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.

STUDY OBJECTIVE(S):

- Document sediment conditions in the bypass reaches and the peaking reach.
- Characterize sediment capture in Project reservoirs and diversion pools and the resulting effect on sediment loading in the bypass and peaking reaches for the existing Project and potential Project betterments.
- 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 and existing 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 AQ9-1).

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 channel upstream and downstream of Project dams and diversions were completed by PCWA in 2005 and 2006 (PCWA 2005 and 2006). This information was collected following methods as described in the 2005-2006 Existing Environment Study Plan Package (PCWA 2005 and 2006), 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 AQ9-2.

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

- Conduct V* methodology in selected pools (less than 10 feet deep) centered on the 2006 geomorphic and riparian quantitative study sites within bypass reaches and the peaking reach and comparison reaches to characterize the amount of residual pool fine sediment (Lisle and Hilton 1993). The average weighted V*w value for a reach will be calculated from these measurements. The locations are listed in Table AQ9-3.
- Compare the range of V*w reach-average weighted residual pool fine sediment between bypass, peaking, and relevant comparison reaches, and with values in the geomorphic literature.

Particle Size Composition and Fine Sediment Content of Spawning Gravels

- Determine particle size distribution and fine sediment content of spawning gravels at 6 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 AQ9-3.
    - 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 reaches 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. Statistical analysis of 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.

Obtain Sediment Management Information

- Obtain information on sediment management practices implemented at Project diversion pools.
    - Summarize existing sediment management conducted by PCWA Operations and Maintenance personnel.

  - o Obtain historic information, as available, pertaining to volume of sediments excavated and frequency of maintenance, for each facility.
  - o Review any historical and recent bathymetry data and studies on Project reservoirs and diversion pools.
  - o Review existing data sources for sediment loads delivered to Project reservoirs and diversion pools.

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

- Survey French Meadows and Hell Hole reservoirs, Ralston Afterbay and Middle Fork Interbay, during low-pool conditions to quantify and characterize sediment capture.
  - o Estimate the proportion in-filled with sediments by a combination of topographic surveys using an automatic level, and visual survey over the exposed reservoir bed above the low-pool.
  - o Identify and photograph any evidence indicating the location of the original, pre-dam valley/river bottom conditions, such as tree-stumps.
- 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.
  - o 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.
  - o 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 16mm).
  - o Visually catalogue all bulk samples for particle size (i.e., proportion of sediments in silt, sand, gravel, cobble size ranges), and photo-document. 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.
  - o 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, they will be re-sampled and particle sizes compared with those obtained from the bulk samples in 2006. A back-hoe will be used to dig test pits for one-half day each at the North and South Fork Long Canyon diversion pools, if there is enough new material collected within the respective reservoirs.
  - o Sketch map 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 10 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)
  - 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.
    - Evaluate potential candidate unimpaired gaging stations for consideration in developing the regional unimpaired flood frequency curve in consultation with the Aquatic TWG. The potential candidate unimpaired gaging stations for consideration are listed in Table AQ9-4.

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

The magnitude of flow needed to initiate motion of the particle sizes represented on the streambed will be determined by a combination of hydraulic modeling and in-situ measurements of sediment transport. In combination, the empirically-based studies and hydraulic modeling provide a more robust basis for assessing the relationship between flow and sediment transport.

- Identify sediment transport flows at the geomorphic and riparian quantitative transects and instream flow transects using the hydraulic models developed for the Instream Flow Technical Study.
  - Collect stage discharge data at high flows at geomorphic and riparian transects in selective reaches to calibrate the hydraulic model.
    - For purposes of the sediment transport assessment, as well as for the Riparian Studies, the range of flows used for calibration will be extended into higher discharges. Stage data (i.e., water surface elevation) 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 Instream Flow Technical Study. The sediment transport modeling will be based on the modeling described in the Instream Flow Study. All of the same study sites on the bypass and peaking reaches proposed for this study will be evaluated for sediment transport conditions (Table AQ1-1).
  - Derive channel geometry data for input to the models from the cross-section and longitudinal topographic surveys performed as part of the Instream Flow Technical Study.
  - Derive channel hydraulic conditions, including flow depth, velocity, energy slope, and bed shear stress, from the models for a range of high flows.
  - Determine the shear stress required to initiate motion for a given particle size from the Shield's criterion that defines the critical shear stress (*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.
  - 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 Technical Study.
- Calibrate and supplement hydraulic modeling results with empirically-based study methods to collect direct evidence of sediment transport conditions. The specific empirical studies to be applied at each study site will be dependent upon the site specific characteristics, to be determined in the field at the time that the cross-section locations are selected for input to the models. 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

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.
- Survey and quantify large woody debris captured at Project reservoirs and diversion pools.
- Characterize the fate of large woody debris transport through 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 2006).

SCHEDULE:

To be developed in early 2007.

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Table AQ9-1. Middle Fork Project Bypass and Peaking Reaches and Comparison Reaches.

River or Stream	Bypass Reach[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]
Middle Fork American River	French Meadows Reservoir to approximately 3 miles upstream
Duncan Creek	Duncan Creek Diversion to approximately 3 miles upstream
North Fork Long Canyon Creek	North Fork Long Canyon Creek Diversion to approximately 2 miles upstream
South Fork Long Canyon Creek	South Fork Long Canyon Creek Diversion to approximately 2 miles upstream
North Fork Middle Fork American River	Confluence with Middle Fork American River to approximately 1 mile upstream
North Fork American River	Lake Clementine to approximately 5 miles upstream

[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 Figure AQ1-1.

Table AQ9-2. 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.

AQ9-3. V*, Bulk Spawning Gravel, and Sediment Transport Hydraulic Model Locations.

River/Reach	Bypassed Reach	Peaking Reach	Number of Sediment Transport Study Reaches	Number of bulk spawning gravel samples	Number of V* pools
Duncan Creek					
Duncan Creek	●		2	6	10 (a)
Middle Fork American River (MFAR)					
MFAR French Meadows – Interbay	●		2	6	10 (a)
MFAR Interbay – Ralston	●		2	6	10 (a, b)
MFAR Ralston – Canyon Creek		●	1-2	6	10 (b)
MFAR Canyon Creek – NF American		●	1-2	6	10 (b)
Rubicon River					
Rubicon River Hell Hole – South Fork	●		1	6	10 (a)
Rubicon River South Fork – Ralston	●		2-3	6	10 (a, b)
Long Canyon Creek					
North Fk Long Canyon	●		1	6	10 (a)
South Fk Long Canyon	●		1	6	10 (a)
Long Canyon	●		1	6	10 (a)
Comparison Streams					
North Fk Middle Fk American				6	10 (a)
North Fk American				6	10 (b)

a: quantitative V* measurement
b: visual V* technique

Table AQ9-4. 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

