Study 1.1

CHANNEL MORPHOLOGY UPSTREAM OF ENGLEBRIGHT RESERVOIR[1]

December 2011

1.0 Project Nexus

Yuba County Water Agency's (Licensee or YCWA) continued operation and maintenance (O&M) of the existing Yuba River Development Project (Project) has a potential to affect channel morphology and fluvial processes, which could affect channel morphology upstream of the United States Army Corps of Engineer's (USACE) Englebright Dam.[2]

2.0 Resource Management Goals of Agencies and Indian Tribes with Jurisdiction over the Resource Studied

YCWA believes that five agencies have jurisdiction over channel morphology and the resources that could be potentially affected in the geographic area covered in this study proposal: 1) the United States Department of Agriculture, Forest Service (Forest Service) on National Forest System (NFS) land; 2) United States Department of Interior, Fish and Wildlife Service (USFWS); 3) United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS); 4) California Department of Fish and Game (CDFG); 5) State Water Resources Control Board Division of Water Rights (SWRCB). Each of these agencies and their jurisdiction, as understood by YCWA at this time, is discussed below.

Forest Service

The Forest Service's jurisdiction and applicable management goals are described by the Forest Service from page 59 to 76 in the Forest Service's March 2, 2011 letter to FERC providing the Forest Service's comments on YCWA's PAD. The Forest Service's jurisdiction and management goals are not repeated here.

USFWS

USFWS's jurisdiction and goals and objectives are described by USFWS on pages 1 through 3 of USFWS's March 7, 2011 letter to FERC that provided USFWS's comments on YCWA's Pre-Application Document (PAD). USFWS's jurisdiction, goals and objectives are not repeated here.

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1 FERC's December 8, 2011 Study Modification required modifications to this Study. Those modifications have been made in this Study plan.

2 Englebright Dam was constructed by the California Debris Commission in 1941; is owned, operated and maintained by the United States Army Corps of Engineers; and is not included as a Project facility in FERC licenses for the Yuba River Development Project.

NMFS

NMFS jurisdiction is described by NMFS in its March 7, 2011 letter to FERC providing NMFS's comments on YCWA's PAD, specifically in Enclosure G – Resource Management Goals and Objectives, as well as NMFS' Request for Information or Study #4, Effects of the Project and Related Facilities on Coarse Substrate for Anadromous Fish: Sediment Supply, Transport and Storage, specifically see page 16, section 5.9 (b): 2.0 Resource Management Goals of NMFS. NMFS's jurisdiction and management goals are not repeated here.

CDFG

CDFG's jurisdiction is described by CDFG on page 1 of CDFG's March 2, 2011 letter to FERC providing CDFG's comments on YCWA's PAD. CDFG's goal, as described on page 2 of CDFG's letter is to preserve, protect, and as needed, to restore habitat necessary to support native fish, wildlife and plant species.

SWRCB

SWRCB has authority under the federal Clean Water Act (33 U.S.C. §11251-1357) to restore and maintain the chemical, physical and biological integrity of the Nation's waters. Throughout the relicensing process the SWRCB maintains independent regulatory authority to condition the operation of the Project to protect water quality and the beneficial uses of stream reaches consistent with Section 401 of the federal Clean Water Act, the Regional Water Quality Control Board Basin Plans, State Water Board regulations, CEQA, and any other applicable state law.

3.0 Study Goals and Objectives[3,4]

The goal of the study is to quantify or characterize river form, process, and interaction with the riparian zone in reaches upstream of the normal maximum water surface elevation (NMWSE) of Englebright Reservoir potentially affected by continued Project operations and under annual regulated (i.e., existing conditions) and unimpaired (by Project facilities operations) coarse sediment supply and transport regimes. To be clear, when used in this Study, "unimpaired" refers to existing inflow conditions to the Project but without the Project facilities in place.

The objectives of the study are to collect information necessary to meet the study goal. Specifically, the study objectives include: 1) develop a quantitative and qualitative understanding

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3 FERC's December 8, 2011 Study Modification directed "*In study 1.1 section 3.0, Study Goals and Objectives, the first sentence should be modified to read as follows, adding the* ***bold italic text****: The goal of the study is to quantify or characterize river form, process, and interaction with the riparian zone in reaches upstream of the normal maximum water surface elevation of Englebright Reservoir potentially affected by continued project operations* ***and under annual regulated (existing conditions) and unimpaired (by project facilities operations) coarse sediment supply and transport regimes."*** (p 6). YCWA has modified the paragraph as directed by FERC.

4 FERC's December 8, 2011 Study Modification directed "*Specifically, in lieu of the information listed in its proposed study, YCWA shall produce the following information based on the study results: the ratio of annual existing sediment supply to project affected stream reaches vs. the potential annual sediment supply if the supply was not trapped within the project reservoirs, which would provide an index of the project's effect on sediment supply in affected stream reaches; a comparison of annual bedload transport capacity in project affected stream reaches under project-regulated flow conditions and under flow conditions unimpaired by operations of project facilities; a comparison of estimated annual coarse sediment supply to estimated annual bedload transport capacity; and an estimate of existing coarse sediment storage in project-affected reaches of the Middle Yuba and Oregon Creek."* (pp 6 & 7). YCWA has added a list of this information in this section and has modified the study accordingly.

of Project effects on substrate mobility, sediment supply, in-channel storage, sediment transport, particle size distribution, spill channel flow effects on channel morphology and erosion, mainstem Yuba River scour and/or deposition from New Colgate Powerhouse releases, and floodplain connectivity at multiple scales.

Specifically, the study will produce the following information:

- The ratio of sediment yield before the dam was constructed to after the dam was constructed to provide an index of sediment availability changes
- An annual bedload transport capacity under regulated and unimpaired conditions
- The ratio of the bedload transport under regulated conditions to the bedload transport under unimpaired conditions to provide an index of the changes in sediment transport capacity
- A comparison of annual transport capacity under unimpaired and regulated conditions
- A coarse sediment balance in Oregon Creek and the Middle Yuba using an estimate of storage in the channel compared against regional bedload yield.

4.0 Existing Information and Need for Additional Information

Considerable information has been obtained or developed by YCWA and is provided in YCWA's Yuba River Development Project relicensing Preliminary Information Package (YCWA 2009). The information includes but is not limited to:

- Topographic and hydrographic information of the Project-affected reaches (Preliminary Information Package, Section 3.0 General Description of River Basin and Appendix D - Project Maps)
- Hydrologic information, modeling and statistics for Project-affected reaches (Preliminary Information Package, Section 7.2 Water Resources and Appendix F - Hydrology)
- Operations procedures for Project facilities (Preliminary Information Package, Section 6.0 Project Location Facilities and Operations)
- Low altitude aerial video of all Project-affected reaches and facilities (Preliminary Information Package, Appendix E - Project Helicopter Video)
- Existing information regarding sediment yields (Preliminary Information Package, Section 7.1.5.1 Geology and Soils)
- Preliminary classification of Project reach types conducted by YCWA in 2009 (Preliminary Information Package, Section 7.1.7.2 Geology and Soils)
- Sediment management and volumes removed from Our House Diversion Dam (Preliminary Information Package, Section 7.7.1.2. Geology and Soils)

Information not included with the Preliminary Information Package, but that is available as Attachment 3.10A to YCWA's Instream Flow Above Englebright Study Proposal (Study 3.10) is a Habitat Mapping Report of the Yuba River Development Project done by YCWA in 2009. This report includes channel and habitat descriptions of ground-mapped and video mapped Project-affected streams; substrate, bank material, large woody debris (LWD) counts, estimated quantity of salmonid spawning sized gravel, potential natural barriers to upstream fish movement, notes regarding access, and photographs.

To achieve the study goals, additional information is needed, which includes:

- Review of current and historic aerial photographs
- Field measurement of cross-section profiles
- Frequency of critical flows under regulated and unimpaired conditions
- Calibration of sediment transport model using tracer rocks
- Quantification of coarse sediment storage at intensive study sites and at selected accessible locations in the Middle Yuba and Oregon Creek
- Field measurement of longitudinal profile
- Mapping and classification of textural facies
- Distribution and size of channel morphological features such as bedrock outcrops, boulders, gravel accumulations, and floodplains
- Assessment of condition of riparian zone and distribution of riparian vegetation (e.g., bars, alluvial fans)
- Spill channel flow and erosion
- Tributary bedload input
- Sediment supply estimates using available data
- Areal extent of bedload deposit upstream of New Bullards Bar Reservoir mean maximum elevation in Slate Creek, and description of geometry and substrate in Slate Creek immediately upstream of influence
- Areal extent of bedload deposit upstream of Our House Diversion Dam in the Middle Yuba upstream of Our House Diversion Dam, and description of geometry and substrate in the Middle Yuba River immediately upstream of influence
- Areal extent of bedload deposit upstream of Log Cabin Diversion Dam in Oregon Creek upstream of Log Cabin Diversion Dam, and description of the geometry and substrate in Oregon Creek immediately upstream of influence

5.0 Study Methods and Analysis

The study includes collecting data to develop a quantitative and qualitative understanding of the effects of regulation on the interactions of hydrology, channel morphology, and the riparian environment in stream reaches upstream of the Englebright Reservoir potentially affected by the Project.

5.1 Study Area

The study area includes: 1) the Middle Yuba River from Our House Diversion Dam to the confluence with the North Yuba River; 2) Oregon Creek from the Log Cabin Diversion Dam to the confluence with the Middle Yuba River; 3) the North Yuba River from New Bullards Bar Dam to the confluence with the Middle Yuba River; 4) the portion of the Yuba River from the confluence of the North and Middle Yuba rivers downstream to the normal maximum water surface elevation of Englebright Reservoir; and 5) the portion of the Middle Yuba, Oregon Creek, and Slate Creek affected by base-level control exerted by either the diversion dam (Our House, Log Cabin) or reservoir water level (New Bullards Bar Reservoir).

If YCWA proposes an addition to the Project, the study area will be expanded if necessary to include areas potentially affected by the addition.

5.2 General Concepts and Procedures

The following general concepts and practices apply to the study:

- Personal safety is the most important consideration of each fieldwork team.
- Licensee will make a good faith effort to obtain permission to access private property where needed well in advance of entering the property.
- Field crews may make minor variances to the FERC-approved study in the field to accommodate actual field conditions and unforeseen problems. When minor variances are made, Licensee's field crew will follow the protocols in the FERC-approved study.
- When Licensee becomes aware of major variances to the FERC-approved study, Licensee will issue an e-mail to the Relicensing Contact List describing the variance and reason for the variance. Licensee will contact by phone the Forest Service (if the variance is on National Forest System land), USFWS, SWRCB and CDFG to provide an opportunity for input regarding how to address the variance. Licensee will issue an e-mail to the Relicensing Contact List advising them of the resolution of the variance. Licensee will summarize in the final study report all variances and resolutions
- Licensee's performance of the study does not presume that Licensee agrees to, or is responsible in whole or in part for measures that may be proposed arising from the study.
- Global Positioning System (GPS) data will be collected using either a Map Grade Trimble GPS (sub-meter data collection accuracy under ideal conditions), a Recreation Grade Garmin GPS unit (3 meter data collection accuracy under ideal conditions), or similar units. GPS data will be post-processed and exported from the GPS unit into Geographic Information System (GIS) compatible file format in an appropriate coordinate system using desktop software. The resulting GIS file will then be reviewed by both field staff and Licensee's relicensing GIS analyst. Metadata will be developed for deliverable GIS data sets. Upon request, GIS maps will be provided to agencies in a form, such as ESRI Shapefiles, GeoDatabases, or Coverage with appropriate metadata, that is useful for interactive data

analysis and interpretation. Metadata will be Federal Geographic Data Committee (FGDC) compliant.[5]

- Licensee's field crews will record incidental observations of aquatic and wildlife species observed during the performance of this study. All incidental observations will be reported in the appropriate Licensee report (e.g., incidental observations of special-status fish recorded during fieldwork for the Special-Status Turtles – Western Pond Turtle Study will be reported in Licensee's Stream Fish Populations Study report). The purpose of this effort is not to conduct a focused study (i.e., no effort in addition the specific field tasks identified for the specific study) or to make all field crews experts in identifying all species, but only to opportunistically gather data during the performance of the study.
- Field crews will be trained on and provided with materials (e.g., Quat) for decontaminating their boots, waders, and other equipment between study sites. Major concerns are amphibian chytrid fungus, *Didymosphenia geminate* algae, and invasive invertebrates (e.g., zebra mussel, Dreissena polymorpha). This is of primary importance when moving: 1) between tributaries and mainstem reaches; 2) between basins (e.g., Middle Yuba River, Yuba River, and North Yuba River); and 3) between isolated wetlands or ponds and river or stream environments.

5.3 Study Methods

The study will be performed in six steps: 1) select study sites; 2) field measurements; 3) assess sediment mobility; 4) QA/QC data; 5) analyze data; and 6) prepare report. Each step is described below.

5.3.1 Step 1 - Select Study Sites

YCWA will co-locate study sites to the extent possible with the YCWA's Study 3.9 Instream Flow Above Englebright Reservoir and Study 6.1 Riparian Habitat Above Englebright Reservoir. Instream Flow study sites (transect or transect cluster locations as part of the PHABSIM ["Physical Habitat Simulation"] aspect of the Instream Flow study) are selected within a reach to represent the range of channel and habitat types in the reach (Bovee 1982). The characteristic feature of a PHABSIM study reach is homogeneity of the channel structure and flow regime. The sites chosen for this study will represent those sites most likely to exhibit effects of Project features and operations on channel morphology and habitat features. YCWA will consult with Relicensing Participants on study site selection. Specifically, YCWA will send an e-mail notice to Relicensing Participants as early as possible but no less than 2 weeks in advance regarding an office meeting to select potential study sites. During the meeting, maps, the aerial video (HDR 2009a) and the habitat mapping data (HDR 2009b) will be reviewed and potential sites for study will be selected.

Based on historic and habitat mapping information, in the Middle and North Yuba rivers and in the Yuba River upstream of Englebright Reservoir, channel characteristics are primarily controlled by bedrock and boulders, rather than fluvial processes. In other words, these channels

[5] The Forest Service and CDFG each requested that a copy of the GIS maps be provided to them when the maps are available.

are not usually "self-formed" and boulders and bedrock control lateral and vertical stability. Bedrock channels are generally insensitive to short-term changes in sediment supply or discharge. Only a persistent decrease in discharge and/or an increase in sediment supply sufficient to convert the channel to an alluvial morphology would significantly alter bedrock channels (Montgomery and Buffington 1993). However, there may be localized changes to morphology and substrate distribution that may affect aquatic ecology.

Characteristics of the areas where channel morphology sites will be placed are gradients less than 2 percent, accumulations of gravel and finer material in channel and on margins, and floodplain and/or terrace development. There are bedload deposits upstream of Log Cabin Diversion Dam, Our House Diversion Dam, and New Bullards Bar Reservoir mean high water level in Slate Creek due to base control by these diversions/water levels. To evaluate the extent of the deposits, sites will be established in Oregon Creek, Middle Yuba, and Slate Creek immediately upstream of these controls. Based on habitat mapping information, the study could consider 10 possible study-site locations (Table 5.3-1).

Table 5.3-1. Potential location and character of reaches within which to locate channel morphology study sites.

Stream	Potential Location	Character
Middle Yuba River	Below Oregon Creek in the vicinity of Freemans Crossing	Moderately and unconfined channel, ~1% gradient, alluvial and depositional.
	Above Oregon Creek	Steeper (>1% gradient), confined, more transport-dominated than below Oregon Creek, though some lateral cobble/gravel bar development.
	Below Our House Dam	Steeper (>1% gradient), confined, more transport-dominated bedrock control channel
	Above Our-House Dam, within influence of base level control effected by Our House Diversion[1]	Low gradient (1.7% map gradient), depositional.
Oregon Creek	Vicinity of Celestial Valley	Confined 1.6% gradient, planar bedform, gravel-sized material in channel and on margins.
	Above Log Cabin Dam within influence of base level control affected by Log Cabin Diversion.[1]	Confined ~1.8% map gradient.
North Yuba River	Below New Bullards Bar Dam.	Reach has very little accessibility due to vertical cliffs, and dominance of bedrock and boulders within channel. Large, immobile substrate, lateral and vertical controls by bedrock limit responsiveness to changes in inputs of sediment and to changes in hydrology.
Slate Creek	Within mean high water influence of New Bullards Bar[1]	Confined, 2.4% map gradient.
Yuba River	Above New Colgate Powerhouse	Confined; map gradient of less than 1% but habitat mapping data shows numerous high gradient riffles of up to 11% gradient separated by long, deep mid-channel pools and short low-gradient riffles with substrate dominated by boulders and bedrock.
Yuba River	Below New Colgate Powerhouse	Confined, less than 1%, cobble and boulder-dominated bed with very deep pools immediately below the Powerhouse, but increasing alluvial deposition moving downstream.

[1] Sites will be located to evaluate the effects of base-level control of the Project on bedload deposition; the level of analysis is limited to physical extent of bedload deposition and a "snapshot" of the channel just upstream of the influence that will include some limited measurements.

One study site could potentially be selected in each location and, to the extent possible, each channel morphology study site may be co-located with PHABSIM study sites. If it makes sense to co-locate a channel morphology cross section with a PHABSIM transect, it will be done. Study sites will be selected to mimic as closely as possible the gradient, width, and vegetation reach characteristics within the Project area. YCWA will invite interested and available Relicensing Participants into the field to comment on the channel morphology study sites.

5.3.2 Step 2 – Data Collection

5.3.2.1 Stream Cross Sections

All elevations will be surveyed by standard differential survey techniques using an auto-level or total station instrument (e.g., Harrelson et al. 1994). Headpin and tailpin elevations, water surface elevations (WSE), hydraulic controls, and above-water bed and bank elevations will be referenced to a temporary benchmark serving a single cross section or cross section cluster. Cross-sections will include, at a minimum, the stage at twice the maximum bankfull depth (floodprone elevation). Every break in slope will form a vertical point on the graph, and what the breaks represent will be noted (e.g., top of bank, edge of floodplain, bankfull, extent of right or left bank that is "moveable"). The top of the rock elevation for bedrock within the channel, and the thalweg will be included. The thalweg will be assumed to be the minimum elevation below which the bed cannot erode, unless there are some other characteristics that suggest an alternative maximum scour depth at that cross section, which would then be estimated. Cross sections will be monumented with headpins and tailpins (e.g., rebar, pins in bedrock), benchmarks, and UTM coordinates.

Three-cross sections will be selected at any study site at which to measure the full suite of characteristics studied, except where collaboratively agreed to by Relicensing Participants in the field during site/cross section selection. Some cross sections may be surveyed across areas of possible sediment deposition, and where channel geometry (including bankfull and floodprone characteristics if they occur) is most representative of the reach, and representative of potential effects of the Project to site-specific aquatic habitat within the reach. The cross section sites will be selected in order to provide needed information for sediment transport analysis. YCWA will invite interested and available Relicensing Participants into the field to comment on the channel morphology cross section locations in sites selected during previous consultation (Section 5.3.1). Notice for the field visit will be sent to Relicensing Participants as early as possible, but no less than 2 weeks prior to field site visits.

5.3.2.2 Stage-Discharge Relationship

The stage-discharge relationship can be estimated by entering cross section data into WinXSPRO (Hardy et al. 2005) initially. If PHABSIM sites are co-located at these cross sections in 2012, the stage-discharge relationship developed during modeling can be used.

5.3.2.3 Longitudinal Profile

A longitudinal profile will be done for each geomorphology study reach, measuring at least 20 times the bankfull width, unless there is a major geomorphic change that limits the extent (e.g., waterfall). Cross sections within runs, riffle, and glide-habitat will be selected preferentially. Benchmarks used in the instream flow PHABSIM analysis (often there is one benchmark established for each cross-section) will be "tied together" so that only the lowermost benchmark has an assumed elevation of 100 ft. Water surface, thalweg, floodplain, and bankfull elevations will be measured along the profile, making sure to include breaks in slope and each cross section location as a vertical.

5.3.2.4 Particle Size

Surficial substrate composition will be evaluated by compiling a facies map, which is delineation of the surface bed texture into distinct units by dominant and sub-dominant grain-size classes (Level I, Buffington and Montgomery 1999). Each patch that represents a facies must have a minimum size of 12 ft^2 (~2 m^2) to be considered as part of the facies. Wolman (1954) pebble counts will be done across each cross section and for each textural facies. For the facies pebble counts, 100 pebbles will be measured for each facies but particles may be spread across several patches that represent the textural facies. Particles will be measured using a gravel template, also known as a gravelometer, a square grain-size template, and a particle size distribution by number (not weight) will be created. If particles can not be lifted to pass through the gravelometer, size will be estimated using a ruler.

Armoring within a channel is a reflection of sediment supply and transport capability. The armoring ratio, defined as the ratio of surface to sub-surface particle size, will be quantified at five sites. The sites selected for analysis are: 1) Middle Yuba below Our House Dam, 2) Middle Yuba above Oregon Creek, 3) Middle Yuba below Oregon Creek, 4) Middle Yuba above the North Yuba junction, and 5) Oregon Creek in Celestial Valley. Three samples will be taken from exposed bars with surface particles generally less than 128 mm (e.g., D_{84} less than 128 mm). Surface particles will be removed to the depth of the largest particle that was part of the surface layer yet embedded into the substrate. All the surface particles larger than 16 mm will be passed through a gravel template with 14 square holes of 0.5 phi-unit classes ranging from 2 mm to 180 mm (US SAH-97 Handheld Size Analyzer from Rickly.com). Particles larger than 180 mm will be measured along the b-axis of the particle with a ruler and placed into a size-finer-fraction class that would be "retained" on the next smaller size class. For example, a 280 mm particle would be retained as part of the 256 mm size class. Particles less than 16 mm will be thoroughly mixed and a sub-sample will be placed into a sample bag for off-site sieve analysis. When all the surface particles have been removed, measured and weighed, the sub-surface particles will be excavated to a depth equal to the depth removed for the surface particles, or to 5", whichever is greater. Particles will be separated, weighed and bagged using the method described above for the surface samples. It is anticipated that only one surface and one sub-surface sample among each of the three samples needed per site will be needed for a total of six samples to be sieved per site. Results will be presented as a ratio of median particles size of surface and sub-surface particles. Low values of $D_{50surface}$:$D_{50subsurface}$ (e.g., less than 1.3 means relatively weak armoring) are generally indicative of relatively high mean annual sediment transport rates, whereas high values of $D_{50surface}$: $D_{50subsurface}$ (e.g., greater than 4 means relatively strong armoring) are generally indicative of relatively low mean annual sediment transport rates (Dietrich et al. 1989, Parker 2004).

5.3.2.5 Site Map

A to-scale site map sketch will be done of the surveyed reach and will include major features such as pools, riffles, bedrock outcrops, boulders, bridges, sediment deposits; location of cross sections; and substrate descriptions. Substrate will be separated into groups of like-particles, or facies ("textural mapping"), given a textural type (Level I, Buffington and Montgomery 1999) and mapped. Grain size distribution of these textural patches will be measured with Wolman pebble counts (see Section 5.3.2.4) and area of each facies will be quantified. Depth of the sediment deposits believed to be part of the mobile load will be measured by forcing a metal probe into the sediments, or estimated using resistant boundary elements of the deposits such as bedrock or thalweg depth to estimate the depth. The mobile load grain size will be defined for the purposes of this exercise as particles with D_{84} generally less than 128 mm, which can be refined by facies mapping and if particles can be moved easily by pushing a toe into the sediments (Wilcock et al. 2009).

5.3.2.6 Streambank Erosion Potential

Streambank erosion potential of each cross section for both left and right streambanks will be determined based on a "bank erosion hazard index" method developed by Rosgen (1996), that classifies reaches into categories of relative bank erosion potential (i.e., very low, low, moderate, high, very high, and extreme). Measured criteria include ratio of streambank height to bankfull stage, ratio of riparian vegetation rooting depth to streambank height, degree of root density, bank angle, and degree of bank surface protection.

5.3.2.7 Channel Stability

Channel stability will be rated using the Pfankuch (1975) method as modified by Rosgen (1996). The Pfankuch procedure "was developed to systemize measurements and evaluations of the resistive capacity of mountain stream channels to the detachment of bed and bank materials and to provide information about the capacity of streams to adjust and recover from potential changes in flow and/or increases in sediment production." (Pfankuch 1975). Channel stability will be used to assess the potential for lateral or vertical movement, in addition as input to the riparian condition assessment (Section 5.3.3.8).

5.3.2.8 Input of Bedload from Tributaries

Tributaries naturally add sediment to the Project reaches. The aerial video (HDR 2009) and maps will be used to assess if an alluvial fan exists at the junction of the tributaries, or to assess if there are other indications of bedload build up from the tributaries. If the tributary junctions are easily accessible, a qualitative field review will be made of the junction. Evaluation will include a discussion of the size and type of material delivered, the type of deposit, if any, an estimate of the physical extent of the deposit, the geology of the tributary, any known sediment sources, and an estimate of sediment yield based on regional estimates. A discussion of the availability and fate of bedload from tributaries will be included in the report.

5.3.2.9 Sediment Supply

As part of the California Bay-Delta Authority Upper Yuba River Studies Program, estimates of sediment yield in the Yuba River basin were estimated to be between 160 and 340 tonnes/km^2/year (Snyder et al. 2004) based on an estimated accumulation rate behind Englebright Dam. The average of 250 tonnes/km^2/year will be used to estimate a total sediment yield. Nearby Feather River at the Oroville gage had an estimated pre-dam yield of 132 tonnes/km^2/yr (CDWR 2004), and Minear and Kondolf (2009) estimated a yield of 160 tonnes/km^2/year using the reservoir sedimentation rate of Bullard Bars between 1919 and 1939. So the 250 tonnes/km^2/year is at the high end of yield estimates. Bedload is estimated to be 15% of the total sediment yield, based on a range of 10-20% for the region (e.g., CDWR 2004, Snyder et al. 2004). These numbers will be used to develop a sediment supply estimate at "sediment supply nodes" in the study area: North Yuba above and below New Bullards Bar; Oregon Creek upstream and downstream of Log Cabin Diversion Dam; Middle Yuba upstream and downstream of Our House Dam, below Oregon Creek confluence, at confluence with North Yuba; mainstem Yuba at confluence of North and Middle Yuba and below New Colgate Powerhouse.

The supply estimate can be used to compare pre- and post-dam sediment supply based on the change in drainage area due to dam construction at each study site. For example, at a study site just below Our House Dam, the pre-dam construction drainage area is 144.8 mi^2, while the post-dam-construction drainage area is near zero. This ratio provides a modified dimensionless sediment supply value (S*, Grant et al. 2003) at each site that is the ratio of sediment supply below the dam to supply without the dam:

$$S^* = (\text{Drainage Area}_{\text{post-dam}} * \text{Sed Yield}) \div (\text{Drainage Area}_{\text{pre-dam}} * \text{Sed Yield})$$

As the distance below the dam increases, sediment supply increases and S* will increase.

Coarse sediment will be evaluated at accessible locations at twenty sites on the Middle Yuba and ten sites on Oregon Creek. The volume of coarse sediment will be assessed in the intensive study sites, and coarse sediment assessment locations will be added to Middle Yuba and Oregon Creek until the necessary total of sites/stream have been reached. Volume of channel storage above the thalweg will be measured by estimating the length, width, and height of coarse sediment storage elements for a distance of about 100 m at locations not associated with an intensive study site. Length can be adjusted so that the evaluation begins and ends at a similar feature, e.g., at a riffle crest. Storage elements will be sorted into active, semi-active, inactive, and stable as set out in Curtis et al. (2005b).

5.3.2.10 Extent of Deposition Upstream of Log Cabin Diversion Dam in Oregon Creek, Our House Diversion Dam in the Middle Yuba River, and Normal Mean High Water Elevation of New Bullards Bar Reservoir in Slate Creek

To characterize the upstream extent of impoundment influence, the area from mean high water level of New Bullards Bar Reservoir to the upper extent of influence within Slate Creek, and from Log Cabin Diversion Dam and Our House Diversion Dams to the upper extent of the deposits will be measured. YCWA will also measure a cross section, characterize the substrate with a Wolman pebble count along the cross section, and take photographs just upstream of the influence. While measuring the cross section, the gradient of the channel within site distance of the cross section will also be measured (i.e., no long-profile will be done and only a quick shot will be taken in the vicinity of the cross section).

5.3.2.11 Coordination with Licensee's Riparian Habitat Study Upstream of Englebright Reservoir

The assessment of the riparian zone in the channel morphology study sites will be conducted in close cooperation and collaboration with riparian and hydrology specialists. YCWA believes it will be beneficial to co-locate the channel morphology study sites with the study sites selected for YCWA's Riparian Habitat Upstream of Englebright Reservoir Study. At a minimum, existing data, including Geographic Information System (GIS) data, historical information, reports, maps, and aerial photography relevant to both channel morphology and riparian vegetation will be collected and reviewed where available for the selected sites.

5.3.2.12 Examine Effects of Uncontrolled Spill over Project Dams on Sediment Particle Size and Composition

History and magnitude of spill from Project dams will be summarized. Fate and distribution of sediment eroded from spill channels will be evaluated. At each spill channel, the amount of material removed from each spill channel will be estimated, along with an estimate of particle sizes that may have been contributed to the mainstem of the river. Potential fate of this material will be based on review of channel immediately below the spill channel and any remaining downstream indicators of scour or deposition that can be linked to the spill channel. Aerial photos (current and historical if available), the aerial video, and any anecdotal information will be reviewed to assist in the interpretation of the history and fate of spill channel erosion.

5.3.2.13 Examine Effects of New Colgate Powerhouse Tailrace on Channel Morphology and Sediment Distribution

The New Colgate Powerhouse discharges water into the Yuba River. The vicinity of the powerhouse release will be investigated for signs of erosion at the outflow and downstream on the channel banks. Since the backwater effect from the Englebright Reservoir is within 1.3 miles of the powerhouse, evidence of bank erosion, scour or extensive deposition that can be linked to that resulting from erosion and/or high magnitude discharges as a result of discharges from the tailrace will be investigated within this 1.3 mile area. Erosion, scour and deposition will be evaluated using the release history from New Colgate Powerhouse.

5.3.3 Step 3 - Assess Sediment Mobility

The objectives of this component of the study are to evaluate discharges that mobilize particles composing the channel bed, and to assess how Project operations have affected the frequency of bed- and particle-mobilizing flows.

The ideal location for sediment transport modeling and for the testing of the model are straight sections of the channel with minimal variation in width, slope, bed material, and roughness with nothing in the flow to take up stress acting on the bed (Wilcock et al. 2009). Reaches with obstructions such as boulders, vegetation, or debris jams and highly variable topography or bed material should be avoided.

5.3.3.1 Develop Transport Model

Surveyed cross-sections, longitudinal profiles, and particle size distributions will be used as input to develop a calibrated hydraulic model for each reach. Annual sediment mobility can be estimated using the BAGS model (Bedload Assessment in Gravel-Bedded Streams; Wilcock et al. 2009; Pitlick et al. 2009). To compare bedload transport rates under regulated to unimpaired conditions, the bedload rating curve provided as output from BAGS (Figure 1 is an example developed for mixed-sized sediment on the Middle Yuba by Curtis et al. [2005a]) will be combined with annual exceedance discharges (i.e., the percentage of time the mean daily flow exceeds the mobilization threshold) to provide annual bedload transport capacity under regulated and unimpaired conditions (Sections 5.3.3.3 and 5.3.3.4). Mannings "n" will be estimated using photos and cross sections as in Barnes (1967); channel slope as measured along 20 channel widths will be used as input to the model for slope.

5.3.3.2 Estimate Substrate Mobility

Particle size analysis, developed by pebble counts, will be used to develop a particle size distribution for up to three cross sections in each study site. The relationship of forces driving and resisting particle movement at the moment of entrainment is a dimensionless parameter expressed as the Shield's number. The critical Shield's number may vary from 0.02 to 0.086 with a common average value for gravel of about 0.046 (Miller et al. 1977; Buffington and Montgomery 1997, Mueller et al. 2005). The critical Shields number (τ_{*c}) for the particle of interest (d_s) will be estimated using the formula (Guo 2002):

$$d_* = [(G-1)g/\upsilon^2]^{(1/3)} * d_s \quad \text{and} \quad \tau_{*c} = 0.23/ d_* + 0.054[1-\exp\{-(d_*)^{0.85}/23\}]$$

where d_* = dimensionless sediment diameter, G = specific gravity of sediment, g = gravity, and υ = kinematic viscosity of water.

Due to inaccuracies found using the above equation for d_* less than 1, the following equation will be used for small values of d_*:

$\tau_{*c} = 0.5*\tan Ø$ for d_* less than 0.3
$\tau_{*c} = 0.25* d_*^{-0.6} * \tan Ø$ for d_* between 0.3 and 1
where Ø is assumed to be 30º for particles within this range

The particles of interest (d_s) will include gravel and cobble sizes: 2, 4, 8, 16, 32, 64, and 128 mm (Wentworth Scale, p. 20 Vanoni [ed.] 1975), and the D_{16} (fine particles, or the particle diameter where 16 percent of the particles are finer), D_{50} (median-size particles), and D_{84} (coarse particles, or the particle diameter where 84 percent of the particles are finer) for each cross section. Critical shear stress is defined as $\tau_c = \tau_{*c} (\gamma_s - \gamma)\, d_s$, where τ_{*c} = Shield's parameter (as calculated above), γ = specific weight of the fluid, γ_s = specific weight of the sediment, and d_x = particle diameter of interest. Channel shear stress must be exceeded by critical shear stress for movement to occur. Channel shear stress for each cross section will be estimated using the depth/slope product: ρgRS, where ρ = density of water, g = gravity, R = hydraulic radius at a given discharge, and S = reach-average bed slope. This analysis assumes that the bed is composed entirely of the particles for which critical shear is evaluated and does not accommodate mixed-grain sizes but may be useful as an indicator as to when bedload discharge becomes "meaningful". For example, if it is assumed that the cross section is composed of 128 mm particles and the analysis indicates that the critical shear stress exceeds channel shear at 2,000 cfs for that particle at a particular cross section, the 2,000 cfs can be used as a hypothesis for the beginning of "meaningful" bedload transport capacity as calculated in BAGS above. Tracer particle movement during the first freshet following placement can confirm or negate this hypothesis (Section 5.3.3.5 below).

5.3.3.3 Estimate Changes in Bedload Transport under Regulated and Unimpaired Conditions

Annual flow exceedance values and recurrence intervals will be presented using the best available flow data under regulated and unimpaired conditions (e.g., modeled regulated or unimpaired daily annual maximum values). Annual exceedance flows are the percentage of time certain flows are met or exceeded (i.e., 25 percent exceedance represents a "high" flow as this is the flow that is met or exceeded only 25 percent of the time, and 50 percent exceedance represents the median flow). Usually, exceedance values are based on instantaneous peak flow events (generally one per year for the period of record). However, none of the sites have gage data so data must be synthesized and annual maximum daily flow data are all that are available ("best available data") so exceedance values are somewhat underestimated. Total annual sediment transport capacity will be estimated using the percentage of time a critical discharge is exceeded under regulated conditions and compared against the amount of time the critical discharge is exceeded under unimpaired conditions using mean daily flow. Additionally, flow recurrence intervals (which are the inverse of the flow exceedance) will be calculated using the PeakFQ statistical program developed by the USGS based on Bulletin 17B (USGS 1982). Results of the hydrologic models and PeakFQ analysis will be provided as tables that show recurrence interval (year) and the Bulletin 17B discharge estimate (cfs).

5.3.3.4 Dimensionless Transport Ratio (T*)

The dimensionless transport ratio (T*) is the ratio of the critical flows under regulated conditions (T_{reg}) to the critical flows under unimpaired conditions (T_{unimp}) (Grant et al. 2003). Using annual flow exceedance curves as above (Section 5.3.3.3), sediment transport capacity will be assessed under regulated and unimpaired conditions using mean daily flow. T* will be calculated by estimating the total bedload transported annually under regulated conditions divided by total bedload transported under unimpaired conditions.

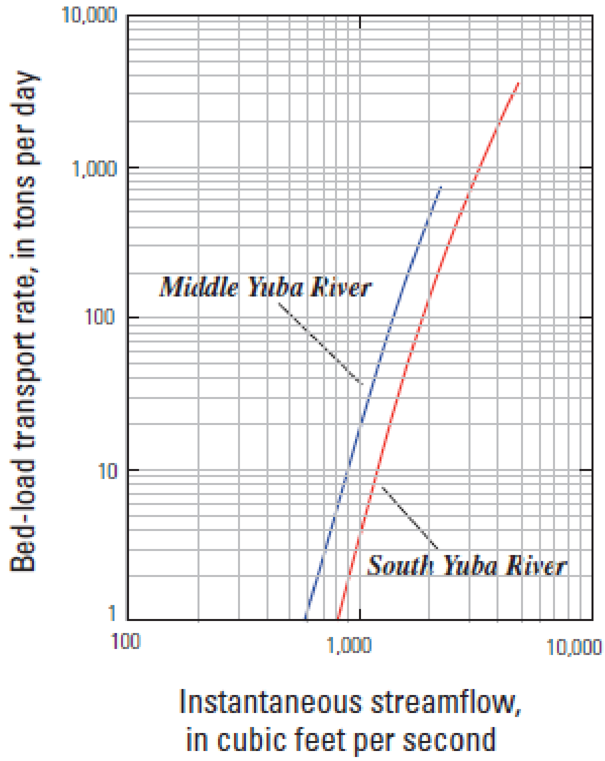

Figure 1. Relation of bed-load transport to instantaneous streamflow for the Middle Yuba River (11410000) and South Yuba River (11417500) gaging stations in the Upper Yuba watershed, California. Bedload rating curves were developed using an empirical transport model for mixed-sized sediment (Wilcock and Crow 2003). Note that the bed-load transport was developed only for the range of flows observed during the study period 2001 to 2003. (Reproduced from Figure 12, Curtis et al. 2005a).

5.3.3.5. Comparison of Coarse Sediment Supply to Transport Capacity[6]

Coarse sediment supply to the streams estimated at the seven intensive geomorphology study-site locations below Project facilities (Table 5.3.1) (in tons/year) under unimpaired conditions,[7] as calculated in Section 5.3.2.9, will be compared to annual sediment transport capacity (in tons/year) as provided as output from BAGS model (Section 5.3.3.1) using hydrology under unimpaired (by Project facilities) conditions. Additionally, coarse sediment availability will be estimated under regulated conditions, and compared to annual sediment transport capacity using hydrology under regulated (by Project) conditions.

For transport capacity, the regulated flow scenario will utilize existing project flow releases for the period of record and any accretion flows to project-affected stream reaches as the baseline

[6] FERC's December 8, 2011 Study Modification directed "*The following section should also be added to study 1.1 as follows: …[Text from FERC letter not repeated here due to the length of the text]*." (p 7). YCWA has added the section as directed by FERC.

[7] Unimpaired coarse sediment supply scenario is one in which sediments currently trapped within Project reservoirs on an annual basis are assumed to pass downstream of Project dams to Project-affected stream reaches.

condition for the analysis. The unimpaired flow scenario will utilize existing inflows to project reservoirs (from the period of record), and assume Project facilities operate in a run-of-river mode, where inflow equals outflow on a near instantaneous basis, and with any accretion flows ot Project-affected stream reaches.

5.3.3.5 Test Sediment Transport Model

In order to test the incipient motion analysis for particles, a tracer particle test will be done at two locations most suitable for transport modeling (i.e., having none of the factors such as large roughness or changes in width that complicate assumptions regarding normal flow), and those that are easily accessible. Likely sites are two cross sections within the potential study site in the vicinity of Celestial Valley on Oregon Creek and two cross sections within the potential study sites on the Middle Yuba below Oregon Creek. Particles that will be tested will encompass the surface D_{50} at the cross section being tested. During the low flow period, tracer rocks will be placed in a line along the cross section by removing a similar-sized particle from the bed, placing a tracer rock of similar size in the same location, and pushing the rock slightly into the bed to emulate natural particle packing and embeddedness. The rocks will be referenced to a vertical position within the cross section. Photographs will be taken along the channel. Following PHABSIM high calibration flows or a threshold of mobility that is established by initial estimates of mobility from the BAGS model and incipient motion analysis, cross sections will be re-surveyed for each rock presence/absence and photographs will be retaken. Tracer rocks will be considered mobilized if they moved at least 3 feet (1 m) (Haschenburger and Wilcock 2003). Interested and available Relicensing Participants will be invited to comment on the appropriate cross sections and sites used for tracer rock analysis during cross section selection in the field.

5.3.4 Step 4 - QA/QC Data

Following data collection, all data will be subject to quality assurance/quality control (QA/QC) procedures including, but not limited to:

- Field data sheets will be checked against entered data to be sure no corrections are needed.
- The hydraulic and sediment transport models will be placed on YCWA's website for external review by Relicensing Participants. YCWA will schedule a conference call with Relicensing Participants within two weeks of posting the models to discuss models.
- Data and report will be reviewed for completeness.
- Datasets will be reviewed graphically to check for errors.

5.3.5 Step 5 – Analyze Data

The goal of the study is to quantify or characterize river form and process and interaction with the riparian zone. Table 5.3-2 presents the relationship between potential channel morphology issues, data to be collected by this study, and data analysis that will occur as part of this study.

Table 5.3-2. Relationship between perceived channel morphology issues, data to be collected by this study, and data analysis that will occur as part of this study.[8]

Issue	Data	Analysis
Project effects on channel morphology and channel condition below Project facilities	• Longitudinal profile • Cross sections • Surface Wolman pebble count • Stage-discharge relationship • Hydrologic information – regulated and unimpaired • Sediment availability changes • Particle mobility changes • Transport rate changes • Age and function of riparian zone	• Longitudinal profile and cross sections will be used in the sediment transport model to estimate bed shear. Critical shear for specific particle sizes data can be calculated and used with the estimate of bed shear to show the discharges where critical shear exceeds bed shear. Wolman pebble counts organized into particle size distribution graphs shows what particles exist on each transect. Flow exceedance tables show the recurrence interval of flows under regulated and unimpaired conditions. Combining all the tools provides an estimate of flows that mobilize particles and the frequency of those flows under different operating conditions. • Stage-discharge relationship provides at what flow various surfaces in the riparian zone are inundated; combined with hydrology data, this provides the frequency of inundation for regulated and unimpaired conditions. • Flow exceedance tables provided by hydrologic information under regulated and unimpaired conditions show the changes in recurrence interval of critical flows and are used in the estimate of bedload transport capacity.
Project effects on channel morphology and channel condition below Project facilities (continued)	• Annual sediment yield • Channel and bank stability • Review of historical aerial photographs • Sketch map • Coarse sediment storage	• Existing annual sediment supply at various locations in project affected stream reaches compared with estimated annual sediment supply at those same locations if the annual sediment loads currently trapped in project reservoirs under existing conditions were able to pass the project dam using basin sediment yield of 250 tonnes/km^2/yr.provides an index of sediment availability changes (modified S* - Grant et al. 2003). • Annual bedload transport capacity estimated using the BAGS model under regulated and unimpaired conditions provides an index of annual sediment transport capacity changes (e.g., T* Grant *et al.* 2003). • Age and function of riparian zone provides a history of disturbance and role of riparian zone in shape and form of channel. • Assessment of channel and bank stability provides how likely the channel is to move from its current form • Historical photos show the relationship between current form and prior form (depending upon the photos available) • Sketch map provides context for assessment, and provides a facies map that provides a template for stratifying other physical and biological measurements. • Coarse sediment storage in Oregon Creek and the Middle Yuba can be compared against regional bedload yield estimates to evaluate coarse sediment balance. • Comparison of annual coarse sediment yield in tons/year to annual bedload transport capacity in tons/year.
Project effects on floodplains	• Cross sections • Stage-discharge relationship • Hydrologic information • Age and function of riparian zone • Historical aerial photographs	• Cross sections provide the location and elevation of bankfull, depositional surfaces, and floodplains. • Stage-discharge relationship provides at what flow various surfaces are inundated; combined with hydrology data, this provides the frequency of inundation for regulated and unimpaired conditions. • Age and function of riparian zone provides the history of floodplain development and role vegetation plays in the history, development and future of the channel. • Historical photos show the history and interaction of the active channel with floodplains, conversion to or from terraces; changes in vegetation; disturbance history.

[8] FERC's December 8, 2011 Study Modification directed "*YCWA should revise and add language to study 1.1 and modify Section 5.3.5, Table 5.3-2, to include an analysis and summary of channel morphology under annual existing and unimpaired coarse sediment supply[8] and transport regimes. This analysis will not require any additional data gathering and can be accomplished by estimating the annual bedload sediment supply as calculated in section 5.3.2.9 and the annual coarse sediment transport capacity as calculated in section 5.3.3.3. Existing annual sediment supply at various locations in project affected stream reaches should be compared with estimated annual sediment supply at those same locations if the annual sediment loads currently trapped in project reservoirs under existing conditions were able to pass the project dams (section 5.3.2.9). The annual sediment transport capacity will be estimated by the BAGS model (section 5.3.3.1 and 5.3.3.2).*" (p 8). YCWA has modified the table and study as directed by FERC.

Table 5.3-2. (continued)

Issue	Data	Analysis
Project effects on bedload distribution	• Textural facies mapping, Wolman pebble counts • Channel armoring • Evaluation of tributary inputs of sediment. • Evaluation of influence of diversions and reservoir level. • Estimates of critical flows. • Estimates of substrate mobility. • Coarse sediment storage	• Textural mapping, quantified by Wolman pebble counts, yields a visual record of channel conditions, and provides an areal weighting of grain sizes. • Ratio of surface to sub-surface particles provides an armoring ratio. Surface layer is commonly coarser than the sub-surface, and the size distribution of the sub-surface gravel is often similar to that of the transported bedload. Low values of $D_{50surface}$:$D_{50subsurface}$ (e.g., less than 1.3 means relatively weak armoring) are generally indicative of relatively high mean annual sediment transport rates, whereas high values of $D_{50surface}$: $D_{50subsurface}$ (e.g., greater than 4 means relatively strong armoring) are generally indicative of relatively low mean annual sediment transport rates. • Discussion of tributary input of sediments and fate within the Project streams. • Discussion of base level control on Slate Creek, Oregon Creek upstream of Log Cabin Diversion, and Middle Yuba upstream of Our House Diversion. • Comparison of critical flows under unimpaired and regulated conditions. • Comparison of annual transport capacity under unimpaired and regulated conditions (T* Grant *et al.* 2003). • Coarse sediment storage in Oregon Creek and the Middle Yuba can be compared against regional bedload yield estimates to evaluate coarse sediment balance in those channels.
Project effects on particle size and composition from dam release outlets, minimum flow, uncontrolled spill	Summary of spill history	Discussion of channel form, sediment size and distribution as it relates to releases from dam outlets and minimum flow release flows, and erosion and/or hydrology due to spill releases from Project dams
Project effects on channel morphology and sediment distribution from releases from New Colgate Powerhouse	• Bank erosion assessment below New Colgate PH • Assessment of scour and deposition below New Colgate PH • Flow release history from New Colgate PH.	Discussion of erosion, scour, and deposition using flow release history for New Colgate Powerhouse.

5.3.6 Step 6 – Prepare Report

At the conclusion of the study, YCWA will prepare a report that includes the following sections: 1) Study Goals and Objectives; 2) Methods; 3) Results; 4) Discussion; and 5) Description of Variances from the FERC-approved study proposal, if any. The report will include the following attachments:

- Scanned field data (*.PDF format) of cross sections, longitudinal profiles, sketch maps, and particle size measurements. Raw data will be made available to Relicensing Participants prior to the publishing of the final study report upon request, if YCWA has completed its QA/QC review of the data.
- For each geomorphic study site, data associated with each of the geomorphic parameters will be shown in a tabular format.
- Maps showing study site and cross section locations.
- Photo-documentation and UTM coordinates of cross sections; UTM coordinates of longitudinal profile downstream and upstream limits.
- Cross sections and longitudinal profiles will be graphically plotted, with bankfull and flood prone widths identified.

- Pebble counts for up to three cross sections per study site will be graphically plotted as cumulative particle size distribution curves.
- The hydraulic/sediment transport model input and output files.
- Table showing the critical shear stress (N/m^2) for gravels (2, 4, 8, 16, 32, 64, 128 mm), and the D_{16}, D_{50}, and D_{84} for each cross section using estimated Shield's parameters.
- Estimated bed shear for each cross section using the depth/slope product calculation.
- Graphs presenting bedload transport capacity (tons/year) versus discharge (cfs) for each cross section (up to three cross sections per study site).
- Table showing T* and modified S* for each study site. Flow exceedance tables under regulated and unimpaired conditions.
- Comparison of annual sediment yield and annual sediment transport capacity in tons/year at the seven intensive geomorphic study site locations below YCWA facilities.
- Summary of riparian condition.

6.0 Study-Specific Consultation

The study includes three study-specific consultations:

- YCWA will consult with Relicensing Participants on study site selection. Specifically, YCWA will send an e-mail notice to Relicensing Participants as early as possible but no less than 2 weeks in advance regarding an office meeting to select potential study sites. During the meeting, maps, the aerial video (HDR 2009a) and the habitat mapping data (HDR 2009b) will be reviewed and potential sites for study will be selected. (Step 1.)
- YCWA will invite interested and available Relicensing Participants into the field to comment on the channel morphology cross section locations in sites selected during previous consultation (Section 5.3.1). Notice for the field visit will be sent to Relicensing Participants as early as possible, but no less than 2 weeks prior to field site visits. (Step 2.)
- The hydraulic and sediment transport models will be placed on YCWA's website for external review by Relicensing Participants. YCWA will schedule a conference call with Relicensing Participants within two weeks of posting the models to discuss models. (Step 4.)

7.0 Schedule

YCWA anticipates the schedule to complete the study as follows assuming FERC issues its Study Determination by September 16, 2011 and the study is not disputed by a mandatory conditioning agency:

Study Site and Cross Section Selection .... October - November 2011
Field Work ....October 2011 - August 2012
Data Entry, QA/QC, & Analysis... January - August 2012
Report Preparation ....July – September 2012

8.0 Consistency of Methodology with Generally Accepted Scientific Practices

Geomorphology studies are common in hydroelectric relicensing projects to determine channel condition, and determine whether flow or sediment measures are necessary and/or whether channel restoration is necessary. The field methods proposed have been used recently in other California relicensing efforts. Determination of bedload transport versus discharge is discussed for BAGS model use (Wilcock et al. 2009).

9.0 Level of Effort and Cost

YCWA estimates the cost to complete this study in 2011 dollars is between $280,000 and $310,000.[9]

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[9] YCWA's Channel Morphology Upstream of Englebright Reservoir Study in its August 2011 Revised Study Plan had an estimate cost range of between $270,000 and $300,000. With the modifications required by FERC in its December 8, 2011 Study Modification, the estimated cost range is between $280,000 and $310,000.

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