Application for a New License Major Project – Existing Dam

Lower Yuba River Aquatic Monitoring Plan

Security Level: Public

Yuba River Development Project

FERC Project No. 2246

December 2016

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GLOSSARY – DEFINITIONS OF TERMS, ACRONYMS AND ABBREVIATIONS

Term	Definition
BMI	Benthic Macroinvertebrate
°C	degrees Celsius
Cal Fish and Wildlife	California Department of Fish and Wildlife
CWT	Coded-Wire Tags
Ecological Group	The group formed by YCWA's Proposed Measure GEN1, *Organize and Hold Ecological Group Meetings*
FERC	Federal Energy Regulatory Commission
Forest Service	United States Department of Agriculture, Forest Service
GIS	Geographic Information System
GPS	Global Positioning System
Hydrolab	Hydrolab DataSonde 5
LWM	Large Woody Material
NFS	National Forest System
NMFS	United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service
Plan	Lower Yuba River Aquatic Monitoring Plan
PNF	Plumas National Forest
Project	Yuba River Development Project, FERC Project No. 2246
RST	rotary screw trap
SWRCB	State Water Resources Control Board
TNF	Tahoe National Forest
USFWS	United States Department of the Interior, Fish and Wildlife Service
USACE	United States Army Corps of Engineers
YCWA	Yuba County Water Agency

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SECTION 1.0 INTRODUCTION

In April 2014, the Yuba County Water Agency (YCWA), pursuant to Section (§) 5.18 of Title 18 of the Code of Federal Regulations, filed with the Federal Energy Regulatory Commission (FERC) an Application for a New License for Major Project – Existing Dam - for YCWA's 361.9 megawatt Yuba River Development Project, FERC No. 2246 (Project). In December 2016, YCWA amended its April 2014 Application for a New License. The initial license for the Project was issued by the Federal Power Commission (FERC's predecessor) to YCWA on May 16, 1963, effective on May 1, 1963. The Federal Power Commission's May 6, 1966, Order Amending License changed the license's effective date to May 1, 1966, for a term ending on April 30, 2016.

YCWA included this Lower Yuba River[1] Aquatic Monitoring Plan (Plan) in its December 2016 Amended Application for a New License.

The United States Department of Agriculture, Forest Service's (Forest Service) Federal Power Act Section 4(e) authority only applies in this Plan to monitoring sites on National Forest System (NFS) lands. The Forest Service administers the Plumas National Forest (PNF) in conformance with the PNF Land and Resource Management Plan (Forest Service 1988), as subsequently amended, and administers the Tahoe National Forest (TNF) in conformance with TNF Land and Resource Management Plan (Forest Service 1990), as subsequently amended. When the TNF or PNF Forest Plan revisions occur, those revised plans will supersede the 1990 TNF and 1988 PNF plans.

1.1 Background

1.1.1 Yuba River Development Project

The Project is located in Yuba, Sierra and Nevada counties, California, on the main stems of the Yuba River, the North Yuba River and the Middle Yuba River, and on Oregon Creek, a tributary to the Middle Yuba River. Major Project facilities, which range in elevation from 280 feet to 2,049 feet, include: 1) New Bullards Bar Dam and Reservoir; 2) Our House and Log Cabin diversion dams; 3) Lohman Ridge and Camptonville diversion tunnels; 4) New Colgate and Narrows 2 power tunnels and penstocks; 5) New Colgate, New Bullards Minimum Flow and Narrows 2 powerhouses; and 6) appurtenant facilities and features (e.g., administrative buildings, switchyards, roads, trails and gages). The existing Project does not include any above-ground open water conduits (e.g., canals or flumes) or any transmission lines.

[1] For the purposes of this Plan, "Upper Yuba River" means the collective stream segments: Middle Yuba River from Our House Diversion Dam to the confluence with the North Yuba River; Oregon Creek from Log Cabin Diversion Dam to the confluence with the Middle Yuba River; the North Yuba River from New Bullards Bar Dam to the confluence with the Middle Yuba River and the Yuba River from the North and Middle Yuba rivers to the normal maximum water surface elevation of Englebright Reservoir.

In addition, the Project includes 16 developed recreation facilities. These include: 1) Hornswoggle Group Campground; 2) Schoolhouse Campground; 3) Dark Day Campground; 4) Cottage Creek Campground;[2] 5) Garden Point Boat-in Campground; 6) Madrone Cove Boat-in Campground; 7) Frenchy Point Boat-in Campground; 8) Dark Day Picnic Area; 9) Sunset Vista Point; 10) Dam Overlook; 11) Moran Road Day Use Area; 12) Cottage Creek Boat Launch;[3] 13) Dark Day Boat Launch, including the Overflow Parking Area; 14) Schoolhouse Trail; 15) Bullards Bar Trail; and 16) floating comfort stations.[4] All of the recreation facilities are located on NFS land, with the exception of the Dam Overlook, Cottage Creek Boat Launch and small portions of the Bullards Bar Trail, which are located on land owned by YCWA. All of the developed recreation facilities are located within the existing FERC Project Boundary, except for a few short segments of the Bullards Bar Trail to the east of the Dark Day Boat Launch. In addition, the Project includes two undeveloped recreation sites at Our House and Log Cabin diversion dams, both located on NFS land and within the existing FERC Project Boundary.

Figure 1.1-1 shows the Project Vicinity,[5] proposed Project, and proposed FERC Project Boundary.[6]

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[2] Cottage Creek Campground was burned in 2010 and has not been rebuilt. Yuba County Water Agency (YCWA) is in discussions with the United States Department of Agriculture (Forest Service) regarding rebuilding the burned campground.

[3] Emerald Cove Marina provides visitor services at Cottage Creek Boat Launch, including houseboat and boat rentals, boat slips and moorings, fuel and a general store. The marina is operated under a lease from YCWA by a private company.

[4] The Project recreation facilities included one campground that is no longer part of the Project. Burnt Bridge Campground was closed initially by the Forest Service in 1979 due to low use levels. The Federal Energy Regulatory Commission (FERC), in an August 19, 1993 Order which approved YCWA's Revised Recreation Plan, directed YCWA to remove all improvements and restore the Burnt Bridge Campground to the condition it was in prior to development of the facility. YCWA consulted with the Forest Service and all that remains of Burnt Bridge Campground today is the circulation road and vehicle spurs; all other facilities were removed.

[5] For the purpose of this Plan, "Project Vicinity" refers to the area surrounding the proposed Project on the order of United States Geological Survey 1:24,000 quadrangles.

[6] The FERC Project Boundary is the area that YCWA uses for normal Project operations and maintenance. The Boundary is shown in Exhibit G of YCWA's Application for New License, and may be changed by FERC with cause from time to time during the term of the new license.

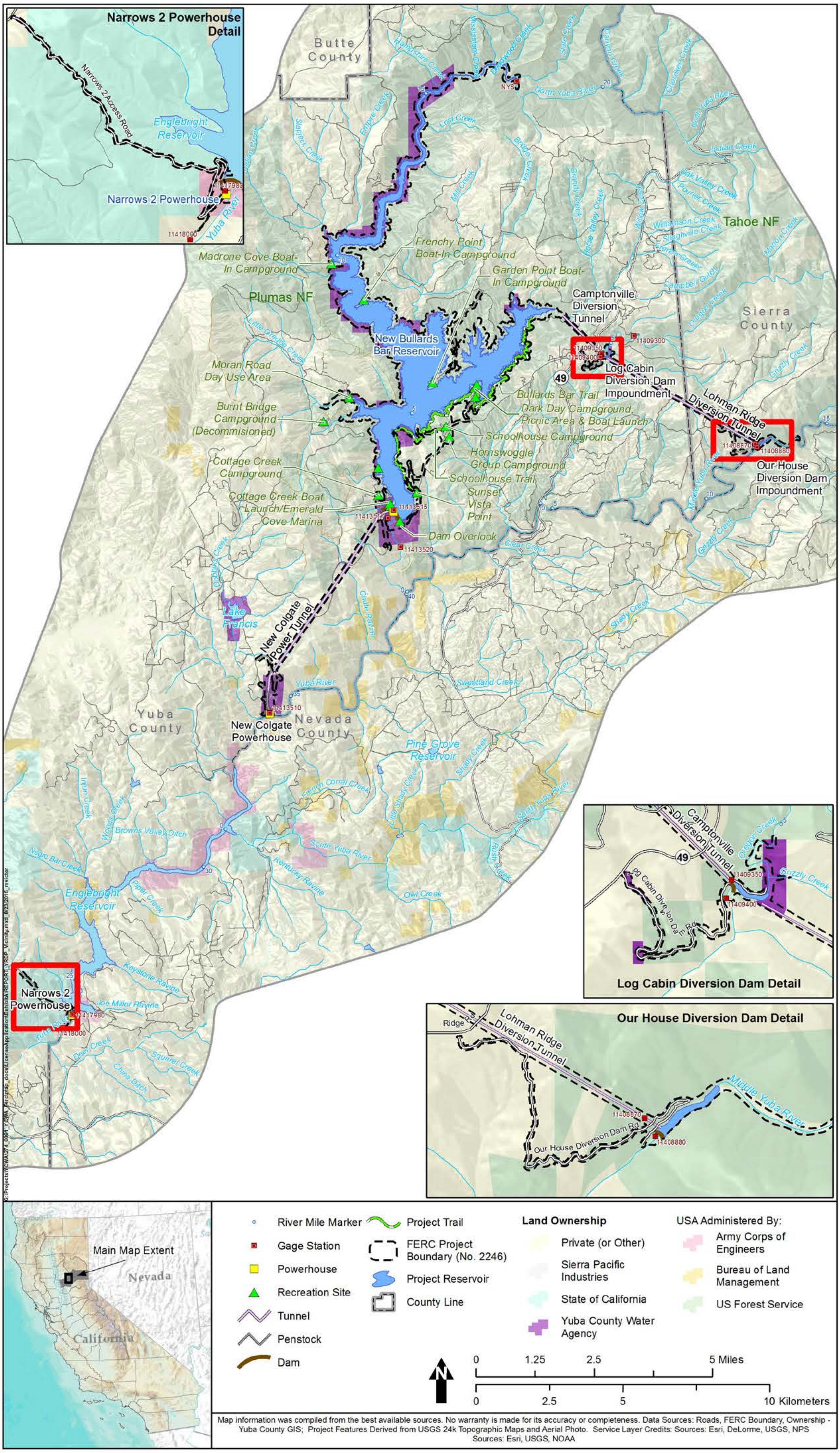

Figure 1.1-1. Yuba County Water Agency's Yuba River Development Project and Project Vicinity.

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1.2 Purpose of the Lower Yuba River Aquatic Monitoring Plan

The purpose of the Plan is to develop information regarding aquatic resources in the Lower Yuba River in response to changes in flow conditions from the initial license to the new license.

YCWA will coordinate, to the extent appropriate, the efforts required under this Plan with other Project resource efforts, including implementation of other resource management plans and measures included in the new license.

1.3 Objectives of the Lower Yuba River Aquatic Monitoring Plan

The objectives of the Plan are as follows:

- Monitor passage of fish by species at Daguerre Point Dam year-round
- Monitor annual spawning population abundance for spring-run Chinook salmon, fall-run Chinook salmon and steelhead
- Monitor the temporal and spatial distributions and habitat use of spawning steelhead upstream and downstream of Daguerre Point Dam
- Monitor abundance, size and timing of emigrating salmonids
- Monitor interactions of anadromous fish with Narrows 2 Facilities and operations
- Monitor channel substrate and large woody material (LWM)
- Monitor riparian vegetation cover and community structure
- Monitor benthic macroinvertebrate (BMI) community structure

This Plan does not include water temperature or water quality monitoring in the lower Yuba River because they are addressed in the relicensing Water Temperature Monitoring Plan and the relicensing Water Quality Monitoring Plan.

1.4 Contents of the Lower Yuba River Aquatic Monitoring Plan

This Plan includes the following:

- Section 1.0. Introduction. This section includes introductory information, including a description of the Project and the purpose and goals of the Plan.
- Section 2.0. Monitoring Methods and Analysis. This section describes the monitoring methods and analysis that will be used to monitor and analyze aquatic data.
- Section 3.0. Consultation, Reporting and Plan Revisions. This section describes consultation, reporting and Plan revisions.
- Section 4.0. References Cited. This section lists references cited in this Plan.

SECTION 2.0 MONITORING METHODS AND ANALYSIS

This section describes, by resource area, the methods that will be used to monitor aquatic resources in the Lower Yuba River. [7]

2.1 Concepts That Apply to All Aquatic Monitoring

The following concepts and practices apply to all aquatic monitoring:

- Personal safety is the most important consideration of each fieldwork team.
- Prior to performing fieldwork, YCWA will obtain all necessary permits and approvals required to perform the fieldwork (e.g., scientific collection permits). All fieldwork will be performed by individuals who hold the necessary current permits to perform the fieldwork.
- All fieldwork will occur under normal operating flow conditions (i.e., requests for variance to minimum streamflow requirements not needed).
- YCWA will make a good faith effort to obtain permission to access private property, where needed, well in advance of entering the property.
- Prior to performing fieldwork, YCWA shall notify the United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS); United States Department of Interior, Fish and Wildlife Service (USFWS); California Department of Fish and Wildlife (Cal Fish and Wildlife); and State Water Resources Control Board (SWRCB).
- YCWA's performance of the monitoring does not presume that YCWA is responsible in whole or in part for measures that may arise from the monitoring.
- Where required, Global Positioning System (GPS) data will be collected using either a Map Grade Trimble GPS (sub-meter data collection accuracy under ideal conditions), a Recreation Grade Garmin GPS unit (3 meter data collection accuracy under ideal conditions), or similar units. GPS data will be post-processed and exported from the GPS unit into Geographic Information System (GIS) compatible file format in an appropriate coordinate system using desktop software. The resulting GIS file will then be reviewed by both field staff and YCWA's GIS analyst. Metadata will be developed for GIS data sets.

[7] Besides the Lower Yuba River aquatic monitoring described in this Plan, specific resource monitoring is identified in five other license implementation plans. The Log Cabin and Our House Diversion Dams Sediment Management Plan requires that, prior to excavating sediment from the Log Cabin Diversion Dam impoundment and the Our House Diversion Dam impoundment, YCWA samples the sediment to be removed for hazardous metals; and that, during sediment excavation in the impoundment, YCWA monitor water entering the creek form the impoundment for turbidity and dissolved oxygen. The Water Temperature Monitoring Plan describes water temperature monitoring, and the Water Quality Monitoring Plan describes water quality monitoring. The Streamflow and Reservoir Level Compliance Monitoring Plan describe the gages at which YCWA will perform streamflow and reservoir level compliance monitoring. Last, the Upper Yuba River Aquatic Monitoring Plan descries aquatic monitoring upstream of Englebright Dam.

- YCWA's field crews will record incidental observations of aquatic and wildlife species observed during the performance of the monitoring. The purpose of this effort is not to conduct a focused study (i.e., no effort in addition the specific field tasks identified for the specific study) or to make all field crews experts in identifying all species, but only to opportunistically gather data during the performance of the study. In particular, all incidental observations of at least the following species will be recorded: foothill yellow-legged frogs (FYLF, *Rana boylii*), western pond turtle (WPT, *Actinemys marmorata*), western ridge mussel (*Gonidea angulate*), beaver (*Castor canadensis*), river otter (*Lontra canadensis*), didymo (*Didymosphenia geminata*), invasive centrarchids (e.g., bluegill, crappie, yellow perch, largemouth bass and smallmouth bass), striped bass, giant reed (*Arundo donax*), American bullfrog (*Lithobates catesbeianus*) and North American green sturgeon (*Acipenser medirostris*), and field crews will be trained on the identification of these species. Any fish species easily distinguishable, but previously not observed in the study reaches will also be noted. The incidental observation records will include the species, location, and an estimate of number of individuals per observation. Records of special-status species observations will be submitted to the California Natural Diversity Database , and included in the appropriate monitoring reports.

- Field crews will be trained on and provided with materials (e.g., Quat) for decontaminating their boots, waders and other equipment between monitoring sites. Major concerns are amphibian chytrid fungus and invasive invertebrates (e.g., zebra mussel [*Dreissena polymorphaI*]). Field crews will adhere to accepted decontamination guidelines to minimize the likelihood of transmitting diseases (USFWS 2005), as appropriate.

- During each monitoring event at each monitoring site, YCWA will collect *in situ* water quality measurements at one location within the monitoring site. The measurements will include water temperature (±0.1°C), dissolved oxygen (±0.2 mg/L), specific conductance (±0.001 micromhos per centimeter [µomhos/cm]), pH (±0.1 units) and turbidity ((±0.1 Nephelometric Turbidity Units, NTU). These will be measured using a Hydrolab DataSonde 5 or other similar instrument that has equivalent precision and accuracy. Prior to and after each use, the instrument will be calibrated using manufacturer's recommended calibration methods, and any variances will be noted on the field data sheet and final report and recalibration or repair done as necessary. In addition, site identification including GPS coordinates at top and bottom of a site, air temperature, weather conditions, date and time of the monitoring and field crew members will also be recorded on the field data sheet. The measurements will be taken at the beginning of the monitoring event and, if the monitoring takes more than 3 hours, at the end of the monitoring event.

2.2 Salmonid Monitoring

To allow for comparison of post-license anadromous salmonid information[8] with pre-license issuance information, the post-license issuance monitoring generally will use the same methods and be at the same locations as the pre-license issuance sampling. Anadromous salmonid monitoring methods are described below.

2.2.1 Salmonid Spawning Stock Escapement

Based upon redd surveys and the timing of Chinook salmon spawning in the Lower Yuba River, spring-run Chinook salmon (*Oncorhynchus tshawytscha*) spawning occurs upstream of Daguerre Point Dam (RMT 2013; YCWA 2014). Consequently, annual spring-run Chinook salmon spawning stock escapement can be estimated by application of the VAKI Riverwatcher™ system data and associated abundance estimation (see below). By contrast, fall-run Chinook salmon spawning occurs both upstream and downstream of Daguerre Point Dam. Fall-run Chinook salmon spawning stock escapement includes that portion of the run passing upstream of Daguerre Point Dam, as indicated by the VAKI Riverwatcher™ system data, and that portion of the run spawning downstream of Daguerre Point Dam estimated through carcass surveys. Although the vast majority (about 85 – 95%) of steelhead (*O. mykiss*) redds are located upstream of Daguerre Point Dam (USFWS 2007; RMT 2013), some spawning does occur downstream of the dam. However, because not all steelhead die after spawning, carcass surveys are not conducted to estimate spawning stock escapement abundance of steelhead. Instead, the annual abundance of steelhead spawning downstream of Daguerre Point Dam is estimated through steelhead redd surveys. All of these specific monitoring components are described in detail below.

2.2.1.1 VAKI Riverwatcher™ Monitoring

2.2.1.1.1 Monitoring Component Objectives

For each year of monitoring (i.e., a "biological year", described below), the time series of VAKI Riverwatcher™ fish passage data will be evaluated to accomplish the technical objectives of characterizing:

- The temporal distributions of Chinook salmon and steelhead net daily passage upstream of Daguerre Point Dam over a biological year, defined as extending from March 1 through February 28 for Chinook salmon and from August 1 through July 31 of the next year for steelhead (RMT 2013)
- The temporal distributions of adipose fin-clipped Chinook salmon and steelhead net daily passage upstream of Daguerre Point Dam over a "biological year"
- The annual abundance of spring-run and fall-run Chinook salmon, and steelhead upstream of Daguerre Point Dam, for both adipose fin-clipped and non-clipped fish

[8] Information regarding anadromous salmonids in the Lower Yuba River prior to issuance of the new license is included in Technical Memorandum 7-8, *ESA- and CESA-Listed Salmonids Below Englebright Dam*, in Appendix E6 of Exhibit E in YCWA's Application for New License.

- Multi-year trends in the abundance and temporal distributions of both adipose fin-clipped and non-clipped spring-run and fall-run Chinook salmon, and steelhead that pass upstream of Daguerre Point Dam
- Annual and multi-year temporal distributions of Chinook salmon and steelhead net daily passage upstream of Daguerre Point Dam and potential associations with corresponding time series of Lower Yuba River flows and water temperatures
- The annual length-frequency distributions of spring-run and fall-run Chinook salmon, and steelhead that pass upstream of Daguerre Point Dam

2.2.1.1.2 Survey Area

Daguerre Point Dam is located approximately 11.5 mi upstream from the mouth of the Lower Yuba River and has two fish ladders (located on the north and south sides of the dam) to allow fish passage. Each ladder is currently outfitted with a VAKI Riverwatcher™ system.

2.2.1.1.3 Sampling Period and Frequency

In the first full calendar year following license issuance, YCWA will apply for the permits and approvals necessary to install and maintain a VAKI Riverwatcher™ system, or similar system, in each of the fish ladders at Daguerre Point Dam. Within 6 months of obtaining the permits and approvals continuing until YCWA obtains a new license, YCWA will monitor fish passage of adult Chinook salmon and steelhead using two VAKI Riverwatcher™ systems, or a similar system,[9] at Daguerre Point Dam. Both VAKI Riverwatcher™ systems will operate continuously (i.e., year-round).

Passage data from both VAKI Riverwatcher™ systems will be downloaded every Monday, or as soon thereafter if a given Monday is an observed holiday, or if staff is not available due to illness, injury, or other unanticipated reason. Files will be transferred onto a universal serial bus flash drive. These files will be subsequently uploaded to the database computer. The uploaded data will be analyzed weekly and reviewed for quality assurance and quality control . All data will be routinely backed-up to an external hard drive.

2.2.1.1.4 Data Collection

The VAKI Riverwatcher™ infrared system records both silhouettes and electronic images of each fish passage event in both of the Daguerre Point Dam fish ladders. The time/date of each fish passage event, the upstream or downstream direction of passage, the speed of the fish moving through the system in meters per second (m/sec), and the fish's body depth in millimeters (mm) will be collected. In addition, digital photography and videographic imaging will be conducted concurrently with VAKI Riverwatcher™ imaging. Daily time series indicating the number of hours per day that the VAKI Riverwatcher™ systems were fully operational at each Daguerre Point Dam ladder will be reported for each monitoring year.

[9] For the purpose of this Plan, YCWA assumes the VAKI Riverwatcher™ system will be used. However, YCWA may choose to use a different system that provides equivalent data as the VAKI Riverwatcher™ system, pending FERC approval (see Plan Revisions, Section 3.3 of this Plan).

Since their installation in 2003, although the VAKI Riverwatcher™ systems have been operational during most days of the year, system failures reduced the ability of the equipment to document Daguerre Point Dam ladder use during some months. VAKI Riverwatcher™ system non-operation events will be classified into one or more of three categories: (1) low-voltage disconnections ; (2) system maintenance; and or (3) unknown malfunctions. Due to these system outages, a complete census of the adult Chinook salmon and steelhead migrating daily upstream of Daguerre Point Dam is not always be possible for each year. The manner in which the data will be processed during periods of system non-operation events is described in Data Processing, Section 2.2.1.1.5.1 of this Plan.

YCWA will notify USFWS, Cal Fish and Wildlife, SWRCB, and NMFS within 3 days if either VAKI Riverwatcher™ system is not operational for greater than 6 hours in a 24-hour period. If either VAKI Riverwatcher™ system is not operational for greater than 24 hours, YCWA will notify USFWS, Cal Fish and Wildlife, SWRCB, and NMFS within 2 days with explanation of the operational outage and a plan and expected time frame to return the system to regular operation. YCWA will notify USFWS, Cal Fish and Wildlife, SWRCB, and NMFS within 24 hours of when the system becomes operational again. If the VAKI Riverwatcher™ system is operating at less than 95 percent efficiency over a period of greater than 7 days, YCWA will notify USFWS, Cal Fish and Wildlife, SWRCB, and NMFS within 21 days, with explanation of the operational outage and a plan and expected time frame to return the system to 100 percent efficiency.

2.2.1.1.5 Data Processing

Data collected for individual fish passage events will be reviewed to: 1) identify fish species; 2) examine if Chinook salmon have an adipose fin; and 3) identify non-fish passage events (e.g., debris). Body depth of a fish will be converted to a length measurement in centimeters (cm) utilizing a body length-to-depth ratio.

2.2.1.1.5.1 Complete Annual Daily Time Series of Chinook Salmon Passage

Prior to applying any analysis of temporal modalities to the annual time-series of Chinook salmon daily counts, the annual daily count series at each Daguerre Point Dam ladder will be adjusted to account for days when the VAKI Riverwatcher™ systems are not fully operational. The procedure used to obtain complete annual daily counts of Chinook salmon passing upstream of Daguerre Point Dam will be based on fitting smoothing splines to the observed daily counts.

Various smoothing splines will be fitted to each of the two available time-series (north and south Daguerre Point Dam ladders, respectively, for a particular biological year) varying the value of their smoothing parameter λ until the residual deviance is no longer minimized with increasing value of λ to identify the best fitted spline for each time series. The values predicted by the spline on days of partial operation of the VAKI Riverwatcher™ systems will be used to adjust Chinook salmon daily passage counts for days when the VAKI Riverwatcher™ systems are not fully operational. Once this process is finished for the series of daily counts separately for the north ladder and the south ladder, the resulting corrected series will be combined into one series of daily counts of Chinook salmon moving upstream of Daguerre Point Dam by summing the corresponding daily values for each ladder.

Once daily counts of Chinook salmon moving upstream of Daguerre Point Dam are determined, four series of daily tallies of Chinook salmon will be prepared - one per ladder (i.e., north or south) and direction of movement (i.e., upstream or downstream). Then, the daily counts in the "Downstream" series of a particular ladder will be subtracted from the daily counts in the corresponding "Upstream" series to generate a series of "net" daily counts of upstream passage per ladder. The approach of using net upstream passage was adopted by the RMT based upon observations of individuals: 1) repeatedly passing upstream, then "falling back" through the systems, and again passing upstream; and 2) swimming back-and-forth in front of the detection device and cameras, both of which can result in potential overestimation of total upstream passage. The resulting two series of "net" daily counts will be summed by day to generate one series of net daily counts of Chinook salmon moving upstream of Daguerre Point Dam each year.

2.2.1.1.5.2 Spring-run vs. Fall-run Chinook Salmon Demarcation

The procedure to select annually variable temporal demarcation dates to separate spring-run and fall-run Chinook salmon during the annual time series of Chinook salmon daily passage upstream of Daguerre Point Dam will consist of the following steps:

- Step 1. For the particular biological year y of Chinook salmon VAKI Riverwatcher™ data, select the first temporal demarcation (i.e., a cutting day) D from the range D = 107 through D = 199 (i.e., with D 107 representing June 15 and D 199 representing September 15).
- Step 2. Separate the set of daily observations n_d for year y into two subsets. One subset that includes all observations that occur prior to day D will describe potential spring-run Chinook salmon counts upstream of Daguerre Point Dam, and will sum to a total N_S. The other subset that includes all observations that occur from day D through day 365 or 366 (leap year) will describe potential fall-run Chinook salmon counts upstream of Daguerre Point Dam, and will sum to a total N_F.
- Step 3. Calculate the daily relative cumulative distributions for the two data subsets of the previous step. The cumulative distribution of potential spring-run Chinook salmon daily observations to day $d = X$ will be calculated as $Ys_X = \sum_{d=1}^{X<D} n_d \big/ N_S$, while the cumulative distribution of potential fall-run Chinook salmon daily observations through day $d = X$ will be calculated as $Y_{F_X} = \sum_{d \geq D}^{X \leq 365} n_d \big/ N_F$.
- Step 4. Fit an asymmetric logistic function (Richards 1959) to each of the two sets of daily relative cumulative distributions calculated in the previous step using a nonlinear minimum least squares procedure. The asymmetric logistic distribution is used because it is desired that the smoothed function representing each group should be continuous, unimodal and plastic enough to allow for asymmetry.

- Step 5. The expected cumulative distribution of potential spring-run Chinook salmon daily passage upstream of Daguerre Point Dam to day d = X as represented by the corresponding fitted asymmetric logistic function has the formula: $\hat{Y}S_X = 1 \big/ \left[1 + \exp\left(\alpha_S - \beta_S \times X\right)\right]^{(1/\delta_S)}$. Similarly, the expected cumulative distribution of potential fall-run Chinook salmon daily passage upstream of Daguerre Point Dam through day d = X as represented by the corresponding fitted asymmetric logistic function has the formula: $\hat{Y}F_X = 1 \big/ \left[1 + \exp\left(\alpha_F - \beta_F \times X\right)\right]^{(1/\delta_F)}$. The α_S, α_F, β_S, β_F, δ_S and δ_F are the fitted parameter values that describe the shapes of the resulting distribution functions. In particular, the parameter δ, whose value is constrained to be greater than or equal to 0.1 and less than or equal to 10, determines the asymmetry of the resulting functions.
- Step 6. Using the fitted asymmetric logistic functions from the previous step, calculate $\hat{n}_d$ with formula $\hat{n}_d = N_S \times \left(\hat{Y}S_{d+1} - \hat{Y}S_d\right) + N_F \times \left(\hat{Y}F_{d+1} - \hat{Y}F_d\right)$, where $\hat{n}_d$ is the expected number of Chinook salmon on day d and N_S and N_F are as defined in Step 2.
- Step 7. Calculate and record the proportion of the annual daily variability explained by the expected daily observations $\hat{n}_d$ using the following formula:

$$\varphi_D^2 = 1 - \frac{\sum_{d=1}^{365}\left(n_d - \hat{n}_d\right)^2}{\sum_{d=1}^{365}\left(n_d - \bar{n}\right)^2}$$

  where $\bar{n}$ is the annual average of the daily Chinook salmon observations n_d.
- Step 8. Select the next temporal demarcation (*i.e*., a cutting date) D from the range D = 107 through D = 199, and repeat *Steps* 2 through 7.
- Step 9. Repeat Step 8 with each of the remaining cutting dates D.
- Step 10. Once an φ_D^2 has been obtained for each of the D from the range 107 through 199 corresponding to the selected year y, select the maximum φ_D^2 in the set. The selected temporal demarcation D_{max} for year y is the cutting date D associated with the maximum φ_D^2 in the set.

Once the above procedure to select annually variable temporal demarcations has been applied to a biological year of Chinook salmon daily VAKI Riverwatcher™ system counts and a temporal demarcation D_{max} has been selected, the abundance of spring-run Chinook salmon upstream of Daguerre Point Dam will be calculated by summing the observed Chinook salmon daily counts for all days prior to the day corresponding to D_{max}. The abundance of fall-run Chinook salmon upstream of Daguerre Point Dam will be calculated as the sum of the Chinook salmon daily counts for the remaining days that year.

2.2.1.1.5.3 Steelhead Identification

A fish identified as *O. mykiss* passing through the Daguerre Point Dam VAKI Riverwatcher™ systems will be classified as adult steelhead if its length is 16 inches or longer. If the length of a fish identified as *O. mykiss* passing through Daguerre Point Dam is less than 16 inches, then the fish will be considered to be "other" *O. mykiss* (e.g., juvenile or adult rainbow trout, or juvenile steelhead).

2.2.1.1.5.4 Complete Annual Daily Time Series of Adult Steelhead Passage

Four series of daily tallies of adult steelhead will be prepared - one per ladder (i.e., north or south) and direction of movement (i.e., Upstream or Downstream). Then, the daily counts in the "Downstream" series of a particular Daguerre Point Dam ladder will be subtracted from the daily counts in the corresponding "Upstream" series to generate a series of "net" daily counts of upstream passage per Daguerre Point Dam ladder. The resulting two series of "net" daily counts will be summed by day to generate one series of net daily counts of steelhead moving upstream of Daguerre Point Dam each year.

Unlike the methodology employed for Chinook salmon, the daily counts of adult steelhead passing upstream of Daguerre Point Dam are not corrected for days when the VAKI Riverwatcher™ systems are not fully operational. The RMT (2013a) determined it would be inappropriate to attempt to correct the adult steelhead counts due to: 1) the relatively low numbers of adult steelhead recorded during most of the steelhead biological years; and 2) the frequently extended durations when the VAKI Riverwatcher™ systems were not fully operational during the steelhead immigration season. Instead, the daily counts of adult steelhead passing upstream at Daguerre Point Dam are used to represent the abundance of steelhead, with the understanding that the resultant estimates are minimum numbers, and most of the survey years considerably underestimate the potential number of steelhead because the annual estimates do not include periods of VAKI Riverwatcher™ system non-operation (including the inability to obtain clear photographs), and do not consider the fact that not all steelhead migrate past Daguerre Point Dam, due to some spawning occurring downstream of Daguerre Point Dam (RMT 2013).

2.2.1.1.6 Data Analysis

2.2.1.1.6.1 Daily Passage at Daguerre Point Dam and Annual Abundance

A histograph will be prepared displaying the daily number of Chinook salmon that pass upstream of Daguerre Point Dam during each Chinook salmon biological year. The fitted generalized logistic functions describing the distributions of spring-run and fall-run Chinook salmon resulting from the application of the annually variable temporal demarcation procedure will be overlaid on the histograph.

A table will be prepared summarizing the total number of spring-run and fall-run Chinook salmon estimated to have passed upstream of Daguerre Point Dam annually, and the estimated annual percentage of spring-run Chinook salmon relative to all Chinook salmon each year. An additional table will be prepared differentiating the counts of Chinook salmon with adipose fin clips from those without adipose fin clips, as well as the annual percentage contribution of adipose-clipped phenotypic spring-run Chinook salmon to the total estimated annual run of spring-run Chinook salmon, and separately for fall-run Chinook salmon.

A histograph will be prepared displaying the daily number of steelhead that pass upstream of Daguerre Point Dam during each steelhead biological year. A table will be prepared differentiating the counts of steelhead with adipose fin clips from those without adipose fin clips, and the annual percentage contribution of ad-clipped steelhead to the total estimated annual run of steelhead.

2.2.1.1.6.2 Multi-Year Trends

The statistical approach recommended by Lindley et al. (2007) will be followed to examine whether the abundance of both adipose fin-clipped and non-adipose fin-clipped spring-run Chinook salmon, fall-run Chinook salmon, and steelhead exhibit a statistically significant linear trend over time during the years for which reliable VAKI Riverwatcher™ data are available. The natural logarithms of the annual abundance estimates of these salmonids will be linearly regressed against time using a simple least-squares approach. The estimated slope of the resulting line is a measure of the average rate of change of the abundance in the population over time. The antilogarithmic transformation of the estimated annual numbers of these groups of salmonids passing upstream of Daguerre Point Dam will be plotted, along with the regression line. The coefficient of determination (r2) and the level of significance (P) will be indicated.

2.2.1.1.6.3 Relation to Flows and Water Temperature

To examine potential relationships between flows and water temperatures in the Lower Yuba River and passage at Daguerre Point Dam, the daily counts of spring-run Chinook salmon, fall-run Chinook salmon and steelhead will be plotted with mean daily flows and water temperatures at the Marysville gage (USGS Gage 11421000).

To evaluate the influence of “attraction” flows and water temperatures on the straying of adipose fin-clipped adult phenotypic spring-run Chinook salmon into the lower Yuba River, variables related to flows and water temperatures in the Lower Yuba River at the Marysville Gage and the lower Feather River at the Gridley Gage (USGS Gage 11407150, which is maintained and operated by USGS) will be developed and statistically related to the weekly proportions of adipose fin-clipped phenotypic spring-run Chinook salmon (relative to all spring-run Chinook salmon) passing upstream of Daguerre Point Dam during each of the years when annual VAKI Riverwatcher™ counts at Daguerre Point Dam are available (i.e., since 2004). The Marysville Gage is located on the Yuba River approximately 6 mi upstream of the Feather River confluence and the Gridley Gage is located on the Feather River approximately 20 mi upstream confluence with the Yuba River.

For the multi-year annual phenotypic spring-run Chinook salmon adult immigration periods, the daily numbers of adipose-fin-clipped (*i.e.*, $n_{\text{Ad-clip}_w}$) and not adipose-fin-clipped (*i.e.*, $n_{\text{Not Ad-clip}_w}$) spring-run Chinook salmon that pass upstream of Daguerre Point Dam will be combined into weekly proportions of adipose-fin -clipped fish (*i.e.*, $\pi_{\text{Ad-clip}_w}$) using the formula:

$$\pi_{\text{Ad-clip}_w} = \sum_{i=d}^{d+6} n_{\text{Ad-clip}_i} \Big/ \sum_{i=d}^{d+6} \left(n_{\text{Ad-clip}_i} + n_{\text{Not Ad-clip}_i} \right).$$

Each year, the first weekly proportion corresponds to the week that starts on the date of the first phenotypic spring-run count at Daguerre Point Dam, and the last weekly proportion corresponds to the last week ending prior to the annual demarcation date of phenotypic spring-run and fall-run Chinook salmon.

The relationship of the weekly proportion of adipose-fin-clipped phenotypic spring-run Chinook salmon will be modeled as a logistic response to variables developed to measure the weekly attraction influence of the Yuba River flows (i.e., X_{Q_w}) and water temperatures (i.e., X_{WT_w}), relative to flows and water temperatures in the lower Feather River. Details on the computation of these "attraction" variables are provided below. The modeled response of the weekly proportions $\pi_{\text{Ad-clip}_w}$ as a function of the attraction variables X_{Q_w} and X_{WT_w} has the expression:

$$\pi_{\text{Ad-clip}_w} = \frac{\exp\left(\alpha + \beta_1 \times X_{Q_w} + \beta_2 \times X_{WT_w} + \beta_3 \times X_{Q_w} \times X_{WT_w}\right)}{1 + \exp\left(\alpha + \beta_1 \times X_{Q_w} + \beta_2 \times X_{WT_w} + \beta_3 \times X_{Q_w} \times X_{WT_w}\right)}, \qquad \textbf{(1)}$$

where $X_{Q_w} \times X_{WT_w}$ represents the interaction between the weekly attraction influence of Yuba River flows relative to lower Feather River flows, and the weekly attraction influence of Yuba River water temperatures relative to lower Feather River water temperatures. The symbols α, β_1, β_2 and β_3 are the response function parameters.

Prior to fitting the model, equation **(1)** will be linearized using a logit transformation (the inverse of the sigmoidal logistic function). Through this logit transformation the modeled response **(1)** becomes:

$$logit\left(\pi_{\text{Ad-Clip}_w}\right) = \ln\left(\frac{\pi_{\text{Ad-Clip}_w}}{1 - \pi_{\text{Ad-Clip}_w}}\right) = \alpha + \beta_1 \times X_{Q_w} + \beta_2 \times X_{WT_w} + \beta_3 \times X_{Q_w} \times X_{WT_w}. \qquad \textbf{(2)}$$

Equation (**2**) will be fitted to the data using a weighted least squares regression approach to handle the unequal variance of the error terms. The weekly weights will be calculated using the formula: $Weight_w = \left(n_{\text{Ad-clip}_w} + n_{\text{Not Ad-clip}_w}\right) \times \pi_{\text{Ad-clip}_w} \times \left(1 - \pi_{\text{Ad-clip}_w}\right)$.

Because the weekly proportions of adipose-fin-clipped fish should not take values of 0 or 1, cases where the observed $\pi_{\text{Ad-clip}_w}$ = 1 will be replaced by $\pi_{\text{Ad-clip}_w} = 1 - \left(1 \big/ 2 \times \left(n_{\text{Ad-clip}_w} + n_{\text{Not Ad-clip}_w}\right)\right)$ prior to estimation (Neter et al. 1985). Similarly, cases where the observed $\pi_{\text{Ad-clip}_w}$ = 0 will be replaced by $\pi_{\text{Ad-clip}_w} = 1 \big/ 2 \times \left(n_{\text{Ad-clip}_w} + n_{\text{Not Ad-clip}_w}\right)$ prior to fitting equation **(2)**.

Attraction Flow Variables

The values of the variables developed to measure the weekly attraction influence of Yuba River flows relative to lower Feather River flows (i.e., X_{Q_w} in equations 1 and 2) will be derived from mean daily flows measured at the Marysville Gage and the Gridley Gage.

The "attraction" flow variables consist of weekly attraction indices calculated as weekly averages. Ten "attraction" flow variables will be used in the analysis as the explanatory variable X_{Q_w} in equations 1 and 2. The only difference among these variables consists of the week over which the attraction indices are averaged with respect to the week of the corresponding weekly proportions $\pi_{\text{Ad-clip}_w}$.

For example, the first weekly attraction flow index variable (*i.e.*, AFI_0) will be computed as the average of the daily ratios of Marysville flows (Q_{MRY_i}) to Gridley flows (Q_{GRL_i}) for the same days used in computing the corresponding weekly proportion $\pi_{\text{Ad-clip}_w}$. Thus, AFI_0 is computed as $AFI_0 = \frac{1}{7} \times \sum_{i=d}^{d+6} \frac{Q_{MRY_i}}{Q_{GRL_i}}$, where *d* is the first day in the week of the corresponding weekly proportions $\pi_{\text{Ad-clip}_w}$. The second weekly attraction flow index variable (*i.e.*, AFI_7) that corresponds to the average of the daily ratios of Marysville and Gridley flows for the week prior to the week of the corresponding weekly proportion $\pi_{\text{Ad-clip}_w}$ is then computed as $AFI_7 = \frac{1}{7} \times \sum_{i=d-7}^{d-7+6} \frac{Q_{MRY_i}}{Q_{GRL_i}}$. The remaining eight variables used in the analysis (i.e., AFI_{14}, AFI_{21}, AFI_{28}, AFI_{35}, AFI_{42}, AFI_{49}, AFI_{56} and AFI_{63}) correspond to weekly averages of the mean daily ratios of Marysville and Gridley flows for two, three, four, five, six, seven, eight and nine weeks prior to the week of the corresponding weekly proportion $\pi_{\text{Ad-clip}_w}$. These explanatory variables are developed to represent differences in attraction to the Yuba River relative to the lower Feather River for up to nine weeks prior to phenotypic spring-run Chinook salmon passing Daguerre Point Dam because of the extended holding periods exhibited by acoustically-tagged spring-run Chinook salmon in the lower Yuba River prior to passing (see RMT 2013).

Because weekly attraction flow indices are averages of flow ratios, they do not have units associated with them. The AFI_j can only take values greater than 0. AFI_j values greater than 1 indicate that the Yuba River flow at the Marysville Gage are higher than the lower Feather River flows at the Gridley Gage. Similarly, AFI_j values greater than 0 but smaller than 1 indicate that lower Yuba River flows for a specific week are less than the lower Feather River flows.

Attraction Water Temperature Variables

The values of the variables developed to measure the weekly attraction influence of lower Yuba River water temperatures relative to lower Feather River water temperatures (i.e., X_{WT_w} in equations 1 and 2) will be derived from mean daily water temperatures (°F) measured at the Marysville Gage and at the Gridley Gage.

Consistent with the "attraction" flow variables previously discussed, the "attraction" water temperature variables consist of weekly attraction indices calculated as weekly averages of the ratios of daily lower Yuba River to lower Feather River water temperatures. Ten "attraction" water temperature variables will be used in the analysis as the explanatory variable X_{WT_w} in equations 1 and 2. The ten "attraction" water temperature variables used (*i.e.*, $AWTI_0$, $AWTI_7$, $AWTI_{14}$, $AWTI_{21}$, $AWTI_{28}$, $AWTI_{35}$, $AWTI_{42}$, $AWTI_{49}$, $AWTI_{56}$ and $AWTI_{63}$) correspond to weekly averages of mean daily ratios of the Marysville and Gridley gages water temperatures for the week of the corresponding weekly proportion $\pi_{\text{Ad-clip}_w}$ (i.e., $AWTI_0$) and for one, two, three, four, five, six, seven, eight and nine weeks prior to the week of the corresponding weekly proportion $\pi_{\text{Ad-clip}_w}$.

As with the weekly attraction flow indices, the weekly attraction water temperature indices are averages of water temperature ratios and therefore also do not have units associated with them. Similarly, the $AWTI_j$ can only take values greater than 0. $AWTI_j$ values greater than 1 indicate that the water temperatures at the Marysville Gage are warmer than the water temperatures at the Gridley Gage. Similarly, $AWTI_j$ values greater than 0 but smaller than 1 indicate that the lower Yuba River water temperatures are less than the lower Feather River water temperatures.

Relationships with Attraction Flow and Water Temperature Indices

Equation 2 will be fitted ten times. In each case, a particular attraction flow variable (*i.e.*, AFI_0, AFI_7, AFI_{14}, AFI_{21}, AFI_{28}, AFI_{35}, AFI_{42}, AFI_{49}, AFI_{56} and AFI_{63}) will be combined with the attraction water temperature variable for the same week. The ten combinations of flow and water temperature explanatory variables will be examined to identify the combination that produces the largest coefficient of determination (R^2) (i.e., the largest amount of explained data variability among the ten explanatory variable combinations that are analyzed).

To further demonstrate the role of flows and water temperatures in the lower Yuba and Feather rivers on adipose-fin-clipped spring-run Chinook salmon entering the Yuba River, total and adipose-fin-clipped spring-run Chinook salmon passage counts at Daguerre Point Dam will be plotted with mean daily flows and mean daily water temperatures at the Marysville Gage and at the Gridley Gage.

2.2.1.1.6.4 Size and Age Structure

The VAKI Riverwatcher™ system records the body depth of fish, and body depth is converted to a length measurement utilizing a body length-to-depth ratio. Subsequently, the length-frequencies of identified spring-run Chinook salmon, fall-run Chinook salmon and steelhead annually passing upstream of Daguerre Point Dam will be plotted for each year of available VAKI Riverwatcher™ data. The plots will be inspected to identify modes that could be useful in identifying size classes and, therefore, age classes. Smoothing splines will be fitted to the data and plotted to represent length-frequency modalities.

2.2.1.2 Chinook Salmon Carcass Surveys

2.2.1.2.1 Monitoring Component Objectives

Objectives of the carcass survey include:

- Estimate the total annual abundance of Chinook salmon downstream of Daguerre Point Dam
- Use recovered coded-wire tags (CWT) to determine the origin of Chinook salmon (i.e., hatchery and river of origin)
- Conduct biometric surveys to characterize Chinook salmon population demographics

2.2.1.2.2 Survey Area

The survey area for the mark-recapture carcass survey will be the Yuba River and side channel habitats from Daguerre Point Dam to the Simpson Lane Bridge (i.e., approximate distance of 10 mi), which includes all known Chinook salmon spawning habitat downstream of Daguerre Point Dam. Biometric sampling conducted concurrently with the mark-recapture surveys downstream of Daguerre Point Dam will be conducted in this same survey area.

The survey area for biometric sampling of Chinook salmon carcasses upstream of Daguerre Point Dam will include the areas of Timbuctoo Bend and Parks Bar.

2.2.1.2.3 Sampling Period and Frequency

In the first full calendar year following license issuance, YCWA will apply for the permits and approvals necessary to monitor anadomous salmonid carcasses. YCWA will monitor Chinook salmon escapement by conducting weekly mark-recapture carcass surveys. Mark-recapture surveys downstream of Daguerre Point Dam will be initiated during the first year after the permits and approvals are obtained. Each year of sampling, YCWA will commence monitoring for Chinook salmon spawning in mid-August and then begin weekly surveys approximately 10-14 days after the first Chinook salmon redd is observed in the survey area and will continue until no carcasses are observed in the survey area during a weekly survey, or until January 31, whichever occurs first.

Mark-recapture surveys will be conducted during the first 10 years after license issuance, unless the Ecological Group (YCWA's Proposed Measure GEN1, *Organize and Hold Ecological Group Meetings*) decides to discontinue the surveys before the 10 years are complete. Thereafter, mark-recapture surveys downstream of Daguerre Point Dam will be conducted in conjunction with the biometric surveys downstream of Daguerre Point Dam. Thus, subsequent to the first 10 years, mark-recapture and biometric surveys downstream of Daguerre Point Dam will be conducted during 3 years of each 10-year block through the term of the license. The average percentage of Chinook salmon spawning downstream of Daguerre Point Dam during the first 10 years will be added to the VAKI Riverwatcher™ data in subsequent years to estimate annual spawning stock abundance, subject to modification as determined by the Ecological Group based upon subsequent estimates derived from surveys conducted during 3 years of each 10-year block through the term of the license.

Biometric surveys conducted upstream of Daguerre Point Dam in the Timbuctoo and Parks Bar areas will be conducted beginning September 1 until no carcasses are observed in the survey area during a weekly survey, or until January 31, whichever occurs first. Each year of sampling, a minimum of two biometric surveys will be conducted for spring-run Chinook salmon, and a minimum of two biometric surveys will be conducted for fall-run Chinook salmon. For each Chinook salmon run, the two biometric surveys will be separated by at least two weeks. Biometric surveys upstream of Daguerre Point Dam according to this intra-annual schedule will be conducted during the first 10 years after license issuance, unless the Ecological Group (YCWA's Proposed Condition GEN1) decides to discontinue the surveys before the 10 years are complete. Subsequent to the first 10 years, biometric surveys will be conducted during 3 years of each 10-year block through the term of the license.

2.2.1.2.4 Data Collection

YCWA will avoid using prior knowledge of carcass locations when searching to avoid biasing the sample. All observed carcasses will be collected using a gaff or spear pole for examination in order to determine freshness of a carcass. A fresh carcass has at least one clear eye (i.e., no milky color in eye) and gills that are red or pink. A Non-fresh (i.e., decomposed) carcass has no clear eyes and/or no red or pink gills. YCWA will inspect all carcasses for a disc tag in the lower jaw from the previous weeks' surveys. In addition, surveyors will examine carcasses for the presence of an adipose fin and floy/hallprint tag from hatchery marking practices and other scientific studies in the Central Valley. If a floy/hallprint tag is found, surveyors will record the floy/hallprint tag number with the other data collected for that carcass.

Surveyors will sample all fresh carcasses observed. All sampled carcasses, both adipose fin-clipped and non-clipped, will be tagged for abundance estimation from the mark-recapture surveys. The following data will be collected from each fresh carcass: 1) sex; 2) fork length in mm; 3) if a female carcass, egg retention status; 4) adipose fin presence; and 5) location where the fish was observed in GPS coordinates. In addition, each sampled carcass will have otoliths removed and genetic tissue samples taken and archived, unless or until a genetic evaluation program is implemented through another process.

If the number of carcasses encountered during weekly sampling exceeds the capability of surveyors to complete collections during one day, a sub-sampling strategy will be employed in which every Nth fresh carcass observed will be sampled for biological data. This subsampling strategy must be chosen at the beginning of the survey week and maintained throughout the survey week. The Nth sampling frequency must be recorded in the PDA or on the data sheet. VAKI Riverwatcher™ fish passage data or historic carcass survey data will be used to help establish the sampling frequency for Chinook salmon carcasses.

All fresh carcasses that are missing an adipose fin will be identified as potentially having a CWT. For adipose-fin-clipped fish, the upper maxillary will be removed for CWT recovery using a serrated knife, as the lower jaw will be marked with a disc tag. Required data will be recorded on a head tag provided by Cal Fish and Wildlife for identification and in the field datasheet. The upper maxillary and head tag will be placed in a Ziploc bag for storage. Upon returning from the field, heads will be placed into a chest freezer for storage. A chain of custody form will be filled out to track possession of the heads. The chain of custody will include information such as head number, sample location, dates and time of collection, and name of person who collected the head(s). For each change in possession, the person relinquishing the sample and the person receiving it will sign and date/time the chain of custody form.

To estimate escapement from the mark-recapture carcass surveys, YCWA will use the superpopulation modification of the Cormack Jolly-Seber model (CJS model) (Bergman et al. 2012), or a similar mark-and-recapture model. Mark-recapture population estimators (like the CJS model) require the capture history of individual carcasses. If a carcass is a recapture, the following information will be recorded: 1) disc tag number; 2) if the carcass was released for multiple recaptures or removed from the system (chopped); and 3) the date that the carcass was recaptured.

Surveyors will release all recaptured carcasses to allow for multiple recapture events. Freshness status will be recorded for each individual carcass and can be used in the CJS model when estimating escapement. If a recaptured carcass exhibits a high level of decomposition, surveyors will record the disc tag number and chop the carcass. In addition, the chopped recapture will be recorded as being removed from the system for the CJS model.

2.2.1.2.5 Data Processing

Weekly recorded data will be checked for quality assurance and quality control and entered into a relational database that will be used to manage all of the data collected during the carcass surveys. A metadata document will be developed for the database that contains at least: 1) a data dictionary and description of all of the codes; 2) a list of all of the fields in each table; 3) units of measure for each field; 4) description of how the tables are related; 5) description of the purpose of each table; and 6) step-by-step explanation of the process to enter data and use any developed queries.

The super-population modification of the CJS model will be implemented using the mark-recapture analysis (mra) contributed package (McDonald 2010) for R (Dalgaard 2010), or similar software package. R is a free-ware software package for statistical analysis and graphics. The required input to the mra function for estimating the parameters of the super-population modification of the CJS model includes a matrix of capture histories, with one row for each carcass tagged with a unique number during the surveys. The matrix will be of size N x W, where N is the total number of uniquely numbered disc tags released during the annual mark-recapture carcass survey, and W is the number of survey weeks. When a carcass enters the marked population or is found marked and released back into the population, a 1 is entered into the appropriate cell of the capture history matrix to indicate "capture." A value of 2 in the matrix represents when a carcass is removed from the marked population. All other cells in the matrix receive a value of 0, indicating the carcass was not handled.

2.2.1.2.6 Data Analysis and Spawning Stock Escapement Estimation

The CJS model will be used to estimate the probability of survival and detection between recapture events.

The CJS model's 'super-population' approach involves estimating the total number of births (i.e., new carcasses) that occurred during the survey.

To describe the approach, the following definitions are needed:

- S = the number of survey periods
- p_j = the probability of capture in period j
- $ø_j$ = the probability of a carcass surviving in the system from period j to period j + 1
- M_j = the marked population size just before period j
- N_j = the population size in period j
- B_j = the number of new carcasses (births) in the interval from period j to period j + 1
- m_j= the number of carcasses captured at sampling occasion j that are marked
- n_j= the total number of carcasses captured (and checked for marks) at sampling occasion j
- R_j= the total number of carcasses at sampling occasion j that are released with marks

- r_j= the number of members of the Rj captured again on some later occasion
- z_j= the number of carcasses in the marked population not captured at sampling occasion j that are captured again later. Note that the number of marked individuals not captured at occasion j is (M_j – m_j)

The superpopulation modification to the JS first computes two slightly different estimates of the total marked population size just before period *j*:

$$\tilde{M}_j = m_j + \frac{(R_j + 1)z_j}{r_j + 1} \quad [1]$$

and

$$\hat{M}_j = m_j + \frac{(R_j)z_j}{r_j} \quad [2]$$

for *j* = 2, 3, …, *S*-1. Then, an estimate of the probability of a carcass surviving in the system from period *j* to period *j* + 1 (*j* = 1, 3, …, *S*-2) is estimated using

$$\tilde{\phi}_j = \frac{\tilde{M}_{j+1}}{\hat{M}_j + R_j - m_j} \quad [3]$$

The total number of individual carcasses in the system during each period *j* (*j* = 2, 3, …, *S*-1) is then estimated using

$$\tilde{N}_j = \frac{\tilde{M}_j(n_j + 1)}{m_j + 1}, \quad [4]$$

and the total number of births for each period *j* (*j* = 2, 3, …, *S*-2) is estimated as

$$\tilde{B}_j = \tilde{N}_{j+1} - \tilde{\phi}_j\left[\tilde{N}_j - (n_j - R_j)\right]. \quad [5]$$

The number of births is then adjusted for those that entered the system between periods *j* and *j*+1 but did not survive to period *j*+1:

$$B^*_j = \tilde{B}_j \frac{\ln(\tilde{\phi}_j)}{\tilde{\phi}_j - 1}. \quad [6]$$

This adjustment assumes that carcasses leave the system uniformly between periods *j* and *j*+ 1 (Crosbie and Manly 1985). Other distributions can be used (see Schwarz et al.

1993), but a uniform seems most appropriate for Chinook salmon carcasses and a systematic survey schedule.

Finally, an estimate of total escapement can be obtained using

$$\hat{N}_{escapement} = \tilde{N}_2 \frac{\ln(\tilde{\phi}_1)}{\tilde{\phi}_1 - 1} + B^*_2 + B^*_3 + \ldots + B^*_{S-2}. \quad [7]$$

To apply the CJS model, the parameters $ø_j$ and p_j will be estimated via maximizing the CJS likelihood using numerical optimization (i.e., via Maximum Likelihood), and then estimating $N\sim j$ using the Horvitz-Thompson (1952) population estimator. Total escapement downstream of Daguerre Point Dam is then estimated using equations [5] – [7] above.

Total annual Chinook salmon spawning stock escapement for the first 10 years following license issuance will be estimated by adding VAKI Riverwatcher™-obtained abundance to the estimated abundance using the CJS model downstream of Daguerre Point Dam. For subsequent years, the total annual Chinook salmon spawning stock escapement will be estimated by adding VAKI Riverwatcher™-obtained abundance to the calculated 10-year average estimated abundance using the CJS model downstream of Daguerre Point Dam to estimate annual spawning stock abundance, subject to modification as determined by the Ecological Group based upon subsequent estimates derived from surveys conducted during 3 years of each 10-year block through the term of the license.

2.2.1.3 Steelhead Redd Surveys

2.2.1.3.1 Monitoring Component Objectives

YCWA will conduct redd surveys to determine the location and timing of steelhead spawning activity upstream and downstream of Daguerre Point Dam in the Lower Yuba River, and to estimate redd abundance and associated adult breeding population size (i.e., spawning stock escapement) downstream of Daguerre Point Dam.

The steelhead redd survey also includes the following specific objectives:

- Describe the temporal and spatial spawning distribution of steelhead upstream and downstream of Daguerre Point Dam
- Characterize the size and shape of steelhead redds to assist in species-specific redd identification
- Provide an estimate or index of adult steelhead spawning abundance downstream of Daguerre Point Dam to compliment the VAKI Riverwatcher™-based annual abundance estimation upstream of Daguerre Point Dam

2.2.1.3.2 Survey Area

Steelhead redd surveys will extend from Englebright Dam downstream to the Simpson Lane Bridge.

2.2.1.3.3 Sampling Period and Frequency

In the first full calendar year following license issuance, YCWA will apply for the permits and approvals necessary to monitor steelhead redds. Steelhead redd surveys will be initiated during the first year after the permits and approvals are obtained. YCWA will conduct steelhead redd surveys from January 1 to May 31 of each year, or until newly constructed redds are not seen over two consecutive survey periods. All surveys sites will be visited at least once every 14 days.

Thus, complete surveys will be conducted bi-weekly, suitable (i.e., visibility > 1.2 m (4 ft) Secchi depth) and safe (e.g., no flood flows) river conditions permitting steelhead redd surveys according to this intra-annual schedule will be conducted during the first 5 years after license issuance. Subsequent to the first 5 years, steelhead redd surveys will be conducted during 3 years of each 10-year block through the term of the license. The 3 years monitored during each 10-year block will target schedule 5, 6 and conference years, based on the Yuba Accord NYI. It is recognized that water year type determinations by January 1 (when steelhead redd surveys are to commence) are uncertain, and that survey planning will need to commence based upon available information (e.g., New Bullards Bar Reservoir storage, long-term weather forecasts).

2.2.1.3.4 Data Collection

Surveys will be conducted by two or more surveyors as needed, using kayaks and/or catarafts, but may also require crews to conduct surveys on foot. If required, surveys by foot would occur with the surveyors being positioned on opposite sides of the river and working in tandem to scan the river bank-to-bank, working downstream to examine potential spawning habitats. The kayaks or catarafts will be maneuvered slowly working in a downstream direction or otherwise maneuvered to cover potential spawning habitats. Surveyors will wear polarized sunglasses to reduce glare and improve visibility.

All newly constructed redds observed will be identified to species based on presence of adults, classified in the field as "unknown salmonid" or other, or denoted as "test" (i.e., redds that appear incomplete to observers), marked and counted during each survey period. Test redds (i.e., incomplete redds, or redds that were begun but abandoned due to insufficient intragravel flow, or other reason) will be reexamined on consecutive surveys and reclassified appropriately based on their apparent completion.

2.2.1.3.4.1 Redd and Environmental Data

Each observed redd will be numbered consecutively from the first redd observed during the steelhead redd survey through the entire redd survey season. For each new redd observed throughout the survey season, the following data will be recorded: 1) a GPS location taken at the head of the redd's pot with a unique identifying number (i.e., Date + plus redd number; e.g. 20150126-001); 2) redd species identification, if determinable (see Figures 2.2-1 through 2.2-4); 3) number of fish on or proximate to the redd; 4) comments regarding observable redd overlap; 5) redd dimensions; and 6) any additional comments.

After conducting the survey, the following data will be recorded: 1) streamflow at the Marysville Gage; and 2) Secchi disk depth (ft).

The GPS and a data dictionary will be used to ensure redds counted during previous surveys are not double-counted. In addition, surveyors will mark each new redd immediately upstream of the pot with a painted cotton bag filled with cobble.

2.2.1.3.4.2 Redd Measurement Details

In order to accurately estimate the area of the redd and use these data to differentiate species and estimate escapement, YCWA will measure the pot area and tail spill of each newly constructed redd. The total area of the redd will be calculated from the field measurements by treating the pot as a circle or ellipse and the tail spill as a square, triangle, or rectangle depending on the individual measurements.

The physical dimensions of each observed redd will be measured using a fiberglass extendable rod demarcated at every 0.1 ft according to the procedures identified in Figure 2.2-5 and Figure 2.2-6, and in Table 2.2-1.

Figure 2.2-1. Steelhead redd (ODFW 1999).

Figure 2.2-3. Lamprey nest showing the placement of excavated rocks upstream and perpendicular to flow (ODFW 1999).

Figure 2.2-2. Lamprey nest (ODFW 1999).

Figure 2.2-4. Lamprey nest showing the placement of excavated debris to the side of the nest (ODFW 1999).

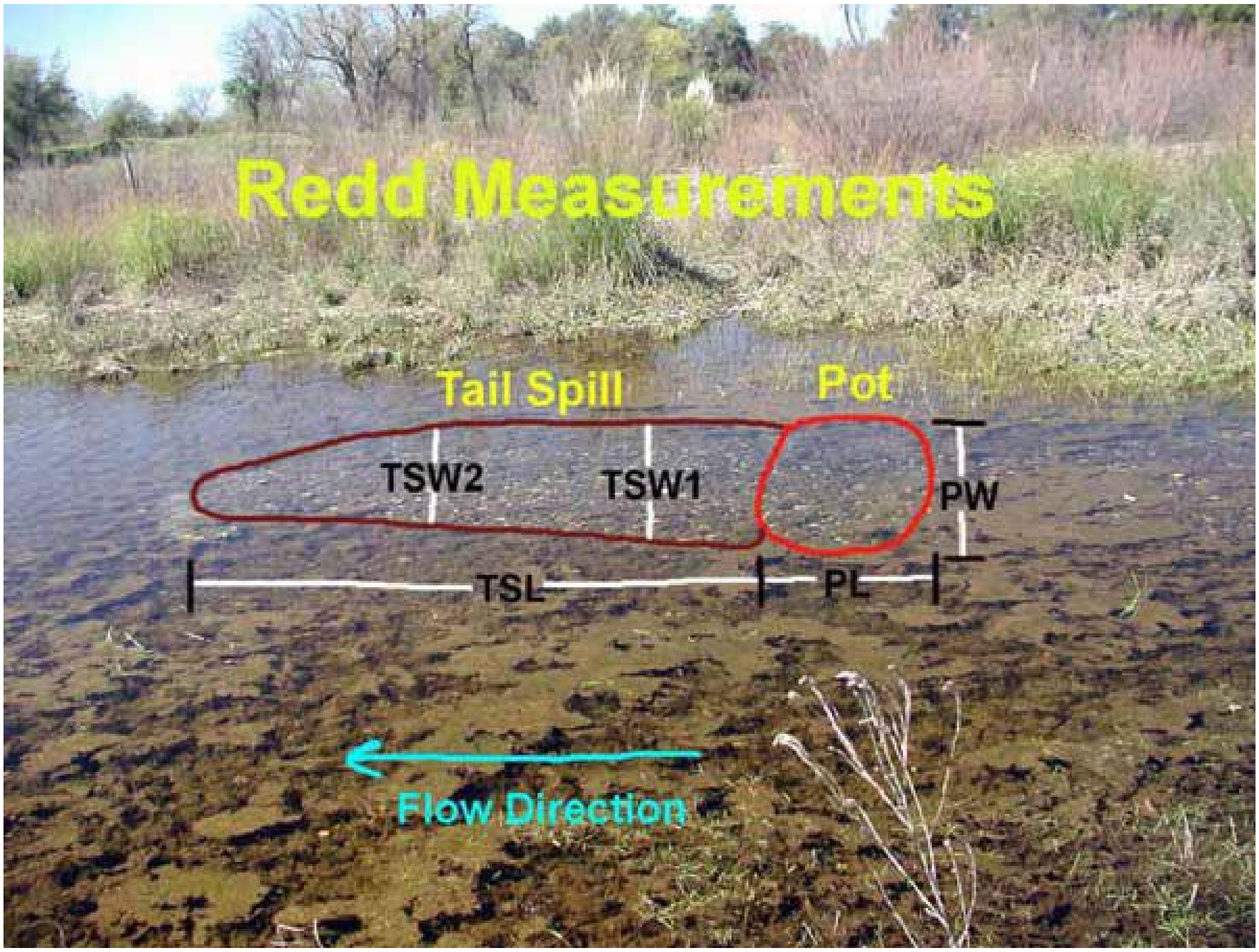

Figure 2.2-5. Illustration of steelhead redd measurements (PL = pot length; PW = pot width; TSL = tail-spill length; TSW2 and TSW1 = tail-spill widths), as presented in Hannon and Deason (2005).

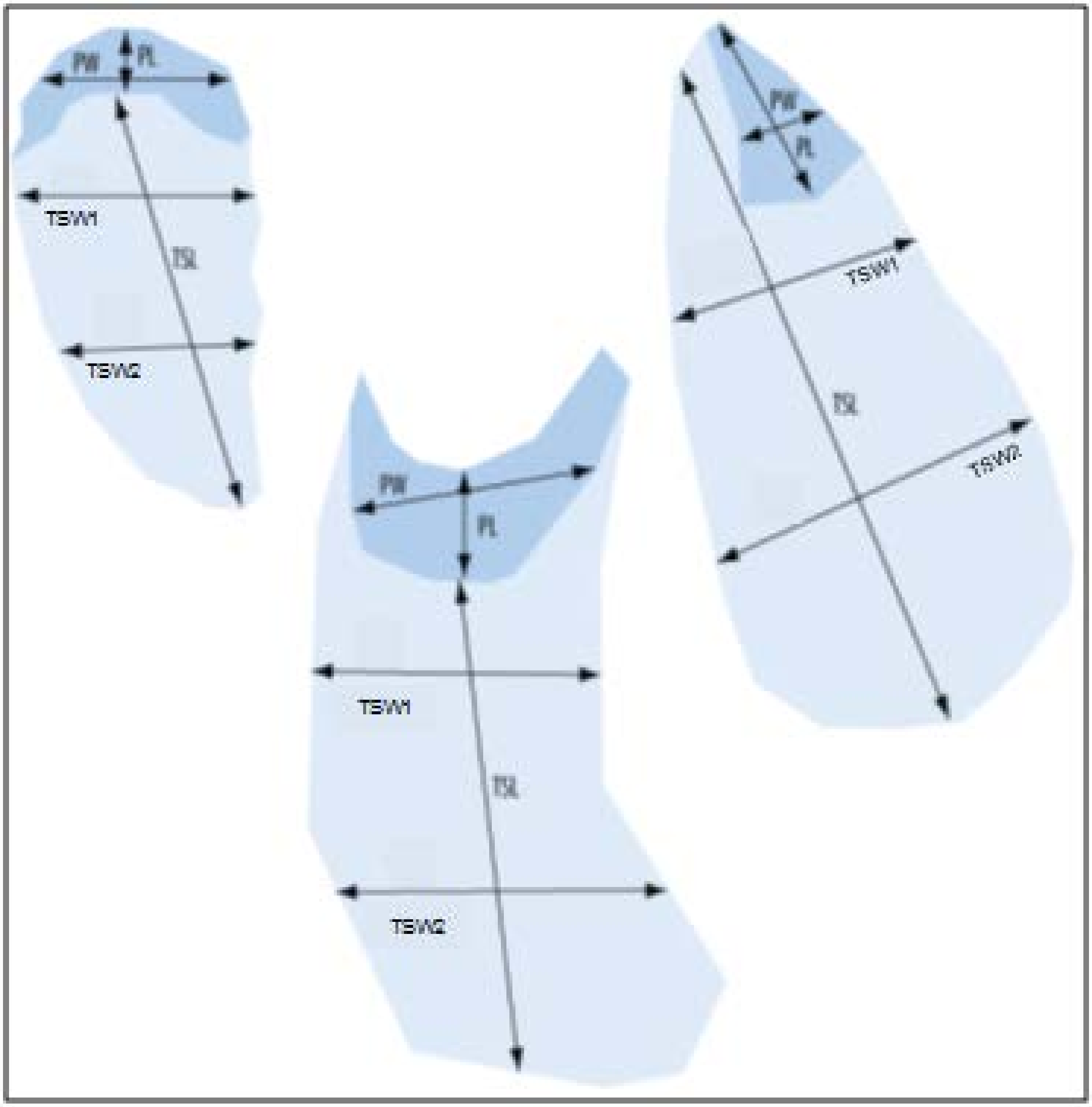

Figure 2.2-6. Measurements for unusually shaped redds (PL = pot length, PW = pot width, TSL = tail-spill length, TSW1 and TSW2 = tail-spill widths). Illustration reproduced from Gallagher et al. (2007).

Table 2.2-1. Description of redd measurements displayed on Figure 2.2-5 and Figure 2.2-6.

Pot Length (PL)	Total length of the pot parallel to the stream flow in feet (to the nearest 0.1 ft) and measured from the top to bottom edge. When the pot is irregularly shaped, estimate the total length as accurately as possible.
Pot Width (PW)	Maximum width of the pot perpendicular to the stream flow or pot length in feet (to the nearest 0.1 ft) and measured from one edge to the other. When the pot is irregularly shaped, estimate the maximum width as accurately as possible.
Pot Depth (PD)	Maximum depth of the excavation relative to the undisturbed stream bed in feet (to the nearest 0.1 ft).
Pot Substrate (PS)	Size of the dominant and subdominant substrate in the pot. Estimate the size of the dominant and subdominant substrate in the pot in inches. Substrate sizes will be estimated as the length of the diameter of the smallest axis that will pass through a sieve.
Tail Spill Length (TSL)	Total length of the tail spill parallel to the stream flow in feet (to the nearest 0.1 ft). Measurements will be taken from the top edge (i.e., downstream edge of the pot) to bottom edge of the tail spill.
Tail Spill Width 1 (TSW1)	Maximum width of the tail spill perpendicular to the stream flow or pot length in feet (to the nearest 0.1 ft). Measurements will be taken from one edge to the other, about one-third of the distance downstream from the top edge of the tail spill. When the tail spill is irregularly shaped, estimate the maximum width as accurately as possible.
Tail Spill Width 2 (TSW2)	Maximum width of the tail spill perpendicular to the stream flow or pot length in feet (to the nearest 0.1 ft). Measurements will be taken from one edge to the other, about two-thirds of the distance downstream from the top edge of the tail spill.
Tail Spill Substrate (TSS)	Size of the dominant and subdominant substrate in the pot. Estimate the size of the dominant and subdominant substrate in the pot in inches. Substrate sizes will be estimated as the length of the diameter of the smallest axis that will pass through a sieve.

2.2.1.3.5 Data Processing

Redd longevity and surveyor efficiency in redd detection will be estimated by tracking the condition of individual redds measured during previous surveys and YCWA’s ability to find all previously identified redds. YCWA’s efficiency will be calculated as the average of the percentage of known redds observed during each survey (Gallagher et al. 2007).

2.2.1.3.5.1 Salmonid Redd Distributions

The total numbers of freshly built redds identified to species (i.e., steelhead or Chinook salmon) and those assigned to the “unknown salmonid” category will be tallied for each survey period, and the results displayed in a table format.

2.2.1.3.5.2 Redd Sizes

The five redd size measurements (i.e., PL, PW, TL, TW1 and TW2) collected on the fresh redds observed during the survey period by species category identified in the field (i.e., steelhead, Chinook salmon, unknown salmonid) will be presented. The measurements also will be used to calculate redd area by species category. Additionally, the individual redd size measurements will be utilized in the discriminant analysis described below.

2.2.1.3.5.3 Discriminant Analyses

Because redds observed during the survey period will be assigned in the field to a particular salmonid species (i.e., Chinook salmon or steelhead) only if adults are observed actively constructing or guarding the redds, some observed redds are likely to be classified as “unknown salmonid” redds or “other”. Consequently, discriminant analyses will be performed to determine whether the “unknown salmonid” redds could be reclassified as steelhead.

Discriminant analysis is a multivariate classification technique that uses “training data” to estimate a linear or quadratic function that can be used to assign additional observations (e.g., the redd size measurements of the “unknown salmonid” redds) to the correct group. For the proposed discriminant analyses, the training dataset will consist of the pot length (PL), pot width (PW), tail-spill length (TSL), tail-spill widths (TSW1 and TSW2) and date of observation expressed as day of the year (DoY). Extensive redd surveys over the same study area proposed for this monitoring component were conducted by the RMT during 2009/2010 and 2010/2011, and by YCWA during 2015. Those redds positively identified to species in the field during previous and future surveys would be used each year to update the training dataset. The six models in the family of classical discriminant models will be fitted to the training data set, and the main characteristics of the fitted six models will be summarized and displayed in tabular format.

After fitting the six discriminant models, a sequence of five likelihood ratio tests will be performed to assist in the identification of the most plausible covariance structure for the groups (i.e., the two species in the training dataset). For each test, the less complex model in the test will be rejected if the significance level (P-value) of the likelihood ratio test is significant (e.g., P value < 0.05).

After selection of the best fitted model, its derived discriminant function will be used to reassign all redds as either Chinook salmon or steelhead that are assigned to the “unknown salmonid” category in the field. Redds assigned as steelhead will be included in the datasets used to characterize spatial and temporal distributions, and habitat use. Additionally, two types of misclassification rates for the selected model will be calculated with the training data. One is the apparent error rate, where each observation in the training data is classified using the discriminant function derived from the selected fitted model, and the number of misclassifications for each group (i.e., species) is divided by the group sample size. The alternative type of misclassification rate will be based on cross-validation, a leave-one-out technique for estimating the error rate. The misclassification rates for the selected model will be calculated to provide a quantitative assessment of the power of the discriminant function derived from the selected fitted model.

2.2.1.3.6 Data Analysis

2.2.1.3.6.1 <u>Steelhead Redd Temporal, Spatial Distributions, and Habitat Use</u>

For each annual survey, the GPS locations of all freshly built steelhead redds will be plotted on maps of the surveyed area, each map corresponding to one of the bi-weekly survey periods, to facilitate the intra-annual comparison of the spatial distribution of redds. The proportion of the total annual number of redds observed in each reach of the Lower Yuba River will be reported. In addition, the cumulative relative proportions of the total number of steelhead redds observed will be presented as a function of their distance from the confluence of the Feather and Yuba rivers expressed in thousands of feet, to examine potential preferential longitudinal selection of spawning sites. The cumulative temporal distribution of new redd construction will be presented on a seasonal basis, corresponding to the sampling period and frequency described above (section 2.2.1.3.3). Water temperatures associated with the estimated time of new redd construction also will be presented.

2.2.1.3.6.2 Spawning Stock Escapement Estimation

An index of steelhead abundance downstream of Daguerre Point Dam will be based upon calculating a spawner/redd ratio using VAKI Riverwatcher™ data and redd survey counts upstream of Daguerre Point Dam, then applying that ratio to the number of redds observed below Daguerre Point Dam. Based upon examination of VAKI Riverwatcher™ data conducted by the RMT (2013), the steelhead upstream migration and holding period generally extends from the preceding August through the spawning period. Thus, the observed number of steelhead passing through Daguerre Point Dam from the preceding August to the completion of the redd survey season, and the number of steelhead redds located upstream of Daguerre Point Dam for the entire spawning season will be used to calculate the spawner/redd ratio above Daguerre Point Dam. That ratio will then be applied to the number of redds located downstream of Daguerre Point Dam. The resultant estimated number of spawners, based upon the assumption that the spawner/redd ratio above Daguerre Point Dam is applicable to below Daguerre Point Dam, serves as a rough index of annual steelhead spawner abundance downstream of Daguerre Point Dam. Application of specific spawner/redd ratios to the number of redds located downstream of Daguerre Point Dam will be subject to modification as determined by the Ecological Group based upon information obtained from surveys conducted during the first 5 years after license issuance, or from surveys conducted during the 3 years of each 10-year block through the term of the license.

2.2.1.4 Integrated Salmonid Spawning Stock Escapement Estimation

Tables will be prepared summarizing the total number of spring-run and fall-run Chinook salmon, and steelhead estimated to have passed upstream of Daguerre Point Dam annually. Abundance upstream of Daguerre Point Dam will be defined as the total net upstream passage in the VAKI Riverwatcher™ systems.

Total adult fall-run Chinook salmon annual spawning stock escapement abundance will be estimated by combining the sum of the net VAKI Riverwatcher™ count for both ladders at Daguerre Point Dam, and the CJS escapement estimate downstream of Daguerre Point Dam.

Total adult steelhead annual spawning stock escapement abundance will be estimated by combining the sum of the net VAKI Riverwatcher™ count for both ladders at Daguerre Point Dam, and the estimated abundance based upon the steelhead redd surveys.

2.2.2 Juvenile Downstream Movement

2.2.2.1 Monitoring Component Objectives

Objectives of the rotary screw trapping (RST) monitoring include:

- Estimate and examine trends in the weekly, monthly, seasonal and annual abundances of emigrating juvenile Chinook salmon from the lower Yuba River.

- Evaluate time-period specific size structure during juvenile Chinook salmon emigration.

2.2.2.2 Survey Area

In order to estimate the number of juvenile Chinook salmon that emigrate from the Yuba River, one to a maximum of three RSTs will be deployed in the lower Yuba River. In the past, Cal Fish and Wildlife and the RMT conducted RST sampling in the Lower Yuba River near Hallwood Boulevard. If the previously used site or proximal site is suitable for RST location, then efforts will be made to locate the RST(s) at this location. Once a suitable trap site has been found, the trap distance upstream from the mouth of the Yuba River should remain fixed each year unless changes in channel configuration or hydraulic conditions warrant adjustments.

To the extent possible, RST(s) will be positioned in a location: 1) where a relatively high percentage of the total river flow passes through the RST cone; 2) where they can operate effectively over the entire range of streamflow conditions, including floods, that may exist during a sampling season; 3) directly downstream of a riffle, as opposed to the downstream end of a pool; and 4) in the thalweg of the stream channel, unless high discharge or flood conditions dictate the RST should be moved to a position with lower water velocities.

The specific RST location will be selected by YCWA using the following criteria as guidance for installation, operation, and maintenance: 1) water depth greater than 6 feet at minimum flow; 2) water velocity greater than 2 fps at minimum flow; 3) suitable anchoring point(s); and 4) limited public access. If the RSTs need to be moved due to varying flows, movement of the RSTs will be documented and trap efficiency tests will be conducted at the new location.

If the RSTs are considered to sample a low proportion of the total river discharge and not collect juvenile Chinook salmon in an efficient manner, channel modifications to divert more flow into the trap cone may be needed to increase trap efficiency. If the location where the RST is operated is not prone to “flashy” conditions, sandbag walls, gabion walls, fyke-net guidance panels, or hardware fence panels may be used to divert a greater percentage of the total stream volume into the RST. RSTs will be held in place with 6 mm diameter or thicker cable fastened to large, permanent structures on the bank, or to anchors placed in the river, but not to live trees. If possible, overhead cables will be used to secure traps. A safety cable will be attached to the rear of the trap, such that the trap will swing to shore if other cables fail.

2.2.2.3 Sampling Period and Frequency

In the first full calendar year following license issuance, YCWA will apply for the permits and approvals necessary to install, maintain and operate RSTs. RST sampling will be initiated during the first year after the permits and approvals are obtained. RST sampling will be conducted annually for the first 5 years of the license. Subsequent to the first 5 years, RST monitoring will be conducted during 3 consecutive years of each 10-year block through the term of the license. The RST monitoring period for juvenile Chinook salmon will be from November 15 through June 15 of each year of sampling. The RSTs will be operated Monday through Friday of each week during the monitoring period except from January 15 through May 15 when the RST’s will be operated 7 days each week.

Modifications to the start or end of the monitoring period, or interruptions of sampling effort within a particular survey period due, for example, to excessive debris, high streamflow or logistic problems will be recorded.

RSTs will be checked at least once per day when they are operated to remove debris and process captured fish. When water velocities or debris loads are relatively high, RSTs will be serviced at least twice per day to keep them rotating continuously and reduce the potential for fish mortality. When staff are not scheduled to service RSTs at least once every 24 hours, the RST cone will be stored in the non-fishing position.

2.2.2.4 Data Collection

Depending on the selected RST location, a 5-ft and/or 8-ft diameter RST will be used to collect juvenile Chinook salmon. If YCWA determines an 8-ft diameter trap can successfully be operated at a RST site (i.e., hydraulic conditions or water depth at a trap site do not impair cone rotation), then this size RST will be used to collect juvenile Chinook salmon because it will sample a greater volume of water than a 5-ft diameter trap. If a RST site similar to past sampling activities is selected by YCWA for this monitoring component, the same RST configuration would continue to be used if possible. Also, if possible RSTs may be used side-by-side to increase sampling volume. Maintaining a consistent RST set-up will contribute to consistent data collection with previous sampling efforts.

RSTs possess a mechanical counter that measures the number of revolutions the RST makes each day. To reduce fish losses from the livebox, fish refuge devices and debris separators will be installed within the livebox to dissipate water velocities and reduce predation. If fish refuge devices and debris separators cause size-selective mortality with respect to Chinook salmon, these features will be modified to reduce their adverse effects.

During each trap check, debris and fish inside the livebox will be retrieved using long-handled nets. To ensure their safety, YCWA will not climb or reach into the trap as the contents are removed from the livebox. Fish will be carefully separated from debris and a special effort will be made to look for smaller fish. As fish are found, they will be placed in 5-gallon buckets of fresh water for processing. If captured piscivorous fish species have the potential to harass or eat juvenile Chinook salmon during the period when fish are processed, piscivorous fish and salmon will be held in separate buckets. Attempts will be made to place no more than about 60 fish in each bucket at a time. If the total catch is more than 150 fish, fish will be processed in lots of 150 fish, returning to the trap until all fish have been removed.

As fish are processed, several steps will be taken to reduce stress in the fish. During processing and if necessary, fish will be anaesthetized using MS-222, CO2, or Tricaine-S. Anaesthetized fish will be allowed to recover in fresh water with small amounts of PolyAqua prior to release. A battery-operated air bubbler will be used to oxygenate the water in the bucket used to hold juvenile Chinook salmon, and the water temperature in the bucket will be continuously monitored with a thermometer. The water in the bucket will be changed as frequently as needed to prevent stress or mortality of fish. Each of the captured fish will be counted and Chinook salmon will be examined for clips or marks that indicate they originated at a fish hatchery. Juvenile Chinook salmon will be processed before other fish species. The lifestage of each of the sampled juvenile Chinook salmon will be classified according to one of five lifestages that include yolk-sac fry, fry, parr, and smolts. YCWA may elect to classify salmon according to other life stages (e.g., silvery parr), if desired. The following characteristics will serve as guidelines for lifestage classification:

- Yolk-Sac Fry (yolk sac is clearly visible)
- Fry (parr marks are evident but abdomen not fully zipped)
- Parr (parr marks are clearly evident and abdomen fully zipped)
- Smolt (parr marks are absent or extremely faded and noticeable scale loss)

Under ideal circumstances and because the external characteristics that are used to classify Chinook salmon are not mutually exclusive, the same personnel will be used to classify Chinook salmon to minimize bias on how Chinook salmon are classified. If this is not possible, all the staff that potentially could classify Chinook salmon will be trained to classify fish in a consistent fashion. Regardless, ontogenetic characterizations will be presented with caution.

Data will be collected to characterize the length of captured Chinook salmon to the nearest mm. If less than 100 juvenile Chinook salmon are likely to be captured during a day, the length of each captured Chinook salmon will be measured. If more than 100 juvenile Chinook salmon are likely to be captured during a day, at least 50 randomly selected Chinook salmon will be measured each time the RST is checked. The same length measurement strategy will apply to *O. mykiss*. For non-salmonid species, the lengths of a random sub-sample of up to 20 individuals of each species will be measured each day. After the fish are processed, they will be released far enough downstream of the RST that they are not likely to re-enter the trap (e.g., at least 300 m from the trap).

A RST's ability to generate high quality data (i.e., trap reliability) is affected by the: 1) orientation of the trap to stream flow; 2) instantaneous rotation rate of the trap cone; 3) total number of rotations the trap cone makes each 12- or 24-hour period; 4) velocity of water moving into the trap cone; and 5) amount of debris collected by the trap. It is therefore important to document each of these variables each time the trap is checked. Ideally, the trap's long axis will be parallel to the axis of the stream flow. The instantaneous rotation rate of the trap cone will be measured each time fish are processed at the trap, and these measurements will be made before and after the trap cone is cleaned. Instantaneous rotation rate of the trap cone will be quantified by measuring the average amount of time it takes the trap cone to make three revolutions using the formula $RPM = \frac{p}{3P}$, where p is the number of panels counted, and P is the number of panels for one revolution of the RST cone (*e.g.*, P = 6 panels for 5-foot diameter RSTs and P = 10 panels for 8-foot diameter RSTs). The total number of rotations the trap cone makes during a 12- or 24- hour period is quantified using a mechanical counter mounted on the RST. The mechanical counter will be reset each time fish are processed.

Velocity of water moving into the trap cone will be measured in fps using a mechanical or digital meter. The location where the water velocity is measured will be in the center of the trap cone just below the water surface. If a measurement at this location is not possible, the location where the velocity is measured will be done at a consistent X, Y, and Z coordinate and this location will be noted on a datasheet.

The amount of debris collected by the trap will be documented each day. For example, the physical makeup of the debris could be described (e.g., leaves, aquatic vegetation, sticks/woody debris) and the amount could be measured by counting how many 5-gallon buckets filled with debris are required to empty the trap (*e.g.*, one bucket = light debris load; two buckets = medium debris load; and three or more buckets = heavy debris load). This debris data will provide insight into whether or not small fish may have been missed as fish were processed.

Standardized data sheets will be used to document fish captures and trap reliability. If trapping or handling operations lead to the injury or mortality of fish, this will be recorded on the data sheets and measures will be implemented to avoid and minimize similar injuries or mortalities in the future.

If feasible, water depth-velocity profiles across the stream or river channel at the trap site will be conducted to document the bathymetry and channel profile at the trapping site and assess the total volume of water moving past the trap. These profiles will be conducted: 1) at the beginning of the trapping season, and 2) after each event that causes a significant change in channel morphology.

A recording thermograph will also be installed at the trap site to monitor water temperature on a continuous basis. The recording thermograph will be checked at least once per week using an accurate thermometer. Turbidity will be measured with a turbidity meter and recorded in NTUs each time the trap is serviced.

2.2.2.5 Data Processing

2.2.2.5.1 Trap Efficiency Tests

To estimate the number of juvenile Chinook salmon that emigrate from the Lower Yuba River, RST efficiency tests will be conducted to convert raw catch data to estimates of total Chinook salmon. RST efficiency tests will not be conducted when water temperature or other conditions could result in elevated levels of Chinook salmon mortality. Wild Chinook salmon (i.e., non-adipose fin clipped) will be used to the maximum extent practicable when trap efficiency tests are conducted. In most, if not all cases, these fish will be captured with the RST.

If sufficient numbers of wild Chinook salmon can be caught with the RST to conduct a trap efficiency test, they will be caught in the one to five day period prior to the test; a shorter holding period (e.g., one to two days) is preferable. If a RST cannot capture a sufficient number of wild test fish, YCWA will attempt to use other gear (e.g., beach seines or fyke nets) to collect the requisite number of test fish.

Efficiency tests will be conducted with the goal of recapturing a sufficient number of fish that the RST efficiency estimate is not altered by more than 5 percent if an additional Chinook salmon is captured during a given test. The total number of test fish needed during an efficiency test will depend on trap efficiency, and may be heavily dependent on Yuba River discharge during the efficiency test. Chinook salmon RST efficiency tests performed in the lower Yuba River from December 2007 through June 2009 (RMT 2013, Table 4-6) indicated that releases of at least 1,000 test fish guaranteed efficiency estimates that do not change by more than 5 percent if an additional fish is captured during a given test 96 percent of the time. Therefore, RST efficiency tests will target 1,000 test fish.

RST efficiency tests will be conducted frequently during a sampling period (e.g., weekly), particularly when changes in fish size or environmental conditions (e.g., stream or river discharge and turbidity) have the potential to significantly affect trap efficiency. To the extent feasible, several trap efficiency tests will be conducted during high flow conditions because these events frequently coincide with large numbers of outmigrating juvenile Chinook salmon. If large numbers of test fish can be obtained, several (i.e., 10 or more) efficiency tests will be conducted during a monitoring period. Replicate trap efficiency tests will be conducted on different days with similar environmental conditions. Similarities, or the lack thereof, in the replicate tests provide a quantitative basis for understanding how trapping success is affected by similar environmental conditions.

Attempts will be made to conduct RST efficiency test releases at dusk and dawn to assess the effect of light conditions on trap efficiency. If substantial numbers of test fish are not available to conduct trials at dusk and dawn, emphasis will be given to conducting trials during evening conditions because this is when larger numbers of juvenile wild salmon tend to move downstream.

The process for marking and holding test fish until they are used involves multiple steps. A variety of techniques are currently available to mark test fish (e.g., fish can be marked with fin clips, tags, photonic guns and dye, or Bismark brown dye). One to 4 days prior to release, test fish will be marked. Once marked, test fish will be held in pens where they are allowed to recover at least 24 hours prior to release during an efficiency test. Structures that provide a refuge from high water velocities will be provided within the pens, and the pens will be enclosed in a locked cyclone fence enclosure, such as a dog kennel, to prevent vandalism. Prior to their release, the length of at least 100 test fish will be measured so their lengths can be compared to non-test fish caught during the efficiency test.

The site where test fish are released during an efficiency test will generally be approximately 400 to 800 m upstream from the trap site. The distance between the RST site and the release site must be great enough that it results in the mixing of fish across the stream channel and within the water column, but short enough that predation effects do not result in the loss of fish before they have an opportunity to arrive at the trap site. Under ideal conditions, test fish will be released in an area with a noticeable current (i.e., in a channel constriction) that has a greater potential to disperse test fish in the water column and across the stream channel. Prior to release, test fish will be examined to ensure they have a recognizable mark. If they do not, they will not be used during the efficiency test. During the efficiency test, test fish will be selected at random and released in small groups (e.g., ~10-20 fish) a few minutes apart until all Chinook salmon are released. By releasing test fish in small groups over a period of time, the Chinook salmon will be less likely to behave as a single school and facilitate the mixing of marked and unmarked fish as they move downstream. If access to both sides of the river at the release site is possible, test fish will be released on randomly alternating sides of the stream or river channel to aid in uniform mixing of unmarked and marked fish. Immediately before release, the release group will be examined for dead fish or abnormal behavior. These fish will be removed from the release group to ensure that only healthy fish are released. The exact number of fish released, the date, release location, release time, personnel, water temperature, and weather will be recorded on a specific data sheet developed for the trap efficiency tests.

RSTs will be checked following the release of test fish to monitor the timing and number of recaptures to ensure problems with the trap do not invalidate the efficiency test. Most recaptures occur within the first day of release, though past observations have shown recaptures up to 6 days after release. Traps will continue to be checked several times per day until four consecutive daily checks do not result in the capture of a test fish. The effort to mark test fish, conduct efficiency tests, and document the environmental conditions during an efficiency test will be summarized on data sheets.

2.2.2.5.2 Diel Fish Captures

To the maximum extent practicable, capture data will be summarized using a standardized 24-hour diel collection period (e.g., 8:00 AM to 7:59 AM the following day). When multiple trap checks are performed in one 24-hour period, captures from different trap checks should be combined to produce a daily tally of the number of Chinook salmon individuals and separate totals should be presented for each life stage of Chinook salmon.

For days when traps are not operated, daily catch will be estimated by averaging the actual catch on an equal number of days before and after the days not fished. For example, if a trap did not fish for 2 days, the daily catch for those days will be estimated by averaging the catch from two days before and 2 days after the period when the trap did not operate.

2.2.2.6 Data Analysis

2.2.2.6.1 Abundance Estimation

The following procedures and formulas described in Volkhardt et al. (2007) will be used to develop estimates of the number of Chinook salmon in the Lower Yuba River. Procedure A (below) will be used pending the regression estimation (i.e., moderately strong (i.e., $r^2 > 0.5$) and statistically significant ($P<0.05$)) predictive capability of independent variable(s) for trap efficiency. Otherwise, Procedure B will be used if the analytic conditions indicated below for the application of that procedure are met.

A. <u>Use a regression model to estimate outmigrant abundance</u>

   With this method, trap efficiency estimates are based on an independent variable such as mean daily discharge, and a regression model is used to estimate trap efficiency over a range of conditions pertaining to the independent variable. If this approach is used to estimate Chinook salmon production several efficiency tests must be conducted over a range of conditions pertaining to the independent variable, and a significant relationship must exist between trap efficiency and the variable. Data from previous trapping activities in the lower Yuba River will be analyzed to characterize the relationship between trap efficiency, the independent variable (e.g., stream discharge, turbidity and average water velocity), and length of migrating Chinook salmon to identify the variable(s) most suitable for extrapolating daily catch data to total production estimates. Draper and Smith (1998) suggest the observed F statistic should exceed the chosen test statistic by a factor of four or more if an efficiency estimate is to be successfully modeled using an independent variable. If a regression model is used to estimate trap efficiency, migration during day *i* is calculated using equations 1 and 2.

$$\hat{N}_i = \frac{n_i M_i}{m_i} = n_i \ \hat{e}_i^{-1} \qquad \text{Equation 1}$$

where

$$\hat{e}_i = \frac{m_i}{M_i} \qquad \text{Equation 2}$$

and where

$\hat{N}_i =$ Estimated number of downstream migrants during period *i*

$M_i =$ Number of salmon marked and released during period *i*

$n_i =$ Number of salmon captured during period *i*

$m_i =$ Number of marked salmon captured during period *i*

$\hat{e}_i =$ Estimated trap efficiency during period *i*

The variance of this estimate is calculated using equation 3.

$$V\left(\hat{N}_i\right) = V\left(\hat{e}_i\right)\left(\frac{\hat{n}_i}{\hat{e}_i^2}\right)^2 + \frac{V\left(\hat{n}_i\right)}{\hat{e}_i^2} \qquad \text{Equation 3}$$

where:

$\hat{e}_i =$ Trap efficiency predicted for period *i* by the regression equation $f\left(X_i\right)$

$MSE =$ Mean square error of the regression equation $f\left(X_i\right)$

$k =$ Number of trap efficiency tests used in the regression

$X_i =$ Value of independent variable during period *i*.

Equation 3 assumes that the number of salmon captured during period *i* was estimated as $\hat{n}_i$. This occurs at times during the season when the trap is not operated (e.g., when debris stops the trap). In most cases, the number of salmon captured during period *i* is a known count. Therefore, the second part of equation 3 reduces to zero and is not part of the calculation of $V\left(\hat{N}_i\right)$ (page 260 in Volkhardt et al. 2007).

If linear regression is used to estimate trap efficiency, the variance is estimated using equation 4.

$$V\left(\hat{e}_i\right) = MSE\left(1 + \frac{1}{n} + \frac{\left(X_i - \bar{X}\right)^2}{\sum_{i=1}^{k}\left(X_i - \bar{X}\right)^2}\right) \qquad \text{Equation 4}$$

The precision of the production estimate should be characterized using 95 percent confidence intervals. The formula for calculating these confidence intervals is provided in equation 5.

$$\hat{N} \pm 1.96\sqrt{V\left(\hat{N}\right)} \qquad \text{Equation 5}$$

B. Use a seasonal or monthly average to estimate fish production

Recaptures of marked Chinook salmon may be pooled from different efficiency tests during the entire trapping season or a given month to create an average efficiency estimate. This approach will only be used if YCWA's evaluation of the data demonstrates that similar recapture rates were likely to occur during the different efficiency tests. This may be difficult to demonstrate unless similar environmental conditions (e.g., stream discharges) occur during all the efficiency tests. It is also important to note that test fish captured in an RST during an efficiency test must not be included in the population estimate because they were either counted as wild unmarked fish before they were collected and marked as test fish. If data from different efficiency tests are pooled to develop an average estimate of trap efficiency, equation 6 is used to estimate the number of unmarked salmon during period i, and equation 7 is used to calculate its variance.

$$\hat{U}_i = \frac{u_i\left(M_i + 1\right)}{m_i + 1} \qquad \text{Equation 6}$$

$$V\left(\hat{U}_i\right) = \frac{\left(M_i + 1\right)\left(u_i + m_i + 1\right)\left(M_i - m_i\right)u_i}{\left(m_i + 1\right)^2\left(m_i + 2\right)} \qquad \text{Equation 7}$$

where:

$U_i =$ Number of unmarked salmon migrating during discreet period *i*

$u_i =$ Number of unmarked salmon captured during discreet period *i*

$M_i =$ Number of salmon marked and released during period *i*

$m_i =$ Number of marked salmon captured during period *i*

Total juvenile production $\hat{U}$ and its associated variance $V\left(\hat{U}\right)$ are estimated by equations 8 and 9, respectively.

$$\hat{U} = \sum_{i=1}^{n}\hat{U}_i \qquad \text{Equation 8}$$

$$V\left(\hat{U}\right) = \sum_{i=1}^{n}V\left(\hat{U}_i\right) \qquad \text{Equation 9}$$

The precision of the production estimate should be characterized by presenting 95 percent confidence intervals. The formula for calculating these confidence intervals is provided in equation 10.

$$\hat{U} \pm 1.96\sqrt{V\left(\hat{U}\right)} \qquad \text{Equation 10}$$

To further explore whether catch expansions should be conducted during periods when capture efficiency tests are not conducted due to lack of sufficient number of test fish for release or logistic difficulties, regression analyses will be used to explore potential relationships between efficiency values, RST performance variables and environmental river conditions. Environmental conditions and performance variables will be examined for correlative associations with trap efficiency values. Parameters for the predictive functions will be estimated using least squares estimation procedures. Predictive capabilities of the regression models will be reviewed to examine the variability in the data. Determination by YCWA will be made whether it is appropriate to apply capture efficiency results to periods when capture efficiency tests are not conducted as an effort to numerically estimate the abundance of emigrating juvenile salmonids. If YCWA determines that it is inappropriate to apply capture efficiencies during periods when no efficiency evaluations are conducted, observed catch will be used in lieu of abundance estimates.

2.2.2.6.2 Temporal Distribution

Expected temporal distributions will be determined from fitting an asymmetrical logistic function to the weekly observed catch of juvenile Chinook salmon for each monitoring year. A histograph will be prepared demonstrating the cumulative catch distribution over the sampling year. Descriptive statistics will be developed for the dates on which percentages of the cumulative distribution pass the RST.

An evaluation of peak emigration dates and the median (i.e., 50% of the cumulative distribution) dates for juvenile Chinook salmon passing the RST site will be conducted. The methods for determining peak emigration and median dates will follow the methods proposed by Keefer et al. (2008) using a 10-day moving average as the basis for the peak calculations. Peak emigration date will be compared with the median date of outmigration each year.

2.2.2.6.3 Size Structure

The size structure of sampled juvenile Chinook salmon emigrants will be characterized for each monitoring year. The number and annual proportion of the entire annual sampling period will be tabulated for six size class bins (i.e., <30 mm, 30-49 mm, 50-69 mm, 70-89 mm, 90-109 mm and 110+ mm). In addition, weekly average size of sampled juvenile Chinook salmon will be plotted for each annual survey year.

2.2.2.6.4 Potential Relationships between Outmigrant Abundance and Flow and Water Temperature

To examine potential relationships between flows and water temperatures in the lower Yuba River and outmigration abundance, the daily estimates of the number of Chinook salmon will be plotted with mean daily flows and water temperatures in at the Marysville Gage.

2.3 Narrows 2 Anadromous Salmonid Stranding

From July through February of each year, or as superseded by a Biological Opinion from NMFS for the relicensing, YCWA will survey for stranded Chinook salmon and steelhead in the Yuba River when any of the following occurs:

- The Full Bypass ceases operations (i.e., flow through the Full Bypass is reduced to 0 cfs)
- At a starting flow of 1,500 cfs or greater, the combined discharge from the Narrows 2 Facilities decreases by more than 400 cfs within any 1-hour period
- At a starting flow of less than 1,500 cfs, the combined discharge from the Narrows 2 Facilities decreases by more than 250 cfs within any 1-hour period

Surveys will be conducted in consideration of the following conditions which are established for safety: 1) surveys will only occur in daylight; 2) surveys will only occur when Englebright Dam is not spilling; and 3) surveys will only occur after YCWA's operations staff has ensured that the Narrows 2 Facilities will not increase flows that could endanger the field crew in the river.

Depending on the source of the flow variation, the area to be surveyed will be as follows:

- Full Bypass. The area that will be surveyed in relation to Full Bypass shutdown will include the extent of the spray and flow effects from the Full Bypass when operating at full capacity. This includes the large pool in front of the bypass, the pool perimeter, and the south bank of the Yuba River (including gravel bars) from the Full Bypass downstream to immediately upstream of PG&E's Narrows 1 Powerhouse.
- Flow Reduction from Combined Discharge of Narrows 2 Facilities. The area that will be surveyed in relation to the above-specified reduction in combined flow from the Narrows 2 Facilities includes the large pool in front of the Full Bypass, the pool perimeter, and the north and south banks of the Yuba River (including gravel bars) from the Narrows 2 Powerhouse downstream to immediately upstream of PG&E's Narrows 1 Powerhouse.

For a Full Bypass shutdown, if YCWA determines it is unsafe to enter the river channel, then YCWA staff or designee trained in identifying Chinook salmon and steelhead will survey using binoculars from the Narrows 2 Powerhouse deck. If flows allow safe access to the river channel, similarly trained YCWA staff or designee will survey by walking or wading along or boating around the perimeter of the Full Bypass pool and then continuing along the bank opposite the Full Bypass slowly downstream searching edgewater, backwater, perched habitats, and exposed bars for stranded Chinook salmon and steelhead. Particular attention will be given to the area of the bank previously wetted by the Full Bypass and in spaces between large boulders. Surveyors will wear polarized sunglasses and, to the extent possible, face the sun or observe at an oblique angle to avoid shadows.

For a reduction in the combined discharge of the Narrows 2 Facilities that triggers surveys , two YCWA staff or designees trained in identifying Chinook salmon and steelhead will survey by foot or using a boat and, from upstream to downstream, search edgewater, backwater, perched habitats, and exposed bars for stranded Chinook salmon and steelhead within the survey areas described above. The crew will exit the boat to perform surveys where it is safe to do so and when needed. Particular attention will be given to exposed isolated pools and large interstitial spaces that were wetted and are now dry.

If stranded live Chinook salmon or steelhead are found:

- YCWA will record: 15-minute discharge through the Partial Bypass, Narrows 2 Powerhouse, Full Bypass, and Narrows 1 Powerhouse and spill over Englebright Dam (if occurring) in the 4 hours before the survey began, and flow at the Smartsville Gage.

Surveyors will record:

- The time the survey was triggered.
- The time the survey began and ended.
- Weather conditions during the survey.
- Conditions in the monitoring area and any incidental observations.
- The number of stranded fish by species. All dead fish will be counted. All live adult fish will be counted. If 100 or less juvenile fish are estimated at each stranding location, then all juvenile fish will be counted. If more than 100 live juvenile fish are present, abundance will be estimated.
- If the field crew has the necessary permits/approvals to handle the fish, they will measure the length of each individual fish. If more than 100 live juvenile fish are found in an area, the crew will estimate the number and size of live juvenile fish in size bins of 0 to 50 millimeters (mm), 50 to 100 mm, 100 to 150 mm, 150 mm to 200 mm, and larger than 200 mm. If the field crew does not have the necessary permits to handle the fish, they will estimate the size and number of fish in the above bins.
- If stranded or dead fish are found and the field crew does not have the necessary permits or approvals to handle the fish, the field crew will contact NMFS and Cal Fish and Wildlife as soon as possible and no later than 24 hours for assistance. The field crew will not handle any fish until appropriate authorization has been obtained from NMFS and Cal Fish and Wildlife.
- If the field crew has the necessary permits/approvals to handle the fish and live Chinook salmon or steelhead are found, then the crew will rescue the fish by returning it to the water and record apparent condition (i.e., signs of stress) and how and where the fish was returned to the flowing water in the main channel (i.e., preferred method will be to fill a bucket with water from the nearby main channel, use a hand net to capture the stranded

fish and place it in the bucket, and place the bucket in the main channel so the fish can swim out of the bucket into the flowing water). Behavior of the fish (e.g., actively swims away or lethargic) as it leaves the bucket will be documented.

- If the field crew has the necessary permits/approvals to handle the fish and the fish is dead, the crew will record the condition of the carcass (i.e., gravid, spent, signs of hemorrhaging, rigor mortis, state of decomposition, and wounds likely inflicted by predators). Deceased fish will be marked (i.e., tail removed), a genetic sample will be collected, and the fish will be returned to the water to prevent it from being re-documented during future surveys.
- Location of stranding or mortality, including GPS coordinate, distance from the wetted edge of the main channel and Narrows 2 Facilities, estimate of how far above the flowing water in the main channel stranding occurred, depth of water at stranding location, and dominant/subdominant substrate at and nearby the stranding location.
- Temperature of the water (i.e., °C to the nearest tenth of a degree) if the stranded fish is found in water, and the temperature of the water in the main channel nearest to the stranded fish.
- Photographs of where stranding or mortality occurred to document the dimensions, general habitat features, and ability of the fish to return to the main channel. The ability of fish to return to the main river will be visually assessed based on fish size (i.e., body depth) and the depth, continuity, and direction of flow between the stranding location and the main channel.
- In addition to the notification requirements described above to obtain approval to handle fish, YCWA will notify NMFS, Cal Fish and Wildlife, USFWS, and the State Board regarding the stranding and/or mortality event within 48 hours of occurrence. YCWA will also notify NMFS, Cal Fish and Wildlife, USFWS, and the State Board of any actions taken in response to the stranding and/or mortality event, and YCWA will attach such notifications to the agencies in the annual report.

2.4 Substrate and Large Woody Material

The goal of substrate and LWM monitoring in the lower Yuba River is to inform how sediment and LWM may be changing under the influence of new license terms and conditions. The methods for each of the two components of monitoring under this section are generally consistent with Study 1.2, *Channel Morphology Downstream of Englebright Dam*, including Attachment 1-2A, *Summary of Methodologies From Studies Used in Study 1-2 (Pasternack 2010)* and Study 6.2, *Riparian Habitat Downstream of Englebright Dam*, implemented by YCWA during the relicensing of the Project.

2.4.1 Monitoring Component Objectives

The objectives of the monitoring are to: 1) characterize the spatial distribution of substrate in the lower Yuba River; 2) determine the location and distribution of areas of fine sediment, which may be more suitable for riparian recruitment and whether particle size distributions suitable for anadromous salmonid spawning habitat are changing over time; and 3) determine the spatial distribution and composition of LWM in the lower Yuba River.

2.4.2 Survey Area

Monitoring substrate and LWM changes in the lower Yuba River will be conducted from downstream of the Englebright Dam Reach to the confluence with the Feather River. The Englebright Dam Reach will not be included because it is relatively unresponsive to changes in sediment at normal Project operational flows due to its slope and shape, and the Narrows Reach will not be included due to safety and access concerns. The reaches for which data will be synthesized and analyzed are the reaches as defined in Wyrick and Pasternack (2011) (Table 2.4-1).

Table 2.4-1. Reaches in the lower Yuba River.

Reach Name	Description	Slope (%)[1]	Start (RM)[1]	End (RM)[1]
Marysville	Junction with Feather River to RM 3.3	0.05	0	3.3
Hallwood	RM 3.3 to slope break near Eddie Drive at RM 8.3	0.13	3.3	8.3
Daguerre Point Dam	RM 8.3 to Daguerre Point Dam	0.18	8.3	11.6
Dry Creek	Daguerre Point Dam to Dry Creek	0.14	11.6	13.9
Parks Bar	Dry Creek to 0.35 miles upstream of Highway 20	0.19	13.9	18.55
Timbuctoo Bend	Upstream of Highway 20 to end of emergent gravel bar	0.20	18.55	22.25

[1] Closest river mile from base map drafted by HDR for LWM survey 2012. River miles were digitized at a larger scale over a high resolution aerial imagery along the active river alignment.

2.4.2.1 Substrate Monitoring

YCWA will conduct substrate monitoring by mapping substrate distribution in the lower Yuba River utilizing methods consistent with the methods described in Attachment 1-2D, *Specific Sampling Protocols and Procedures for Classifying and Mapping Substrate and Cover* (Pasternack 2010) of Technical Memorandum 1-2.

YCWA's mapping of substrate and analysis of change will focus on areas of fine sediment most suitable for riparian recruitment and substrates suitable for anadromous salmonid spawning, both within the area of normal Project operations. Methods will be consistent with the methods described in Attachment 1-2D, *Specific Sampling Protocols and Procedures for Classifying and Mapping Substrate and Cover* (Pasternack 2010), of Technical Memorandum 1-2, with the exceptions and clarifications set out below:

- The length of the monitoring site within each reach will be 20 times the bankfull width (i.e., estimated to be the width at a flow of 5,000 cfs), or to the maximum length of the reach, whichever is less. Table 2.4-2 describes the areas to be surveyed.
- Lateral extent of the mapping will include only up to the bankfull width (i.e., width at flow of about 5,000 cfs).
- Areas that are submerged will be assessed using kayaks only (i.e., there will be no snorkeling nor video of the submerged areas). Estimates will be made of the substrate either by feeling the bottom with a probing rod or paddle, and extrapolating from visible

to not visible, and from where the substrate can be probed to where it cannot. Only one pass will be done as the team makes its way down the section.

- Maps of the substrate will be generated in the field using a base map that includes the 5,000 cfs designated line set out in Technical Memorandum 1-2 that is loaded onto a mobile device (e.g., tablet or laptop). The mobile device also will be loaded with data collection software that can collect features (e.g., polygons, lines and areas, points) from an external GPS source. All data will be collected with a differential GPS antenna capable of 1 meter or better accuracy. Substrate data will be added directly to the mobile device to reduce data reduction and analysis costs. Substrate codes are as set out in Attachment 1-2D, *Specific Sampling Protocols and Procedures for Classifying and Mapping Substrate and Cover* (Pasternack 2010) of Technical Memorandum 1-2, but are included as Attachment A to this document for reference.

Table 2.4-2. Reach name, total length, and total river miles that will be surveyed for substrate, LWM and riparian vegetation.

Reach	Total Length (miles)	River Mile for Survey		Total Distance to be Surveyed (miles)
		Begin	End	
Marysville	3.3	0.1	1.0	0.9
Hallwood	5.0	3.8	5.1	1.3
Daguerre Point Dam	3.3	10.0	11.5	1.5
Dry Creek	2.3	12.1	13.7	1.6
Parks Bar	4.7	16.1	17.3	1.2
Timbuctoo Bend	3.7	19.8	20.8	1.0
Narrows	1.1	--	--	0
Englebright Dam	0.8	--	--	0
Total	**24.2**	**--**	**--**	**7.5**

2.4.2.2 Large Woody Material Monitoring

YCWA will monitor for the presence and function of LWM by conducting a census of all un-rooted wood meeting minimum size requirements of greater than 3 ft in length and 4 inches diameter at the large end within a sub-section of each reach following the methodologies utilized during Project relicensing for Study 6.2, with the following changes/exceptions:

- LWM will be tallied in each of the diameter/size classes for each of the river sections in Table 2.4-2 below the 5,000 cfs line.
- LWM locations will be captured in the field using a base map that is loaded onto a mobile device (e.g., tablet or laptop), loaded with data collection software that can collect features (e.g., polygons, lines, areas, points) from an external GPS source. All data will be collected with a differential GPS antenna capable of 1 meter or better accuracy. LWM locations will be added directly to the mobile device to reduce data reduction and analysis costs. Maps loaded onto the mobile device will include the 5,000 cfs and floodway lines (21,100 cfs) delineation as set out in Technical Memorandum 1-2 (see for example Attachment 1-2Q).

- Once all pieces have been captured as points within the section below the 5,000 cfs line, five concentrations of LWM will be chosen randomly. To establish concentrations, circles will be drawn around 10 or more pieces of LWM and given a number. The full suite of characteristics set out in Section 2.4.2.2.1, below, will be collected only on pieces within 100 ft of the center of the concentration. Data will be collected directly onto the mobile device. Attachment B shows the original field form used in Technical Memorandum 1.2 and can be used as a guide for data collection.
- Key piece data will be collected for the surveyed section only, with the full suite of characteristics collected for each key piece as set out in Technical Memorandum 1.2, and captured directly onto the mobile device (see also Attachment B).

Table 2.4-2 shows the length of each reach, and the river miles where monitoring will occur.

2.4.2.2.1 All LWM Pieces

All LWM below the 5,000 cfs line will be tallied by size and diameter class. Diameter classes are: 4 inches to less than 12 inches; 12 inches to less than 24 inches; 24 inches to less than 36 inches; and greater than or equal to 36 inches. Length classes are: 3 ft to less than 25 ft; 25 ft to less than 50 ft; 50 ft to less than 75 ft; and greater than or equal to 75 ft. Locations of concentrated wood densities (i.e., wood covering more than 50% of a contiguous area) and diffuse wood density (i.e., 25 to 50% coverage) will be marked on maps.

Data collected for each piece of wood within five randomly selected concentrations of ten or more pieces within 100 ft of the centerpoint of the concentration will include the following (as set out in Attachment B):

- Piece number – Piece identification number
- Category – LWM or rootwad
- Size:
  - Top diameter – Measured with calipers if accessible; otherwise, estimated
  - Bottom diameter – Measured with calipers if accessible; otherwise, estimated
  - Length – Measured if accessible; otherwise, estimated
- Species category – Conifer, Hardwood, or Unknown
- Stability – Y or N. A piece is considered “stable” and therefore likely to be in situ long enough to perform a geomorphic role as a “key piece”[10], if any of the following criteria are met (Schuett-Hames et al. 1999):

[10] As described in Technical Memorandum 6-2, LWM that exceed half of the average bankfull widths for each reach, exceed 25 inches in diameter and 25 ft in length, or show morphologic influence (e.g., trapping sediment or altering flow patterns) are considered “key” LWM pieces.

- Root system: LWM had one or more identifiable roots projecting from the root-ball that is at least as long as the root collar diameter or is likely to hang up on something when floating.
- Buried: Complete burial of either end, or lateral burial of 50 percent or more of the diameter.
- Pinned/Pegged: If another qualifying LWM piece is on top or it is pegged between other logs, standing trees, boulders, or bedrock.

- Recruitment class – Undermined (by flow), Floated in high flow, or Fell to current location from riparian zone
- Channel forming function, if any:
  - Bank Stability: Bank stability is increased (banks are protected from erosion, undermining through deflection or protection by LWM) or decreased (LWM forces water into banks and directly causing erosion undermining).
  - Sediment Storage: A minimum of 9 ft^2 of sediment storage is enhanced by the LWM piece upstream, downstream, and/or adjacent to the LWM, or LWM contributes to the formation of a mid-channel bar.
  - Accumulation: Could piece, while *in situ*, lead to other pieces accumulating in the same location
  - Pool Forming Function: LWM directly contributes to a dammed pool, plunge pool, or scour pool. Pool must meet minimum criteria as defined in Table 2.4-3 below.
- Decay – Classified as 1 through 5 (Table 2.4-4)

Table 2.4-3. Minimum unit surface area size and minimum residual pool depth criteria by channel bankfull width.

Bankfull Width (ft)	Minimum Unit Surface Area (ft^2)	Minimum Residual Depth (ft)
0 to 8	5	0.3
≥8 to <16	11	0.7
≥16 to <33	22	0.8
≥33 to <49	32	1
≥49 to 66	43	1.1
≥66	54	1.3

Table 2.4-4. Decay classification system for evaluating coniferous and deciduous LWM.

Decay Class	Bark	Twigs 1.2 in (3 cm)	Surface Texture	Shape	Wood Color
1	Intact	Present	Intact/Firm	Round	Original
2	Intact	Absent	Intact/Firm	Round	Original
3	Trace	Absent	Smooth to some surface abrasion	Round	Original to darkening
4	Absent	Absent	Abrasion to some holes and openings	Round to oval	Dark
5	Absent	Absent	Vesicular with many holes and openings	Irregular	Dark

Source: Robison and Beschta 1990; reproduced from Schuett-Hames et al. 1999.

2.4.2.2.2 Key Pieces

Additional information will be collected for key pieces of wood located within the floodway (Example Attachment B for data collection form). Key pieces of LWM are defined as those of sufficient size and/or are deposited in a manner that alters channel morphology and aquatic habitat (e.g., trapping sediment or altering flow patterns). LWM is also considered a key piece if it meets the criterion of 25 ft in length and 25 inches in diameter at the large end. Detailed measurements, which are listed below, will be taken for each key piece:

- Piece location, either mapped onto aerial photos or documented with GPS
- Piece length
  - Piece diameter
  - Piece orientation
  - Position relative to the channel
  - Whether the piece has a rootwad
  - Tree species or type (e.g., conifer or hardwood)
  - Whether the piece is associated with a jam or not
  - The number of large pieces in the jam
  - Recruitment mechanism
  - Function in the channel

2.4.3 Sampling Period and Frequency

YCWA will monitor for substrate and LWM as described above once within the first three years of license issuance and then in License Year 10 and every 10 years thereafter (i.e., License Years 20 and 30) until a new license is issued.

2.4.4 Analysis

2.4.4.1 Substrate Monitoring

To analyze and illustrate the particle size distribution in each reach, the mean percent abundance of each size class among all polygons will be computed according to the categories presented in Technical Memorandum 1-2. The abundances do not need to sum to 100 percent exactly because the values are means and the sum of means (not equaling 100% exactly) and is not the same as the mean of the sums (which would equal 100% exactly). A table and pie chart of each reach will be provided showing the substrate size breakdown by reach within bankfull (5,000 cfs delineation). Additionally, YCWA will provide a summary that compares current substrate data to previous surveys.

2.4.4.2 Large Woody Material Monitoring

YCWA will summarize LWM data into tables that provide the: 1) acres of LWM by type of concentration of material and flow below 5,000 cfs; 2) volume of LWM in the sub-sampled area of each reach by decay class; 3) number of logs by recruitment type in the sub-sampled area of each reach; 4) tally of LWM in the sampled area of each reach by size and diameter class; 5) Chi-square ($\chi 2$) analysis of LWM longitudinal distribution; and 6) the data for key pieces of LWM found in the sampled area for each reach (see Tables 3.6-1 through 3.6-7 of Technical Memorandum 1-*2*). YCWA will also develop a map showing key pieces in each reach. Additionally, YCWA will provide a summary that compares current LWM data to previous surveys.

2.5 <u>Riparian Vegetation</u>

The goal of riparian vegetation monitoring in the lower Yuba River is to inform how riparian habitat and riparian habitat-related processes may be changing under the influence of new license terms and conditions. The methods for each of two components of monitoring under this section are generally consistent with Study 6.2, *Riparian Habitat Downstream of Englebright Dam*, implemented by YCWA during the relicensing of the Project.

2.5.1 Monitoring Component Objectives

The objectives of the riparian habitat monitoring in the lower Yuba River are to characterize:

- The spatial distribution and the magnitude of change in vegetation cover, and the structure of riparian vegetation as defined by height and species categories.
- The spatial distribution of cottonwood seedling recruitment and cottonwood tree establishment to the riparian community.

2.5.2 Survey Area

Monitoring riparian habitat changes in the lower Yuba River will be conducted in the locations shown in Table 2.4-2 This will make up the survey area for aerial photography and cottonwood field surveys.

2.5.3 Sampling Period and Frequency

YCWA will take aerial photography and monitor for cottonwood recruitment once within the first three years of license issuance, once in License Year 10 and every 10 years thereafter (i.e., License Years 20 and 30) until a new license is issued.

2.5.4 Data Collection

2.5.4.1 Aerial Photography

YCWA will obtain 1 meter resolution aerial color photography for the areas shown in Table 2.4-2.

2.5.4.2 Cottonwood Field Surveys

YCWA will monitor the recruitment of cottonwood trees by conducting field surveys for cottonwood seedlings and recruits. Seedlings are defined as trees less than 3.2 ft tall. Recruits are defined as less than 3 inches diameter at breast height (dbh), and greater than 3.2 ft tall and less than 30 ft tall (USACE 1987). Data collected for each tree will include height, dbh, and GPS location. Surveys will be conducted in the elevations inundated by flows up to 21,100 cfs. Attachment C provides an example of the Cottonwood Field Survey form.

2.5.5 Analysis

2.5.5.1 Aerial Photography

A combination of the aerial photographs (true color) and LIDAR information obtained from a legitimate source (e.g., Central Valley Floodplain Evaluation and Delineation Program) will be utilized to produce maps of riparian vegetation by vegetation type (VegCAMP classification) at a minimum mapping unit of 1 acre and four height categories: less than 10 ft, 10-<30 ft, 30 ft-<60 ft, and over 60 ft, based on an average of estimated heights from LiDAR. Approximately 5 percent of the polygons delineating vegetation classification and stand heights categories will be field verified during cottonwood counts. Field staff will generally verify that the dominant vegetation (top two species) and stand height matches the classification. Polygons to be field verified will be randomly selected from the maps. YCWA will report the data obtained by producing a summary report of vegetation categories, acreage, and heights and will quantify the change in riparian habitat from previous surveys, including the vegetation map produced by WSI and Fremier (2012). In addition, YCWA will produce and GIS shapefile of vegetation polygons attributed with height and vegetation classification. Attachment D provides and example of the Classification Verification form.

2.5.5.2 Cottonwood Field Surveys

The field survey data (i.e., cottonwood seedling or recruit, dbh and height) will be tabulated and averaged/summarized for each sub-reach. The analysis will be used as one measure to assess cottonwood recruitment along the lower Yuba River. GPS locations of cottonwood seedlings, or areas of their concentration, and recruits identified during the survey will be identified on a map.

YCWA will analyze and report changes in cottonwood recruited by sub-reach. A graph and data table will be provided for number of recruits and trees in the incremental elevation bands below these approximate flow levels: 1,500, 2,000, 3,000, 4,000, 5,000, 7,500, 10,000, 15,000, and 21,100 cfs.

2.6 Benthic Macroinvertebrates

The goal of BMI monitoring in the Yuba River downstream of Englebright Dam is to inform how benthic macroinvertebrate communities and associated ecological processes may be changing under the influence of new license terms and conditions.

2.6.1 Monitoring Component Objectives

The objective of the BMI monitoring is to examine the community composition of BMIs in the lower Yuba River and how the community composition changes over time.

2.6.2 Survey Area

Monitoring BMI changes in the lower Yuba River will be conducted in four of the six reaches surveyed by YCWA during Project relicensing under *Study 3.2 Aquatic Macroinvertebrates Downstream of Englebright Reservoir* (*Study 3.2*), as described below:

- Near the University of California Field Station (Timbuctoo Bend) (RMs 20.3 to 20)
- Parks Bar to Long Bar Area (RMs 17.8 to 17.5)
- Downstream of USACE's Daguerre Point Dam (RMs 11.4 to 11.1)
- Near Hallwood Boulevard (RMs 7.5 to 7.2)

2.6.3 Sampling Period and Frequency

Once within the first three years of license issuance and then in License Year 10 and every 10 years thereafter (i.e., License Years 20 and 30) until a new license is issued. In addition, BMI monitoring will be triggered by consecutive Schedule 5, 6, and Conference Water Years. Specifically, monitoring will occur in the second year of two consecutive Schedule 5, 6, or Conference Years (i.e., two back-to-back Schedule 5 Years, two back-to-back Schedule 6 Years, two back-to-back Conference Years, or a combination of Schedule 5, 6, or Conference Years, as determined by the May Schedule Water Year determination, unless monitoring will otherwise occur in that year (i.e., regularly scheduled monitoring)., such as in License Year 2).

2.6.4 Data Collection

YCWA will conduct BMI monitoring in the lower Yuba River as described below and following the protocols and procedures developed by the Environmental Protection Agency (Flotemersch, Stribling, and Paul 2006) and as recommended by Cal Fish and Wildlife (J. Harrington, CDFW, Pers. Comm., 2016).

2.6.4.1 Reach Layout and Documentation

As a desk exercise, lay out 11 transects (Transects A-K in Figure 2.6-1 below) within each of the 4 monitoring reaches:

- On an aerial photo or a 1:100:000 topographic map, locate the index site or "X-site," which should be the centerpoint of the reach sampled during Study 3-2 for comparability of results.
- Determine the average wetted width of the channel at the X-site using maps or aerial photographs. To get an average, determine the wetted width of the channel at 5 places of "typical" width within approximately 5 channel widths upstream and downstream from the X-site. Average the readings together and round to the nearest 1 m.
- Multiply the average wetted width by 40 to determine the sampling reach length. If the average width is > 100 m, use 4 km as a maximum reach length.
- From the X-site, measure a distance of 20 channel widths downstream using GIS software. Be careful to measure all of the bends of the river; do not artificially straighten out the line of measurement. The downstream endpoint is marked as Transect K. Measure 20 channel widths upstream of X-site, the upstream end is marked Transect A.
- Measure 1/10 of the reach length downstream from Transect A, and mark this spot as Transect B. Continue marking the 11 transects A-K in increments of 1/10 of the reach length. Enter the waypoints for the transects into a GPS unit so the transects are easy to find on sampling day.
- Assign the sampling station (10 m X 15 m) at Transect A randomly (e.g., use the seconds display on a digital watch to select the initial sampling station: 1-5 Left Bank, 6-9 Right Bank). From here, three stations will be on the first side of the river (i.e., Transect A, B, and C), then 2 on the other, then 2 on the first side, and so on through Transect K (Figure 2.6-1), for a total of 11 sampling stations.

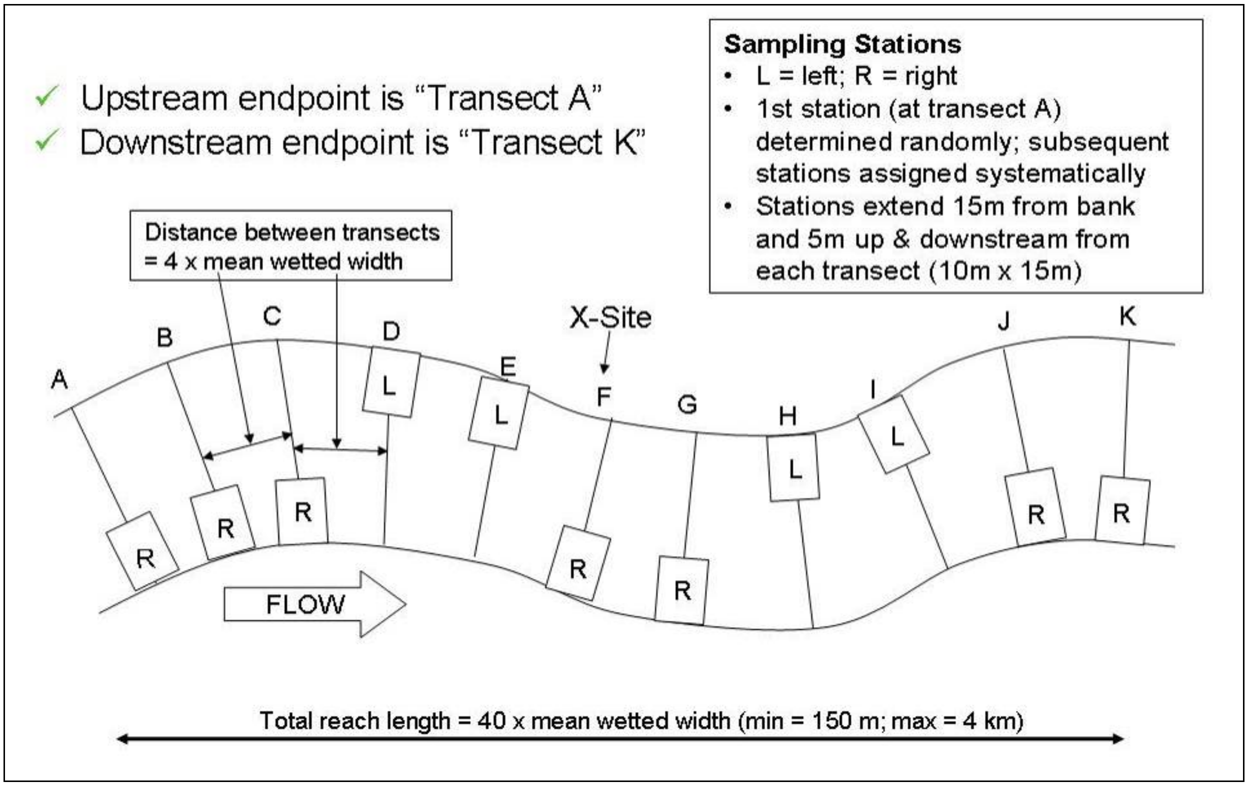

Figure 2.6-1. Sampling reach features for a non-wadeable stream site.
Source: Flotemersch, Stribling, and Paul 2006

2.6.4.2 Water Quality Sampling

At the upstream end of each of the 11 sampling stations (Transect A) within each sampling reach, on the same day of benthic macroinvertebrate sampling (see below), collect the following water quality parameters utilizing a handheld water quality meter (Hydrolab Quanta) or compatible instrument:

- temperature (°C)
- conductivity (µomhos/cm)
- pH (± 0.2 su)
- turbidity (± 1 NTU)
- dissolved oxygen

2.6.4.3 Benthic Macroinvertebrate and Physical Habitat Sampling

Collect BMI samples at the 11 sample stations within each sampling reach using a D-frame net with 500 µm mesh openings using the sampling procedures described below.

- After locating the sampling stations described above (see Reach Layout and Documentation section above), identify the dominant habitat type within each of the 10 m X 15 m sampling stations:
  - Rocky/cobble/gravel/large woody debris
  - Macrophyte beds
  - Organic fine mud or sand
  - Leaf pack
- Use the D-frame dip net (equipped with 500 μm mesh) to sweep through 1 linear meter of the most dominant habitat type within each of the 10 m X 15 m sampling stations, making sure to disturb the substrate enough to dislodge the organisms. Move in a downstream to upstream fashion, so the opening of the net is facing upstream and flow brings macroinvertebrates into the net (Figure 2.6-2).
  - If the dominant habitat type is rocky/cobble/gravel/large woody material, and if necessary, exit the boat and disturb the substrate (e.g., overturn rocks, logs) using your feet while sweeping the net through the disturbed area.
  - Because a dip-net is being used for sampling, the maximum depth for sampling will be approximately 0.5 m; therefore in cases in which the depth of the river quickly drops off it may be necessary to sample in the nearest several meters to the shore.
- After completing the 1 linear meter sweep, remove all organisms and debris from the net and place them in a bucket following the sample processing procedures (see Sample Processing in the Field section below).
- Record the sampled habitat type on the data sheet:
  - Fine/sand: not gritty (silt/claymuck: 0.06 mm diam.); too gritty (up to ladybug sized: 2 mm diam.)
  - Gravel: fine to coarse gravel (ladybug to tennis ball sized: 2 mm to 64 mm diam.)
  - Coarse: cobble to boulder (tennis ball to car sized: 64 mm to 4000 mm diam.)
  - Other: bedrock (larger than car sized; >4000mm diam.), hardpan (firm consolidated substrate), wood of any size, aquatic vegetation, etc. Note "other" substrate on the datasheet in the comments field.
- Identify the channel habitat type where the sampling quadrat was located and record on the data sheet.
  - Pool: still water, low velocity, smooth, glassy surface; usually deep compared to other parts of the channel.
  - Glide: water moving slowly, with smooth, unbroken surface, low turbulence
  - Riffle: water moving, with small ripples, waves, and eddies; waves not breaking; and surface tension is not broken; "babbling" or "gurgling" sound.

- Rapid: water movement is rapid and turbulent; surface water with intermittent "white water" with breaking waves; continuous rushing sound.

- Proceed to the next sampling station and repeat steps A-E. The organisms and detritus collected at each station on the river should be combined in a single bucket to create a single composite sample. After the 11 stations have been sampled, process the composite sample using the procedures described below.
- If the sample contains primarily organic material or if adverse weather conditions exist (i.e., hot humid weather), process the sample at each station by placing it in a 1 L nalgene jar with ethanol using procedures in the Sample Processing in the Field section below.

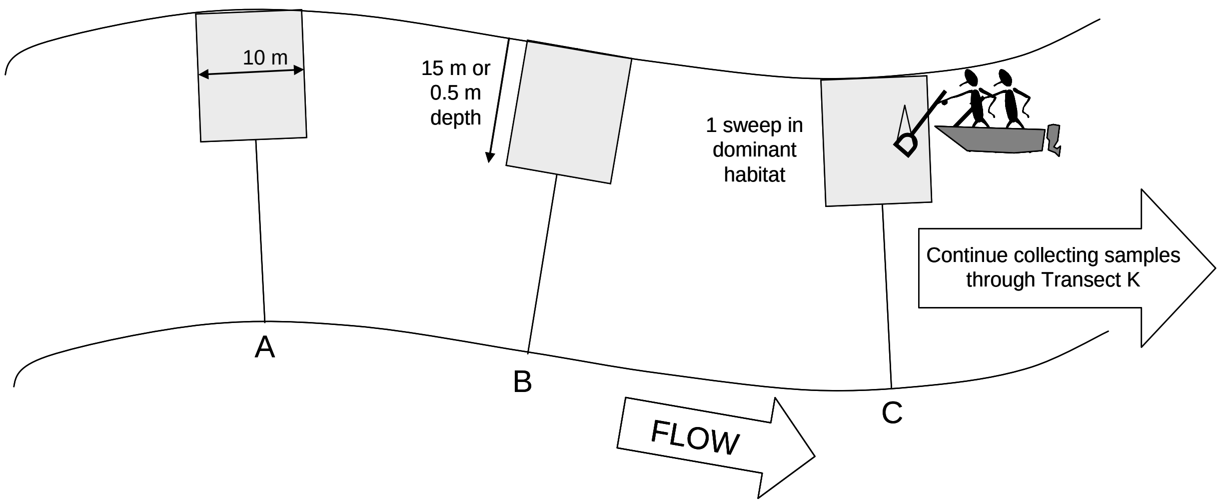

Figure 2.6-2. Transect sample design for non-wadeable streams benthic macroinvertebrate collection.
Source: Flotemersch, Stribling, and Paul 2006

2.6.4.4 Sample Processing in the Field

Use a 500 µm mesh sieve bucket placed inside a larger bucket full of site water while sampling to carry the composite sample. Once the sample from all the stations has been composited in the bucket, follow the procedures below to composite the sample.

Compositing Samples for Benthic Macroinvertebrates Collected Estimate the total volume of the sample in the sieve and determine how large of a jar will be needed for the sample (500 mL or 1 L) and how many jars will be required. No more than five 1 L jars should be used at each site.

Fill in a sample label with the Sample ID and date of collection. Attach the completed label to the jar and cover it with a clear tape strip. Record the Sample ID for the composite sample on the data sheet. For each composite sample, make sure the number on the data sheet matches the number on the label.

Wash the contents of the sieve to one side by gently agitating the sieve in the water. Wash the sample into a jar using as little water from the wash bottle as possible. Use a large-bore funnel if necessary. If the jar is too full, pour off some of the water through the sieve until the jar is not more than a half full, or use a second jar or larger jar. Carefully examine the sieve for any remaining organisms and use watchmakers' forceps to place them into the sample jar. Remove any inorganic material, such as cobble, by rinsing the material and examining it and removing it from the sample.

If a 2nd jar is needed, fill out a blank label. Record the ID number that is on the first jar. Attach the label to the 2nd jar and cover it with a strip of clear tape. Record the number of jars on the data sheet. Write "Jar *N* of *X*" on each sample label using a waterproof marker.

Place a waterproof label inside each jar with the following information written with a #2 lead pencil:

- Site ID
- Collectors initials
- Type of sampler and mesh size used
- Number of stations sampled
- Name of site
- Date of collection
- Jar "N" of "X"

Completely fill the jar with 95% ethanol (no headspace). It is very important that sufficient ethanol be used, or the organisms will not be properly preserved. Existing water in the jar should not dilute the concentration of ethanol below 70%. Replace the cap on each jar. Slowly tip the jar to a horizontal position, then gently rotate the jar to mix the preservative. Do not invert or shake the jar. After mixing, seal each jar with plastic tape. Store labeled composite samples in a container with absorbent material that is suitable for use with 70% ethanol until transport or shipment to the laboratory.

2.6.4.5 Sample Processing in the Laboratory

Each composite sample will be rinsed in a standard no. 35 sieve (0.5 mm) and transferred to a tray with twenty, 4-inch-square grids for subsampling, which will be performed using a stereomicroscope with magnifications of 10 to 20 times magnification.

Subsamples will be transferred from randomly selected grids to Petri dishes where the BMI will be removed indiscriminately with the aid of a stereomicroscope and placed in vials containing 70 percent ethanol and 2 percent glycerol. In cases where BMI abundance exceeds 100 organisms per grid, half grids will be delineated to assure that a minimum of three discreet areas within the tray of benthic material will be subsampled. At least 500 aquatic macroinvertebrates will be subsampled from a minimum of five grids, or five half grids.
The debris from the processed grids will be placed in a remnant jar and preserved in 70 percent ethanol for later quality control testing. Subsampled BMI will be identified by a taxonomist

approved by the Cal of Fish and Wildlife for USEPA evaluations using standard aquatic macroinvertebrate identification keys (e.g., Kathman and Brinkhurst 1998, Merritt and Cummins 1996, Stewart and Stark 1993, Thorp and Covich 2001, Wiggins 1996) and other appropriate references.

All organisms retained on a 0.5-mm screen will be removed from the subsample and a standard level one taxonomic effort will be used as specified in the Southwestern Association of Freshwater Invertebrate Taxonomists (SAFIT) (SAFIT 2006). Historical datasets that may have been identified using a different method, such as CAMLnet (CDFG 2003) or to a different taxonomic level will be standardized to the SAFIT level 1 before calculating metrics or running statistical analyses.

2.6.5 Data Analysis

Standard biological metrics, plus additional relevant metrics, will be calculated by YCWA for each site (Table 2.6-1) and presented in graphical or tabular form. YCWA will compare BMI data collected to any previous BMI data collected in the sampling reaches in order to determine changes (if any) in BMI assemblage metrics.

Table 2.6-1. Biological metrics calculated to assess BMI assemblages.

BMI Metrics	Description	Predicted Response to Impairment
RICHNESS MEASURES		
Taxonomic Richness	Total number of individual taxa	Decrease
Number of EPT Taxa	Number of taxa in the insect orders Ephemeroptera, Plecoptera, and Trichoptera	Decrease
Ephemeroptera Taxa	Number of mayfly taxa	Decrease
Plecoptera Taxa	Number of stonefly taxa	Decrease
Trichoptera Taxa	Number of caddisfly taxa	Decrease
Coleoptera Taxa	Number of beetle taxa	Decrease
COMPOSITION MEASURES		
% EPT	Percent of the composite of mayfly, stonefly, and caddisfly larvae	Decrease
% Ephemeroptera	Percent of mayfly nymphs	Decrease
Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness	Decrease
TOLERANCE/INTOLERANCE MEASURES		
California Tolerance Value (CTV)	CTVs between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) and intolerant (lower values)	Increase
Number of Intolerant Taxa	Taxa richness of those organisms considered to be sensitive to perturbation	Decrease
% Tolerant Organisms	Percent of macrobenthos considered to be tolerant of various types of perturbation	Increase
% Dominance Taxon	Measures the dominance of the single most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa	Increase
FEEDING MEASURES		
% CF+CG Individuals	Percentage of BMIs within the collector-filterer and collector gatherer functional feeding groups	Increase
% Scrapers	Percent of macroinvertebrates that graze upon periphyton	Variable
% Non-gastropoda Scrapers	Percentage of BMIs within the scraper functional feeding group excluding gastropod scrapers	Decrease
% Predators	Percent of macroinvertebrates that prey on living organisms	Decrease
% Shredders	Percent of macroinvertebrates that shred leaf litter	Decrease

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SECTION 3.0 CONSULTATION, REPORTING AND PLAN REVISIONS

3.1 Reporting

By March 15 of each year, YCWA will file with FERC, and provide to the NMFS, USFWS, Cal Fish and Wildlife and SWRCB a Lower Yuba River Aquatic Monitoring Report (Report). The report will include the information described in this Plan for each resource that was monitored in the previous calendar year, and will document non-compliance with this Plan during the performance of the monitoring surveys, if any.

By January 15 of each year, YCWA will provide a draft of the Report to NMFS, USFWS, Cal Fish and Wildlife and SWRCB for a 30 day-review period. If YCWA does not adopt a particular written recommendation by NMFS, USFWS, Cal Fish and Wildlife or SWRCB, the Report YCWA files with FERC on March 15 will include the reasons for not doing so.

3.2 Consultation

Each year during the term of the license, YCWA will meet with the Ecological Group to answer any questions regarding the Lower Yuba River Aquatic Monitoring Report from the previous calendar year and planned monitoring in that calendar year. The meeting will occur as described in YCWA's Proposed Condition GEN1, *Organize and Hold Ecological Group Meetings*.

3.3 Plan Revisions

YCWA, in consultation with the NMFS, USFWS, Cal Fish and Wildlife and SWRCB will review, update, and/or revise the Plan, as needed, when significant changes in the existing conditions occur including but not limited to changes in the listing status of aquatic species and changes in recommended sampling technology. Sixty days will be allowed for NMFS, USFWS, Cal Fish and Wildlife and SWRCB to provide written comments and recommendations before YCWA files the updated Plan with FERC for FERC's approval. YCWA will include all relevant documentation of coordination/consultation with the updated Plan filed with FERC. If YCWA does not adopt a particular recommendation by NMFS, USFWS, Cal Fish and Wildlife or SWRCB, the filing will include the reasons for not doing so. YCWA will implement the Plan as approved by FERC.[11]

[11] The Plan will not be considered revised until FERC issues its approval.

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SECTION 4.0
REFERENCES CITED

Allan, J. D., M. S. Wipfli, J. P. Caouette, A. Prussian, and J. Rodgers. 2003. Influence of streamside vegetation on inputs of terrestrial invertebrates to salmonid food webs Canadian Journal of Fisheries and Aquatic Sciences 60:309–320.

Bergman, J. M., R. M. Nielson, and A. Low. 2012. Central Valley In-river Chinook Salmon Escapement Monitoring Plan. Fisheries Branch Administrative Report Number: 2012-1. California Department of Fish and Game. Sacramento, CA.

California Department of Fish and Wildlife (Cal Fish and Wildlife). 2015. 2015/2016 California Freshwater Sportfishing Regulations. Effective March 1, 2015 - February 29, 2016.

Campos, C. and D. Massa. 2010a. Lower Yuba River Accord Monitoring and Evaluation Plan: Annual Rotary Screw Trapping Report: October 1, 2007 – September 30, 2008.

Campos, C. and D. Massa. 2010b. Lower Yuba River Accord Monitoring and Evaluation Plan: Annual Rotary Screw Trapping Report: October 1, 2008 – August 31, 2009.

Dalgaard, P. 2010. R Development Core Team (2010): R: A Language and Environment for Statistical Computing [Computer programme]. http://www.R-project.org/

DeHaven, R.W. 2002. Steelhead Spawning Surveys, Wheatfield Fork and Other Selected Reaches, Gualala River, California, 2002. Site accessed July 17, 2003. URL= www.krisweb.com/krisgualala/krisdb/html/krisweb/biblio/gualala_xxxx_dehaven_2002.pdf. September 2002.

Draper, N.R., and H. Smith. 1998. Applied regression analysis, 3rd edition. John Wiley &Sons, Inc., New York.

Flotemersch, J. E., J. B. Stribling, and M. J. Paul. 2006. Concepts and Approaches for the Bioassessment of Non-wadeable Streams and Rivers. EPA 600-R-06-127. US Environmental Protection Agency, Cincinnati, Ohio.

Gallagher, S. P., and C. M. Gallagher. 2005. Discrimination of Chinook Salmon, Coho Salmon, and Steelhead Redds and Evaluation of the Use of Redd Data for Estimating Escapement in Several Unregulated Streams in Northern California. North American Journal of Fisheries Management 25:284-300.

Gallagher, S. P., P. J. Hahn, and D. H. Johnson. 2007. Redd Counts. Pages 197-234 in D. H. Johnson, B. M. Shrier, J. S. O'Neal, J. A. Knutzen, X. Augerot, T. A. O'Neil, and T. N. Pearsons, editors, Salmonid Field Protocols Handbook: Techniques for Assessing Status and Trends in Salmon and Trout Populations. American Fisheries Society, Bethesda MD.

Hannon, J. and B. Deason. 2005. American River Steelhead (*Oncorhynchus mykiss*) Spawning 2001 - 2005. Central Valley Project, American River, California Mid-Pacific Region. United States Bureau of Reclamation.

Horvitz, D. G. and D. J. Thompson. 1952. A Generalization of Sampling without Replacement from a Finite Universe. Journal of the American Statistical Association. 47:663–685.

Kathman, R.D., and R.O. Brinkhurst. 1998. Guide to the freshwater oligochaetes of North America. Aquatic Resources Center, College Grove, TN. 264 pp.

Kawaguchi, Y., Y. Taniguchi, and S. Nakano. 2003. Terrestrial Invertebrate Inputs Determine the Local Abundance of Stream Fishes in a Forested Stream. *Ecology* 84(3):701-708.

Lindley, S. T., R. S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C.Hanson, B. P. May, D. R. McEwan, R. B. MacFarlane, C. Swanson, J. G. Williams. 2007. Framework for assessing the viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin. Vol. 5, Issue 1 [February 2007]. Article 4. http://repositories.cdlib.org/jmie/sfews/vol5/iss1/art4.

McDonald, T. L. 2010. mra: Analysis of mark-recapture data. R package version 2.7. http://CRAN.R-project.org/package=mra.

Merritt, R.W. and K.W. Cummins (eds.). 1996. 3rd Edition. An Introduction to the Aquatic Insects of North America. Kendall and Hunt Publishing Co., Dubuque, IA.

Nakano, S., Y. Kawaguchi, H. Miyasaka, Y. Shibata, H. Urabe, and N. Kuhara. 1999. Selective foraging on terrestrial invertebrates by rainbow trout in a forested headwater stream in northern Japan. Ecological Research 14(4):351–360.

Neter, J., W. Wasserman, and M. Kutner. 1985. Applied Linear Statistical Models. Homewood, IL.

Oregon Department of Fish and Wildlife (ODFW). 1999. Evaluation of Spawning Ground Surveys for Indexing the Abundance of Adult Winter Steelhead in Oregon Coastal Basins. http://oregonstate.edu/dept/ODFW/spawn/pdf%20files/reports/steel.pdf

Richards, F. J. 1959. A Flexible Growth Function for Empirical Use. Journal of Experimental Biology. Volume 10: 290-300.

Stewart, K.W. and B.P. Stark. 1988. Nymphs of North American Stonefly genera (Plecoptera). Monograph 12. Thomas Say Foundation. 460 pp.

Thorp, A.P. and A.P. Covich (eds.) 1991. Ecology and Classification of North American Freshwater Invertebrates. Academic Press, Inc., San Diego, CA.

United States Department of Agriculture, Forest Service (Forest Service). 1990. Tahoe National Forest Land and Resource Management Plan. Department of Agriculture. Nevada City, California. 687 pp. and appendices.

_____. 1988. Plumas National Forest Land and Resource Management Plan. Department of Agriculture. Quincy, California. Available online: < http://www.fs.usda.gov/detail/plumas/landmanagement/?cid=fsm9_034925>.

United States Fish and Wildlife Service. 2007. Flow-Habitat Relationships for Spring and Fall-run Chinook Salmon and Steelhead/Rainbow Trout Spawning in the Yuba River. Prepared by the Energy Planning and Instream Flow Branch. May 2007.

United States Fish and Wildlife Service. 2010. Flow-Habitat Relationships for Spring and Fall-run Chinook Salmon and Steelhead/Rainbow Trout Spawning in the Yuba River. Prepared by the Energy Planning and Instream Flow Branch. August 2010.

Volkhardt, G.C., S.L. Johnson, B.A. Miller, T.E. Nickelson, and D.E. Seiler. 2007. Rotary Screw Traps and Inclined Plane Screen Traps. Pages 235-266, *In* Salmonid Field Protocols Handbook: Techniques for Assessing Status and Trends in Salmon and Trout Populations. American Fisheries Society, Bethesda, Maryland.

Watershed Sciences, Inc. (WSI) and A. Fremier. 2012. Riparian vegetation analysis. Yuba River, California. April 27, 2012. Delivered to South Yuba Citizens League (Gary Reedy) and University of California (Greg Pasternack) as members of Yuba River Management Team (RMT).

Wiggins, G.B. 1996. Larvae of the North American Caddisfly Genera (Trichoptera). 2nd ed. Univ. Toronto Press, Canada.

Yoshiyama, R.M., F.W. Fisher, and P.B. Moyle. 1998. Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California. North American Journal of Fisheries Management. 18(3):487-521.

Yuba Accord River Management Team (RMT). 2009. Lower Yuba River Accord Monitoring and Evaluation Program. Appendix K – Protocols and Procedures for Rotary Screw Trapping. Draft. July 14, 2009.

_____. 2013. Aquatic Resources of the Lower Yuba River – Past, Present & Future, Yuba Accord Monitoring and Evaluation Program, Draft Interim Report. April 2013.

Yuba County Water Agency (YCWA). 2014. Applicant-Prepared Draft Biological Assessment for Central Valley Spring-Run Chinook Salmon, Central Valley Steelhead and North American Green Sturgeon. Yuba River Development Project FERC Project No. 2246. April 2014.

_____. 2015. Yuba River Accord River Management Team 2015 Steelhead Redd Survey Monitoring Plan. Specific Sampling Protocols and Procedures for Conducting Steelhead Redd Surveys - Winter/Spring 2015. January 13, 2015. Submitted to FERC January 20, 2015.

Lower Yuba River Aquatic Monitoring Plan

Attachment A

Particle Size Classes to be used in Substrate Classification

Yuba River Development Project

FERC Project No. 2246

December 2016

PARTICLE SIZE CLASSES TO BE USED IN SUBSTRATE CLASSIFICATION

Table 4[1]. New substrate classification that links statistical properties of LYR bed material grain size distributions and physical habitat suitability.

Class	Particle Size Range (mm)	Habitat suitability
Bedrock	No alluvium	Periphyton only
Boulder Field*	D>256	Chinook salmon and steelhead trout fry, parr, and smolt cover and foraging
Large Cobble	**128<D<256	Chinook salmon and steelhead trout fry and parr cover and foraging
Cobble	90<D< 128**	Chinook salmon spawning, embryo incubation, and fry cover
Medium Gravel/Small Cobble	32<D<90	Chinook salmon and steelhead trout spawning, embryo incubation, and fry cover
Fine Gravel	2<D<32	Steelhead trout spawning and embryo incubation
Sand	0.0625<D<2	
Silt/Clay	D<0.0625	SAV

1. Source: Pasternack, G.B. Specific sampling protocols and procedures for classifying and mapping substrate and cover.

*The boulder field designation is not intended for individual boulders, but for A) boulders arrayed as a step or B) a large, plane-bedded area of boulders.

**Following the procedure described in section 1.4.3, if field crews cannot distinguish the cobble and large cobble classes in a test, then the threshold between the classes will be shifted from 128 to 140 mm and another test will be done to see if this is more effective.

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Lower Yuba River Aquatic Monitoring Plan

Attachment B

Large Woody Debris Measurement
Criteria Data Form

Yuba River Development Project
FERC Project No. 2246

December 2016

LWD (for each piece within each of 5 randomly selected concentrations within reach) and Key Piece information

Stream Reach/Concentration ____ Crew:________________ Date________________

Piece #	Piece Cat	Piece Diam (in)	Piece Length (ft)	Spp Cat	Piece Stability (Y or N)				Piece Decay	Recruit	Pool FF	Bank Stab	Sed Store	Acc	GPS	Channel Orient	Photo #	Comments
	L R	Top/ Bot	Len/ Zone	C H U	R	B	P	S	1 - 5	under float fall other	dam plunge scour	I D	u/s d/s adj mc bar	Y/N	# or N/E	us or ds/ degrees		

Header: Identify **Stream Reach/Concentration** on each sheet: Marysville, Hallwood, Daguerre Point Dam, Dry Creek, Parks Bar, or Timbuctoo Bend. Number the randomly selected concentrations from 1 to 5 and indicate each on mobile device. Identify **crew** carrying out the survey, and the **date** of the survey.

Label	**Description**
Piece #	Unique identifier for each piece of wood. Each piece of wood that meet the criteria for either LWD or Rootwad will have a number.
Piece Cat	Category – either **L**WD or **R**ootwad. LWD defined p. 10 TFW protocol. Rootwad defined p. 12-13 TFW protocol.
Piece Diam Top/Bot	Diameter (in inches) as measured with caliper or biltmore or tape of top (thin end; written left of slash mark) and bottom (thick end written right of slash mark). Measure if can, else estimate average and use classes: **a**≡4 to <12”; **b**≡ 12 to <24”; **c**≡ 24 to <36”; **d**≡ ≥36”
Piece Length Len/Zone	Length (in feet) as measured with laser range finder or tape. Length defined on p.12 TFW protocol. Measure of can, else estimate length class: **I**≡3 to <25’; **II**≡ 25 to <50’; **III**≡ 50’ to < 75’; **IV**≡ ≥75’. At right side of slash, put lowest Zone into which any part of the piece extends. Zones defined p. 15 TFW protocol, usually Zone 1or Zone 2. There will be no pieces in Zone 4 (outside bankfull); bankfull designated as 5,000 cfs line set out on mobile device.
Spp Cat	Species Category – either **C**onifer or **H**ardwood or **U**nknown. Only specify C or H if absolutely sure. Defined p.20 TFW category
Piece Stability	Enter “Y” when apply, else “N”: **R**oot system or **B**uried or **P**inned and whether **S**table or not. Piece is considered “stable” if it is likely to remain in situ following high flows. R, B, and P criteria are defined on p.20 of TFW protocol; stability is defined differently than TFW protocol.
Piece Decay	Give a decay class from 1 to 5 based on Table 7 and described on p. 22 of TFW criteria.
Recruit	Recruitment: Identify if piece added to channel by being undermined by flow, floated in with high flow, fell to current location from riparian zone.
Channel Influence – defined as “Key Piece” [enter “Y” if apply, else “N” – each cell should have a value]	
Pool FF	Pool forming function provided by LWD; pool must meet minimum criteria as defined on Table 5, and described on p.20 TFW criteria. If LWD directly contributes to a **d**ammed pool, **p**lunge pool, or **s**cour pool, so note with appropriate letter.
Bank Stab	Bank stability is **I**ncreased (banks are protected from erosion, undermining through deflection or protection by LWD or **D**ecreased (LWD forces water into banks and directly caused erosion or undermining.
Sed Store	Sediment Storage: A minimum of 1 m^2 (9 ft^2) of sediment storage is enhanced by the LWD piece upstream (**u/s**), downstream (**d/s**), adjacent (**adj**) or LWD contributes to the formation of a mid-channel bar (**mc**). Defined partially on p.23 of TFW protocol.
Acc	Accumulation: **Y**es or **N**o. Will piece, while **IN SITU**, lead to other pieces accumulating in the same location.
If piece has ANY channel influence marked, and/or meets the 25-25 criteria (25” diameter at large end AND 25’ long), add following measurements:	
GPS	Note number as stored in GPS Unit “XX##” (XX≡Reach Initials; ##≡piece number) and document point number, or northing/easting in “Comment” column.
Channel Orient	Orientation in Channel: Stand at most accessible end and note whether facing upstream or downstream and take a compass reading along the major axis of the piece. Make sure declination of the compass has been set properly for the year and location.
Photo #	Take pictures of each piece. Note the camera at the beginning of the day, and make sure to note the photo number for each piece.
Comments	Note anything out of the ordinary such as pieces that might be linked but connection has been buried or cut, what the stability is provided by, human influence.
Root wad	A piece can be considered a root wad (in addition to being less than 2 m long from the end of the root ball to the to of the remaining part of the bole and minimum 20 cm diameter at the root collar [p. 12 and 13 TFW protocol]) if the roots are at least as long as the diameter of the root collar. There may be a judgment call if the roots don’t quite meet the length requirement but the root ball is so gnarly that it is highly likely for the root mass to catch on something and perhaps be more stable in the stream.

Reference:

“TFW”. Authors: Schuett-Hames, D, A.E. Pleus, J.Ward, M.Fox, J.Light. 1999. TFW Monitoring Program method manual for the large woody debris survey. Prepared for the Washington State Dept. of Natural Resources under the Timber, Fish and Wildlife Agreement. TFW-AM9-99-004. DNR #106.

Lower Yuba River Aquatic Monitoring Plan

Attachment C

Lower Yuba River Cottonwood
Field Survey Form

Yuba River Development Project
FERC Project No. 2246

December 2016

Lower Yuba River Cottonwood Field Surveys
Yuba River Development Project

Name:____________________ Sub-reach:________________________

Date:_____________________

Cottonwood Recruitment Data: seedlings (less than 3.2 ft tall) recruits (less than 3 inches dbh; greater than 3.2 ft tall and less than 30 ft tall)

Number	Seedling/Recruit	Height	DBH	GPS coordinates
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

QA/QC Initials:__________ Date:_____________

Data Entry Initials:________ Date:_____________

Lower Yuba River Aquatic Monitoring Plan

Attachment D

Lower Yuba River
Classification Verification Form

Yuba River Development Project
FERC Project No. 2246

December 2016

Lower Yuba River Vegetation Classification Verification
Yuba River Development Project

Name:____________________ Sub-reach:________________________

Date:_____________________

Verification Data (Approximately 5% of polygons should be field verified)

Polygon Number	VegCAMP Classification	Top Two Plant Species	Field Verified Y/N	If No, what potential VegCAMP Classification
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

QA/QC Initials:__________ Date:_____________

Data Entry Initials:________ Date:_____________