncorhynchus nerka*) and one spotted bass (*Micropterus punctulatus*). During sampling, the power intake was never shallower than 231.4 ft. In Englebright Reservoir, gillnets set near and at the depth of the power intake (57 ft to 72 ft) captured two rainbow trout and one brown trout.

The study was conducted in conformance with the FERC-approved Study 3.11, *Entrainment*, with one exception. On a few occasions, YCWA temporarily removed the antenna arrays for maintenance. YCWA believes this does not affect the overall results of the study. Antennas operated 99.7 percent and 98.0 percent of the monitoring period at the Lohman and Camptonville diversion tunnel arrays, respectively. The Lohman Ridge Diversion Tunnel array was inoperable for a total of 25.5 hours and Camptonville Diversion Tunnel array was inoperable for 126.2 hours.

The study is complete.

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ENTRAINMENT[2]

Yuba County Water Agency's (YCWA) continued operation and maintenance of the existing Yuba River Development Project (Project) has a potential to affect fish and western pond turtle (*Actinemys marmorata*) populations due to entrainment into Project intakes. The western pond turtle (WPT) is considered a Forest Sensitive Species by the United States Department of Agriculture, Forest Service (Forest Service), when it occurs on National Forest System (NFS) land, and is a Species of Special Concern by the California Department of Fish and Wildlife (Cal Fish and Wildlife).

1.0 Goals and Objectives

The goal of the study was to determine if the withdrawal of water at the Project's tunnel intakes is likely to have adverse effects on rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*) and WPT populations.

The study included two objectives. The first was the characterization of entrainment rates into the Lohman Ridge and Camptonville diversion tunnels. The second was to characterize the occurrence of fish, using data from YCWA's Study 3.7, *Reservoir Fish Populations* (YCWA 2012a), in the vicinity of the New Colgate Power Tunnel intake in New Bullards Bar Reservoir and the Narrows 2 intake in the United States Army Corps of Engineers' (USACE) Englebright Reservoir[3] near the Narrows 2 Power Tunnel intake.

2.0 Methods

2.1 Study Area

The study area included: 1) the impoundment behind Our House Dam (OHD Impoundment) and 2 miles (mi) of the Middle Yuba River upstream of the dam; 2) the impoundment behind Log Cabin Dam and 2 mi of Oregon Creek upstream of the dam, 3) New Bullards Bar Reservoir near

[2] This technical memorandum presents the results of Study 3.11, *Entrainment*, which was included in YCWA's August 17, 2011 Revised Study Plan for Relicensing of the Yuba River Development Project, and was approved by FERC's September 30, 2011 Study Plan Determination. There were no modifications to Study 3.11 subsequent to FERC's May 14, 2011 Determination.

[3] Englebright Reservoir is formed by Englebright Dam. The dam is about 260 ft high, was constructed by the California Debris Commission in 1941, and is owned by the United States, and the dam and reservoir is not included as a Project facility in FERC's License for the Yuba River Development Project. When the California Debris Commission was decommissioned in 1986, administration of Englebright Dam and Reservoir passed to the USACE. The primary purpose of the dam is to trap and contain sediment derived from extensive historic hydraulic mining operations in the Yuba River watershed. Englebright Reservoir is about 9 miles long with a surface area of 815 acres. When the dam was first constructed in 1941, it had a gross storage capacity of 70,000 ac-ft; however, due to sediment capture, the gross storage capacity today is approximately 50,000 ac-ft (USGS 2003).

the New Colgate Power Tunnel intake; and 4) Englebright Reservoir near the Narrows 2 Power Tunnel intake (Figure 2.1-1).

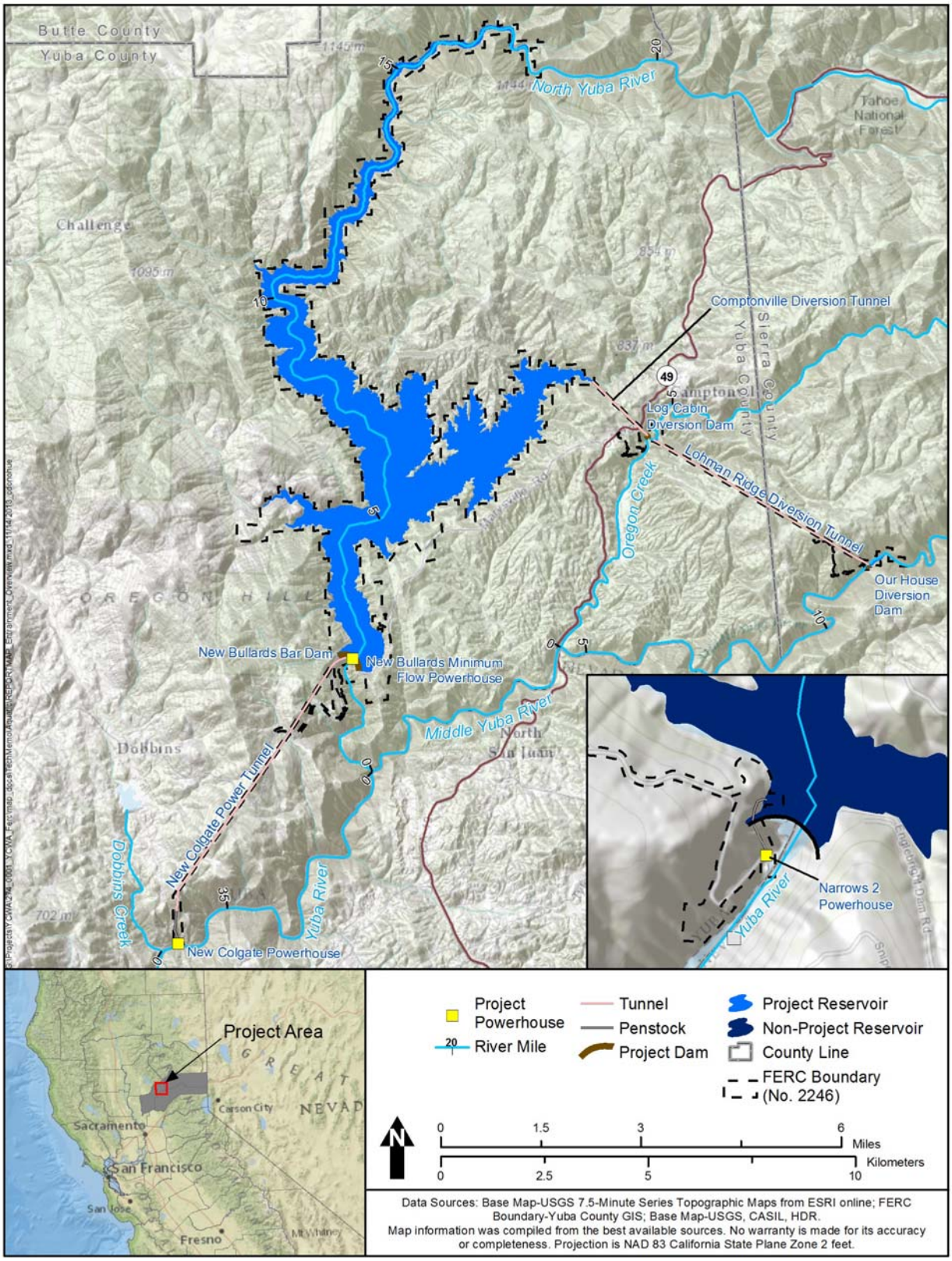

Figure 2.1-1. Overview map of Project facilities and features. Inset features Englebright Dam and Narrows 2 Powerhouse.

2.1.1 Our House Diversion Dam

Our House Diversion Dam diverts up to 860 cubic feet per second (cfs) through the 15 feet (ft) by 12 ft Lohman Ridge Diversion Tunnel. The tunnel invert (i.e., lowest elevation of inlet) elevation is 2,015 ft, which is 15 ft below the normal maximum water surface elevation (NMWSE) for Our House Diversion Dam. The dam has a spillway, a low level outlet and a fish release outlet.

Water diversion to the Lohman Ridge Diversion Tunnel does not occur until two criteria are met: The water surface elevation (WSE) in the impoundment is greater than 2,015 ft and the minimum flow release is exceeded. The minimum flow releases are 30 cfs from July through March and 50 cfs from April through June, with a provision for flows to go as low as 21 cfs in the driest years. When inflow to the impoundment is less, the minimum flow requirement is equal to the inflow.

2.1.2 Log Cabin Diversion Dam

Log Cabin Diversion Dam diverts up to 1,100 cfs through the 14.5 ft by 14.5 ft Camptonville Diversion Tunnel. The tunnel invert elevation is 1,952 ft, which is 18 ft below the NMWSE for Log Cabin Diversion Dam. The dam has a spillway, a low level outlet and a fish release outlet.

Water diversion to the Camptonville Diversion Tunnel does not occur until two criteria are met: the WSE in the impoundment is greater than 1,952 ft and the minimum flow release is exceeded. The minimum flow releases are 8 cfs from July through March and 12 cfs from April through June, with a provision for flows to go as low as 5.6 cfs in the driest years. When inflow to the impoundment is less, the minimum flow requirement is equal to the inflow.

2.2 Diversion Tunnel Entrainment

Monitoring entrainment at the Lohman Ridge and Camptonville diversion intakes included five tasks: 1) install automatic Passive Integrated Transponder (PIT) readers and calibrate the reader system; 2) tag trout; 3) tag WPT; 4) monitor entrainment; and 5) analyze data.

2.2.1 Installation and Calibration of Antennas

A three-antenna stacked array was installed at each diversion site (Figure 2.2-1). Arrays were fabricated from fiberglass in a ‘wing’ shape (Figure 2.2-1A). The fiberglass material ensured that the large antenna would be resilient and the ‘wing’ shape reduced hydrodynamic drag. The PIT detection wire was embedded into the fiberglass as it was fabricated (Figure 2.2-1B). Fiberglass provided strength and, did not interfere with the detection field. Each of the array weighed over 500 pounds (Figure 2.2-1C), and was capable of operating at high flows and being cleaned as necessary (Figure 2.2-1D). Arrays at both diversion tunnels were set well beyond the opening of the tunnel, approximately 10 to 15 ft downstream of the trash racks.

A) Initial creation of fiberglass antenna body.

B) PIT antenna wire is embedded into the fiberglass layers.

C) Final array is a stacked series of 3 individual antennas.

D) Blue antenna being cleaned after debris rack is removed.

E) Propane powered (thermoelectric) generator runs the detection center from an onsite propane tank.

F) Series of 3 antenna logic 'detector' boards (in case) and single data logger on left. This is protected in a YCWA locked storage case onsite.

Figure 2.2-1. Series of photos cataloging the development and installation of the PIT antennas into the Lohman Ridge and Camptonville diversion tunnels.

Each array included the antennas, a power supply (Figure 2.2-1 E), a control unit or reader, and a data logger (Figure 2.2-1F). The reader was used to 'tune' the antenna (i.e., adjust frequency to increase detection area) and detect transmitters as they were passed into the zone of detection. A detected transmitter was uniquely identified by a number and logged with a date and time stamp by the datalogger. The datalogger was similar to a handheld mobile computer or smartphone. The information for each identification tag was stored in a log text file on the datalogger. The entire PIT monitoring system was powered by a thermoelectric propane generator that was fueled by propane tanks housed onsite. The generator, wiring, fuel lines and detection equipment were all housed in protective metal cases or conduit for protection from the environment and public.

The initial efficiency test at the Lohman Ridge Diversion Tunnel antenna was conducted on October 3, 2012. Efficiency testing at the Camptonville Diversion Tunnel was conducted on October 10, 2012 and periodically throughout the monitoring period when conditions allowed.

Two PIT tag sizes (23 mm and 12 mm) were used for testing. Several methods were employed to test detection efficiencies of the antennas. Under safe wading conditions (e.g., when discharge was lower than 80 cfs in the tunnels), a 1-foot by 1-foot grid was tested by passing a test tag through the grid by hand. This method was also used during periods in which the antenna arrays were lifted out of the tunnels during cleaning, maintenance, and/or repairs. During periods when discharges were greater than 80 cfs, tags were either lowered from the top or floated through the antennas from upstream. The latter method did not allow testing of the one-foot grid, but the middle portion of each antenna was tested. Detection efficiency is challenged with distance away from the antenna walls; therefore, testing the center of the antenna ensured that any performance issue would be identified. Testing of the antennas was sometimes constrained by availability of crane operators and in some cases, the amount of daylight. During periods when efficiency tests were not conducted, individual antenna amperages were used to monitor detection efficiency and performance of each array. Individual antenna amperages were positively correlated with individual antenna detection efficiency and thus were a useful proxy to evaluate weekly antenna performance. When either amperages or detection efficiencies decreased, the antenna arrays were retuned.

A marker tag is a PIT transmitter that can be hidden for specified periods of time and then reveal itself for detection on set intervals. As a measure of antenna operation, the hourly number of marker tag detections was summarized for each antenna array. The marker tag was initially set to emit a signal every three minutes. This particular setting yielded about 20 detections of the marker tag per hour. It should be noted that gaps in operation or detection of the marker tag does not necessarily mean that the antennas were not functioning properly. However, these periods were examined for potential issues with antenna performance.

2.2.2 Tagging Target Species

2.2.2.1 Trout

YCWA collected and tagged juvenile and adult fish from Oregon Creek and the Middle Yuba River upstream of each diversion over 1.7 mi (mi) and 1.3 mi, respectively. Rainbow and brown

trout were the focal species of the study and no other fish species were tagged. The study required fish collection for 5 days, or until a total of 1,000 juvenile/adult trout were tagged on each stream, whichever occurred first. The minimum field crew size was five people with two backpack electrofishers. A cataraft boat electrofishing unit was also utilized to sample the Our House Diversion Dam Impoundment. After unsatisfactory catch during daytime boat electrofishing, an additional three nights of boat electrofishing were conducted at the request of Relicensing Participants. This resulted in two discreet sampling efforts, four days each for the stream reach and the impoundment. The cataraft was not employed at Log Cabin Diversion Dam impoundment because the impoundment pool was too low. The impoundment was sampled instead with seining and angling.

PIT tags were implanted in each fish greater than or equal to 60 millimeters (mm) fork length (FL). Additionally, consultation with the Relicensing Participants took place during the sampling period to evaluate sampling efficiency, anticipated sample size, and any minor modifications to the methodologies needed to provide a minimum sample size.

Mortality resulting from PIT tagging was generally low. PIT tags are relatively small in volume, lack a battery, and are lightweight. The surgical procedure generally took less than 2 minutes, which is comparable to past studies (Moore et al. 1990). The minimal handling time and reduced influence of the tag has been shown to result in low mortality rates (Jonasson et al. 2004 and Jones and Burum 1998). Tagged fish were held for observation and recovery following surgery. Generally, when mortality occurred, it was readily observed.

For each trout tagged, YCWA recorded the individual's FL in mm, weight in grams, and the location at which the individual was captured (i.e., Global Positioning System, or GPS, coordinates of beginning and end of each zone where fish were captured). A zone was approximately 0.1 mi in length and corresponded to the total distance upstream of the diversion dam (e.g., zone 13 was 1.2 – 1.3 mi upstream of the diversion dam). Each tagged fish was released in the same general location where it was captured.

2.2.2.2 Western Pond Turtle

Visual surveys in 2012 under YCWA's Study 3.6, *Special-Status Turtles – Western Pond Turtle*, identified WPT habitat in the Our House Diversion Dam impoundment and the Log Cabin Diversion Dam impoundment. During the visual surveys, WPT were sighted at Log Cabin Diversion Dam impoundment, but not at Our House Diversion Dam impoundment. Accordingly, no efforts to capture and tag WPT occurred at Our House Diversion Dam impoundment or upstream of the impoundment on the Middle Yuba River.

Baited hoop traps and basking traps were deployed at Log Cabin Diversion Dam impoundment from July 22 to July 29, 2012. In addition to trapping within the impoundment, YCWA placed hoop traps in a pool 0.3 mi upstream of the impoundment. This was the only significant pool within the 0.5-mi reach upstream of the impoundment. During this same time period, hand nets were used during active searches for juvenile turtles in potential habitat.

An underwater epoxy was used to affix PIT tags to the carapace (top shell) of captured turtles. Each tagged WPT was held until the epoxy was set, ensuring that no epoxy set between scutes (i.e., shell plate).

For each WPT tagged, YCWA recorded the individual's carapace length in mm, weight in grams, and the location at which the individual was captured (i.e., GPS coordinates). Each WPT was released in the same general location at which it was captured.

2.2.3 Monitor Diversion Tunnel Entrainment

Entrainment monitoring in each diversion tunnel began on October 22, 2012 and continued through November 7, 2013. Antennas were set to scan at a rate of 12.3 times per second resulting in discreet detection events (i.e., detection of a single fish) represented by tens to thousands of records. A fish moving straight through the detection radius of the antenna in two seconds would, therefore, result in 24 records for a single detection event. The detection radius of the antennas was approximately 2.5 ft for the 23 mm tags and approximately 1.0 ft for the 12 mm tags. This created an area of approximately 707 and 854 cubic feet, for the Lohman Ridge and Camptonville Tunnels respectively, in which a 23 mm tag could be detected with the zone extending approximately 2.5 ft upstream and downstream of the antenna. A fish moving in and out of this zone during foraging would trigger hundreds to thousands of recordings within minutes. As such, it was necessary to select a period of time to delineate one detection event from another. A period of 30 minutes between detection records was chosen.

Velocity data were collected using an Acoustic Doppler Velocimeter (ADV) at both of the tunnels. Velocity measurements were along a single transect across the upstream margin of the trash racks in one foot intervals. For depths over 2.5 ft, measurements were taken at 40 and 90 percent of the depth. Data were processed to produce upper and lower velocity bins at one ft intervals.

2.2.4 Data Analysis

YCWA correlated the number of PIT-tagged fish entrained into each diversion tunnel to the percent of the total fish population upstream of the diversion that would potentially be entrained. The calculation was performed as follows:

- Assume survival of the PIT-tagged fish in the stream through the diversion season is equal to that of untagged fish in the stream, and assume approximately greater than 99 percent PIT tag retention and survivorship of tagged fish.
- Calculate the percent of the trout population in the sampling reach PIT-tagged, using the sampling from YCWA's Study 3.8, *Stream Fish Populations Upstream of Englebright Reservoir* (YCWA 2013), fish population estimate (i.e., number of fish per mile) and the

number of fish PIT-tagged (PIT-tagged fish/estimated number of fish in the section of stream where fish were tagged).[4]

- Calculate the percent of the PIT-tagged fish entrained at the end of the diversion season (PIT-tagged fish entrained/PIT-tagged fish).
- Calculate a population entrainment rate, based on the total number of the fish in the sampling reach where fish were tagged present during fall 2012 and the total number of fish estimated that were entrained during the diversion season (percent of fall 2012 PIT-tagged fish entrained multiplied by the estimated number of fish in the reach where fish were tagged in fall 2012).

Repeated efforts at the Our House Diversion Dam impoundment provided suitable data for mark/recapture analysis. Ideally, a multiple mark/recapture analysis would require a closed population with no recruitment or mortality, but it is still useful even if these conditions are loosely satisfied (Ricker 1975). Several approaches to this estimate are available, Schumacher and Eschmeyer's estimate (Ricker 1975) was chosen for its simplicity. The estimate represents a line fitted to values for recaptured fish divided by catch for a given day plotted against the number marked for the same day with the restriction that the line pass through the origin. The slope of this line is an estimate of the inverse of the population given by:

$$1/N = \frac{\Sigma(M_t R_t)}{\Sigma(C_t M_t^2)}$$

where N is the estimated population; M_t is the number of marked fish on day t; R_t is the number of recaptured fish on day t; and C_t is the number of fish captured on day t.

The variance was estimated by:

$$s^2 = \frac{\Sigma(R_t^2/C_t) - [\Sigma(R_t M_t)^2/\Sigma(C_t M_t^2)]}{m\text{-}1}$$

The 95 percent confidence interval was calculated using t-values corresponding to the degrees of freedom (m-1). In this case, three degrees of freedom for a 95 percent confidence interval resulted in a t-value of 3.182. The upper and lower bounds were estimated by taking the inverse of those for 1/N.

Analysis of WPT entrainment data consisted of comparing the number of PIT-tagged WPT detected passing through the tunnel entrances to the total numbers tagged. YCWA did not extrapolate WPT entrainment data to the population level, because quantitative population estimates of WPT were not developed.

[4] As part of YCWA's Study 3.8, *Stream Fish Populations Upstream of Englebright Reservoir*, YCWA performed a three-pass electrofishing quantitative sampling in fall 2012 at one site in the Middle Yuba River, approximately 0.5 mi upstream of Our House Diversion Dam impoundment and at one site in Oregon Creek approximately 0.5 mile upstream of Log Cabin Diversion Dam impoundment. Based on this sampling, YCWA estimated 409 rainbow trout per mile in the Middle Yuba River and 72 rainbow trout per mile in Oregon Creek.

2.3 Reservoir Fish Sampling

Gillnet sampling occurred twice during 2012, coinciding with low and high pool levels within New Bullards Bar Reservoir (January 16-19 and June 18-21, 2012) and once during summer 2012 in Englebright Reservoir (June 22-24, 2012). Adult and juvenile variable mesh gillnets were deployed at eight sites in New Bullards Bar Reservoir and four sites in Englebright Reservoir. Adult variable mesh gillnets were 125-ft long and 8-ft deep and consisted of five, 25-ft long panels. Panel mesh sizes were 0.75-, 1.5-, 2-, 2.5-, and 3-inches (in). Panels were successively arranged by mesh size with the smallest mesh size placed nearest the shore. Juvenile gillnets were 25-ft long and 8-ft deep and included two panels 12.5 ft long that had mesh sizes of 0.5 in and 0.75 in respectively. Reservoir operations including annual surface level and relative depth of Project intakes were evaluated against the timing and depth of sampling. Refer to YCWA's technical memorandum 3.7, *Reservoir Fish Populations* (YCWA 2012a), for more information regarding methods used to sample by gill net near the power tunnel intakes.

3.0 Results

3.1 Diversion Tunnel Entrainment

3.1.1 Antenna Operations

The PIT antenna arrays were operable at each diversion tunnel from October 22, 2012 at 10:00 AM until November 7, 2013 at 8:00 AM, except for the period shown in Table 3.1-1. Water diversion at the Lohman Ridge Diversion Tunnel and the Camptonville Diversion Tunnel was first recorded on October 22, 2012 at 12:00 PM.

Table 3.1-1. Date, duration, and discharge when antennas at Lohman Ridge Diversion Tunnel and Camptonville Diversion Tunnel were out of service.

Lohman Ridge Diversion Tunnel			
Date	**Minutes**	**Hours**	**Discharge (cfs)**
10/25/2012	19	0.3	23
11/18/2012	86	1.4	528
11/29/2012	68	1.1	267
12/1/2012	111	1.8	771
12/5/2012	218	3.6	696
12/7/2012	49	0.8	687
12/7/2012	53	0.9	656
12/11/2012	19	0.3	304
12/11/2012	244	4.1	302
12/13/2012	340	5.7	329
12/18/2012	78	1.3	461
12/20/2012	4	0.1	277
12/28/2012	78	1.3	336
1/8/2013	42	0.7	173
1/25/2013	69	1.2	243
2/3/2013	53	0.9	241
Total	**1,531**	**25.5**	--

Camptonville Diversion Tunnel			
Date	**Minutes**	**Hours**	**Discharge (cfs)**
10/25/2012	35	0.6	22
11/1/2012	215	3.6	61
11/18/2012	93	1.5	612
11/29/2012	66	1.1	300
12/5/2012	112	1.9	981
12/11/2012	111	1.9	361
12/18/2012	51	0.8	609
12/28/2012	77	1.3	451
1/8/2013	290	4.8	227
1/11/2013	337	5.6	288
1/15/2013	323	5.4	212
2/3/2013	38	0.6	280
4/4/2013	66	1.1	375
9/2/13 - 9/3/13	5,760	96	28[1]
Total	**7,574**	**126.2**	--

[1] Mean discharge during outage, mean daily discharge September 2 and September 3, 2013 was 16.6 cfs and 40.1 cfs, respectively.

Antennas operated 99.7 percent and 98.0 percent of the monitoring period at the Lohman and Camptonville diversion tunnel arrays, respectively. Tunnel maintenance and antenna repair led to removal of the arrays on a few occasions. The Lohman Ridge Diversion Tunnel array was inoperable for a total of 25.5 hours and Camptonville Diversion Tunnel array was inoperable for 126.2 hours in total (Table 3.1-1). Entrainment could not be monitored during these periods.

3.1.1.1 Efficiency

Efficiency tests were conducted 19 times at the Lohman Ridge Diversion Tunnel array (Table 3.1-2). The Lohman Ridge Diversion Tunnel antenna array tested better than the required 80 percent overall detection efficiency. All efficiency tests for the 23 mm tag were 100 percent. Detection efficiencies with the 12 mm tag were slightly lower, but all still above the required criterion of 80%, with the exception of the efficiency test conducted on December 18, 2012. From December 5 – 20, 2012, the top reader was not functioning which may have caused a decrease in antenna performance in the lower and middle antennas. The replacement reader, installed on December 11, worked for several hours and then failed. The second replacement reader was installed on December 20, 2012 and operated for the duration of the study.

Table 3.1-2. Detection efficiency at the Lohman Ridge antenna array.

Date	23 mm			12 mm			Method
	Bottom	Middle	Top	Bottom	Middle	Top	
10/3/2012	100	100	100	100	100	100	In tunnel by hand
11/6/2012	100	100	100	100	100	100	In tunnel by hand
11/28/2012	100	100	100	100	100	100	In tunnel by hand
12/11/2012	100	100	100	100	100	100	Out of tunnel by hand
12/18/2012[1]	100	100	--	80	10	--	Out of tunnel by hand
12/28/2012	100	100	100	100	100	100	Out of tunnel by hand
1/8/2013	100	100	100	100	100	100	Out of tunnel by hand
1/25/2013	100	100	100	100	100	100	Out of tunnel by hand
2/3/2013	100	100	100	100	100	85	Out of tunnel by hand
2/8/2013	100	100	100	100	100	100	Lowered tag into array
2/15/2013	100	--	--	100	--	--	Floated tag into array
3/1/2013	100	--	--	100	--	--	Floated tag into array
3/22/2013	100	100	--	100	100	--	Floated tag into array
4/19/2013	100	--	--	100	--	--	Floated tag into array
5/10/2013	100	--	--	100	--	--	Floated tag into array
5/16/2013	100	100	100	100	100	100	In tunnel by hand
6/12/2013	100	100	100	100	100	100	In tunnel by hand
6/28/2013	--	--	--	100	--	--	Floated tag into array
8/20/2013	--	--	--	100	100	100	In tunnel by hand
Mean	**100**	**100**	**100**	**98**	**100**	**98**	
Minimum	**100**	**100**	**100**	**80**	**10**	**85**	**--**
Maximum	**100**	**100**	**100**	**100**	**100**	**100**	

[1] Top antenna reader replaced on 12/20/2013.

The Camptonville Diversion Tunnel array efficiency tests were conducted 17 times during the monitoring period (Table 3.1-3). Detection efficiency of the 23 mm tag at the Camptonville tunnel array was higher than for the 12 mm tag. The 23 mm tag was detected on 100 percent of the grids in nearly all tests. Notable exceptions were on January 8, 2013 when the bottom and middle antenna arrays had detection efficiencies of 50 percent. The antennas were retuned on the same day to increase detection efficiency for the 23 mm tag. After re-tuning, the bottom and middle antennas read the 23 mm test tag in 100 percent of the grids.

Because of the larger size of each individual antenna at the Camptonville Diversion Tunnel array, detection efficiencies for the 12 mm tag were lower relative to the Lohman Ridge Diversion Tunnel array. This was most notably documented in the middle antenna. Detection efficiency for the 12 mm tag of the middle antenna at the Camptonville Diversion Tunnel array was consistently lower (mean 55.4% and range 20 – 100%) than either the bottom or top antennas at the site (bottom, mean 94.7% and range 30-100%; top, mean 89.6% and range 30-100%).

A noticeable decrease in detection efficiency of the middle antenna at the Camptonville Diversion Tunnel array was observed around December 28, 2012. Several attempts (on January 8, 11, and 15, 2013) were made to remedy the poor efficiency of the middle antenna, often with little success or with decreased performance of the more important bottom antenna (Table 3.1-3). The bottom antenna was the primary antenna wetted during the study; therefore, the entire array was tuned to maximize the performance and detection efficiency of the bottom antenna. This approach was often at the expense of the middle antenna, but maximized detectable or wetted area. Water levels at the Camptonville Diversion Tunnel after January 15, 2013 only exceeded the bottom of the middle antenna for an estimated 12.5 percent of the remaining study period and thus allowed for system efficiency within required parameters.

Table 3.1-3. Detection efficiency at Camptonville tunnel site.

Date	23 mm Tag			12 mm Tag			Method
	Bottom	Middle	Top	Bottom	Middle	Top	
10/10/2012	100	100	100	100	100	100	In tunnel by hand
11/6/2012	100	100	100	100	70	100	In tunnel by hand
12/18/2012	100	100	100	90	65	95	Out of tunnel by hand
12/28/2012	100	100	100	90	30	100	Out of tunnel by hand
1/8/2013[1]	50	50	100	30	30	30	Out of tunnel by hand
1/11/2013[1]	100	100	100	100	65	100	Out of tunnel by hand
1/15/2013[1]	100	100	100	100	25	100	Out of tunnel by hand
2/3/2013	75	100	100	100	100	100	Out of tunnel by hand
2/8/2013	100	100	100	100	50	50	Lowered tag into array
2/15/2013	100	--	--	100	--	--	Floated tag into array
4/12/2013	--	--	--	100	--	--	Floated tag into array
4/19/2013	100	--	--	100	--	--	Floated tag into array
5/10/2013	100	--	--	100	--	--	Floated tag into array
5/16/2013	100	100	100	100	20	100	In tunnel by hand
6/12/2013	100	100	100	100	20	100	In tunnel by hand
6/28/2013	--	--	--	100	--	--	Floated tag into array
8/20/2013	--	--	--	100	90	100	In tunnel by hand
Mean	**94.6**	**95.5**	**100**	**94.7**	**55.4**	**89.6**	
Minimum	**50**	**50**	**100**	**30**	**20**	**30**	**--**
Maximum	**100**	**100**	**100**	**100**	**100**	**100**	

[1] Attempts to retune made on January 8, 11 and 15. Efficiency increased to adequate efficiency with 23 mm tag. Similar attempts failed with 12 mm tag.

3.1.1.2 Marker Tag Detections

At the Lohman Ridge Diversion Tunnel array, notable gaps in marker tag operation were observed during seven events. For a brief description of marker tags, see Section 2.2.1. The first event (238 hours) occurred on December 2, 2012, when the Middle Yuba River peaked at around 7,300 cfs below Our House Diversion Dam. The Lohman Ridge Diversion Tunnel antenna array operated throughout this period, but sustained some damage to the inner panels of the antenna.

The high flows ripped the marker tag from the antenna and it was not replaced until December 11, 2012. Six fish were detected during this period suggesting the antenna array was functioning properly. Failed marker tag detections on December 31, 2012 (24 hours) was likely due to a software malfunction as the same problem occurred at the Camptonville Diversion Tunnel antenna array. The longest event occurred from January 16, 2013 to February 3, 2013. During this period, the marker tag malfunctioned, which caused it to emit a signal approximately every second for this period. This resulted in a high amount of records, during which no tags from fish were detected. It is unclear if the high frequency of marker tag signals interrupted detections of tagged fish during this period.

The Lohman Ridge Diversion Tunnel antenna array was operating correctly during this period as no major problems were noted. Additionally, two efficiency tests conducted during this period indicated proper antenna performance, one on January 25, 2013 and the other on February 3, 2013. Another gap in marker tag detections occurred between June 12–14, 2013 when the array was turned off at the end of spring diversions. Several gap events could not be explained and these occurred on December 18, 2012 (9 hours), on October 4 and 5, 2013 (17 hours), and again on October 23 and 24, 2013 (16 hours). The antenna array was functioning properly when data were downloaded after these occurrences, which suggests that the array was properly functioning during these periods.

At the Camptonville Diversion Tunnel array, notable gap events in marker tag operation occurred four times. A gap in marker tag detection on December 31, 2012 (24 hours) was the result of the same software malfunction that occurred at the Lohman Ridge Diversion Tunnel array. The longest event occurred from January 8, 2013 to January 25, 2013 (408 hours) and was a result of the batteries failing in the marker tag. During this period, several efficiency tests were conducted to ensure operation of the Camptonville Diversions Tunnel arrays. A gap event from June 12, 2013 to June 14, 2013 reflected a shut down of the antennas and not a failure of the marker tags. Another gap in marker tag detections from August 30, 2013 to September 5, 2013 (140 hours) was the result of power loss to the antennas. The problem was remedied on September 3, 2013 when the antenna readers were turned back on using five 12V deep-cycle batteries in place of the propane power source.

3.1.2 Tagging

3.1.2.1 Middle Yuba River and Our House Dam Impoundment

Electrofishing was the most commonly used method to capture fish in the Middle Yuba River (Table 3.1-4). A total of 189 rainbow trout and two brown trout were captured over the 8-day sampling effort, of which 159 rainbow trout and both brown trout were PIT tagged. More fish received 23 mm PIT tags (n=132, 82.0%) than 12 mm PIT tags (n=29, 18.0%), primarily because of fish size. Nearly all tagged fish 130 mm or greater in the Middle Yuba River received 23 mm tags (Figure 3.1-2). The exception was a single fish in the 135 mm range. Other fish species observed were Sacramento sucker (*Catostomus occidentalis*) and Sacramento pikeminnow (*Ptychocheilus grandis*).

Table 3.1-4. Effort, number of tagged fish, and total catch by 0.1 mile intervals (zones) on Middle Yuba River upstream of Our House Diversion Dam.

Zone[1]	E-Fish (seconds)	Hook/Line (hours)	Gillnet (hours)	Trout Tagged		Total Tagged	Not Tagged[2]	Total Catch
				12 mm tag	23 mm tag			
1[3]	17,197	--	--	6	69	75	4	79
	--	43.3	--	0	12	12	1	13
	--	--	9.25	0	2	2	0	2
2	2,137	--	--	6	1	7	1	8
3	1,885	--	--	1	1	2	0	2
4	1,622	--	--	0	3	3	3	6
5	827	--	--	0	0	0	8	8
6	2,067	--	--	1	4	5	3	8
7	11,841	--	--	11	12	23	0	23
8	995	--	--	3	3	6	1	7
9	--	--	--	0	0	0	0	0
10	596	--	--	0	3	3	0	3
11	1,687	--	--	0	16	16	4	20
12	--	--	--	0	0	0	4	4
13	1,153	--	--	1	6	7	1	8
Total Effort	**42,007**	**43.3**	**9.25**	**--**	**--**	**--**	**--**	**--**
Total Catch	**176**	**13**	**2**	**29**	**132**	**161**	**30**	**191**

[1] Zone 1 was Our House Diversion Dam impoundment; upstream of the impoundment; each subsequent zone was approximately 0.1 mi in length.
[2] Not tagged due to size (i.e., generally less than 60 mm FL).
[3] Fish tagged in zone 1 included two brown trout.

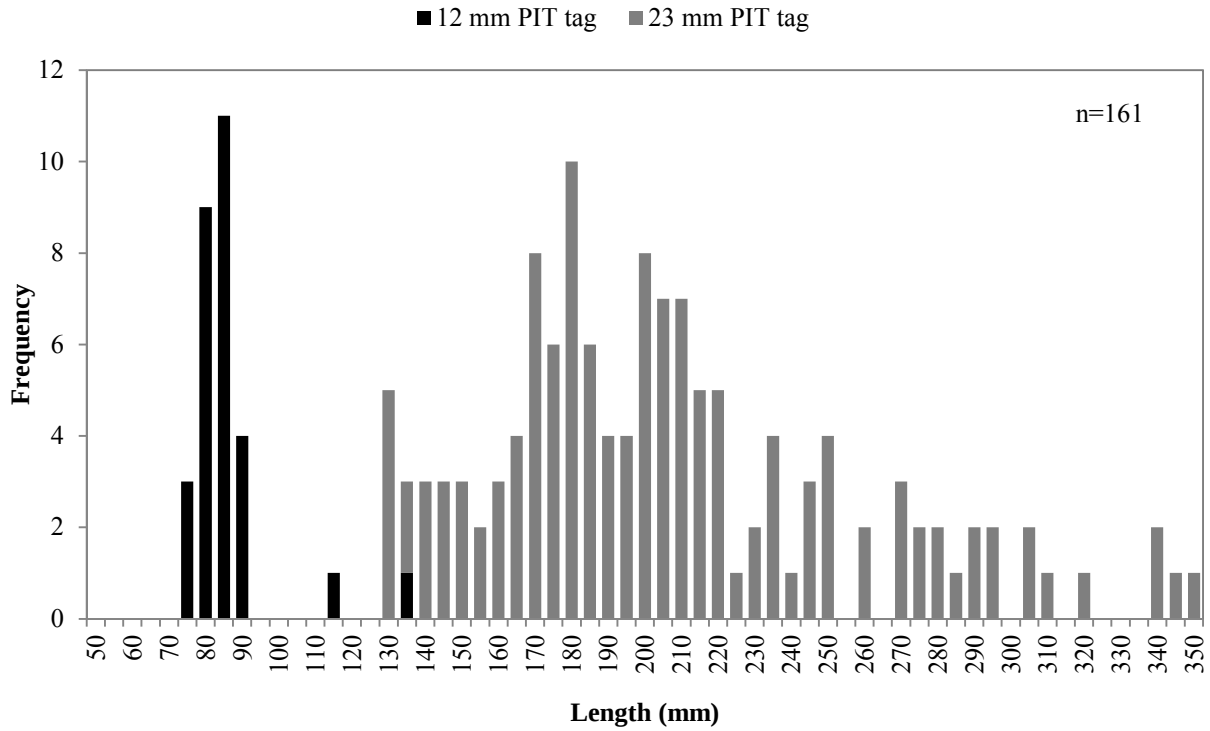

Figure 3.1-2. Length frequency and PIT tag size of rainbow and brown trout tagged in the Middle Yuba River in the Our House Diversion Dam impoundment and in the river upstream of the impoundment. Note: Only two brown trout were tagged (235 mm and 273 mm).

The greatest effort and highest catch occurred in Zone 1 (Figure 3.1-3). An analysis of multiple mark/recapture data from the four day effort in the Our House Diversion Dam impoundment is presented in Section 3.1.4. Effort in Zone 11 resulted in a relatively high number of larger fish tagged with 23 mm PIT tags (n=16). Zones 9 and 12 were snorkeled to determine fish presence and concentration. These zones consisted of long, stagnant pools. The snorkeler determined whether the concentration of trout in the pools warranted use of another method (e.g., seine net) to capture fish, because electrofishing deep pools (>1.5 meters) is unsafe and ineffective. The snorkeler did not observe trout in the Zone 9 pool and very few fish in Zone 12. These zones were not sampled in an effort to maximize the efficiency of sampling time and effort. WPTs were not found in the Middle Yuba River upstream of Our House Diversion Dam, thus none were tagged.

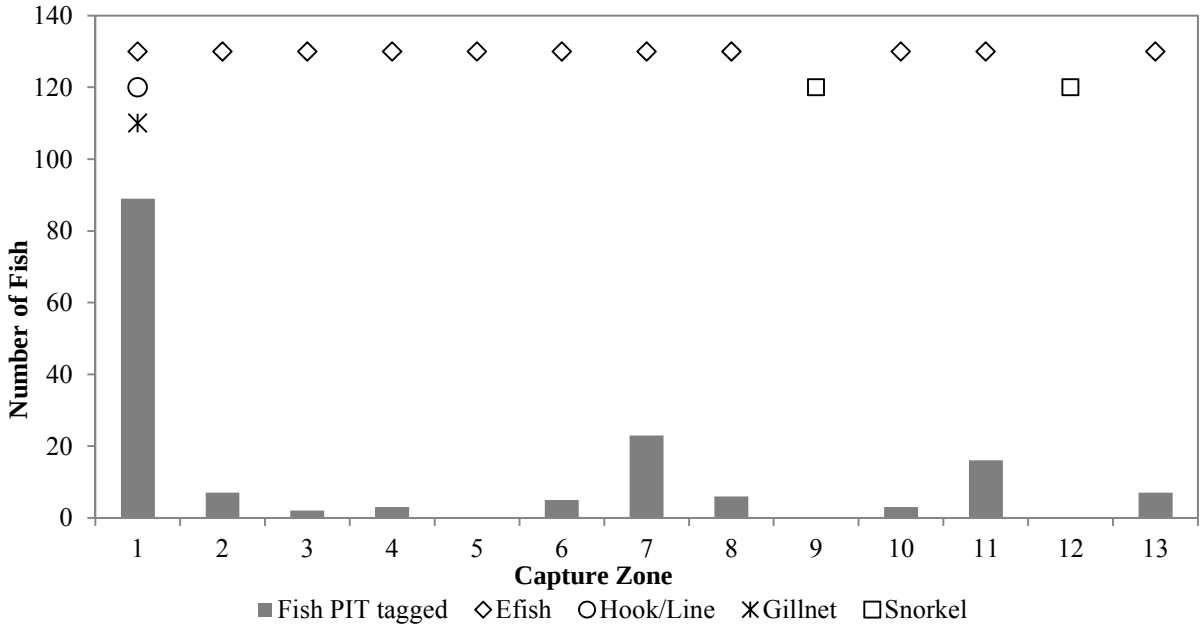

Figure 3.1-3. Number of fish captured by method and zone upstream of Our House Diversion Dam.

3.1.2.2 Oregon Creek and Log Cabin Diversion Dam Impoundment

Fish

Electrofishing, hook-and-line sampling, and seining were used to capture fish in the Oregon Creek (Table 3.1-5). The 5-day sampling effort resulting in 379 fish PIT-tagged out of 436 trout captured (n=436 rainbow trout). More fish received 12 mm PIT tags (n=317, 83.6%) than 23 mm PIT tags (n=62, 16.4%) in Oregon Creek. Nearly all fish 125 mm or smaller were tagged with 12 mm tags. Fish in the 125–160 mm range were tagged with either 12 or 23 mm pit tags (Figure 3.1-4) based on variable weights for fish of the same length and professional judgment. Other fish species observed during the tagging effort was Sacramento sucker.

Table 3.1-5. Effort, number of tagged fish, and total catch by 0.1 mile intervals (zones) on Oregon Creek upstream of Log Cabin Diversion Dam.

Zone[1]	E-Fish (seconds)	Hook/Line (hours)	Seine (passes)	Trout Tagged		Total Tagged	Not Tagged[2]	Total Catch
				12 mm tag	23 mm tag			
1	--	3.8	--	1	4	5	0	5
1	--	--	2	0	0	0	0	0
2	1,049	--	--	5	0	5	1	6
3	3,704	--	--	4	0	4	0	4
4	1,796	--	--	6	2	8	0	8
5	3,084	--	--	40	3	43	5	48
6	1,678	--	--	28	0	28	1	29
7	--	--	--	0	0	0	0	0
8	--	--	--	0	0	0	0	0
9	--	--	--	0	0	0	0	0
10	631	--	--	8	5	13	0	13
11	617	--	--	20	8	28	4	32
12	642	--	--	50	10	60	15	75
13	1,039	--	--	32	10	42	19	61
14	546	--	--	35	6	41	6	47
15	623	--	--	34	6	40	5	45
16	--	--	--	0	0	0	0	0
17	1,331	--	--	54	8	62	1	63
Total Effort	**16,740**	**3.8**	**2**	--	--	--	--	--
Total Catch	**431**	**5**	**0**	**317**	**62**	**379**	**57**	**436**

[1] Zone 1 was the Log Cabin Diversion Dam impoundment, which was a small pool; upstream of the impoundment, each zone was approximately 0.1 mi in length.
[2] Not tagged due to size (i.e., generally less than 60 mm FL).

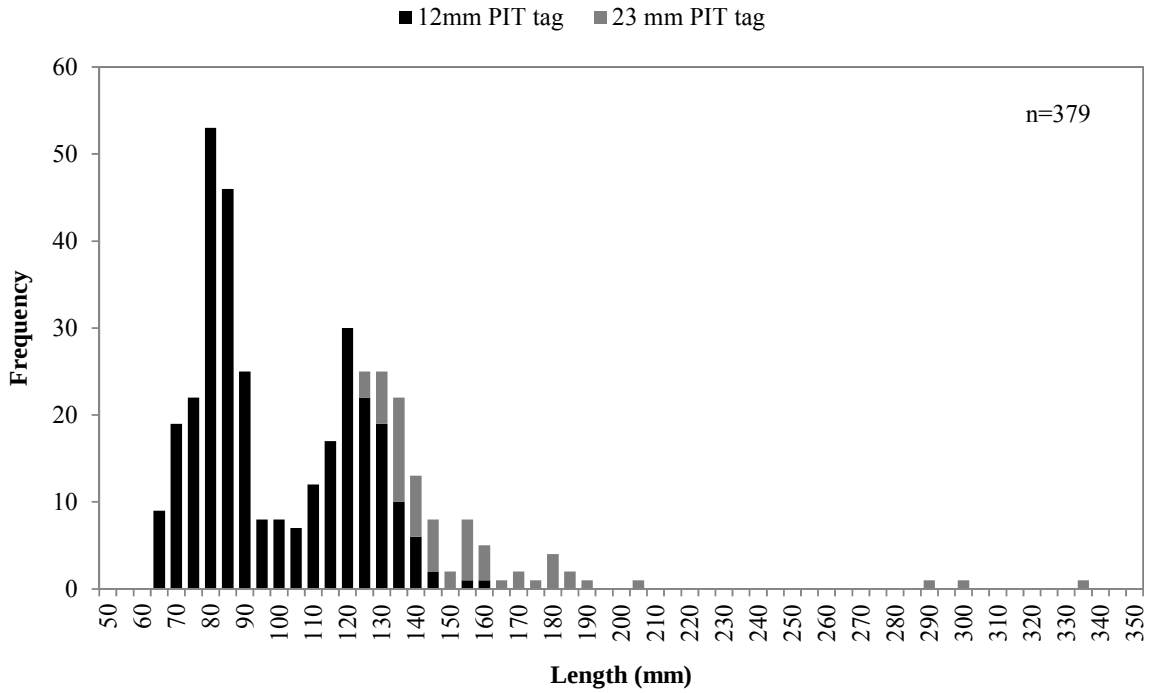

Figure 3.1-4. Length frequency of rainbow trout and PIT tag size of fish tagged in Oregon Creek in the Log Cabin Diversion Dam impoundment and in the creek upstream of the impoundment.

The majority of fish were captured upstream of Zone 4 (Figure 3.1-5). Electrofishing effort was highest in Zone 3, but resulted in few captured fish. Zone 12 accounted for the highest capture

of rainbow trout (n=75), but Zone 17 accounted for the most PIT tagged (n=63). Rainbow trout in Zone 12 were smaller in size. Zone 17, the most upstream zone on Oregon Creek, had the highest use of 12 mm tags (n=54), while Zones 12 and 13 accounted for larger rainbow trout and the highest use of 23 mm PIT tags (n=10 each). Waterfalls located upstream of Zone 6 and downstream of Zone 10 precluded sampling in Zones 7 through 9 due to inaccessibility. YCWA intended to sample Zone 16, but were not able to conduct sampling within the 5-day field effort.

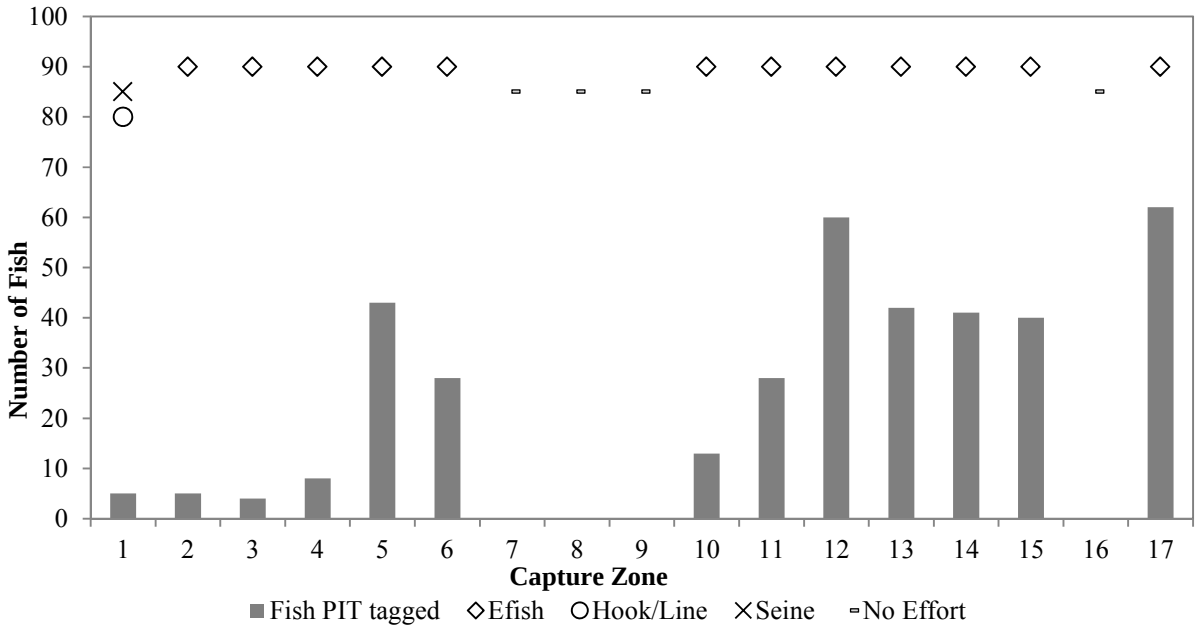

Figure 3.1-5. Number of rainbow trout captured by method and zone upstream of Log Cabin Diversion Dam.

Western Pond Turtle Tagging

Field sampling for WPT resulted in the collection and tagging of one adult male and one adult female at the Camptonville Diversion pool (Table 3.1-6). Neither were subsequently detected.

Table 3.1-6. Summary of results of trapping for WPT at Log Cabin Diversion Dam Impoundment for Study 3-11 (Entrainment).

Date/ Time[1]	Air / Water Temp. (°C)[2]	Captures/ PIT-tag ID[3]	Comments[4]
HOOP NET TRAP 1 (RM 4.1) (UTM E 667086, UTM N 4367404)			
7/23/12/ 13:45 to 14:00	29/18	None	Closed trap (tied shut) was first deployed on 7/12/12 on left bank of Log Cabin Dam impoundment near where western pond turtle (WPT, *Actinemys marmorata*), was observed basking on 5/24/12 and 6/7/12 at Site LCDD-2. Trap was opened and baited with sardines on 7/22/12 at about 18:00 hr.
7/24/12/ 08:15 to 08:30	16/18	None	Trap was re-located to the left bank in impoundment pool facing the boom where WPT activity was observed in July. Cat food bait was added to trap.
7/25/12 08:15 to 08:30	13/18	None	--
7/26/12 08:15 to 08:30	13/18	None	Bait was refreshed in trap.

Table 3.1-6. (continued)

Date/ Time[1]	Air / Water Temp. (°C)[2]	Captures/ PIT-tag ID[3]	Comments[4]
HOOP NET TRAP 1 (RM 4.1) (UTM E 667086, UTM N 4367404) (cont.)			
7/27/12 08:15 to 08:30	15/18	None	--
7/28/12 08:45 to 09:00	16/17	None	Trap was removed from site.
HOOP NET TRAP 2 (RM 4.1) (UTM E 667087, UTM N 4367458)			
7/23/12 14:00 to 14:15	29/18	None	Closed trap deployed 7/12/12 on left bank near impoundment pool upstream of boom. Trap opened and baited with sardines on 7/22/12 at ~18:00.
7/24/12 08:30 to 08:45	16/18	None	Cat food bait was added to trap.
7/25/12 08:30 to 08:45	13/18	None	--
7/26/12 08:30 to 08:45	13/18	None	Bait was refreshed in trap.
7/27/12 08:30 to 08:45	15/18	None	--
7/28/12 09:00 to 09:15	16/17	None	Trap was removed from site.
BASKING TRAP 1 (RM 4.1) (UTM E 667063, UTM N 4367429)			
7/23/12 13:30 to 14:45	29/18	None	Closed trap (trap fitted with lid) deployed 7/12/12 attached to upstream side of boom near where WPT was observed on 5/24/12 and 7/12/12. Trap opened and baited with sardines on 7/22/12 at ~18:00.
7/24/12 08:00 to 8:15	16/18	None	--
7/25/12 08:00 to 8:15	13/18	None	--
7/26/12 08:00 to 8:15	13/18	None	Sardine bait was refreshed in trap.
7/27/12 08:00 to 8:15	15/18	None	--
7/28/12 08:30 to 8:45	16/17	None	Trap was removed from site.
BASKING TRAP 2 (RM 4.15) (UTM E 667097, UTM N 4367392)			
7/23/12 14:00 to 14:15	29/18	None	Closed trap deployed 7/12/12 near bedrock on left bank where WPT was observed on 5/24/12. Trap opened and baited with sardines on 7/22/12 at ~18:00.
7/24/12 08:30 to 08:45	16/18	None	Trap was baited with cat food.
7/25/12 08:30 to 08:45	13/18	None	--
7/26/12 08:30 to 08:45	13/18	None	Sardine bait was refreshed in trap.
7/27/12 08:30 to 08:45	15/18	None	--
7/28/12 09:00 to 09:15	16/17	None	Trap was removed from site.
HOOP NET TRAP 3 (RM 4.4) (UTM E 667175, UTM N 4367586)			
7/25/12 07:30 to 07:45	13/18	None	Trap was deployed and baited with sardines and cat food on 7/24/12 in the morning. Trap located near upstream end of large mid-channel pool, towards left bank.
7/26/12 07:30 to 07:45	13/18	None	Sardine bait was refreshed in trap.
7/27/12 07:30 to 07:45	15/18	None	--
7/28/12 07:45 to 08:00	16/17	None	Trap was removed from site.

Table 3.1-6. (continued)

Date/ Time[1]	Air / Water Temp. (°C)[2]	Captures/ PIT-tag ID[3]	Comments[4]
HOOP NET TRAP 4 (RM 4.41) (UTM E 667142, UTM N 4367590)			
7/25/12 07:15 to 07:30	13/18	1 adult WPT Female #80703909	Trap was deployed and baited with sardines and cat food on 7/24/12 in the morning at the upstream end of the large midchannel pool, near left bank. WPT carapace length = 145 mm; carapace height = 51mm; plastron length = 134 mm; and mass = 445 g. PIT tag affixed with epoxy putty to left front costal shield. Right front marginal shield nicked; left and right rear marginal shield nicked; left anal shield on plastron damaged.
7/26/12 07:15 to 07:30	13/18	1 adult WPT Male #80703905	WPT carapace length = 154 mm; carapace height = 51mm; plastron length = 134 mm; and mass = 540 g. PIT tag affixed with epoxy putty to right front costal shield. Left costal shield damaged; left rear marginal shield damaged. Plastron undamaged. Sardine bait was refreshed in trap.
7/27/12 07:15 to 07:30	15/18	None	--
7/28/12 08:00 to 08:15	16/17	None	Trap was removed from site.

[1] Date and time indicate when trap was checked for captures. Basking Traps #1 and #2 and Hoop Net Trap #2 were checked by separate surveyors.
[2] Temperatures when trap was checked.
[3] WPT = western pond turtle. PIT tag ID = unique tag number. Both tags were 32 mm length.
[4] carapace = upper shell; plastron = lower shell; mm = millimeters; g = grams

YCWA shared basking survey and trapping results with the Relicensing Participants on August 10, 2012. The Relicensing Participants requested additional effort to hand-capture a WPT that was observed basking on multiple occasions in the vicinity of Log Cabin Dam Impoundment. On August 21, 2012 a snorkeler attempted to flush the WPT out from under logs and other underwater refugia; however, visibility in the pool was poor (<1 ft), and the turtle was never viewed underwater. The field crew stayed until after shade fell on the pool, but the WPT did not emerge.

3.1.3 Diversions and Detections

3.1.3.1 Water Year 2012-2013 Diversions

Lohman Ridge Diversion

The Lohman Ridge Diversion Tunnel began diverting water on October 22, 2012. Diversion greater than 100 cfs began November 17, 2012. The highest 7-day mean daily discharge began November 30, 2012, with maximum diversion (845 cfs) occurring on December 2, 2012. Diversion continued until June 7, 2013 and resumed June 17, 2013 through July 4, 2013. Diversion began again on September 2, 2013 and was intermittent with relatively low discharge throughout the rest of the study period.

Camptonville Diversion

The Camptonville Diversion Tunnel began diverting water on October 22, 2012. Diversion greater than 100 cfs began November 17, 2012 and maximum diversion (1,072 cfs) through the tunnel occurred on November 30, 2012, initiating the highest 7-day mean daily discharge. Diversion continued until June 8, 2013, and diversion resumed June 14, 2013 through July 10,

2013. Diversion did not occur again until September 2, 2013 and was intermittent with relatively low discharge throughout the rest of the study period.

3.1.3.2 Detections

A total of 220 detections representing 58 fish were observed at the two diversion tunnels (Attachment 3-11C). Most detections occurred at the Camptonville Diversion Tunnel; however, more individual fish were detected at the Lohman Ridge Diversion Tunnel. Most detected fish at both tunnels originated from the Middle Yuba River (Table 3.1-7). Many fish were detected multiple times (n=34); and 30 fish were detected at both stations. Five fish were documented moving upstream through the Lohman Ridge tunnel.

Table 3.1-7. Detections, number of fish, and origin of fish detected at Lohman Ridge and Camptonville diversion tunnels.

Detection Station	Detections	Individual Fish Detected	Middle Yuba River Origin	Oregon Creek Origin	# of Fish per Day
Lohman Ridge Diversion Tunnel	65	49	48	1	0.13
Camptonville Diversion Tunnel	155	39	30	8	0.10
Total[1]	**220**	**58**	**48**	**9**	--

[1] The total is not the sum of the two tunnels because some fish passed through both tunnels, and back through tunnels.

3.1.3.2.1 Lohman Ridge Detections

A total of 65 detections occurred at the Lohman Ridge Diversion Tunnel, representing 49 individual fish. One fish tagged in Oregon Creek traveled up the tunnel and was detected at the antenna array. Of the 161 fish tagged in the Middle Yuba River, 48 (29.8%) were detected in the tunnel.

Most detections (n=49) occurred early in the study, prior to December 31, 2012 (Figure 3.1-6). The remaining 16 detections occurred between January 1, 2013 and June 19, 2013. The most fish detected on one day (12 fish or 25% of all detected fish in Lohman Diversion Tunnel), were recorded on December 15, 2012 at a flow of 197 cfs. Most detections (67.7%) occurred at flows less than or equal to 200 cfs, which were the most common diversion rates (79.1% of total) throughout the study (Figure 3.1-7).

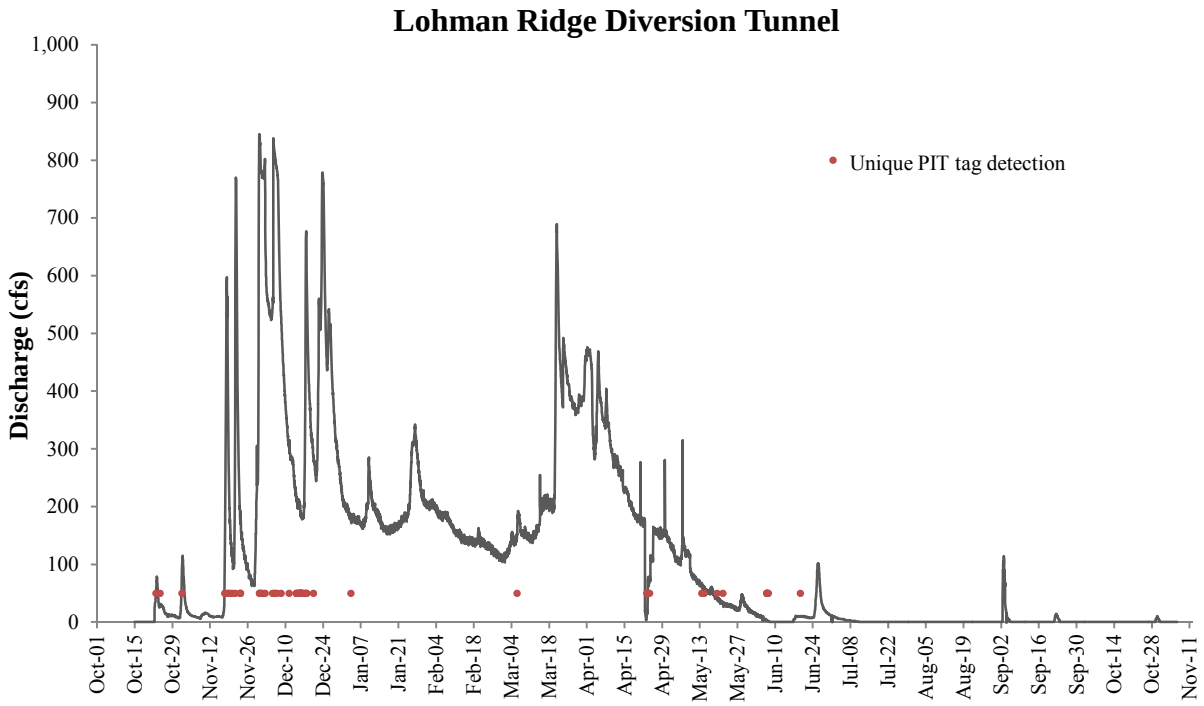

Figure 3.1-6. Summary of detection and rate of diversion at Lohman Ridge Diversion Tunnel. Note: multiple detections within a short time period may be difficult to ascertain.

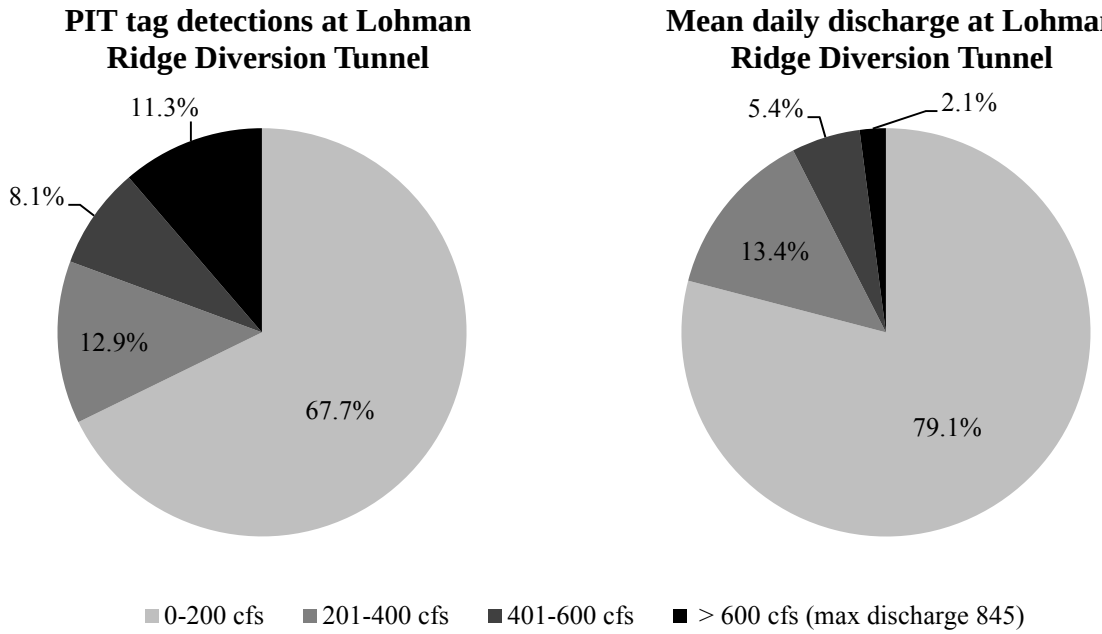

Figure 3.1-7. Percent of PIT tag detections by discharge and percent of mean daily discharges at the Lohman Ridge Diversion Tunnel for the period October 22, 2012–November 7, 2013. Note: Duplicate detections at a given flow in a 24 hour period were omitted.

Fish detected in the tunnel ranged in length from 79 mm to 349 mm (Figure 3.1-8). Few fish less than 100 mm in length were entrained relative to the number tagged (Figure 3.1-2).

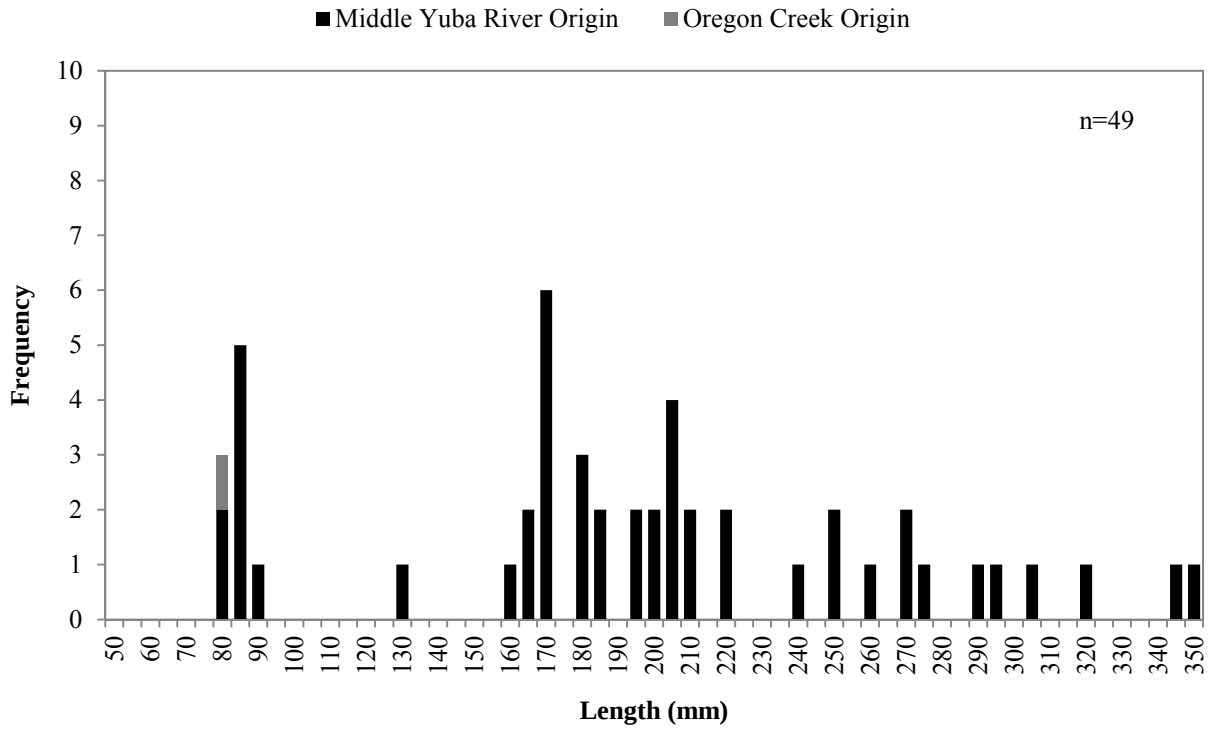

Figure 3.1-8. Length-frequency of fish detected at Lohman Ridge Diversion Tunnel.

3.1.3.2.2 Camptonville Detections

A total of 155 detections occurred at the Camptonville Diversion Tunnel, representing 39 individual fish. Most fish detected (n=30) in the tunnel were of Middle Yuba River origin. Of the 379 fish tagged in Oregon Creek, only eight fish (2.1% of total) were detected in the tunnel.

Detections were well distributed throughout the study period through May 15, 2013, although the highest frequency of detections (n=58) occurred in April 2013 (Figure 3.1-9). One subsequent detection occurred on June 29, 2013. The most fish detected (n=5) on a single day at Camptonville Diversion Tunnel occurred December 16, 2012 at a mean daily flow of 237 cfs. Of the five fish detected that day, four were tagged in Oregon Creek. Most detections (63.8%) occurred at diversion rates less than or equal to 250 cfs, which were the most common (79.1% of total) diversion rate throughout the study (Figure 3.1-10).

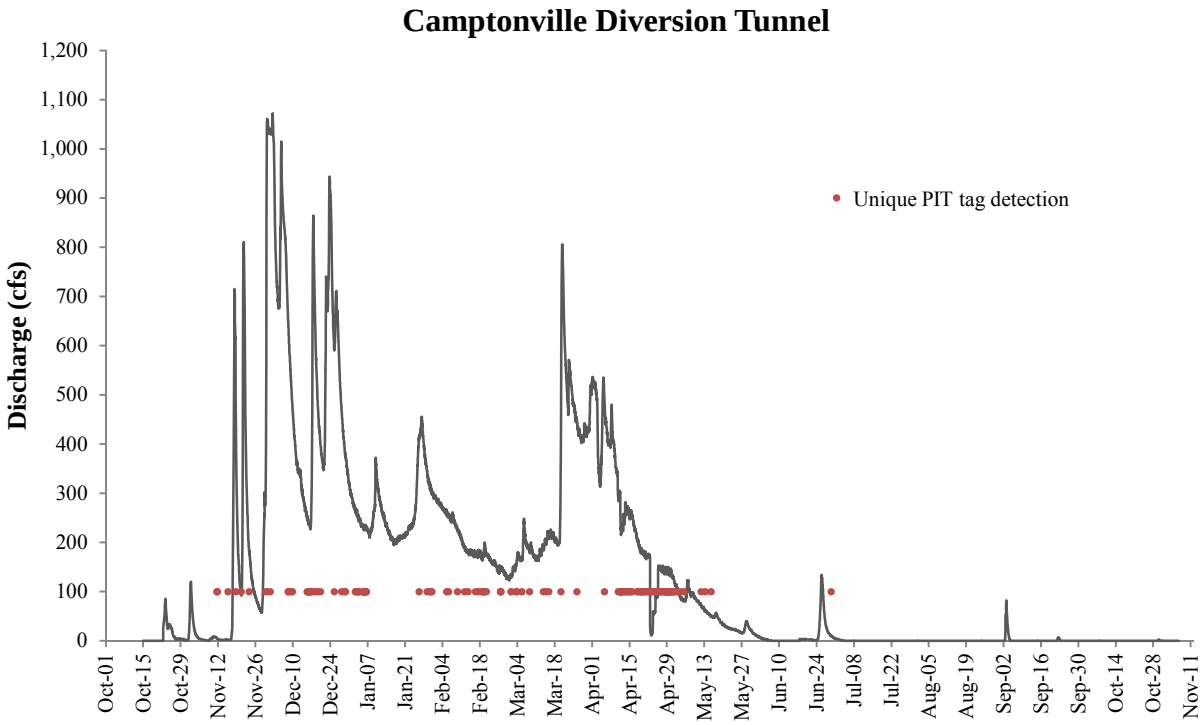

Figure 3.1-9. Summary of detection and rate of diversion at Camptonville Diversion Tunnel. Note: Multiple detections within a short time period may be difficult to ascertain.

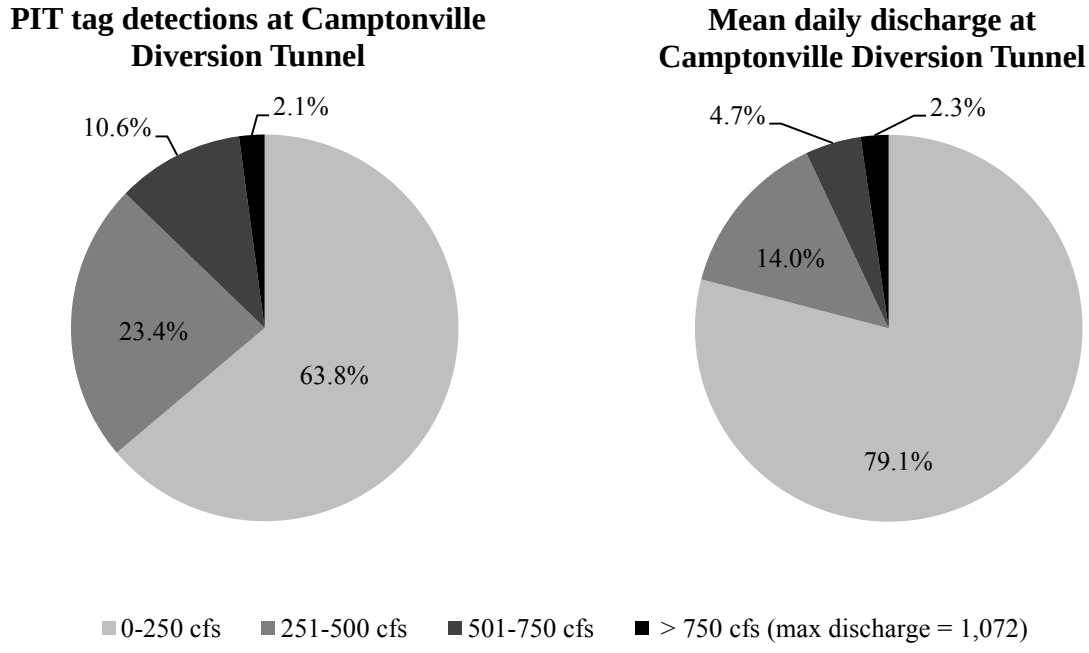

Figure 3.1-10. Percent of PIT tag detections by discharge and percent of mean daily discharges at the Camptonville Diversion Tunnel for the period October 22, 2012–November 7, 2013. Note: Duplicate detections at a given flow in a 24 hour period were omitted.

Fish detected in the tunnel ranged in length from 71 mm to 349 mm (Figure 3.1-11). Very few fish less than100 mm in length were entrained relative to the number tagged (Figure 3.1-4).

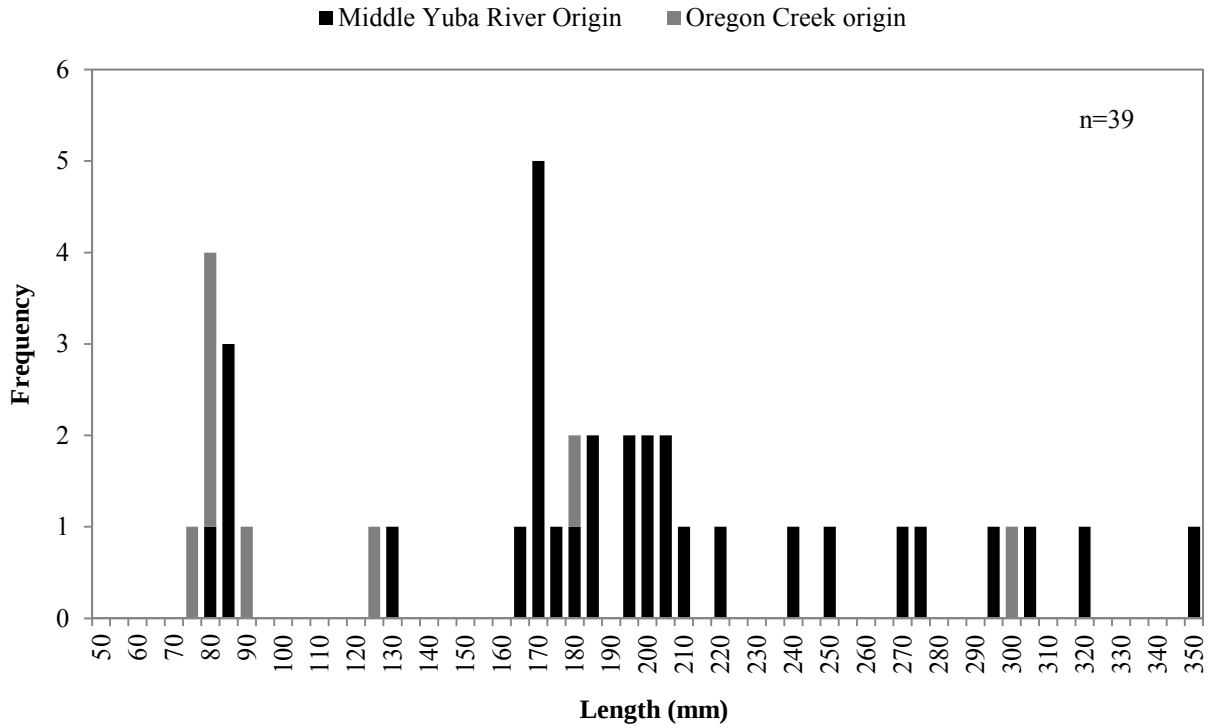

Figure 3.1-11. Length frequency and origin of fish detected at the Camptonville Diversion Tunnel.

Unique Detections

A number of unique detection scenarios unfolded over the course of the study. Multiple detections at an array in no more than a 24-hour period by the same fish, an indicator of milling behavior, were observed at both antenna arrays (Table 3.1-8). At the Lohman Ridge Diversion Tunnel array two fish approximately 165 mm FL were detected multiple times at flows ranging from 32 to 250 cfs. Multiple detections in a 24-hour period were more common at the Camptonville Diversion Tunnel array. Five fish ranging from 80 to 349 mm FL were detected multiple times at flows ranging from 2 to 327 cfs. Some fish were observed holding in the turbulent water downstream of debris against the trash racks at the Camptonville Diversion tunnel, but similar debris conditions were not observed at the Lohman Ridge Diversion Tunnel.

Table 3.1-8. Summary of fish that generated multiple detections with no more than a 24 hour period between detections.

PIT tag ID	Length (mm)	Period	# Detections	Mean Daily Flow (cfs)
LOHMAN RIDGE DIVERIONS TUNNEL PIT ARRAY DETECTIONS				
ACCAB3B	167	4/23/2013 – 4/24/2013	3	32 – 85
ACCABF8	166	12/14/2012 – 12/15/2013	2	207 – 250

Table 3.1-8. (continued)

PIT tag ID	Length (mm)	Period	# Detections	Mean Daily Flow (cfs)
CAMPTONVILLE DIVERSION TUNNEL PIT ARRAY DETECTIONS				
ACCAB9B	220	12/16/2012	2	237
		01/2/2013 – 1/3/2013	6	253 – 265
ACCABF6	129	4/10/2013 – 4/15/2013	15	235 – 327
		4/17/2013 – 5/2/2013	47	25 – 218
ACCAC2F	349	1/5/2013 – 1/6/2013	10	229 – 232
		1/30/2013 – 1/31/2013	3	297 – 312
		2/5/2013 – 2/6/2013	2	254 – 261
		2/18/2013 – 2/20/2013	6	174 – 182
		2/25/2013	4	147
		3/14/2013 – 3/15/2013	2	199 – 214
ACCAC57	296	11/11/2012	2	5
349EA81B9C	80	6/6/2013 – 6/7/2013	6	2 – 4

Detections also documented the occurrence of five fish moving upstream through the Lohman Ridge Tunnel (Table 3.1-9). Four of these fish were documented making a round trip from the Middle Yuba River to Oregon Creek and back. These four fish were each detected at least once at the Lohman Ridge Diversion Tunnel antenna, followed by sequential detections at the Camptonville and Lohman Ridge diversion tunnel antennas. The duration of these movements ranged from weeks to months. The fifth fish was tagged 1.1 mi upstream of Log Cabin Diversion Dam and was detected six times in June at the Lohman Ridge Diversion Tunnel antenna. This fish was not detected at the Camptonville Diversion Tunnel antenna.

Table 3.1-9. Summary of fish that moved up the Lohman Ridge Tunnel.

PIT Tag ID	Length (mm)	# Detections	Detection History
ACCAB9B	220	13	Fish was tagged in Middle Yuba River on 10/2/2012 and initially detected during a flow of 197 cfs at Lohman array on 12/15/2012. It was then detected at Camptonville array from 12/16/2013 to 5/15/2013 11 times at flows ranging 51 – 395 cfs. It was last detected at Lohman array on 5/15/2013 at a flow of 41 cfs.
ACCABB6	208	5	Fish was tagged in Middle Yuba River on 10/16/2012 and initially detected during flow of 460 cfs at Lohman array on 12/17/2012 then again at 181 cfs on 1/3/2013. It was then detected at Camptonville array during a flow of 336 cfs on 1/29/2013 and 61 cfs on 5/13/2013. It was last detected at Lohman array on 5/14/2013 at a flow of 59 cfs.
ACCABF6	129	67	Fish was tagged in Middle Yuba River on 10/3/2012 and initially detected during flow of 460 cfs at Lohman array on 12/17/2012. It was then detected at Camptonville array from 4/5/2013 to 5/5/2013 65 times at flows ranging 25 – 498 cfs. It was last detected at Lohman array on 6/19/2013 at a flow of 10 cfs.
ACCAC2F	349	38	Fish was tagged in Middle Yuba River on 10/3/2012 and initially detected during flow of 775 cfs at Lohman array on 12/1/2012. It was then detected at Camptonville array from 1/5/2013 to 3/15/2013 36 times at flows ranging 130 – 312 cfs. It was last detected at Lohman array on 5/21/2013 at a flow of 32 cfs.
349EA81B9C	80	6	Fish was tagged on 10/1/2012 in Oregon Creek and was then detected at the Lohman array six times from 6/6/2013 to 6/7/2013 at a flows ranging from 2 – 4 cfs.

Tunnel Velocities

Velocities were measured at each tunnel on December 13, 2012. Measurements at the Lohman Ridge Diversion Tunnel were taken between 11:43 a.m. and 12:30 p.m. at an average flow of 238 cfs. Velocities were recorded at 13 stations and at depths of 2.0 and 4.6 ft from the surface. Velocities across the 13 stations ranged from -2.2 to 5.0 feet per second (ft/s), with an average of 2.7 ft/s (Table 3.1-10). Debris against the trash rack caused turbulent flow resulting in three negative values.

Table 3.1-10. Velocities measured at the Lohman Ridge Diversion Tunnel on December 13, 2012 at approximately 238 cfs.[1]

Depth Below Surface	Station												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Velocity in ft per second at 2.0 ft	2.8	3.4	5.0	4.7	1.2	4.0	4.1	3.7	0.1	4.7	4.7	4.7	4.6
Velocity in ft per second at 4.6 ft[1]	2.8	2.8	3.9	4.6	1.1	-2.0	-2.2	3.1	0.7	3.8	4.1	1.8	-1.0

[1] Positive values are downstream flow and negative values are upstream flow.

The Camptonville Diversion Tunnel measurements were recorded between 13:57 p.m. and 14:37 p.m. at an average flow of 296 cfs. Velocities were recorded across the sampling transect at 15 stations and at depths of 2.0 and 4.6 ft from the surface. Velocities ranged from -0.8 to 5.0 ft/s, with an average of 3.7 ft/s (Table 3.1-11). As with the Lohman Ridge Diversion Tunnel measurements, negative velocity values were recorded at the Camptonville Diversion Tunnel due to turbulent flows behind the trash rack attached to the tunnel.

Table 3.1-11. Velocities measured at the Camptonville Diversion Tunnel on December 13, 2012 at approximately 296 cfs.

Depth Below Surface	Station														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Velocity in ft per second at 2.0 ft	2.7	1.8	3.7	3.5	4.2	4.1	4.0	4.4	4.3	4.3	4.4	4.3	4.4	4.3	5.0
Velocity in ft per second at 4.6 ft[1]	4.7	4.0	4.0	-0.8	-0.5	4.2	4.2	4.4	4.2	4.4	4.9	2.6	4.4	4.5	3.7

[1] Positive values are downstream flow and negative values are upstream flow.

3.1.4 Analysis

A mark recapture estimate resulted in a rainbow trout population estimate for the Our House Diversion Dam impoundment of 150 fish, with a 95 percent confidence interval of 124 to 189 fish. This estimate, combined with 265 days of diversions, yielded a rainbow trout population entrainment rate of 0.22 fish/day for the impoundment (Table 3.1-12). Based on the Middle Yuba River 2012 density estimate of 409 fish/mi from YCWA (2013), the population within the 1.2 mi length of the Middle Yuba River upstream of the impoundment is 491 fish. The entrainment rate of these rainbow trout fish is 0.34 per day. The overall entrainment rate into the Lohman Ridge Diversion Tunnel is 0.56 rainbow trout per day. (Table 3.1-12.)

The 379 rainbow trout tagged in Oregon Creek exceeded the YCWA (2013) estimated population density of 72 fish/mi dramatically (405%). The 2 percent entrainment rate of tagged fish resulted in an extrapolated population entrainment rate for the Camptonville Tunnel of 0.01 fish/day, based on 253 days of diversions.

Only two brown trout and two WPT were tagged and none of these were detected during the study.

Table 3.1-12. Estimated entrainment of rainbow trout into the Lohman Ridge and Camptonville diversion tunnels based on 2012/2013 Entrainment Study.

	Rainbow Trout Tagged in Sampled Area[1]				Rainbow Trout in Sampled Area		
Site	Number of Tagged Fish in Sampled Area	Number of Tagged Fish Entrained	% of Tagged Fish Entrained[2]	Rate of Tagged Fish Entrainment[3]	Number of Fish in Sampled Area	Assumed Number of Fish in Sampled Area Entrained[7]	Rate of Fish in Sampled Area Entrained[8]
LOHMAN RIDGE DIVERSION TUNNEL – MIDDLE YUBA RIVER							
Our House Dam Impoundment	89	35	39.3%	0.13 fish/day	150[4]	59	0.22 fish/day
Middle Yuba River Upstream of Our House Diversion Dam Impoundment	72	13	18.1%	0.05 fish/day	491[5]	89	0.34 fish/day
subtotal	161	48	29.8%	0.18 fish/day	641	148	0.56 fish/day
CAMPTONVILLE DIVERSION TUNNEL – OREGON CREEK							
Oregon Creek Upstream of Log Cabin Dam	379	8	2.1%	0.1 fish/day	436[6]	9	0.04 fish/day

[1] The sampled area in the Middle Yuba River included the Our House Diversion Dam impoundment and 1.3 mi upstream of the impoundment. The sampled area in Oregon Creek included 1.7 mi upstream of Log Cabin Dam (i.e., the dam did not create an impoundment during the sampling period).

[2] From October 22, 2012 through November 7, 2013, during the periods that the antenna arrays were operating, water was diverted into the Lohman Ridge Diversion Tunnel and the Camptonville Diversion Tunnel for 265 days and 253 days, respectively.

[3] Calculated by dividing the number of tagged fish entrained by the total number of days that water was diverted and the antenna array was operating.

[4] Based on mark-and-recapture calculations.

[5] Based on multiplying the estimated 409 fish/mi found during YCWA's Study 3.8, *Stream Fish Populations*, times the 1.2-mi length of stream sampled.

[6] Since the tagging effort caught substantially more fish per mile (257 fish/mi) than estimated during YCWA's Study 3.8, *Stream Fish Populations*, (72 fish/mi), YCWA used the larger number in this entrainment calculation. Note that YCWA collected 436 fish, but tagged 379 because some were too small to tag.

[7] Calculated by multiplying the percent of tagged fish entrained by the number of fish in the sampled area.

[8] Calculated by dividing the assumed number of fish in sampled area entrained by the total number of days that water was diverted and the antenna array was operating.

3.2 Entrainment in Reservoirs

3.2.1 New Bullards Bar

Of the eight sites sampled with gill nets in New Bullards Bar Reservoir, catch was lowest at the site closest to the dam and deep water intake. Sixteen individuals were collected in surface nets, including green sunfish (*Lepomis cyanellus*, n=1), rainbow trout (n=3), and spotted bass (*Micropterus punctulatus,* n=12). Catch in deep water nets included one kokanee (*Oncorhynchus nerka*) and one spotted bass, representing 11% of all collected fish at Site 1 (Table 3.2-1). All the remaining fish were collected near the surface, which was the general trend throughout the reservoir.

Table 3.2-1. Summary of catch by gillnet depth at Site 1 near New Bullards Bar Dam in January and June 2012.

Species	Event 1 (n=2)				Event 2 (n=16)			
	Shore	Floating	Midwater	Deep	Shore	Floating	Midwater	Deep
Green Sunfish	0	0	0	0	1	0	0	0
Kokanee	0	0	0	0	0	0	0	1
Rainbow Trout	1	0	0	0	2	0	0	0
Spotted Bass	0	0	1	0	11	0	0	1
Total	**1**	**0**	**1**	**0**	**14**	**0**	**0**	**2**

In 2012, New Bullards Bar Reservoir reached its lowest elevation at 1,874 ft on January 19 (Figure 3.2-1), which also corresponded with the last day of gillnet sampling. The water surface elevation peaked, for the year, on May 22, 2012 at 1,954 ft, just under a month before the June 18 sampling event. Sampling was as deep as 100 ft, but the power tunnel intake was never shallower than 231.4 ft throughout both sampling events.

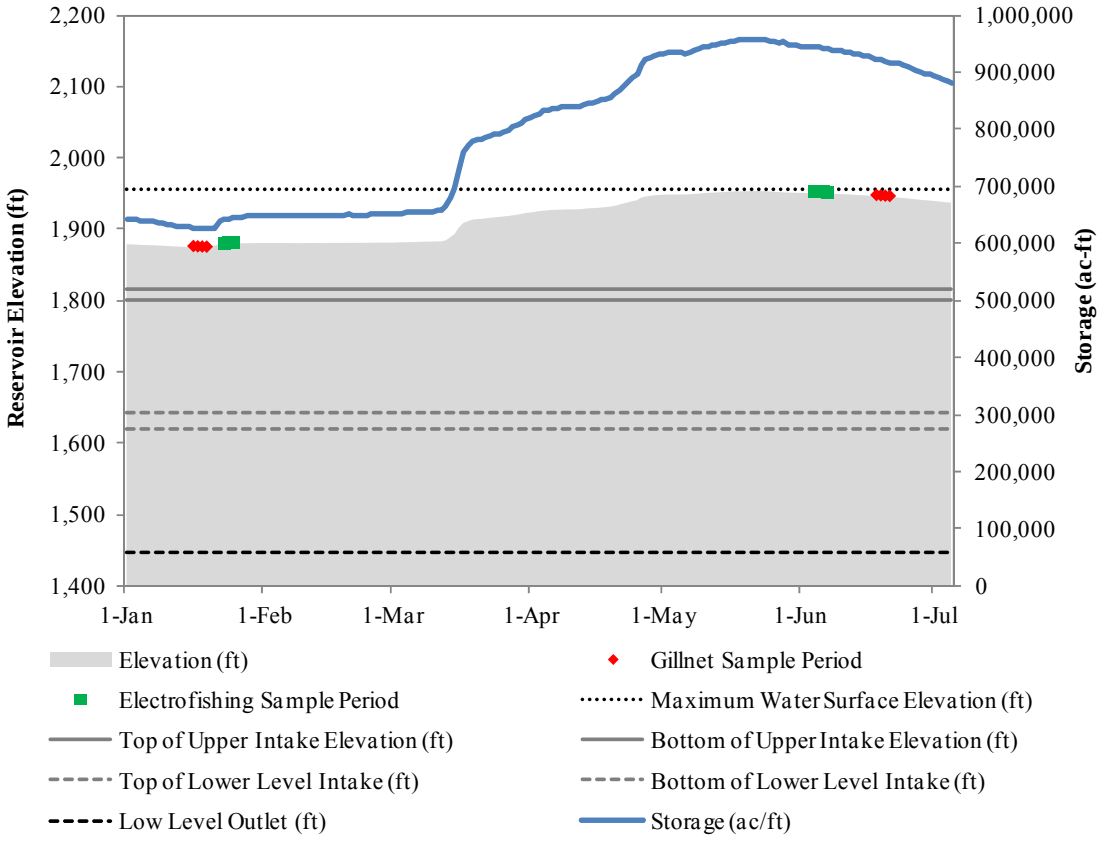

Figure 3.2-1. Summary of reservoir stage and capacity in New Bullards Bar Reservoir along with other notable project features. The upper intake has not been used since 1993.

3.2.2 Englebright Reservoir

Of the four sites sampled with gill nets in Englebright Reservoir, catch was lowest at the site closest to the deep water intake. Catch in deep water nets included two rainbow trout and one brown trout, representing 20 percent of all fish collected at Site 1 (Table 3.2-2). All other fish were found near the surface, which was the general trend throughout the reservoir.

Table 3.2-2. Summary of catch by gillnet depth at Site 1 near Englebright Dam from June 22-24, 2012.

Species	Shore	Floating	Midwater	Deep-water
Brown Trout	0	0	0	1
Green Sunfish	1	0	0	0
Hardhead	3	0	0	0
Rainbow Trout	0	1	0	2
Spotted Bass	4	0	0	0
Sacramento Pikeminnow	1	0	0	0
Sacramento Sucker	2	0	0	0
Total	**11**	**1**	**0**	**3**

Historic Project operations show a consistent mildly-fluctuating reservoir elevation throughout the year. Coordinated operations of New Colgate and Narrows 2 powerhouses, and coordination between PG&E and YCWA in operating Narrows 1 and 2 powerhouses, minimize fluctuations in the river downstream for the protection of fish and reservoir elevations in Englebright Reservoir. Reduced reservoir fluctuations limit adverse effects to recreation and results in annual total fluctuations of less than 15 ft in reservoir stage (Figure 3.2-2). Mild fluctuations occurred during the 2012 sampling period and were generally representative of normal operations.

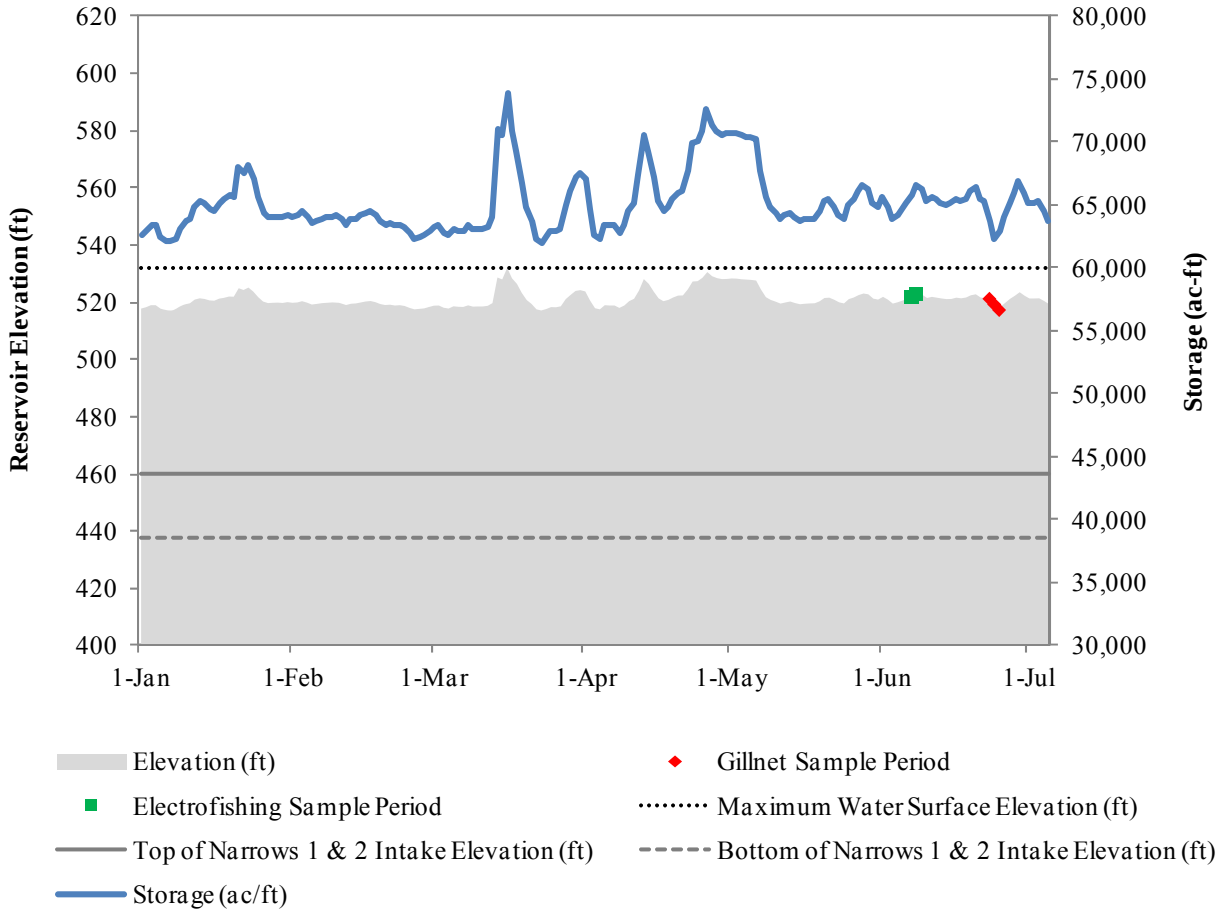

Figure 3.2-2. Summary of reservoir stage and capacity in Englebright Reservoir along with other notable project features.

4.0 Discussion

4.1 Diversion Tunnel Entrainment

Assessing the effects of entrainment into the Lohman Ridge and Camptonville diversion tunnels requires: 1) effective methods to detect entrained fish (and WPTs); 2) estimating the frequency of entrainment; 3) interpreting the implications of being entrained; and 4) describing the likely fate of entrained fish. Assessing effectiveness of the method chosen (PIT antenna arrays) was

quantifiable by determining the percent of diverted flows monitored and the effectiveness of the arrays when monitoring occurred. Estimating the frequency of entrainment was determined by relying on detections of a known number of potentially vulnerable fish with PIT tags. Interpreting the implications of being entrained and describing the likely fate of entrained fish is not as easily quantified, and requires professional assessment and inference.

4.1.1 Antenna Performance

The antenna arrays and tag detection systems for both tunnels operated at very high levels for the entire duration of the study with few exceptions. Regular checks of antenna detection efficiencies and detections of known marker tags provide confidence that at least 99.0 percent of all diverted flows were monitored for entrained fish. The relatively poor performance of the middle antenna in the Camptonville Diversion Tunnel was likely due to a resonance effect of the top and bottom antennas. Although efficiency testing dropped below the target of 80 percent for this array, YCWA is confident that overall detection performance was not substantially affected because the middle antenna was out of the water for most of the periods when performance was less than optimal.

Marker tag and fish detection data also provide confidence in antenna performance. All but one gap in marker tag detections are explained by operational deficits, known damage to the marker tags, or occurred when fish were detected (confirming performance and operation). Only the gap on December 31, 2012 remains unexplained, although the number of detections prior to and after the gap was consistent. It is possible that software for the PIT detection readers did not account for 2012 being a leap year, leading to a malfunction in the readers on December 31. This suggests that the antenna arrays at each site were running correctly during this period, but no data was recorded on the readers. Although the one instance of a fish tagged in the Middle Yuba River being detected only at the Camptonville Diversion Tunnel seems to raise questions about antenna performance at the Lohman Ridge tunnel, the 30 fish detected at both antennas confirms overall excellent performance.

4.1.2 Fish Entrainment

Efficiency reports suggest that antenna arrays were properly functioning and therefore, low detection rates would provide evidence of low rates of entrainment. Because most detections (67.7%) occurred at flows less than 200 cfs, it is likely that most detected fish were not entrained involuntarily.

The ability to avoid entrainment is related to swimming ability, which is a function of size. Froese and Pauly (2003) reported mean rainbow trout sustained speeds of 4.9 lengths per second and mean burst speeds of 13.4 lengths per second. Most rainbow trout caught were between 100 mm and 300 mm in length, sustained swimming speeds ranged from about 1.6 to 4.8 fps, and burst speeds ranged from about 4.4 to 13.2 fps. Velocities were low enough that most rainbow trout in the study area are capable of burst speeds to avoid involuntary entrainment as discharges were less than 200 cfs into the Lohman Ridge tunnel and less than 250 cfs into the Camptonville tunnel about 79% of the time. Observations of fish of various sizes maintaining position or

swimming upstream in diversion tunnels is further evidence that many detected fish were likely not involuntarily entrained.

4.1.3 Interpreting Detections and Fate of Fish

Detections do not provide explicit information regarding the fate of detected fish. Although a single detection at either antenna indicates that the fish moved out of the impoundment and into the tunnel, nothing further can be determined. Similarly, multiple detections by the same antenna over a short time indicate that the fish has the ability to hold station within the tunnel and the diversion headworks, but nothing more can be determined.

Two scenarios do provide further information regarding the disposition of detected fish. Although unusual, one detection in the Camptonville Diversion Tunnel of a fish tagged in the Middle Yuba River (but not detected in the Lohman Ridge Tunnel) provided direct evidence of entrainment into and downstream passage through the Lohman Ridge tunnel. Detection at both antennas also confirms movement through Lohman Ridge tunnel. This movement was generally downstream, but in five instances fish moved upstream through the Lohman Ridge tunnel.

Beyond indicating residence behavior near one of the antennas and direction of movement, none of these scenarios provided information on the eventual fate of the fish. However, it is safe to assume that movement through either of the tunnels was unlikely to result in injury or death of a fish due to the lack of turbines at the downstream ends of the tunnels. Two possibilities are likely: 1) movement from one watershed to another; or 2) movement back into the original diversion impoundment.

4.1.4 Western Pond Turtle Entrainment

The study provided no evidence of entrainment of WPT. This result was not surprising given the small number of WPT that were tagged (n=2) and other evidence that relatively few WPT occur in the vicinity of the Log Cabin Diversion Dam impoundment. Repeated surveys in 2012 documented only one adult WPT in the impoundment (YCWA 2012b). Entrainment of WPT is likely a rare event partly because stream-dwelling WPT typically leave stream environments in the autumn and over-winter on land (Reese 1996; Goodman 1997), which may be an adaptation to escape or avoid high flow conditions (Ashton et al. 1997).

Importantly, WPT are likely to avoid areas where entrainment could occur. Unlike fish, which inhabit the water column and often feed near high velocity areas, WPTs inhabit areas near stream banks in backwaters and slow-moving water, particularly where suitable basking substrates and closely associated underwater hiding places, such as under rocks, logs, or undercut banks, are present. Western pond turtles spend long periods basking out of the water, which greatly limits the potential for entrainment, particularly when water temperatures are low, such as during high flow periods in spring and early summer. Similarly, potential exposure to entrainment is also likely limited by WPT foraging behavior, which includes scavenging on carrion; browsing on plants in shallow, slow-moving water, taking floating food objects at the surface, feeding within algal mats, feeding along the bottom in leaf litter and detritus, and filter-feeding for microcrustaceans (Holland 1985; Bury 1986; Holland and Bury 1998). The tunnel intake at Log

Cabin Diversion Dam is located in the deepest part of the impoundment and is not immediately adjacent to WPT basking or hiding habitat.

4.2 Reservoir Entrainment

The capture of most fish in surface gillnets rather than deeper net sets near the New Colgate and Narrows 2 intake structures was unsurprising for visual predators active during the day such as rainbow trout. Similarly, catch was greatest near shore where protection from predation and some food sources are concentrated. Low catch in deep-set gillnets near intake structures indicates that relatively few fish spend time near the diversion tunnel intakes where they may more easily be entrained.

Rainbow trout and other salmonids are attracted to areas of flow. At times of the greatest diversion volume, it is possible that the diversion intakes are great enough to attract curious fish, while at other times, diversion flows are not substantial enough to be attractive. Fish are more likely attracted to natural surface flow associated with a cascade or inflowing tributary rather than deep water flow.

5.0 Study-Specific Consultation

The FERC-approved study included four study-specific consultations, each of which is discussed below.

5.1 Consult Regarding Gill Net Sampling in New Bullards Bar and Englebright Reservoirs

The FERC-approved study states:

> The results of YCWA's Reservoir Fish Populations Study (Study 3.7) gillnet sampling near the Project intakes in New Bullards Bar and Englebright reservoirs will be presented in the Entrainment Study technical memorandum. YCWA will collaborate with the Forest Service, USFWS, CDFG, SWRCB and other interested Relicensing Participants regarding the results of the gillnet sampling and the need for additional entrainment-related information in New Bullards Bar and Englebright reservoirs. If it is collaboratively agreed that additional information is needed, YCWA, in collaboration with the agencies, will develop a study plan to gather the information and file the plan with FERC for approval.

The results of the gillnet sampling near the Project intakes in New Bullards Bar and Englebright reservoirs is provided in this technical memorandum.

YCWA met with Relicensing Participants to discuss the gill net sampling data for New Bullards Bar and Englebright Reservoirs on February 8, 2013. YCWA and relicensing participants disagreed on the need for additional study. On July 3, 2013 the USFWS and CDFW filed

requests for additional study of entrainment at the Narrows 2 Powerhouse intake. YCWA filed comments on the requests on July 17 (CDFW) and July 23, 2013 (USFWS). As of November 27, 2013 FERC has not responded to these requests. No additional action is required under the FERC approved study plan.

5.2 Consult During Tagging of Fish

The FERC-approved study states:

> During the capture and tagging of fish, YCWA will consult with Relicensing Participants to evaluate sampling efficiency, anticipated sample size, and any minor modifications to the methodologies needed to provide a statistically defensible study (i.e., appropriate sample size). (Step 1)[5]

and

> After all PIT tags have been implanted, YCWA will promptly report the total number of fish and turtles tagged to the Relicensing Participants. (Step 1 and 2). If sufficient numbers of WPT cannot be captured and tagged to obtain meaningful entrainment results in either impoundment, YCWA will collaborate with the Forest Service, USFWS, CDFG and SWRCB to determine if this study aspect (i.e., WPT entrainment monitoring) should still be conducted. (Step 2)

YCWA reported the number of WPTs tagged to Relicensing Participants on August 10, 2012. Relicensing Participants requested additional effort to hand-capture a single WPT observed in the Log Cabin Diversion Dam impoundment. YCWA agreed and multiple attempts by YCWA were made to capture the individual with traps and by hand. The attempts were unsuccessful.

Following the conclusion of fish sampling on Friday, October 5, 2012, YCWA consulted with Relicensing Participants on Monday, October 8, 2012. YCWA agreed to three additional boat electrofishing days, during nighttime hours in Our House Diversion Dam impoundment, as requested by Relicensing Participants. YCWA completed the sampling from October 16-18, 2012.

5.3 Consult if PIT Tag Calibration Is Less Than 80 Percent

The FERC-approved study states:

> If PIT tag calibration is less than 80 percent for any tag group, YCWA will collaborate with the interested Relicensing Participants to determine

[5] This study specific consultation with Relicensing Participants was a modification by FERC in its May 14, 2012 Study Determination.

how best to correct measurements of entrainment based on initial efficiency testing results. Note that this collaboration will occur soon after the calibration so that the study can proceed in fall 2012. (Step 3)

Over the entire monitoring period, the Lohman Ridge and Camptonville antennas operated 99.7 percent and 98.0 percent of the time, respectively.

6.0 Variances from FERC-Approved Study

Periodic removal of the antenna arrays from both tunnels during diversion flows was the only variance from the FERC approved study plan. YCWA maintains the tunnel openings by removing large material from the trash racks and allowing small material to pass through. This activity ensured the safe operation of the tunnels and was also a protective measure for the antennas. In total, the antennas were removed for 0.3 percent and 1.0 percent of diversions at the Lohman Ridge and Camptonville diversion tunnels, respectively.

7.0 Attachments to This Technical Memorandum

This technical memorandum includes three attachments:

- Attachment 3-11A Representative Photographs [1 Adobe PDF file: 1.6 MB; 10 pages formatted to print on 8 ½ x 11 paper]
- Attachment 3-11B Field Data Submission [1 Adobe PDF file: 553 kB; 10 pages formatted to print on 8 ½ x 11 paper]
- Attachment 3-11C All Fish Detections [1 Adobe PDF file: 54 kB; 8 pages formatted to print on 8 ½ x 11 paper]

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Technical Memorandum 3-11

Entrainment

Attachment A

Representative Photographs

Yuba River Development Project
FERC Project No. 2246

November 2013

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Figure 1. Oregon Creek Upstream of Log Cabin Dam, diversion pool sampling.

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Figure 5. Oregon Creek Upstream of Log Cabin Dam, waterfall limiting access to middle part of reach.

Figure 6. Oregon Creek Upstream of Log Cabin Dam, upper waterfall limiting access to middle part of reach.

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Figure 9. Oregon Creek Upstream of Log Cabin Dam, western pond turtle basking trap in diversion pool.

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Figure 12. Oregon Creek Upstream of Log Cabin Dam, adult male western pond turtle trapped and tagged on July 26, 2012.

Figure 13. Oregon Creek Upstream of Log Cabin Dam, western pond turtle that could not be captured in diversion pool.

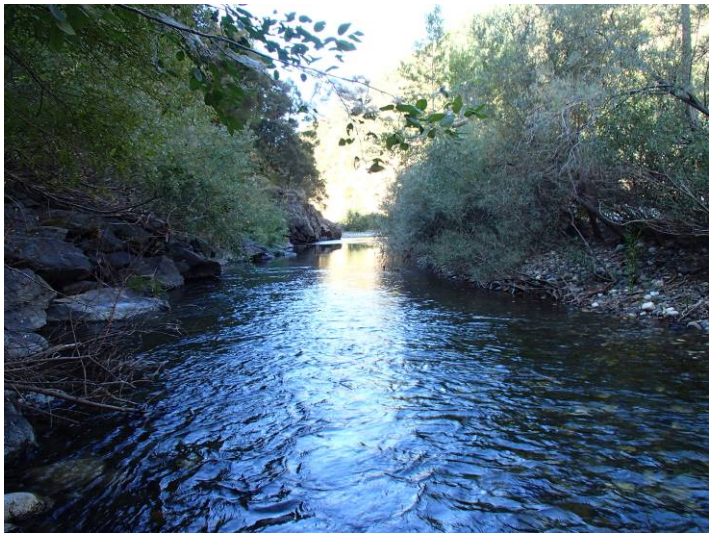

Figure 14. Middle Yuba River Upstream of Our House Dam, typical habitat.

Figure 15. Middle Yuba River Upstream of Our House Dam, typical habitat.

Figure 16. Middle Yuba River Upstream of Our House Dam, population sampling site.

Figure 17. Middle Yuba River Upstream of Our House Dam, large pools snorkeled to look for fish.

Figure 18. Middle Yuba River Downstream of Our House Dam, night electrofishing of diversion pool.

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Entrainment

Attachment B

Field Data Submission

Yuba River Development Project
FERC Project No. 2246

November 2013

Attachment 3.11B. Fish Collection Data

This spreadsheet includes data from all fish collected during field work conducted for the Entrainment Study on the Middle Yuba River above Our House Diversion Dam and Oregon Creek above Log Cabin Diversion Dam. Zones are approximately 0.1 miles and the zone number roughly corresponds with the ending river mile above the diversion dam. A tagged/recaptured fish was captured multiple times by electrofishing and does not indicate the fish was entrained. Forklength is measured in millimeters; weight is measured in grams.

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Oregon Creek

Species	Forklength	Weight	Tag Status
Zone 1 - 5 tagged fish			
rainbow	82	7.1	tagged
rainbow	296	268.1	tagged
rainbow	286	239	tagged
rainbow	331	390	tagged
rainbow	190	66.7	tagged
Zone 2 - 5 tagged fish			
rainbow	74	4.4	tagged
rainbow	71	4.2	tagged
rainbow	69	3.9	tagged
rainbow	76	6.2	tagged
rainbow	90	8.2	tagged/recaptured
rainbow	59	2.5	not tagged
Zone 3 - 4 tagged fish			
rainbow	143	34.4	tagged
rainbow	67	3.3	tagged
rainbow	70	4	tagged
rainbow	87	8.5	tagged
Zone 4 - 8 tagged fish			
rainbow	86	7.7	tagged
rainbow	174	65.5	tagged
rainbow	116	17.3	tagged
rainbow	64	3.2	tagged
rainbow	76	5.1	tagged
rainbow	135	26.7	tagged
rainbow	76	5.7	tagged
rainbow	75	4.6	tagged
Zone 5 - 43 fish tagged			
rainbow	130	25.7	tagged
rainbow	55	2.1	not tagged
rainbow	178	59.5	tagged
rainbow	124	21.6	tagged
rainbow	125	23.2	tagged
rainbow	115	19.6	tagged
rainbow	126	23	tagged
rainbow	116	17.7	tagged
rainbow	134	25.5	tagged
rainbow	124	20	tagged
rainbow	81	6	tagged
rainbow	76	4.3	tagged
rainbow	130	25	tagged
rainbow	79	5.4	tagged
rainbow	120	16.9	tagged
rainbow	61	2.8	tagged
rainbow	70	3.8	tagged
rainbow	67	3.4	tagged
rainbow	65	3.1	tagged
rainbow	113	15.6	tagged
rainbow	124	22.5	tagged
rainbow	143	32.1	tagged
rainbow	126	24.3	tagged
rainbow	59	2.2	not tagged
rainbow	63	2.9	tagged
rainbow	130	25.5	tagged
rainbow	105	12.8	tagged
rainbow	64	2.7	tagged
rainbow	62	2.8	tagged
rainbow	94	9.5	tagged
rainbow	107	14.3	tagged
rainbow	70	3.8	tagged
rainbow	145	32.1	not tagged-mort
rainbow	148	37	not tagged-mort

Species	Forklength	Weight	Tag Status
Zone 5 - continued			
rainbow	178	53.5	tagged
rainbow	160	43.7	tagged
rainbow	146	34.6	not tagged-mort
rainbow	66	3.1	tagged
rainbow	85	6.3	tagged
rainbow	90	8.3	tagged
rainbow	76	5.5	tagged
rainbow	79	4.8	tagged
rainbow	64	2.8	tagged
rainbow	75	5.4	tagged
rainbow	64	2.8	tagged
rainbow	69	3.8	tagged
rainbow	82	6.2	tagged
rainbow	78	4.4	tagged
Zone 6 - 28 fish tagged			
rainbow	84	6.9	tagged
rainbow	76	5.3	tagged
rainbow	127	22.8	tagged
rainbow	100	11.2	tagged
rainbow	110	15.6	tagged
rainbow	135	25.8	tagged
rainbow	81	6.3	tagged
rainbow	72	4.5	tagged
rainbow	71	4.3	tagged
rainbow	69	3.5	tagged
rainbow	125	22.7	tagged
rainbow	121	21.1	tagged
rainbow	68	3.7	tagged
rainbow	112	17.3	tagged
rainbow	110	14.8	tagged
rainbow	66	3.5	not tagged-mort
rainbow	67	3.8	tagged
rainbow	74	4.4	tagged
rainbow	102	12.3	tagged
rainbow	69	3.7	tagged
rainbow	83	6.6	tagged
rainbow	107	14.7	tagged
rainbow	127	26.9	tagged
rainbow	154	44.2	tagged
rainbow	69	3.8	tagged
rainbow	68	3.6	tagged
rainbow	76	5.1	tagged
rainbow	78	5.7	tagged
rainbow	108	14.8	tagged
Zone 10 - 13 fish tagged			
rainbow	86	6.8	tagged
rainbow	79	5.7	tagged
rainbow	82	6.1	tagged
rainbow	82	6.1	tagged
rainbow	87	7.4	tagged
rainbow	115	17.8	tagged
rainbow	76	4.9	tagged
rainbow	130	25.2	tagged
rainbow	141	30	tagged
rainbow	141	33.5	tagged
rainbow	144	32.2	tagged
rainbow	155	37.4	tagged
rainbow	158	45.5	tagged
Zone 11 - 28 fish tagged			
rainbow	81	6.3	tagged
rainbow	76	5.3	tagged

Oregon Creek

Species	Forklength	Weight	Tag Status
Zone 11 - continued			
rainbow	114	17.8	tagged
rainbow	90	8.3	tagged
rainbow	75	5	tagged
rainbow	128	23.9	tagged
rainbow	147	36	tagged
rainbow	73	4.8	not tagged
rainbow	71	3.3	not tagged
rainbow	83	6.9	tagged
rainbow	69	3.6	not tagged
rainbow	80	5.6	tagged
rainbow	79	5.6	tagged
rainbow	123	20.5	tagged
rainbow	118	20.5	tagged
rainbow	117	13.1	tagged
rainbow	94	9.6	tagged
rainbow	92	8.9	tagged
rainbow	77	6.2	tagged
rainbow	85	7.2	tagged
rainbow	83	6.7	tagged
rainbow	75	4.2	not tagged
rainbow	90	9.1	tagged
rainbow	113	16.1	tagged
rainbow	130	25.2	tagged
rainbow	131	27.5	tagged
rainbow	163	47.9	tagged
rainbow	181	64.9	tagged
rainbow	153	38.7	tagged
rainbow	205	91.2	tagged
rainbow	133	26.6	tagged
rainbow	118	18.4	tagged
Zone 12 - 60 fish tagged			
rainbow	58	3.8	not tagged
rainbow	70	4.2	not tagged
rainbow	88	5.7	tagged
rainbow	83	6.6	tagged
rainbow	85	6.9	tagged
rainbow	130	24.8	tagged
rainbow	124	21.2	tagged
rainbow	154	38.9	tagged
rainbow	129	25.1	tagged
rainbow	140	30.2	tagged
rainbow	78	5.8	tagged
rainbow	82	5.9	tagged
rainbow	80	5.6	tagged
rainbow	73	4.5	not tagged
rainbow	78	5.7	tagged
rainbow	82	6.1	tagged
rainbow	138	31.4	tagged
rainbow	154	39.8	tagged
rainbow	138	29.9	tagged
rainbow	136	28.8	tagged
rainbow	124	23.5	tagged
rainbow	66	2.6	not tagged
rainbow	67	2.7	not tagged
rainbow	89	9	tagged
rainbow	77	5.3	tagged
rainbow	75	4.5	not tagged
rainbow	76	5	tagged
rainbow	87	8.1	tagged
rainbow	69	3.8	not tagged
rainbow	117	19.4	tagged

Species	Forklength	Weight	Tag Status
Zone 12 - continued			
rainbow	80	5.4	tagged
rainbow	116	17.6	tagged
rainbow	125	22.8	tagged
rainbow	129	25.3	tagged
rainbow	100	11.1	tagged
rainbow	76	5	tagged
rainbow	72	3.8	not tagged
rainbow	71	4.1	not tagged
rainbow	68	3.3	not tagged
rainbow	78	6.4	tagged
rainbow	119	18.4	tagged
rainbow	112	16.2	tagged
rainbow	89	8	tagged
rainbow	84	6.7	tagged
rainbow	116	18.4	tagged
rainbow	121	20.7	tagged
rainbow	134	26.2	tagged
rainbow	94	9.7	tagged
rainbow	117	19.5	tagged
rainbow	75	5	tagged
rainbow	82	6.8	tagged
rainbow	76	5	tagged
rainbow	71	4.8	not tagged
rainbow	133	25.6	tagged
rainbow	75	4.8	not tagged
rainbow	80	7.2	tagged
rainbow	80	7.4	tagged
rainbow	137	30.9	tagged
rainbow	132	30.5	tagged
rainbow	82	6.6	tagged
rainbow	160	49.1	tagged
rainbow	125	24.3	tagged
rainbow	83	8.4	tagged
rainbow	136	28.5	tagged
rainbow	126	24.1	tagged
rainbow	130	25.4	tagged
rainbow	81	6.3	tagged
rainbow	70	4.2	not tagged
rainbow	86	7.4	tagged
rainbow	80	6.4	tagged
rainbow	70	3.4	not tagged
rainbow	86	6.3	tagged
rainbow	80	5.6	tagged
rainbow	80	6.5	tagged
rainbow	72	4.3	not tagged
Zone 13 - 42 fish tagged			
rainbow	67	3.3	not tagged
rainbow	64	3.2	not tagged
rainbow	94	10.4	tagged
rainbow	138	29.5	tagged
rainbow	86	8.1	tagged
rainbow	136	28.8	tagged
rainbow	133	30.3	tagged
rainbow	81	5.9	tagged
rainbow	113	17.1	tagged
rainbow	135	29.1	tagged
rainbow	65	3.3	not tagged
rainbow	73	4.4	not tagged
rainbow	73	4.4	not tagged
rainbow	76	5.1	tagged
rainbow	76	5.5	tagged

Oregon Creek

Species	Forklength	Weight	Tag Status
Zone 13 - continued			
rainbow	62	2.5	not tagged
rainbow	74	4.6	tagged
rainbow	87	7.7	tagged
rainbow	79	5.6	tagged
rainbow	92	9.7	tagged
rainbow	65	3.5	not tagged
rainbow	81	6.6	tagged
rainbow	79	5.8	tagged
rainbow	134	26.3	tagged
rainbow	128	22.7	not tagged-mort
rainbow	133	27.2	tagged
rainbow	118	17.4	tagged
rainbow	85	7.5	tagged
rainbow	65	2.9	not tagged
rainbow	66	3.5	not tagged
rainbow	78	5.4	tagged
rainbow	83	6.4	tagged
rainbow	71	4.1	not tagged
rainbow	62	2.5	not tagged
rainbow	71	4	not tagged
rainbow	84	6.6	tagged
rainbow	86	7.5	tagged
rainbow	168	49.1	tagged
rainbow	159	43.3	tagged
rainbow	124	20.4	tagged
rainbow	70	4.3	not tagged
rainbow	77	5.4	tagged
rainbow	115	17.4	tagged
rainbow	122	20.5	tagged
rainbow	122	23.1	tagged
rainbow	131	25.1	tagged
rainbow	130	26.5	tagged
rainbow	132	26.4	tagged
rainbow	181	66.7	tagged
rainbow	134	28.8	tagged
rainbow	129	23.8	tagged
rainbow	122	20.9	tagged
rainbow	70	3.5	not tagged
rainbow	78	5.7	tagged
rainbow	69	3.7	not tagged
rainbow	123	22.6	tagged
rainbow	70	3.6	not tagged
rainbow	65	3.4	not tagged
rainbow	72	4	not tagged
rainbow	120	18.1	tagged
rainbow	105	14	tagged
Zone 14 - 41 fish tagged			
rainbow	139	31.5	tagged
rainbow	77	5.1	tagged
rainbow	74	5	tagged
rainbow	86	7.8	tagged
rainbow	111	16.5	tagged
rainbow	86	9.4	tagged
rainbow	115	16.8	tagged
rainbow	110	15.1	tagged
rainbow	132	26.4	tagged
rainbow	72	4	not tagged
rainbow	78	5.1	tagged
rainbow	78	4.8	tagged
rainbow	75	3.6	not tagged
rainbow	78	5.6	tagged

Species	Forklength	Weight	Tag Status
Zone 14 - continued			
rainbow	73	4.5	not tagged
rainbow	78	5.9	tagged
rainbow	99	10	tagged
rainbow	77	5.3	tagged
rainbow	76	4.6	not tagged
rainbow	118	20.3	tagged
rainbow	72	4.5	not tagged
rainbow	84	6.7	tagged
rainbow	153	35.1	tagged
rainbow	155	43.1	tagged
rainbow	137	33.1	tagged
rainbow	137	28.9	tagged
rainbow	129	23.1	tagged
rainbow	135	25.4	tagged
rainbow	130	24.1	tagged
rainbow	83	6.9	tagged
rainbow	115	18.7	tagged
rainbow	128	22.6	tagged
rainbow	97	10	tagged
rainbow	92	9.7	tagged
rainbow	80	5.8	tagged
rainbow	84	6.1	tagged
rainbow	82	6.2	tagged
rainbow	88	8.5	tagged
rainbow	85	6.7	tagged
rainbow	74	4.9	tagged
rainbow	78	5.5	tagged
rainbow	98	10.6	tagged
rainbow	88	7.6	tagged
rainbow	84	7.1	tagged
rainbow	82	6.5	tagged
rainbow	85	6.9	tagged
rainbow	66	3.4	not tagged
Zone 15 - 40 fish tagged			
rainbow	82	6.9	tagged
rainbow	77	5.4	tagged
rainbow	75	4.9	tagged
rainbow	124	22.6	tagged
rainbow	116	13.2	tagged
rainbow	124	22.4	tagged
rainbow	143	35.3	tagged
rainbow	113	15.8	tagged
rainbow	131	27.1	tagged
rainbow	160	44.6	tagged
rainbow	120	19.3	tagged
rainbow	118	18.4	tagged
rainbow	104	12.7	tagged
rainbow	119	18.4	tagged
rainbow	105	14.1	tagged
rainbow	118	19.9	tagged
rainbow	69	4.1	not tagged
rainbow	123	21.5	tagged
rainbow	73	4.4	not tagged
rainbow	123	20.1	tagged
rainbow	82	6.6	tagged
rainbow	85	7.2	tagged
rainbow	70	4.1	not tagged
rainbow	80	6.3	tagged
rainbow	81	6.1	tagged
rainbow	80	5.9	tagged
rainbow	69	3.5	not tagged

Oregon Creek

Species	Forklength	Weight	Tag Status
Zone 15 - continued			
rainbow	81	6.1	tagged
rainbow	86	6.7	tagged
rainbow	85	6.7	tagged
rainbow	119	20.1	tagged
rainbow	107	13.6	tagged
rainbow	90	8.4	tagged
rainbow	90	8.2	tagged
rainbow	70	4.2	not tagged
rainbow	73	4.8	tagged
rainbow	122	19.3	tagged
rainbow	135	27.3	tagged
rainbow	79	5.8	tagged
rainbow	177	55.8	tagged
rainbow	130	25.8	tagged
rainbow	113	16.5	tagged
rainbow	134	28.9	tagged
rainbow	94	9.1	tagged
rainbow	123	22.2	tagged
Zone 17 - 62 fish tagged			
rainbow	105	12.2	tagged
rainbow	75	5.2	tagged
rainbow	65	2.9	tagged
rainbow	138	28.3	tagged
rainbow	81	5.4	tagged
rainbow	125	22	tagged
rainbow	127	22.6	tagged
rainbow	68	3.7	tagged
rainbow	168	45.2	tagged
rainbow	109	11.8	tagged
rainbow	132	20	tagged
rainbow	120	18.3	tagged
rainbow	118	17.2	tagged
rainbow	100	10.8	tagged
rainbow	102	12.9	tagged
rainbow	116	18	tagged
rainbow	82	6.5	tagged
rainbow	72	4.4	tagged
rainbow	100	11	tagged
rainbow	70	3.6	tagged
rainbow	55	1.9	not tagged
rainbow	80	6.2	tagged
rainbow	74	4.4	tagged
rainbow	120	20.5	tagged
rainbow	112	21.1	tagged
rainbow	116	17.4	tagged
rainbow	147	36	tagged
rainbow	153	37.8	tagged
rainbow	106	14.4	tagged
rainbow	83	6.5	tagged
rainbow	132	24.8	tagged
rainbow	67	3.4	tagged
rainbow	84	6.2	tagged
rainbow	106	15.2	tagged
rainbow	111	15.1	tagged
rainbow	74	4.4	tagged
rainbow	119	17.2	tagged
rainbow	136	26.6	tagged
rainbow	129	24.3	tagged
rainbow	117	20.8	tagged
rainbow	75	4.9	tagged
rainbow	73	4.7	tagged

Species	Forklength	Weight	Tag Status
Zone 17 - continued			
rainbow	116	17.5	tagged
rainbow	80	5.7	tagged
rainbow	130	24.5	tagged
rainbow	142	35.5	tagged
rainbow	84	6.4	tagged
rainbow	72	4.3	tagged
rainbow	69	4.1	tagged
rainbow	78	5.6	tagged
rainbow	90	8.6	tagged
rainbow	108	12.4	tagged
rainbow	114	16.1	tagged
rainbow	116	16.7	tagged
rainbow	110	15	tagged
rainbow	124	21.4	tagged
rainbow	116	19.8	tagged
rainbow	98	11	tagged
rainbow	128	21.9	tagged
rainbow	70	4	tagged
rainbow	75	4.9	tagged
rainbow	178	61.1	tagged
rainbow	141	29.4	tagged

Middle Yuba River

Species	Forklength	Weight	Tag Status
Zone 1 - 89 tagged fish			
rainbow	178	61.6	tagged/recaptured
brown	235	148.7	tagged/recaptured
rainbow	85	7.8	tagged
rainbow	75	4.6	tagged
rainbow	240	129.3	not tagged-mort
rainbow	180	72.6	not tagged-mort
rainbow	209	92.4	tagged/recaptured
rainbow	214	100.7	tagged
rainbow	186	77.4	tagged/recaptured
rainbow	340	432.2	tagged
rainbow	265	178.3	not tagged-mort
rainbow	198	76.4	tagged
rainbow	167	53.8	tagged/recaptured
brown	273	196	tagged
rainbow	233	141.6	tagged
rainbow	287	301.6	tagged/recaptured
rainbow	185	63.2	tagged
rainbow	176	58.4	tagged/recaptured
rainbow	204	91.9	tagged
rainbow	176	60.4	tagged
rainbow	70	2.7	not tagged
rainbow	212	116.8	tagged/recaptured
rainbow	170	49.1	tagged/recaptured
rainbow	168	48.9	tagged
rainbow	169	49.8	tagged/recaptured
rainbow	162	48.7	tagged
rainbow	249	144.6	tagged/recaptured
rainbow	198	85	tagged
rainbow	180	58.9	tagged
rainbow	257	166.9	tagged
rainbow	166	49.3	tagged
rainbow	337	411.7	tagged/recaptured
rainbow	310	313.7	tagged
rainbow	172	63.1	tagged
rainbow	268	220.3	tagged
rainbow	178	60.1	tagged
rainbow	210	94.8	tagged/recaptured
rainbow	179	64.3	tagged
rainbow	208	92.3	tagged/recaptured
rainbow	114	11.8	tagged/recaptured
rainbow	184	184	tagged
rainbow	169	169	tagged
rainbow	272	272	tagged/recaptured
rainbow	228	228	tagged
rainbow	249	249	tagged
rainbow	202	202	tagged
rainbow	248	248	tagged/recaptured
rainbow	184	84.7	tagged
rainbow	342	407.9	tagged
rainbow	216	113	tagged/recaptured
rainbow	208	106.5	tagged
rainbow	186	63	tagged
rainbow	235	88.2	tagged
rainbow	237	139.8	tagged/recaptured
rainbow	198	103.1	tagged
rainbow	162	42.1	tagged/recaptured
rainbow	140	29.3	tagged
rainbow	230	169	tagged
rainbow	218	119.7	tagged/recaptured
rainbow	175	55.7	tagged
rainbow	200	83.9	tagged

Species	Forklength	Weight	Tag Status
Zone 1 - continued			
rainbow	242	147.8	tagged
rainbow	132	24.1	tagged/recaptured
rainbow	316	319	tagged
rainbow	219	109.1	tagged
rainbow	191	81.8	tagged
rainbow	190	72.5	tagged
rainbow	200	95.6	tagged
rainbow	160	43.7	tagged
rainbow	202	97.6	tagged
rainbow	194	83.8	tagged/recaptured
rainbow	268	175	tagged
rainbow	170	50.3	tagged
rainbow	181	62.1	tagged
rainbow	287	261.3	tagged
rainbow	225	135.2	tagged
rainbow	278	207.1	tagged
rainbow	294	309.2	tagged
rainbow	206	107.3	tagged
rainbow	179	68.2	tagged
rainbow	166	51.3	tagged
rainbow	162	46.3	tagged
rainbow	175	52.8	tagged
rainbow	198	79.8	tagged
rainbow	302	330	tagged
rainbow	185	63.7	tagged
rainbow	84	5.2	tagged
rainbow	79	5.3	tagged
rainbow	215	112.7	tagged
rainbow	241	135.7	tagged
rainbow	295	218.9	tagged
rainbow	157	47.3	tagged
rainbow	266	172.6	tagged
Zone 2 - 7 fish tagged			
rainbow	82	6.9	tagged
rainbow	72	4.1	tagged
rainbow	70	4.2	not tagged-mort
rainbow	82	6.2	tagged
rainbow	87	8.5	tagged
rainbow	84	6.7	tagged
rainbow	131	26.2	tagged
rainbow	82	6.8	tagged
Zone 3 - 2 fish tagged			
rainbow	180	71.2	tagged/recaptured
rainbow	78	4.6	tagged
Zone 4 - 3 fish tagged			
rainbow	177	62.2	tagged
rainbow	162	47.4	tagged
rainbow	143	32.9	tagged
rainbow	65	1.3	not tagged-mort
Zone 6 - 5 fish tagged			
rainbow	72	4.2	not tagged
rainbow	58	2.5	not tagged
rainbow	68	3.2	not tagged
rainbow	154	36.8	tagged
rainbow	203	100.3	tagged
rainbow	213	100.6	tagged
rainbow	215	118.1	tagged
rainbow	76	5.4	tagged
Zone 7 - 23 fish tagged			
rainbow	258	153.9	tagged
rainbow	203	95.9	tagged

Middle Yuba River

Species	Forklength	Weight	Tag Status
Zone 7 - continued			
rainbow	172	56.3	tagged
rainbow	81	5.8	tagged
rainbow	64	2.9	not tagged
rainbow	62	2.6	not tagged
rainbow	80	5.4	tagged
rainbow	73	4.2	not tagged
rainbow	79	5.6	tagged
rainbow	64	3	not tagged
rainbow	78	5.3	tagged
rainbow	70	3.7	not tagged
rainbow	64	3	not tagged
rainbow	90	7.8	tagged
rainbow	71	3.8	not tagged
rainbow	81	6.3	tagged
rainbow	86	7.8	tagged
rainbow	81	7.3	tagged
rainbow	84	6.5	tagged
rainbow	85	9.2	tagged
rainbow	185	71.4	tagged
rainbow	87	9.5	tagged
rainbow	208	98.5	tagged
rainbow	126	22.5	tagged
rainbow	195	81.3	tagged
rainbow	196	74.5	tagged
rainbow	220	100.7	tagged
rainbow	64	3.1	not tagged
rainbow	126	23.2	tagged
rainbow	205	105.1	tagged
rainbow	191	78.7	tagged
Zone 8 - 6 fish tagged			
rainbow	156	47.4	tagged
rainbow	174	66.8	tagged
rainbow	80	5.7	tagged
rainbow	80	5.6	not tagged-mort
rainbow	71	4.4	not tagged
rainbow	172	47.2	tagged/recaptured
rainbow	66	3.2	not tagged
rainbow	72	4.8	tagged
rainbow	78	4.7	tagged
Zone 10 - 3 fish tagged			
rainbow	61	3	not tagged
rainbow	150	37	tagged
rainbow	154	38.1	tagged
rainbow	141	32	tagged
Zone 11 - 16 fish tagged			
rainbow	349	450.3	tagged
rainbow	218	119.3	tagged
rainbow	186	71.5	tagged
rainbow	150	40.4	tagged
rainbow	132	28.7	tagged
rainbow	248	147.6	tagged
rainbow	243	143.3	tagged
rainbow	277	175	tagged
rainbow	127	23.1	tagged
rainbow	177	56.6	tagged
rainbow	140	29	not tagged-mort
rainbow	129	22.6	tagged
rainbow	58	2.3	not tagged
rainbow	65	2.9	not tagged
rainbow	208	104.5	tagged
rainbow	136	27.5	tagged

Species	Forklength	Weight	Tag Status
Zone 11 - continued			
rainbow	150	37.8	tagged
rainbow	130	24.9	tagged
rainbow	204	86.5	tagged
Zone 13 - 7 fish tagged			
rainbow	301	313	tagged
rainbow	142	32.1	tagged
rainbow	233	140.1	tagged
rainbow	281	215.8	tagged
rainbow	73	3.2	not tagged
rainbow	139	28.9	tagged
rainbow	66	2.8	not tagged
rainbow	74	3.4	not tagged
rainbow	193	81.8	not tagged-mort
rainbow	80	6	tagged
rainbow	196	82.2	tagged

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Entrainment

Attachment C

All Fish Detections

Yuba River Development Project
FERC Project No. 2246

November 2013

List of Tables

Table 1. PIT tag detections at the Lohman Ridge Diversion Tunnel.

PIT Tag Number	Detection Date	Detection Site	Mean Daily Diversion	Location Tagged	Zone Tagged	Forklength
ACCABD4	10/22/2012	Lohman Ridge	24	Middle Yuba	1	162
ACCABA8	10/24/2012	Lohman Ridge	29	Middle Yuba	1	249
ACCABE2	11/1/2012	Lohman Ridge	70	Middle Yuba	1	180
ACCABE2	11/17/2012	Lohman Ridge	149	Middle Yuba	1	180
ACCABFF	11/17/2012	Lohman Ridge	149	Middle Yuba	1	185
ACCAC40	11/18/2012	Lohman Ridge	452	Middle Yuba	1	295
349EA814F1	11/18/2012	Lohman Ridge	452	Middle Yuba	7	87
349EA814E0	11/19/2012	Lohman Ridge	168	Middle Yuba	7	80
ACCAC02	11/20/2012	Lohman Ridge	105	Middle Yuba	1	268
349EA81BCF	11/21/2012	Lohman Ridge	512	Middle Yuba	2	82
ACCAB7D	11/23/2012	Lohman Ridge	167	Middle Yuba	1	249
ACCABA3	11/23/2012	Lohman Ridge	167	Middle Yuba	1	237
349EA81537	11/23/2012	Lohman Ridge	167	Middle Yuba	7	79
ACCAB68	11/30/2012	Lohman Ridge	769	Middle Yuba	1	166
ACCAB74	11/30/2012	Lohman Ridge	769	Middle Yuba	1	210
ACCAB7F	11/30/2012	Lohman Ridge	769	Middle Yuba	1	169
ACCAC33	11/30/2012	Lohman Ridge	769	Middle Yuba	1	160
ACCAC2F	12/1/2012	Lohman Ridge	775	Middle Yuba	11	349
ACCAC0C	12/2/2012	Lohman Ridge	704	Middle Yuba	1	257
ACCAB24	12/5/2012	Lohman Ridge	686	Middle Yuba	1	198
ACCABE6	12/5/2012	Lohman Ridge	686	Middle Yuba	7	203
ACCABC6	12/6/2012	Lohman Ridge	795	Middle Yuba	1	170
349EA81BE2	12/6/2012	Lohman Ridge	795	Middle Yuba	2	82
349EA81981	12/8/2012	Lohman Ridge	523	Middle Yuba	1	84
ACCAC1A	12/11/2012	Lohman Ridge	300	Middle Yuba	1	162
ACCAB7C	12/13/2012	Lohman Ridge	240	Middle Yuba	1	198
ACCAB31	12/14/2012	Lohman Ridge	207	Middle Yuba	1	194
ACCAB9A	12/14/2012	Lohman Ridge	207	Middle Yuba	1	191
ACCABAE	12/14/2012	Lohman Ridge	207	Middle Yuba	1	202
ACCABF8	12/14/2012	Lohman Ridge	207	Middle Yuba	1	166
ACCAB34	12/15/2012	Lohman Ridge	197	Middle Yuba	1	168
ACCAB85	12/15/2012	Lohman Ridge	197	Middle Yuba	6	203
ACCAB9A	12/15/2012	Lohman Ridge	197	Middle Yuba	1	191
ACCAB9B	12/15/2012	Lohman Ridge	197	Middle Yuba	7	220
ACCABB1	12/15/2012	Lohman Ridge	197	Middle Yuba	1	178
ACCABBB	12/15/2012	Lohman Ridge	197	Middle Yuba	1	185
ACCABF0	12/15/2012	Lohman Ridge	197	Middle Yuba	1	342
ACCABF8	12/15/2012	Lohman Ridge	197	Middle Yuba	1	166
ACCAC12	12/15/2012	Lohman Ridge	197	Middle Yuba	1	204
ACCAC3B	12/15/2012	Lohman Ridge	197	Middle Yuba	1	316
ACCAC4F	12/15/2012	Lohman Ridge	197	Middle Yuba	1	273
ACCAC59	12/15/2012	Lohman Ridge	197	Middle Yuba	1	170
ACCAB61	12/16/2012	Lohman Ridge	184	Middle Yuba	1	302
ACCABDD	12/16/2012	Lohman Ridge	184	Middle Yuba	1	266
ACCAB5D	12/17/2012	Lohman Ridge	460	Middle Yuba	1	179
ACCABB6	12/17/2012	Lohman Ridge	460	Middle Yuba	1	208
ACCABF6	12/17/2012	Lohman Ridge	460	Middle Yuba	11	129
349EA81504	12/17/2012	Lohman Ridge	460	Middle Yuba	7	81
ACCAC17	12/20/2012	Lohman Ridge	288	Middle Yuba	1	287
ACCABB6	1/3/2013	Lohman Ridge	181	Middle Yuba	1	208

Table 1. (continued)

PIT Tag Number	Detection Date	Detection Site	Mean Daily Diversion	Location Tagged	Zone Tagged	Forklength
349EA81515	3/6/2013	Lohman Ridge	177	Middle Yuba	7	81
ACCAB3B	4/23/2013	Lohman Ridge	32	Middle Yuba	1	167
ACCAB3B	4/23/2013	Lohman Ridge	32	Middle Yuba	1	167
ACCAB3B	4/24/2013	Lohman Ridge	85	Middle Yuba	1	167
ACCAC3B	5/13/2013	Lohman Ridge	65	Middle Yuba	1	316
ACCABB6	5/14/2013	Lohman Ridge	59	Middle Yuba	1	208
ACCAB9B	5/19/2013	Lohman Ridge	41	Middle Yuba	7	220
ACCAC2F	5/21/2013	Lohman Ridge	32	Middle Yuba	11	349
349EA81B9C	6/6/2013	Lohman Ridge	4	Oregon Creek	12	80
349EA81B9C	6/6/2013	Lohman Ridge	4	Oregon Creek	12	80
349EA81B9C	6/6/2013	Lohman Ridge	4	Oregon Creek	12	80
349EA81B9C	6/7/2013	Lohman Ridge	2	Oregon Creek	12	80
349EA81B9C	6/7/2013	Lohman Ridge	2	Oregon Creek	12	80
349EA81B9C	6/7/2013	Lohman Ridge	2	Oregon Creek	12	80
ACCABF6	6/19/2013	Lohman Ridge	10	Middle Yuba	11	129

Table 2. PIT tag detections at the Camptonville Diversion Tunnel.

PIT Tag Number	Detection Date	Detection Site	Mean Daily Diversion	Location Tagged	Zone Tagged	Forklength
ACCABB7	11/11/2012	Camptonville	5	Oregon Creek	5	178
ACCAC57	11/11/2012	Camptonville	5	Oregon Creek	1	296
ACCAC57	11/11/2012	Camptonville	5	Oregon Creek	1	296
349EA8196D	11/15/2012	Camptonville	2	Oregon Creek	14	78
ACCAC40	11/18/2012	Camptonville	537	Middle Yuba	1	295
ACCAC02	11/20/2012	Camptonville	104	Middle Yuba	1	268
ACCAB7D	11/23/2012	Camptonville	205	Middle Yuba	1	249
349EA81537	11/29/2012	Camptonville	258	Middle Yuba	7	79
349EA81BCF	11/30/2012	Camptonville	941	Middle Yuba	2	82
ACCAB7F	12/1/2012	Camptonville	1,035	Middle Yuba	1	169
ACCABE6	12/8/2012	Camptonville	625	Middle Yuba	7	203
ACCABFF	12/8/2012	Camptonville	625	Middle Yuba	1	185
ACCAC06	12/8/2012	Camptonville	625	Middle Yuba	1	175
349EA814FE	12/9/2012	Camptonville	514	Oregon Creek	13	122
349EA81A5A	12/9/2012	Camptonville	514	Oregon Creek	2	71
ACCAB24	12/15/2012	Camptonville	250	Middle Yuba	1	198
ACCAB85	12/15/2012	Camptonville	250	Middle Yuba	6	203
ACCAB9A	12/15/2012	Camptonville	250	Middle Yuba	1	191
ACCABF8	12/15/2012	Camptonville	250	Middle Yuba	1	166
ACCAB34	12/16/2012	Camptonville	237	Middle Yuba	1	168
ACCAB7C	12/16/2012	Camptonville	237	Middle Yuba	1	198
ACCAB9B	12/16/2012	Camptonville	237	Middle Yuba	7	220
ACCAB9B	12/16/2012	Camptonville	237	Middle Yuba	7	220
ACCAC3B	12/16/2012	Camptonville	237	Middle Yuba	1	316
ACCAC4F	12/16/2012	Camptonville	237	Middle Yuba	1	273
ACCAB5D	12/17/2012	Camptonville	631	Middle Yuba	1	179
ACCAB31	12/18/2012	Camptonville	631	Middle Yuba	1	194
ACCABBB	12/19/2012	Camptonville	473	Middle Yuba	1	185
ACCAB9B	12/20/2012	Camptonville	395	Middle Yuba	7	220
ACCAC59	12/25/2012	Camptonville	620	Middle Yuba	1	170
ACCABC6	12/28/2012	Camptonville	453	Middle Yuba	1	170

Table 2. (continued)

PIT Tag Number	Detection Date	Detection Site	Mean Daily Diversion	Location Tagged	Zone Tagged	Forklength
349EA81504	12/29/2012	Camptonville	389	Middle Yuba	7	81
349EA81B84	12/29/2012	Camptonville	389	Oregon Creek	12	80
ACCAB9B	1/2/2013	Camptonville	265	Middle Yuba	7	220
ACCAB9B	1/2/2013	Camptonville	265	Middle Yuba	7	220
ACCAB9B	1/3/2013	Camptonville	253	Middle Yuba	7	220
ACCAB9B	1/3/2013	Camptonville	253	Middle Yuba	7	220
ACCAB9B	1/3/2013	Camptonville	253	Middle Yuba	7	220
ACCAB9B	1/3/2013	Camptonville	253	Middle Yuba	7	220
ACCAB61	1/5/2013	Camptonville	232	Middle Yuba	1	302
ACCAB9B	1/5/2013	Camptonville	232	Middle Yuba	7	220
ACCAC2F	1/5/2013	Camptonville	232	Middle Yuba	11	349
ACCAC2F	1/5/2013	Camptonville	232	Middle Yuba	11	349
ACCAC2F	1/5/2013	Camptonville	232	Middle Yuba	11	349
ACCAC2F	1/5/2013	Camptonville	232	Middle Yuba	11	349
ACCAC2F	1/5/2013	Camptonville	232	Middle Yuba	11	349
ACCAC2F	1/5/2013	Camptonville	232	Middle Yuba	11	349
ACCAC2F	1/5/2013	Camptonville	232	Middle Yuba	11	349
ACCAB61	1/6/2013	Camptonville	229	Middle Yuba	1	302
ACCAC2F	1/6/2013	Camptonville	229	Middle Yuba	11	349
ACCAC2F	1/6/2013	Camptonville	229	Middle Yuba	11	349
ACCAC2F	1/6/2013	Camptonville	229	Middle Yuba	11	349
349EA81AAC	1/26/2013	Camptonville	417	Oregon Creek	4	86
ACCABB6	1/29/2013	Camptonville	336	Middle Yuba	1	208
ACCAC2F	1/30/2013	Camptonville	312	Middle Yuba	11	349
ACCAC2F	1/30/2013	Camptonville	312	Middle Yuba	11	349
ACCAC2F	1/31/2013	Camptonville	297	Middle Yuba	11	349
ACCAC2F	2/5/2013	Camptonville	261	Middle Yuba	11	349
ACCAC2F	2/6/2013	Camptonville	254	Middle Yuba	11	349
ACCAC2F	2/9/2013	Camptonville	229	Middle Yuba	11	349
ACCAC2F	2/12/2013	Camptonville	188	Middle Yuba	11	349
ACCAC2F	2/13/2013	Camptonville	181	Middle Yuba	11	349
ACCAC2F	2/16/2013	Camptonville	176	Middle Yuba	11	349
ACCAC2F	2/17/2013	Camptonville	176	Middle Yuba	11	349
ACCAC2F	2/18/2013	Camptonville	174	Middle Yuba	11	349
ACCAC2F	2/19/2013	Camptonville	182	Middle Yuba	11	349
ACCAC2F	2/19/2013	Camptonville	182	Middle Yuba	11	349
ACCAC2F	2/19/2013	Camptonville	182	Middle Yuba	11	349
ACCAC2F	2/19/2013	Camptonville	182	Middle Yuba	11	349
ACCAC2F	2/20/2013	Camptonville	177	Middle Yuba	11	349
ACCAC2F	2/25/2013	Camptonville	147	Middle Yuba	11	349
ACCAC2F	2/25/2013	Camptonville	147	Middle Yuba	11	349
ACCAC2F	2/25/2013	Camptonville	147	Middle Yuba	11	349
ACCAC2F	2/25/2013	Camptonville	147	Middle Yuba	11	349
ACCABA3	3/1/2013	Camptonville	130	Middle Yuba	1	237
ACCAC2F	3/1/2013	Camptonville	130	Middle Yuba	11	349
ACCABC6	3/3/2013	Camptonville	154	Middle Yuba	1	170
ACCAC2F	3/3/2013	Camptonville	154	Middle Yuba	11	349
ACCAC2F	3/5/2013	Camptonville	167	Middle Yuba	11	349
ACCAC1A	3/8/2013	Camptonville	186	Middle Yuba	1	162
ACCAC2F	3/13/2013	Camptonville	187	Middle Yuba	11	349
ACCAC2F	3/14/2013	Camptonville	199	Middle Yuba	11	349
ACCAC2F	3/15/2013	Camptonville	214	Middle Yuba	11	349

Table 2. (continued)

PIT Tag Number	Detection Date	Detection Site	Mean Daily Diversion	Location Tagged	Zone Tagged	Forklength
349EA81515	3/20/2013	Camptonville	551	Middle Yuba	7	81
349EA81532	3/26/2013	Camptonville	439	Oregon Creek	13	77
ACCABF6	4/5/2013	Camptonville	498	Middle Yuba	11	129
ACCABF6	4/10/2013	Camptonville	327	Middle Yuba	11	129
ACCABF6	4/11/2013	Camptonville	272	Middle Yuba	11	129
ACCABF6	4/11/2013	Camptonville	272	Middle Yuba	11	129
ACCABF6	4/11/2013	Camptonville	272	Middle Yuba	11	129
ACCABF6	4/11/2013	Camptonville	272	Middle Yuba	11	129
ACCAC1A	4/11/2013	Camptonville	272	Middle Yuba	1	162
ACCABF6	4/12/2013	Camptonville	235	Middle Yuba	11	129
ACCABF6	4/12/2013	Camptonville	235	Middle Yuba	11	129
ACCABF6	4/12/2013	Camptonville	235	Middle Yuba	11	129
ACCABF6	4/13/2013	Camptonville	261	Middle Yuba	11	129
ACCABF6	4/13/2013	Camptonville	261	Middle Yuba	11	129
ACCABF6	4/14/2013	Camptonville	265	Middle Yuba	11	129
ACCABF6	4/14/2013	Camptonville	265	Middle Yuba	11	129
ACCABF6	4/15/2013	Camptonville	258	Middle Yuba	11	129
ACCABF6	4/15/2013	Camptonville	258	Middle Yuba	11	129
ACCABF6	4/15/2013	Camptonville	258	Middle Yuba	11	129
ACCABF6	4/17/2013	Camptonville	218	Middle Yuba	11	129
ACCABF6	4/18/2013	Camptonville	197	Middle Yuba	11	129
ACCABF6	4/18/2013	Camptonville	197	Middle Yuba	11	129
ACCABF6	4/19/2013	Camptonville	183	Middle Yuba	11	129
ACCABF6	4/19/2013	Camptonville	183	Middle Yuba	11	129
ACCABF6	4/19/2013	Camptonville	183	Middle Yuba	11	129
ACCABF6	4/19/2013	Camptonville	183	Middle Yuba	11	129
ACCABF6	4/19/2013	Camptonville	183	Middle Yuba	11	129
ACCABF6	4/20/2013	Camptonville	177	Middle Yuba	11	129
ACCABF6	4/20/2013	Camptonville	177	Middle Yuba	11	129
ACCABF6	4/21/2013	Camptonville	173	Middle Yuba	11	129
ACCABF6	4/21/2013	Camptonville	173	Middle Yuba	11	129
ACCABF6	4/22/2013	Camptonville	130	Middle Yuba	11	129
ACCABF6	4/22/2013	Camptonville	130	Middle Yuba	11	129
ACCABF6	4/23/2013	Camptonville	25	Middle Yuba	11	129
ACCABF6	4/23/2013	Camptonville	25	Middle Yuba	11	129
ACCABF6	4/24/2013	Camptonville	66	Middle Yuba	11	129
ACCABF6	4/24/2013	Camptonville	66	Middle Yuba	11	129
ACCABF6	4/25/2013	Camptonville	107	Middle Yuba	11	129
ACCABF6	4/25/2013	Camptonville	107	Middle Yuba	11	129
ACCABF6	4/26/2013	Camptonville	149	Middle Yuba	11	129
ACCABF6	4/26/2013	Camptonville	149	Middle Yuba	11	129
ACCABF6	4/26/2013	Camptonville	149	Middle Yuba	11	129
ACCABF6	4/27/2013	Camptonville	144	Middle Yuba	11	129
ACCABF6	4/27/2013	Camptonville	144	Middle Yuba	11	129
ACCABF6	4/28/2013	Camptonville	143	Middle Yuba	11	129
ACCABF6	4/28/2013	Camptonville	143	Middle Yuba	11	129
ACCABF6	4/28/2013	Camptonville	143	Middle Yuba	11	129
ACCABF6	4/28/2013	Camptonville	143	Middle Yuba	11	129
ACCABF6	4/28/2013	Camptonville	143	Middle Yuba	11	129
ACCABF6	4/29/2013	Camptonville	142	Middle Yuba	11	129
ACCABF6	4/29/2013	Camptonville	142	Middle Yuba	11	129
ACCABF6	4/29/2013	Camptonville	142	Middle Yuba	11	129

Table 2. (continued)

PIT Tag Number	Detection Date	Detection Site	Mean Daily Diversion	Location Tagged	Zone Tagged	Forklength
ACCABF6	4/29/2013	Camptonville	142	Middle Yuba	11	129
ACCABF6	4/29/2013	Camptonville	142	Middle Yuba	11	129
ACCABF6	4/29/2013	Camptonville	142	Middle Yuba	11	129
ACCABF6	4/29/2013	Camptonville	142	Middle Yuba	11	129
ACCABF6	4/30/2013	Camptonville	139	Middle Yuba	11	129
ACCABF6	4/30/2013	Camptonville	139	Middle Yuba	11	129
ACCABF6	4/30/2013	Camptonville	139	Middle Yuba	11	129
ACCABF6	4/30/2013	Camptonville	139	Middle Yuba	11	129
ACCABF6	5/1/2013	Camptonville	126	Middle Yuba	11	129
ACCABF6	5/1/2013	Camptonville	126	Middle Yuba	11	129
ACCABF6	5/1/2013	Camptonville	126	Middle Yuba	11	129
ACCABF6	5/1/2013	Camptonville	126	Middle Yuba	11	129
ACCABF6	5/2/2013	Camptonville	111	Middle Yuba	11	129
ACCABF6	5/2/2013	Camptonville	111	Middle Yuba	11	129
ACCABF6	5/4/2013	Camptonville	86	Middle Yuba	11	129
ACCABF6	5/5/2013	Camptonville	82	Middle Yuba	11	129
ACCAC3B	5/11/2013	Camptonville	75	Middle Yuba	1	316
ACCABB6	5/13/2013	Camptonville	61	Middle Yuba	1	208
ACCAB9B	5/15/2013	Camptonville	51	Middle Yuba	7	220
ACCABC6	6/29/2013	Camptonville	10	Middle Yuba	1	170

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