

Study 2.1  
**HYDROLOGIC ALTERATION<sup>1</sup>**  
January 2012

**1.0 Project Nexus**

Yuba County Water Agency's (Licensee or YCWA) continued operation and maintenance (O&M) of the Yuba River Development Project (Project) affects stream flow.

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

YCWA believes that five agencies have jurisdiction over hydrology and the resources that could be potentially affected in the geographic area included in this study proposal: 1) the United States Department of Agriculture, Forest Service (Forest Service) on National Forest System (NFS) land; 2) United States Department of Interior, Fish and Wildlife Service (USFWS); 3) United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS); 4) California Department of Fish and Game (CDFG); and 5) 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.

Forest Service

The Forest Service's jurisdiction and applicable management goals are described by the Forest Service from page 59 to 76 in the Forest Service's March 2, 2011 letter to FERC providing the Forest Service's comments on YCWA's Pre-Application Document or PAD (YCWA 2010). The Forest Service's jurisdiction and management goals are not repeated here.

USFWS

USFWS's jurisdiction and goals and objectives are described by USFWS on pages 1 through 3 of USFWS's March 7, 2011 letter to FERC that provided USFWS's comments on YCWA's PAD. 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.

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

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<sup>1</sup> YCWA's included a Hydrologic Alteration Study in its August 2011 Revised Study Plan. FERC's September 30, 2011 Study Determination and December 28, 2011 Resolution of Study Disputes Determination required modifications to the study. Those modifications have been made in this study plan.

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 this study is to characterize various metrics of hydrologic alteration due to Project O&M.

## **4.0 Existing Information and Need for Additional Information**

Section 6.0, and in particular Sections 6.3 (Project Operations) and 6.4.1 (Current FERC Project License), of YCWA's Preliminary Information Package (YCWA) describes current Project operations, including flow and ramping rate requirements. Appendix F in the Preliminary Information Package includes extensive stream and reservoir hydrology data.

### **4.1 Existing Information Available for Indicators of Hydrologic Alteration Analysis**

Provided below is a summary of existing "full range" regulated streamflow gage data on Project-affected streams with a record of at least 20 years, and the period of available data. A 20-year minimum for continuous regulated streamflow data was selected per the recommendations of The Nature Conservancy (TNC) in their Indicators of Hydrologic Alteration (IHA) Version 7 Users Manual (TNC 2007). A detailed description of IHA and its proposed use as part of this study is provided in Section 5.

- Middle Yuba River below Our House Diversion Dam (USGS Gage 11408880 available from October 1, 1968 through October 1, 2008)
- Oregon Creek Below Log Cabin Diversion Dam (USGS Gage 11409400 available from September 1, 1968 through September 1, 2008)

- Middle Yuba River near North San Juan (USGS Gage 11410000 available from July 1, 1900 through March 17, 2005)<sup>2</sup>
- North Yuba River below New Bullards Bar Dam (USGS Gage 11413520 available from August 13, 1966 through September 30, 2004)
- Yuba River at Smartville (USGS Gage 11418000 available from October 1, 1941 through September 30, 2008)
- Yuba River near Smartville (USGS Gage 11419600 available from October 3, 1960 through December 11, 2002)
- Yuba River near Marysville (USGS Gage 11421000 available from October 1, 1943 through September 30, 2008)

In addition, synthesized regulated streamflow data have been developed by YCWA at several other locations. YCWA anticipates using synthesized streamflow data for analysis under this study proposal at the following locations:

- Middle Yuba River above confluence with Oregon Creek (from October 1, 1969 through September 30, 2008)<sup>2</sup>
- Middle Yuba River above confluence with the North Yuba River (from October 1, 1969 through September 30, 2008)<sup>2</sup>
- Middle Yuba River below the confluence with Oregon Creek (from October 1, 1969 through September 30, 2008)
- Yuba River below confluence with Middle Yuba River (from October 1, 1969 through September 30, 2008)
- Yuba River below New Colgate Powerhouse (from October 1, 1969 through September 30, 2008)
- Yuba River below confluence with Deer Creek (from October 1, 1969 through September 30, 2008)

## 4.2 Existing Information Available for Flood Frequency Analysis

Annual peak instantaneous flow rates are available at the stream gage locations listed below. These data can be used to generate flood recurrence intervals using statistical methods.

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<sup>2</sup> FERC's December 28, 2011 Resolution of Study Disputes Determination required YCWA "Include an IHA analysis of "with project" and "without project" conditions at the following additional locations: 1) the Middle Yuba River just upstream of Oregon Creek; 2) the Middle Yuba River just upstream of the confluence with the North Fork Yuba River; and 3) the Middle Yuba River near North San Juan, USGS gage 11410000." (Appendix A, p. 13). These locations have been added to the IHA portion of the Study.

- Middle Yuba River near North San Juan (USGS Gage 11410000 from WY 1912 through 1941)<sup>3</sup>
- Yuba River at Smartville (USGS Gage 11418000 from WY 1942 through 2008)<sup>3</sup>
- Yuba River at Marysville (USGS Gage 11421000 from WY 1944 through 2008)<sup>3</sup>

In addition, synthesized daily average streamflow data have been developed by YCWA at several other locations. YCWA anticipates using peak annual mean daily synthesized streamflow data for flood frequency analysis at the following locations:

- Oregon Creek below Log Cabin Dam (from October 1, 1969 through September 30, 2008)<sup>4</sup>
- Middle Yuba River below Our House Dam (from October 1, 1969 through September 30, 2008)<sup>4</sup>
- Middle Yuba River above confluence with the North Yuba River (from October 1, 1969 through September 30, 2008)<sup>4</sup>

## **5.0 Study Methods and Analysis**

### **5.1 Study Area**

For the purpose of this study, the study area includes 1) the Middle Yuba River from and including Our House Diversion Dam Impoundment to the confluence with the North Yuba River, 2) Oregon Creek from and including the Log Cabin Diversion Dam Impoundment to the confluence with the Middle Yuba River, 3) the North Yuba River from and including New Bullards Bar Dam Reservoir to the confluence with the Middle Yuba River, and 4) the portion of the Yuba River from the confluence of the North and Middle Yuba rivers to the Feather River, including USACE's Englebright Reservoir.

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

### **5.2 General Concepts and Procedures**

The following general concepts and practices apply to the study:

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<sup>3</sup> FERC's December 28, 2011 Resolution of Study Disputes Determination required YCWA "Perform Log Pearson III peak flow analyses at: 1) Yuba River at Smartville (USGS gage 1141800) using the records from 1942 to 1969 and, separately, records from 1970 to 2008; 2) Yuba River at Marysville (USGS gage 1142100) using the records from 1944 to 1969 and, separately, records from 1970 to 2008; and 3) Middle Yuba River near North San Juan (USGS gage 11410000) using records from 1912 through 1941." (Appendix A, p. 13). These locations have been added to the peak flow analysis portion of the Study.

<sup>4</sup> FERC's December 28, 2011 Resolution of Study Disputes Determination required YCWA "Perform Log Pearson III peak flow analysis on the Middle Yuba River just upstream of the North Fork confluence and on Oregon Creek below the Log Cabin diversion and on Middle Yuba River below Our House dam using mean daily flows and "with project" and "without project" data sets used for the IHA analysis." (Appendix A, p. 13). These locations have been added to the peak flow analysis portion of 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 is responsible in whole or in part for measures that may arise 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. 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.<sup>5</sup>
- 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.

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<sup>5</sup> 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 Methods**

The study will be completed in six steps, each of which is described below.

### **5.3.1 Step 1 – Ramping Rate Analysis**

YCWA will analyze 15 minute data from WYs 1970 through 2008 below the New Colgate and Narrows 2 powerhouses and 1-hour data for WYs 1970 through 2008 below the Log Cabin and Our House diversion dams. YCWA's existing FERC license includes ramping rate limitations at one location - below Narrows 2 Powerhouse.

An exceedance probability of change in flow and stage in 15 minute and 1 hour intervals for the New Colgate and Narrows 2 powerhouses and 1 hour interval for the Log Cabin and Our House diversion dams as measured at the nearest stream gage below the facility will be calculated for up-ramps and down-ramps as observed during the period of record. The greatest hourly rate of change in flow for the largest 10 rate-of-change events will also be provided to illustrate change events. For the 10 largest events, 24-hour hydrographs with descriptions of event conditions will be provided.

Flow change events will be separated into controlled and uncontrolled conditions for comparison, where controlled conditions are defined as time periods when YCWA has full control of downstream flow and ramping.

### **5.3.2 Step 2 - Spill Analysis**

YCWA will compute the magnitude, duration, and volume of historical spill events below the following dams:

- North Yuba River – New Bullards Bar Dam
- Middle Yuba River – Our House Diversion Dam
- Oregon Creek – Log Cabin Diversion Dam
- Yuba River – Englebright Dam

In addition to this cataloging, YCWA will calculate the starting storage condition that would have been necessary to prevent these spill events, based on the total volume of spilled water. This hypothetical storage condition will be compared to typical storage targets for the time period spills occurred. Since neither USACE's Englebright Reservoir nor the Log Cabin Dam or Our House Diversion Dam impoundments have flood management responsibilities, only New Bullards Bar Reservoir will be evaluated.

### **5.3.3 Step 3 - Indicators of Hydrologic Alteration Analysis**

In order to assess the impacts of flow regulation on Project-affected streams, flow characteristics will be computed and comparison tables prepared for the regulated and unimpaired flow condition on the stream locations listed in Section 4.1. The IHA methodology will be applied

(Richter *et al.* 1996). Richter suggests that the hydrologic attributes of a stream can be described by five fundamental groups of statistics.<sup>6</sup>

- Group #1: Magnitude of monthly water conditions
- Group #2: Magnitude and duration of annual extreme water conditions
- Group #3: Timing of annual extreme water conditions
- Group #4: Frequency and duration of high and low pulses
- Group #5: Rate and frequency of change in water conditions

Statistics will be computed for the five IHA Groups using IHA Version 7.1, a software package developed by Totten Software Design and Smythe Scientific Software. Statistics will be further aggregated into five water year type categories (critical, dry, below normal, above normal and wet; Yuba River Index year-types per SWRCB RD-1644). IHA is generally used to calculate statistics for pre-project and post-project conditions using a continuous gage record. If adequate pre-project data are not available for analysis, developed unimpaired hydrology can be joined with existing regulated-condition data to create a record long enough for IHA analysis. When this is done, the first half of the record used for IHA analysis contains simulated without-project flows, and the second half includes historical gaged flows under regulated conditions. Since the Yuba River watershed has been regulated long before the Project was constructed, and the Project has been subjected to multiple sets of regulatory conditions, several adjustments to the standard IHA procedure will be used. Those adjustments are as follows:

- Because the reaches to be analyzed have experienced flow regulation well before the Relicensing Hydrology Period of Record, in most cases extending to the term of the gaging records, the inflow hydrology data (developed for Water Years 1970-2008) will be used to analyze without-Project conditions.<sup>7</sup> The inflow hydrology data is the historic gaged flows upstream from the Project, and synthesized accretions within and downstream of the Project. Non-Project operations and features downstream from the Project will be reflected in the Without-Project conditions.
- Since the Project has been subject to several different regulatory conditions since its initial license, historical regulated conditions from prior to the implementation of the most recent regulatory conditions are not representative of the Project's current effect on Yuba River hydrology. Accordingly, the Water Balance-Operations Model (described in Study 2.2) will be used to simulate the With-Project condition for the Relicensing Hydrology Period of Record, reflecting the current regulated condition of the project with historical gaged flows upstream from the Project, and synthesized accretions within and downstream from the

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<sup>6</sup> IHA Version 7 includes additional parameters called Environmental Flow Components (EFC.) Licensee will use the five groups of statistics listed above to analyze hydrologic variability, but do not propose to utilize or provide the output from the newer EFC module of IHA.

<sup>7</sup> To create the record for IHA analysis, the simulated inflow record for the 1970-2008 WY period will be falsely dated for the WY 1931-1969 pre-project period, and IHA will be run to analyze a flow record from 1931 through 1969, providing 39 years of data representing both with- and without-project conditions. Although the historical WY 1931-1969 period did not experience the same frequency and distribution of water years as the WY 1970-2008 period, this approach provides a reasonable comparison of hydrologic attributes for with- and without-regulation conditions

Project. As in the Without-Project condition, the With-Project condition will reflect non-Project operations and features downstream of the Project.

### 5.3.4 Step 4 - Flood Frequency Analysis

#### 5.3.4.1 Flood Frequency

YCWA will develop flood frequency curves utilizing annual peak flow data at the locations listed in Section 4.2<sup>8</sup> representing both the before Project (prior to 1969) and with Project (after 1969) conditions<sup>9</sup>. For the locations using synthesized data, the two Project conditions described above will be used to represent the with- and without-Project conditions.<sup>1011</sup> These curves will be generated using PeakFQ, a software package developed by the United States Geological Survey which provides estimates of instantaneous annual-maximum peak flows for a range of recurrence intervals using a Pearson Type III (logarithmic) frequency distribution (Flynn et al. 2006). The parameters of the Pearson Type III frequency curve are estimated by the logarithmic sample moments (i.e., mean, standard deviation, and coefficient of skewness) with adjustments for low outliers, high outliers, historic peaks, and generalized skew. Data for this analysis will be the series of annual instantaneous peak flows for the period of record of each gage listed in Section 4.2. As sample size warrants at each streamflow gage, standard recurrence interval flows will be reported including 1.5, 2, 2.33, 5, 10, 25, 50, 100, 200, and 500 years.

#### 5.3.4.2 Seasonal Flood Frequency

Flood peaks, defined as significant storm or spring runoff events will be characterized for three time periods, the fall, winter and spring seasons. For these three seasons the following items will be tabulated for the two hydrologic data sets, as described in footnote 8 on page 7 for the IHA analysis for with and without-Project conditions:

- Average and median peak magnitude
- Minimum and maximum peak magnitude
- Number of fall and winter flood events per season (no snowmelt)

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<sup>8</sup> FERC's December 28, 2011 Resolution of Study Disputes Determination required YCWA "Perform Log Pearson III peak flow analyses at: 1) Yuba River at Smartville (USGS gage 1141800) using the records from 1942 to 1969 and, separately, records from 1970 to 2008; 2) Yuba River at Marysville (USGS gage 1142100) using the records from 1944 to 1969 and, separately, records from 1970 to 2008; and 3) Middle Yuba River near North San Juan (USGS gage 11410000) using records from 1912 through 1941." (Appendix A, p. 13). These locations have been added to the peak flow analysis portion of the Study.

<sup>9</sup> USGS Gage 11410000 only includes an extended period of record for the Middle Yuba River near North San Juan for WY 1912-1941; it will only be used to examine without-Project conditions.

<sup>10</sup> FERC's December 28, 2011 Resolution of Study Disputes Determination required YCWA "Perform Log Pearson III peak flow analysis on the Middle Yuba River just upstream of the North Fork confluence and on Oregon Creek below the Log Cabin diversion and on Middle Yuba River below Our House dam using mean daily flows and "with project" and "without project" data sets used for the IHA analysis." (Appendix A, p. 13). These locations have been added to the peak flow analysis portion of the Study.

<sup>11</sup> To create the record for IHA analysis, the simulated inflow record for the 1970-2008 WY period will be falsely dated for the WY 1931-1969 pre-Project period, and IHA will be run to analyze a flow record from 1931 through 1969, providing 39 years of data representing both with- and without-Project conditions. Although the historical WY 1931-1969 period did not experience the same frequency and distribution of WYs as the WY 1970-2008 period, this approach provides a reasonable comparison of hydrologic attributes for with- and without-regulation conditions



### 5.3.4.3 Snowmelt Recession<sup>12</sup>

For the snowmelt season the median of the Julian Calendar data of the peak and an approximation of the seasonal duration of the snowmelt runoff season will be determined.

The average rate of change in flow during the snowmelt recession in cfs per day will be determined for the two hydrologic data sets as the average change in the flow rate on successive days within a defined time period of the start and end of the spring snowmelt recession for each year.

#### 5.3.5 Step 5 - Data Quality Assurance/Quality Control

All data, including both input data and output data, will undergo a quality assurance/quality control (QA/QC) procedure, and then will be entered into and organized in both Excel and HEC-DSS formats, where applicable, and will be made available to the Relicensing Participants. IHA data will be presented in their standard output format.

#### 5.3.6 Step 6 – Prepare Report

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

## 6.0 Study-Specific Consultation

This study proposal does not include any study-specific consultation requirements.

## 7.0 Schedule

YCWA anticipates the schedule to complete the study as follows:

Ramping Rates at Select Conveyance Reaches (Step 1)	October – November 2011
Spill Cataloging (Step 2)	October – November 2011
Indicators of Hydrologic Alteration (Step 3)	August 2012
Indicators of Flood Frequency Analysis (Step 4)	January 2012
Data Quality Assurance/Quality Control (Step 5)	August 2011 – June 2012
Prepare Report (Step 6)	July – September 2012

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<sup>12</sup> YCWA’s Hydrologic Alteration Study in its August 2011 Revised Study Plan did not include a snowmelt recession analysis. FERC’s September 30, 2011 Study Determination stated: “..we are recommending that Study 2.1, Hydrologic Alteration, Subpart 5.3.4 Flood Frequency Analysis be modified to include the determination of the average daily rate of change in flow (cfs) during the snowmelt recession (cfs/day) for the stations and data sets proposed for analysis in study 2.1” (Appendix A, p 50). The study plan has been modified accordingly.

## **8.0 Consistency of Methodology with Generally Accepted Scientific Practices**

IHA and PeakFQ are widely used hydrologic assessment tools and are endorsed by several state and federal agencies. All other analyses will be conducted using best available scientific practices

## **9.0 Level of Effort and Cost**

YCWA estimates the cost to complete this study in 2011 dollars is between \$28,000 and \$38,000.<sup>13</sup>

## **10.0 References Cited**

- Flynn, K.M., W.H. Kirby, and P.R. Hummel. 2006. User's Manual for Program PeakFQ, Annual Flood-Frequency Analysis Using Bulletin 17B Guidelines. Online document: <http://pubs.usgs.gov/tm/2006/tm4b4/tm4b4.pdf>.
- Hersh, E.S. and D.R. Maidment. October 2006. Assessment of Hydrologic Alteration Software: Final Report. Center for Research in Water Resources. The University of Texas at Austin. Austin, TX. Online document: [http://www.twdb.state.tx.us/RWPG/rpgm\\_rpts/2005483029\\_HydrologicSoftware.pdf](http://www.twdb.state.tx.us/RWPG/rpgm_rpts/2005483029_HydrologicSoftware.pdf).
- Richter, B.D., J.V. Baumgartner, J. Powell, and D.P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. *Conservation Biology* 10:1163-1174.
- State Water Resources Control Board (SWRCB). 2003. Revised Water Right Decision 1644 in the Matter of Fishery Resources and Water Right Issues of the Lower Yuba River.
- The Nature Conservancy (in collaboration with Totten Software Design and Smythe Scientific Software). 2007. Indicators of Hydrologic Alteration – Version 7 User's Manual. Online document.
- Yuba County Water Agency (YCWA). 2010. Yuba River Development Project Relicensing Pre-Application Document. Yuba County Water Agency, Marysville, CA. <http://www.ycwa-relicensing.com>.

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<sup>13</sup> YCWA's Hydrologic Alterations Study in its August 2011 Revised Study Plan had an estimate cost range of between \$25,000 and \$35,000. With the modifications required by FERC in its September 30, 2011 Study Determination, the estimated cost range is between \$28,000 and \$38,000.