APPENDIX A

Stakeholder-Approved Technical Study Plans

POTENTIAL RESOURCE ISSUE:

Aquatic and riparian resources.

PROJECT NEXUS:

Project operations and potential Project betterments modify or could potentially modify the flow regime in the bypass reaches below the reservoirs/diversions and in the peaking reach downstream of Oxbow Powerhouse. The modified flow regime in the bypass and peaking reaches may affect the amount and distribution (temporal and spatial) of aquatic and riparian habitat.

POTENTIAL LICENSE CONDITION(S):

- Instream flow releases.
- Facility modifications.

STUDY OBJECTIVE(S):

The overall study objective is to characterize aquatic and riparian habitat as a function of flow using site specific data, ecological principles, and modeling methodologies derived from the literature (e.g., Bovee et al. 1998). The information developed from this study, in combination with other resource studies (e.g., water temperature, bioenergetics, fish passage, fish population, and special-status amphibian and reptile studies), will provide a basis for streamflow-related resource management decisions.

The specific objectives of the study include:

- Quantify the habitat versus flow relationships for fish, special-status amphibian, benthic macroinvertebrate, and riparian resources in the bypass and peaking reaches;
- Use the habitat versus flow relationships to develop a time series analysis of aquatic habitat under existing and unimpaired flow scenarios in the bypass and peaking reaches;
- Identify the time periods, flow conditions, and life stages when habitat may be a limiting factor for fish, benthic macroinvertebrate, special-status amphibian, and riparian populations for the existing and unimpaired scenarios; and
- Provide information necessary to quantify the potential effects of other alternative flow scenarios on aquatic and riparian habitat.

EXTENT OF STUDY AREA:

The study area includes the active channel and floodplain in bypass reaches downstream of Project reservoirs/diversions, the peaking reach downstream of Oxbow Powerhouse, and selected reaches upstream of the Project facilities. The study area is identified in Table AQ 1-1 and Map AQ 1-1. Some portions of the study area are very difficult to access due to the rugged terrain (see Map AQ 1-1) and thus, field data will only be collected in portions of the study area that are accessible. The reaches upstream of the Project facilities will be used to interpret riparian vegetation versus flow relationships; therefore, data collection in these reaches will be limited to that purpose.

STUDY APPROACH:

The following describes the general instream flow modeling approach for all streams, including specific methods for the peaking reach. The topics are selection of target species and/or guilds, development of habitat suitability criteria (HSC), stratification and study site selection, coordination of study site selection, study site modeling, hydrodynamics modeling, habitat modeling, and methods specific to the peaking reach.

Selection of Target Species and/or Guilds

A species distribution map for special-status amphibians and reptiles, fish, and riparian resources within the bypass and peaking reaches will be generated from the results of the AQ 2 – Fish Population Technical Study Plan (TSP), AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP, and AQ 10 – Riparian Resources TSP. Existing information (e.g., literature and qualified biologist observations) and pertinent study results will be used to develop a life stage periodicity chart (i.e., season of occurrence) for the aquatic species and riparian vegetation present in each study reach in consultation with the Aquatic Technical Working Group (TWG).

The species and life stages (and/or guilds) that will be used for instream flow habitat modeling will be selected in collaboration with the Aquatic TWG based on management importance and/or sensitivity to Project operations. Placer County Water Agency (PCWA) proposes that most life stages (e.g., juvenile rearing, adult rearing, spawning) of rainbow trout, brown trout (where brown trout have been targeted as a management objective), and hardhead and breeding and larval development (tadpoles) for foothill yellow-legged frogs (FYLF) will be modeled. All other aquatic species/life stages are proposed to be modeled using a guild approach.

Development of Habitat Suitability Criteria

HSC for each selected species/life stage will be developed in collaboration with the Aquatic TWG. For fish species, HSC criteria will be developed using a two-stage approach. First, existing HSC data, including HSC that have been used in recent instream flow projects in Sierra Nevada streams, will be compiled to create a database of HSC that can be reviewed for applicability to the Project. If there are uncertainties within the Aquatic TWG related to the appropriate HSC to use or if there are alternative HSC, the alternative HSC will be modeled and a sensitivity analysis will be conducted to identify the effects of alternative HSC on habitat versus flow relationships. If Aquatic TWG concurrence on acceptable sets of HSC can be achieved for individual species and life stages, then no additional data collection will occur. If concurrence is not reached regarding habitat suitability for juvenile or adult brown trout (where brown trout have been targeted as a management objective), rainbow trout, or hardhead, then PCWA will collect snorkeling-based summer/fall habitat suitability criteria data in the bypass reaches for validating or modifying the existing habitat suitability criteria data sets in question. At least 150 observations, if possible, of each juvenile and adult rainbow trout, brown trout, and/or hardhead will be collected. Data will be collected on an equal-effort basis for at least six different depth and velocity categories to minimize any habitat availability bias or sampling bias in the data. Data will be collected at the highest steady summer flow available to maximize the availability of habitat. Specific sampling locations will be selected in collaboration with the Aquatic TWG.

A guild or spatial niche approach will also be developed in collaboration with the Aquatic TWG to provide HSC for the aquatic (fish, amphibians, benthic macroinvertebrates) in the study area. Different categories of depth and velocity (e.g., slow-shallow, fast-shallow, deep-slow) will be developed that approximately correspond to the depths and velocities utilized by different species/life stage guilds (e.g., fry).

HSC for FYLF breeding and larval development (tadpoles) will be developed as part of the AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP. Riparian vegetation requirements, such as flow recession rates and inundation frequencies and durations, will be developed in the AQ 10 – Riparian Resources TSP.

Stratification and Study Site Selection

Geomorphology, hydrology, and habitat data collected as part of previous studies (PCWA 2006a; PCWA 2006b; PCWA 2006c) will be used to stratify the bypass and peaking reaches. Instream flow data will be collected and analyzed within these strata. The largest strata will be based on the results of the 2005-2006 geomorphic classification of the river channels (PCWA 2007) (Map AQ 1-2) and hydrological management reaches (i.e., reaches that have similar flow regimes as a result of Project operations). Within these geomorphic/hydrologic reaches, the river will be further stratified based on mesohabitat types. All accessible bypass and peaking reaches have been (or will be) mesohabitat mapped (typed) (either by aerial video, helicopter, or foot travel) using the most detailed level of mesohabitat typing outlined in McCain et al. (1990) (i.e., a potential of 22 mesohabitat types). These habitat types will be collapsed into a lower level of detail to facilitate river stratification for instream flow modeling. PCWA proposes to aggregate the McCain et al. (1990) mesohabitat types into approximately five types (pool, run, low gradient riffle, high gradient riffle, and cascade) for stratification of the study sites and river reaches. The specifics of this aggregation will be determined based on the results of the 2005-2006 Aquatic Habitat Characterization Study (PCWA 2007) and consultation with the Aquatic TWG. The aggregate mesohabitat types may be different for the large river (e.g., peaking reach), medium river, and small stream reaches.

Due to difficult access, study sites used to represent the different geomorphic/hydrologic reaches will be representative reaches stratified by mesohabitat type. The stratified representative reaches will be at least 20 to 40 channel widths in length (or longer) and will contain a full complement of mesohabitat types that are representative of the larger geomorphic reach. Where possible, the sites will overlap the 2006 Geomorphology and Riparian Habitat quantitative study sites (QSS) (PCWA 2006a). The 2006 Aquatic Habitat Characterization Study results will be used to check that the selected study sites contain all major mesohabitat types contained in the larger geomorphic reach and that the mesohabitat units are representative of those in the larger reach.

The preliminary geomorphic/hydrologic management reaches are shown in Table AQ 1-1 and Maps AQ 1-1 and AQ 1-2. The proposed number and general locations of the study sites within these geomorphic reaches are also shown in Table AQ 1-1 and Map AQ 1-1. The specific locations and lengths of the study sites will be selected in the field with concurrence from the Aquatic TWG (Table AQ 1-2). Prior to study site selection in the field, PCWA will summarize the geomorphic and hydrological data and work with the Aquatic TWG to finalize the delineation of geomorphic/hydrologic reaches. PCWA will also summarize the aquatic habitat characterization data and study site access data and work with the Aquatic TWG to make a preliminary recommendation of study site locations. A field trip will be scheduled in the late summer of 2007 with the Aquatic TWG to select study sites and specific habitat units and transects to model (Table AQ 1-2) (also see Study Site Modeling below).

Coordination of Study Site Selection

Study site selection will be coordinated with the AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP to include FYLF habitat, where appropriate, within the study sites. In addition, if unique locations (e.g., breeding sites) are identified by the AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP and the Aquatic TWG, then they will be modeled as part of the AQ 1 – Instream Flow TSP.

Selection of study sites will also be coordinated with the AQ 10 – Riparian Resources TSP and the AQ 9 – Geomorphology TSP to provide hydrodynamics modeling data for these studies within the general instream flow study sites. In addition, the AQ 1 – Instream Flow TSP will coordinate with the AQ 10 – Riparian Resources TSP to provide hydrodynamics modeling input during the selection of several riparian comparison study sites located upstream of selected Project diversions and in reference reaches (Table AQ 1-1 and Map AQ 1-1).

Study Site Modeling

Aquatic habitat modeling will be accomplished by sampling and modeling representative mesohabitat types in each study site with one-dimensional and/or two-dimensional hydrodynamics and habitat models. The results for each mesohabitat type will be weighted and combined to develop a representation of hydrodynamics and habitat for the larger geomorphic/hydrologic reach. The weighting will be based on the percentage of each mesohabitat within the geomorphic/hydrologic reach.

The sampling effort within each study site will be coordinated and determined in collaboration with the Aquatic TWG. The goal is to obtain a relatively accurate representation of the habitat versus flow relationship for each geomorphic/hydrologic reach. Some geomorphic/hydrologic river reaches, however, have greater (or lesser) importance in relation to the amount of habitat they provide (e.g., length of the reach or quality of the habitat) or the potential the Project has to modify habitat; therefore, the sampling effort will be adjusted as appropriate. In addition, there is some difficulty determining *a priori* the sampling effort (number and type of habitat units sampled) necessary to provide accurate habitat versus flow relationships.

In general, it is proposed that within a study site mesohabitat types will be sampled approximately in proportion to their abundance. Adjustments to the proportional sampling may be made based on the importance or variability of particular mesohabitat types. Typically, 10 mesohabitat units within a geomorphic reach will be sampled (modeled). This provides enough sampling to replicate each major mesohabitat type (e.g., two mesohabitat samples of each type) and provides for additional sampling in abundant and/or important mesohabitat types (e.g., 3 or more mesohabitat samples of abundant and/or important types). Each major mesohabitat type (greater than approximately 5-10% of the geomorphic/hydrologic reach) will be modeled. Rare mesohabitat types (<5%) that provide unique or important habitat (e.g., spawning, passage) will be modeled if they exist in the study site. In particular, patches of spawning gravel may be important habitat features to sample in the Project study sites. Mesohabitat types (e.g., cascades) that do not contain significant habitat for the primary target species or rare mesohabitat types (<5%) that do not have unique habitat importance will not be modeled.

The stratified representative study sites may contain more mesohabitat units than will be modeled. The specific mesohabitat units selected for modeling will be those that are most representative of the mesohabitats in the geomorphic/hydrologic reach. Results from the 2005-2006 Aquatic Habitat Characterization Study (PCWA 2007) will be used to compare (e.g., average length, width, depth, and substrate) mesohabitat types in the geomorphic reach with the mesohabitats in the study site. These data, along with a visual assessment of the representativeness of the mesohabitat units within the study site, will be used to select units to model. Final selection of the habitat units will be completed in the field in collaboration with the Aquatic TWG. PCWA does not recommend random sampling of mesohabitat units because unrepresentative results could occur.

For one-dimensional modeling, typically three cross-sections will be visually placed in the mesohabitat units to best represent the habitat over a range of flows. Fewer cross-sections may be placed in simple mesohabitat units with little variability or where the cross-sections are being placed to sample a variety of mesohabitat units of a particular type and not necessarily to fully characterize particular mesohabitat units. In some cases, additional cross-sections may be placed in highly variable mesohabitat units, if appropriate. Concurrence regarding cross-section placement within mesohabitat units will be obtained from the Aquatic TWG. The study sites where one-dimensional modeling is currently proposed and the approximate number of mesohabitat units to be sampled is shown in Table AQ 1-1.

The proposed sampling effort at three specific study sites is lower (6 mesohabitat units) compared to the effort at other sites due to the flow patterns, diversion operations, and reach length (Table AQ 1-1). Specifically, flows in the stream reaches on the North Fork Long Canyon Creek, South Fork Long Canyon Creek, and Long Canyon Creek are not affected by Project operation during the summer and fall low flow periods when the diversions are not operating. As a result, habitat modeling is primarily limited to quantifying habitat in winter and spring when diversion may occur. In addition, the natural summer/fall flows are very low (e.g., <1 cfs), which limits habitat availability.

Overall, for the 10 one-dimensional modeling sites identified in Table AQ 1-1 (not including the riparian comparison sites) the target total number of modeling cross-sections is 210 or less. This is an average 24 cross-sections for each of the seven typical sites and 14 cross-sections for each of the three reduced sampling effort sites. The final number of cross-sections and mesohabitat samples at each sampling site will be determined in the field with the Aquatic TWG.

Two-dimensional modeling will be targeted for application at the study sites in the peaking reach (Table AQ 1-1), if the habitat and logistics warrant its use. The potential benefits of two-dimensional modeling in the peaking reach are better spatial representation of habitat, improved representation of complex flow patterns, and efficient integration of various habitat analyses (fish, amphibians, macroinvertebrates, riparian vegetation, sediment transport). Also, two-dimensional modeling is capable of representing how habitat moves spatially with changes in flow, which is important when flow changes rapidly (e.g., peaking). However, to efficiently collect large amounts of topography for two-dimensional modeling on a large river, good site access and good survey grade Global Positioning System (GPS) coverage typically is necessary (the narrow canyon may limit GPS coverage). The most appropriate modeling methodology in the peaking reach (two- or one-dimensional) will be determined on the ground in collaboration with the Aquatic TWG when the study sites are selected. Because the mesohabitat units are very long in the peaking reach (larger river), the number of mesohabitat units sampled may need to be reduced (i.e., less than the 10 mesohabitat units proposed for one-dimensional modeling sites in the smaller river locations). A reasonable length of river to model at each site in the peaking reach is 0.5 to 1.0 miles.

Two additional study sites, one each in the Middle Fork American and Rubicon rivers upstream of Ralston Afterbay, will likely have some 2-D modeling at amphibian breeding locations (see AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP). Any two-dimensional habitat modeling completed in the bypass or peaking reaches as part of the AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP will be included in the fish habitat modeling as appropriate.

Hydrodynamics Modeling

PHABSIM (e.g., Milhouse et al. 1989) or equivalent one-dimensional hydraulics modeling procedures, as appropriate for the study site and specific objectives for the site, will be used for modeling water surface elevations and velocities across each cross-section. These procedures include stage-discharge regressions, Manning's equations, backwater step models (e.g., WSP, HecRas), and IFG4. Two-dimensional models, where used, will include River2D (Steffler and Blackburn 2001), MD-SWMS (McDonald et al. 2006), or comparable models.

Hydrodynamics (depth, velocity, water surface elevations) will be modeled over a wide range of discharges, appropriate to the project hydrology of each reach. Specific data to be collected using standard techniques include:

- Channel topography, either in the form of cross-sections (1-D) or three-dimensional (2-D) topography. Cross-sections will be marked with semi-permanent headpins and approximate GPS locations will be recorded.
- For one-dimensional modeling, empirical water surface elevations will be measured (surveyed) for at least three calibration discharges at each cross-section. For two-dimensional modeling empirical water surface elevations will be measured along the length of each study site at three calibration discharges. The discharges will span the range of flows of interest (Table AQ 1-1). The calibration flows will be determined by the Aquatic and Recreation TWGs once the hydrology has been compiled.
- Empirical velocity data will be collected across each cross-section (15-20 locations) at the high calibration discharge (or middle calibration discharge if determined by the Aquatic TWG to be the most appropriate discharge). In the peaking reach, if cross-section modeling is done, velocity data will be collected at the high discharge (e.g., 700 – 1,000 cfs) and at the middle calibration discharge. Table AQ 1-1 shows the target calibration discharges and the discharges where velocity will be measured. At all two-dimensional study sites, validation velocities will be collected across several cross-sections at an intermediate or low flow. All velocities will be collected with calibrated velocity meters. Discharges will be measured using standard gaging techniques (Rantz 1982) and/or an acoustic doppler current profiler (ADCP).

Substrate height and vegetation polygons for hydrodynamics roughness will be collected at all two-dimensional modeling study sites.

Habitat Modeling

Habitat modeling will be conducted using an approach consistent with the Instream Flow Incremental Methodology (IFIM) approach (Bovee et al. 1998). Where appropriate, the habitat modeling will include an additional bioenergetics based habitat analysis (e.g., Guensch et al. 2001, Hayes et al. 2000) (see AQ – 5 Bioenergetics TSP). The specific details of the habitat modeling will be developed in consultation with the Aquatic TWG. The general approach will be as follows:

- Collect substrate and cover information for habitat modeling across each cross-section (1-D) or in polygons (2-D) that is compatible with the HSC criteria developed in consultation with the Aquatic TWG.
- Develop habitat modeling algorithms or approaches appropriate for each selected species and life stage or guild in consultation with the Aquatic TWG. As part of this process, conduct a small pilot study on large slow-water pools to assist in the development of a logical habitat modeling approach for large pools.

  - Snorkel three large slow-water pools on the Rubicon River and record fish locations and behavior (e.g., drift versus benthic feeding) related to location and water velocity in the pools. Develop a technical memorandum describing the results and suggestions regarding potential modeling approaches for large, slow-water pools. Include a brief literature review of approaches to modeling large pools.

- Develop habitat versus flow relationships for each species life stage or guild over a wide range of flows (15 to 30 flows).
- Complete a habitat time series analysis comparing the seasonal and daily distribution of habitat for the existing and unimpaired project hydrology over the period of record (1975 to 2004). Compare and contrast the amount of habitat during different biologically significant time periods (e.g., reproduction, rearing) and identify potential habitat limiting factors and time periods.
- Coordinate with the AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP to identify outputs from the instream flow modeling that will assist in analyzing the relationship between instream flow and FYLF habitat.
- Coordinate with the AQ 10 – Riparian Resources TSP to identify key outputs from the instream flow modeling required for analyzing the relationship between instream flow and establishment and health of riparian vegetation in the bypass and peaking reaches.
- Potential collection of species observations at 2-D modeling sites for the purpose of habitat modeling validation will be determined in coordination with the Aquatic TWG following selection of the study sites in the field and following a review of the 2007 fish population and amphibian sampling results at the sites.

Methods Specific to the Peaking Reach

- Summarize existing and unimpaired hydrology data in the peaking reach to characterize between-day and within-day flow fluctuations.
- Install continuous stage monitors and develop rating curves at three to six key locations throughout the peaking reach to develop a flow fluctuation travel-time/flow attenuation monitoring and modeling relationship. In the summer, monitor a series of flow fluctuations in the peaking reach that includes flow fluctuations from approximately 200 to 1,000 cfs.
- Select the instream flow modeling sites in the peaking reach (Table AQ 1-1) to include representative habitat of fish, benthic macroinvertebrate, amphibian, and riparian resources that is sensitive to flow fluctuations. For example, select sites that have fry rearing habitat, potential fish stranding locations, amphibian breeding habitat, and benthic macroinvertebrate habitat.
- Model fish, special-status amphibian, benthic macroinvertebrate, and riparian habitat to address within-day flow fluctuations that result from hydropower peaking. This includes effective habitat analysis and stranding analysis for fry, spawning, benthic macroinvertebrates, amphibian egg masses, and tadpoles (e.g., Bovee et al. 1998).
- Conduct a one-time stranding evaluation downstream of Ralston Afterbay. Immediately after the first peaking event in late spring/early summer or during some other stranding sensitive time period determined in consultation with the Aquatic TWG, quantify stranding of aquatic species in sensitive habitats along 1,000 m of stream. If possible, this reach of stream will overlap with one of the instream flow study sites. This is a screening level stranding evaluation and will be used to identify the type (e.g., riffle, run, pool) and character (e.g., slope, dominant substrate, etc.) of habitats where stranding

potentially may be occurring under the current flow regime. Results will be used in conjunction with the instream flow modeling stranding analysis to identify the potential level of stranding that may be occurring within the peaking reach.

SCHEDULE:

Date	Activity
June 2007	Select calibration flows in consultation with the Aquatic and Recreation TWGs
July and August 2007	Select instream flow modeling site selection, installation of pressure transducers in the peaking reach
November 2007 through February 2008	Consult with the Aquatic TWG regarding: habitat suitability criteria, periodicity charts, and habitat modeling methods
March through October 2008	Conduct field surveys (topography, water surface elevations, velocities, substrate/cover data collection)
November 2008 through June 2009	Analyze data and prepare draft report
June 2009	Distribute draft report to the Aquatic TWG
July through September 2009	Aquatic TWG 90 day review and comment period
October through December 2009	Resolve comments and prepare final report
January 2010	Distribute final report to the Aquatic TWG and Plenary

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TABLES

Table AQ 1-1. Instream Flow Study Reaches and Modeling Methods.

Study Reaches/Sites	Bypass Reaches	Peaking Reach	Reach Upstream of Project Facilities	Site Name	Approximate Number of Mesohabitat Units to Sample[1]	Approximate Discharges for Model Calibration (cfs)[2] (V = Velocity data collection)				Modeling Methods
						Aquatic Habitat Modeling			Riparian /Geomorphic Modeling	
						Base	Med	High		
Duncan Creek										
Duncan Creek upstream of Diversion			●	IF D9.0	1-3	NA	NA	NA	Based on availability of spring high flows (HF)	Develop stage-discharge relationship for riparian vegetation comparisons
Duncan Creek below Diversion	●			IF D6.3/ D8.3	10	4-8	16[v]	44	HF[7]	1D
Middle Fork American River Upstream of Middle Fork Interbay										
Middle Fork American River upstream of French Meadows Reservoir			●	IF MF51.8	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons (potential)
Middle Fork American River below French Meadows Reservoir	●			IF MF44.7	10	4-8	48[v]	187	HF[7]	1D
Middle Fork American River Immediately above Middle Fork Interbay[5]	●			IF MF36.2	TBD	12-23	100[v]	374	HF[7]	1D
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay										
Middle Fork American River between Middle Fork Interbay and Ralston Afterbay	●			IF MF26.2	10	12-23	100[v]	374[8]	HF[7]	1D (some 2D for Amphibian habitat)

Table AQ 1-1. Instream Flow Study Reaches and Modeling Methods (continued).

Study Reaches/Sites	Bypass Reaches	Peaking Reach	Reaches Upstream of Project Facilities	Site Name	Approximate Number of Mesohabitat Units to Sample [1]	Approximate Discharges for Model Calibration (cfs) [2] (V = Velocity data collection)				Modeling Methods
						Aquatic Habitat Modeling			Riparian/ Geomorphic Modeling	
						Base	Med	High		
Middle Fork American River Downstream of Ralston Afterbay										
Middle Fork American River below Ralston Afterbay		●		IF MF14.1	10[3] or 0.5-1 mile[4]	75	368[v]	1000	HF[7]	2D/1D
Middle Fork American River above North Fork American River confluence		●		IF MF4.8	10[3] or 0.5-1 mile[4]	75	368[v]	1000	HF[7]	2D/1D
Rubicon River										
Rubicon River above Hell Hole Reservoir			●	IF R36.2	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons (potential)
Rubicon River below Hell Hole Reservoir	●			IF R25.7	10	10-20	80[v,9]	315[9]	HF[7]	1D
Rubicon River Near Ellicott Bridge	●			IF R20.9	10	10-20[6]	80[v,6]	315[6]	HF[7]	1D
Rubicon River Near Ralston Afterbay	●			IF R3.5	10	10-20[6]	80[v,6]	315[6]	HF[7]	1D (some 2D for Amphibian habitat)

Table AQ 1-1. Instream Flow Study Reaches and Modeling Methods (continued).

Study Reaches/Sites	Bypass Reaches	Peaking Reach	Reaches Upstream of Project Facilities	Site Name	Approximate Number of Mesohabitat Units to Sample[1]	Approximate Discharges for Model Calibration (cfs)[2] (V = Velocity data collection) – Aquatic Habitat Modeling: Base	Med	High	Riparian/ Geomorphic Modeling	Modeling Methods
North Fork Long Canyon Creek										
North Fork Long Canyon Creek upstream of Diversion			●	IF NFLC3.8	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons (potential)
North Fork Long Canyon Creek below Diversion	●			IF NFLC1.9	6	2	5[v]	11	HF[7]	1D
South Fork Long Canyon Creek										
South Fork Long Canyon Creek upstream of Diversion			●	IF SFLC4.2	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons
South Fork Long Canyon Creek below Diversion	●			IF SFLC2.3	6	2.5-5	10[v]	21	HF[7]	1D
Long Canyon Creek										
Long Canyon Creek below North and South Fork Long Canyon Creek	●			IF LC9.0	6	4.5-7	15[v]	47.5	HF[7]	1D

Table AQ 1-1. Instream Flow Study Reaches and Modeling Methods (continued).

Study Reaches/Sites	Bypass Reaches	Peaking Reach	Reaches Upstream of Project Facilities	Site Name	Approximate Number of Mesohabitat Units to Sample [1]	Approximate Discharges for Model Calibration (cfs) [2] (V = Velocity data collection)				Modeling Methods
						Aquatic Habitat Modeling			Riparian/ Geomorphic Modeling	
						Base	Med	High		
Other Tributaries										
North Fork Middle Fork American River			●	IF NFMF2.3	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons
North Fork American River			●	IF NF31.3	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons
North Fork American River			●	IF NF35.7	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for amphibian breeding habitat.
North Fork American River			●	IF NF53.7	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons. Limited access at high flows.

[1]Number of habitat units to model in some reaches may be reduced due to circumstances in the particular reach. See text for details.
[2]The target discharges were developed in consultation with the Aquatic and Recreation TWG. The discharges are approximate (or target releases) and the exact discharge may vary depending on circumstances during the release period (e.g., ability to accurately release flows, weather, etc.). The intent of the target discharges is to provide water surface elevations and a velocity data set to calibrate the hydraulic models. If flows during field data collection greatly deviate from the target discharges identified here, the Aquatic TWG will be notified and a decision will be made if additional data is required to calibrate the hydraulic models. A detailed table used by the Aquatic TWG to develop the flows is included in Appendix A.
[3]The number of mesohabitat units sampled may need to be reduced in this reach because habitat units are very long.
[4]If two-dimensional modeling is determined to be the most appropriate method in the reach, up to one mile (0.5 – 1.0 miles) of habitat will be modeled.
[5]The accessible section of stream in this section of river is short in length and may not be representative.
[6]Hell Hole release plus natural accretion, approximate target flows are 10-20, 104, and 370 cfs
[7]Based on availability of spring high flows.
[8]The canyon is narrow in this reach and 374 cfs may be too high to safely work in the channel. A flow release will be made as close to 374 cfs as can be safely worked.
[9]The facilities below Hell Hole Reservoir are limited in their release capabilities. The medium flow may need to be reduced to approximately 65 cfs. The highest flow may depend on the availability of spill events. The Aquatic TWG will be informed regarding the flows that can be released and consulted regarding hydraulic model development options

Table AQ 1-2. Instream Flow Study Detailed Site Information.[1]

Site Name	Geomorphic Reach[2]	River Mile Location of Site	UTM-Coords at Beginning of Site (Downstream River Mile) (Zone 10N, NAD83)	Number of Mesohabitats (Cross-sections) Total	HGR	LGR	RUN	POOL	Number of Special Purpose Cross-sections	Comments
Duncan Creek										
IF D9.0	Abv Diversion	9.0 - 9.2	718174, 4335012	3 (3)	n/a	n/a	n/a	n/a	3	Riparian Site Only
IF D6.3	DUN-R2	6.1 - 6.5	715520, 4332094	10 (22)	2 (4)	2 (2)	2 (4)	4 (12)	0	Instream Flow, Geomorphic, and Riparian Site
IF D8.3	DUN-R2	8.0 - 8.5	717228, 4334321	3 (3)	n/a	n/a	n/a	n/a	3	Limited Purpose Site 3 Geomorphic Cross-sections Only
Middle Fork American River Upstream of Middle Fork Interbay										
IF MF51.8	Abv Reservoir	Not a suitable comparison reach								Riparian Site (potential)
IF MF44.7	MFAR-R5	44.7 - 45.1	716554, 4329824	8 (19)	2 (3)	1 (1)	2 (3)	3 (12)	0	Instream Flow, Geomorphic, and Riparian Site
IFMF36.2[3]	MFAR-R5	36.0-36.2	708184, 4322341	11 (17)	3 (4)	1 (1)	3 (3)	4 (9)	0	Instream Flow, Geomorphic, and Riparian Site
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay										
IF MF26.2	MFAR-R4	25.9 - 26.4	696388, 4320083	9 (23)[4] 2[8] (20)	2 (4)	2 (2)	2 (7)[4] 1 (20)	3 (10)[4] 1[8] (20)	0	Instream Flow, Geomorphic, and Riparian Site (2D Amphibian Site)
Middle Fork American River Downstream of Ralston Afterbay										
IF MF14.1[5]	MFAR-R3	13.8 – 14.5	685560, 4313771	10 (2D)[5]	1 (2D)[5]	3 (2D)[5]	2 (2D)[5]	4 (2D)[5]	0	Instream Flow, Geomorphic, and Riparian Site
IF MF4.8[5]	MFAR-R1	4.1 – 4.8	675208, 4310856	11 (2D)[5]	0[5]	3 (2D)[5]	4 (2D)[5]	4 (2D)[5]	0	Instream Flow, Geomorphic, and Riparian Site
Rubicon River										
IF R36.2	Abv Reservoir	Not a suitable comparison reach								Riparian Site (potential)
IF R25.7	RUB-R3	25.1 - 26.2	720666, 4319717	11 (26)	2 (4)	3 (4)	3 (6)	3 (11)	1	Instream Flow, Geomorphic, and Riparian Site
IF R20.9	RUB-R2	20.2 - 21.0	717255, 4314092	13 (22)	3 (5)[7]	1 (1)	5 (5)	4 (11)	0	Instream Flow, Geomorphic, and Riparian Site

Table AQ 1-2. Instream Flow Study Detailed Site Information.[1]

Site Name	Geomorphic Reach[2]	River Mile Location of Site	UTM-Coords at Beginning of Site (Downstream River Mile) (Zone 10N, NAD83)	Number of						Comments
				Mesohabitats (Cross-sections)					Special Purpose Cross-sections	
				Total	HGR	LGR	RUN	POOL		
IF R3.5	RUB-R1	2.6 - 3.7	697150, 4319188	11 (22)[6] 2[8] (20)	2 (3)	2 (3)	3 (5)	3 (11)[6] 2[8] (20)	0	Instream Flow, Geomorphic, and Riparian Site (2D Amphibian Site)
North Fork Long Canyon Creek										
IF NFLC3.8	Abv Diversion	Not a suitable comparison reach								Riparian Site (potential)
IF NFLC1.9	NFLONG-R1	1.7 - 2.1	716314, 4324314	12 (18)	2 (3)	3 (3)	3 (3)	4 (9)	0	Instream Flow, Geomorphic, and Riparian Site
South Fork Long Canyon Creek										
IF SFLC4.2	Abv Diversion	4.6 - 4.9	720388, 4326694	3 (3)	n/a	n/a	n/a	n/a	3	Riparian Site Only
IF SFLC2.3	SFLONG-R1	2.2 - 2.6	717821, 4324192	11 (19)	2 (2)	2 (3)	3 (5)	4 (9)	0	Instream Flow, Geomorphic, and Riparian Site
Long Canyon Creek										
IF LC9.0	LONG-R2	8.7 - 9.2	712229, 4319403	8 (18)	1 (2)	2 (4)	2 (3)	3 (9)	0	Instream Flow, Geomorphic, and Riparian Site
Other Tributaries (North Fork American River and North Fork of the Middle Fork American River)										
IF NFMF~~1.7~~2.3	Other Trib.	3.1 - 2.4	697380, 4321935	3 (4)	n/a	n/a	n/a	n/a	4	Riparian and Amphibian Site
IF NF31.3	Other Trib.	30.5 – 31.8	677360, 4317941	4 (4)	n/a	n/a	n/a	n/a	4	Riparian Site Only
IF NF35.7	Other Trib.	35.6 - 36.0	681311, 4322809	2 (2)	n/a	n/a	n/a	n/a	2	Amphibian Site Stage Only
IF NF53.7	Other Trib.	53.1 - 53.3	691215, 4338605	3 (3)	n/a	n/a	n/a	n/a	3	Riparian Site Only (Limited Access at High Flows)

[1]Table to be completed in the field and in coordination with the Aquatic TWG. Study sites and modeling cross-sections were selected in the field in coordination with the Aquatic TWG in August and October 2007. Detailed information regarding mesohabitats and cross-sections is available in the PCWA Instream Flow Field Site Visit Data Packet (PCWA 2007b).
[2]See Map AQ 1-2 for reach descriptions.
[3]The accessible section of stream in this section of river is short in length and may not be representative.
[4]Three of the pool and three of the run cross-sections will be replaced with 2D modeling for amphibian breeding habitat.
[5]Site selected for 2D modeling. No cross-sections are required for 2D modeling.
[6]Three of the pool cross-sections will be replaced with 2D modeling for amphibian breeding habitat.
[7]One cross-section comes from a run mesohabitat.
[8]2D Modeling sites will in some cases extend downstream into portions of other mesohabitat units.

MAPS

APPENDIX AQ 1-A

Target Instream Flow Modeling Calibration Flows Working Table

Appendix AQ 1-A. Target Instream Flow Modeling Calibration Flows Working Table.

Facility/ Location	License Requirement[1]	1975 - 2003 Hydrology (cfs)		Target Calibration Flow/Release[3, 4, 8]	Approximate Duration (days)	Approximate Timing in 2008	Frog Breeding Considerations During Flow Releases	Comments
		Min, Avg, Max, 30% of Avg	% Exceedance 90, 80, 50, 20, 10, 40% of 10					
Duncan Creek Diversion Dam	Dry: 4 cfs or natural Wet: 8 cfs or natural	Imp : 0.1, 13.0, 2560, 3.9 UnImp : 0.1, 38.6, 2800, 11.6	0.7, 1.1, 5.9, 13, 16, 6.4 0.8, 1.2, 8.2, 55, 110, 44.0	4-8, 16[5], 44	1, 2, 1	Sp, Sp, Sp	Likely Not	---
French Meadows Dam	Dry: 4 cfs Wet: 8 cfs	Imp : 2.6, 19.4, 3430, 5.8 UnImp : 0.2, 165.3, 10373, 49.6	5.5, 7.7, 9.6, 11, 14, 5.6 4.5, 9.3, 46.4, 248, 467, 187.0	4-8, 48[5], 187	1, 2, 1	Su, Sp/Early Su, Sp	Likely Not	---
Middle Fork Interbay	Dry: 12 cfs or natural Wet: 23 cfs or natural	Imp : 4.8, 67.9, 7600, 20.4 UnImp : 2.8, 344.4, 17359, 103.3	13.0, 18.0, 24.0, 46, 85, 34.1 15.3, 23.6, 98.4, 552, 935, 374.1	12-23, 100[5], 374[9]	1, 2, 1	Su, Sp/Early Su, Sp	May/Early June	---
Below Oxbow Powerhouse	All Times: 75 cfs bl. NF of MF Confluence	Imp : 41.0, 1123.7, 64500, 337.1 UnImp[2]: 15.4, 1244.5, 88473, 373.4 UnImp : 17.1, 1481.6, 87662, 444.5	119.0, 277.0, 743.0, 1510, 2310, 924.0 76.6, 116.3, 362.8, 1971, 3229, 1291.4 81.2, 124.0, 466.6, 2428, 3863, 1545.0	75, 368[5], 1000[5,6]	2, 4, 2	Su, Su, Su	Likely Not, Typical Summer Operations Are Within The Range Of Target Flow Releases	---
Hell Hole Dam	Dry: 10 cfs June 1 – Oct 14 6 cfs Oct 15 – May 31 Wet: 20 cfs May 15 – Dec 14 10 cfs Dec 15 – May 14	Imp : 0.3, 39.4, 17100, 11.8 UnImp[2]: 0.1, 278.9, 22985, 83.7 UnImp : 0.1, 405.7, 25762, 121.7	10.0, 12.0, 20.0, 23, 26, 10.4 5.1, 11.3, 75.1, 416, 789, 315.4 9.1, 19.6, 120.4, 596, 1174, 469.6	10-20, 80[5,10], 315[10]	3, 6 (** may be able to reduce), 3	Su, Sp/Early Su, Sp	May/Early June	---
Rubicon Bl South Fork	None	Imp : 8.3, 117.4, 27544, 35.2 UnImp[2]: 3.7, 356.9, 34973, 107.1 UnImp : 3.0, 599.1, 36353, 179.7	26.0, 32.3, 47.1, 106, 193, 77.3 19.2, 29.4, 101.3, 533, 924, 369.5 19.1, 35.4, 178.7, 933, 1667, 666.8	10-20*, 80*, 315* (*Hell Hole release plus natural accretion, approx. target 10-20, 104, 370)	** same days as above	Su, Sp/Early Su, Sp	May/Early June	---
South Fork Long Canyon Diversion Dam	Dry: 2.5 cfs or natural Wet: 5 cfs or natural	Imp : 0.0, 8.7, 1304, 2.6 UnImp : 0.0, 18.4, 1304, 5.5	0.4, 0.7, 3.4, 6, 10, 4.2 0.4, 0.7, 4.4, 30, 52, 20.7	2.5-5[7], 10[5], 21	1, 2, 1	Sp, Sp, Sp	Presently Unknown	---
North Fork Long Canyon Diversion Dam	All Times: 2 cfs or natural	Imp : 0.0, 5.1, 742, 1.5 UnImp : 0.0, 9.8, 742, 2.9	0.3, 0.4, 2.0, 4, 8, 3.2 0.3, 0.4, 2.4, 15, 27, 11.0	2[7], 5[5], 11	1, 2, 1	Sp, Sp, Sp	Presently Unknown	---
Long Canyon Creek	None	Imp : 0.1, 29.3, 3424, 8.8 UnImp : 0.1, 43.8, 3424, 13.1	1.2, 1.8, 8.3, 29, 64, 25.6 1.2, 1.8, 10.6, 65, 119, 47.5	4.5-7[7], 15[5], 47.5 (NF and SF releases above plus natural accretion)	1, 2, 1 (** same days as NF and SF above)	Sp, Sp, Sp	Presently Unknown	---

[1]CDWR current year forecast of unimpeded run-off of the American River to Folsom Reservoir: Dry <1,000,000 a/f, Wet > 1,000,000 a/f.

[2]UnImp* = Unimpaired flows without PCWA Project, but impaired by SMUD.

[3]The lowest flow is the existing minimum flow. The medium flow is the higher of (A) the 2X the highest existing minimum flow or (B) the average of the 50% exceedance flow and the 30% of average flow (typically the latter). The highest flow is 40% of the 10% exceedance flow (allows modeling up to the 10% exceedance flow). Some exceptions exist to these rules. Below the Oxbow Powerhouse the maximum flow is set at 1000 cfs as this is the maximum flow that can be released through the powerhouse. In the North and South Forks of Long Canyon the medium flow target was set higher, between the minimum and high flows, to facilitate hydraulic modeling.

[4]These are target flows identified by the Aquatic TWG based on current information. The target flows may need to be modified if for instance the Recreation studies indicate that a flow outside the range of flows that can be modeled by the target flows needs to be evaluated.

[5]These flows are proposed for velocity data collection and will need to be maintained for several days during daylight hours. The other flows can be measured quickly and require shorter duration releases.

[6]An additional water surface elevation measurement near 2000 cfs will be measured if possible during spring runoff.

[7]An additional water surface elevation measurement lower than the minimum flow, will be obtained if possible, to facilitate low flow modeling.

[8]The target discharges were developed in consultation with the Aquatic and Recreation TWG. The discharges are approximate (or target releases) and the exact discharge may vary depending on circumstances during the release period (e.g., ability to accurately release flows, weather, etc.). The intent of the target discharges is to provide water surface elevations and a velocity data set to calibrate the hydraulic models. If flows during field data collection greatly deviate from the target discharges identified here, the Aquatic TWG will be notified and a decision will be made if additional data is required to calibrate the hydraulic models.

[9]The canyon is narrow in this reach and 374 cfs may be too high to safely work in the channel. A flow release will be made as close to 374 cfs as can be safely worked.

[10]The facilities below Hell Hole Reservoir are limited in their release capabilities. The medium flow may need to be reduced to approximately 65 cfs. The highest flow may depend on the availability of spill events. The Aquatic TWG will be informed regarding the flows that can be released and consulted regarding hydraulic model development options.

POTENTIAL RESOURCE ISSUE:

Fish species composition, distribution, and abundance.

PROJECT NEXUS:

Project operations and potential Project betterments modify or could potentially modify the flow regime and fish habitat in the bypass reaches and the peaking reach.

Changes in reservoir water surface elevations resulting from Project operations and potential Project betterments may affect fish habitat availability.

POTENTIAL LICENSE CONDITION:

- Instream flow releases.
- Modification of Project reservoir operations (reservoir water surface elevations).

STUDY OBJECTIVES(S):

- Document fish species composition, distribution, and abundance in the bypass and peaking reaches.
- Characterize fish growth, condition factor, and population age structure in the bypass and peaking reaches.
- Characterize fish species composition, relative abundance, and size in Project reservoirs and diversion pools.

EXTENT OF STUDY AREA:

The study area includes bypass and peaking reaches, comparison reaches upstream of Project facilities and diversions, and Project reservoirs and diversion pools. Specific study areas are identified in Tables AQ 2-1 and AQ 2-2 and Map AQ 2-1. Some portions of the study area are very difficult to access due to the rugged terrain (see Map AQ 1-1). Field data will only be collected in portions of the study area that are accessible.

STUDY APPROACH:

Study Sites

The general location of study sites for developing fish standing crop estimates (fish per mile and/or lbs per acre) in selected bypass, peaking, and comparison river reaches and for developing relative catch-per-unit-effort (CPUE) fish abundance in Project reservoirs and diversion pools is shown in Tables AQ 2-1 and AQ 2-2 and Map AQ 2-1. River sampling sites (electrofishing and or snorkeling) will generally be 100 meters long. Some of the larger river sites (e.g., the lower Rubicon and Middle Fork American rivers) may require reaches up to 300 meters to be sampled to include multiple habitat types. The specific locations of the sampling sites will be determined in the field in coordination with the Aquatic Technical Working Group (TWG). The 2005-2006 mesohabitat mapping results (PCWA 2007) will be used to help identify representative reach sampling sites with mesohabitat types in similar proportion to the larger geomorphic reaches of the river. Where possible, sampling sites will be chosen that overlap with the instream flow study sites (see the AQ 1 – Instream Flow Technical Study Plan (TSP)) and historic sampling sites (e.g., wild trout sampling data on the Rubicon River). Sampling sites will be chosen far enough upstream or downstream of access locations to minimize the effects of fishing on fish population results. Where comparisons likely are to be made between locations upstream and downstream of Project facilities, comparison study sites will be located in sections of river with similar habitat types and similar sampling methods will be used (see below). Table AQ 2-3 shows the specific location, length, sampling methods, and frequency of sampling for each sampling site (table to be completed by the Aquatic TWG). The reservoirs will be sampled (gillnets) at three locations along the length of the reservoir and the small diversion pools will be sampled in their entirety (snorkeling).

River Sampling

The river study sites will be sampled in year one to identify the spatial distribution and abundance of fish species. After year one, the Aquatic TWG will review the data to determine which sites will be sampled in year two and possibly in year three. to identify the temporal abundance of fish species. The goal will be to sample one to two sites per reach (Table AQ 2-3).

Quantitative river sampling will be conducted during the late summer/early fall base flow period using a combination of electrofishing (shallow water) and/or snorkeling (deep water) (Table AQ 2-3). Multi-pass electrofishing (e.g., Reynolds 1996; Van Deventer and Platts 1989; Rexstad and Burnham 1992) will be used to sample and estimate fish populations in shallow stream habitats (<1.5 m) at each representative reach study site. Where possible, the representative reach sampling sites will be partitioned into mesohabitat types for sampling using block nets. Captured fish from each pass will be kept in separate live wells or buckets. Fish will be anesthetized (CO_2), enumerated, identified to species, measured (fork length and weight), and scale samples will be obtained. Fish will be returned to the study site when the sampling is completed. Sampling protocols and field data forms will be consistent with those in Flosi et al. 1998. Habitat data consistent with those collected during the 2005-2006 Aquatic Habitat Characterization Study (PCWA 2007) will be collected at the study sites. In particular, the lengths and widths of the habitat units sampled will be recorded to calculate fish abundance by length and area (density) of stream sampled. Very small hardhead or pikeminnow that cannot be identified to species will be recorded as hardhead/pikeminow guild. Very small fish of all species that cannot be identified to species (or family) will be recorded as fry.

Snorkeling (e.g., Dolloff et al. 1996) will be used to assess fish populations in deep water habitats (≥ 1.5 m) at each representative reach study site (Table AQ 2-3). Snorkelers will survey in lanes along the river and will identify, count, and estimate the length of each fish observed. Fish data will be recorded by habitat unit type and detailed habitat information consistent with that collected during the 2005-2006 Aquatic Habitat Characterization Study (PCWA 2007) will be recorded. Snorkeling protocols and field data forms will be consistent with those in Flosi et al. 1998. Juvenile hardhead and pikeminnow (less than approximately 10 inches) will be recorded as a single category, hardhead/pikeminnow guild, where identification is uncertain. Very small fish of all species that cannot be identified will be recorded as fry.

At three study sites, snorkeling efficiency and species identification will be tested by snorkeling and electrofishing portions of the sampling sites where both techniques are feasible and comparing the results. The sampling sites and the mesohabitat units where the comparisons will be made will be determined in the field when sampling site locations are chosen. Sampling sites with a high likelihood of hardhead and pikeminnow presence will be chosen, if possible. These three locations will be the first sites sampled. If there is a problem with fish identification (e.g., hardhead versus pikeminnow) or with consistency of the snorkeling counts for target species (trout and hardhead), then the Aquatic TWG will be notified. Appropriate adjustments to the sampling protocol will be made where possible.

Along the river reaches, between or above the quantitative study sites (QSS), qualitative presence/absence sampling may be used to identify the upstream distribution of fish species. Snorkeling will be used, if necessary, to spot check between the study sites to identify the approximate late summer/early fall distribution of hardhead. Qualitative electrofishing will be used during the same time period to determine the upstream distribution limit of trout in North Fork Long Canyon Creek, South Fork Long Canyon Creek, and Duncan Creek if the upstream distribution is unknown.

Reservoir Sampling

French Meadows and Hell Hole reservoirs, Middle Fork Interbay, and Ralston Afterbay will be sampled once during the late summer/early fall using variable mesh gillnets. Two nets will be placed vertically at each of three sampling locations. The sampling locations will be distributed along the length of the reservoir (upper, middle, lower). If possible, historical California Department of Fish and Game (CDFG) sampling sites will be included. Nets will be set for one day and one night. Fish will be enumerated, weighed, and measured (total length). The primary purpose of the sampling will be to identify fish species composition, relative abundance (CPUE), and size. Where possible, wild fish and hatchery fish will be identified based on fin wear.

Ralston Afterbay will be sampled more intensively than the other Project reservoirs to help understand hardhead abundance and distribution, if present. The reservoir will be sampled twice in 2008; once in the late spring/early summer and once in early fall prior to the powerhouse maintenance drawdown. A combination of boat electrofishing along representative shoreline segments at night, gillnets, and sonar transects will used to sample the reservoir. (Note: during the first sampling trip, a qualitative test of day versus night electrofishing will be conducted to guide future sampling). If a CDFG electrofishing boat is not available to assist with this work, then some modification of the sampling plan may be required. This would be done in collaboration with the Aquatic TWG. The objective of this sampling is to determine the relative abundance of fry, juvenile, and adult hardhead and their spatial distribution in the reservoir related to horizontal and vertical water temperature gradients, if present. Water temperature will be quantified at each sampling site. The fall sampling will be coordinated with the river population sampling (above) to provide comparative data (i.e., relative abundance in the river sites compared to the reservoir). In the event that the above sampling methods do not identify hardhead use of the reservoir, an alternative sampling methodology using trawling will be used to verify the results.

Diversion Pool Sampling

The Duncan Creek, North Fork Long Canyon Creek, and South Fork Long Canyon Creek diversion pools will be snorkeled once during the late summer/early fall. The number, species, and size of fish in the diversion pools will be identified.

Special Purpose Qualitative Sampling

Qualitative sampling using electrofishing, hook-and-line, and/or seining gear may also be used for the following purposes:

- To collect additional trout and hardhead, if necessary, to develop age versus growth relationships in the Rubicon River (e.g., near Ellicott Bridge and above Ralston Afterbay) and in the Middle Fork American River below Ralston Afterbay where bioenergetics (temperature, food availability, and growth) may be an important issue. Scales from 50 rainbow trout, 50 brown trout, and 50 hardhead will be collected, if fish are present and sufficiently abundant in these reaches, for age and growth analysis (see AQ 5 – Bioenergetics TSP).
- To collect seasonal information on emergence of fry (i.e., to identify timing of spawning and early fry rearing). This sampling will occur in Duncan, North Fork Long Canyon, and South Fork Long Canyon creeks to identify the timing and abundance of fry in the vicinity of Project diversions. Three samplings will be equally spaced through the early May to early July time period if access to the streams is possible (i.e., roads are open). This qualitative sampling will also occur upstream of Ralston Afterbay (Rubicon River and Middle Fork American River) to identify the approximate timing of hardhead spawning and early fry rearing in these reaches. Three samplings will be equally spaced from May through July.

Data Reporting

- Summarize fish standing crop estimates for each species at each study site in terms of density (e.g., fish/ft^2 and fish/mile) and biomass (lbs/acre and lbs/mile).
- Identify appropriate fish standing crop comparison datasets in collaboration with the Aquatic TWG and with approval of the US Forest Service, CDFG, and the State Water Resources Control Board.
- Develop a distribution map for each species in the bypass reaches and the peaking reach using the quantitative abundance estimates and qualitative sampling data.
- Develop a fish life stage periodicity chart (or life history chronology chart by month) for each species for each study reach based on available literature, consultation with qualified fisheries biologists, and the fish population sampling data.
- Develop length frequency histograms of sampled fish and examine distribution modality, in conjunction with scale data, to determine the age structure of fish populations.
- Summarize fish growth and age data using length frequency and scale analysis.
- Calculate fish condition factors using measured weight and length data.
- For reservoir fishes, compile existing information (including fish species assemblages from historic sampling, stocking records, and fishing success) and compare to data from this study.
- Provide an electronic database (Excel spreadsheet) of all fish sampling data (date, location, fish species, fish size, sampling pass, etc.) to stakeholders.

SCHEDULE:

Date	Activity
May and June 2007	Conduct qualitative fish sampling (YOY emergence) and Ralston Afterbay sampling
July and August 2007	Select fish population sampling sites in collaboration with the Aquatic TWG
Late August through November 2007	Conduct quantitative fish sampling (electrofishing/ snorkeling/ reservoir sampling) and fish tissue collection for water quality study
December 2007 through February 2008	Analyze data and prepare draft report
March 2008	Distribute draft report to the Aquatic TWG
March 2008	Review 2007 fish population data results with the Aquatic TWG and determine which sites will be sampled in 2008 and possibly in 2009
March and April 2008	Aquatic TWG 60 day review and comment period
May and June 2008	Resolve comments and prepare final report
July 2008	Distribute final report to the Aquatic TWG and Plenary
2008 and possibly 2009 Fish Population Sampling	
May/June and September/October	Conduct Ralston Afterbay fish sampling
September and October 2008	Conduct 2008 river fish population sampling
October through December 2008	Complete data analysis and prepare draft report
January 2009	Distribute draft report to the Aquatic TWG
February and March 2009	Aquatic TWG 60 day review and comment period
March 2008	Review 2007 and 2008 fish population sampling results with the Aquatic TWG and determine if additional sampling is needed in 2009. Develop a schedule for additional sampling and reporting (if appropriate)
May and June 2009	Resolve comments and prepare final report

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TABLES

Table AQ 2-1. Fish Population River Sampling Reaches.

Study Reach	Site ID	Bypass Reaches	Peaking Reach	Reaches Upstream of Project Facilities or Comparison Rivers	Number of Fish Population Sampling Sites
Duncan Creek					
Duncan Creek upstream of Diversion	Fish D9.0			●	1
Duncan Creek from Diversion to confluence with Middle Fork American River	Fish D8.3 or D6.3	●			1
Middle Fork American River Upstream of Middle Fork Interbay					
Middle Fork American River upstream of French Meadows Reservoir	Fish MF51.8			●	1
Middle Fork American River from French Meadows to confluence with Duncan Creek	Fish MF44.7	●			1
Middle Fork American River from confluence with Duncan Creek to Middle Fork Interbay[1]	Fish MF36.2	●			1
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay					
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay	Fish MF26.2	●			1
Ralston Afterbay Downstream					
Middle Fork American River from Ralston Afterbay to confluence with Canyon Creek	Fish MF14.1 or MF19.1 or MF21.0		●		1
Middle Fork American River from confluence of Canyon Creek to confluence with North Fork American River	Fish MF4.8		●		1
Rubicon River					
Rubicon River upstream of Hell Hole Reservoir	Fish R36.2			●	1
Rubicon River from Hell Hole Reservoir to Ralston Afterbay	Fish R1.2 or R3.5 & R20.9 & R25.7	●			3
Long Canyon Creek					
North Fork Long Canyon Creek upstream of Diversion	Fish NFLC3.8			●	1
North Fork Long Canyon Creek from Diversion to confluence with Long Canyon Creek	Fish NFLC1.9	●			1
South Fork Long Canyon Creek					
South Fork Long Canyon Creek upstream of Diversion	Fish SFLC4.2			●	1
South Fork Long Canyon Creek from Diversion to confluence with Long Canyon Creek	Fish SFLC2.3	●			1
North Fork Long Canyon Creek					
Long Canyon Creek from North and South Fork Long Canyon creeks confluence to confluence with Rubicon River	Fish LC9.0	●			1
North Fork of the Middle Fork American River					
North Fork of the Middle Fork American River below the highway crossing	Fish NFMF2.3			●	1

Table AQ 2-1. Fish Population River Sampling Reaches.

Study Reach	Site ID	Bypass Reaches	Peaking Reach	Reaches Upstream of Project Facilities or Comparison Rivers	Number of Fish Population Sampling Sites
North Fork American River					
Upper North Fork American River	Fish NF53.7			●	1
North Fork American River above Lake Clementine	Fish NF31.3			●	1
North Fork American River below the confluence with the Middle Fork American River	Fish NF18.4		●		1

[1]Short segment of accessible stream, may not be representative.

Table AQ 2-2. Reservoir and Diversion Pool Sampling Locations.

Study Reservoir or Diversion Pool	Number of Sampling periods	Number of Fish Population Sampling locations
Duncan Creek		
Duncan Creek Diversion Pool	1	1
Middle Fork American River		
French Meadows Reservoir	1	3[1]
Interbay Reservoir	1	3[1]
Ralston Afterbay Downstream		
Ralston Afterbay Reservoir	2	3[1]
Rubicon River		
Hell Hole Reservoir	1	3[1]
Long Canyon Creek		
North Fork Long Canyon Creek Diversion Pool	1	1
South Fork Long Canyon Creek Diversion Pool	1	1

[1]Refers to the number of gillnetting locations in the reservoir.

Table AQ 2-3. Fish Population River Sampling Locations[1].

Study River and Site ID	Sampling Location		Site Length (m)	Sampling Dates[3]	Sampling Method	Comments
	River Miles	GPS at Downstream Starting location				
Duncan Creek						
Fish D9.0			100	Fall 2007	E	
Fish D8.3 or D6.3			100	Fall 2007	E	
Middle Fork American River Upstream of Middle Fork Interbay						
Fish MF51.8			100	Fall 2007	E	
Fish MF44.7			100	Fall 2007	E/S	
Fish MF36.2[2]			100-300	Fall 2007	E/S	
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay						
Fish MF26.2			100-300	Fall 2007	E/S	
Middle Fork American River Downstream of Ralston Afterbay						
Fish MF14.1 or MF19.1 or MF21.02			100-300	Fall 2007	S/E?	
Fish MF4.8			100-300	Fall 2007	S/E?	
Rubicon River						
Fish R36.2			100	Fall 2007	E/S?	
Fish R20.9			100-300	Fall 2007	S/E	
Fish R1.2 or 3.5			100-300	Fall 2007	S/E	
North Fork Long Canyon Creek						
Fish NFLC3.8			100	Fall 2007	E	
Fish NFLC1.9			100	Fall 2007	E	
South Fork Long Canyon Creek						
Fish SFLC4.2			100	Fall 2007	E	
Fish SFLC2.3			100	Fall 2007	E	
Long Canyon Creek						
Fish LC9.0			100	Fall 2007	E	

Table AQ 2-3. Fish Population River Sampling Locations[1].

Study River and Site ID	Sampling Location		Site Length (m)	Sampling Dates[3]	Sampling Method	Comments
	River Miles	GPS at Downstream Starting location				
North Fork of the Middle Fork American River						
Fish NFMF2.3			100	Fall 2007	E/S	
North Fork American River						
Fish NF53.7			100-300	Fall 2007	S/E	
Fish NF31.3[4]			100-300	Fall 2007	S/E	
Fish NF18.4			100-300	Fall 2007	S	

[1]All information is tentative. Information to be determined in the field and completed in coordination with the Aquatic TWG.
[2]Accessible section of stream short in length and may not be representative.
[3]After year one, the Aquatic TWG will review the data to determine which sites will be sampled in year two and possibly in year three. The goal will be to sample one to two sites per reach.

MAPS

POTENTIAL RESOURCE ISSUE:

Macroinvertebrate community distribution and abundance and special-status aquatic mollusk presence or absence.

PROJECT NEXUS:

Project operations and Project betterments modify or could potentially modify flow regimes and water quality (including water temperature) in the bypass reaches and the peaking reach, potentially affecting the macroinvertebrate community and food availability for fish.

If special-status aquatic mollusk species are present, Project operations and Project betterments could potentially modify their habitat or affect their populations.

POTENTIAL LICENSE CONDITION:

- Instream flow releases.
- Site-specific water quality measures.

STUDY OBJECTIVE(S):

- Document the seasonal density and size distribution of drifting macroinvertebrates in selected bypass reaches and the peaking reach for input to bioenergetics growth and habitat modeling.
- Document the benthic macroinvertebrate community in the peaking reach and compare to adjacent bypass and comparison reaches to characterize general habitat conditions.
- Sample the benthic macroinvertebrate community at long-term United States Department of Agriculture - Forest Service (USDA-FS) sampling sites to supplement existing data sets.
- Document the benthic macroinvertebrate community in the bypass reaches downstream of each large reservoir (Middle Fork American River below French Meadows Reservoir and Rubicon River below Hell Hole Reservoir).
- Document the benthic macroinvertebrate community in areas with known water quality issues as determined in the AQ 11 – Water Quality Technical Study Plan (TSP).
- Determine the presence or absence of three special-status[1] mollusk species (California Floater, *Anodonta californiensis*, scalloped juga, *Juga occata*, and Great Basin rams-horn snail, *Helisoma newberryi*) and identify potentially suitable habitat for these species (Furnish 2007).

EXTENT OF STUDY AREA:

The study area includes accessible bypass reaches, the peaking reach, and potential comparison reaches identified in Table AQ 3-1 and Map AQ 3-1.

[1] Special-status species is defined as any species that is listed as rare, threatened, or endangered or as a species of special concern by a federal, state, or local agency. The species identified are USDA-FS sensitive species.

STUDY APPROACH:

Macroinvertebrate Drift Sampling for input to Bioenergetics Modeling

- Collect drift samples at select AQ 1 – Instream Flow TSP sites (Table AQ 3-1 and Map AQ 3-1). Identify two representative riffles and sample drift at the downstream end of each riffle. Collect three drift samples at each riffle using a sampling methodology similar to that used in Hayes et al. 2000. Daytime only drift samples will be collected.
- Collect drift samples at three different times (June, August, and October). Process samples based on average drift density (number/m^3) at each site by 2 mm prey size classes (e.g., lengths 1-3 mm, 3-5 mm, 5-7 mm, etc.). Use general aquatic invertebrate length versus weight relationships to convert macroinvertebrate drift to energy equivalents (joules/m^3/size class) for bioenergetics modeling.
- Compare/contrast drift density and size between the study reaches and with the literature.
- Use the drift density information as an input to bioenergetics models to assist in the identification of limiting factors related to fish growth (food, water temperature, habitat) (See AQ 5 – Bioenergetics TSP).

Benthic Macroinvertebrate Sampling for General Habitat Conditions

In the bypass, peaking, and comparison reaches collect benthic samples and inventory data following the Surface Water Ambient Monitoring Program (SWAMP) (Ode 2007) protocols. Collect the composite benthic samples and physical habitat assessment data using the SWAMP methodology and process macroinvertebrate taxonomy to Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) level 2 (Richards and Rogers 2006). Include in the analysis ongoing California Stream Bioassessment Procedure (CSBP) (CDFG 2003) sample data being collected as part of the Ralston Sediment Management Project (Jones & Stokes 2002; Jones & Stokes 2006). Report benthic macroinvertebrate metrics as outlined in Rehn et al. (2007) as part of the data summary and provide other benthic maroinvertebrate metrics requested by the Aquatic TWG. Statistically compare/contrast SWAMP and CSBP sampling results between reaches and with data reported in the literature. Proposed sampling sites for benthic macroinvertebrates are identified in Table AQ 3-1 and Map AQ 3-1.

<u>Peaking Reach</u>

- Conduct SWAMP sampling in the peaking reach and adjacent bypass and comparison reaches (the Middle Fork American and Rubicon rivers above Ralston Afterbay, the North Fork of the Middle Fork American River, and the North Fork American River) to compare and contrast the macroinvertebrate communities.
    - To ensure comparability, select sample locations in the peaking reach and in the comparison reaches that are similar in substrate and hydraulic characteristics.
    - Include the ongoing Ralston Sediment Management Project fall CSBP sampling and sampling locations (Jones & Stokes 2002; Jones & Stokes 2006) within this sampling plan (Table AQ 3-1). The existing Jones & Stokes 2006 CSBP sampling sites will be re-sampled during the same year the SWAMP data are collected. Jones & Stokes staff will be integrated into the data collection at the existing CSBP sampling sites to ensure consistency with historical and ongoing sample collection.

Long-Term Agency and below Large Reservoir Sampling Sites

- Conduct SWAMP sampling at the long-term agency CSBP sampling sites above and below the diversions on Duncan and South Fork Long Canyon creeks.
- Conduct SWAMP sampling downstream of French Meadows Reservoir on the Middle Fork American River and downstream of Hell Hole Reservoir on the Rubicon River.

Special-Status Aquatic Mollusks Sampling

- Identify potential habitat using aerial photographs, helicopter video, Project maps, United States Geological Survey (USGS) 7.5 minute topographic maps, existing literature, and archeological information (e.g., mussel shells).
- Determine the number and location of representative survey sites based on the extent of identified suitable habitat. Presently, 20 survey sites have been identified (Map AQ 3-2). The mollusk sampling sites are co-located at the benthic macroinvertebrate sampling sites (Table AQ 3-1) and AQ 1 – Instream Flow TSP study sites. Sites are also located at the main tributary inflow locations of French Meadows and Hell Hole reservoirs. Also, if mussel shells are observed at fish sampling sites (See AQ 2 – Fish Population TSP) and/or at foothill yellow-legged frog survey sites (See AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP), mollusk sampling sites will be added at these locations. If the potential habitat evaluation identifies other mollusk survey sites (e.g., perennial springs or archeological sites with shells), then these sites will be surveyed.
- Survey sites will be a minimum of 100 m in length and surveyed in an upstream direction on each side of the river. River edges will be surveyed to a depth of approximately 60 cm. A viewing tube or snorkeling will be used to survey the deeper water. All substrates will be sampled. Sub-sampling will be used if necessary. If mud or silt substrate is present, then it will be sub-sampled at several locations using sieving.
- All site surveys will be timed and surveyed for a minimum of two hours.
- Physical habitat characteristics will be collected (water temperature, substrate composition, water velocity, and estimated channel gradient, width, and mean depth) at each study site.
- Aquatic gastropods will be field identified to family, genus, or species using keys in Burch (1989), McMahon (1991), and Frest and Johannes (1999) and representative specimens will be collected and preserved for laboratory verification.
- Mussels will be field identified using keys in Burch (1975 a, b) and McMahon (1991), and shells will be collected if present for further identification.

Data

All data (drift, benthic invertebrate, and mollusk) will be provided to the Aquatic Resources Technical Working Group (TWG) in an Excel spreadsheet electronic format.

Contingency Sampling

Coordinate with the AQ 11 – Water Quality TSP to identify any additional SWAMP sampling locations based on water quality results.

SCHEDULE:

Date	Activity
June 2007	In consultation with the Aquatic TWG select macroinvertebrate sampling sites
June 2007	Conduct drift sampling
August 2007	Conduct drift sampling
September and October 2007	Conduct benthic and drift sampling
November 2007 through March 2008	Analyze data and prepare draft report
April 2008	Distribute draft benthic and drift sampling report to the Aquatic TWG
April and May 2008	Aquatic TWG 60 day review and comment period
June and July 2008	Resolve comments and prepare final report
August 2008	Distribute final benthic and drift sampling report to the Aquatic TWG and Plenary
August 2008	Where appropriate conduct mollusk sampling
September 2008 through June 2009	Conduct contingency macroinvertebrate sampling, data analysis and report production
February 2009	Distribute draft mollusk sampling report to the Aquatic TWG
February and March 2009	Aquatic TWG 60 day review and comment period
April and May 2009	Resolve comments and prepare final report
June 2009	Distribute final mollusk report to the Aquatic TWG and Plenary

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TABLES

Table AQ 3-1. Macroinvertebrate Sampling Reaches.

Study Reach	Bypass Reaches	Peaking Reach	Comparison Reach	Long-Term Agency Sampling Sites	Number of SWAMP Benthic Macroinvertebrate Sample Locations (River Mile)	Number of Drift Macroinvertebrate Sample Locations (River Mile)	Jones & Stokes (2002, 2006) Ongoing CSBP Benthic Macroinvertebrate Sample Locations (Transects)
Duncan Creek							
Duncan Creek upstream of Diversion				●	1 (D9.0)	--	--
Duncan Creek from Diversion to confluence with Middle Fork American River	●			●	1 (D6.3)	--	--
Middle Fork American River							
Middle Fork American River from French Meadows Reservoir to Interbay	●				1 (MF44.7)	--	--
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay	●				1[a] (MF26.2)	1 (MF26.2)	1 (Transects 25, 27, 29)
Middle Fork American River from Ralston Afterbay to confluence with Canyon Creek		●			1[a] (MF14.1 and MF19.1)	1 (MF14.1 and MF19.1)	3[b] (Transects1, 3, 7, 9, 11, 13, 16, 18, 20, 23)
Middle Fork American River from confluence of Canyon Creek to confluence with North Fork American River		●			1 (MF4.8)	1 (MF4.8)	--
Rubicon River							
Rubicon River from Hell Hole Reservoir to confluence with South Fork Rubicon River	●				1 (R25.7)	1 (R25.7)	--
Rubicon River from confluence with South Fork Rubicon River to Ralston Afterbay	●				2[a] (R20.9 and R1.2/3.5 [d])	2 (R20.9 and R1.2)	1 (Transects 36, 40, 43)
Long Canyon Creek							
South Fork Long Canyon Creek upstream of Diversion				●	1[c] (SFLC4.2)	--	--
South Fork Long Canyon Creek from Diversion to confluence with Long Canyon Creek	●			●	1[c] (SFLC2.3)	--	--
Other Tributaries							
North Fork of the Middle Fork American River			●		1[a] (NFMF2.4)	--	1 (Transects 31, 33, 35)
North Fork American River			●		1 (NF31.3)	--	--

[a]Some of these samples would be in approximately the same area as the Jones & Stokes ongoing monitoring, but would enhance that sampling effort.
[b]One sampling location is split into two locations above and below the confluence of North Fork Middle Fork American River confluence.
[c]Samples on the South Fork Long Canyon Creek above and below the diversion will be used as surrogates for the North Fork Long Canyon Creek above and below the diversion. The Star Fire in 2001 may have affected the benthic macroinvertebrate community in North Fork Long Canyon Creek.
[d] The drift sampling site was originally started at R1.2 (June and early August 2007) and continued at R1.2 (September/October 2007). The instream flow study site was selected in the field by the agencies to be at R3.5 (August 2007). Fall 2007 benthic sampling was sampled at the instream flow study site R3

MAPS

POTENTIAL RESOURCE ISSUE:

Aquatic habitat quantity and quality.

Basin Plan objectives compliance.

PROJECT NEXUS:

Project operations and potential Project betterments modify or could modify the flow regime in the bypass reaches and the peaking reach, and storage levels in Project reservoirs, thereby influencing instream water temperatures.

POTENTIAL LICENSE CONDITION:

- Instream flow releases

STUDY OBJECTIVE(S):

- Characterize the relationship between flow and water temperature in bypass reaches and the peaking reach using an appropriate model supported by existing water temperature data.
- Characterize water temperature conditions in the bypass reaches and the peaking reach for the existing and unimpaired flow regimes.
- Document the availability of cold water temperature refugia in bypass reaches where water temperatures exceed established technical evaluation criteria.
- Assess the potential effects of increased air temperature due to global warming on water temperatures over the term of the new Federal Energy Regulatory Commission (FERC) license.

EXTENT OF STUDY AREA:

- The study area for water temperature modeling includes: five stream reaches in the Middle Fork American River between French Meadows Reservoir and the confluence with the North Fork American River; two stream reaches in the Rubicon River between Hell Hole Reservoir and Ralston Afterbay; and one reach in the North Fork American River between the Middle Fork American River confluence and Folsom Reservoir (Table AQ 4-1 and Map AQ 4-1). Water temperature models also are proposed for French Meadows and Hell Hole reservoirs. Duncan Creek and Long Canyon Creek (including the North and South Forks of Long Canyon Creek) will not be included in the temperature modeling study area because Placer County Water Agency (PCWA) has committed to not divert flow from these streams during the summer, after July 1, in the new license. The highest summer water temperatures occur in late July and early August (PCWA 2006; PCWA 2007a) and water temperature during this period will not be affected by the Project. Water temperature monitoring data will continue to be collected for these streams (see PCWA 2007a).

STUDY APPROACH:

- Summarize water temperature data from the 2005-2006 Water Temperature Study (e.g., PCWA 2006), including seasonal patterns and daily averages, minimums, and maximums as a function of time and location in the bypass and peaking reaches. Summarize the thermal profiles in the Project reservoirs. Also summarize the temperature data upstream of Project facilities. Summarize meteorological conditions (relative humidity, wind speed, solar radiation, air temperature) in the study area based on the meteorological data collected in the 2005-2006 Water Temperature Study (e.g., PCWA 2006).
- Continue to collect water temperature and meteorological data through the summers of 2007 and 2008 as part of the Water Temperature Study (PCWA 2007a). Map AQ 4-2 shows the water temperature and meteorological data collection locations.
- Establish a Water Temperature Modeling Subgroup (WTMG) to provide oversight and technical review of modeling procedures/decisions.
- Select and develop appropriate reservoir and river water temperature models with seasonal, daily, and within-day temperature modeling capability, as necessary for specific study reaches. RMA-2 and RMA-11 (King 1994; King 1997) are proposed for the river temperature modeling. RMA has dynamic flow routing capability and within-day temperature modeling capability. A new version of HEC-RAS (Brunner 2006) has been released with both dynamic flow routing and temperature modeling capability. This model may provide a more user friendly temperature and flow modeling platform than the RMA models. HEC-RAS will be investigated in collaboration with the Aquatic TWG as an alternative to the RMA models. CE-QUAL-W2 (Cole and Wells 2004) or CE-QUAL-R1 (Environmental Laboratory 1986) will be used for the reservoir water temperature modeling. CE-QUAL-W2 will be used if suitable bathymetric data are available. The reservoir temperature models at French Meadows and Hell Hole reservoirs will be integrated to characterize the potential effects on reservoir release temperatures associated with the French Meadows-Hell Hole Pump Storage potential Project betterment.
- The models will be developed to simulate average, maximum, and minimum daily water temperature during the summer months when water temperature may be of most concern to aquatic species. Modeling development steps to be completed in collaboration with the WTMG include:
  - Collect/develop model inputs including channel and reservoir geometry data, solar shading data (topographic and riparian), meteorological data (air temperature, wind speed, relative humidity, solar radiation), hydrology data, and boundary condition flow and water temperature data for the modeled river reaches and reservoirs.
    - Develop channel slopes and reservoir geometry using United States Geological Survey (USGS) Digital Elevation Model (DEM) data.
    - Generate daily and seasonal topographic solar shading data using Geographic Information System (GIS) algorithms and USGS DEM data. Estimate riparian solar shading using the 2005-2006 Riparian and Aquatic Characterization Study results (PCWA 2007b).
    - Use the 2005-2008 measured Project meteorological data and, if possible, extend the measured meteorological data to the 1975-2004 period through correlation with a long-term meteorological station. Suitable meteorological

stations will be identified and the correlation results will be evaluated as part of this study.

- Hydrology data will be generated from the operating flow gages during the 2005-2008 period, the Project Operations Model, and from the 1975-2004 existing and unimpaired hydrology developed in the Hydrology Study (2007).
- Channel cross-section data will be collected in the AQ 1 Instream Flow Technical Study Plan (TSP) and extended to the study reaches, as appropriate, using mesohabitat mapping data collected as part of the 2006 Aquatic Characterization Study (PCWA 2007b).

o Calibrate and validate the hydrodynamics and heat budget portions of the water temperature model(s) with empirical water temperature (river reaches and reservoirs) and meterological data (e.g., use data collected in 2005-2008). Calibrate water travel time in the peaking reach using the flow fluctuation travel times collected in the AQ 1 Instream Flow TSP.

- Characterize modeled water temperatures (i.e., seasonal, daily, within-day temperatures) for existing, unimpaired, and alternative flow conditions. For alternative flow conditions, model a range of flow releases determined by the WTMG.
- Incorporate available literature predictions of changes in air temperature as a result of global warming into a limited number of model runs (2-3) to evaluate the resulting effect on water temperature over the anticipated term of the FERC license period (limited sensitivity analysis).
- Model the potential effects of the French Meadows-Hell Hole Pump Storage potential Project betterment on reservoir temperature regimes and associated instream release temperatures.
- In selected reaches of the lower Rubicon River and the Middle Fork American River, collect water temperature data at tributary inflows and in deep pools to identify the potential availability of water temperature refugia for trout. In particular, review the 2005-2006 Water Temperature Study results (e.g., PCWA 2006) to identify river reaches with summer temperatures above 20°C. Within these reaches, identify likely tributaries with potential cold water inflows and characterize the extent of the cold water refugia (e.g., amount of tributary habitat, extent of influence in the main channel). Identify two deep pools upstream and two downstream of the tributary and collect water temperature profiles to examine potential thermal stratification.
- In the Project reaches where water temperature will not be modeled (e.g., Duncan Creek, North Fork Long Canyon Creek, South Fork Long Canyon Creek, and Long Canyon Creek), use existing water temperature and meteorological data to quantify the relationships between air temperature and water temperature.

SCHEDULE:

Date	Activity
January through October 2008	Develop and validate preliminary temperature model in collaboration with the Aquatic TWG
November 2008 through June 2009	Analyze data, develop the water temperature analysis in collaboration with the Aquatic TWG, and prepare draft report
July 2009	Distribute draft report to the Aquatic TWG
July through September 2009	Aquatic TWG 90 day review and comment period
October through December 2009	Resolve comments and prepare final report
January 2010	Distribute final report to the Aquatic TWG and Plenary

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TABLES

Table AQ 4-1. Water Temperature Modeling Reaches.

Study Reach	Bypass Reaches	Peaking Reach	Reservoir	Water Temperature Modeling
Duncan Creek				
Duncan Creek from Diversion to confluence with Middle Fork American River	●			No
Middle Fork American River				
French Meadows Reservoir			●	Yes
Middle Fork American River from French Meadows to confluence with Duncan Creek	●			Yes
Middle Fork American River from confluence with Duncan Creek to Middle Fork Interbay	●			Yes
Middle Fork Interbay			●	Yes[1]
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay	●			Yes
Ralston Afterbay Downstream				
Ralston Afterbay			●	Yes[1]
Middle Fork American River from Ralston Afterbay to confluence with Canyon Creek		●		Yes
Middle Fork American River from confluence of Canyon Creek to confluence with North Fork American River		●		Yes
North Fork American River from confluence with Middle Fork American River to Folsom Reservoir		●		Yes
Rubicon River				
Hell Hole Reservoir			●	Yes
Rubicon River from Hell Hole Reservoir to confluence with South Fork Rubicon River	●			Yes
Rubicon River from confluence with South Fork Rubicon River to Ralston Afterbay	●			Yes
Long Canyon Creek				
North Fork Long Canyon Creek from Diversion to confluence with Long Canyon Creek	●			No
South Fork Long Canyon Creek from Diversion to confluence with Long Canyon Creek	●			No
Long Canyon Creek from North and South Fork Long Canyon creeks confluence to confluence with Rubicon River	●			No

[1]These small reservoirs will be modeled using the river temperature model.

MAPS

POTENTIAL RESOURCE ISSUE:

Salmonid growth and habitat.

PROJECT NEXUS:

Project operations and potential Project betterments either modify or could potentially modify the flow, water temperature, and food resources (e.g., macroinvertebrates) in the bypass reaches and the peaking reach.

POTENTIAL LICENSE CONDITION:

- Instream flow releases.

STUDY OBJECTIVE(S):

- Determine factors limiting salmonid growth (food and/or water temperature).
- Predict the effects of changes in water temperature and food availability on salmonid growth and habitat.
- Determine the feasibility and appropriateness of predicting the effects of changes in water temperature and food availability on hardhead growth and habitat.

EXTENT OF STUDY AREA:

The study area for bioenergetics modeling and analysis includes the Rubicon River below Hell Hole Reservoir and the peaking reach. Temperature and food (macroinvertebrates) appear to be key environmental and management variables in these river reaches with potential to strongly control the amount and quality of fish habitat.

STUDY APPROACH:

- Use a salmonid bioenergetics model (e.g., Hanson 1997; Elliott and Hurley 1999; From and Rasmussen 1984; From and Rassmussen 1991) to analyze growth and water temperature relationships in the Rubicon River and the peaking reach. All model development work will be done in collaboration with the Aquatic TWG. Model development steps include:
    - Use historic water temperature data and observed growth of salmonids for a 3 to 4-year period (growth data will be collected in the AQ 2 – Fish Population Technical Study Plan (TSP) to calibrate the bioenergetics model. In other words, calculate the amount of food fish are consuming based on observed growth under the existing temperature regime. Growth for the 3 to 4-year period will be determined by back-calculation (e.g., Busacker et al. 1990) using the scale length versus fish length relationships generated from fish samples collected in the AQ 2 – Fish Population TSP.
    - Use the calibrated model to predict growth for the unimpaired flow/water temperature regime and alternative flow/temperature regimes.
- Use a bioenergetics foraging model that incorporates food availability, water temperature, depth, velocity, fish size, substrate/cover, and turbidity to quantify the

amount and quality of habitat for salmonids (e.g., Hughes and Dill 1990; Hughes 1992; Hill and Grossman 1993; Hayes et al. 2000; Guensch et al. 2001). The model will also aid development of salmonid habitat suitability criteria (see AQ 1 – Instream Flow TSP).

- Calibrate/validate the model with the depth and velocity habitat suitability data collected in the AQ 1 – Instream Flow TSP.
- Use the calibrated/validated bioenergetics foraging model to develop relationships between salmonid habitat availability and water temperature (see AQ 4 – Temperature Modeling TSP), food availability (see AQ 3 – Macroinvertebrate and Aquatic Mollusk TSP), discharge, and fish size in the Rubicon River and the peaking reaches.

- Determine the availability of bioenergetics data for hardheads (e.g., water temperature versus growth) to determine the feasibility of addressing water temperature and/or food availability through modeling; model if sufficient information is available and deemed appropriate.

SCHEDULE:

Date	Activity
November 2008 through June 2009	Conduct model development, data analysis and prepare draft report
July 2009	Distribute draft report to the Aquatic TWG
July through September 2009	Aquatic TWG review and provide comments on draft report
October through December 2009	Resolve comments and prepare final report
January 2010	Distribute final report to the Aquatic TWG and Plenary

REFERENCES:

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Rasmussen, G., and From, J. 1991. Improved estimates of a growth model and body composition of rainbow trout, Oncorhynchus mykiss (Walbaum, 1792) as function of feeding level, temperature and body size. Dana, 9:15-30.

POTENTIAL RESOURCE ISSUE:

Migration and dispersal of fish.

PROJECT NEXUS:

Project facilities and operations and potential Project betterments may affect fish passage.

POTENTIAL LICENSE CONDITION:

- Instream flow releases.
- Seasonal reservoir elevation constraints.
- Facility modifications.

STUDY OBJECTIVE(S):

- Document the location, nature, and characteristics of fish barriers in bypass reaches, the peaking reach, and the inlets to Project reservoirs and diversion pools.
- Identify Project facilities and operations (e.g., diversion structures, instream flow releases and reservoir water surface elevations) that may affect fish passage.

EXTENT OF STUDY AREA:

The study area includes the bypass reaches, peaking reach, and Project reservoirs and diversion pools. In addition to the reservoir dams (French Meadows, Hell Hole, Middle Fork Interbay, Ralston Afterbay), specific fish passage study locations include the following:

- The confluence of the Middle Fork American River with French Meadows Reservoir and the confluence of Five Lakes Creek and the Rubicon River with Hell Hole Reservoir.
- Tributary confluences within the bypass and peaking reaches: Duncan Creek, South Fork Rubicon River, Pilot Creek, Long Canyon Creek, North Fork of the Middle Fork American River, Volcano Canyon Creek, Otter Creek, and Canyon Creek.
- Project diversion pool dams: Duncan Creek, South Fork Long Canyon, North Fork Long Canyon.
- Potential fish barriers identified during the 2005-2006 Aquatic Habitat Characterization Study (PCWA 2006; PCWA 2007).

STUDY APPROACH:

- Identify and classify potential fish passage barriers in bypass and peaking reaches.
    - Use the 2005-2006 field habitat mapping results (PCWA 2006; PCWA 2007) to identify the location and nature (natural or Project-related) of potential barriers (e.g., natural falls, tributary junctions, road crossings, shallow riffles, and diversion or dam structures) in the bypass and peaking reaches and at tributary confluences.
    - Classify each potential barrier identified in the field mapping into to the falls, chute, and cascade types defined by Powers and Orsborn (1985) or as critical riffles (Thompson 1972).

  - Summarize fish passage data collected at the barriers during the field mapping (e.g., fall height, plunge pool depth, photographs, field biologist observations).
  - Use the aerial video of the Middle Fork American and Rubicon rivers to identify and classify (where possible) potential barriers within the reaches of river where no field mapping was conducted.
- Identify and classify potential tributary junction or reservoir inlet fish passage barriers along mainstem river reaches or at Project reservoirs.
  - At each reservoir and diversion pool, survey for barriers along the low pool to high pool length of each significant tributary (i.e., tributaries that provide rearing or spawning habitat). Identify the location and reservoir elevation of any potential tributary barriers. The following reservoir/diversion pool tributaries will be surveyed:
    - Duncan Creek (Duncan Diversion Pool)
    - South Fork Long Canyon Creek (South Fork Diversion Pool)
    - North Fork Long Canyon Creek (North Fork Diversion Pool)
    - Middle Fork American River (French Meadows Reservoir)
    - Five Lakes Creek and Rubicon River (Hell Hole Reservoir)
  - At the river tributary junctions, identify any barriers that are within the influence of the mainstream high to low flow water surface elevations. The following tributaries have been identified for assessment: Pilot Creek, Long Canyon Creek, North Fork of the Middle Fork American River, Volcano Canyon Creek, Otter Creek, and Canyon Creek.
  - Classify the potential barriers based on the falls, chute, or cascade types defined by Powers and Orsborn (1985) or as critical riffles (Thompson 1972).
    - Collect data necessary to evaluate fish passage at the barrier (e.g., fall height, riffle cross-section topography, stage elevation of the tributary junction barrier relative to the main channel).
- Quantitatively evaluate fish passage at the potential Project-related fish barriers during the base flow (low flow) period using the following information:
  - Leaping and swimming capabilities of the fish based on the literature (Powers and Orsborn 1985; Hoar et al. 1978) and fish size and water temperature information from the AQ 2 – Fish Population Technical Study Plan (TSP) and the AQ 4 – Water Temperature Modeling TSP;
  - Physical and hydraulic characterization of potential barriers based on measurements from the field and/or Project engineering drawings;
  - The fish passage assessment methodology outlined in Powers and Orsborn (1985) and Thompson (1972) modified, where necessary, for the specific species (e.g., rainbow trout, brown trout, hardhead) and barriers within in the study area.
- Qualitatively assess whether low flow barriers have the potential to become passable at flows higher than base flow.
- Identify and evaluate fish passage at Project diversion dams in collaboration with the Aquatic Technical Working Group (TWG).

- In collaboration with the Aquatic TWG, identify barriers, if any, that require hydrodynamics modeling to assess fish passage at a range of flows as determined by the Aquatic TWG other than base flow. Only barriers that prevent access to sections of river with important spawning or rearing habitat (as determined in collaboration with the Aquatic TWG) would be considered for modeling. If there are barriers that require hydrodynamics modeling do the following:
  - Characterize the seasonality, magnitude, and frequency of flows at the barrier over a range of water year types using the existing and unimpaired flow information.
  - Coordinate with the AQ 1 – Instream Flow TSP to provide hydrodynamics data and modeling to estimate fish passage over the range of flows determined by the Aquatic TWG.

SCHEDULE:

Date	Activity
November and December 2007	Conduct field surveys
January through March 2008	Analyze data and prepare draft report
April 2008	Distribute draft report to the Aquatic TWG
April and May 2008	Aquatic TWG 60 day review and comment period
May 2008	Meet with the Aquatic TWG to determine if there are any barriers that require hydrodynamics modeling
June through October 2008	Collect hydrodynamics data if necessary, resolve comments and prepare final report
November 2008	Distribute final report to the Aquatic TWG and Plenary

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PCWA. 2007. Middle Fork American River Hydroelectric Project (FERC 2079) 2006 Draft Physical Habitat Characterization Study. April 2007.

Powers, P. D. and J. F. Orsborn. 1985. Analysis of Barriers to Upstream Migration: An Investigation of the Physical and Biological Conditions Affecting Fish Passage Success at Culverts and Waterfalls. BPA Report No. DOE/BP-36523-1.

Thompson, K. 1972. Determining Stream Flows for Fish Life in Pacific Northwest River Basins Commission Instream Flow Requirement Workshop, March 15-16, 1972.

POTENTIAL RESOURCE ISSUE:

Fish mortality or translocation associated with flow diversion, intake structures or powerhouse facilities.

PROJECT NEXUS:

Project diversions and potential Project betterments could result in non-lethal or lethal entrainment of fish species at Project powerhouses and diversion facilities.

POTENTIAL LICENSE CONDITION:

- Modification of Project facilities or operations.

STUDY OBJECTIVE(S):

- Characterize Project facilities (diversions, intake structures and intakes, and powerhouse turbines) and operations in relation to factors that may affect entrainment or mortality.
- Develop the information necessary to assess the feasibility of screening intake structures (technical feasibility, feasibility level cost estimates, and maintenance requirements of screens).
- Indirectly estimate the potential for entrainment and mortality using the Project facility characterizations and literature information.
- Determine the need to directly sample entrainment and mortality at Project facilities in coordination with the Aquatic Technical Working Group (TWG).
- If appropriate, directly sample mortality and entrainment at selected Project facilities.

EXTENT OF STUDY AREA:

The study area for characterization of the Project diversions, intake structures, and powerhouse turbines includes Duncan Creek Diversion, North Fork Long Canyon Diversion, South Fork Long Canyon Diversion, French Meadows Powerhouse, Hell Hole Powerhouse, French Meadow-Hell Hole Tunnel Intake, Hell Hole-Middle Fork Tunnel Intake, Middle Fork Powerhouse, Middle Fork-Ralston Tunnel Intake, Ralston Powerhouse, Ralston-Oxbow Tunnel Intake, and Oxbow Powerhouse.

STUDY APPROACH:

- Characterize Project diversion structures and intakes, diversion operations, and powerhouse turbines. Provide either calculated or measured intake velocity fields at each intake structure over the range of potential inflows.
- Develop the information necessary to assess the feasibility of screening intake structures. This would include feasibility level estimates of screen installation costs, characterization of the technical feasibility of installing screens, and maintenance requirements of screens.
- Indirectly estimate entrainment and mortality potential.

- Specific to the Project diversions and powerhouses, summarize the literature on fish entrainment and mortality based on intake velocity fields, powerhouse characteristics (e.g., turbine type, turbine velocity, head), size class of fish species present, and fish swimming performance capabilities.
- Collaborate with the Aquatic TWG to fully develop the preliminary draft fish entrainment threshold calculation approach (CDFG 2007) to evaluate potential fish population and production effects of entrainment at Project diversions, intake structures and powerhouse facilities. The approach uses Project operations, fish population data obtained from the AQ 2 – Fish Population Technical Study Plan (TSP), additional qualitative fish sampling, literature information, and approximate calculations. Additional qualitative fish sampling will be conducted upstream of Duncan Creek, North Fork Long Canyon, and South Fork Long Canyon Creek diversions to identify the length of habitable stream above diversion structures.
    - At the Duncan Creek Diversion, North Fork Long Canyon Diversion, and South Fork Long Canyon Diversion, calculations of the potential annual fish production entrained into the diversions using the length of habitable stream above the diversions, fish population density in the stream above the diversion, literature-based reproduction rates, habitat-based carrying capacity estimates, and entrainment estimates (based on percent of flow diverted).
    - At the deep water reservoir powerhouse intakes, calculated intake velocity fields, vertical temperature profiles, and literature based estimates of entrainment will be used to calculate entrainment potential.
    - Potential mortality at powerhouses will be calculated using the entrainment estimates and literature-based powerhouse survival estimates.

- Collaborate with the Aquatic TWG to determine whether or not direct measurements of entrainment and mortality are warranted. Either the resource agencies or PCWA can determine that direct entrainment and/or mortality sampling is necessary. If entrainment sampling is necessary, then PCWA will collaboratively determine with the agencies a scope and schedule for direct sampling. If warranted, at a minimum, PCWA will complete the following sampling:
    - During four representative time periods (spring, early summer, late summer, and fall), sample entrainment at the Duncan Diversion, Ralston Powerhouse, and Oxbow Powerhouse (if diversions are occurring during these time periods). The feasibility of sampling each location has initially been assessed, but a final determination will need to be made prior to study implementation. If sampling at a location is not feasible (dangerous), then the location will not be sampled.
        - Sample entrainment for three consecutive days during each sample period.
        - Sample using a modified Kodiak trawl (or similar net) and measure the proportion of flow sampled by the trawl.
        - Identify, enumerate, and measure the length of entrained fish and record their status (uninjured, injured, and killed).
    - At the same time entrainment sampling is occurring, use a combination of sonar and conventional fish sampling gear (e.g., electrofishing, seining, gillnets) to estimate fish abundance, species composition, and size distribution near the diversion and powerhouse intakes (Duncan Creek Diversion Pool, Middle Fork Interbay, and Ralston Afterbay).

SCHEDULE:

Date	Activity
January through March 2008	Summarize literature and fish population data and meet with the Aquatic TWG to fully develop the fish entrainment threshold calculation approach and prepare a draft report
April 2008	Distribute draft report to the Aquatic TWG
May and June 2008	Aquatic TWG review and comment period
June 2008	Consult with the Aquatic TWG to determine need for entrainment sampling
July and August 2008	Resolve comments and prepare final report
August 2008	Distribute final report to the Aquatic TWG and Plenary
August 2008 through January 2010	If appropriate, develop contingency entrainment sampling scope, conduct contingency entrainment sampling, data analysis, and reporting

REFERENCES:

California Department of Fish and Game (CDFG) 2007. Preliminary draft fish entrainment thresholds prior to development of PM&E's or additional Phase II entrainment studies. California Department of Fish and Game. June 2007.

POTENTIAL RESOURCE ISSUE:

Reservoir fish habitat.

PROJECT NEXUS:

Project operations and potential Project betterments could affect reservoir fish habitat.

POTENTIAL LICENSE CONDITION:

- Reservoir operational constraints.

STUDY OBJECTIVE(S):

- Characterize management of reservoir water surface elevations and its relationship to availability of fish habitat under existing Project operations and potential Project betterment operations.

EXTENT OF STUDY AREA:

The study area is Project reservoirs including French Meadow Reservoir, Hell Hole Reservoir, Middle Fork Interbay, and Ralston Afterbay.

STUDY APPROACH:

- Summarize current fish species assemblage data, stocking records, and fishing success in each Project reservoir (see AQ 2 – Fish Population Technical Study Plan (TSP) and REC 2 – Recreation Opportunities TSP).
- Characterize the daily water surface elevation patterns and approximate pool volumes at each reservoir over the 1975–2004 period of record, using available water surface elevation records.
- Characterize historical hourly water surface elevation patterns and approximate pool volumes at Ralston Afterbay over the 1975–2004 period of record, when peaking operations were occurring (it appears the available data is limited). Either install a water surface elevation monitor or obtain access to the existing water surface elevation data to record within-day fluctuations (e.g., hourly).
- Characterize the daily water surface elevation patterns and approximate pool volumes of each reservoir associated with potential Project betterments using the Project Operations Model.
- Characterize the hourly water surface elevation patterns and approximate pool volumes at Ralston Afterbay associated with Project betterments (when peaking operations are occurring) using the Project Operations Model.
- Summarize water quality information with respect to thermocline location, epilimnion and hypolimnion water temperatures and dissolved oxygen concentrations for each Project reservoir under existing operations and under potential Project betterment operations (see AQ 11 – Water Quality TSP and AQ 4 – Water Temperature Modeling TSP).
- Provide all data to the Aquatic TWG in an Excel spreadsheet electronic format.

SCHEDULE:

Date	Activity
June through August 2009	Analyze data and prepare draft report
September 2009	Distribute draft report to the Aquatic TWG
September and October 2009	Aquatic TWG review and provide comments on draft report
November and December 2009	Resolve comments and prepare final report
January 2010	Distribute final report to the Aquatic TWG and Plenary

REFERENCES:

None.

POTENTIAL RESOURCE ISSUES:

Stable channel form and fluvial processes.

PROJECT NEXUS:

Project operations modify or could potentially modify the flow regime in the bypass and peaking reaches and capture sediment in Project reservoirs and diversion pools, resulting in changes to channel morphology and fluvial processes.

POTENTIAL LICENSE CONDITION:

- Channel riparian maintenance flows.
- Sediment Management Plan.
- Pulsed Flows.
- Channel Restoration.

STUDY OBJECTIVE(S):

- Document sediment conditions in the bypass reaches and the peaking reach.
- Characterize sediment capture in Project reservoirs and diversion pools under existing Project operations and potential Project betterments operations.
- Develop information to assist in the identification of flows necessary to maintain geomorphic processes in the bypass reaches and the peaking reach.
- Characterize large woody debris capture in reservoirs and diversion pools and document the historical large woody debris management practices.

EXTENT OF STUDY AREA:

The study area will include the bypass reaches, the peaking reach, comparison streams, and Project reservoirs and diversion pools (Table AQ 9-1).

STUDY APPROACH:

The following describes the geomorphology study approach which includes data collection and analyses for evaluating: (1) sediment conditions in the bypass and peaking reaches, (2) sediment capture in Project reservoirs and diversion pools, (3) flows necessary to maintain geomorphic processes, and (4) large woody debris (LWD) capture and management in reservoirs and diversion pools.

- Initial studies to characterize the geomorphic conditions of the river channels upstream and downstream of Project dams and diversions were completed by PCWA in 2005 and 2006 (PCWA 2005, PCWA 2007). This information was collected following methods as described in the 2005-2006 Existing Environment Study Plan Package which is available at the PCWA website: http://relicensing.pcwa.net/. Technical reports summarizing the 2005 and 2006 data are also available on the website. The objectives for these studies are summarized in Table AQ 9-2.

Sediment Conditions in the Bypass and Peaking Reaches

The amount of fine sediment in pools and the particle size composition and fine sediment content of spawning gravels will be determined in the bypass and peaking reaches, as described below.

Fine Sediment in Pools

A quantitative analysis (Hilton and Lisle, 1993) of fine sediment volume in 12 pools in the Middle Fork American and Rubicon rivers above Ralston Afterbay in the fall of 2006 found that the amount of fine sediment was very low; V* values averaged 0.03 (PCWA 2007). V* values less than 0.1 are indicative of low amounts of fine sediment.

- Conduct V* visual estimates in 10 pools at each of 11 sampling locations (Table AQ 9-1) centered on the 2006 geomorphic and riparian quantitative study sites within the bypass reaches, peaking reach, and comparison reaches to characterize the amount of residual pool fine sediment. Pools with V* values that are relatively low (less than 0.1) can be reasonably approximated by visual estimation (Hilton and Lisle, 1993). If there are problems completing the V* estimates (for example, due to excessive pool depths or V* values exceed 0.1), then this will be immediately communicated to the Aquatic TWG for further consultation.
  - Due to their very large size and depth (can be over ½-mile long and exceed 10-feet deep), pools on the Middle Fork American River below Ralston Afterbay and on the North Fork American River above Lake Clementine (comparison stream), will require a significantly greater effort to sample. Therefore, a total of 5 pools, instead of 10, will be visually surveyed on these two stream reaches.
  - Visual estimates of V* will be made using a snorkel and mask, and may require the assistance of divers (due to the excessive pool depth and size) at some locations. The visual surveys will be supported by a combination of photographic documentation of pool bottom sediments and sketch maps, and measurements of the surface area and depth of any fine sediment patches observed.

Particle Size Composition and Fine Sediment Content of Spawning Gravels

- Determine particle size distribution and fine sediment content of spawning gravels at 4 sites in each bypass, peaking, and comparison reach using bulk sampling techniques (McNeil and Ahnell, 1960). The sites will be selected within or immediately adjacent to the 2006 geomorphic and riparian quantitative sites. These locations are listed in Table AQ 9-1.
  - Collect bulk samples using a modified McNeil sampler (i.e., bottomless bucket) to depths that approximate that of a trout egg pocket in a redd. Coarse sediments will be sieved and weighed on-site. Finer sediments will be packaged for transport from the field site and later dried, sieved, and weighed.
  - One "side-by-side" replicate pair of bulk samples will be taken in each of the study sites to provide a measure of the variability in particle size composition within the same gravel deposit to characterize an expected range of natural variability.
- Plot particle size composition of spawning gravel samples as cumulative distribution curves and histograms. Statistically analyze the particle size composition as represented by the D50, D16, and D84.

- Compare particle size composition and fine sediment content to standards from the scientific literature (Kondolf, 1988 and 2000) and, where applicable, to the relevant comparison streams.

Sediment Capture in Project Reservoirs and Diversion Pools

The capture of sediment in Project reservoirs and diversion pools will be evaluated based on a review of existing sediment management information and data collected from field studies as described below.

<u>Obtain Sediment Management Information</u>

- Obtain information on sediment management practices implemented at Project diversion pools.
  - Summarize existing sediment management conducted by PCWA Operations and Maintenance personnel.
  - Obtain historic information, as available, pertaining to volume of sediments excavated and frequency of maintenance, for each facility.
  - Summarize any historical and recent bathymetry data and studies on Project reservoirs and diversion pools noting change in sediment accumulation over time.

<u>Determine Particle Size Composition and Estimated Sediment Loads Captured at Project Reservoirs and Diversion Pools</u>

- Survey French Meadows and Hell Hole reservoirs, Ralston Afterbay, Duncan Diversion, and Middle Fork Interbay, during low-pool conditions to quantify and characterize sediment capture.
  - Estimate the proportion in-filled with sediments by a combination of methods over the exposed reservoir bed (above the low-pool), including, topographic surveys (using an automatic level), visual surveys, or by aerial photogrammetric methods if pre-dam bathymetric surveys are available. Additionally, data from past dredging, sediment-pass through, and ongoing sediment maintenance studies will be used to estimate sediment loading to reservoirs.
  - Identify and photograph any evidence indicating the location of the original, pre-dam valley/river bottom conditions, such as tree-stumps.
- Estimate erosion and potential sediment loading along the shoreline of Hell Hole Reservoir associated with the Hell Hole Reservoir Seasonal Storage Increase Betterment.
- Conduct pebble counts (Wolman 1954) for surface sediments and bulk sampling for subsurface sediments to determine particle sizes captured and removed. Sampling will occur during either dry or low-pool conditions at each Project reservoir and diversion pools.
  - Perform sampling in representative areas of each reservoir that is dry and accessible during low-pool. The number of sampling points will depend upon the size of the area with visible deposition, and the relative heterogeneity of the deposition. Heterogeneous sampling areas will be visually delineated into relatively

homogeneous units (e.g., sand, gravel, cobble, boulder) and particle size sampling will take place in each defined unit.

- Subsurface bulk sampling will be performed using hand tools to dig below ground surface. A shovel or hand-auger will be used to obtain vertically-integrated depth samples. It is expected that bulk samples will be taken up to approximately 2 feet below ground surface, although a core sample with a hand auger could sample up to 10 ft depths if the subsurface material is no larger than fine gravels (about 16 mm).
- Visually catalogue and photograph all bulk samples for particle size (i.e., proportion of sediments in silt, sand, gravel, cobble size ranges). One-half of the catalogued bulk samples will be retained for sieving and particle size analysis. For the larger reservoirs, collect and catalogue about 24 samples, with about 12 samples retained for particle size analysis.
- Bulk sampling of sediments in the South Fork Long Canyon and North Fork Long Canyon diversion pools was performed in September 2006, just prior to planned maintenance activities at these locations. If these diversion pools re-fill with sediment in 2007 or 2008, then they will be re-sampled and particle sizes compared with those obtained from the bulk samples in 2006.
- Sketch maps of the surface particle size composition of the visible beds of the reservoir and diversion pool beds. The surficial area of any visible gravel deposits will be measured and recorded on the sketch maps.
- In addition to the bulk samples collected by hand tools, a backhoe will be used at French Meadows Reservoir and at Duncan Creek diversion to dig test pits at depths up to approximately 8 feet (assuming that groundwater does not interfere with sampling). The material at depth in the pits will be visually catalogued, photographed, and one sub-sample from each test pit will be retained for sieving and particle size analysis. The test pits will be used to determine if there is any vertical sorting of particle sizes at depth and whether or not the samples obtained by hand tools from shallower depths accurately represent the range of particle sizes deposited at depth in the reservoir.

Identify Flows Necessary to Maintain Geomorphic Processes in Bypass Reaches and the Peaking Reach

Information regarding flows that are necessary to maintain geomorphic processes in the bypass reaches and peaking reach will be developed by comparing impaired and unimpaired hydrologic regimes and evaluating sediment transport conditions under different flow regimes in the bypass and peaking reaches, as outlined below.

Compare Impaired and Unimpaired Hydrologic Regimes

- Compare impaired and unimpaired hydrologic regimes (high flow magnitude, duration, and frequency) in bypass reaches and the peaking reach using methods outlined in Guidelines for determining flood flow frequency: Bulletin 17B of the Hydrology Subcommittee, Interagency Advisory Committee on Water Data (USGS 1982) and Flood Frequency Analyses, Manual of Hydrology (Dalrymple 1960).
  - Determine unimpaired flood flow frequency from existing gaging records where available, as follows:

    - 11433500 Middle Fk American Nr Auburn (1912-1964, pre-dam era)
    - 11431000 Rubicon River Nr Georgetown (1943-1964, pre-dam era)
    - 11427700 Duncan Ck Nr French Meadows (1965-2005)

  - Evaluate the applicability of existing regional flood frequency curves (USGS 1993) based on the above referenced unimpaired flow data. If necessary, develop a regional flood frequency curve using the analytical procedures outlined by the USGS (Dalrymple, 1960) to determine the magnitude and frequency of unimpaired flows for ungaged locations, or locations with insufficient gaging records. The regional flood frequency analysis uses unimpaired flow records from gaging stations within the same hydro-physiographic region as the Middle Fork American River. Climatic trends, if any are identified, will be considered as may be necessary when selecting the appropriate hydrologic data set for flood frequency analysis.
    - Evaluate potential candidate unimpaired gaging stations for consideration in developing the regional unimpaired flood frequency curve in consultation with the Aquatic Technical Working Group (TWG). The potential candidate unimpaired gaging stations for consideration are listed in Table AQ 9-3.

Evaluate Sediment Transport Conditions under Different Flow Regimes at Selected Quantitative Study Sites

- Identify sediment transport flows at the geomorphic and riparian quantitative transects and instream flow transects using the hydraulic models developed for the AQ 1 – Instream Flow Technical Study Plan (TSP).
  - Collect stage-discharge data at high flows at geomorphic and riparian transects in select reaches to calibrate the hydraulic model.
    - For purposes of the sediment transport assessment, the range of flows used for stage-discharge calibration will be extended into higher discharges than typically required for aquatic habitat instream flow modeling. Stage data (i.e., water surface elevations) will be collected either by field observations during high flows (e.g., flagging water surface elevation on the banks, or from pre-installed staff gages) or by installation of automated pressure transducers that provide continuous water depth measurements.
  - Coordinate hydraulic modeling for sediment transport with the AQ 1 – Instream Flow TSP. The sediment transport modeling will be based on the hydraulic modeling described in the AQ 1 – Instream Flow TSP. The same study sites on the bypass and peaking reaches proposed for the AQ 1 – Instream Flow TSP will be evaluated for sediment transport conditions in this study (Table AQ 9-1).
  - Derive channel geometry data for input to the models from the cross-section and longitudinal topographic surveys performed as part of the AQ 1 – Instream Flow TSP.
    - Channel geometry data shall include identification of the bankfull flow elevation (bankfull elevation has already been identified for any transects that may be used from the 2006 geomorphology Level II field studies). The discharge corresponding to the bankfull elevation will be determined from the instream flow model simulations.

    - The specific locations and lengths of the study transects will be selected in the field in collaboration with the Aquatic TWG (Table AQ 9-4).
  - Derive channel hydraulic conditions, including flow depth, velocity, energy slope, and bed shear stress, from the models for a range of high flows.
    - Bed shear stress, which is calculated as a depth-slope product, will be obtained as an output from the AQ 1 – Instream Flow TSP modeling. Bed shear stress (τ) will be expressed as an average force (lbs/sq. ft.) over the transect width.
    - Determine the shear stress required to initiate motion for a given particle size from the Shield's criterion that defines the critical shear stress (τ^*_{ci}, the shear stress threshold at which incipient motion occurs). The bed shear stress obtained from the model and the Shield's criterion will be used to determine the particle sizes that are mobilized over the range of flows. Shield's relationship for critical shear stress is defined as, $\tau^*_{ci} = \beta (\gamma_s - \gamma) d_{50}$. Where: β = Shield's parameter (a dimensionless variable), γ, γ_s = specific weight of the fluid and sediment, respectively, and d_{50} = median particle diameter.
    - A range of commonly accepted values from the geomorphic and engineering literature will be documented and used for Shield's parameter (β). A range of critical shear stress and corresponding range of discharge values at which initiation of motion occurs for a given particle size will be presented.
  - Determine particle sizes in the channel from pebble counts performed for the Rosgen Level II channel classification, and/or bulk sediment samples, or from data collected as part of the Instream Flow TSP.
- In consultation with the Aquatic TWG, determine if additional empirical studies are necessary to characterize sediment transport under different flow regimes. If warranted the specific empirical studies to be applied at each study site will be dependent upon the specific study objective and the site specific characteristics. If empirical studies are warranted develop the scope of the studies in consultation with the Aquatic TWG. The study methods are likely to include one or a combination of the following approaches.
  - Placement and monitoring of tracer gravels
  - Installation and monitoring of pit traps
  - Installation and monitoring of scour chains
- Apply the procedure outlined in Grant et al. (2003) for predicting the geomorphic response of project rivers and streams to Project dams, including developing a graph that shows the response domain for predicted channel adjustments in relation to T* and S*.

Large Woody Debris Capture and Management in Reservoirs and Diversion Pools

The amount of LWD captured in Project reservoirs and diversion pools, and the relative extent to which large woody debris capture may effect the recruitment of LWD in downstream reaches will be characterized, as follows:

- Describe historical and existing large woody debris management by PCWA.
- Survey and quantify large woody debris captured at Project reservoirs and diversion pools.

- Characterize the fate of large woody debris transport into Project reservoirs and diversion pools using a combination of field observations, Project records, operator interviews, and historical water level records.
- Compare LWD amounts and function in bypass and peaking reaches above and below reservoirs and diversion pools. This information was collected as part of the Aquatic Habitat Characterization Study conducted by PCWA in 2006 (PCWA In progress).

SCHEDULE:

Date	Activity
July through December 2007	Conduct sediment survey and hydrology analysis
January and February 2008	Complete data analysis
March through June 2008	Conduct sediment transport field surveys in coordination with instream flow surveys
July through September 2008	Analyze data and prepare draft report. Complete backhoe test pits at Duncan diversion and French Meadows Reservoir for particle size analysis.
October 2008	Distribute draft report to the Aquatic TWG
October and November 2008	Aquatic TWG 60 day review and comment period
December 2008	Aquatic TWG consultation (need for additional empirical studies)
January and February 2009	Resolve comments and prepare final report
March 2009	Distribute final report to the Aquatic TWG and Plenary
April 2009 through January 2010	Conduct contingency geomorphology related studies, data analysis and report production. Complete re-survey of Duncan diversion for sediment loading estimate in summer 2009.

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TABLES

Table AQ 9-1. V*, Bulk Spawning Gravel, and Sediment Transport Hydraulic Model Locations.

River/Reach	Bypassed Reach	Peaking Reach	Initiation of Motion Sediment Transport Modeling Sites	Number of bulk spawning gravel samples	Number of V* pools
Duncan Creek					
Duncan Creek	●		1	4	10
Middle Fork American River (MFAR)					
MFAR French Meadows – Interbay	●		2	4	10[1]
MFAR Interbay – Ralston	●		1	4	10[2]
MFAR Below Ralston		●	2	4	5
Rubicon River					
Rubicon River Hell Hole – South Fork	●		1	4	10
Rubicon River South Fork – Ralston	●		2	4	10[3]
Long Canyon Creek					
North Fk Long Canyon	●		1	4	10
South Fk Long Canyon	●		1	4	10
Long Canyon	●		1	4	10
Comparison Streams					
North Fk of the Middle Fk American				4	10[4]
North Fk American				4	5

[1]Note: Two pools were surveyed in 2006, therefore only 8 additional pools will be surveyed in 2007.
[2]Note: Six pools were surveyed in 2006, therefore only 4 additional pool will be surveyed in 2007.
[3]Note: One pool was surveyed in 2006, therefore only 9 additional pools will be surveyed in 2007.
[4]Note: Three pools were surveyed in 2006, therefore only 7 additional pools will be surveyed in 2007.

Table AQ 9-2. 2005 and 2006 Geomorphology Study Objectives.

2005 and 2006 Geomorphology Purpose
Characterize geomorphic conditions of the river channel upstream and downstream of Project dams and diversions.
2005 and 2006 Study Plan Objectives
Classify and organize bypass reaches into distinct reaches based on stream morphology.
Distinguish the relative responsiveness (i.e., "sensitivity") of river reaches to alterations of flow and sediment regimes.
Describe geomorphic conditions of river reaches immediately upstream of Project facilities to evaluate their suitability to serve as reference reaches in later study phases.
Identify potential comparison streams (reference reaches) in the vicinity of the MFP if reaches immediately upstream of Project facilities are determined to be unsuitable as reference reaches.
Provide framework for organizing future survey efforts.

Table AQ 9-3. Potential Candidate Unimpaired Gaging Stations for Consideration in Development of Regional Unimpaired Flood Frequency Curve.

USGS Gage Number	Gaging Station Name	Period of Record
11433400	Canyon Ck Nr Georgetown	1966-1979
11432500	Pilot Ck Nr Georgetown	1947-1960
11431800	Pilot Ck Abv Stumpy Meadows Res	1960-2005
11430000	So Fk Rubicon R Bl Gerle Ck Nr Georgetown	1911-2005
11426150	Onion Ck Nr Soda Springs	1961-1979
11428000	Rubicon R A Rubicon Springs Nr Meeks Bay	1955-1996
11426200	NF Forbes Ck Nr Dutch Flat	1955-1985
11426400	N Shirttail Ck Nr Dutch Flat	1955-1984
11426500	NF American River Nr Colfax	1912-1941
14270000	NF American River Abv North Fk Dam	1942-2005
11433260	NF of MF American R Nr Foresthill	1966-1984
11434000	NF American River A Rattlesnake Bar	1931-1955
11433500	Middle Fk American Nr Auburn	1912-1964, pre-dam era
11431000	Rubicon River Nr Georgetown	1943-1964, pre-dam era

Table AQ 9-4. Geomorphology Study Detailed Site Information.[1]

Site Name	Geomorphic Reach[2]	River Mile Location of Site	UTM-Coords at Beginning of Site (Downstream River Mile) (Zone 10N, NAD83)	Number of						Comments
				Mesohabitats (Cross-sections)					Special Purpose Cross-sections	
				Total	HGR	LGR	RUN	POOL		
Duncan Creek										
IF D9.0	Abv Diversion	9.0 - 9.2	718174, 4335012	3 (3)	n/a	n/a	n/a	n/a	3	Riparian Site Only
IF D6.3	DUN-R2	6.1 - 6.5	715520, 4332094	10 (22)	2 (4)	2 (2)	2 (4)	4 (12)	0	Instream Flow, Geomorphic, and Riparian Site
IF D8.3	DUN-R2	8.0 - 8.5	717228, 4334321	3 (3)	n/a	n/a	n/a	n/a	3	Limited Purpose Site 3 Geomorphic Cross-sections Only
Middle Fork American River Upstream of Middle Fork Interbay										
IF MF51.8	Abv Reservoir	Not a suitable comparison reach								Riparian Site (potential)
IF MF44.7	MFAR-R5	44.7 - 45.1	716554, 4329824	8 (19)	2 (3)	1 (1)	2 (3)	3 (12)	0	Instream Flow, Geomorphic, and Riparian Site
IFMF36.2[3]	MFAR-R5	36.0-36.2	708184, 4322341	11 (17)	3 (4)	1 (1)	3 (3)	4 (9)	0	Instream Flow, Geomorphic, and Riparian Site
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay										
IF MF26.2	MFAR-R4	25.9 - 26.4	696388, 4320083	9 (23)[4] 2[8] (20)	2 (4)	2 (2)	2 (7)[4] 1 (20)	3 (10)[4] 1[8] (20)	0	Instream Flow, Geomorphic, and Riparian Site (2D Amphibian Site)
Middle Fork American River Downstream of Ralston Afterbay										
IF MF14.1[5]	MFAR-R3	13.8 – 14.5	685560, 4313771	10 (2D)[5]	1 (2D)[5]	3 (2D)[5]	2 (2D)[5]	4 (2D)[5]	0	Instream Flow, Geomorphic, and Riparian Site
IF MF4.8[5]	MFAR-R1	4.1 – 4.8	675208, 4310856	11 (2D)[5]	0[5]	3 (2D)[5]	4 (2D)[5]	4 (2D)[5]	0	Instream Flow, Geomorphic, and Riparian Site
Rubicon River										
IF R36.2	Abv Reservoir	Not a suitable comparison reach								Riparian Site (potential)
IF R25.7	RUB-R3	25.1 - 26.2	720666, 4319717	11 (26)	2 (4)	3 (4)	3 (6)	3 (11)	1	Instream Flow, Geomorphic, and Riparian Site
IF R20.9	RUB-R2	20.2 - 21.0	717255, 4314092	13 (22)	3 (5)[7]	1 (1)	5 (5)	4 (11)	0	Instream Flow, Geomorphic, and Riparian Site

Table AQ 9-4. Geomorphology Study Detailed Site Information.[1]

Site Name	Geomorphic Reach[2]	River Mile Location of Site	UTM-Coords at Beginning of Site (Downstream River Mile) (Zone 10N, NAD83)	Number of						Comments
				Mesohabitats (Cross-sections)					Special Purpose Cross-sections	
				Total	HGR	LGR	RUN	POOL		
IF R3.5	RUB-R1	2.6 - 3.7	697150, 4319188	11 (22)[6] 2[8] (20)	2 (3)	2 (3)	3 (5)	3 (11)[6] 2[8] (20)	0	Instream Flow, Geomorphic, and Riparian Site (2D Amphibian Site)
North Fork Long Canyon Creek										
IF NFLC3.8	Abv Diversion	Not a suitable comparison reach								Riparian Site (potential)
IF NFLC1.9	NFLONG-R1	1.7 - 2.1	716314, 4324314	12 (18)	2 (3)	3 (3)	3 (3)	4 (9)	0	Instream Flow, Geomorphic, and Riparian Site
South Fork Long Canyon Creek										
IF SFLC4.2	Abv Diversion	4.6 - 4.9	720388, 4326694	3 (3)	n/a	n/a	n/a	n/a	3	Riparian Site Only
IF SFLC2.3	SFLONG-R1	2.2 - 2.6	717821, 4324192	11 (19)	2 (2)	2 (3)	3 (5)	4 (9)	0	Instream Flow, Geomorphic, and Riparian Site
Long Canyon Creek										
IF LC9.0	LONG-R2	8.7 - 9.2	712229, 4319403	8 (18)	1 (2)	2 (4)	2 (3)	3 (9)	0	Instream Flow, Geomorphic, and Riparian Site
Other Tributaries (North Fork American River and North Fork of the Middle Fork American River)										
IF NFMF~~1.7~~2.3	Other Trib.	3.1 - 2.4	697380, 4321935	3 (4)	n/a	n/a	n/a	n/a	4	Riparian and Amphibian Site
IF NF31.3	Other Trib.	30.5 – 31.8	677360, 4317941	4 (4)	n/a	n/a	n/a	n/a	4	Riparian Site Only
IF NF35.7	Other Trib.	35.6 - 36.0	681311, 4322809	2 (2)	n/a	n/a	n/a	n/a	2	Amphibian Site Stage Only
IF NF53.7	Other Trib.	53.1 - 53.3	691215, 4338605	3 (3)	n/a	n/a	n/a	n/a	3	Riparian Site Only (Limited Access at High Flows)

[1]Table to be completed in the field and in coordination with the Aquatic TWG. Study sites and modeling cross-sections were selected in the field in coordination with the Aquatic TWG in August and October 2007. Detailed information regarding mesohabitats and cross-sections is available in the PCWA Instream Flow Field Site Visit Data Packet (PCWA 2007b).
[2]See Map AQ 1-2 for reach descriptions.
[3]The accessible section of stream in this section of river is short in length and may not be representative.
[4]Three of the pool and three of the run cross-sections will be replaced with 2D modeling for amphibian breeding habitat.
[5]Site selected for 2D modeling. No cross-sections are required for 2D modeling.
[6]Three of the pool cross-sections will be replaced with 2D modeling for amphibian breeding habitat.
[7]One cross-section comes from a run mesohabitat.
[8]2D Modeling sites will in some cases extend downstream into portions of other mesohabitat units.

POTENTIAL RESOURCE ISSUE:

Riparian Resources

PROJECT NEXUS:

Project operations and potential Project betterments modify or could potentially modify the flow regime in bypass reaches and the peaking reach, affecting riparian resources. Operations of Project reservoirs or potential Project betterments could also modify the water surface elevations and potentially affect riparian resources. Additionally, Project maintenance activities could result in removal of riparian resources.

POTENTIAL LICENSE CONDITION:

- Channel riparian maintenance flows (CRMF).
- Vegetation and Integrated Pest Management Plan.
- Riparian Restoration.

STUDY OBJECTIVE(S):

- Characterize the relationship between riparian resources and the hydrologic regime(s) in the bypass and peaking reaches.
- Characterize the relationship between riparian resources and Water Surface Elevation (WSE) fluctuations in Project reservoirs.
- Document the location of riparian resources at existing proposed Project facilities; potential Project betterment construction and staging areas, and new inundation areas.

EXTENT OF STUDY AREA:

The study area includes bypass reaches and the peaking reach, comparison streams, and Project reservoirs and diversion pools.

The study area will be expanded to include areas around potential Project betterments including:

- 100 feet around trails; staging and disposal sites; and new inundation areas.
- 300 feet around construction areas associated with new facilities and roads.

STUDY APPROACH:

The following describes the riparian resources study approach which includes data collection and analyses for (1) Project bypass and comparison reaches, (2) Project reservoirs, (3) potential Project betterments, and (4) Project maintenance activities.

Project Bypass and Comparison Streams

- Conduct initial riparian habitat characterization studies to identify, map, and describe the riparian and meadow habitat upstream and downstream of the Project dams and diversions (Table AQ 10-1). This information was collected during studies completed by PCWA as described in the 2005-2006 Existing Environment Study Plan Package (PCWA 2006a) which is available at the PCWA Hydroelectric website: http://relicensing.pcwa.net/. A technical report summarizing the 2005 data is also available on the website. The 2006 data will be summarized in a report available in early 2007. The objectives for these studies are summarized in Table AQ 10-2.
- Conduct quantitative studies in comparison stream reaches (Table AQ 10-1) consistent with data collection completed along the bypass reaches and the peaking reach (Table AQ 1-1 and Map AQ 1-1).
  - The selection of the composition stream reaches will be based on similarities with the bypass and peaking reaches in terms of watershed characteristics, including drainage area, geology, substrate, geomorphic landform development, channel gradient, valley width, availability of hydrology data, and existing and historical land uses. Final selection with be determined in consultation with the Aquatic Technical Working Group (TWG).
  - Summarize riparian resources along these selected comparison stream reaches using the same methods, as appropriate, described in the Existing Environment Study Plan Package (PCWA 2006a).
    - Community composition.
    - Age class structure.
    - Regeneration.
    - Encroachment.
    - Special-status and invasive plant species.
- Summarize the distribution, characteristics, and condition of the riparian resources in relation to the life history strategies of the dominant species and fluvial geomorphic processes along bypass reaches, the peaking reach, and comparison reaches.
  - Summarize the life history strategy requirements of dominant woody riparian species based on existing scientific information and expert knowledge.
  - Determine water surface elevations over a wide range of discharges appropriate to the Project hydrology at selected study sites on Project bypass and comparison streams, and the peaking reach. These reaches are identified in the AQ 1 – Instream Flow Technical Study Plan (TSP).
    - The reaches were identified based on data collected as part of previous geomorphology study (PCWA 2006a and 2006b) used to stratify the bypass and peaking reaches. Instream flow and riparian data will be collected and analyzed within these strata (Map AQ 1-2).
    - Select transect locations in consultation with the Aquatic TWG as part of the AQ 1 – Instream Flow TSP within the reaches. The transect locations on the bypass and peaking reaches will also be coordinated with AQ 9 – Geomorphology TSP to provide hydrodynamics modeling data for these studies within the general instream flow study sites.

        - Establish one to three transects in each reach and collect three stage-discharge pairs to develop stage-discharge relationships (Table AQ 1-1).
        - The specific locations and lengths of the study transects will be selected in the field with concurrence from the Aquatic TWG (Table AQ 10-3).
    - Using the impaired and unimpaired hydrologic data and modeling results from the AQ 1 – Instream Flow TSP determine:
        - Extent of inundation of floodplains and bars over a range of flows
        - Frequency, duration, and timing of inundation of riparian zones
        - Rate of flow recession in selected reaches
        - Flow paths through bars and floodplain surfaces
        - Water availability in summer months
    - Identify reaches with possible encroached riparian vegetation.
    - Compare recruitment classes, regeneration success, species composition, and potential encroachment under the historic and current hydrologic conditions on the bypass and peaking, and the appropriate comparison stream reaches using quantitative data and tree cores. The comparison may include:
        - Histogram of size-class distributions of dominant woody riparian species
        - Frequency analysis of distribution of dominant species
        - Ordination to compare species composition of plots and/or reaches
        - Proportion of wetland and non-wetland species
        - Proportion of exotic and native species
- Characterize the relationship between historic and existing land uses, recreation activities, and riparian resources.
- Develop indicators for riparian health in consultation with the Aquatic TWG to be used for the development of the PM&Es.

Project Reservoirs

- Summarize the distribution, characteristics, and condition of the riparian resources at Project reservoirs in relation to WSE fluctuations such as:
    - Annual patterns and inter-annual fluctuations, and;
    - Inundation area-water surface elevation relationships.

Potential Project Betterments

- Identify and map the distribution of riparian resources at proposed Project Facilities, betterments, construction and staging, and new inundation areas.

Project Maintenance Activities

- Identify Project maintenance activities that occur near existing riparian resources.

SCHEDULE:

Date	Activity
July and August 2007	Select riparian transects in consultation with the Aquatic TWG,
August and October 2007	Conduct comparison stream, betterments, and Project reservoirs field surveys and summarize life history strategies
November 2007 through February 2008	Complete data analysis
March through October 2008	Conduct field surveys (topography, water surface elevations, velocities) and conduct betterment surveys
November 2008 through June 2009	Analyze data and prepare draft report
June 2009	Distribute draft report to the Aquatic TWG
July through August 2009	Aquatic TWG 60 day review and comment period
September through October 2009	Resolve comments and prepare final report
November 2009	Distribute final report to the Aquatic TWG and Plenary

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PCWA. 2007b. PCWA Instream Flow Field Site Visit Data Packet. October, 2007.

TABLES

Table AQ 10-1. Middle Fork Project Bypass and Peaking Reaches and Comparison Reaches.

River or Stream	Bypass Reaches[1]
Middle Fork American River	French Meadows Dam to Middle Fork Interbay
	Middle Fork Interbay Dam to Ralston Afterbay
Duncan Creek	Duncan Creek Diversion Dam to the Middle Fork American River Confluence
Rubicon River	Hell Hole Dam to Ralston Afterbay
North Fork Long Canyon Creek	North Fork Long Canyon Diversion Dam to the Confluence of Long Canyon Creek
South Fork Long Canyon Creek	South Fork Long Canyon Diversion Dam to the Confluence of Long Canyon Creek
Long Canyon Creek	Confluence of North and South Forks of Long Canyon Creek to confluence of Rubicon River
	Peaking Reaches[2]
Middle Fork American River	Oxbow Powerhouse to the North Fork American River Confluence
North Fork American River	Middle Fork American River Confluence to the Folsom Reservoir High Water Mark
	Comparison Reaches[3]
Duncan Creek	Duncan Creek Diversion to approximately 3 miles upstream (D9.0)
North Fork Long Canyon Creek	North Fork Long Canyon Creek Diversion to 1/2 mile upstream (NFLC3.8)
South Fork Long Canyon Creek	South Fork Long Canyon Creek Diversion to approximately 2 miles upstream (SFLC4.2)
North Fork Middle Fork American River	Confluence with Middle Fork American River to approximately 4 miles upstream (NFMF2.3)
North Fork American River	Lake Clementine to approximately 30 miles upstream (NF31.3 and NF53.7)

[1]Bypass reaches are those where water is rerouted from the stream or river at a diversion dam and reintroduced below a powerhouse.
[2] Peaking reaches are those reaches where daily and within-day changes in river flow occur as a result of power releases that are scheduled to follow power demand.
[3]The approximate locations for comparison stream reaches are shown on Map AQ 1-1.

Table AQ 10-2. 2005 and 2006 Riparian Habitat Characterization Study Objectives.

2005 and 2006 Riparian Habitat Characterization Study Purpose
Identify, map, and describe the riparian and meadow habitat upstream and downstream of the Project dams and diversions.
2005 Study Plan Objectives
Identify the locations of riparian and meadow habitat along the streams and rivers upstream and downstream of the MFP dams and reservoirs.
Qualitatively describe riparian and meadow habitats.
Identify unregulated streams in the vicinity of the Project that could serve as comparison reaches for subsequent studies.
Identify potential historical and existing activities that may have or are currently affecting the development of the riparian habitat.

Table AQ 10-3. Riparian Study Detailed Site Information.[1]

Site Name	Geomorphic Reach[2]	River Mile Location of Site	UTM-Coords at Beginning of Site (Downstream River Mile) (Zone 10N, NAD83)	Number of						Comments
				Mesohabitats (Cross-sections)					Special Purpose Cross-sections	
				Total	HGR	LGR	RUN	POOL		
Duncan Creek										
IF D9.0	Abv Diversion	9.0 - 9.2	718174, 4335012	3 (3)	n/a	n/a	n/a	n/a	3	Riparian Site Only
IF D6.3	DUN-R2	6.1 - 6.5	715520, 4332094	10 (22)	2 (4)	2 (2)	2 (4)	4 (12)	0	Instream Flow, Geomorphic, and Riparian Site
IF D8.3	DUN-R2	8.0 - 8.5	717228, 4334321	3 (3)	n/a	n/a	n/a	n/a	3	Limited Purpose Site 3 Geomorphic Cross-sections Only
Middle Fork American River Upstream of Middle Fork Interbay										
IF MF51.8	Abv Reservoir	Not a suitable comparison reach								Riparian Site (potential)
IF MF44.7	MFAR-R5	44.7 - 45.1	716554, 4329824	8 (19)	2 (3)	1 (1)	2 (3)	3 (12)	0	Instream Flow, Geomorphic, and Riparian Site
IFMF36.2[3]	MFAR-R5	36.0-36.2	708184, 4322341	11 (17)	3 (4)	1 (1)	3 (3)	4 (9)	0	Instream Flow, Geomorphic, and Riparian Site
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay										
IF MF26.2	MFAR-R4	25.9 - 26.4	696388, 4320083	9 (23)[4] 2[8] (20)	2 (4)	2 (2)	2 (7)[4] 1 (20)	3 (10)[4] 1[8] (20)	0	Instream Flow, Geomorphic, and Riparian Site (2D Amphibian Site)
Middle Fork American River Downstream of Ralston Afterbay										
IF MF14.1[5]	MFAR-R3	13.8 – 14.5	685560, 4313771	10 (2D)[5]	1 (2D)[5]	3 (2D)[5]	2 (2D)[5]	4 (2D)[5]	0	Instream Flow, Geomorphic, and Riparian Site
IF MF4.8[5]	MFAR-R1	4.1 – 4.8	675208, 4310856	11 (2D)[5]	0[5]	3 (2D)[5]	4 (2D)[5]	4 (2D)[5]	0	Instream Flow, Geomorphic, and Riparian Site
Rubicon River										
IF R36.2	Abv Reservoir	Not a suitable comparison reach								Riparian Site (potential)
IF R25.7	RUB-R3	25.1 - 26.2	720666, 4319717	11 (26)	2 (4)	3 (4)	3 (6)	3 (11)	1	Instream Flow, Geomorphic, and Riparian Site
IF R20.9	RUB-R2	20.2 - 21.0	717255, 4314092	13 (22)	3 (5)[7]	1 (1)	5 (5)	4 (11)	0	Instream Flow, Geomorphic, and Riparian Site

Table AQ 10-3. Riparian Study Detailed Site Information.[1]

Site Name	Geomorphic Reach[2]	River Mile Location of Site	UTM-Coords at Beginning of Site (Downstream River Mile) (Zone 10N, NAD83)	Number of						Comments
				Mesohabitats (Cross-sections)					Special Purpose Cross-sections	
				Total	HGR	LGR	RUN	POOL		
IF R3.5	RUB-R1	2.6 - 3.7	697150, 4319188	11 (22)[6] 2[8] (20)	2 (3)	2 (3)	3 (5)	3 (11)[6] 2[8] (20)	0	Instream Flow, Geomorphic, and Riparian Site (2D Amphibian Site)
North Fork Long Canyon Creek										
IF NFLC3.8	Abv Diversion	Not a suitable comparison reach								Riparian Site (potential)
IF NFLC1.9	NFLONG-R1	1.7 - 2.1	716314, 4324314	12 (18)	2 (3)	3 (3)	3 (3)	4 (9)	0	Instream Flow, Geomorphic, and Riparian Site
South Fork Long Canyon Creek										
IF SFLC4.2	Abv Diversion	4.6 - 4.9	720388, 4326694	3 (3)	n/a	n/a	n/a	n/a	3	Riparian Site Only
IF SFLC2.3	SFLONG-R1	2.2 - 2.6	717821, 4324192	11 (19)	2 (2)	2 (3)	3 (5)	4 (9)	0	Instream Flow, Geomorphic, and Riparian Site
Long Canyon Creek										
IF LC9.0	LONG-R2	8.7 - 9.2	712229, 4319403	8 (18)	1 (2)	2 (4)	2 (3)	3 (9)	0	Instream Flow, Geomorphic, and Riparian Site
Other Tributaries (North Fork American River and North Fork of the Middle Fork American River)										
IF NFMF~~1.7~~2.3	Other Trib.	3.1 - 2.4	697380, 4321935	3 (4)	n/a	n/a	n/a	n/a	4	Riparian and Amphibian Site
IF NF31.3	Other Trib.	30.5 – 31.8	677360, 4317941	4 (4)	n/a	n/a	n/a	n/a	4	Riparian Site Only
IF NF35.7	Other Trib.	35.6 - 36.0	681311, 4322809	2 (2)	n/a	n/a	n/a	n/a	2	Amphibian Site Stage Only
IF NF53.7	Other Trib.	53.1 - 53.3	691215, 4338605	3 (3)	n/a	n/a	n/a	n/a	3	Riparian Site Only (Limited Access at High Flows)

[1] Table to be completed in the field and in coordination with the Aquatic TWG. Study sites and modeling cross-sections were selected in the field in coordination with the Aquatic TWG in August and October 2007. Detailed information regarding mesohabitats and cross-sections is available in the PCWA Instream Flow Field Site Visit Data Packet (PCWA 2007b).
[2] See Map AQ 1-2 for reach descriptions.
[3] The accessible section of stream in this section of river is short in length and may not be representative.
[4] Three of the pool and three of the run cross-sections will be replaced with 2D modeling for amphibian breeding habitat.
[5] Site selected for 2D modeling. No cross-sections are required for 2D modeling.
[6] Three of the pool cross-sections will be replaced with 2D modeling for amphibian breeding habitat.
[7] One cross-section comes from a run mesohabitat.
[8] 2D Modeling sites will in some cases extend downstream into portions of other mesohabitat units.

POTENTIAL RESOURCE ISSUE:

Water quality compliance.

PROJECT NEXUS:

Project structures, operations, maintenance activities, and Project betterments could affect water quality.

POTENTIAL LICENSE CONDITION(S):

- Instream flow releases
- Best management practices (BMPs)
- Spill Prevention Control Countermeasure (SPCC) Plan

STUDY OBJECTIVE(S):

Characterize physical, chemical, and bacterial water quality conditions in the bypass reaches and the peaking reach, comparison reaches, and Project reservoirs and diversion pools and compare to the Central Valley Regional Water Quality Control Board (CVRWQCB 1998) *Basin Plan* objectives and water quality standards.

EXTENT OF STUDY AREA:

The study area will include bypass and comparison reaches, the peaking reach, Project reservoirs, and diversion pools (Tables AQ 11-1 and AQ 11-2, Maps AQ 11-1 and AQ 11-2).

STUDY APPROACH:

Water Quality Sampling Field Program

The following describes the water quality sampling field program which includes the collection of (1) *in-situ* water quality measurements; (2) general water quality samples; (3) fecal coliform samples; (4) fish tissue samples; and (5) contingency water quality and/or macroinvertebrate samples.

In-situ Field Measurements

- Collect *in-situ* water quality measurements at sampling locations listed in Table AQ 11-1 (i.e., bypass reaches, the peaking reach, Project reservoirs, and diversion pools) using a YSI® meter. Samples will be collected once during the spring runoff (April or May, access permitting), and once during the summer low flow or base flow period (August or September). Pre- and post-sampling calibration of *in-situ* instrumentation will be conducted following the manufacturer's instructions.
- Monitor *in-situ* water quality parameters at bypass reaches and the peaking reach, including dissolved oxygen (DO), pH, specific conductance, and water temperature. *In-situ* parameters will be measured in a representative location of the stream.
- Monitor *in-situ* water quality parameters at all Project reservoirs and diversion pools including DO, pH, specific conductance, water temperature, and Secchi depth.

Reservoir profile analysis will be conducted at sampling locations in French Meadows Reservoir, Hell Hole Reservoir, and Ralston Afterbay. Collect reservoir profile *in-situ* measurements of water temperature and DO at 1-meter (m) depth intervals to determine if thermal stratification is present. If a thermocline is present, the water quality parameters will be measured below the thermocline at 2-m intervals to the bottom of the reservoir.

- Document if the results of the *in-situ* monitoring meet the water quality objectives identified in the Basin Plan (CVRWQCB 1998).

General Water Quality Sampling

- Collect general water quality samples at sampling locations listed in Table AQ 11-1 and depicted on Map AQ 11-1. Samples will be collected once during the spring runoff and once during the summer low flow or base flow period.
- Collect water quality samples in bypass reaches and the peaking reach in a representative portion of the stream channel, using methods consistent with the Environmental Protection Agency (EPA) 1669 sampling protocol *Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria*. Water quality samples collected from streams will be analyzed for the parameters listed in Table AQ 11-3, which include general parameters, total Mercury, a suite of dissolved metals, and total and fecal coliform.
- Collect water quality samples from Project reservoirs and diversion pools at the surface and immediately below the thermocline, where present. If the Project reservoir or diversion pool is not thermally stratified, then water quality samples will be collected at mid-depth of the reservoir. Water quality samples for laboratory analysis will be collected using a Teflon® Kemmerer style sampler to ensure integrity of the sample collected from depth. Water quality samples collected from reservoirs will be analyzed for the parameters listed in Table AQ 11-3, which include general parameters, hydrocarbons, total Mercury, a suite of dissolved metals, and total and fecal coliform. Laboratory analysis for hydrocarbons will be conducted only on water quality samples collected from French Meadows and Hell Hole reservoirs, where motorized boating typically occurs.
- Water quality samples will be decanted into laboratory-supplied sample containers. The sample containers will be labeled with the date and time that the sample is collected, sampling site or identification label. The sample container will be preserved (as appropriate), stored and delivered to a State-certified water quality laboratory for analyses in accordance with maximum holding periods. A chain-of-custody record will be maintained with the samples at all times. The sampling site location will be recorded using a Global Positioning System (GPS) unit and the coordinates will be recorded in a field log book.

Coliform Sampling

- Conduct total and fecal coliform sampling to determine if study waters meet Basin Plan (CVRWQCB 1998) objectives for contact recreational activities. Samples will be collected at near-shore locations adjacent to recreation facilities at Project reservoirs and along bypass reaches where substantial contact recreation (swimming, fishing, rafting, etc.) occurs. Fecal coliform sampling locations are listed in Table AQ 11-2 and depicted on Map AQ 11-2. In accordance with the fecal coliform sampling protocols, samples will be collected no less than five times within a thirty-day period between July 4 and Labor

Day and will include one holiday weekend. If early summer weather indicates that the July 4 weekend will be a large recreational weekend, sampling will include the July 4 weekend in preference to Labor Day.

Laboratory Analysis and Reporting

- Provide water quality samples collected during the field program to a State-certified laboratory approved by the State Water Resources Control Board (SWRCB) for chemical analysis. The laboratory will report each chemical parameter analyzed with the laboratory method detection limit, reporting limit, and practical quantification limit. The laboratory will attempt to attain reporting detection limits that are at or below the applicable regulatory criteria. The parameters to be analyzed by the analytical laboratory are provided in Table AQ 11-3.

Fish Tissue Analysis

- Conduct a screening level study of methyl mercury concentrations in sport fish muscle tissue in consultation with the Aquatic Technical Working Group (TWG).
- Collect a total of 10 native (nonhatchery) sport fish of edible size, if present, from each of the following locations: French Meadows Reservoir, Hell Hole Reservoir, Middle Fork Interbay, Ralston Afterbay, and one location in the Middle Fork American River below Ralston Afterbay.
  - Submit fish to an analytical laboratory for individual fish muscle tissue analysis (fillets). Field procedures will be consistent with those outlined in California Environmental Protection Agency (Cal EPA) (2005) and those used at the Department of Fish and Game Marine Pollution Studies Laboratory at Moss Landing (Method # MPSL-102a).
  - Larger fish and species with greater potential for bioaccumulation will be targeted. Five fish each of two different species will be collected from each location based on the following priority ranking. The two species present with the highest priority ranking will be collected (1 = highest priority):
    - 1) bass
    - 2) pikeminnow
    - 3) lake trout
    - 4) brown trout
    - 5) rainbow trout
  - Handle fish per Method # MPSL 102a. Use clean nylon nets and polyethylene-gloves. Record the species, fork length, and weight of each fish. Place fish in Teflon sheets and into zipper-closure bags and place immediately on ice for delivery to the analytical laboratory.
- The analytical laboratory will analyze muscle tissue from each fish for concentrations of methyl mercury in accordance with the General Protocol for Sport Fish Sampling and Analysis developed by the Cal EPA (2005) and with methods comparable to those used at the Department of Fish and Game Marine Pollution Studies Laboratory at Moss Landing.

Contingency Sampling

Water Quality

- Consult with the Aquatic TWG if results from the general water quality sampling program indicate a potentially adverse water quality condition. If appropriate, develop an additional sampling program to further investigate the cause or source of the potentially adverse water quality condition.

Fish Tissue Analysis

- If methyl mercury in fish tissue exceeds the OEHHA guidelines of 0.08 ppm (Cal EPA 2005; Klasing and Brodberg 2006) during the initial sampling, the Aquatic TWG will be consulted concerning the need for additional sampling. If additional sampling is deemed appropriate, a sampling protocol will be developed.

- Fish tissue sampling may be expanded in the event water quality sampling identifies locations that are of potential concern due to the presence of levels of total Mercury that exceed the EPA Freshwater Aquatic Life criteria as described in 40 CFR §131. If this occurs, the Aquatic TWG will be consulted concerning the need for fish tissue sampling. If fish tissue sampling is deemed appropriate, a sampling protocol will be developed.

Benthic Macroinvertebrate Sampling

- Implement California Stream Bioassessment Procedures to quantify benthic macroinvertebrate (BMI) species compositions, abundance, and distribution at locations where potentially adverse water quality issues may exist or are identified by the water quality sampling program (see AQ 3 – Macroinvertebrate Technical Study Plan (TSP)). Develop sampling to address potential water quality issues in consultation with the Aquatic TWG.

SCHEDULE:

Date	Activity
May 2007	Collect water quality samples
August and September 2007	Collect coliform samples
September 2007	Collect water quality samples
October 2007 through January 2008	Complete data analysis and prepare draft report
February 2008	Submit draft report to the Aquatic TWG
February and March 2008	Aquatic TWG 60 day review and comment period
April through June 2008	Resolve comments and prepare final report
July 2009	Submit final report to the Aquatic TWG and Plenary
September 2008 through June 2009	Conduct contingency water quality related studies, data analysis and report production

REFERENCES:

California Environmental Protection Agency (Cal EPA). 2005. General Protocol for Sport Fish Sampling and Analysis. Pesticide and Environmental Toxicology Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. December 2005.

Klasing, S. and R. Brodberg. 2006. Draft Development of Guidance Tissue Levels and Screening Values for Common Contaminants in California Sport Fish: Chloradane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene. Pesticide and Environmental Toxicology Branch Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. http://www.oehha.ca.gov/fish/gtlsv/pdf/draftGTLSVchddt.pdf

Central Valley Regional Water Quality Control Board (CVRWQCB). 1998. Basin Plan. Fourth Edition, The Sacramento River Basin and the San Joaquin River Basin. September 1998.

TABLES

Table AQ 11-1. Water Quality Monitoring and Sampling Locations.

Study Reach	Water Quality Sampling Sites	Water Quality Monitoring and Sampling Locations
Duncan Creek		
Duncan Creek upstream of Diversion	DC-1	Duncan Creek above diversion
Duncan Creek from Diversion to confluence with Middle Fork American River	DC-2 DC-3	Duncan Creek below diversion Duncan Creek above Middle Fork American River confluence
Middle Fork American River		
Middle Fork American River upstream of French Meadows Reservoir	MFAR-1	Middle Fork American River above French Meadows Reservoir
French Meadows Reservoir	FM-1, FM-2, and FM-3	Three locations in French Meadows Reservoir
Middle Fork American River from French Meadows to confluence with Duncan Creek	MFAR-2 MFAR-3	Middle Fork American River below French Meadows Dam Middle Fork American River above Duncan Creek confluence
Middle Fork American River from confluence with Duncan Creek to Middle Fork Interbay	MFAR-4 MFAR-5	Middle Fork American River below Duncan Creek confluence Middle Fork American River above Interbay Reservoir
Middle Fork Interbay	IR-1	In Middle Fork Interbay
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay	MFAR-6 MFAR-7	Middle Fork American River below Middle Fork Interbay Middle Fork American River above Ralston Afterbay
Ralston Afterbay Downstream		
Ralston Afterbay	RA-1	In Ralston Afterbay
Middle Fork American River from Ralston Afterbay to confluence with Canyon Creek	MFAR-8[1] MFAR-9[1]	Middle Fork American River below dam Middle Fork American River below Oxbow Powerhouse tailrace
Middle Fork American River from confluence of Canyon Creek to confluence with North Fork American River	MFAR-10[1] MFAR-11[1]	Middle Fork American River below the Drivers Flat Road Rafting Take-Out Middle Fork American River above North Fork American River
North Fork American River from confluence with Middle Fork American River to Folsom Reservoir	NFAR-1[1]	North Fork American River below Middle Fork American River

Table AQ 11-1. Water Quality Monitoring and Sampling Locations (continued).

Study Reach	Water Quality Sampling Sites	Water Quality Monitoring and Sampling Locations
Rubicon River		
Rubicon River upstream of Hell Hole Reservoir	RR-1	Rubicon River above Reservoir
Hell Hole Reservoir	HH-1, HH-2, and HH-3	Three locations in Hell Hole Reservoir
Rubicon River from Hell Hole Reservoir to confluence with South Fork Rubicon River	RR-2 RR-3 SFRR-1	Rubicon River below dam Rubicon River above South Fork Rubicon River confluence South Fork Rubicon River above Rubicon River confluence
Rubicon River from confluence with South Fork Rubicon River to Ralston Afterbay	RR-4 RR-5 RR-6 RR-7	Rubicon River below South Fork Rubicon River confluence Rubicon River above Long Canyon Creek confluence Rubicon River below Long Canyon Creek confluence Rubicon River above Ralston Afterbay
Long Canyon Creek		
North Fork Long Canyon Creek upstream of Diversion	NFLCC-1	North Fork Long Canyon Creek above diversion
North Fork Long Canyon Creek from Diversion to confluence with Long Canyon Creek	NFLCC-2 NFLCC-3	North Fork Long Canyon Creek below diversion North Fork Long Canyon Creek above Long Canyon Creek confluence
South Fork Long Canyon Creek upstream of Diversion	SFLCC-1 SFLCC-2	South Fork Long Canyon Creek above diversion South Fork Long Canyon Creek below diversion
South Fork Long Canyon Creek from Diversion to confluence with Long Canyon Creek	SFLCC-3	South Fork Long Canyon Creek above Long Canyon Creek confluence
Long Canyon Creek from North and South Fork Long Canyon creeks confluence to confluence with Rubicon River	LCC-1 LCC-2	Long Canyon Creek below North Fork and South Fork Long Canyon creeks confluence Long Canyon Creek above Rubicon River confluence

[1]If peaking operations are occurring during sampling periods, water quality samples will be collected during high and low flow events.

Table AQ 11-2. Fecal Coliform Sampling Locations Using SWRCB Protocols.

Sample Identification Label	Sample Location
FC-1	Middle Fork American River below Ahart Campground
FC-2	Middle Fork American River below Gates Group Campground
FC-3	Middle Fork American River below Coyote and Lewis Campground
FC-4	French Meadows Reservoir near McGuire Picnic Area
FC-5	French Meadows Reservoir near McGuire Boat Ramp
FC-6	French Meadows Reservoir near French Meadows Campground
FC-7	French Meadows Reservoir near French Meadows Boat Ramp
FC-8	French Meadows Reservoir near Poppy Campground
FC-9	Hell Hole Reservoir near Upper Hell Hole Reservoir Campground
FC-10	Hell Hole Reservoir near Hell Hole Boat Ramp
FC-11	South Fork Long Canyon Creek above Big Meadows Campground
FC-12	South Fork Long Canyon Creek below Big Meadows Campground
FC-13	South Fork Long Canyon Creek above Middle Meadows Campground
FC-14	South Fork Long Canyon Creek below Middle Meadows Campground
FC-15	Ralston Afterbay near Ralston Picnic Area
FC-16	Middle Fork American River below Oxbow Powerhouse (Horseshoe Bar Area)
FC-17	Middle Fork American River below the Drivers Flat Road Camping and Rafting Take-out

Table AQ 11-3. Parameters for Water Quality Monitoring and Laboratory Analysis.

Parameter	Analysis Method	Sample Holding Times	Sample Locations to be Analyzed
Water Quality Monitoring Parameter			
In-Situ Measurements			
Dissolved Oxygen (DO)	Water Quality Meter	Not Applicable	All
Secchi Depth	Secchi Disk	Not Applicable	Reservoir
PH	Water Quality Meter	Not Applicable	All
Water Temperature	Water Quality Meter	Not Applicable	All
Specific Conductance	Water Quality Meter	Not Applicable	All
Laboratory Analysis Parameter			
General Parameters			
Calcium	EPA - 200.7	180 days	All
Chloride	EPA - 300.0	28 days	All
Hardness	EPA - 130.2	180 days	All
Magnesium	EPA - 200.7	180 days	All
Nitrate/Nitrite	EPA - 353.2	48 hours	All
Ammonia as N	EPA - 350.1	28 days	All
Total Kjeldahl Nitrogen	EPA - 351.2	28 days	All
Total Phosphorus	EPA - 365.2	28 days	All
Ortho-phosphate	EPA - 365.1	48 hours	All
Potassium	EPA - 200.7	180 days	All
Sodium	EPA - 200.7	180 days	All
Sulfate	EPA - 300.0	180 days	All
Total Dissolved Solids	EPA - 160.1	7 days	All
Total Suspended Solids	EPA - 160.2	7 days	All
Turbidity	EPA - 180.1		All
TOC	EPA - 415.1	28 days	All
Total Alkalinity	EPA - 310.1	14 days	All
Metals – Dissolved			
Arsenic	EPA - 1638	48 hours	All
Cadmium	EPA - 1638	48 hours	All
Copper	EPA - 1638	48 hours	All
Iron	EPA -1638	48 hours	All
Lead	EPA - 1638	48 hours	All

Table AQ 11-3. Parameters for Water Quality Monitoring and Laboratory Analysis (continued).

Parameter	Analysis Method	Sample Holding Times	Sample Locations to be Analyzed
Laboratory Analysis Parameter (continued)			
Manganese	EPA - 1638	48 hours	All
Nickel	EPA - 1638	48 hours	
Chromium	EPA - 1638	48 hours	
Metals – Total			
Mercury	EPA - 1631e	48 hours	All
Hydrocarbons			
Methyl-tertiary Butyl Ether (MtBE)	EPA - 8260	14 days	Reservoir
Total Petroleum Hydrocarbons	EPA - 8020	14 days	Reservoir
Oil and Grease	EPA - 1664	48 hours	Reservoir
Bacteria			
Total Coliform	EPA - SM9222B	24 hours	All
Fecal Coliform	EPA - SM922B	24 hours	(1)

(1) At fecal coliform sampling locations listed in Table AQ 11-2 and depicted in Map AQ 11-2.

MAPS

POTENTIAL RESOURCE ISSUE:

Special-status amphibians and aquatic reptiles and their habitat.

PROJECT NEXUS:

Project operations, maintenance activities, and potential Project betterments could result in direct and indirect effects on special-status amphibians and aquatic reptiles and their habitat.

In bypass reaches, Project operations influence the seasonal flow and temperature regimes, and in the peaking reach downstream of Oxbow Powerhouse, Project operations can cause daily and monthly fluctuations in flow, which could affect instream habitat conditions.

For California red-legged frog (CRLF), flow conditions in the bypass reaches may affect off-channel wetted areas and backwater pools, potentially influencing habitat availability. In the peaking reach, flow fluctuation could affect habitat availability and the suitability of backwater pools and off-channel wetted areas.

For Foothill yellow-legged frog (FYLF), flow conditions in the bypass reaches could affect habitat availability and suitability (e.g., water temperature) for all life stages. Project operations that result in flow fluctuations could create changes in water stage and velocity that could affect the suitability of instream habitat and potentially scour or strand egg masses and tadpoles. Water temperature regimes downstream of Project facilities could alter the timing of breeding and subsequent tadpole development.

For western pond turtle (WPT), Project reservoir fluctuations could result in the inundation of potential nesting habitat.

POTENTIAL LICENSE CONDITION:

- Instream flow releases.
- Recreation flows.
- Vegetation and Integrated Pest Management Plan.
- Special-status amphibian and aquatic reptile protection measures.

STUDY OBJECTIVE(S):

- Identify and map potential habitat for CRLF and FYLF in the study area.
- Document the distribution and abundance of CRLF populations in the study area, as required by U.S. Fish and Wildlife Service (USFWS).
- Document the distribution and abundance of FYLF populations in the study area.
- Document the timing and length of FYLF breeding season.
- Identify existing data and obtain new data necessary to develop habitat suitability criteria (HSC) for FYLF.
- Characterize the water stage, velocity, and temperature of various flow regimes as it relates to FYLF habitat through coordination with the instream flow and water temperature studies.

- Document the presence of potential WPT nesting habitat near Project reservoirs and potential Project betterment inundation zones.
- Document the presence of WPT during CRLF and FYLF surveys.

EXTENT OF STUDY AREA:

The study area for CRLF, FYLF, and WPT is limited to the elevational distribution of each species within the Project area and includes bypass and peaking reaches, and Project reservoirs and diversion pools.

The elevational distribution for each species is listed below:

- CRLF - below 5,000 feet in elevation (Jennings and Hayes 1994);
- FYLF - below 4,500 feet in elevation (personal communication with Jan Williams, U.S. Forest Service (USFS) regarding known sightings in the region; this would be increased if individuals are found near this elevation); and
- WPT - below 6,000 feet in elevation.

The study area for CRLF and WPT also includes off-channel ponds and wetlands that may be present within the following study areas around Project facilities and features, recreation facilities, and other stakeholder identified recreation areas where maintenance activities occur.

Study Area	Project Facilities and Features, Recreation Facilities, and Other Stakeholder Identified Recreation Areas
10 feet	▪ on either side of trails
20 feet	▪ around the perimeter of the large reservoirs, medium reservoirs and diversion pools ▪ outside the perimeter fence of powerhouses, switchyards, and substations ▪ around ancillary support facilities and Project fences
30 feet	▪ on either side of penstocks, valve houses, and removable sections ▪ around gaging stations and weirs ▪ on either side of communication lines, powerlines, photovoltaic poles and lines, and roads and access points
60 feet	▪ around gatehouses, surge tanks, adits, portals, microwave reflectors, radio towers, sediment disposal and laydown areas
100 feet	▪ around recreation facilities and dispersed concentrated use areas

The study area for CRLF and WPT also includes off-channel ponds and wetlands that may be present within a buffer area (100 feet) around potential Project betterments including new facilities, roads, trails, staging and disposal sites, as well as new inundation areas.

Additional information describing the species-specific study sites is described below.

STUDY APPROACH:

The study approaches for each species are provided below.

California Red-legged Frog (CRLF)

The following describes the approach to complete a protocol-level site assessment and surveys for CRLF.

Site Assessment

- Conduct USFWS protocol-level site assessment in accordance with *Revised Guidance on Site Assessments and Field Surveys for the California Red-legged Frog, August 2005* (USFWS 2005). This includes:
  - Identify and map known occurrences of CRLF within one mile of the study area, based on agency consultation, museum records, and other existing information. Preliminary information is available in the *Middle Fork American River Project (FERC No. 2079) Draft Existing Resource Information Report, First Series* (PCWA 2006);
  - Identify and map CRLF habitats within one mile of the study area based on review of aerial photography, helicopter surveys, and video surveys;
  - Conduct a field reconnaissance survey to verify habitat mapped in the study area. This includes verification of accessible habitat identified at off-channel ponds and wetlands and in the bypass and peaking reaches. Verification of habitat in the bypass and peaking reaches will be completed in conjunction with FYLF habitat characterization surveys. See FYLF approach below for detailed information of habitat characterization survey methods; and
  - Prepare a Site Assessment Report for submittal to USFWS and the Aquatic Technical Working Group (TWG) that includes the following:
    - Copies of data sheets;
    - Copies of field notes;
    - Global Positioning System (GPS) data for all field reconnaissance sites;
    - List of known occurrences of CRLF locations within one mile of the study area;
    - Photographs of the study area including a map of photo locations;
    - Geomorphic Information System (GIS) map of potential CRLF habitat within 1 mile of the study area; and
    - Description of the Middle Fork American River Project (Project or MFP) and potential Project betterments.

Protocol-level Surveys

- Following submittal of the Site Assessment Report to USFWS, USFWS will determine if Protocol-level CRLF surveys are required. If USFWS determines that surveys are required, then PCWA will complete the surveys in accordance with the *Revised Guidance on Site Assessments and Field Surveys for the California Red-legged Frog, August 2005* (USFWS 2005). USFWS decontamination guidelines will be implemented during the surveys.

- Complete CRLF surveys in areas requested by USFWS that are accessible and can be safely surveyed by a qualified biologist. Protocol-level surveys consist of up to eight visits (two day visits and four night visits during the breeding season and one day and one night visit during the non-breeding season). If necessary, survey protocols will be modified, in consultation with USFWS, to provide for safety of survey personnel.
- Prepare a CRLF survey report that includes the following:
  - Copies of datasheets;
  - Copies of field notes;
  - GPS data for all surveyed sites;
  - Photographs of individual CRLF observed during surveys and habitats where the individual was observed; and
  - GIS map documenting the location of each individual CRLF observed during the surveys.
- Notify USFWS within three working days if CRLF are detected at any location.
- Prepare and submit a California Native Species Field Survey Form for all CRLF recorded to the California Natural Diversity Database (CNDDB).
- Record any incidental sightings of CRLF during implementation of any aquatic technical studies.

Foothill Yellow-legged Frog (FYLF)

<u>Study Sites</u>

In order to determine the distribution and abundance of FYLF within the bypass and peaking reaches, different types of sampling sites were selected. These include representative sites, tributary confluence sites, comparison sites, and qualitative sampling sites. A stratified sampling approach was used to select representative sampling sites that reflect the range of habitats present in the study area, rather than selecting sites at subjectively defined ‘good’ habitat locations. In this approach, stream reaches were first stratified by geomorphic type. The geomorphic stream reaches were further stratified by accessibility. Refer to the 2006 Geomorphology and Riparian Habitat Characterization Study Plan (PCWA 2006) for more information on selection of representative study sites. Additional sampling sites were selected at the confluences of accessible perennial tributaries where potential breeding habitat may exist. Comparison sampling sites will be selected in non-Project affected reaches (e.g., Shirttail Creek on the North Fork American River and the North Fork of the Middle Fork American River). Qualitative sampling sites, where surveys will be less frequent (one visit), were selected at perennial tributaries where potential breeding habitat may exist or where the FYLF distribution is uncertain, but access is difficult. Map AQ 12-1 provides the locations of all amphibian and reptile study sites, delineated by type: representative sampling study sites, additional study sites (e.g., at tributary confluences), comparison study sites, and qualitative sampling locations. Table AQ 12-1 lists details about each study site, including survey type, geomorphic type, presence of FYLF (from incidental sightings) and relation to study plan objectives.

Incidental sightings during previous stream surveys indicate that FYLF are present throughout much of the study area. FYLF are present above Ralston Afterbay in lower portions of both the Middle Fork American and Rubicon rivers (also the downstream portion of Long Canyon Creek). FYLF are present below Ralston Afterbay, but their distribution appears to be more limited to tributary confluences along the Middle Fork American River (e.g., Otter Creek, North Fork of the

Middle Fork American River). In terms of distribution and abundance, the study sites were spatially located to help identify the upstream distribution of FYLF (above Ralston Afterbay) and the distribution along the length of the peaking reach (below Ralston Afterbay). The study sites also were located to facilitate comparison of FYLF abundance between stream reaches.

Methods

The following describes the approach to meet each of the study objectives: (1) identify and map potential habitat; (2) determine the distribution and abundance of FYLF in the study area; (3) determine the timing and length of the breeding season; (4) develop HSC; and (5) characterize the potential effects of stage and velocity fluctuations on FYLF and their habitat through coordination with the AQ 1 – Instream Flow Technical Study Plan (TSP).

Habitat Characterization:

- Identify and map potential breeding and rearing habitat for FYLF in collaboration with resource agencies in the bypass reaches and the peaking reach based on review of aerial photography, video surveys, and helicopter surveys. Potential breeding and rearing habitat are defined as:

  > *Breeding Habitat* - Shallow, near-shore areas of low velocity with cobble/boulder substrate in open, sunny areas with little riparian vegetation; often adjacent to low gradient cobble/boulder bars, tributary confluences, side and backwater pools, or pool tail-outs with coarse substrates.
  >
  > *Rearing Habitat* - Similar to breeding habitats early in the season; but tadpoles may distribute to shallow, warm, low velocity near-shore habitats with smaller substrate (i.e., gravel/sand) as the season progresses.

- Complete a habitat characterization of the study sites and comparison sites (see Map AQ 12-1) in the field during distribution and abundance surveys that includes information on the presence of predators and food availability. This information will be used to extrapolate observed habitat conditions to potential habitats identified during helicopter surveys and review of existing data.
- Following completion of habitat mapping, develop a GIS map of potential FYLF habitat.

Distribution and Abundance Surveys:

- Identify and map known occurrences of FYLF within the study area based on agency consultation and a review of existing information. Preliminary information is available in the *Middle Fork American River Project (FERC No. 2079) Draft Existing Resource Information Report, First Series* (PCWA 2006).
- Conduct surveys at study sites and comparison sites identified on Map AQ 12-1 to determine the distribution and abundance of FYLF. Surveys will follow the Visual Encounter Protocol described in *Measuring and Monitoring Biological Diversity:* Standard *Methods for Amphibians* (Heyer et al, 1994; Appendix AQ 12-A) and will incorporate USFWS decontamination guidelines (USFWS 2005 (Appendix B)). Specifically, two surveyors will search stream banks, back channel areas, and potential instream habitats for FYLF progressing in a slow, methodical fashion. To aid in the detection of eggs and tadpoles, surveyors will use a viewing box in shallow margin areas and snorkel in deeper water where needed and possible. During surveys, a minimum of

1,000 meters (m) will be surveyed. For sites located at tributary confluences, a minimum of 1,000 m will be surveyed in the mainstem as well as 1,000 m up the tributary where possible. Data collected during each survey includes:

- Sampling Site: time of survey (start, end and total search effort), GPS locations (start and end), weather conditions, and water and air temperatures (at start, mid-day, and end of survey) in both the channel margin and main channel, and;
- Observation: lifestage, sex, size, and GPS location.

- Three visits will be conducted; two visits in the spring/early summer for the detection of eggs and early tadpoles, and one in the late summer/early fall to detect older tadpoles and young-of-the-year. The first spring visit will be completed when river temperatures have reached a daily average of 11ºC and/or when breeding has been verified in one or more comparison sites or the survey sites immediately above Ralston Afterbay.
- Conduct a one-time site visit and qualitative presence or absence survey at six locations that have difficult access (Map AQ 12-1). These sites have the potential to be breeding locations (tributary confluences) and/or upstream distribution locations. The surveys will be conducted at the end of the breeding season when the likelihood of detecting individuals is high, or in early fall to detect young-of-the-year should access in spring prove difficult. If possible, 1,000 m of stream will be sampled.
- If FYLF are found at the highest sampling sites in the study area (near 4,500 feet in elevation), then PCWA will consult with the Aquatic TWG to determine if additional sampling sites, at higher elevations, should be identified and surveyed to adequately determine the upstream extent of the FYLF population.
- Prepare and submit a California Native Species Field Survey Form for all FYLF recorded to the California Natural Diversity Database (CNDDB).

Timing and Length of Breeding Season:

- As described above, the onset of breeding will be determined by monitoring water temperatures and by monitoring the onset of breeding at one or more comparison sites or the survey sites immediately upstream of Ralston Afterbay.
- Water temperature will be continuously (15-minute intervals) monitored at one of the comparison sites (e.g., Shirttail Creek on the North Fork American River) and in the Rubicon River (RR0.7) and the Middle Fork American River (MF26.0) near Ralston Afterbay.
- If breeding does not appear to be finished following completion of the two Distribution and Abundance Survey visits in the spring (i.e., fresh 1-2 day old eggs are found during the second survey), then a third visit will be completed at up to three breeding sites to identify the end of the breeding season. The breeding sites to be surveyed will be determined from data obtained in the previous surveys and in consultation with the Aquatic TWG. The third survey visit at the selected breeding sites will follow the same survey methods as described above under Distribution and Abundance Surveys.
- Because the timing and length of breeding can vary from year to year depending on climatic and hydrologic factors, data collected during the study will be compared to ongoing studies in other Sierran watersheds to determine if breeding in the Project area is coincident to breeding in other watersheds. This data will be used to help determine a range of dates when breeding is likely to occur.

Habitat Suitability Criteria Development:

- Compile and review existing FYLF HSC information. Information on habitat use is available from previous relicensing and academic studies, and HSC are in development for a concurrent relicensing project (Desabla-Centerville Project, FERC No. 803).
- Collect additional HSC information in conjunction with the Distribution and Abundance Surveys at three study sites where FYLF breeding populations have been identified. These data will be used independently or in conjunction with existing FYLF HSC in the AQ 1 – Instream Flow TSP to quantify effects of flow alterations in the Middle Fork American and Rubicon rivers (peaking and bypass reaches) on potential FYLF habitat. Specifically, results from the instream flow analysis will be used to determine stage and velocity effects from various flow regimes on eggs, once laid, and tadpoles.
  - During spring visits, habitat suitability data on eggs and early tadpoles will be obtained. In the late summer/early fall visits, data on older tadpoles will be obtained.
  - Data will be collected on individuals (i.e., egg masses and tadpole groups) at three of the survey study sites. The three sites will be determined from data obtained in the initial Distribution and Abundance survey, and will be selected based on the following criteria: 1) FYLF are abundant; and 2) a wide variety of depth, velocity, and substrate habitat is available at the site. Two of the three sites will be selected from those in the Middle Fork American and Rubicon rivers, and the third site will be selected from a comparison river study site on the North Fork American River or the North Fork of the Middle Fork American River.
  - The number of observations collected will depend on the abundance of individuals at each study site. The target is to collect a total number of observations greater than 150 (but not more than 250) for each lifestage (egg masses, early tadpoles, late tadpoles) distributed across each of the three study sites. It is possible that fewer observations will be obtained if densities are low.
  - Habitat suitability data will be collected in an equal effort sampling approach where possible in order to minimize habitat availability and habitat sampling biases in the resulting habitat use data. The amount of area sampled in different depth, velocity, and substrate categories will be recorded. If there is enough variety of habitats at the sampling sites, the sampling will be approximately evenly distributed over a range of depths and velocities greater than the maximum depth and velocity that egg masses and tadpoles are found.
- Data to be collected at each observation includes:
  - Specimen lifestage; size; and developmental Gosner stage;
  - Microhabitat data (type, GPS location);
  - Riparian data (type, extent of cover);
  - Water temperature;
  - Substrate (size, composition);
  - Distance to waters edge;
  - Hydraulic data (total depth, mid-column velocity, depth and velocity) at each observation; and
  - Hydraulic habitat (depth, velocity) availability in the surveyed areas. This is the planform area of available hydraulic habitat searched at the survey site, where

'hydraulic habitats' are regions of categorical depth and velocity (e.g. depth 0-0.5 m, velocity 0-0.1 m/s; depth 0.5-1.0 m, velocity 0.1-0.2 m/s; etc). See Appendix AQ 12-B for the habitat availability survey protocol, including details on the hydraulic habitat categories. Area is calculated from a scaled field sketch of hydraulic habitat polygons and hydraulic habitats are verified with field measurements of depth and velocity.

- Develop HSC for eggs and tadpoles in consultation with the Aquatic TWG, based on data collected during surveys and existing information sources.
- Develop a life stage periodicity chart for FYLF that identifies the season of the year (time period) when each life stage is likely to be present within the Project area. This data will be used to determine when the HSC information is applicable in evaluating effects of flow alterations on potential FYLF habitat.

Coordination to Determine Stage and Velocity Effects

- Coordinate with the instream flow 1D/2D modeling effort to evaluate habitat suitability for FYLF egg masses and tadpoles under unimpaired and impaired flow regimes. Specific objectives for the FYLF modeling effort include:
    1. Determine the range of flows that creates suitable breeding habitat.
    2. Assess the potential effects of flow fluctuations on breeding and rearing habitat (i.e., what flow regime maintains effective breeding and rearing habitat).
    3. Identify the range of flows that provides suitable basking habitat below the riparian vegetation line.
    4. Assess the potential effects of seasonal flow changes on breeding and rearing habitat connectivity.

- FYLF modeling sites will be identified in coordination with the Aquatic TWG as part of the AQ 1 – Instream Flow TSP study site selection process that includes field visits during the summer of 2007. The locations of FYLF breeding sites observed during the spring 2007 FYLF distribution and abundance sampling will be used to aid selection of modeling sites. Modeling sites will be chosen in the bypass and peaking reaches that are representative of the range of habitats present and include active breeding locations, where possible. PCWA anticipates that there will be two modeling sites in the bypass reaches and two modeling sites in the peaking reach:
    - Rubicon River upstream of Ralston Afterbay (bypass reach);
    - Middle Fork American River upstream of Ralston Afterbay (bypass reach); and
    - Middle Fork American River downstream of Ralston Afterbay (peaking reach).

  AQ 1 – Instream Flow TSP, Table AQ 1-2 provides details on the potential FYLF modeling sites that will be assessed in the field by the Aquatic TWG. At each site selected by the Aquatic TWG, a minimum of two breeding locations (e.g., breeding bars) will be modeled, if present. Details on the modeling can be found in the AQ 1 – Instream Flow TSP (see Tables AQ 1-1 and AQ 1-2). A determination of the modeling method at each site (1D, 2D, or a combination of 1D/2D) and the habitat units to be modeled will be made in collaboration with the Aquatic TWG based on the site characteristics (channel and hydrodynamic complexity) and the modeling objectives listed above (note: Table AQ 1-2 will be filled in by the Aquatic TWG during the field visit).

- At modeling sites with active breeding, egg and tadpole location data will be collected to validate the habitat suitability output from the model. If an active breeding site is not found in the peaking reach, then the modeling sites will be chosen where suitable breeding habitat is present.
- At the North Fork American River (NF 35.7) and North Fork of the Middle Fork American River (NFMF 1.6) FYLF comparison study sites, one to three cross-sections will be located on FYLF breeding and rearing habitat to quantify stage-discharge relationships (Table AQ 12-1). The cross-section will be co-located with the AQ 1 – Instream Flow TSP riparian stage-discharge cross-sections in these same reaches where possible (Table AQ 1-1).
- Evaluate output from the AQ 4 – Water Temperature Modeling TSP and compare changes in average, maximum, and minimum daily temperatures in FYLF breeding and rearing habitat between unimpaired and impaired flow regimes. Data on margin versus channel water temperatures collected during the Distribution and Abundance Survey will be used to help characterize habitat conditions and aid in relating the temperature model output to FYLF suitability.

Western Pond Turtle (WPT)

- Identify and map known occurrences of WPT within the study area, based on agency consultation and a review of existing information. Preliminary information is available in the *Middle Fork American River Project (FERC No. 2079) Draft Existing Resource Information Report, First Series* (PCWA 2006).
- Record sightings of WPT during implementation of aquatic technical studies. In particular, surveyors will be visually inspecting pools and backwaters for WPT at each study site during the FYLF and CRLF surveys.
- Develop a GIS map of potential WPT nesting habitat locations in the Project area. GIS selection criteria include:
  - Slope of 15 degrees or less;
  - Southeast, south or southwest aspect;
  - 150 foot buffer around perennial streams and reservoirs; and
  - below 6,000 ft in elevation.
- Conduct a field reconnaissance survey of potential nesting locations identified in the GIS map near Project reservoirs and within the potential inundation zones for Project betterments to verify habitat mapping.
- Evaluate output from the AQ 4 – Water Temperature Modeling TSP and compare changes in water temperature (average, maximum, and minimum) near potential nesting habitats between unimpaired and impaired flow regimes.

- Prepare and submit a California Native Species Field Survey Form for all WPT recorded to the CNDDB.

Contingency Study 2008

If ambiguities arise during the analysis of data collected in 2007 that preclude meeting the study objectives, the Aquatic TWG will review the analysis and may determine that additional limited-scope studies are needed in 2008. Specifically, ambiguities in determining the distribution and abundance of FYLF or in determining the timing and length of the FYLF breeding season may require additional limited data collection at select sites in 2008. If FYLF are not found at a site during the first year of surveys, the site will be revisited or another site may be surveyed if the Aquatic TWG determines it is necessary. The number of sites revisited, the data to be collected, and the number of times a site is revisited will be determined in consultation with the Aquatic TWG.

Reporting

The study objectives, methodologies, and results of the study will be distributed in a draft report to the Aquatic TWG for review and comment. A final report incorporating the Aquatic TWG comments will be produced and distributed to the Aquatic TWG and Plenary.

SCHEDULE:

Date	Activity
May through June, 2007	Conduct spring field surveys
Early July 2007	Meet with Aquatic TWG to determine if additional sites should be surveyed in 2007
August through September, 2007	Conduct fall field surveys
October through December 2007	Complete data analysis and prepare draft report
January 2008	Distribute draft report to the Aquatic TWG
February through March 2008	Aquatic TWG review and provide comments on draft report
March 2008	Meet with the Aquatic TWG to determine if additional limited-scope studies are needed in 2008. This includes determining if sites need to be revisited or if additional sites need to be visited,
April through May 2008	Resolve comments and prepare final report on 2007 data collection
May 2008	Distribute final report on 2007 data collection to the Aquatic TWG and Plenary
2008 Contingency Studies	
May through September 2008	Conduct contingency studies if needed
October through December 2008	Complete data analysis and prepare draft report
January 2009	Distribute draft report to the Aquatic TWG
January and February 2009	Aquatic TWG review and provide comments on draft report
March through May 2009	Resolve comments and prepare final report
May 2009	Distribute final report to the Aquatic TWG and Plenary

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United States Fish and Wildlife Service (USFWS). 2005. *Revised Guidance on Site Assessments and Field Surveys for the California Red-legged Frog, August 2005.*

TABLES

Table AQ 12-1. Amphibian Study Sites on Project Rivers and Streams.

River and Study Sites[1] (River Mile)	Amphibian Habitat Modeling Site	Study Site Type	Rosgen Geomorphic Channel Type (Mainstem)[2]	Tributary Confluence Site	FYLF Observations[3]	Relation to Study Plan Objectives
Middle Fork American River						
AMPH MF 6.4	No	Tributary/Mainstem	F	Yes – American Canyon	Mainstem – Not Visited Tributary - Not Visited	Distribution
AMPH MF9.3	Yes	Tributary/Mainstem	F (at transition to B2c)	Yes – Todd Creek	Mainstem – Yes Tributary – Not Visited	Distribution, abundance and timing of breeding season
AMPH MF11.0	No	Qualitative (One Visit)	F	Yes – Canyon Creek	Mainstem – No Tributary – No	Distribution, abundance and timing of breeding season
AMPH MF14.1	Yes[6]	Tributary/Mainstem	F	Yes – Otter Creek	Mainstem - No Tributary – Yes	Distribution, abundance and timing of breeding season
AMPH MF19.1	Yes[6]	Representative Geomorphic QSS[4]	F	No	Mainstem – No	Distribution, abundance and timing of breeding season
AMPH MF21.0	Yes[6]	Tributary/Mainstem	F	Yes – Volcano Creek	Mainstem – Not Visited Tributary - Not Visited	Distribution, abundance and timing of breeding season
AMPH MF24.1	No	Tributary/Mainstem	F	Yes – NF MF American	Mainstem - Yes Tributary – Yes	Distribution, abundance and timing of breeding season; possible HSC[5] site
AMPH MF26.2	Yes	Representative Geomorphic QSS	Bc/F	No	Mainstem - Yes	Distribution, abundance and timing of breeding season; possible HSC site
AMPH MF29.4	No	Representative Geomorphic QSS	Bc/F	No	Mainstem - Yes	Distribution, abundance and timing of breeding season
AMPH MF30.4	No	Qualitative (One Visit)	Bc/F	Yes – Brushy Canyon	Mainstem – Not Visited Tributary - Not Visited	Distribution
AMPH MF35.3	No	Qualitative (One Visit)	Bc/F	No	Mainstem - Not Visited	Distribution
AMPH MF36.2	No	Representative Geomorphic QSS	Ba/Fb	No	Mainstem - No	Distribution, abundance and timing of breeding season
AMPH MF39.7	No	Qualitative (One Visit)	Ba/Fb	Yes – Duncan Creek	Mainstem – Not Visited Tributary - Not Visited	Distribution
Rubicon River						
AMPH R1.2	Yes[6]	Representative Geomorphic QSS	Bc/F	No	Mainstem - Yes	Distribution, abundance and timing of breeding season; possible HSC site
AMPH R5.2	No	Qualitative (One Visit)	B/Fb	Yes – Pilot Creek	Mainstem – Not Visited Tributary - Not Visited	Distribution
AMPH R14.3	No	Representative Geomorphic QSS	B/Fb	No	Mainstem - Yes	Distribution, abundance and timing of breeding season
AMPH R20.9	No	Representative Geomorphic QSS	B/Fb	No	Mainstem - No	Distribution, abundance and timing of breeding season

Table AQ 12-1. Amphibian Study Sites on Project Rivers and Streams.

River and Study Sites[1] (River Mile)	Amphibian Habitat Modeling Site	Study Site Type	Rosgen Geomorphic Channel Type (Mainstem)[2]	Tributary Confluence Site	FYLF Observations[3]	Relation to Study Plan Objectives
AMPH R22.6	No	Qualitative (One Visit)	B/Fb	Yes – South Fork Rubicon	Mainstem – Not Visited Tributary - Not Visited	Distribution
AMPH R25.7	No	Representative Geomorphic QSS	C	No	Mainstem - No	Distribution, abundance and timing of breeding season
Long Canyon Creek						
AMPH LC0.0	Yes[6]	Representative Geomorphic QSS	B at mouth (but A upstream)	Yes – Long Canyon	Mainstem - Yes Tributary - Yes	Distribution, abundance and timing of breeding season; possible HSC site
AMPH LC9.0	No	Representative Geomorphic QSS	F	No	Mainstem - No	Distribution, abundance and timing of breeding season
North and South Fork Long Canyon Creeks Confluence						
AMPH LC11.4	No	Tributary/Mainstem	F and B (North and South Forks)	Yes – SF/NF Long Canyon	Mainstem – Not Visited Tributary - Not Visited	Distribution, abundance and timing of breeding season
North Fork American River						
AMPH 21.2	No	Comparison	F	Yes – MF American	Mainstem – Not Visited Tributary - Not Visited	Distribution, abundance and timing of breeding season
AMPH NF35.7	Stage Only	Comparison	F/G Transition	Yes – Shirttail Creek	Mainstem - Yes Tributary - Yes	Distribution, abundance and timing of breeding season; possible HSC site
North Fork of the Middle Fork American River						
AMPH NFMF1.7/2.3	Stage Only	Comparison	F/B	No	Mainstem - Not Visited	Distribution, abundance and timing of breeding season

[1]All study sites to be surveyed a minimum of 1000m in stream length. Tributary sites will also include a minimum of 1,000m upstream on the tributary where possible.
[2]Rosgen, D. L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, Colorado.
[3]FYLF = Foothill Yellow-Legged Frog
[4]QSS = 2006 geomorphology and riparian Quantitative Study Site
[5]HSC = Habitat Suitability Criteria data collection
[6]This site is being looked at by the Aquatic TWG as a potential instream flow modeling site. Final determination of the instream flow modeling sites will be done in the field (summer 2007).

MAPS

APPENDIX AQ 12-A

Visual Encounter Survey Protocol

Visual Encounter Survey Protocol for *Rana boylii* in Streams

Standard VES (Heyer et al. 1994) with augmented field datasheets
Yarnell, S. 2007.

This Visual Encounter Survey (VES) protocol and associated datasheet are for use in stream reaches up to several thousand feet in length where information on all lifestages and the micro-habitat associations of each individual is desired. The data from this survey protocol is intended to 1) describe the abundance, distribution and micro-habitat associations of *R. boylii*, and 2) provide the data necessary to coordinate with other stream reach study efforts, such as instream flow studies where hydrodynamic modeling will be used.

The VES protocol is as described in Heyer et al. (1994), and is summarized for stream habitats as follows. Habitats are searched along a several meter wide transect parallel to the stream at the water's edge, and the number of animals encountered over a period of time is recorded. Using a moderate level of search effort, individuals active on the surface of the ground, on rocks, or at the water's edge are identified, and captured and measured if possible. Rocks, logs and other surface cover objects are also overturned in search of individuals, then returned to their original position to minimize disturbance to the habitat. Habitats are not systematically destroyed in order to find animals, and voucher specimens are not collected unless absolutely necessary for identification. In shallow water habitats, hand dip nets are used to capture individual adults and sub-adults, and to seine the channel bottom to collect tadpoles. This search effort in shallow water habitats is balanced to minimize habitat disturbance, but adequately sift through any silt, gravel or vegetation where individuals may be hiding. Use of a viewing box in shallow, wadable areas to help in detection of egg and tadpole lifestages is recommended. Likewise, where safe and possible, snorkeling in deeper water (0.5-2m deep) adjacent to good breeding habitat (e.g. edges of cobble bars) can greatly aid in detection of egg masses, and is recommended during spring surveys. To effectively survey stream segments, both banks are walked with a minimum of two surveyors. Wherever possible, surveys are completed walking upstream so that as individuals seek cover in the stream, often swimming downstream, they are not counted twice. In addition, eggmasses are generally attached to the downstream side of cobbles and are easier to detect when walking upstream. However, surveys could proceed in the downstream direction if surveyors are well-practiced in identification, are manually feeling and checking behind cobbles and boulders for eggmasses, and can adequately keep track of any downstream migrating individuals.

A list of field equipment required to complete the surveys is attached at the end of this protocol. In general, equipment should be selected to be lightweight and compact enough to fit within a daypack so that surveyors can be fully mobile.

The associated datasheet was developed to document the additional microhabitat data needed at each observation. It is similar to datasheets used in previous academic research and hydropower relicensing studies (Lind, 1997; PG&E 2002; Yarnell, 2005). In order to simplify the complications and potential errors associated with multiple datasheets each for a different lifestage, a single datasheet is used for each survey, regardless of time of year and focus of survey (ex: breeding surveys in spring vs. tadpole/rearing surveys in summer). The data for each lifestage observed during the survey is recorded on a single row. The microhabitat data collected for each lifestage may differ and as a result, some fields in the row may be marked as N/A (ex: depth at eggmass for an adult observation). Small modifications to the datasheet may be made to accommodate unique survey situations (such as associated mesohabitat number rather than associated GPS point when identifying observation location), but these should be kept to a minimum.

Note that the datasheet is designed to be printed in landscape format on 8x14 paper with the code list printed on the back side of the page (see FYLF VES survey datasheet.xls file). Details on recording data are provided below. The datasheet is designed for collection of data in metric units, so use of English units must be explicitly noted.

General Data

Site: Name of stream and reach to be surveyed. If sub-reaches are used, clarify which sections are to be surveyed. For example: South Yuba River, Reach A-1, river mile 12.5-13.5.

Start/End UTM: Coordinates of start and end survey locations on the stream in NAD27 datum (designate other datum if needed). Record saved waypoint (wypt) number accuracy of point (in meters).

Elevation: Record from Topo map or GPS and circle source (note range of error)

Photo numbers: Record digital photo ID numbers for photos taken throughout survey. Include photos of the start and end locations, typical mid-channel habitat, typical edgewater and backwater habitats, examples of breeding habitat (occupied or otherwise), example individuals where possible (adults, juveniles, eggs and tadpoles) and any other interesting or unique habitat features.

Observers(s): Names of surveyors

Date: Month, Day, Year

Survey Start/End Time: Record start/end times of survey (note time of breaks for lunch, etc on bottom of sheet if necessary). This should reflect actual survey/search time.

Weather: Describe general cloud cover; enter code from list:

C Clear
PC Partly Cloudy
MC Mostly Cloudy
O Overcast
R Rainy

Start/End Temp (C): Record temperature of air (in the shade) and water (thalweg and edgewater) at start, mid-day (if applicable) and end of survey. Edgewater temp should be within 0.3m of shore in a shallow slow-moving location.

Bullfrogs? Fish? Note presence/absence of bullfrogs, fish or crayfish anywhere in survey reach. If needed, add notes at bottom of page.

Field sketch completed? At the bottom of the page, note whether a rough field sketch was completed on the back of the datasheet. The sketch serves as rough indicator of habitat throughout the survey reach and can be used to delineate which portions of the reach may *not* have been surveyed (e.g. very deep or fast areas near a steep heavily vegetated bank).

Detailed Data

***Note: Microhabitats are defined as the immediate/local habitat surrounding the observation site of the individual. This may be the shallow side habitat or backwater where eggs and tads occur or the habitat immediately adjacent to an adult perch site. Measurements should be made as near to the individual as possible but still describing the average conditions of the immediately adjacent habitat. On average, but not always, the microhabitat would be within a 0.5m or so of the observation.

***Note: Some fields are applicable only to certain lifestages. Be sure to record N/A in the datasheet field for field not appropriate to the observation. Do not leave fields blank.

Life Stage/Sex: Note life stage of individual; enter code from list:

AF Adult Female
AM Adult Male

AU Adult Unknown
J Juvenile/Sub-adult
Y Young of Year/metamorph (newly emerged – fall only)
T Tadpole
E Egg mass

Total #: Number of individuals noted in a single micro-habitat (ex: 1 adult male on emergent boulders in a riffle vs. 50 tadpoles in a single small side channel pool)

Length (mm): Snout to vent length for adults/sub-adults; Total length for tadpoles; Diameter for egg masses

Developmental Stage: Gosner stage for egg masses and tadpoles. If categorized, then note categories on back of datasheet.

Mesohabitat Type: Local larger-scale habitat where individual was observed based on USFSR5 meso-habitat types (see USFSR5 publication for more info on defining mesohabitats); enter code from list:

CAS Cascade
- jumbled steep reaches with either coarse substrate or bedrock

SPO Step-pool
- includes steep reaches with plunge pools and vertical scour pools

SCP Side-channel Pool
- includes eddies, backwater pools, lateral scour pools, corner pools

POO Pool
- includes flatwater, dammed pools, confluence pools, mid-channel pools and pool tail-outs

EDG Edgewater
- shallow edgewater habitat adjacent to riffles, runs

RUN Run
- slow gently moving flow, faster than a pool, slower than a riffle

HGR High Gradient Riffle/Rapid
- rippled swift water, rapids of high gradient (~ >2%)

LGR Low Gradient Riffle
- rippled swift water of low gradient (~ <2%)

OTH Other
- describe either in same field or in comments field

Riparian Type: Describe dominant riparian/adjacent channel vegetation based on Lind 1997 to provide data on vegetation encroachment; enter code from list:

GCBar	Gravel/Cobble Bar (side or mid channel, clear of veg)
WIL	Pure Willow
WIL/ALD	Willow/Alder Mix
MRIP	Mature Riparian
BDX	Bedrock (clear of veg)

Canopy Cover Class: Cover directly above microhabitat where individual was noted; enter code from list:

1	0 – 25%
2	25 – 50%
3	50 – 75%
4	75 – 100%

Distance to Shore (m): Distance from observation perpendicular to water's edge at closest shore. Primarily important for eggs/tadpoles.

Microhabitat Substrate: Dominant substrate type near perch for adults/sub-adults, microhabitat substrate for tadpoles or egg masses

SLT	Silt
SND	Sand (< 2mm)
GRV	Gravel (2 – 64 mm)
COB	Cobble (64 – 256 mm)
BLD	Boulder (> 256 mm)
BDX	Bedrock
MXD	Mixed (describe how mixed – GC or CG with dominant size first)

Attach/Perch Substrate: Substrate size of perch for adults/sub-adults/juveniles or attachment site for egg masses (N/A for tadpoles)

SLT	Silt
SND	Sand (< 2mm)

GRV	Gravel (2 – 64 mm)
COB	Cobble (64 – 256 mm)
BLD	Boulder (> 256 mm)
BDX	Bedrock
VEG	Vegetation/LWD - specify

Total Depth (m): For all lifestages, record average total depth of the microhabitat

Depth to eggs/tads (m): For egg masses, record depth to center of egg mass; for tadpoles, record depth to tads if different than average total depth of microhabitat, if it's the same, note 'same'.

Mid-column Velocity (m/s): For all lifestages, record average local mid-column flow velocity of the microhabitat. Mid-column velocity should be taken at 0.6 times the total depth for depths < 1m. For depths > 1m, record the average of the velocity at 0.2 times the depth and 0.8 times the depth. For egg masses, this should be directly above or immediately adjacent to the oviposition site.

Velocity at eggs/tads (m/s): For egg masses, record velocity at/adjacent to center of egg mass; for tadpoles, record velocity at tads if different than mid-column velocity of microhabitat, if it's the same, note 'same'.

Local Water Temp (C): Temperature of water in local microhabitat

Location of Observation: Code or some identifier of location in survey reach where observation was recorded. Could be a GPS waypoint number or an associated meso-habitat number correlating to another study.

Comments: Include here any information on local habitat condition, species condition, presence of non-natives, photo description, etc.

References:

Heyer, W. R., M. A. Donnelly, R. W. McDiarmid, L. C. Hayek and M. S. Foster, Eds. (1994). Measuring and monitoring biological diversity: Standard methods for amphibians. Biological Diversity Handbook Series. Washington D.C., Smithsonian Institution Press.

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USFSR5 meso-habitat types

Field Equipment List

Required:

Field notebook
Datasheets (w/copy of survey protocol) and clipboard
Clean copies of study site aerial/topo maps (for sketching habitats, etc)
Pencil, pen, sharpie
Stopwatch
Flagging
Thermometer
Binoculars
Dip net or small handheld net for scooping tadpoles and catching individuals
Clear see-thru rulers (marked in metric) to measure individual length
Small clear plastic vial or wide-mouth bottle to capture tads for identification
Camera – extra batteries, memory card
Scale for pictures (ruler, pencil of known length, etc)
Handheld GPS – extra batteries
Velocity meter w/wading rod or other stick/device to measure depth – Marsh McBirney recommended – need accuracy in low velocities - +/- 0.01 m/s ideal.
Waders
First Aid kit
Personal – water, food, sunscreen, bug juice, etc

Recommended:

Viewing box (ideal if made of plexiglass, but could be lightweight plastic with clear plastic affixed to hole in bottom)
Snorkeling gear – drysuit, mask/snorkel, shoes
Rope to tie off and use in swift water
Hand lens (aid in identifying mouth parts on tadpoles)
30m tape – w/metric markings

Optional:

Range finder – to record large scale distances (river width, length of bar, etc)
Compass
Walkie talkies
Inflatable kayak, inner tube, or some means of floating river if needed – includes lifejackets, drybags, paddles, ropes, etc.

Site (stream/reach/subreach)____ Date: ____________________________ Page _____ of _____

Start North UTM: East UTM:	WYPT: Accuracy:	Elevation: GPS Topo	Photo #s: start: end: breeding: Other: mid-channel: Edgwtr: adults: eggs/tads:				Observer(s):
End North UTM: East UTM :	WYPT: Accuracy:	Survey Start Time: End Time:	Weather:		Start Temp (C) - Air: Thalweg: Edgwtr:	End Temp (C) - Air: Thalweg: Edgwtr:	Bullfrogs? Fish? Crayfish?

Life Stage /Sex	Total #	Length (mm)	Develop. Stage	Meso-habitat Type	Riparian Type	Canopy Cover Class	Dist to Shore (m)	Microhabitat Substrate (mm)	Attach/Perch Substrate (mm)	Total Depth (ft)	Dist. From Surface to Eggs/Tads (ft)	Mean Column Velocity* (ft/s)	Velocity at Eggs/Tads (ft/s)	Local Water Temp (C)	Location of Observation	Comments

* If depth is ≤ 2.5 ft then measure velocity at 0.6 of depth from the surface. If depth is ≥ 2.5 ft than measure velocity at 0.8 and 0.2 of depth from the surface.

Foothill Yellow-legged Frog VES Survey Form CODES

VARIABLE	CODE	Description	Comments
Life Stage/Sex	AF	Adult - Female	
	AM	Adult - Male	
	AU	Adult - Unknown	
	J	Juvenile/Sub-adult	
	Y	Young of Year/Metamorph (fall only)	
	T	Tadpole	
	E	Egg Mass	
Length (mm)	Snout to vent length for adults/sub-adults; Total length for tadpoles; Diameter for egg masses		
Mesohabitat Type	CAS	Cascade	jumbled steep reaches with either coarse substrate or bedrock
	SPO	Step-pool	includes steep reaches with plunge pools and vertical scour pools
	SCP	Side-channel Pool	includes eddies, backwater pools, lateral scour pools, corner pools
	POO	Pool	includes flatwater, dammed pools, edgewater, confluence pools, mid-channel pools and pool tailouts
	EDG	Edgewater	shallow edgewater habitat adjacent to riffles, runs
	RUN	Run	slow gently moving flow, faster than a pool, slower than a riffle
	HGR	High Gradient Riffle/Rapid	riffles, rapids of high gradient (~ > 2%)
	LGR	Low Gradient Riffle	riffles of low gradient (~ < 2%)
	OTH	Other	describe in comments field
Riparian Type	GCBar	gravel/cobble bar (no veg)	
(stage of succession)	WIL	pure willow	
	WIL/ALD	willow/alder mix	
	MRIP	mature riparian	
	BDX	Bedrock (little/no veg)	
Microhabitat Substrate	SLT	silt	
	SND	sand (< 2mm)	
	GRV	gravel (2 - 64 mm)	
	COB	Cobble (64 - 256 mm)	
	BLD	Boulder (> 256 mm)	
	BDX	Bedrock	
	MXD	Mixed	describe how mixed - e.g. GC for dominant gravel, secondary cobble
Microhabitat Depth	TOTAL Depth of microhabitat (m)		
Depth at Eggs/Tads	Eggs - depth to center of egg mass; Tads - depth to tads if diff than average total depth		
Microhabitat Velocity	Average MID-COLUMN velocity of microhabitat (m/s)		
Velocity at Eggs/Tads	Eggs - velocity at/adjacent to center of egg mass; Tads - velocity at tads if diff than mid-column velocity		
Local Water Temp	Water Temperature in microhabitat		
Distance to Shore (m)	Distance from observation perpendicular to water's edge on nearest shore		

VARIABLE	CODE	Description
Developmetal Stage		Gosner stage for egg masses and tadpoles.
Eggs	1	New 1-3 days old - compact, blue, no silt, small eggs
	2	~ 1 week old - looser, some silt on eggs, water in eggs
	3	~2 wks old (close to hatching) - very loose, eggs detaching, start to see tail in embryos, possibly strung out if subject to slight flow
Tadpoles	1	
	2	
	3	
	4	
	5	
Canopy Cover Class	1	0-25%
	2	25-50%
	3	50-75%
	4	75-100%
Attach/Perch Substrate	SLT	silt
	SND	sand (< 2mm)
	GRV	gravel (2 - 64 mm)
	COB	Cobble (64 - 256 mm)
	BLD	Boulder (> 256 mm)
	BDX	Bedrock
	VEG	Vegetation/LWD - specify veg type

Rough field sketch - delineate areas NOT surveyed (too deep/fast, heavy veg)

APPENDIX AQ 12-B

Habitat Availability Survey Protocol

Habitat Availability Survey Protocol for *Rana boylii* in Streams

Yarnell, S. 2007.

This protocol is for determining the amount of available habitat in a survey reach potentially suitable for *R. boylii* egg and tadpole lifestages. It is intended to provide habitat availability data that can be used with habitat suitability data collected for eggs and tadpoles in order to minimize bias in developing suitability curves.

The associated datasheet is used to record data on point depth and velocity measurements throughout the survey reach. The associated field sketch form is used to create a scaled map of the survey reach, showing locations of control points, point measurements and general habitat characteristics (geomorphic features, mesohabitat type, substrate, etc). Data from both forms are then used to calculate the area of hydraulic habitats defined in a specified series of depth/velocity bins.

Details on the protocol and filling out the datasheets are provided below.

Note that the datasheet and field sketch form are designed to be printed in landscape format on 8.5x14 paper with the codes and description boxes printed on the back side of the page (see files: FYLF VES survey datasheet.xls and Habitat sketch form.pdf). The datasheet is designed for collection of data in metric units, so use of english units must be explicitly noted.

PROTOCOL

1. *Complete a scaled sketch of the survey reach*. Be sure to include:
   - Control points throughout the reach were possible for measuring distances and determining an appropriate map scale
   - Outlines of basic geomorphic features
   - Outlines/shading of mesohabitat unit types
   - Outlines/shading of substrate size patches
   - Outlines of large, dense vegetation patches
   - Locations of point depth/velocity measurements and/or cross-section transects depending on resolution of map

2. *Take point measurements of depth and velocity across the specified range.* Using the datasheet, record the location of each point measurement (longitudinal distance from control point, cross-sectional distance from longitudinal line if using scope and rod; survey point numbers if using a total station), total depth, mid-column velocity and substrate size. Measurements should be taken throughout the survey reach in an effort to equalize area surveyed in the following depth/velocity categories:

	Depth (m)			
Velocity (m/s)	0.0 - 0.5	0.5 - 1.0	1.0 - 1.5	1.5 - 2.0
0.0 - 0.1	x	x	x	x
0.1 - 0.2	x	x	x	x
0.2 - 0.4	x	x	x	x
0.4 - 0.6	x	x	x	x

In order to maximize efficiency, select a cross-section across a mesohabitat. With the tape zeroed on a longitudinal tape line or perpendicular to the water's edge, start at the water's edge and take a point measurement where the velocity first reaches 0.1 m/s. Continue along the cross-section, taking point measurements when velocity reaches 0.2 m/s, 0.4 m/s and 0.6 m/s. Data is not needed at velocities higher than 0.6m/s. Continue in this fashion until a series of cross-sections have been completed throughout the reach.

3. *Calculate the area surveyed within each bin.* Using locations of point measurements recorded on the field sketch map, trace contours at each velocity level and draw polygons around each the area representing each depth-velocity bin. Count squares to determine the area within each bin and record in the depth-velocity bin table on the back of the field sketch form. If some bins are underrepresented (area too low in relation to others), select additional point measurement locations throughout the reach in an effort to equalize area sampled across the range of bins.

<u>Point measurement datasheet details</u>

Control Point: Code for specific control point from which longitudinal and cross-sectional distances are measured or point used as a benchmark if using a total station. Descriptions of control points, including an assigned code, are to be recorded on the back of the field sketch form. A list of the codes can be added to the back of the datasheet for reference if needed.

Survey Point: Number of point taken with a total station. If using a scope and rod, record station point number for cross-reference to a field notebook with the details on station and elevation information.

Mesohabitat Unit Type Based on USFSR5 mesohabitat unit designations. See codes on the back of the VES survey datasheet.

Depth (m) Total depth at measurement point

Velocity (m/s) Mid-column velocity at measurement point

Substrate Categorical size of substrate at measurement point. See categories listed on back of datasheet.

Notes Record any anomalies or error in measurements; describe any local influences on the measurement (ex: boulder just upstream, etc)

Site (stream/reach/subreach):____

Date: Page _____ of _____

Start North UTM: East UTM:	WYPT: Accuracy:	End North UTM: East UTM:	WYPT: Accuracy:	Weather:
Elevatoin: GPS Topo	Survey Start Time: End Time:		Assoc. Field Sketch Form: Assoc. Photo #s:	
Discharge:	Observers:	Notes:		

Survey Point	Mesohabitat Unit Type	Depth (m)	Velocity (m/s)	Substrate	Notes

Notes on Collecting Habitat Suitability Criteria (HSC) availability data

Data is collected to determine range of depths and velocities available throughout the survey reach, and will be used to develop HSC curves for FYLF eggs and tadpole lifestages.

Control Point -	Code for contol points identified at each site. Describe control points in description box below.		
Survey Point -	Point number from Total Station (**If scope and rod used instead, then reference where in field notebook details on station, elevation, etc		
Mesohabitat Unit Type -	Based on USFSR5 mesohabitat unit designations. See codes for VES datasheet.		
Depth (m) -	Total Depth at measurement point		
Velocity (m/s) -	Mid-column velocity at measurement point		
Substrate -	Categorical size of substrate at measurement point:		
	Silt/fines	Small Cobble (64-128n	Large Boulder (>512mm)
	Sand (<2mm)	Large Cobble (128-256	Bedrock
	Gravel (2-64mm)	Small Boulder (256-512mm)	
Notes -	Any anomalies, errror or description pertaining to that measurement point		

CONTROL POINTS

Code	Description