Study 1.2

CHANNEL MORPHOLOGY DOWNSTREAM OF ENGLEBRIGHT DAM[1,2]

March 2012

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 downstream of the United States Army Corps of Engineer's (USACE) Englebright Dam.[3]

2.0 Resource Management Goals of Agencies with Jurisdiction Over the Resource to be Studied

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

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 or PAD (YCWA 2010). USFWS's jurisdiction, goals and objectives are not repeated here.

NMFS

[1] YCWA's included a Channel Morphology Downstream of Englebright Dam Study in its August 2011 Revised Study Plan. FERC's September 30, 2011 Study Determination required modifications to the study. YCWA filed a modified Study with FERC on March 8, 2012, and the modified Study was approved by FERC on May 14, 2012 without modification. This Study includes the modifications.

[2] Where this study proposal states that information for the study is being developed by the Lower Yuba River Accord River Management Team (RMT), if the RMT does not develop the information as described in this study proposal, YCWA will develop the information. Also, all information developed as part of the relicensing, whether it is developed in the relicensing process or developed in the RMT process and brought into the relicensing, will be made public when YCWA files its final study report (i.e., study technical memorandum). Further, if this study relies on information from RMT data, report or analytics, YCWA will attach the relevant RMT report to the relicensing final study technical memorandum.

[3] 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's statutory authorities and responsibilities are described by NMFS in Section 2.0 of Enclosure A in NMFS's March 7, 2011 letter to FERC providing NMFS's comments on YCWA's PAD. NMFS's jurisdiction and responsibilities 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

The goal of the study is to quantify or characterize river form and process in the Yuba River downstream of the Englebright Dam, and to assess potential impacts to the river form and process due to continued operation of the Project.

The objectives of the study are to develop additional information and analysis necessary to meet the study goal, then to assimilate study data and existing information. As described in Section 4.0 and detailed in Attachment 1-2A, considerable information regarding the fluvial geomorphology of the Yuba River downstream of Englebright Dam exists. The data collection objectives of this study include development of a quantitative and qualitative understanding of Project effects on geomorphologic elements that have not already been assessed, including: 1) substrate mobility; 2) particle size distribution including specifically salmonid spawning distribution; and 3) LWM role and function in the Yuba River downstream of Englebright Dam. The assimilation of existing and new information will include the analysis described in Section 5.[4]

4.0 Existing Information and Need for Additional Information

The Yuba River downstream of Englebright Dam has an extensive history of impacts to channel morphology resulting from hydraulic mining activities in the Yuba River watershed. From the late 19th Century through to the early part of the 20th Century, vast amounts of hydraulic mining debris and sediment were deposited in the Yuba River from the confluence of the Feather River upstream for more than 20 miles. Sediment depths at the Narrows were more than 75 feet deep,

[4] In its February 16, 2012 letter providing comments on the draft modified Study plan, USFWS requested editing the goals and objectives to better reflect the Study. YCWA has done this.

and more than 15 feet deep near Marysville in the early 20th Century (CDC 1906). While degradation of the river bed commenced in the early 20th Century with the decline in hydraulic mining activity and the construction of various debris dams, several tens of millions of cubic yards of sediment remain in the Yuba River downstream of Englebright Dam (James et al. 2009). Channel processes and changes over the course of the next several decades will largely be a function of the continued degradation of the river bed through layers of mining debris, as the river strives to equilibrate with the base levels associated with geomorphic controls at the Feather River and at Daguerre Point Dam.

Englebright Dam has been completely effective in blocking the downstream movement of sediment. It is estimated that as much as 17,500 acre-feet (over 28 million cu yards) of sediment is impounded behind Englebright Dam (Childs et al. 2003).

The Yuba River downstream of Englebright Dam is one of the more thoroughly studied rivers in the Central Valley of California. A considerable amount of information relating to the impacts of hydraulic mining and the operation of the Yuba River as an element of the state flood control system has been developed. Additionally, extensive information regarding: 1) geomorphic drivers; 2) landforms and boundary conditions; 3) hydrogeomorphic dynamics; 4) physical habitat and ecological dynamics; and 5) river management actions have been developed through time, and a compendium of the existing information specific to the Yuba River downstream of Englebright Dam is included as Attachment 1.2A to this study proposal.

Information is available from both previously conducted studies dating back to the early 1900s through current information from ongoing data collection, monitoring, and evaluation activities, particularly from the Lower Yuba Accord Monitoring and Evaluation (M&E) Program (RMT 2010). A summary list of recent information currently available includes, but is not limited to:

- Topographic and geologic maps, including a digital elevation model (DEM) of the Yuba River downstream of Englebright Dam (RMT 2010)[5]
- Hydrologic modeling and statistics for the Yuba River (YCWA 2007)
- Operations procedures for Project facilities (YCWA 2009a)
- Physical Habitat Simulation (PHABSIM) habitat modeling of the Yuba River conducted by Beak Consultants for CDFG (Beak 1989)
- Two-dimensional (2D) hydrodynamic habitat modeling (River2D) of 18 sites on the Yuba River conducted by the USFWS (Gard 2007; 2008)
- Two-dimensional hydrodynamic modeling (SRH-2D) of the Yuba River by University of California at Davis (UC Davis) for the River Management Team (RMT 2010)
- Low-altitude aerial video of the Yuba River (YCWA 2009b)
- Spatial Structure Analysis Interim Report for the lower Yuba River by UC Davis for the RMT (RMT 2011)

[5] M&E Program documents and work products are located at the RMT's website at www.yubaaccordrmt.com.

Information from ongoing data collection, monitoring, and evaluation activities, particularly from the Yuba Accord M&E Program (RMT 2010) addressing geomophological conditions and physical habitat conditions in the Yuba River downstream of Englebright Dam that will be available for the conduct of this study includes, but is not limited to:

- Yuba River Development Project Water Balance/Operations Model (Study 2.2)
- Substrate and cover classification maps of the Yuba River downstream of Englebright Dam to characterize microhabitat and mesohabitat conditions (RMT 2010).
- Spawning habitat data collection information for the lower Yuba River (RMT 2009, 2010, 2011).
- Morphological unit classification map of the lower Yuba River (RMT 2010).
- Discharge-dependent mesohabitat characterization of morphological units of the Yuba River.
- Historic aerials analysis of the Yuba River downstream of Englebright Dam

YCWA believes that sufficient information generally exists to characterize the geomorphologic conditions for the Yuba River downstream of Englebright Dam without the undertaking of additional field study effort.

5.0 Study Methods and Analysis

5.1 Study Area

For the purpose of this study, the study area includes the Yuba River from Englebright Dam to the Feather River. The reaches for which data will be synthesized and analyzed, for the purposes of this study are the reaches as defined in Wyrick and Pasternak (2011) (Table 5.1-1, Figure 5.1-1), with the exception of the Narrows Reach. The Narrows Reach is excluded in all instances as there is very little data collected in this reach, nor is it feasible to get additional data due to accessibility and safety concerns. The Narrows Reach is characterized by steep bedrock valley walls and a lack of finer sediments in which rapids prevent topographic and bathymetric surveys due to safety and accessibility issues. Therefore, the wetted area width, slope, and thalweg location cannot be accurately determined at this time.[6]

Table 5.1-1. Reaches in the lower Yuba River.

Reach Name	Description	Slope (%)[1]	Start (RM)[1]	End (RM)[1]
Marysville	Junction with Feather River to RM 3.3	0.05	0	3.3
Hallwood	RM 3.3 to slope break near Eddie Drive at RM 8.3	0.13	3.3	8.3
Daguerre Point Dam	RM 8.3 to Daguerre Point Dam	0.18	8.3	11.6
Dry Creek	Daguerre Point Dam to Dry Creek	0.14	11.6	13.9
Parks Bar	Dry Creek to 0.35 mi u/s of Hwy 20	0.19	13.9	18.55
Timbuctoo Bend	Upstream of Hwy 20 to end of emergent gravel bar	0.20	18.55	22.25
Narrows	Emergent gravel to Dry Creek	Not measurable[2]	22.25	23.3

[6] NMFS requested specificity in the reaches that will be in the data analyses in an e-mail dated February 15, 2012.

Table 5.1-1. (continued)

Reach Name	Description	Slope (%)[1]	Start (RM)[1]	End (RM)[1]
Englebright Dam	Confluence with Deer Ck	0.31	23.3	24.3

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

[2] The Narrows reach is very confined with rapids that prevent topographic and bathymetric surveys due to safety and accessibility issues. Slope and thalweg location cannot be accurately determined at this time (Wyrick and Pasternak 2011).

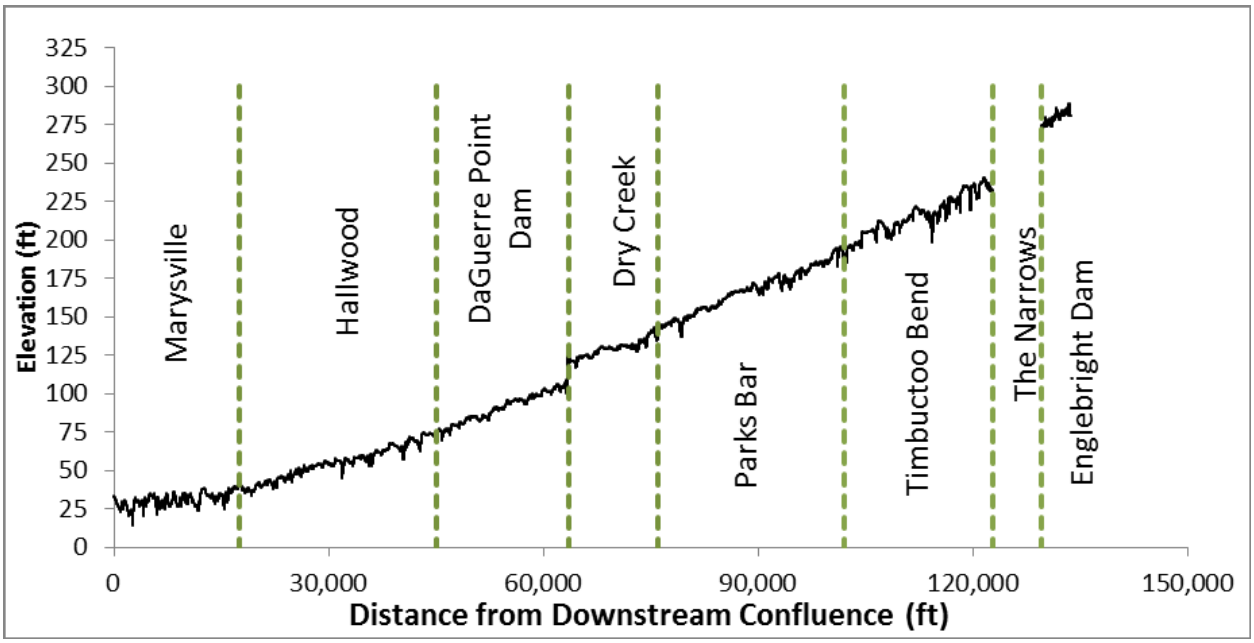

Figure 5.1-1. Reach designations for the Lower Yuba River (reproduced from Figure 4, Wyrick and Pasternak 2011).

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, NMFS, 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 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.[7]
- 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 to 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

This study consists of the following four steps: 1) compile data from previously conducted studies; 2) compile ongoing data collection and information; 3) conduct the analyses necessary to accomplish the previously stated goals and objectives; and 4) prepare report.

5.3.1 Step 1 – Compile Data from Previously Conducted Studies

Information regarding geomorphology in the Yuba River downstream of Englebright Dam will be obtained from previously conducted studies, including the dates and locations of data collection to the extent possible.

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

5.3.2 Step 2 – Compile Ongoing Data Collection and Information

Data collected during the Yuba Accord M&E Program will be compiled for this study plan report. Data compilation and analyses conducted by the RMT for the Yuba Accord M&E Program will be obtained and utilized from the following ongoing monitoring and evaluation activities associated with the M&E Program Protocols:

- Flow and Water Temperature Monitoring
- Topographic Mapping (Digital Elevation Model) – physical habitat assessment
- Substrate and Cover Mapping – spawning/juvenile rearing habitat characterization
- 2D Hydrodynamic Modeling – physical habitat dynamics and availability
- Morphological unit Classification – meso-scale physical habitat characterization
- Riparian Vegetation Mapping
- Large Woody Material (LWM) frequency and function[8]

5.3.3 Step 3 – Analyze Data

The goal of the study is to quantify or characterize the lower Yuba River form and processes and key contributing factors. The following analyses will be conducted to evaluate the relationship between potential channel morphology issues, data to be compiled by this study, and data analysis that will occur as part of this study.

- Utilize Morphological Unit and Reach Breaks Descriptions
  - A comprehensive analysis of reach breaks and morphological units for the Yuba River downstream of Englebright Dam is has been completed by the RMT. The procedure used in the morphologic analysis involved four phases: 1) topographic mapping; 2) 2D hydrodynamic modeling; 3) classification of hydraulic and topographic patterns; and 4) analysis of resulting landform types at the segment, reach, and morphologic unit scale. At the segment scale, metrics were calculated within the 2D-model derived wetted boundaries of the three representative flows, when simulated in the absence of vegetation. At the reach scale, eight distinct reaches were delineated and characterized for the lower Yuba River. The key geomorphic indicators of reach breaks were presence of tributary confluences, presence of dams, valley width, riverbed slope breaks, and substrate. Flow-dependent statistics were also calculated at the reach scale on channel widths and wetted areas.

- Sediment Transport Analysis Using Shields-Stress Metric
  - In this approach, the 2D model is being used to simulated hydrodynamics over a wide range of geomorphically relevant discharges. Given that the geometric channel

[8] FERC's September 30, 2011, Study Plan Determination directed *"…YCWA modify study 1.2 to include provisions for describing how LWD functions as a geomorphic control and forcing mechanism in the lower Yuba River. We note that with our recommendations, the proposed study 6.2 would provide information regarding LWD frequency in the lower Yuba River"* (Appendix A, p.4). YCWA has added language as directed by FERC.

overflows for discharges ranging from about 3,000 to 7,000 cfs, a mid-value of 5,000 cfs is used to represent the near-bankful condition. Relative to that benchmark, flows will be run from 700 to 5,000 cfs for within bankful processes. Also, overbank flows will be run for 7,500, 10,000, 15,000, 21,100, 42,200, 84,400, and 110,400 cfs, which is the maximum observed with the current map and model in hand (from the New Year's 2006 floods). Because the largest floods spill into the Goldfields and the lowermost floodplain region, which is far outside the domain of interest for this study proposal, some reaches may not be feasible to assess with the 2D model at the highest discharges. Once models are run, the sediment transport analysis involves the following steps:

- ✓ The 2D model automatically calculates bed shear stress at each node using a drag-force equation that is a function of depth, velocity, and model parameters.
- ✓ Define a representative spawning bed-material size for a heterogeneous gravel/small cobble mixture and calculate the non-dimensional Shields stress (τ^*).
- ✓ Calculate a spatially distributed, weighted average, mean substrate grain size for each 3 foot by 3 foot cell in the 2D model domain based on the visually estimated grain size distributions from the RMT's 2010 substrate map[9]. Calculate a spatially distributed τ^* using these actual grain size data.
- ✓ Shields stress values are binned where values of τ^* less than 0.01 correspond to negligible transport, 0.01 less than τ^* less than 0.03 correspond to intermittent entrainment, 0.03 less than τ^* les than 0.06 corresponds to partial transport, and τ^* greater than 0.06 corresponds to full transport of a carpet of sediment 1-2 D_{90} thick, where D_{90} is the size that 90 percent of the surficial bed material is smaller than.
- ✓ Use the available hydraulic regime to estimate the local critical particle size at the incipient-motion threshold for a given reach, wherein a Shields stress of 0.045 is utilized to identify the initiation of motion for particles size(s) of interest.
- ✓ For each variable that is predicted using a 2D model or is derived from model predictions, results from all model domains are combined into a single raster mosaic of the whole river (excluding Narrows). The raster mosaic for each variable is analyzed statistically as a whole, which is termed segment-scale analysis. Next, digital reach maps are used to extract the statistical results for each variable by reach. After that, digital maps of the river's morphological units are used to extract the statistical results for each variable by morphological unit. This procedure is repeated for each discharge. Consequently, model predictions are all analyzed in identical fashion spanning segment, reach, and morphological-unit scales for the entire river, except for the Narrows Reach.[10]

- Geomorphic Process Flows
  - ➢ Calculate return interval and duration analysis of flows that achieve full bed mobility for greater than 50 percent of the area of each of the following morphological units (except

[9] FERC's September 30, 2011, Study Plan Determination directed that *"…YCWA include an analysis of bed mobility/sediment transport analysis using the actual grain size distribution of the existing bed surface substrate maps as requested by NMFS in its Request # 4, Element # 4: Calculation of Bed Mobility and Sediment Transport Capacity."* (Appendix A, p. 8). YCWA made the modifications as directed by FERC.

[10] In its February 15, 2012 e-mail that provided comments on the draft modified Study plan, NMFS expressed concern about the Englebright Reach 2D analysis. YCWA has added this sentence to clarify the analysis.

for those determined to not meet this threshold within the range of floods simulated): pools, riffles, lateral bars, and point bars.

- Calculate return interval and duration analysis of flows that achieve full bed mobility for greater than 50 percent of the area of each reach

- Sediment Export Analysis
  - Develop DEMs and uncertainty-adjusted DoD's ("DEM of Difference") for all reaches in the study area for the 1999 to 2009 period, which is the period when suitably accurate elevation data is available for the river. Based on a thorough uncertainty assessment, the best uncertainty adjustment involves subtracting all deviations less than the half-contour interval of the 1999 count-based DEM (i.e., 1 ft cut-off) and subtracting all deviations below a "level of detection" at the 95 percent confidence interval.
  - Calculate total deposition, total scour, and net change, which must be scour, given that there is no significant source of sediment below Englebright Dam for each reach and morphological unit in the study area.
  - Use a mass balance equation to track downstream changes in sediment volume using the DoDs.
  - Calculate the annual rate of change in sediment export by dividing the 10-year volumetric total by 10, which assumes equal export for each year.[11]

- Channel Morphology Adjustments[12]
  - Analyze the entire DoD raster to evaluate how topographic change varies between (a) in-channel versus out-of-channel, (b) in vegetated versus non-vegetated pixels, (c) above versus below DPD, and (b) different morphological units.
  - Assess which morphological units (as identified in the 2009 map) are experiencing the most cut and most fill using the DoDs.
  - Using the available DEM difference analysis from 1999 to 2009 (with the exception of the Englebright Dam Reach where the 1999 map was not available, and excepting the Narrows Reach as stated previously)[7], the gross cut and fill volumes for each reach beginning at the top of Timbuctoo Bend where the alluvial valley begins will be used to produce a flow chart of the export and storage of sediment by reach down to the confluence with the Feather River (6 reaches in all).

- Characterization Of Substrate Distribution (Can be analyzed using existing substrate maps and spawning substrate measurement to assess):
  - Relative substrate distribution by reach

[11] FERC's September 30, 2011, Study Plan Determination directed that *"YCWA modify its study plan in accordance with study NMFS-4 Element #6, as outlined above…"* (Appendix A, p. 6). NMFS requested that *"…YCWA calculate the annual rate of change in sediment export.*" (Appendix A, p. 5). YCWA has made the modification as directed by FERC.

[12] FERC's September 30, 2011, Study Plan Determination directed that *"YCWA modify its study plan in accordance with study NMFS-4 Element #6, as outlined above…"* (Appendix A, p. 6). NMFS requested that *"…YCWA compare export amounts and morphologic unit adjustments to estimates of sediment volumes stored in the lower Yuba River and each geomorphic reach.*." (Appendix A, p. 5). YCWA has made the modifications as directed by FERC.

- Relative substrate distribution by morphologic unit.
- Substrate size distribution for spawning

- Characterization of LWM Presence and Distribution:
  - YCWA's Riparian Habitat Downstream of Englebright Dam Study (Study 6.2) will collect on-the-ground counts of LWM in the lower Yuba River. YCWA will use that information to: 1) provide a 'snapshot' inventory of LWM pieces; 2) using simple longitudinal distribution analysis, assess whether the longitudinal distribution of LWM is random or organized; 3) stratify LWM by reach and morphological unit to assess what landforms it tends to be associated with; 4) intersect LWM polygons with wetted area polygons up to 5,000 cfs to determine what flows access available LWM; and 5) using the above information, discuss geomorphic function and forcing mechanism of LWM in the lower Yuba River.

5.3.4 Step 4 – 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:

- Map of Yuba River downstream of Englebright Dam (*.PDF format) including topography, substrate, riparian vegetation, LWM, and other river features
- Floodplain inundation map, showing inundation area at 1:1, 1:2, 1:5, 1:10 and 1:20 return interval flood flows
- Summary of riparian condition.
- Summary of LWD quantity and function.
- 2D model output in GIS 3x3' raster of the spatial pattern of shear stress.[13]
- Input variables of grain size and Shields parameter used in each raster used to create the sediment transport regime for each reach.
- Analysis and summary of sediment mobility (based on Shield's stress approach).[14]
- Summary of particles size distribution by reach (excluding Narrows for which data have not and cannot be collected), including substrate size distributions specific for salmonid spawning.[15]

[13] FERC's September 30, 2011, Study Plan Determination directed that *"YCWA modify its study plan in accordance with study NMFS-4 Element #6, as outlined above…"* (Appendix A, p. 6). NMFS requested that *"…YCWA provide GIS and tabular formats when providing hydraulic/sediment transport input and output files.*" (Appendix A, p.5). YCWA has made the modification as directed by FERC.

[14] In its February 14, 2012 e-mail that provided comments on th edrfat modified Study plan, CDFG requested these bullets be added. IN its February 15, 2012 e-mail, NMFS supported CDFG's comment.

- Executable folders, data file with details of each model run, and control file with miscellaneous parameters.
- Stage/discharge tables.

6.0 Study-Specific Consultation

This study does not require any study-specific consultation.

7.0 Schedule

FERC's December 8, 2011 letter required that YCWA provide a modified study to FERC for approval no later than March 8, 2012. The schedule provided below assumes FERC will approve the modified study no later than mid March 2012.

Compile Data from Previous Studies (Step 1)..... March - May 2012
Compile Data from Ongoing Studies (Step 2)..... May - July 2012
Analysis (Step 3)..... July - August 2012
Prepare Report (Step 4)..... August - September 2012

8.0 Consistency of Methodology with Generally Accepted Scientific Practices

The methods presented in this study plan are consistent with other generally accepted scientific study methods concerning geomorphological function assessment, including those conducted by the Resource Agencies in California.

9.0 Level of Effort and Cost

YCWA estimates the cost to complete this study in 2011 dollars is between $110,000 and $150,000.[15]

10.0 Attachments

This study plan includes four attachments:

Attachment 1-2A Channel Morphology Downstream of Englebright Dam – Existing Information Summary

Attachment 1-2B Documentation of Transmittal of Draft Study Plan to USFWS, NMFS, CDFG and SWRCB for 30-Day Review and Comment

[15] YCWA's Channel Morphology Dowsntream of Englebright Dam Study in its August 2011 Revised Study Plan had an estimate cost range of between $90,000 and $120,000. With the modifications required by FERC in its September 30, 2011 Study Determination, the estimated cost range is between $110,000 and $150,000.

Attachment 1-2C Written Comments from USFWS, NMFS and CDFG

Attachment 1-2D YCWA's Reply to Written Comments

11.0 References Cited

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ATTACHMENT 1-2A
TO
CHANNEL MORPHOLOGY DOWNSTREAM OF ENGLEBRIGHT DAM STUDY PROPOSAL

EXISTING INFORMATION SUMMARY

(red painted tracers for sediment transport study in the lower Yuba River)

Dr. Gregory B. Pasternack
September 2010

Introduction

Geomorphology is the study of the landforms on the surface of the earth. Geomorphic analysis involves mapping the shape of landforms to describe their spatial patterns, observing landforms over time to record their changes, exploring the drivers and mechanisms of landform change, and evaluating the responses of biological, chemical, and hydrological processes to geomorphic change. Beyond understanding natural conditions and dynamics, geomorphology is essential in planning societal use of the landscape and in figuring out the impacts of societal activity on the environment and through it the externalities that come back and harm society and economics.

Traditionally it is has been thought that rivers possess the capability of adjusting their attributes to accommodate flow and sediment transport regimes so that sediment in- and out-fluxes are balanced and landform conditions are "stable". However, in reality geomorphic drivers and boundary conditions are much more independently dynamic and fast changing than classically envisioned, such that landforms may always be in a state of adjustment in response to external drivers and internal free oscillations that is normal and appropriate. Rather than thinking of landforms as "stable", it is more appropriate to think of them and the ecosystem functions they are associated with as resilient in the face of change. Knowledge of historic, pre-human baseline conditions or regional reference conditions is limited and may not be as useful in understanding natural geomorphic and ecosystem services as once envisioned. In light of this natural complexity, a geomorphic assessment of conditions after a large dam or other facility is built and operated may not be as simple as documenting geomorphic instability and attributing that to human impacts relative to the presumed stable baseline conditions.

Rather than compare human-impacted conditions to theoretical baseline or reference conditions, a more effective approach is to deduce the geomorphic processes in a system under different regimes and evaluate the implications for resiliency of ecosystem services. Through a mechanistic understanding of environmental systems, it may be possible to rationally rehabilitate an ecosystem to achieve resiliency in cases where it has been lost or is desirable to instill, even if it was not historically present.

The goal of this report is to thoroughly document the studies that have been done that provide insight about the fluvial geomorphology of the lower Yuba River (LYR) and its relation to the resiliency of ecosystem services. A description of the geomorphology of the river requires consideration of A) geomorphic drivers, B) landforms and boundary conditions, C) hydrogeomorphic dynamics, D) physical habitat and ecological dynamics, and E) river management actions. As the report details, a lot of research has been performed already and more is being done presently as a result of the Yuba Accord. Rather than describe the existing information chronologically or by considering each study completely one at a time, the approach taken is to focus on each essential geomorphic topic and draw from across all relevant knowledge sources to address each issue. Sources referenced in the body of the report are listed with full citations at the end of this report. Throughout the report, an effort is made to assess the adequacy of existing information and identify data gaps that limit the ability to assess dam impacts on fluvial geomorphology.

A. Geomorphic Drivers

The chain of geomorphic processes in a river corridor begins with driving forces that cause landforms to change. Slow geologic forces such as tectonics and sedimentary subsidence establish the context of a river basin and explain its long-term landform evolution as a result of erosion and deposition over thousands to millions of years. Faunt (2009) investigated both natural and anthropogenically induced subsidence in the Central Valley and did not report any concerns for the LYR region.

Glacial processes are nonexistent in the LYR. Similarly, freeze-and-thaw erosion of riverbanks is not an important process in the LYR, because air temperature rarely dips below the freezing point. Given a lack of sand- and mud- sized sediments, wind processes are likely to be geomorphically unimportant. Kinetic erosion by rainsplash and chemical weathering do play a role in the breakdown of hillside bedrock and soils, but do not influence the coarse-grained floodplain and channel.

A1. Surficial Inflow of Water and Associated Materials

The most significant driving force for geomorphic change in the LYR corridor is flowing water. Water is a powerful force for landform change in and of itself, but it also carries with it sediment that is even more powerful in its geomorphic impacts. Diverse chemical and biological materials also move with the flow. Hydrological analysis of the LYR flow regime is critical to understanding the river's behavior and conditions, and thus has been performed by many investigators.

Traditional U.S. Geological Survey (USGS) gaging stations are used to record water levels and estimate flow rate; records are publically available on the internet at no cost. Gaging stations operated by local and state organizations are also present, but data is more difficult to obtain. Additional water level recorders have been placed into the LYR on a temporary basis in support of several individual projects.

The LYR is gaged at two locations and three of its tributaries are gaged. The gages are

> The Yuba River USGS gaging station #11418000 is near Smartville, CA. This gage is located in the EDR. Its stage-discharge relation is dynamic due to its location upstream from an alluvial cross-channel bar, requiring regular re-calibration. The record is from 10/1/1941 to present.
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> The Yuba River USGS gaging station #11421000 is near Marysville, CA. This gage is located downstream of Daguerre Point Dam and agricultural water diversions, so its values are often lower than those recorded at the Smartville gage. Also, it is located relatively far upstream of the confluence with the Feather River, because flow fluctuations in the Feather River cause significant water level variations in the lowermost LYR, precluding the ability to create an independent stage-discharge relation for the LYR near its mouth. The record is from 10/1/1943 to present.

The Deer Creek USGS gaging station #11418500 is at the Mooney Flat Road bridge over Deer Creek near Smartville, CA. It is located in a bedrock channel. The record is from 10/1/1935 to present.

The Shubert subcatchment at the University of California Sierra Foothills Research and Extension Center flows into the LYR in the Narrows and has been gaged for over 60 years. It has a small amount of flow, but its long record has been used to study the influence of different land management practices on runoff generation and water quality, particularly with respect to cattle grazing.

Dry Creek is gaged at Collins Lake, but the data is not publically available on the internet. Typical controlled releases are ~2 cfs. Uncontrolled winter floods occur and appear to transport sediment and alter Dry Creek's morphology, but the fluvial geomorphology has not been documented as of yet.

No other minor tributaries (e.g., Big Ravine and Blue Point mine) have gages.

Overall, the LYR is well gaged, providing the baseline data necessary to evaluate hydrological drivers of geomorphic processes. A basic hydrological analysis including monthly flow distribution was performed by DWR and USACE (2003).

A1a. Yuba River Development Project

YCWA (2009) presented the hydrology of the Yuba River watershed. They reported on measured tributary inflows, estimated ungaged flow accretions, and accumulated flows.

A1b. Flow Release Schedules

Flow release schedules are presently established by the Yuba Accord and are available on the River Management Team (RMT) web site (www.yubaaccordrmt.com).

A1c. Flood Analyses

DWR and USACE (2003) report the largest floods at the gages affecting the LYR.

Moir and Pasternack (2008) and Pasternack (2008) performed flood frequency analysis for the pre-Englebright (before 1942), Englebright-to-New Bullards Bar (NBB) (1942-1971), and NBB-to-present (1971-2004) time series using the Smartville gaging station data. They found the present-day statistical bankful discharge to be 5,620 cfs and that for pre-NBB to be 11,600 cfs. The 2-, 5-, 10-, and 50-yr return interval discharges for 1971–2004 were 10,600, 37,000, 51,200, and 142,000 cfs, respectively.

MEI (2008) performed flood frequency analysis using the Marysville gaging station data (actual span of years used were not reported, but might have included all years irrespective of dam regimes). The 2-, 5-, and 10-year recurrence interval peak flows were found to be 17,100, 48,000 and 80,500 cfs, respectively.

Pasternack (2008) performed an analysis of flood types using the Flood Regime Characterization computer code for MATLAB 7 written by Eric Booth (UC Davis Hydrologic Sciences M.S. student) in 2006. This code analyzes the magnitude and duration of flood events from a daily discharge time series to create classes of flood types. This classification process is facilitated by expert-based input of significant hydrologic and geomorphic thresholds. Once flood types are created, then water year types are created by clustering similar water years together based on the number of days each flood type occurs during each water year. The frequency of each water year type throughout the record is also calculated.

MBK (2006) provided a list of reports about flooding and drainage issues in Yuba County. It also summarized the findings about flood control infrastructure. They state that a serious threat exists along the LYR due to the ever-present possibility of levee failure and that the dams in the system can only provide protection for floods up to the ~70-year event.

NBB and Englebright Dams regulate flows into the LYR, but they do not hinder large floods, because the South and Middle Yuba Rivers have no large dams to abate winter floods driven by large raintorms or rain-on-snow events. For example, the present LYR flow regime includes channel-changing floods that occur every ~9 years (e.g. 1986, 1997, and 2005/2006). For example, in 1997 there was a flood that produced a peak mean daily discharge of ~154,000 cfs. On New Years Eve at the end of 2005, there was a flood with a peak mean daily discharge of ~95,600 cfs. On top of each of these flows over Englebright Dam, one also has to factor in the significant contributions of Deer Creek and Dry Creek, which help to sustain the duration of the peak flood. For example, the combined hourly peak discharge for the 2005/2006 New Years Flood at the highway 20 bridge was ~109,000 cfs. Large floods that occur on the LYR pose a hazard to Marysville and Yuba City, because levees protecting those cities have historically been prone to failure.

A1d. Indicators of Hydrologic Alteration (IHA)

Indicators of Hydrologic Alteration (IHA) is a widely used method to measure the variation of the flow with respect to the natural flow regime or pre-impact hydrograph. IHA defines 32 hydrologic parameters among the five components of the flow regime for the evaluation of changes between natural and manufactured flows. The Range of Variability Approach (RVA) provides flow targets based on the statistics of the natural flow regime (Richter et al., 1997). An IHA analysis was performed by Dr. Marisa Escobar at UC Davis to compare the flow regime pre- and post NBB (NBB), and some of the results were documented in Escobar and Pasternack (2010), but no comprehensive IHA report was written. Pasternack (2008) also presents some metrics of hydrologic changes before and after Englebright Dam.

IHA analysis of LYR median monthly flows showed a decline in spring-snowmelt flows after NBB was built. During the pre-Englebright era, median monthly discharge peaked during the snowmelt season in April at ~6300-6700 cfs. After Englebright was built that dropped to about 4,600 cfs. After NBB was built it dropped down to a peak of ~2500 cfs. Similarly, for the month of May, monthly flows decreased on average from ~5,200 cfs before to 2,000 cfs after NBB.

Therefore, like other regulated rivers, the LYR has a degraded monthly flow distribution in which there are the lowest flows during the late summer to early fall and then highest flows during the winter, but the lowest of the low flows are not as low as they used be and the flood peaks are curtailed.

A1e. Climate Change Effects on Unimpaired Flow

There is a very high level of uncertainty about what climate conditions will be like for the northern Sierras in 2050 and beyond. Several studies have been done in which the future climate has been assumed to be one in which conditions are identical to the current climatic regime, except that the mean air temperature is shifted up 1-8 °C. Using that approach, the expected outcome is dramatically less snow water equivalence and snow cover, resulting in an inadequate water supply for California.

The UC Davis Hydrology Program conducted a climate-change analysis of flows in the North Yuba above NBB, whose flow is unregulated. The study included analysis of past effects and projections of future impacts. Mean daily discharge from 1938-2009 was checked for three indicators of climate change effects: calendar day of peak snowmelt discharge, fraction of annual runoff April through July, and the center of mass of snowmelt runoff. All of these metrics showed no statistically significant impacts of climate change on the North Yuba system as of yet. However, a coupled model of regional climate change at 4-km resolution (WRF dynamical downscaling) and distributed hydrodynamic modeling (RHESSys) of the North Yuba catchment predicts a significant increase in snow storage and increase in water supply for 2048-2053. This was contrary to previous studies that assume no change in precipitation and significant warming. In fact, the best projections now suggest that the Yuba catchment will have a significant increase in precipitation, snow, and water supply in 2050.

A1f. Geomorphic Significance of Specific Flow Ranges

Based on multiple lines of observational evidence and hydrological flood frequency data analysis, Pasternack (2008) reported the following flow thresholds for geomorphic processes in Timbuctoo Bend:

- A preferential riffle-scouring discharge range of flow <11,000 cfs
- A modern bankfull discharge of ~5,600 cfs,
- A 1942-1971 bankfull discharge of ~11,600 cfs,
- A preferential run-scouring discharge range of ~9,000-25,000 cfs,
- A floodplain-filling discharge of ~20,000 cfs,
- A preferential pool-scouring discharge range of >45,000 cfs.

The above thresholds may not apply to the rest of the lower Yuba River. The existence of such thresholds in other LYR reaches in presently under investigation.

A2. Groundwater and Hyporheic Flows

California DWR has long-term groundwater monitoring wells throughout the region spanning 1947-present. DWR and USACE (2003) shows that two sites are right along the river just downstream of the Yuba Goldfields, but none are in the river corridor upstream of that. According to that report, groundwater pumping for agriculture has varied over the decades and is now lower than in the past due to surface water deliveries. Also, more water appears at Marysville than is present in the river as it passed over Daguerre Point Dam, indicative of extra inflows from groundwater recharge or from Yuba Goldfields surface outflows.

The Yuba Goldfields are an ~10,000 acre, highly disturbed assemblage of landforms in the LYR corridor that resulted from historic industrial gold mining. The industrial operations involved reprocessing gold out of hydraulic mining debris that deposited on the valley floor. The landforms consist of towering lines of coarse sediment with intervening deep lines of ponds. The LYR and the Yuba Goldfields are hydrologically connected by groundwater and hyporheic fluxes as well as by direct surface water connection during floods. River water has been observed to flow into the Yuba Goldfields during high flows and flow out during low flows. YCWA (2009) estimated that there is 500 TAF of storage of flood waters in the Yuba Goldfields.

USACE (2002) performed MODFLOW groundwater simulations that predict hydraulic head throughout the Marysville region.

YCWA (2007) included groundwater impact analysis, primarily related to diversion flow and agricultural recharge in the vicinity of the LYR.

Three Rivers (2009) performed an assessment of groundwater in the area south of the LYR in support of levee strengthening work.

Faunt (2009) reported on groundwater status and usage for the entire Central Valley, including information about the region containing the Yuba River.

No hyporheic flow studies have been performed on the LYR, but there is ample visual evidence of water flowing through the substrate in large quantities. For example, at the upstream end of all surficially disconnected backwaters there is a visible inflow of water straight out of the gravel. The inflow is strong enough to create observable velocities.

A3. Sediment Sources and Influx

In an unregulated catchment, sediment flux plays an important role in geomorphic change. Once a river is impounded, sediment transport and delivery is disrupted and the rate of geomorphic dynamics is often reduced. Knowledge about the pre-dam influx of sediment can be useful in understanding baseline conditions. However, the LYR is somewhat unique in that it stored a vast amount of sediment in its river corridor prior to damming as a result of historic hydraulic gold mining. Consequently, sediment transport remains vigorous in the LYR even though

sediment influx is small. In this context, information about pre-dam sediment influx provides insight into severity of historic impairment due to gold mining.

Gilbert (1917) characterized the quantity and texture of sediment coming from hydraulic mining in the Yuba River catchment.

USGS Upper Yuba River Studies Program investigation of sediment behind the dam (Snyder et al. 2004a, b). Used drilling down the length of the reservoir to explore the stratigraphy of the thick deposit. Applied two different extrapolation schemes to estimate the volume and mass of each size fraction of sediment in each reach of the reservoir.

Snyder et al. (2006) analyzed the hydrologic history of the Englebright-Lake catchment in the 20th century and related that to variations in lake levels and the lake's depositional history. Englebright Dam is a 100% barrier to the flux of sand, gravel, cobble, and boulders. Turbid water carrying silt and clay sized particles goes over Englebright Dam during floods.

Curtis et al., (2005) developed a conceptual model of sediment processes for the Yuba River watershed. They used GIS to estimate the spatial pattern of hillside susceptibility to erosion.

Pasternack (2008) re-analyzed the Snyder et al. (2004a, b) data to isolate the gravel/cobble loading to have an upper bound on unregulated gravel/cobble influx to the LYR.

James et al. (2009). "The immense deposit in the lower Yuba River alone represents 24% of the hydraulic mining sediment produced from 1853 to 1884". [That is ~253 million cubic meters of sediment.] "Most mines in the Yuba Basin dumped sediment into extremely steep, narrow canyons, where it was quickly and efficiently delivered downstream to alluvial fans and basins in the valley."

Boulder generation on hillsides abutting channel are rolling down into the river is important for cover, but unknown.

A5. Sources and Influx of Chemicals and Biological Materials

Large amounts of mercury were imported and used to process gold-bearing rocks in the Yuba catchment, introducing a serious toxic compound into the system. Studies have been done to assess the scope of the problem, including the risk of methylation, which makes inorganic mercury bioavailable.

Beak Consultants, Inc (1989) evaluated the LYR's water quality (dissolved oxygen, pH, dissolved solids, hardness, alkalinity, nutrients, ammonia, inorganic trace elements, select organic compounds, and turbidity, and found that it was "quite good" and within the acceptable range for salmonids. They did consistently detect mercury in sediments and fish tissue samples.

May et al. (2000) documented significant bioaccumulation of methylmercury in fish in Lake Englebright.

Hunerlach et al. (2004) characterized total mercury and methylmercury in sediments trapped behind Daguerre Point Dam. Higher concentrations of total mercury were found with finer sediment sizes, but total mercury concentrations were relatively low, as were methylmercury concentrations. They also assayed trace elements other than mercury using ICP-Mass Spectrometry (ICP-MS) and major elements (Ca, Mg, Na, K, Si, Fe, and Mn) by ICP-Atomic Emission Spectroscopy (ICP-AES).

Alpers et al. (2006) reported geochemical data for mercury, methylmercury, and other constituents in the sediment under Englebright Lake. Related those to sediment particle size distributions.

James et al. (2009) reported geochemical data for total mercury in sedimentary strata associated with hydraulic mining debris near Marysville, CA.

A6. Role of Tributaries

The influx of sediment, wood and other materials from tributaries (Deer Creek, Dry Creek, Big Ravine and Blue Point Mine) is likely very small in comparison to the amount of sediment stored in the LYR channel and floodplain. Deer Creek and Dry Creek contributions are largely blocked by dams and flow regulation on those streams. Tributary contributions are not a function of main stem Yuba flows or operations, but may be potentially important to understand from the perspective of sand contribution to the LYR.

B. Landforms and Boundary Conditions

As dictated by the mathematics of differential equations, the ability of driving forces to cause geomorphic change is strongly mediated by the characteristics of the landform itself, including surface composition, internal structure, morphology, and vegetation. These characteristics are termed "boundary conditions" in math and engineering. Their status is often influenced by dams, but on the LYR one has to consider the significant role of pre-dam hydraulic gold mining in dictating boundary-condition status.

B1. Aerial Photography and Remote Sensing

Satellites and airplanes serve as excellent platforms for collecting digital imagery of river corridors to study changes over time. Satellites have lower resolution, but return more frequently. Putting the two sources together can provide a strong assessment of river conditions before and after diverse human impacts.

Landsat satellites that take digital images of the Earth's surface have operated since 1972. Landsats 1, 2, and 3 flew over the LYR every 18 days and collected images with 80-m resolution using a multispectral scanner. Landsats 4-7 have an upgraded thematic mapper system with a 30-m resolution and a 16-day return cycle. These images provide the potential to study LYR morphology and vegetation at a high temporal frequency for 36 years. However, the spatial resolution is relatively low compared with airplane-based photography, which is commonly 1-m resolution.

Airplane-based photography of the LYR occurred in 1937, 1947, 1952, 1958, 1984, 1986, 1991, 1995, 1996, 1997, 1999, 2002, and annually since 2004. Historical imagery has largely not been georectified. Most imagery since 1999 is georectified. The National Agricultural Imagery Program has 1-m resolution imagery from 2009 that represents the highest quality georectified imagery available for the present condition.

The RMT had airborne LIDAR flown for the LYR from highway 20 bridge to the mouth of the LYR in autumn 2008. The LIDAR intensity returns provide an image of the river corridor and the raw returns have ~2' spacing.

Jason White at UC Davis georectified all available historical imagery of Timbuctoo Bend (provided by Geography Prof. Allen James of University of South Carolina, originally of the Yuba region) and those images are available. White (2008) and White et al. (in press) report the findings from analyzing those images to answer specific questions about riffle-pool location and persistence in Timbuctoo Bend.

Geography Prof. Allen James of University of South Carolina is undertaking a historical geomorphic and land use / land cover analysis of the LYR utilizing historic aerial images. The project will produce an extensive digital, georectified historical and geomorphic database for the LYR from Englebright Dam to the Feather River confluence. The data and imagery will include historical maps and aerial photographs for the period from 1906 (map) to 1999. The aerial photographs will be manually interpreted and classified to produce geomorphic maps showing contemporary positions of channel margins, gravel bars, terrace scarps, levees, high-water channels, and areas of substantial anthropogenic geomorphic disturbance (dredge spoils, land fills, bridges, dams, agricultural leveling, levees, etc.). Mapping will include digitization of channel margins (lowflow water lines) vectorized into shape files for each period. Finally, the imagery will be interpreted and classified to produce a generalized vegetation map for each of the six periods.

B2. Geology, Physical Geography, and Channel Classification

The studies documented in this subsection provide overviews of the landforms and boundary conditions of the LYR.

> The California Geologic Survey released a new Geologic Map of California in 2010. According to the map, the river segment from Highway 20 bridge to Marysville consists of "Q" Quaternary deposits. The segment from Englebright Lake down to highway 20 bridge consists of "MzV" Mesozoic metavolcanic rocks, though the river bed itself is composed of recent alluvial sediments. A more detailed characterization of soils, seismicity, and geology is presented in Yuba County (1993).
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> Gilbert (1917) and James et al. (2009) provided detailed geographic and geomorphic descriptions of physical conditions in the LYR.

Beak Consultants, Inc (1989) qualitatively divided the LYR into four reaches on the basis of "major changes in stream character (gradient, channel morphology and substrate) and significant alterations in stream discharge". The reaches were 1) The Narrows Study Reach, extending 11,400 ft from Englebright Dam to the downstream terminus of The Narrows, a steep-walled canyon; 2) Garcia Gravel Pit Study Reach, extending 56,400 ft downstream from The Narrows to Daguerre Point Dam; 3) Daguerre Point Dam Study Reach, extending 41,400 ft downstream from the dam to the upstream terminus of the Feather River backwater, and, 4) Simpson Lane Study Reach, extending 18,500 ft from the upstream terminus of the Feather River backwater to the confluence of the Yuba and Feather rivers.

White (2006) used Timbuctoo Bend landform and flow characteristics to describe the LYR according to several river classification schemes.

Pasternack et al. (2010) reported on the 100-year history of channel conditions in the EDR with an emphasis on the status of Sinoro Bar at the junction with Deer Creek.

The general physical geography of the LYR is heavily influenced by the legacy of hydraulic gold mining. The river is still best classified as a wandering gravel-bed river, typical of what is seen in front of retreating glaciers. The degree of wandering is constrained by the large training berms and the presence of the Yuba Goldfields.

B3. Topography

A topographic map is a representation of the elevation pattern of a land surface. Because topography is one of the most fundamental variables controlling ecosystem processes on Earth, it is essential to have a good topographic map to manage the landscape. In the case of rivers, topographic maps are particularly important, because the speed and direction of water flow and sediment transport is directed by landform configuration. In turn, flow and sediment help define instream habitat conditions and they can cause landform change. Repeated topographic mapping can be used to characterize how rivers change through time. Both habitat conditions and channel dynamics are important considerations in river management, particularly in regulated rivers that are actively managed to balance multiple needs and interests.

CDC (1906) included a longitudinal profile of the river bed and information about drilled boreholes to determine mining sediment thickness and depth to bedrock. They found that there was 23 m of fill (75') in the channel at The Narrows. The sediment thickness thinned to 4.8 m at Marysville. Depth to bedrock at DPD was 15.9 m. there was no floodplain sediment fill determination.

Gilbert (1917) described topographic mapping in the reach downstream of Parks Bar before "Barrier no. 1" was built and after it was destroyed by a flood. Mapping consisted of contour-based surveying during low flows and cross-sections spaced ~500' apart during high flows. The whereabouts of these maps is unknown.

Gilbert (1917) described four maps of Timbuctoo Bend made in 1898, 1905, 1906, and 1908. The river's wetted area for each of these maps is shown in Figure 8 of his report, but not the actual maps. The whereabouts of these maps is unknown.

1999 USACE topographic map. Bathymetric cross-sections every 100-300'. Terrestrial points primarily from photogrammetry and secondarily from LIDAR. No mapping of river bed from Englebright Dam down through Narrows. Some sizable data gaps, particularly where there were islands, backwaters, and side channels. The 1999 map of the river channel and floodplain is no longer valid after the floods of 2005 and 2006. The 1999 map was produced in the 1929 NGVD datum, but a version of the map using the 1988 NAVD datum has been produced by Prof. Pasternack at UC Davis.

Childs et al. (2003) produced a bathymetric/topographic map of Englebright Lake.

2006-2009 UCD/USFWS/RMT map. Combination of boat-based, ground-based, and LIDAR mapping was used to create a much higher spatial resolution than the 1999 map. Point spacing on the floodplain was finer than 1 point every 2 feet. In the channel the spacing was more variable, but still on the order of 1 point every 5-20'. The EDR was mapped too, but the Narrows is still not mapped as of spring 2010. No sizable data gaps exist downstream of the Narrows- all islands, backwaters, and side channels mapped. A report explaining the data collection and map production procedures is available from the RMT.

In summary, a high-quality, high-resolution topographic map exists for the LYR in its present configuration. The map is suitable for a wide range of hydraulic, sediment transport, geomorphic, and habitat analyses. The sequence of topographic maps from 1999 to 2009 enables analysis of channel change.

B4. Sedimentology and Substrate

The LYR is largely alluvial and has a loose sedimentary river bed. Surficial sediment composition and structure influence sediment transport and site selection by organisms for different life stages.

Beak Consultants, Inc (1989) stated that spawning gravels in the LYR are abundant and in excellent condition, especially from the Narrows Pool all the way down to the Marysville gaging station. There was no evidence of bed "armoring" in which the surface of the riverbed becomes covered with a nearly impenetrable layer of very coarse cobbles and small boulders. The absence of armoring is evidence of geomorphic maintenance of morphological units and their substrates, which implies dynamic channel changes.

Beak Consultants, Inc (1989) used a visual classification system to characterize LYR substrates at 31 transects with at least 20 points to represent the proportional occurrence of habitat types in each reach.

The U.S. Fish and Wildlife Service Instream Flow Branch performed substrate mapping of 18 study sites (9 salmonid spawning and 9 salmonid rearing sites). At each site, cross-section based visual classification of surface substrates was done. In addition, a faster approach was tested in which surface substrates were visually mapped onto map sheets for areas rather than along cross-sections. Comparison of the two methods found that the facies maps worked equally well as the cross-section approach. No pebble counts.

USACE (1997) reported gravel and cobble particle size distributions for the LYR based on Wolman Pebble Counts performed by Ayres and Associates.

Hunerlach et al. (2004) characterized sediment particle size distributions in sediments trapped behind Daguerre Point Dam. Sand/gravel fraction samples were separated into 10 size fractions using screens with the following sieve sizes: 75, 50, 25, 4.75, 2.36, 1.18, 0.60, 0.30, 0.15 and 0.075 mm. Sandy, silty, and clay-silt fraction samples were conventionally sieved in the 0.063-2 mm range and then all particles <0.063 mm were assayed using a SediGraph 5100 particle-size analyzer with 14 size fractions ranging from 0.00025-0.063.

MEI (2008) performed two Wolman pebble counts of active bar surface sediments in the vicinity of the point of the Brown's Valley diversion intake (one upstream and one downstream of it). The median sizes were 23-28 mm.

Pasternack (2008) and Moir and Pasternack (2010) reported diverse pebble count data for Timbuctoo Bend and the Englebright Dam Reach. In 2004-2006 pebble counts were made on different morphological units at the Timbuctoo Bend Apex Riffle. For this 2004 set of pebble counts at the TBAR site, the median particle size was 62.1 mm. Pebble counts were also done relative to different Chinook salmon spawning periods, including pre-spawning fresh bed conditions, red tailspills, and post-spawning altered beds. The median grain size of fish-mobilized sediment varied from 29.2-79.9 mm (mean = 49.2 mm).

In 2007 a longitudinal survey of bed material grain size distributions was done along the edge of the channel adjacent to each riffle crest and pool through Timbuctoo Bend. For the EDR, so little alluvial sediment is present that pebble counts were done wherever possible. Fulton (2008) reported a comparison of substrate conditions between Timbuctoo Bend and the EDR. The EDR did not have any river-rounded gravels and cobbles.

USACE (2007) described the plans for a pilot gravel injection of 500 short tons (361 yds^3) of gravel and cobble into the Narrows 2 pool to rectify the lack of suitable substrate for spring-run Chinook spawning. The injection took place on November 29, 2007. A residual of 34 yds^3 was left mixed into the aggregate in the parking area and hillside, with the remaining 327 yds^3 being placed into the river.

Pasternack (2009) conducted two reconnaissance trips through the EDR in spring and summer 2009 to photographically document the substrates in that reach. No pre-existing river-rounded gravels or cobbles were observed. Accumulations of small angular rocks were pinpointed and photographed. The gravel injected in 2007 was present. Sediment-budget analysis reveals that 252 yds^3 was still in the Narrows 2 pool. The other 75 yds^3 had moved a

short distance downstream. Nothing had moved past the Narrows 1 facility, presumably because its outflow jet perpendicular to the channel creates a significant hydraulic barrier to bedload transport.

In spring 2010 the RMT approved a protocol for mapping the substrate and cover for the entire LYR systematically. The approach uses a new visual classification system for substrate with size divisions that are much easier to consistently identify in practice, because they were determined by properties of the statistical distribution of particle sizes in a gravel-bed river. Specifically, the mean bed material size for the river is ~60 mm, yet visual classifications often require users to differentiate sizes smaller or larger than 64 mm- right at the peak of the statistical distribution. Also, the new divisions are mindful of important limits on the sizes that different salmonids normally move during spawning. Prior to initiating the survey, field crews were tested twice on the method using 17 samples with various size mixtures of sediment taken from the LYR (and subsequently returned there). Test results showed that crew members performed well at identifying the presence or absence of size classes as well as determining the percent of material in each size class to the nearest 10%. As a result, beginning in July 2010, crews have been using real-time differential GPS units to field-map polygons of the surficial bed material down to polygon sizes >10 m^2. The coverage is for the wetted area of ~5000 cfs, as predicted using the 2009 topographic map and the associated SRH models for the whole river.

Before Englebright Dam was built, the hydraulic mining deposits that filled the entire valley were composed of a mixture of all sizes of non-cohesive alluvial sediments. That mixture is still preserved in alluvial terraces on the hillsides that exist as remnant deposits and under the river bed. However, once those materials wash in to the river or are exhumed as the river incises down, silt and sand sized particles wash away, leaving local patches of gravel and cobble on the bed surface, with the exact size distribution tied to the hydraulics and landform shape of each morphological unit present. On the fall limb of floods, sand from terrace cutbanks and minor tributary inflows settles onto the gravel/cobble surface. On the floodplain, the surface is largely gravel and cobble as well, but riparian vegetation captures large piles of fine gravel and sand.

B5. Vegetation

Beak Consultants, Inc (1989) mapped riparian plant communities and urban development along the LYR from color aerial photographs (scale 1 in = 500 ft). The linear extent of these features along the river was determined by planimetry, and then qualitatively compared to historic vegetation maps (U.S. Army Corps Engineers 1976) to assess changes that may have occurred during the past decade. The plant communities along the river were found to be a combination of remnant Central Valley riparian forests, foothill oak/pine woodlands, agricultural grasslands, and orchards. Native riparian forest (mainly Fremont cottonwood, white alder and willow) was found to line the river channel. Gravel and sandbars were dominated by cottonwood where any vegetation was present at all. Blue oak/digger pine woodland occurred in the upper portion of the study area along the stream course. No meaningful comparison could be made between the vegetation mapping results of this study and those of the U.S. Army Corps of Engineers for the early 1970's due to differences in criteria used to distinguish community types.

Sawyer (2007) applied a methodology for characterizing the hydraulic roughness of willows on the banks of the LYR. She found that the best Manning's n value for use with willows is n=0.057.

The RMT is developing a vegetation map of the LYR downstream of the highway 20 bridge using the results of a LIDAR airborne mapping survey in autumn 2008. For the reaches upstream of that, they will perform image classification on 2009 NAIP digital color imagery. Ground-based verification of the image classification is planned. These efforts are expected to be complete by December 2010.

Because much of the LYR floodplain is composed of coarse sediment, it does not have a topsoil that can hold nutrients and water sufficiently to sustain much vegetation. Willows line the present bankful channel and exist along lines on the floodplain at former channel bank locations that have been abandoned by channel dynamics. Cottonwoods and other riparian species are present around partially connected former channels that are presently "backwaters". The hillsides are oak woodland.

B6. Streamwood and Boulders

The RMT is planning to map the present distribution of streamwood and boulders stored in the river in July and August 2010.

B7. Civil Engineering Structures

Structures have been built into the LYR to serve several societal purposes in and around the river. These structures can impact channel form and flows.

B7a. Levees and Training Berms

James et al. (2009) provided historical analysis of levees and their impacts in the LYR.

B7b. Bridges

The Highway 20 bridge is the only bridge over the LYR upstream of Marysville. It is high above the water, but it does have piers into the river bed. Four bridges exist in Marysville at Simpson Lane, A Street, Route 70 (E Street), and a railroad line.

B7c. Dams

Gilbert (1917) description of "Barrier no. 1" a short distance downstream of Parks Bar. This concrete dam was destroyed by a flood in March, 1907.

SWRI (2003) presented an overview of the history and 2003 status of biological conditions in the LYR as part of a biological assessment of a proposed flow bypass structure being built at Englebright Dam.

Pasternack et al. (2010) reported on the relative roles of Englebright Dam and instream gold mining in influencing current conditions in the EDR.

By design, dams in the Yuba watershed capture a lot of the flow that comes during spring snowmelt, help attenuate winter flood peaks, and trap sediment that would otherwise fill lowland river valleys. Most also block fish passage. Flow releases from NBB provide cold water that helps support anadromous salmonid freshwater life stages.

B7d. Diversions

Beak Consultants, Inc (1989) described existing and proposed water rights and diversions.

DWR and USACE (2003) described diversions and how much overall is removed at Daguerre Point Dam.

SWRI (2003) describes diversions in the Yuba watershed.

YCWA (2007) provides extensive description and modeling of diversions from the LYR.

C. Hydrogeomorphic Dynamics

Water and sediment transport drive landform change on the LYR. Direct observation of these changes is difficult and expensive, especially in a large gravel-bed river. During the 20th century significant changes and improvements to the understanding of coordinate systems and datums make comparisons of topographic surveys from different eras highly uncertain. Determining the underlying causes of observed changes requires computer simulation of individual events.

C1. Channel and Floodplain Hydraulic Models

Several different hydrodynamic models have been used to study LYR hydraulics. The *1D analytical method* involves predicting open channel processes at cross-sections by coupling some combination of a mass-conservation equation, empirical hydraulic-geometry equations, empirical flow-resistance equation, and an empirical or semi-empirical sediment-transport equation. An example computer program that has been used on the LYR for implementing this scheme is *WinXSPro*. A similar analytical routine is incorporated as one of several hydraulic estimation approaches in *PHABSIM*, but this has not been used on the LYR.

A variant of the analytical method is based on the geomorphic concept of "hydraulic geometry" relations and is known as IFG4. This method involves observing stage for each transect and velocity at each point along a transect at 1-3 discharges (preferably with three corresponding to high, middle, and low flows) (there is also a no-velocity observation approach for unwadable areas). Next, the least-squares regression fit is computed for the logarithm of stage against that of discharge for each transect. Similarly, the least-squares regression fit is computed for log-velocity against log-discharge for each point (aka "vertical") along each transect. These regressions are then used to interpolate stages and velocities at the points for unobserved discharges.

Numerical approaches to hydraulic estimation employ computers to approximate solutions of 1D, 2D, or 3D equations of motion where the solution procedures are dependant on adjacent nodes or cross-sections. *1D numerical models* use a standard step method to iteratively solve the energy equation for steady gradually varied flow from one cross section to the next to calculate water surface profiles. An example computer program that has been used on the LYR for implementing this scheme is *HEC-RAS*. This model is freely available from the U.S. Army Corps. of Engineers, but it is also incorporated in to several commercial packages. It is a widely used gold standard for 1D numerical modeling in the U.S. PHABSIM also incorporates a 1D numerical modeling scheme.

2D (depth-averaged) numerical models solve vertically integrated conservation of momentum and mass equations using a finite element, finite difference, or finite volume computation method to acquire local water depth and depth-averaged 2D velocity vectors at each node in a computational mesh. These models further add the ability to consider full lateral and longitudinal variability down to the sub-meter scale, including effects of alternate bars, transverse bars, islands, and boulder complexes, but require highly detailed topographic maps of channels and floodplains. 2D models are more realistically linked to flow, sediment transport, and biological variables measured in the field at the same spatial scale. 2D models have been used to study a variety of hydrogeomorphic processes and they are used in regulated river rehabilitation emphasizing spawning habitat rehabilitation by gravel placement. Four different 2D numerical models have been used on the LYR, including *FLO-2D*, *RIVER2D*, *FESWMS*, and *SRH-2D*. FLO-2D is a high-end commercial package commonly used for floodplain flood assessment. RIVER2D is a free suite of programs used heavily by fisheries biologists to evaluate physical aquatic habitat. FESWMS is a free model produced by the Federal Highway Administration to look at local hydraulics around structures, but it has also been used to study hydrogeomorphic processes and physical aquatic habitat. SRH-2D is a relatively new model that spans may of the capabilities of FLO-2D, RIVER2D, and FESWMS and is more computationally efficient and numerically stable, so it can be used to simulate long river segments in very high resolution.

Associated with each modeling study is a suite of direct observations of depths, water surface elevations, and velocities in the LYR. These observations are compared to model results to characterize the level of uncertainty in the models.

C1a. IFG4 Hydraulic Estimation

Beak Consultants, Inc (1989) used the IFG4 method to characterize the hydraulics of the LYR. They designated 31 transects with at least 20 points to represent the proportional occurrence of habitat types in each reach. At each wadable point, depth, velocity, and substrate was observed. Depth measurements were made with a top-setting wading rod and velocities made with various point-scale current meters. Substrates were assessed based on a visual classification system. The one-velocity and no-velocity approaches to calibrating IFG4 was used.

C1b. Numerical LYR Models For Flood Management Studies.

USACE (2002) made HEC-RAS and FLO-2D hydraulic models of the channel and floodplain with coarse 400'x400' cells (i.e. 400' internodal spacing) for use in studying terrestrial flooding during large floods. HEC-RAS was run first to get the boundary conditions necessary to drive FLO-2D. FLO-2D was then used to assess how water gets onto and off the Yuba Goldfields.

C1c. RIVER2D Models Of 18 Sites On The LYR.

The U.S. Fish and Wildlife Service Instream Flow Branch (Gard, 2007, 2008) performed 2D hydraulic modeling of 18 sites for flows of 400-4500 cfs (the full range of controllable flows). Ten sites were riffles thought to be preferred for spawning, and these were assessed for physical microhabitat for spawning and rearing life stages. Eight sites were in other mesohabitats and were only assessed for rearing life stages. Modeled velocities were compared to observed velocities. Model results were not analyzed to evaluate hydraulic and geomorphic processes, but could be used for that purpose.

C1d. FESWMS Model Of Two Sites On The LYR

Professor Greg Pasternack from UC Davis was sponsored by the U.S. Fish and Wildlife Service to perform 2D hydrodynamic modeling of two different sites on the LYR over a range of discharges with FESWMS. FESWMS was implemented within the Surface Water Modeling System (SMS) 8.1 graphical user interface. One site was the Timbuctoo Bend Apex Riffle (TBAR) whose topography was independently mapped in 2004 and 2005 (before and after the May 2005 flood peak of 42930 cfs). The 2004 TBAR topography was modeled at flows of 400, 622, 827, 1200, 135, 1800, 2250, 2700, 4500, 5620, 11600, and 42930 cfs. The reason these uneven integer values were modeled (which also holds for the subsequent uneven integer values described below) was due to the availability of actual observations of downstream water surface elevations to drive the models at these flows rather than relying on a 1D numerical model or 1D analytical approach to estimate exit conditions, as was done by USACE (2002). A different computational mesh was made for each discharge and the meshes all had an intermodal spacing of ~1 m. For the 2005 TBAR topography, discharges of 650, 747, 855, 1101, 1223, 3347, 9547, 23140, 35260, and 109090 cfs were simulated, facilitated by the New Years 2006 flood. Again, a different computational mesh was made for each discharge and the meshes all had an intermodal spacing of ~1 m. Validation of these models consisted of comparing model predictions against observations of water surface elevations made by surveying, water depths made with a top-setting wading rod, and velocities made with a Marsh-McBirney current meter.

The other site that FESWMS was used to model was the Englebright Dam Site (EDS) in the narrow canyon just below Englebright Dam. This site included the Narrows II Pool just downstream of Englebright Dam, a run, and then another pool upstream of Narrows I. This site was mapped in 2005 and FESWMS was used to model discharges of 800, 1190, 8809, 9580, 25100, 31800, and 91400 cfs.

C1e. RMA2 Modeling Of The LYR at the Brown's Valley Diversion

MEI (2008) used topographic data collected in 2006 to run an RMA2 hydrodynamic simulation of the LYR in the vicinity of the Brown's Valley diversion to evaluate the effects of the preferred fish screen design (Alternative 2-C). RMA2 is similar to FESWMS, but it cannot handle supercritical flows, which is why it was not used for other studies in the EDR or Timbuctoo Bend. Both models may be implemented within the Surface Water Modeling System (SMS) 8.1 graphical user interface. RMA2 models were run for both the baseline channel conditions and for the preferred fish screen design. The flows that were simulated with the 100- and 200-year flood events. Results were used to analyze hydraulic conditions, incipient motion, and bank stability for these very large floods.

C1f. SRH-2D Modeling Of The Entire LYR

With the recent availability of the highly efficient SRH-2D numerical model, the capability now exists to simulate the entire LYR with 1 m intermodal spacing. The primary limitation in model accuracy is topographic modeling and the degree to which the river's slope is in the acceptable range of the assumption of horizontal flow, which is embedded in all 2D models. Greg Pasternack ran a pilot test of SRH-2D in 2008 by re-modeling the TBAR 2004 site at 827 cfs and intercomparing FESWMS and SRH-2D. The results between the two models were very similar, except that SRH-2D slightly underpredicts the highest velocities on steep riffle crests at very low flows. This effect was concluded to not be a concern.

Pasternack (2008) used SRH-2D to simulate flows of 855 and 1600 cfs in the EDR with ~1-m intermodal spacing, which is the reach from the Narrows II pool down to the junction with Deer Creek.

Pasternack (2008) used SRH-2D to simulate flows of 750, 930, 1669, 2986, 4303, and 5620 cfs for the Timbuctoo Bend Reach (Narrows Pool to Highway 20 bridge) with 1-m intermodal spacing in the bankfull channel.

In spring 2010, the RMT prepared computational meshes for the entire LYR downstream of the highway 20 bridge to go with the pre-existing ones for upstream of the bridge. The model reaches now include the EDR, Timbuctoo Bend, the Hammon Reach (Highway 20 bridge to DPD), the Daguerre reach (DPD to USGS Marysville gaging station), and the Feather Reach (USGS gaging station to confluence with the Feather River). SRH-2D models of each reach and at different flows may be run concurrently on a single computer with multiple processor cores or across different computers.

Extensive observational data was collected 2008-2010 to test the SRH models of the LYR. During topographic and bathymetric surveying in 2008 and 2009, many water surface elevation points were surveyed at the flows present during the mapping efforts, which varied widely. In addition, an effort is being made to use the 2008 LIDAR points collected on the water surface to create a continuous water surface elevation map for the flow on the day of that flight, which could be compared against a model of the same flow. Given this large amount of water surface elevation data, a smaller dataset of water depths was collected at cross-sections in December 2009. During December 2009 to August 2010, the RMT

collected ~6000 observations of velocity between Hammon Grove Park and Hallwood Road- the area over which an RTK GPS base station could broadcast positional corrections from a benchmark located on DPD.

In summer 2010, 1-m resolution SRH models of the LYR were run at the discharges for which observational data was available to test the models. These flows ranged from 500 cfs to 5000 cfs. A detailed presentation showing the results of model validation is available from the RMT.

In autumn 2010 a suite of flows between 500-5000 cfs will be simulated using SRH to evaluate flow-habitat relations for the whole LYR systematically.

Overall, the LYR has been extensively modeled to determine depths and velocities. Models have provided information about floods, sediment incipient motion, geomorphic change, and fish habitat. The river changes every 5-10 years, so models must be updated to remain relevant. The new 1-m resolution SRH models of the entire LYR represent the most complete and advanced effort at river modeling in the Central Valley of California.

C2. Morphological Units

A ***morphological unit*** is a discernible landform in the river valley that is typically visible at the spatial scale 1-10 channel widths. Landform pattern is reflected in hydraulic pattern and thus may be delineated with the aid of hydraulic information, but it is independent of hydraulics. Also, the shapes of morphological units are changed by flow over time.

Beak Consultants, Inc (1989) performed visual morphological unit classification for each 100' section of the LYR in October 1986 when the discharge was ~600 cfs above Daguerre Point Dam and ~300 cfs below it. The unit types that were used were low-gradient riffle, moderate-gradient riffle, run/glide, shallow pool, and deep pool. The percentage of river channel composed of each type in each reach was enumerated.

Moir and Pasternack (2008) defined 10 in-channel morphological units (forced pool, pool, chute, run, riffle entrance, riffle, glide, recirculation zone, backwater, and secondary channel) and used expert-based mapping to delineate their pattern at the TBAR site in 2004. They then used the 2004 TBAR FESWMS model results for 827 cfs to characterize water depth, velocity, and Froude number for each unit.

Pasternack (2008) defined an additional 10 morphological units to cover the terrestrial river corridor (lateral bar, point bar, medial bar, floodplain, tertiary channel, tributary delta, cutbank, terrace, tailings, hillside).

Pasternack (2008) used the 2006 Timbuctoo Bend Reach topographic map, a water depth map based on the intersection of aerial imagery and the topographic map, and expert-based assessment of velocity pattern to delineate the morphological units in the entire river corridor in this reach. Physical attributes for each unit were calculated for units in Timbuctoo Bend,

such as area, percent of total area, mean and standard deviation of water depth at specific flows, volumetric channel change 1999-2006, and average rate of downcutting 1999-2006.

The Yuba Accord RMT implemented a protocol based on Pasternack (2008) to create a morphological unit map and comprehensive analysis for whole LYR facilitated by the SRH-2D model results.
The procedure used in the morphologic analysis involved four phases: topographic mapping, 2D hydrodynamic modeling, classification of hydraulic and topographic patterns, and analysis of resulting landform types at all three scales. A combination of ground-based surveying, boat-based bathymetry, and airborne LiDAR was used to construct a river-corridor digital elevation model (DEM), excluding the inaccessible Narrows Reach. The freeware program SRH-2D was then used to model spatial pattern of water surface elevation, depth, velocity, and other derivable variables for the entire mapped river at discharges ranging from very low flows (300 cfs) to valley-filling floods (110,000 cfs).

At the segment scale, metrics were calculated within the 2D-model derived wetted boundaries of the three representative flows (when simulated in the absence of vegetation).
At the reach scale, eight distinct reaches were delineated and characterized for the LYR. The key geomorphic indicators of reach breaks were presence of tributary confluences, presence of dams, valley width, riverbed slope breaks, and substrate. Flow-dependent statistics were also calculated at the reach scale on channel widths and wetted areas.

Using 2D model results, four suites of morphological unit (MU) types that are bounded discretely between two flow boundaries were delineated within the LYR segment. In total, 31 MU types were delineated, with the others occasionally transcending between the relevant discharge boundaries. Statistical abundances were calculated for each MU type across the relevant discharge regimes.

To further explore the question of random organization among the MUs, the in-channel baseflow units were analyzed with respect to the longitudinal distribution of each unit and adjacency probabilities between sets of units. The spatial organization of the MUs was also analyzed with respect to the longitudinal spacings between like units and the lateral variability of units across the channel width.

A suite of maps and graphics, along with a summary report, has been completed by the RMT.

C3. Channel Change

Pristine rivers experience channel change due to a variety of causal factors related to inputs and boundary conditions. Change is a normal and important aspect of the role of physical processes in providing ecosystem services. However, pristine rivers also show resiliency in providing ecosystem services in the face of natural processes that cause channel change. Often, human impacts that cause channel change break a river's natural resiliency, causing sustained impairment. By knowing the types and rates of natural channel change in a system as well as the

underlying mechanisms of change and resiliency, one can determine whether a particular human impact is abnormally ecologically harmful.

C3a. Historic Channel Response To Historic Hydraulic Mining Sediment

Gilbert (1917) described sedimentation and sediment transport right after hydraulic mining stopped. Channel change was frequent and dramatic between 1898 and 1912.

Beak Consultants, Inc (1989) stated that it appears that the recovery from the influx of hydraulic mining debris (incision and accompanying stabilization) was largely complete by about 1950 on the basis of the interpretation that the channel had mostly changed its planform from a braided river to a single-threaded meandering river by that date. Limited specific quantitative evidence was available for this study.

James et al. (2009) discussed historic conditions and stated that, "The high sediment loads overwhelmed the transport capacity of valley channels and caused major geomorphic adjustments such as channel aggradation and avulsions."

USACE (1997) analyzed changes to the river's longitudinal profile between 1899, 1906, 1912, 1929, 1957, and 1992. The river was found to be incising rapidly after hydraulic gold mining was stopped and dams were built.

For over 100 years, the LYR has been a highly dynamic, wandering gravel-bed river. This was not its pre-settlement classification, but it is the template of what was present prior to dam construction. Since dam construction, sediment supply has been reduced, while geomorphically significant floods have continued. This enabled incision into historic deposits under the riverbed.

C3b. Modern Channel Response After Flow Regulation (Post-1972).

Beak Consultants, Inc (1989) stated that channel change between 1973-1986 consisted of normal lateral migration. Their interpretation is that the river is stable in the sense required to justify application of the IFIM approach for determining flow-habitat relations. Specifically, they suggest that changes to the river would not change the statistical distribution of morphological units and would not impact flow-habitat relations. Limited specific quantitative evidence was available for this study.

Sawyer et al. (2010) used the 827, 5620, 11600, and 42930 cfs FWSWMS model results for the TBAR site to characterize hydraulic processes responsible for observed geomorphic changes through the May 2005 flood. The key finding is that flow convergence routing driven by the phasing of coherent bed and valley-width undulations is effectively causing geomorphic maintenance of morphologic units at different discharges at the TBAR site.

White (2008) and White et al. (in press) studied planform channel change and riffle-pool locations/persistence in Timbuctoo Bend for 1937-2006 based on historical aerial imagery and the 1999 and 2006 topographic maps. They found that significant planform channel

change does occur in Timbuctoo Bend, contradicting the assumption/conclusion of Beak Consultants, Inc (1989. Further, the peak flood discharge between two aerial photo sets explained 65% of the area of planform channel change over the same time interval. They also found that valley width oscillations explained the locations of persistent riffles and pools in the reach.

Fulton (2008) used the 2005 TBAR model results to evaluate hydraulic processes responsible for observed geomorphic changes from 2005 to 2006 as a result of the New Years 2006 flood. The site underwent dramatic change as a result of this large flood.

Pasternack (2008) reported digital elevation model differencing between the 2006 and 1999 topographic maps of Timbuctoo Bend. This analysis yielded the spatial pattern of topographic change in ~1-m resolution and the net total export of sediment out of the reach. Roughly 600,000 yds^3 of sediment left Timbuctoo Bend in the 7-year period. That amount of change contradicts the contention of Beaks Consultants, Inc. (1989) that the river is stable. It is unknown yet where all that material went downstream. Also, the estimated vertical channel change and volumetric change were stratified by morphological unit. Each unit exhibited a different rate of change, which means that the statistical distribution of unit types cannot have remained constant, again contradicting Beaks Consultants, Inc. (1989).

Pasternack (2008) studied the mechanism of erosion of riffle crests and discovered that during low flows the riffles behave as upstream-migrating knickpoints. Using an anchored raft, the group positioned themselves in the convergent zone of riffles and measured velocities at the surface, mid-depth, and near the bed. Also, for one wadable riffle they directly measured lift and drag on grains at the bed using a special 6-component force/moment sensor. These measurements indicated that the hydraulic forces were sufficient to scour the bed at flows of ~800-1200 cfs. They also made repeat topographic surveys of the riffles and confirmed that during the time of low flows the bed actually did change in a way that matched the flow configuration. Thus, during low flows water is focused or converged onto riffle crests causing them to erode and behave as knickpoints. The study by Sawyer at al. (2010) showed that during large floods the relief between riffles and pools is rejuvenated, which renews the cycle of riffle erosion for the next low-flow period.

RMT has data needed to assess perform DEM differencing 1999-2009 for the entire LYR, but has not implemented a study on it yet.

The LYR continues to be a highly dynamic wandering gravel-bed river. Damming did not alter the classification of the river as quickly as generally understood for regulated rivers, because so much sediment is stored in the river valley and because floods still occur on a regular interval. Anecdotally, reports suggest that the river has narrowed, incised, and slowly transitioned from braided to meandering as a result of the reduction in bankful flow and lack of upstream sediment supply. In Timbuctoo Bend the river is incising on the floodplain as well as the riverbed, suggesting that dynamics are not constrained by an overgrowth of bank vegetation or disconnection between channel and floodplain. The mechanism of river incision observed in Timbuctoo Bend involves a two-step process: 1) knickpoint-based riffle scour during low flows

and 2) pool scour during high flows. This mechanism is facilitated by undulating valley walls and riffle-island formations in the widest valley cross-sections. Even though the river is still incising, it is sustaining an ecologically useful pattern of riffles, pools, and other morphological units.

C4. Sediment Budgets

A sediment budget is an accounting of all the fluxes of sediment in and out of an area as well as how much is stored within it. Sediment budgets are used to determine whether there is a steady state balance of movement in and out of a system or whether rivers are aggrading or incising.

C4a. Sediment Budgets By Landform Analysis

Gilbert (1917) described topographic changes and estimated sediment fluxes.

Pasternack (2008) created a sediment budget for Timbuctoo Bend by performing digital elevation model differencing between maps from 1999 and 2006. The sediment budget was also partitioned by morphological unit type.

RMT has data needed to assess changes in sediment storage 1999-2006, but has not implemented analysis yet.

C4b. Sediment Budgets By Sediment Load Observation

USACE (1997) presented a limited amount of suspended sediment load data based on observations at the Maryville gaging station.

C5. Sediment Transport and Incipient Motion

A common metric used to understand the link between channel dynamism and fish habitat is the discharge associated with "incipient motion", the condition under which sediment transport is just beginning. However, the idea of a single discharge of incipient motion has always been controversial and may not be useful for a dynamic river like the LYR. This question has been studied carefully on the LYR to find out, and the effort is on-going.

C5a. Hydraulic Modeling of Shear Stress and Inference of Sediment Transport Regime

One approach to evaluating the conditions at the moment of incipient motion is to perform hydraulic modeling to obtain depths and velocities, and then calculate the bed shear stress from those model outputs using one of several formulas. For any grain size, the Shields' criterion for incipient motion may be used to calculate the critical shear stress above which observable transport begins. The method assumes a bed of non-cohesive, homogenously sized particles. More recently, a new approach has been developed for non-cohesive, mixed-size beds that involves calculating a non-dimensional shear stress variable called "Shields stress" (τ^*) and then characterizing the overall sediment transport regime based on the transport mechanics for

established ranges of Shields stress values. The classification is as follows: $\tau^* < 0.01$ is no transport; $0.01 < \tau^* < 0.03$ is intermittent entrainment; $0.03 < \tau^* < 0.06$ is a range of a process known as ‘‘partial transport’’ in which any overabundance of finer particles is removed off the bed tending toward an equilibrium size-distribution for the mixture; $0.06 < \tau^* < 0.10$ is full transport; and $\tau^* > 0.10$ is likely a channel-altering condition.

USACE (1997) performed HEC-6 modeling of 100-, 200-, and 400-year flood hydrographs to assess sediment transport capacity for those extreme events.

DWR and USACE (2003) analyzed the incipient motion conditions for flows of 4,000; 40,000; 65,000; 121,000; and 161,000 cfs using HEC-RAS hydraulic output and a sediment transport tool known as the Shields Diagram. For each flow they determined the maximum particle size moved by the flow. This approach assumes that the entire mixture of sediment is this size and does not account for the effects of a heterogeneous bed.

Sawyer et al. (2010) and Pasternack (2008) used FESWMS 2D models of the Timbuctoo Bend Apex Riffle to evaluate the presence of flow convergence routing and the Shields stress transport regimes for the discharges modeled. They found that each morphological unit experienced the “full transport” ($\tau^* > 0.06$) sediment transport regime over a unique range of flows. Thus, a single incipient motion threshold for the river is not appropriate as a metric for evaluating LYR sediment transport conditions and fluvial geomorphology. Fulton (2008) extended the flow range of the analysis to >109,000 cfs.

Fulton (2008) used the FESWMS 2D model of the EDS in the EDR to evaluate the presence of flow convergence routing and the Shields stress transport regimes for the discharges modeled. As a test metric, more than 10% of the wetted area would have to be in full transport in order for the EDS to be considered “unstable” at that flow. Based on this metric, a flow of 25,100 cfs would be required to mobilize gravel and cobble at the bottom of the Narrows 2 pool. When gravel is loosely piled much higher than the pre-existing bed level, the discharge required to move it would be lower, but no such scenario was investigated. Transport in the constricted channel downstream of the pool was predicted to begin at a lower discharge of 9,570 cfs. The model results for flows 800-91,400 cfs showed the absence of flow convergence routing. That means that present high points (nominally “riffles”) in the riverbed in the EDS are also narrow. As a result, any gravel added to the river over these riffles will wash away preferentially. Any gravel added into pools would be the most difficult to wash away.

C5b. Bedload Tracer Studies

Since a large fraction of bed material in the LYR is gravel and cobble sizes, it tends to roll and hop along the bed as “bedload”. Bedload is very difficult to measure directly. The standardized approach of lowering a Helley-Smith sampler down from a bridge, cableway, or boat-based platform and sampling for 2-minute intervals is notorious for its inability to capture the correct relation between bedload rate and flow rate. Few suitable locations exist on the LYR to perform such measurements anyway, given the lack of bridges and the large width of the river. An

alternate approach is to place painted and/or magnetized "tracer' stones into the riverbed and then track their movements after each event. In 2003-2004 Dr. Hamish Moir and Prof. Greg Pasternack painted 28,439 stone tracers (8-64 mm in diameter) sourced from the LYR using 22 color combinations. Each set of stones with a unique color combination was cored deep into the bed at diverse sites in the Timbuctoo Bend Apex Riffle using a MacNeil Corer. Velocity profiles were conducted over the cores at 1-3 different discharges. Periodically through 2004 the tracer piles were examined for loss of tracers and efforts were made to locate tracers downstream and survey their locations with a robotic total station. Overall, flows were low in 2004 and little movement occurred. Monitoring continued until it was halted as a result of the May 2005 flood event that appeared to obliterate the tracer cores in that none of them could be subsequently found at the bed surface. However, later excavation at the specific locations of the tracer cores determined that some had been entirely scoured away, while others had been covered over by deposited sediment. Generally, cores were entirely scoured away on the south side of the study site and covered over on the north side.

In November 2005, Moir and Pasternack placed 4 rows of painted, numbered tracer stones (366 stones total) with powerful imbedded neodymium magnets in them across the LYR at the Timbuctoo Bend Apex Riffle site. The tracers ranged in size class from 22.6 – 32 mm to 128 – 256 mm and in mass from 0.04 to 4.22 kg. A month later there was the enormous New Years 2006 flood that yielded a major reconfiguration to the river. When the flows finally receded enough in the summer to look for stones, 3 were found very close to the original locations and all the rest were gone with no hope of finding them down the next 20 miles of riverbed and floodplains.

As an alternate approach, in 2004 Moir and Pasternack also installed Bunte bedload traps along the flanks of the run just downstream of the Timbuctoo Bend Apex Riffle. These are short but hefty rectangular metal tubes with wide openings and nets tailing behind to capture bedload. They require emptying periodically during sediment transport events, but they are highly effective at capturing the bedload rate as a function of discharge. Also, they were designed to be used in small streams where samplers may be operated from boardwalks over the channel. Unfortunately, no small transport events occurred in 2004 to yield data and the traps were removed. Had the traps been left in place they would have been wiped out by the May 2005 flood anyway.

Pasternack (2009) reported on the 2007-2009 bedload migration of 500 tons of distinct, rounded river gravel and cobble injected into the Narrows II Pool in November 2007. In the absence of significant flows over Englebright Dam during this initial study period, only a small fraction of that material has migrated so far and that has been for just a short distance downstream. Notably, that 50-ton sediment pile is laced with 361 painted, numbered tracer stones with imbedded neodymium magnets imbedded in them that may be trackable through the EDR.

The overall finding from these efforts is that direct observation of bedload transport on the LYR downstream of the Narrows Pool is extremely difficult to achieve. The river is so dynamic and sediment influx so small that it is far more effective to estimate sediment outflux and redistribution by detailed re-mapping of the river bed and applying DEM differencing.

D. Physical Habitat and Ecological Dynamics

D1. Microhabitat Analyses

The term "microhabitat" is defined as the localized depth, velocity, temperature, and substrate at a point in a river without regard to surrounding conditions

The U.S. Fish and Wildlife Service Instream Flow Branch (Gard, 2007, 2008) sought to establish flow-microhabitat relationships on the basis of 2D hydraulic modeling of 18 sites for flows of 400-4500 cfs (the full range of controllable flows). Ten sites were riffles thought to be preferred for spawning, and these were assessed for physical microhabitat for spawning and rearing life stages. Eight sites were in other mesohabitats and were only assessed for rearing life stages. Habitat suitability curves for depth, substrate, and velocity based on logistic regressions were developed for spawning, fry, and juvenile life stages, using modeled velocities and depths to represent "available" conditions. Other curves were also evaluated. Comparisons of observed habitat occurrence/utilization against model predictions of habitat presence/absence did not "bioverify" and the study results were thus inconclusive.

Pasternack (2008) used the 2004 and 2005 FESWMS 2D model results for the TBAR site along with observations of salmon spawning and redds to perform bioverification of utilization-based habitat suitability curves for fall-run Chinook salmon spawning from the lower Mokelumne River. Although the curves were from a different river in the Central Valley, they passed strict tests for predicting both presence and absence of observed spawning. Notably, no substrate suitability criterion was used.

Fulton (2008) used the 2005 FESWMS 2D model results for the TBAR site to evaluate fall-run Chinook spawning microhabitat conditions over a wide range of discharges. He also analyzed the hydraulic processes responsible for observed geomorphic changes 2005 to 2006.

Fulton (2008) used the FESWMS 2D model results for the EDS site in the EDR to evaluate fall-run Chinook spawning microhabitat conditions over a wide range of discharges. Only 3% of the area in the EDS had suitable hydraulics for Chinook spawning at flows ≥800 cfs. This is in contrast to 30% of the area in the Timbuctoo Bend Apex Riffle site. The little area with suitable hydraulics was composed of narrow patches flanking the channel and had no suitable spawning substrate. Also, no redds were observed at the EDS in 15 site visits over 2 spawning seasons.

Moir and Pasternack (2010) investigated the microhabitat interdependence of depth, velocity, and substrate size related to Chinook salmon spawning. The goal was to determine whether the preference of Chinook to use a single variable was limited to an "inelastic" range not conditioned by the values of the other variables. By comparing available and utilized hydraulics and substrates, it was possible to determine that in fact Chinook preference is very elastic. For example, fish chose to spawn in significantly coarser substrates when the ambient velocity was high enough to aid the fish in moving the material and chose fine substrates when the velocity was low.

Although the issue of what constitutes the best type of habitat suitability curves for the LYR is still under scrutiny, the results of the above studies show that it is possible to predict the spatial patterns of presence and absence of salmon spawning microhabitat to match observed patterns of actual redd locations. By lumping habitat quality types into broad categories, a lot of the uncertainty in 2D model predictions of local depth and velocity is eliminated. The availability of a whole-river 2D model based on SRH-2D now enables a comprehensive census of the flow-microhabitat relationship for the LYR.

D2. Mesohabitat Analyses

Although it is often possible to empirically relate ecological function to microhabitat variables, doing so provides a limited understanding of how and why fluvial-ecological linkages are spatially related. The term "mesohabitat" is defined as the interdependent set of the same physical variables over a discernible landform known as a morphological unit. Three mesohabitat studies have been performed on the LYR, and of those, two nest the microscale requirements of instream species within the mesoscale context of an assemblage of morphological units. Those studies found that linking the mesoscale of morphological units to microhabitat characteristics, did help explain fluvial-ecological linkages better.

U.S. Fish and Wildlife Service instream Flow Branch used an existing CDFG mapping scheme to field-map the mesohabitats for the LYR as it was prior to the 2005 and 2006 floods (Gard, 2008). The mesohabitats were not analyzed in and of themselves but were instead used to facilitate sampling of juvenile salmonids on a equal effort basis for each mesohabitat type.

Moir and Pasternack (2008) used expert-based judgment and geomorphic concepts to map the morphological units at the Timbuctoo Bend Apex Riffle. Then they used the 827 cfs FESWMS 2D model results to quantify the microhabitat hydraulics of the morphological units. These results were lumped to the mesohabitat scale and integrated with observations of salmon spawning in 2004-2005 to delineate preferred mesohabitats and characterize their hydraulics. Analysis of the spatial pattern of flow was used to explain the structure of the mesohabitatts.

Pasternack integrated the 2006 Timbuctoo Bend morphological unit map with mapped water depths and redd observations for fall 2006 to yield availability adjusted preferences for specific mesohabitats (i.e. forage ratios).

The RMT has a protocol in place to create a morphological unit map for the entire LYR similar to the approach of Pasternack (2008). Mesohabitats at specific discharges will be assessed for different lifestages.

D3. Vegetation Patch Dynamics

Beak Consultants, Inc (1989) compared their riparian map to anecdotal reports and pre-existing riparian studies. They reported that the amount of riparian vegetation has been

increasing over the decades in response to flow regulation, but is still insufficient to support juvenile salmonids.

E. River Management Actions

For over 100 years people have been tinkering with the LYR to cope with the impacts of hydraulic mining sediments, flow regulation, and the unforeseen impacts of previous interventions into river conditions.

Gilbert (1917) and James et al. (2009) presented information on some of the early historic activities.

Activity between 1930-1990 has not been reconstructed.

Most recently, the USACE performed a pilot gravel injection of 500 short tons of gravel and cobble into the Narrows II pool at the top of the EDR in November 2007. Pasternack (2009) reported on what happened to that material through summer 2009. In autumn 2009 the RMT mapped spawning redds on the injected sediment. Presently, plans are under consideration for several river rehabilitation projects throughout the LYR.

Conclusion

The LYR has been thoroughly studied over the years. Information exists on all aspects of geomorphology and its linkages to hydrology, hydraulics, and ecology. Timbuctoo Bend is the most thoroughly studied reach. Its fluvial geomorphic dynamics and underlying hydraulic mechanisms have been worked out and described in a series of peer reviewed journal articles. The RMT is planning to complete a suite of additional geomorphic observations by mid-2012 that will answer the same questions for the rest of the river.

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ATTACHMENT 1-2B

Transmittal of Draft Study Plan to USFWS, NMFS, SWRCB and CDFG

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Lynch, Jim

From:	Lynch, Jim
Sent:	Monday, January 16, 2012 3:54 PM
To:	'Daniel_Welsh@fws.gov'; 'ksmith@dfg.ca.gov'; 'alison_willy@fws.gov (Alison_Willy@fws.gov)'; 'Rick Wantuck'; 'Larry Thompson'; 'John Wooster'; 'JParks@waterboards.ca.gov'; 'MaryLisa Lynch'; 'Sharon Stohrer (SSTOHRER@dfg.ca.gov)'
Cc:	'caikens@ycwa.com'; 'Geoff Rabone'; 'Alan Mitchnick'; 'Kenneth Hogan'
Subject:	Yuba Relicensing: Transmittal of Draft Study 1.2, Channel Morphology Downstream of Englebright Dam for 30-Day Review Period
Attachments:	Study 01-02 - Channel Morphology Below Englebright - DRAFT - Modified per FERC 093011 Determination.doc

- YUBA RIVER DEVELOPMENT PROJECT RELICENSING -

Transmittal of Channel Morphology Downstream of Englebright Dam Study (Study 1.2) Plan for 30-Day Review Period
- Written Comments due to YCWA by Close of Business on February 15, 2012 -

On September 30, 2011, FERC's Director of Energy Projects issued a Study Determination related to Yuba County Water Agency's (YCWA) relicensing of its Yuba River Development Project, FERC Project 2246. The Determination required, among other things, that YCWA develop and file with FERC by December 29, 2011 (90 days from the date of the Determination) a modified plan for Study 1.2, Channel Morphology Downstream of Englebright Dam Study (Study). The Determination also required YCWA to consult with the USFWS, NMFS, CDFG and SWRCB regarding at least parts of the Study, providing them 30 days to review the draft Study plan, and include evidence of consultation in YCWA's final plan filed with FERC.

On December 8, 2011, FERC issued a letter that revised the schedule for filing of the final Study with FERC from December 29, 2011 to March 8, 2012 (70 days from the date of the December 8 letter).

Attached to this e-mail for your review is a draft Study 1.2, Channel Morphology Downstream of Englebright Dam Study in Microsoft Word™ format. We would appreciate your written comments on the draft Study plan no later than close of business on February 15, 2012, 30 days from the date of this e-mail.

We will address your written comments in the Study plan that we file with FERC, and attach your written comments to the Study plan we file. We may call you if we have any questions regarding your comments to be sure we understand them or to reconcile differences.

Note that some other studies for which FERC's Determination required YCWA to consult with agencies are in development and we will transmit our draft of those studies to you when they are available.

Let us know if there is anything we can do to facilitate your review.

If you have any questions about this e-mail, please contact Jim Lynch.

Curt Aikens
General Manager
Yuba County Water Agency
530-741-6278 x115

This e-mail sent on behalf of the above party by:

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ATTACHMENT 1-2C

Written Comments from CDFG, NMFS, and USFWS[16]

[16] YCWA did not receive written comments from the SWRCB within the deadline for providing written comments on the draft modified study.

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Pitts, Sheila

From: Sharon Stohrer [SSTOHRER@dfg.ca.gov]
Sent: Wednesday, February 15, 2012 1:05 PM
To: Lynch, Jim; caikens@ycwa.com
Cc: Beth Lawson; MaryLisa Lynch; Bob Hughes; Sean Hoobler; Dennis E Smith; alison_willy@fws.gov; Pitts, Sheila; John.Wooster@noaa.gov; JParks@waterboards.ca.gov; Geoff Rabone
Subject: Fwd: YRDP: Draft Study 1.2, Channel Morphology Downstream of Englebright_30-Day Review Period
Attachments: Study 01-02 - Channel MorphologyBelow Englebright - DRAFT +dfg edits_2-14-12.doc

Jim and Curt,
Attached is an edited version of the draft Channel Morphology Study (SP 1.2). This draft study plan provides DFG comments in the form of redlined edits to assist YCWA in meeting the requirements set forth in FERC's Study Plan Determination.

Thanks.
Sharon

****
Sharon J. Stohrer
Staff Environmental Scientist
Department of Fish and Game
1701 Nimbus Road
Rancho Cordova, CA 95670
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>>> On 1/16/2012 at 3:54 PM, in message <E78DDEBFA1164B4D9E7976CB920800F81E9A9F69@OMAC-INEXDAG1N4.intranet.hdr>, "Lynch, Jim" <Jim.Lynch@hdrinc.com> wrote:

- YUBA RIVER DEVELOPMENT PROJECT RELICENSING -

Transmittal of Channel Morphology Downstream of Englebright Dam Study (Study 1.2) Plan for 30-Day Review Period

- Written Comments due to YCWA by Close of Business on February 15, 2012 -

On September 30, 2011, FERC's Director of Energy Projects issued a Study Determination related to Yuba County Water Agency's (YCWA) relicensing of its Yuba River Development Project, FERC Project 2246. The Determination required, among other things, that YCWA develop and file with FERC by December 29, 2011 (90 days from the date of the Determination) a modified plan for Study 1.2, Channel Morphology Downstream of Englebright Dam Study (Study). The Determination also required YCWA to consult with the USFWS, NMFS, CDFG and SWRCB regarding at least parts of the Study, providing them 30 days to review the draft Study plan, and include evidence of consultation in YCWA's final plan filed with FERC.

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We will address your written comments in the Study plan that we file with FERC, and attach your written comments to the Study plan we file. We may call you if we have any questions regarding your comments to be sure we understand them or to reconcile differences.

Note that some other studies for which FERC's Determination required YCWA to consult with agencies are in development and we will transmit our draft of those studies to you when they are available.

1

Let us know if there is anything we can do to facilitate your review.

If you have any questions about this e-mail, please contact Jim Lynch.

Curt Aikens
General Manager
Yuba County Water Agency
530-741-6278 x115

This e-mail sent on behalf of the above party by:

Yuba County Water Agency
Yuba River Development Project
FERC Project No. 2246

Study 1.2

CHANNEL MORPHOLOGY DOWNSTREAM OF ENGLEBRIGHT DAM[1,2]

January 2012 + DFG edits 2/14/12

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 downstream of the United States Army Corps of Engineer's (USACE) Englebright Dam.[3]

2.0 Resource Management Goals of Agencies with Jurisdiction Over the Resource to be Studied

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

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 or PAD (YCWA 2010). USFWS's jurisdiction, goals and objectives are not repeated here.

NMFS

NMFS's statutory authorities and responsibilities are described by NMFS in Section 2.0 of Enclosure A in NMFS's March 7, 2011 letter to FERC providing NMFS's comments on YCWA's PAD. NMFS's jurisdiction and responsibilities are not repeated here.

[1] YCWA's included a Channel Morphology Downstream of Englebright Dam Study in its August 2011 Revised Study Plan. FERC's September 30, 2011 Study Determination required modifications to the study. Those modifications have been made in this study plan.

[2] Where this study proposal states that information for the study is being developed by the Lower Yuba River Accord River Management Team (RMT), if the RMT does not develop the information as described in this study proposal, YCWA will develop the information. Also, all information developed as part of the relicensing, whether it is developed in the relicensing process or developed in the RMT process and brought into the relicensing, will be made public when YCWA files its final study report (i.e., study technical memorandum). Further, if this study relies on information from RMT data, report or analytics, YCWA will attach the relevant RMT report to the relicensing final study technical memorandum.

[3] 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.

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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

The goal of the study is to quantify or characterize river form and process in the Yuba River downstream of the Englebright Dam, and to assess potential impacts to the river form and process due to continued operation of the Project.

The objectives of the study are to develop information necessary to meet the study goal. Specifically, the study objectives include development of a quantitative and qualitative understanding of Project effects on: 1) substrate mobility; 2) particle size distribution for salmonid spawning; 3) spawning gravel distribution; and 4) spill flow effects on channel morphology in the Yuba River downstream of Englebright Dam.

4.0 Existing Information and Need for Additional Information

The Yuba River downstream of Englebright Dam has an extensive history of impacts to channel morphology resulting from hydraulic mining activities in the Yuba River watershed. From the late 19th Century through to the early part of the 20th Century, vast amounts of hydraulic mining debris and sediment were deposited in the Yuba River from the confluence of the Feather River upstream for more than 20 miles. Sediment depths at the Narrows were more than 75 feet deep, and more than 15 feet deep near Marysville in the early 20th Century (CDC 1906). While degradation of the river bed commenced in the early 20th Century with the decline in hydraulic mining activity and the construction of various debris dams, several tens of millions of cubic yards of sediment remain in the Yuba River downstream of Englebright Dam (James et al. 2009). Channel processes and changes over the course of the next several decades will largely be a function of the continued degradation of the river bed through layers of mining debris, as the river strives to equilibrate with the base levels associated with geomorphic controls at the Feather River and at Daguerre Point Dam.

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Englebright Dam has been completely effective in blocking the downstream movement of sediment. It is estimated that as much as 17,500 acre-feet (over 28 million cu yards) of sediment is impounded behind Englebright Dam (Childs et al. 2003).

The Yuba River downstream of Englebright Dam is one of the more thoroughly studied rivers in the Central Valley of California. A considerable amount of information relating to the impacts of hydraulic mining and the operation of the Yuba River as an element of the state flood control system has been developed. Additionally, extensive information regarding: 1) geomorphic drivers; 2) landforms and boundary conditions; 3) hydrogeomorphic dynamics; 4) physical habitat and ecological dynamics; and 5) river management actions have been developed through time, and a compendium of the existing information specific to the Yuba River downstream of Englebright Dam is included as Attachment 1.2A to this study proposal.

Information is available from both previously conducted studies dating back to the early 1900s through current information from ongoing data collection, monitoring, and evaluation activities, particularly from the Lower Yuba Accord Monitoring and Evaluation (M&E) Program (RMT 2010). A summary list of recent information currently available includes, but is not limited to:

- Topographic and geologic maps, including a digital elevation model (DEM) of the Yuba River downstream of Englebright Dam (RMT 2010)[4]
- Hydrologic modeling and statistics for the Yuba River (YCWA 2007)
- Operations procedures for Project facilities (YCWA 2009a)
- Physical Habitat Simulation (PHABSIM) habitat modeling of the Yuba River conducted by Beak Consultants for CDFG (Beak 1989)
- Two-dimensional (2D) hydrodynamic habitat modeling (River2D) of 18 sites on the Yuba River conducted by the USFWS (Gard 2007; 2008)
- Two-dimensional hydrodynamic modeling (SRH-2D) of the Yuba River by University of California at Davis (UC Davis) for the River Management Team (RMT 2010)
- Low-altitude aerial video of the Yuba River (YCWA 2009b)
- Spatial Structure Analysis Interim Report for the lower Yuba River by UC Davis for the RMT (RMT 2011)

Information from ongoing data collection, monitoring, and evaluation activities, particularly from the Yuba Accord M&E Program (RMT 2010) addressing geomophological conditions and physical habitat conditions in the Yuba River downstream of Englebright Dam that will be available for the conduct of this study includes, but is not limited to:

- Yuba River Development Project Water Balance/Operations Model (Study 2.2)
- Substrate and cover classification maps of the Yuba River downstream of Englebright Dam to characterize microhabitat and mesohabitat conditions (RMT 2010).

[4] M&E Program documents and work products are located at the RMT's website at www.yubaaccordrmt.com.

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- Spawning habitat data collection information for the lower Yuba River (RMT 2009, 2010, 2011).
- Morphological unit classification map of the lower Yuba River (RMT 2010).
- Discharge-dependent mesohabitat characterization of morphological units of the Yuba River.
- Historic aerials analysis of the Yuba River downstream of Englebright Dam

YCWA believes that sufficient information generally exists to characterize the geomorphologic conditions for the Yuba River downstream of Englebright Dam without the undertaking of additional field study effort.

5.0 Study Methods and Analysis

5.1 Study Area

For the purpose of this study, the study area includes the Yuba River from Englebright Dam to the Feather River.

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, NMFS, 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 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

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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 to 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

This study consists of the following four steps: 1) compile data from previously conducted studies; 2) compile ongoing data collection and information; 3) conduct the analyses necessary to accomplish the previously stated goals and objectives; and 4) prepare report.

5.3.1 Step 1 – Compile Data from Previously Conducted Studies

Information regarding geomorphology in the Yuba River downstream of Englebright Dam will be obtained from previously conducted studies, including the dates and locations of data collection to the extent possible.

5.3.2 Step 2 – Compile Ongoing Data Collection and Information

Data collected during the Yuba Accord M&E Program will be compiled for this study plan report. Data compilation and analyses conducted by the RMT for the Yuba Accord M&E Program will be obtained and utilized from the following ongoing monitoring and evaluation activities associated with the M&E Program Protocols:

- Flow and Water Temperature Monitoring
- Topographic Mapping (Digital Elevation Model) – physical habitat assessment

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

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- Substrate and Cover Mapping – spawning/juvenile rearing habitat characterization
- 2D Hydrodynamic Modeling – physical habitat dynamics and availability
- Morphological unit Classification – meso-scale physical habitat characterization
- Riparian Vegetation Mapping
- Large Woody Material (LWM) frequency and function[6]

5.3.3 Step 3 – Analyze Data

The goal of the study is to quantify or characterize the lower Yuba River form and processes and key contributing factors. The following analyses will be conducted to evaluate the relationship between potential channel morphology issues, data to be compiled by this study, and data analysis that will occur as part of this study.

- Uulize Morphological Unit and Reach Breaks Descriptions
  - A comprehensive analysis of reach breaks and morphological units for the Yuba River downstream of Englebright Dam is currently in review by the RMT, and scheduled for publication in September 2011.

- Sediment Transport Analysis Using Shields-Stress Metric
  - In this approach, the 2D model is being used to simulated hydrodynamics over a wide range of geomorphically relevant discharges. Given that the geometric channel overflows for discharges ranging from about 3,000 to 7,000 cfs, a mid-value of 5,000 cfs is used to represent the near-bankful condition. Relative to that benchmark, flows will be run from 700 to 5,000 cfs for within bankful processes. Also, overbank flows will be run for 7,500, 10,000, 15,000, 21,100, 42,200, 84,400, and 110,400 cfs, which is the maximum observed with the current map and model in hand (from the New Year's 2006 floods). Because the largest floods spill into the Goldfields and the lowermost floodplain region, which is far outside the domain of interest for this study proposal, some reaches may not be feasible to assess with the 2D model at the highest discharges. Once models are run, the sediment transport analysis involves the following steps:
    - ✓ The 2D model automatically calculates bed shear stress at each node using a drag-force equation that is a function of depth, velocity, and model parameters.
    - ✓ Define a representative spawning bed-material size for a heterogeneous gravel/small cobble mixture and calculate the non-dimensional Shields stress (τ^*).
    - ✓ Calculate a spatially distributed, weighted average, mean substrate grain size for each 3 foot by 3 foot cell in the 2D model domain based on the visually estimated grain size distributions from the RMT's 2010 substrate map[7]. Calculate a spatially distributed τ^* using these actual grain size data.

[6] FERC's September 30, 2011, Study Plan Determination directed *"...YCWA modify study 1.2 to include provisions for describing how LWD functions as a geomorphic control and forcing mechanism in the lower Yuba River. We note that with our recommendations, the proposed study 6.2 would provide information regarding LWD frequency in the lower Yuba River"* (Appendix A, p.4). YCWA has added language as directed by FERC.

[7] FERC's September 30, 2011, Study Plan Determination directed that *"...YCWA include an analysis of bed mobility/sediment transport analysis using the actual grain size distribution of the existing bed surface substrate maps as requested by NMFS in*

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- ✓ Shields stress values are binned where values of τ^* less than 0.01 correspond to negligible transport, 0.01 less than τ^* less than 0.03 correspond to intermittent entrainment, 0.03 less than τ^* les than 0.06 corresponds to partial transport, and τ^* greater than 0.06 corresponds to full transport of a carpet of sediment 1-2 D_{90} thick, where D_{90} is the size that 90 percent of the surficial bed material is smaller than.
- ✓ Use the available hydraulic regime to estimate the local critical particle size at the incipient-motion threshold for a given reach, wherein a Shields stress of 0.045 is utilized to identify the initiation of motion for particles size(s) of interest.

- Geomorphic Process Flows
  - ➢ Calculate return interval and duration analysis of flows that achieve full bed mobility for greater than 50 percent of the area of each of the following morphological units (except for those determined to not meet this threshold within the range of floods simulated): pools, riffles, lateral bars, and point bars.
  - ➢ Calculate return interval and duration analysis of flows that achieve full bed mobility for greater than 50 percent of the area of each reach

- Sediment Export Analysis
  - ➢ Develop DEMs and uncertainty-adjusted DoD's ("DEM of Difference") for all reaches in the study area for the 1999 to 2009 period, which is the period when suitably accurate elevation data is available for the river. Based on a thorough uncertainty assessment, the best uncertainty adjustment involves subtracting all deviations less than the half-contour interval of the 1999 count-based DEM (i.e., 1 ft cut-off) and subtracting all deviations below a "level of detection" at the 95 percent confidence interval.
  - ➢ Calculate total deposition, total scour, and net change, which must be scour, given that there is no significant source of sediment below Englebright Dam for each reach and morphological unit in the study area.
  - ➢ Use a mass balance equation to track downstream changes in sediment volume using the DoDs.
  - ➢ Calculate the annual rate of change in sediment export by dividing the 10-year volumetric total by 10, which assumes equal export for each year.[8]

- Channel Morphology Adjustments[9]
  - ➢ Analyze the entire DoD raster to evaluate how topographic change varies between (a) in-channel versus out-of-channel, (b) in vegetated versus non-vegetated pixels, (c) above versus below DPD, and (b) different morphological units.
  - ➢ Assess which morphological units (as identified in the 2009 map) are experiencing the most cut and most fill using the DoDs.

---

its Request # 4, Element # 4: Calculation of Bed Mobility and Sediment Transport Capacity." (Appendix A, p. 8). YCWA made the modifications as directed by FERC.

[8] FERC's September 30, 2011, Study Plan Determination directed that *"YCWA modify its study plan in accordance with study NMFS-4 Element #6, as outlined above…"* (Appendix A, p. 6). NMFS requested that *"…YCWA calculate the annual rate of change in sediment export."* (Appendix A, p. 5). YCWA has made the modification as directed by FERC.

[9] FERC's September 30, 2011, Study Plan Determination directed that *"YCWA modify its study plan in accordance with study NMFS-4 Element #6, as outlined above…"* (Appendix A, p. 6). NMFS requested that *"…YCWA compare export amounts and morphologic unit adjustments to estimates of sediment volumes stored in the lower Yuba River and each geomorphic reach.."* (Appendix A, p. 5). YCWA has made the modifications as directed by FERC.

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- Using the available DEM difference analysis from 1999 to 2009, the gross cut and fill volumes for each reach beginning at the top of Timbuctoo Bend where the alluvial valley begins will be used to produce a flow chart of the export and storage of sediment by reach down to the confluence with the Feather River (6 reaches in all).

- Characterization Of Substrate Distribution (Can be analyzed using existing substrate maps and spawning substrate measurement to assess):
  - Relative substrate distribution by reach
  - Relative substrate distribution by morphologic unit.
  - Substrate size distribution for spawning

- Characterization of LWM Presence and Distribution:
  - YCWA's Riparian Habitat Downstream of Englebright Dam Study (Study 6.2) will collect on-the-ground counts of LWM in the lower Yuba River. YCWA will use that information to: 1) provide a 'snapshot' inventory of LWM pieces; 2) using simple longitudinal distribution analysis, assess whether the longitudinal distribution of LWM is random or organized; 3) stratify LWM by reach and morphological unit to assess what landforms it tends to be associated with; 4) intersect LWM polygons with wetted area polygons up to 5,000 cfs to determine what flows access available LWM; and 5) using the above information, discuss geomorphic function and forcing mechanism of LWM in the lower Yuba River.

5.3.4 Step 4 – 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:

- Map of Yuba River downstream of Englebright Dam (*.PDF format) including topography, substrate, riparian vegetation, LWM, and other river features
- Floodplain inundation map, showing inundation area at 1:1, 1:2, 1:5, 1:10 and 1:20 return interval flood flows
- Summary of particle size distributions by reach (including substrate size distributions specific for salmonid spawning)
- Summary of riparian condition.
- Summary of LWD quantity and function.
- 2D model output in GIS 3x3' raster of the spatial pattern of shear stress.[10]

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[10] FERC's September 30, 2011, Study Plan Determination directed that *"YCWA modify its study plan in accordance with study NMFS-4 Element "6, as outlined above…"* (Appendix A, p. 6). NMFS requested that *"…YCWA provide GIS and tabular formats when providing hydraulic/sediment transport input and output files."* (Appendix A, p.5). YCWA has made the modification as directed by FERC.

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- Input variables of grain size and Shields parameter used in each raster used to create the sediment transport regime for each reach.
- Executable folders, data file with details of each model run, and control file with miscellaneous parameters.
- Stage/discharge tables
- Summary and graphic presentation of sediment mobility assessment (based on Shield's stress approach).

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6.0 Study-Specific Consultation

This study does not require any study-specific consultation.

7.0 Schedule

FERC's December 8, 2011 letter required that YCWA provide a modified study to FERC for approval no later than March 8, 2012. The schedule provided below assumes FERC will approve the modified study no later than mid March 2012.

Compile Data from Previous Studies (Step 1)..... March - May 2012
Compile Data from Ongoing Studies (Step 2)..... May - July 2012
Analysis (Step 3)..... July - August 2012
Prepare Report (Step 4)..... August - September 2012

8.0 Consistency of Methodology with Generally Accepted Scientific Practices

The methods presented in this study plan are consistent with other generally accepted scientific study methods concerning geomorphological function assessment, including those conducted by the Resource Agencies in California.

9.0 Level of Effort and Cost

YCWA estimates the cost to complete this study in 2011 dollars is between $110,000 and $150,000.[11]

10.0 Attachments

This study plan includes four attachments:

[11] YCWA's Channel Morphology Downstream of Englebright Dam Study in its August 2011 Revised Study Plan had an estimate cost range of between $90,000 and $120,000. With the modifications required by FERC in its September 30, 2011 Study Determination, the estimated cost range is between $110,000 and $150,000.

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Attachment 1-2A Channel Morphology Downstream of Englebright Dam – Existing Information Summary

Attachment 1-2B Documentation of Transmittal of Draft Study Plan to NMFS, USFWS, SWRCB and CDFG for 30-Day Review and Comment

Attachment 1-2C Written Comments from NMFS, USFWS, SWRCB and CDFG

Attachment 1-2D YCWA's Reply to Written Comments

[USFWS, NMFS, CDFG and SWRCB – Attachments 6-2B, 6-2C and 6-2D are not included in this draft, but will be included in the modified Study filed with FERC. YCWA]

11.0 References Cited

Beak Consultants, Inc. (Beak). 1989. Yuba River Fisheries Investigations, 1986-88, Summary Report Of Technical Studies On The Lower Yuba River, California. Prepared for California State Agencies Department of Fish and Game

California Debris Commission (CDC). 1906. Map of the Yuba River, California from the Narrows to its mouth in the Feather River. Made under direction of Major Wm. W. Harts, U.S. Army Corps of Engineers, by G.G. McDaniel, Jr., August to Nov., 1906: scale 1:9,600.

Childs, J.R., N.P. Snyder, and M.A. Hampton. 2003. Bathymetric and geophysical surveys of Englebright Lake, Yuba-Nevada Counties, California US Geological Survey Open-File Report 03-383.

Gard, M. 2007. Flow-habitat relationships for spring and fall-run Chinook salmon and steelhead/rainbow trout spawning in the Yuba River. Draft report prepared by the Energy Planning and Instream Flow Branch of the USFWS, Sacramento, California. April 19, 2007.

____ 2008. Flow-habitat relationships for juvenile spring/fall-run chinook salmon and steelhead/rainbow trout rearing in the Yuba River. Draft report prepared by the Energy Planning and Instream Flow Branch of the USFWS, Sacramento, California. August 12, 2008.

James, L.A., M.B. Singer, S. Ghoshal and M. Megison. 2009. Historical channel changes in the lower Yuba and Feather Rivers, California: Long-term effects of contrasting river-management strategies, in James, L.A., Rathburn, S.L., and Whittecar, G.R., eds., Management and Restoration of Fluvial Systems with Broad Historical Changes and Human Impacts: Geological Society of America Special Paper 451, p. 57–81, doi: 10.1130/2008.2451(04).

Yuba Accord River Management Team (RMT). 2010. Lower Yuba River Accord Monitoring and Evaluation Program. Draft. June 28, 2010. Individuals who comprise the RMT and are the principal authors: P. Bratovich (YCWA/HDR), T. McReynolds (CDFG), B.

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Elliott (NMFS), E. Campbell (USFWS), E. Geary (PG&E), and G. Reedy (SYRCL – NGO's)

____ 2009a. Preliminary Information Package Public Information. Yuba River Development Project Relicensing FERC Project No. 2246. ©September 2009, Yuba County Water Agency.]

____ 2009b. Helicopter Video. Yuba County Water Agency, Yuba River Development Project (FERC Project No. 2246). Taped 7.07.09; Edited 09.16.09. Public Information. ©2010 Yuba County Water Agency.

_____ 2010. Yuba River Development Project relicensing Pre-Application Document. Yuba County Water Agency, Marysville, CA. http://www.ycwa-relicensing.com.

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Pitts, Sheila

From: John Wooster [john.wooster@noaa.gov]
Sent: Wednesday, February 15, 2012 4:46 PM
To: Lynch, Jim
Cc: caikens@ycwa.com; Beth Lawson; MaryLisa Lynch; Bob Hughes; Sean Hoobler; Dennis E Smith; alison_willy@fws.gov; Pitts, Sheila; JParks@waterboards.ca.gov; Geoff Rabone; Sharon Stohrer; Kenneth Hogan; Alan Mitchnick; Larry Thompson; Richard Wantuck; Thomas Holley
Subject: Re: YRDP: Draft Study 1.2, Channel Morphology Downstream of Englebright_30-Day Review Period

Jim:

NMFS is also in favor of the comments Sharon /DFG provided.

The primary comment that I have pertaining to the latest draft Study 1.2, is the lack of specifying which of the 8 geomorphic reaches will the data analyses (there are 7 bullets) under section 5.3.3 be applied to. The vast majority of these data analyses bullets do not call out where they will be conducted, with the one exception being the arrow for DEM differencing for cut and fill under the channel adjustments bullet which describes that analysis as Timbuctoo Bend and downstream. While the Study Area is described as Englebright Dam to the Feather River confluence, due to 2D model limitations I am assuming YCWA is not intending to ubiquitously apply the listed analyses throughout the study area. For example, as far as I am aware of, there is not a 2D model for the Narrows Reach, which will likely prohibit calculating some of the listed analyses but other analyses or partial analyses may still be possible (such as substrate characterization and LWM characterization/function). Additional uncertainty also pertains to the Englebright Dam Reach where the existing 2D model is a somewhat separate domain and generation of input data collection from the larger model that goes from Timbuctoo Bend to the Feather River (i.e., it is not clear if all of the modeling related analyses will be done in Englebright Dam Reach too).

Many of the analyses and calculations presented in this study plan are relying on existing data or other studies being undertaken outside of the FERC process (i.e., RMT studies), which makes it difficult for RPs to comment on which analyses should go with which reach - without the full knowledge of the limitations/capabilities/geographic scope of these outside data sources. However, NMFS does believe that all of the listed data analyses are relevant to all of the reaches, and as such should be calculated/applied within all of the geomorphic reaches to the extent possible.

NMFS requests that Study 1.2 be modified with detail to list which data analyses will be applied to which geomorphic reach, and subsequently allow the RPs another opportunity to review the study plan once it can be determined where the analyses will be applied and potential data gaps can be identified.

Thank you for the opportunity to comment on the study plan.

-John Wooster
National Marine Fisheries Service

On Wed, Feb 15, 2012 at 1:05 PM, Sharon Stohrer <SSTOHRER@dfg.ca.gov> wrote:

> Jim and Curt,
> Attached is an edited version of the draft Channel Morphology Study (SP 1.2). This draft study plan provides DFG comments in the form of redlined edits to assist YCWA in meeting the requirements set forth in FERC's Study Plan Determination.

1

Thanks.
Sharon

****
Sharon J. Stohrer
Staff Environmental Scientist
Department of Fish and Game
1701 Nimbus Road
Rancho Cordova, CA 95670
(916) 358-2384

>>> On 1/16/2012 at 3:54 PM, in message <E78DDEBFA1164B4D9E7976CB920800F81E9A9F69@OMAC-INEXDAG1N4.intranet.hdr>, "Lynch, Jim" <Jim.Lynch@hdrinc.com> wrote:

- YUBA RIVER DEVELOPMENT PROJECT RELICENSING -

Transmittal of Channel Morphology Downstream of Englebright Dam Study (Study 1.2) Plan for 30-Day Review Period

- Written Comments due to YCWA by Close of Business on February 15, 2012 -

On September 30, 2011, FERC's Director of Energy Projects issued a Study Determination related to Yuba County Water Agency's (YCWA) relicensing of its Yuba River Development Project, FERC Project 2246. The Determination required, among other things, that YCWA develop and file with FERC by December 29, 2011 (90 days from the date of the Determination) a modified plan for Study 1.2, Channel Morphology Downstream of Englebright Dam Study (Study). The Determination also required YCWA to consult with the USFWS, NMFS, CDFG and SWRCB regarding at least parts of the Study, providing them 30 days to review the draft Study plan, and include evidence of consultation in YCWA's final plan filed with FERC.

On December 8, 2011, FERC issued a letter that revised the schedule for filing of the final Study with FERC from December 29, 2011 to March 8, 2012 (70 days from the date of the December 8 letter).

Attached to this e-mail for your review is a draft Study 1.2, Channel Morphology Downstream of Englebright Dam Study in Microsoft Word™ format. We would appreciate your written comments on the draft Study plan no later than close of business on February 15, 2012, 30 days from the date of this e-mail.

We will address your written comments in the Study plan that we file with FERC, and attach your written comments to the Study plan we file. We may call you if we have any questions regarding your comments to be sure we understand them or to reconcile differences.

Note that some other studies for which FERC's Determination required YCWA to consult with agencies are in development and we will transmit our draft of those studies to you when they are available.

2

Let us know if there is anything we can do to facilitate your review.

If you have any questions about this e-mail, please contact Jim Lynch.

Curt Aikens

General Manager

Yuba County Water Agency

530-741-6278 x115

This e-mail sent on behalf of the above party by:

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

In Reply Refer To:

FEB 16 2012

Ms. Kimberly Bose, Secretary
Federal Energy Regulatory Commission
888 First Street NE
Washington, DC 20426

Subject: U.S. Fish and Wildlife Service Comments on Study Plan Determination Modifications for Study 1.2 Channel Morphology Downstream of Englebright Dam, Study 6.2 Riparian Habitat Downstream of Englebright Dam, and Study 7.12 Project Effects on Fish Facilities Associated with Daguerre Point Dam for the Yuba River Hydroelectric Project, Federal Energy Regulatory Commission Project 2246-058; Yuba, Sierra, and Nevada Counties, California

Dear Ms. Bose:

On September 30, 2011, the Director of Energy Projects for the Federal Energy Regulatory Commission (Commission or FERC) issued a Study Plan Determination for the Yuba County Water Agency's (YCWA or Applicant) application for new licensing of its Yuba River Hydroelectric Project, FERC Project 2246-058 (Project). The Determination required, among other things, that YCWA develop and file with FERC by December 29, 2011 (90 days from the date of the Determination) a modified plan for Study 1.2 Channel Morphology Downstream of Englebright Dam, Study 6.2 Riparian Habitat Downstream of Englebright Dam, and a new Study based on NMFS-1, Element #3 and #8, Evaluation of Project Effects on DaGuerre Point Dam's Fish Facilities. The Determination also required YCWA to consult with the U.S. Fish and Wildlife Service (Service or USFWS), the National Marine Fisheries Service (NMFS), California Department of Fish and Game (CDFG), and the California State Water Resources Control Board (SWRCB) regarding at least parts of the aforementioned studies, providing them 30 days to review the draft Study plan modifications, and incorporate or address any resource agency comments into the final plan filed with FERC. By letter filed October 28, 2011, YCWA requested a change in the deadline for filing some of the modified and new study plans, including Studies 1.2, 6.2 and a newly designated 7.12 that was based on NMFS-1(and which was referenced as Study 6.12 in YCWA's request). On December 8, 2011, FERC issued a letter that revised the schedule for filing of the final Study plans with FERC from December 29, 2011 to March 8, 2012 (70 days from the date of the December 8th letter).

As noted above, the Commission's Study Plan Determination required YCWA to allow at least thirty days for agency comment on the proposed modifications to the study plans. The following constitute the Service's comments on the proposed modifications to the above Study Plans. The Service submits these comments and recommendations under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq.*), the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*), and the Federal Power Act (FPA) (16 U.S.C. § 791a, *et seq.*).

The information requested will inform the Service and the Commission in determining: (1) the effects of the Project on juvenile rearing of Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) in the lower river, because Project operations directly affect the amount and quality of rearing habitat available to Chinook salmon and steelhead; and (2) the extent that Project operations impede or otherwise influence upstream and downstream passage of Chinook salmon and steelhead adults and juveniles through the fish facilities at Daguerre Point Dam. The utility of implementing studies 1.2, 6.2, and 7.12 as they are currently described is unclear due to their generally broad goals and objectives and their lack of specificity. The Applicant needs to adequately describe the nexus between Project operations and effects (direct, indirect, and cumulative) on the resource to be studied (18 CFR § 5.11(d)(4)). The Project effects (direct, indirect, and/or cumulative) on in-channel habitat, riparian habitat, and fish passage should be described in further detail in each of the respective studies (18 CFR § 5.11(d)(4)).

Comments on Study Plan Determination Modifications

Study 1.2 – Channel Morphology Below Englebright

General Comment No. 1:

This is a very thorough study that proposes to primarily analyze sediment transport dynamics (i.e., erosion and deposition) over multiple scales. However, the title of Study 1.2: "Channel Morphology Downstream of Englebright Dam," is misleading, as Study 1.2 appears to be primarily focused on sediment transport dynamics as related to the contemporary Project-induced flow regime. Specifically, the study goals and objectives (Section 3.0) only mention "sediment dynamics" (i.e., substrate mobility; particle size distribution for salmonid spawning; spawning gravel distribution) and "spill flow effects on channel morphology in the Yuba River downstream of Englebright Dam" as the primary objectives. Furthermore, under the Study Methods section 5.3, floodplain (through 2D Hydrodynamic modeling), riparian, and large woody material (LWM) are all mentioned as components of the ongoing information collection effort to be utilized in Study 1.2. These processes are fundamental to any "channel morphology study" of a river system (Montgomery and Buffington 1998, Church 2002, Poole 2002, Montgomery and Piegay 2003, Kondolf et al. 2006), especially as they relate to aquatic habitat and fisheries (Schlosser 1991, Maddock 1999, Fausch et al. 2002, Thorp et al. 2006) and should be stated as such up front. However, no mention of any of these analyses is presented within the opening sections and they are not mentioned as specific objectives. Such geomorphological processes are fundamental to the currently stated goal of Study 1.2, which is to "quantify or characterize river form and process in the Yuba River downstream of the Englebright Dam, and

to assess potential impacts to the river form and process due to continued operation of the Project."

If Study 1.2 is to address all the elements of channel morphology, the Service suggests that these processes should be either included as part of the study objectives, or a new objective should be added specifically explaining that a synthesis of Study 1.2 with other studies (e.g., Study 6.2 - Riparian Habitat, Large Woody Material, Substrate and Cover Mapping) will be developed. For clarity purposes, the Service suggests describing these additional elements in more detail in Section 3.0.

General Comment No. 2:

The Applicant needs to adequately describe the nexus between Project operations and effects (direct, indirect, and cumulative) on the resource to be studied (18 CFR § 5.11(d)(4)). The Applicant also needs to further explain the Project effects (direct, indirect, and/or cumulative) on channel morphology downstream of Englebright Dam (CFR 18 § 5.11(d)(4)). The Applicant states that the continued operation and maintenance of the Project has the "potential" to affect channel morphology and fluvial processes but does not elaborate or explain how these processes are important to the various resources (i.e., T&E species, aquatic species, riparian plants, wildlife resources, migratory birds, etc.).

Study 6.2 – Riparian Habitat Below Englebright

General Comments:

We already suspect or know anecdotally and from a few cursory surveys that very few cottonwoods (mostly old) occur on the lower Yuba River, and that most of the willows are the shrubby, quick-colonizing species rather than the tree-like species. This study includes the necessary step of documenting the above existing conditions. More critical, however, the study should examine the effects of YCWA actions on cottonwood recruitment in the lower Yuba River. The effects of flow regime on cottonwood recruitment have been effectively studied in the Sacramento River (e.g., Roberts et al. 2002) and some of the same mechanisms may be at work in the lower Yuba River. However, non-flow related characteristics of the lower Yuba River (e.g., lack of fines, lack of sufficient parental stock, etc.) also may be limiting. It is not clear how the second objective of evaluating "trends in riparian health and factors contributing to riparian conditions in the Study Area" will be meaningfully accomplished with this study, as doing so would require parsing the effects of flow, substrate, parental stock, and other factors. The study objectives and methods should be refocused to conduct this sort of limiting factors analysis so Project effects can be identified.

Specific Comments:

Section 5.2 (General Concepts and Procedures).

Regarding the Global Positioning System (GPS) data collection methods (6th bullet): Will the selected 3 meter level of accuracy meet metadata requirements for use in ESRI Shapefiles and

GeoDatabases? Will map grade, survey grade, or recreation grade GPS units be needed? These vary in data quality and need to be selected beforehand. This comment also applies to Section 5.3.1.3.1 (Vegetation Mapping).
Regarding minimizing the chance of spreading non-native invasive species (8th bullet): It would be useful to develop and implement a Hazard Analysis Critical Control Point (HACCP) Plan which would indicate that zebra mussels are not a concern relative to this proposed study but that New Zealand mudsnails are a concern.

Section 5.3.1.1 (Step 1—Site Selection): The "wetted edge of the river" would be variable depending on water year and existing flow. An explicit methodology for addressing in-channel gravel bars, floodplain and emergent vegetation should be developed, and potential limitations of this protocol should be acknowledged.

Section 5.3.1.3.3 (Digital Elevation Model Topographic Map and Hydrodynamic Model): It is unclear what is meant by determining "vegetation types by heights." The usefulness of the existing LiDAR data set (now a few years old) for the lower Yuba River in classifying riparian vegetation types is still unclear. A recent symposium focusing on this data indicated difficulty in identifying species. Accuracy is much better for taller, isolated trees and is worse for smaller shrubby species. Cottonwood, Sycamore, Willow, and Other classes can be distinguished with "fair accuracy." New LiDAR technology is supposed to be much better.

Study 7.12 – Project Effects on Fish Facilities Associated with Daguerre Point Dam

General Comments:

As the Service indicated in its comments on the Preliminary Application Document (dated March 7, 2011), "the raised water elevation created by Daguerre Point Dam allows YCWA to divert water into the Browns Valley, Hallwood-Cordua, and South Yuba-Brophy diversions." Therefore, it is unclear why Project effects on the operation of the Hallwood-Cordua diversion fish screen are being addressed in this study and not the effects on South Yuba-Brophy and Browns Valley diversion fish screens. All three diversions rely on the presence of Daguerre Point Dam and screen efficiency may be affected by Project operations. Additionally, the Applicant should include an assessment on how the Project directly affects juvenile Chinook salmon and steelhead as outmigrants pass over Daguerre Point Dam. Juvenile mortality from predation as outmigrants pass over Daguerre Point Dam and improving efficiency of fish screening devices and fish bypasses were identified as limiting factors by the Service in the Final Restoration Plan for the Anadromous Fish Restoration Program (AFRP) (USFWS 1995, 2001), a comprehensive plan that has been filed with the Commission pursuant to §10(a)(2) of the Federal Power Act, 16 U.S.C. section 803(a)(2)(A). Consequently, all the existing information on the Project effects that are associated with Daguerre Point Dam that are described in both the AFRP Working Paper (USFWS 1995) and the Final Restoration Plan (USFWS 2001) should be included in Section 4.0 of the study plan and evaluated accordingly.

It is not clear how the various steps of Phase 1 of the proposed study will achieve its stated goal of determining if the Project adversely impacts "the efficiency of the fish facilities as designed." The potential impacts of the Project are described as "unknown," yet several are identified for consideration under Phase 2 which is proposed to occur only if "YCWA and Relicensing Participants collaboratively agree" that it should. Furthermore, the Applicant should elaborate and develop specific study objectives in Section 3.0. This should include a site specific assessment on each of the affected facilities as a separate objective (i.e., Daguerre Point Dam fish ladder, Daguerre Point Dam, Hallwood-Cordua Diversion fish screen, South Yuba-Brophy diversions, etc.).

The ideas identified for consideration under Phase 2 (e.g., examination of bathymetric and hydraulic profiles) actually can be investigated under Phase 1 using existing data (e.g., Deas 1999; USFWS 2010a,b,c; and mapping and modeling data available from the Yuba Accord River Management Team). Phase 1 of this study should be revised with this as its focus.

Specific Comments:

Section 5.3.1 (Phase 1 – Desktop Assessment): The term/concept "efficiency of the fish facilities" should be explained more fully. It is not clear how the activities described in this and subsequent steps will achieve the stated purpose of Phase 1. Presumably, the study is trying to identify what the potential adverse effects of the Yuba River Hydroelectric Project are on adult upstream fish passage, juvenile fish entrainment, or fish screen efficiency. Stating some hypotheses would greatly benefit this section and help direct the study.

Section 5.3.1.2 (Step 2 – Analysis of Collected Data): Simply describing and characterizing operations will not achieve the stated goal of this study. The real focus of this study should be to assess the effects of overall Project operation on the flow, stage, head difference, depth-velocity patterns, and temperature at Daguerre Point Dam.

Section 5.3.1 (Phase 2 – Field Assessment): Despite stating that the potential effects of the Project are "unknown," we do have some idea about what the potential effects might be. For example, Project operations may affect adult passage timing through the fish ladders by affecting attraction flows or the number and timing of juveniles entrained or bypassed in the Hallwood-Cordua diversion facility.

Conclusion

With some revision, the three proposed studies comprising the Study Plan Determination modifications have the potential to provide valuable results that will inform the development of Project license conditions. The Service has worked closely with other resource agencies and the Applicant, in order to design studies that would measure Project-level effects in a scientifically defensible manner and at a reasonable cost. The Service has worked with the Applicant in seeking solutions to Study Plan deficiencies and we appreciate the collaborative discussions in which all participants have engaged.

If you have any questions regarding this response, please contact Deborah Giglio of my staff at (916) 414-6600.

Sincerely,

Daniel Welsh
Assistant Field Supervisor

Enclosures

cc:
FERC #2246 Service List, Yuba River Hydroelectric Project

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USFWS. 2010b. Flow-habitat relationships for juvenile fall/spring-run Chinook salmon and steelhead/rainbow trout rearing in the Yuba River. Sacramento Fish and Wildlife Office, Planning and Instream Flow Branch. October 8, 2010.

USFWS. 2010c. Relationships between flow fluctuations and redd dewatering and juvenile stranding for Chinook salmon and steelhead/rainbow trout in the Yuba River. Sacramento Fish and Wildlife Office, Planning and Instream Flow Branch. September 15, 2010.

BEFORE THE
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

CERTIFICATE OF SERVICE

I hereby certify that U.S. Fish and Wildlife Service Comments on Study Plan Determination Modifications for Study 1.2 Channel Morphology Downstream of Englebright Dam, Study 6.2 Riparian Habitat Downstream of Englebright Dam, and Study 7.12 Project Effects on Fish Facilities Associated with Daguerre Point Dam for the Yuba River Hydroelectric Project, Federal Energy Regulatory Commission Project No. P-2246-058, Yuba, Sierra, and Nevada Counties, California has this day been electronically filed with the Federal Energy Regulatory Commission and electronically served on Parties indicating a willingness to receive electronic service and served, via deposit in U.S. mail, first-class postage paid, upon each other person designated on the service list for Project #2246-058 compiled by the Commission Secretary.

Dated at Sacramento, California, this 16th February, 2012.

Name: Heeja Seto
Heeja Seto
U.S. Fish and Wildlife Service
2800 Cottage Way, Rm. W-2605
Sacramento, CA 95825
(916) 414-6600

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ATTACHMENT 1-2D

YCWA's Reply to Written Comments

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March 8, 2012

Electronically Transmitted

Kent Smith
Regional Manager
State of California – The Natural Resources Agency, Department of Fish and Game
1701 Nimbus Road, Suite A
Rancho Cordova, CA 95670

Subject: Yuba River Development Project
FERC Project No. 2246-058
Reply to Comments on YCWA's
Modified Study 1.2, Channel Morphology Downstream of Englebright Dam

Dear Mr. Smith:

On September 30, 2011, the Federal Energy Regulatory Commission's (FERC) Director of the Office of Energy Projects (Director) issued a Study Plan Determination (Determination) related to Yuba County Water Agency's (YCWA) relicensing of its Yuba River Development Project, FERC Project 2246.

The Determination required, in part, that YCWA modify its proposed Study 2.1, Channel Morphology Downstream of Englebright Dam (Study) and file the modified Study with FERC within 90 days of the date of FERC's letter (i.e., by December 29, 2011), allowing at least 30 days for comment by agencies. The Determination required YCWA include in its filing copies of agency's comments, a discussion of how comments were addressed, and reason for not adopting any agency recommendations.

In a letter dated December 8, 2011, FERC amended the deadline to March 8, 2012 for YCWA to file its modified Study.

YCWA modified the Study as directed by the Determination and, on January 16, 2012, provided the draft modified Study for 30-day review and comment to the United States Department of Interior, Fish and Wildlife Service (USFWS); United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS); California Department of Fish and Game (CDFG); and State Water Resources Control Board (SWRCB).

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NMFS and CDFG each provided comments in e-mails dated February 15, 2012, respectively. USFWS did not provide written comments to YCWA, but filed a letter with FERC date February 16, 2012. That letter included comments on the Study. SWRCB did not provide written comments.

Provided below is YCWA's reply to CDFG's two comments regarding the draft modified Study. For ease of reference, YCWA has duplicated the comment and then provided its reply indicating whether YCWA has adopted the comment, adopted the comment with modification, or did not adopt the comment.

YCWA files this letters with FERC as part of the revised Study.

COMMENTS AND REPLIES

CDFG-1: Insert "*LWM*" in the first bullet in Section 5.3.4, Prepare Report. (Page 8 of 10 of the redline attachment to CDFG's February 15, 2012 e-mail)

YCWA's Reply: ADOPTED. CDFG requested a map of the lower Yuba River including the location of LWM. A map showing the LWM data collected as set out in Study 6.2 Riparian Habitat Downstream Englebright Dam will be included as part of the report.

CDFG-2: Insert the following bullet in Section 5.3.4, Prepare Report: "*Summary of particle size distributions by reach (including substrate size distributions specific for salmonid spawning*)" (Page 8 of 10 of the redline attachment to CDFG's February 15, 2012 e-mail)

YCWA's Reply: ADOPTED. A summary of particle size distribution, including size distributions specific for salmonid spawning, will be provided by reach where such data are collected in the technical memorandum prepared for the Study.

CDFG-3: Insert the following bullet in Section 5.3.4, Prepare Report: "*Summary and graphic presentation of sediment mobility assessment (based on Shield's stress approach).*" (Page 9 of 10 of the redline attachment to CDFG's February 15, 2012 e-mail)

YCWA's Reply: ADOPTED WITH MODIFICATION. An analysis and summary of sediment mobility based on Shield's stress approach will be provided by reach where such data are collected in the technical memorandum prepared for the Study.

Mr. Smith
March 8, 2012
Page 3 of 3

If you have any questions regarding this matter, please contact me

Sincerely,
YUBA COUNTY WATER AGENCY

Curt Aikens
General Manager

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March 8, 2012

Electronically Transmitted

John Wooster
United States Department of Commerce
National Marine Fisheries Service
650 Capitol Mall, Suite 5-100
Sacramento, CA 95814

Subject: Yuba River Development Project
FERC Project No. 2246-058
Reply to Comments on YCWA's
Modified Study 1.2, Channel Morphology Downstream of Englebright Dam

Dear Mr. Wooster:

On September 30, 2011, the Federal Energy Regulatory Commission's (FERC) Director of the Office of Energy Projects (Director) issued a Study Plan Determination (Determination) related to Yuba County Water Agency's (YCWA) relicensing of its Yuba River Development Project, FERC Project 2246.

The Determination required, in part, that YCWA modify its proposed Study 2.1, Channel Morphology Downstream of Englebright Dam (Study) and file the modified Study with FERC within 90 days of the date of FERC's letter (i.e., by December 29, 2011), allowing at least 30 days for comment by agencies. The Determination required YCWA include in its filing copies of agency's comments, a discussion of how comments were addressed, and reason for not adopting any agency recommendations.

In a letter dated December 8, 2011, FERC amended the deadline to March 8, 2012 for YCWA to file its modified Study.

YCWA modified the Study as directed by the Determination and, on January 16, 2012, provided the draft modified Study for 30-day review and comment to the United States Department of Interior, Fish and Wildlife Service (USFWS); United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS); California Department of Fish and Game (CDFG); and State Water Resources Control Board (SWRCB).

NMFS and CDFG each provided comments in e-mails dated February 15, 2012, respectively. USFWS did not provide written comments to YCWA, but filed a letter with FERC dated

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February 16, 2012. That letter included comments on the Study. SWRCB did not provide written comments.

Provided below is YCWA's reply to the three comments in NMFS's e-mail. For ease of reference, YCWA has duplicated the comment and then provided its reply indicating whether YCWA has adopted the comment, adopted the comment with modification, or did not adopt the comment.

YCWA files this letters with FERC as part of the revised Study.

COMMENTS AND REPLIES

NMFS-1: *"NMFS is also in favor of the comments Sharon /DFG provided. The primary comment that I have pertaining to the latest draft Study 1.2, is the lack of specifying which of the 8 geomorphic reaches will the data analyses (there are 7 bullets) under section 5.3.3 be applied to. The vast majority of these data analyses bullets do not call out where they will be conducted, with the one exception being the arrow for DEM differencing for cut and fill under the channel adjustments bullet which describes that analysis as Timbuctoo Bend and downstream. While the Study Area is described as Englebright Dam to the Feather River confluence, due to 2D model limitations I am assuming YCWA is not intending to ubiquitously apply the listed analyses throughout the study area. For example, as far as I am aware of, there is not a 2D model for the Narrows Reach, which will likely prohibit calculating some of the listed analyses but other analyses or partial analyses may still be possible (such as substrate characterization and LWM characterization/function). Additional uncertainty also pertains to the Englebright Dam Reach where the existing 2D model is a somewhat separate domain and generation of input data collection from the larger model that goes from Timbuctoo Bend to the Feather River (i.e., it is not clear if all of the modeling related analyses will be done in Englebright Dam Reach too)."* (NMFS's February 15, 2012 e-mail)

YCWA's Reply: ADOPTED WITH MODIFICATION. The specific reaches where the analysis described in the Study will be performed have been listed in Section 5.1 of the Study Plan. Section 5.3.3 has been modified to clarify that 2D modeling will be performed for the entire Lower Yuba River, where 2D modeling is feasible (Section 5.3.3), and includes all reaches but the Narrows Reach. EDR is in all analyses, except any requiring topographic change detection, as there was no map of EDR in 1999.

NMFS-2: *"Many of the analyses and calculations presented in this study plan are relying on existing data or other studies being undertaken outside of the FERC process (i.e., RMT studies), which makes it difficult for RPs to comment on which analyses should go with which reach - without the full knowledge of the limitations/capabilities/geographic scope of these outside data sources. However, NMFS does believe that all of the listed data analyses are relevant to all of the reaches, and as such should be calculated/applied within all of the geomorphic reaches to the extent possible."* (NMFS's February 15, 2012 e-mail)

YCWA's Reply: ADOPTED WITH MODIFICATION. See reply to NMFS-1, wherein it is described what reaches will be analyzed.

NMFS-3: "*Many of the NMFS requests that Study 1.2 be modified with detail to list which data analyses will be applied to which geomorphic reach, and subsequently allow the RPs another opportunity to review the study plan once it can be determined where the analyses will be applied and potential data gaps can be identified.*" (NMFS's February 15, 2012 e-mail)

YCWA's Reply: NOT ADOPTED. YCWA has modified the Study as required by FERC's September 30, 2011 Study Determination; provided the draft modified Study to USFWS, NMFS, CDFG and SWRCB for 30-day review, as required by FERC's September 30, 2011 Study Determination; and has addressed written comments on the Study. YCWA does not believe another round of reviews, which could affect the study schedule, is necessary.

If you have any questions regarding this matter, please contact me

Sincerely,
YUBA COUNTY WATER AGENCY

Curt Aikens

Curt Aikens
General Manager

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March 8, 2012

Electronically Transmitted

Daniel Welsh
Assistant Field Supervisor
United States Department of the Interior
Fish and Wildlife Service
2800 Cottage Way, Room W-2605
Sacramento, CA 95825-1846

Subject: Yuba River Development Project
FERC Project No. 2246-058
Reply to Comments on YCWA's
Modified Study 1.2, Channel Morphology Downstream of Englebright Dam

Dear Mr. Welsh:

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COMMENTS AND REPLIES

USFWS-1: *"General Comment No.1: This is a very thorough study that proposes to primarily analyze sediment transport dynamics (i.e., erosion and deposition) over multiple scales. However, the title of Study 1.2: "Channel Morphology Downstream of Englebright Dam," is misleading, as Study 1.2 appears to be primarily focused on sediment transport dynamics as related to the contemporary Project-induced flow regime. Specifically; the study goals and objectives (Section 3.0) only mention "sediment dynamics" (i.e., substrate mobility; particle size distribution for salmonid spawning; spawning gravel distribntion* [sic]*) and "spill flow effects on channel morphology in the Yuba River downstream of Englebright Dam" as the primary objectives. Furthermore, under the Study Methods section 5.3, floodplain (through 2D Hydrodynamic modeling), riparian, and large woody material (L WM) are all mentioned as components of the ongoing information collection effort to be utilized in Study 1.2. These processes are fundamental to any "channel morphology study" of a river system (Montgomery and Buffington 1998, Church 2002, Poole 2002, Montgomery and Piegay 2003, Kondolf et al. 2006), especially as they relate to aquatic habitat and fisheries (Schlosser 1991, Maddock 1999, Fausch et al. 2002, Thorp et al. 2006) and should be stated as such up front. However, no mention of any of these analyses is presented within the opening sections and they are not mentioned as specific objectives. Such geomorphological processes are fundamental to the currently stated goal of Study 1.2, which is to "quantify or characterize river form and process in the Yuba River downstream of the Englebright Dam, and to assess potential impacts to the river form and process due to continued operation of the Project."*

If Study 1.2 is to address all the elements of channel morphology, the Service suggests that these processes should be either included as part of the study objectives, or a new objective should be added specifically explaining that a synthesis of Study 1.2 with other studies (e.g., Study 6.2¬Riparian Habitat, Large Woody Material, Substrate and Cover Mapping) will be developed. For clarity purposes, the Service suggests describing these additional elements in more detail in Section 3.0. [pp. 2 and 3 of USFWS's February 16, 2012 letter]

YCWA's Reply: ADOPTED WITH MODIFICATION. Section 3.0 has been modified to better reflect the analyses that are will be performed as part of Study 1.2 and the integration with existing information. Appendix 1-2A has also been modified to describe the Spatial Structural Analysis. The Spatial Structural Analysis mapped and quantified the morphologic structure of the Yuba River downstream of Englebright Dam, at the segment, reach, and morphological-unit scales.

USFWS-2: *"General Comment No.2: The Applicant needs to adequately describe the nexus between Project operations and effects (direct, indirect, and cumulative) on the resource to be studied (18 CFR § 5.11(d)(4». The Applicant also needs to further explain the Project effects (direct, indirect, and/or cumulative) on channel morphology downstream of Englebright Dam (CFR 18 § 5.11 (d)(4». The Applicant states that the continued operation and maintenance of the Project has the "potential" to affect channel morphology and fluvial processes but does not elaborate or explain how these processes are important to the various resources (i.e., T &E species, aquatic species, riparian plants, wildlife resources, migratory birds, etc.).* [p. 3 of USFWS's February 16, 2012 letter]

YCWA's Reply: NOT ADOPTED. USFWS does not specify which effects and what resource issues should be evaluated as influenced by channel morphology process and form. This is a channel morphology study and YCWA is evaluating the effects upon geomorphic form and process from the continued operation of the Project. It is beyond the scope of this study to determine the effects upon various species or resources as a result of geomorphic effects. USFWS is welcome to use the data as necessary to assess effects based upon specific resource issues important to USFWS.

If you have any questions regarding this matter, please contact me

Sincerely,
YUBA COUNTY WATER AGENCY

Curt Aikens

Curt Aikens
General Manager

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