Draft
Environmental Impact Report/ Environmental Impact Statement for the Proposed Lower Yuba River Accord

List of Appendices

APPENDIX A

NOTICE OF PREPARATION/ NOTICE OF INTENT

Notice of Preparation

NOTICE OF PREPARATION
OF A
DRAFT ENVIRONMENTAL IMPACT REPORT/ENVIRONMENTAL IMPACT STATEMENT FOR THE PROPOSED LOWER YUBA RIVER ACCORD
JUNE 20, 2005

TO: Interested Parties

FROM: Yuba County Water Agency

PROJECT TITLE: Proposed Lower Yuba River Accord

LEAD AGENCIES: Pursuant to the California Environmental Quality Act (CEQA), the Yuba County Water Agency (YCWA) as the CEQA lead agency is preparing a Draft Environmental Impact Report (EIR) on the Proposed Lower Yuba River Accord (Yuba Accord). The document will be a joint EIR/Environmental Impact Statement (EIS) with the Bureau of Reclamation (Reclamation) as the federal lead agency under the National Environmental Policy Act (NEPA). An Initial Study will not be prepared for this project.

YCWA is interested in the views of federal, state and local public agencies, non-governmental organizations (NGOs) and the general public as to the scope and content of the environmental information for the Draft EIR/EIS. Public agency responses to this Notice of Preparation (NOP) should be limited to information related to the agency's area of statutory responsibility in connection with the proposed project. NGOs and the public also are invited to submit responses to this NOP.

Please provide your response at the earliest possible date and in compliance with the state-mandated time limit of not later than 30 days after receipt of this notice.

Please send your response to:

Carol Brown
Surface Water Resources, Inc.
2031 Howe Avenue, Suite 110
Sacramento, CA 95825
ATTN: Proposed Yuba Accord NOP

PROJECT PROPONENT: Yuba County Water Agency

Date: 6-14-05

Signature: Curt Aikens
Name: Curt Aikens
Title: General Manager
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PROJECT BACKGROUND

In February 1988, a coalition of fishery groups (United Groups) filed a complaint with the State Water Resources Control Board (SWRCB) alleging that the instream flow requirements that were specified in Yuba County Water Agency's (YCWA) permits did not provide adequate protection for fish. The complaint also alleged that the fish screening facilities that were present in the lower Yuba River at that time were inadequate. In March 1991, the California Department of Fish and Game (CDFG) released a "Lower Yuba River Fisheries Management Plan," which contained specific recommendations for restoration, maintenance, and protection of fishery resources in the lower 24-mile section of the Yuba River. The plan recommended higher minimum flow requirements, maximum water temperature requirements and improved fish screens. CDFG requested that the SWRCB consider modifying YCWA's water rights permits to implement the recommendations contained in the CDFG plan. In response to CDFG's request, and to address various allegations raised by the United Groups concerning several other water agencies, the SWRCB initiated a proceeding to consider fishery protection and water rights issues on the lower Yuba River in late 1991.

The SWRCB conducted two sets of hearings in 1992 and 2000 that led to the adoption of Water Rights Decision 1644 (Decision-1644 or D-1644) on March 1, 2001. In D-1644, the SWRCB: (a) increased the minimum instream flow requirements specified in YCWA's water right permits; (b) directed YCWA and other water districts diverting water from the lower Yuba River at two major diversion facilities to consult with CDFG and federal fishery agencies and prepare a plan to reduce loss of fish at those diversions; (c) addressed several other issues regarding the extent of various parties' water rights on the Yuba River; (d) required YCWA to take action to address potential concerns regarding water temperatures for Chinook salmon and steelhead; and (e) required studies and consultation on various other issues.

YCWA, several local water districts in Yuba County, and a coalition of conservation NGOs all initiated legal actions challenging D-1644 on a variety of issues. After considering some new evidence, the court remanded D-1644 to the SWRCB for reconsideration in light of the new evidence. Following a two day hearing, the SWRCB issued Revised Water Rights Decision 1644 (RD-1644), which contains minor changes from D-1644. The parties that had challenged D-1644 then initiated new legal proceedings challenging RD-1644 on most of the same issues.

Since RD-1644 was issued, YCWA has been engaged in a set of separate but related negotiations with the parties to the litigation, state and federal fisheries agencies, water supply agencies, and other parties in order to try to resolve flow and other fisheries issues on the lower Yuba River. These collaborative, interest-based initiatives led to the development of three interrelated proposed agreements: (1) "Principles of Agreement for Lower Yuba River Fisheries Agreement" (Fisheries Agreement); (2) "Outline of Proposed Principles of Agreements with YCWA Member Units in Connection with Proposed Settlement of SWRCB D-1644" (Conjunctive Use

Agreements); and (3) "Agreement for the Long-term Purchase of Water from Yuba County Water Agency by the Department of Water Resources and the Bureau of Reclamation" (Water Purchase Agreement), and related actions. These agreements collectively are known as the Proposed Lower Yuba River Accord (Yuba Accord). Implementation of the Proposed Yuba Accord requires that these three proposed agreements be approved and implemented by the appropriate parties. The Proposed Yuba Accord is intended to resolve issues associated with operation of the YCWA Yuba River Development Project (Yuba Project) in a way that would protect and enhance lower Yuba River fisheries, protect local water supply reliability, provide revenues for local flood-control and water-supply projects, provide water for protection and restoration of Sacramento-San Joaquin Delta (Delta) fisheries, and improve State Water Project/Central Valley Project (SWP/CVP) water supply management and reliability for state and federal water contractors.

Prior to approval of the final Proposed Yuba Accord agreements, YCWA and Reclamation are preparing an EIR/EIS to analyze the environmental effects of the Proposed Yuba Accord. YCWA and the other parties to the agreements will consider the EIR/EIS and project impacts, alternatives and mitigation measures prior to making their individual final decisions on whether to approve and implement the relevant agreements of the Proposed Yuba Accord. The EIR/EIS will also provide information to regulatory agencies that have jurisdiction over water diversions and resources affected by the Proposed Yuba Accord.

LEAD AGENCY DETERMINATION

YCWA has determined that it will be the lead agency for CEQA compliance. Pursuant to CEQA, where a project is to be carried out or approved by more than one public agency, only one agency, referred to as the lead agency, shall be responsible for preparation of the EIR for the project (15 CCR § 15050). According to CEQA criteria for identifying the lead agency, YCWA is the appropriate lead agency for the Proposed Yuba Accord because: (1) YCWA initiated development of the Proposed Yuba Accord; (2) YCWA will be primarily responsible for implementing the Proposed Yuba Accord elements; (3) YCWA will have the greatest responsibility for supervising or approving the proposed project as a whole; (4) the Proposed Yuba Accord involves the transfer and management of water stored under YCWA water rights in YCWA owned and managed facilities; (5) YCWA principally controls the release of water and flows in the Yuba River; (6) YCWA is the only state or local public agency that would be a party to all of the Proposed Yuba Accord agreements; and (7) it is anticipated that YCWA will be the public agency to act first on the project in question (14 CCR § 15051). YCWA has consulted with the California Department of Water Resources (DWR) and CDFG (two state agency parties to the Proposed Yuba Accord agreements) and each agency concurs with the determination that YCWA is the appropriate CEQA lead agency.

PROJECT PARTICIPANTS AND STAKEHOLDERS

Lead Agencies

- YCWA is the CEQA lead agency.
- Reclamation is the NEPA lead agency.

CEQA Responsible and Trustee Agencies

- DWR is a CEQA responsible agency involved in the Water Purchase Agreement process.
- SWRCB is a CEQA responsible agency involved in making water rights decisions related to diversion and use of water and implementation of the Proposed Yuba Accord.
- CDFG is a CEQA responsible agency and trustee agency involved in the Fisheries Agreement process.
- YCWA Member Units: Brophy Water District, Browns Valley Irrigation District, Ramirez Water District, South Yuba Water District and Wheatland Water District are CEQA responsible agencies involved in the Conjunctive Use Agreements processes.

NEPA Cooperating Agencies (Tentative)

- The U.S. Fish and Wildlife Service (USFWS) may participate as a NEPA federal cooperating agency related to the Water Purchase Agreement and Fisheries Agreement processes.
- The National Marine Fisheries Service (NMFS) may participate as a NEPA federal cooperating agency related to the Water Purchase Agreement and Fisheries Agreement processes.

Other Participating Entities

- State and Federal Water Project Contractors (SWP/CVP)
- Non-Governmental Organizations
    - South Yuba River Citizens League, Friends of the River, Trout Unlimited and The Bay Institute are participants in the Fisheries Agreement process.
- YCWA Member Units (Private Companies)
    - Dry Creek Mutual Water Company and Hallwood Irrigation Company are participants in the Conjunctive Use Agreements processes.
- Native American or Tribal Interests

PROJECT OBJECTIVES – PURPOSE AND NEED

In 1991, CDFG released a fisheries management plan which proposed to increase minimum instream flow requirements in the lower Yuba River to provide desirable fisheries habitat conditions. Following extensive hearings and litigation, the SWRCB adopted RD-1644 on July 16, 2003. During the subsequent lawsuits challenging RD-1644, the litigants identified the need to attempt to find an alternative resolution, which resulted in the separate but parallel negotiations of the three agreements that comprise the Proposed Yuba Accord.

The purpose of the Proposed Yuba Accord is to implement a new set of collaboratively developed, science-based instream flow requirements for use in the operation of the Yuba Project in a way that meets the overall project objectives of YCWA, DWR and Reclamation within Yuba County and the SWP/CVP system, meets or exceeds requirements to protect and enhance lower Yuba River fisheries, local water supply reliability, and protects and enhances Delta fisheries and water supply reliability.

The specific objectives of the Proposed Yuba Accord include:

Yuba County and Lower Yuba River (Local Study Area)

- Resolve fifteen years of controversy and settle litigation over Yuba River instream flow issues associated with operation of the Yuba Project;
- Implement a level of protection for lower Yuba River fisheries equivalent to or greater than requirements in RD-1644;
- Improve Yuba County water supply management and reliability;
- Implement a comprehensive conjunctive use program managing surface water and groundwater supplies to improve water use efficiency;
- Maintain the ability to deliver water to meet current and future local service area needs;
- Provide revenues to fund Proposed Yuba Accord actions (e.g., conjunctive use and River Management Team [RMT] and Yuba County flood control improvements, water supply and other YCWA projects, including but not limited to constructing a new fish screen at the South Canal Diversion); and
- Implement a lower Yuba River long-term fisheries monitoring, studies and enhancement program.

SWP/CVP System (Regional Study Area)

- Provide water for use in the protection and restoration of Delta fisheries, including the CALFED Environmental Water Account (EWA) Program; and
- Improve SWP and CVP water supply management and reliability.

PROJECT LOCATION

The project area is depicted on **Figure 1** located at the end of this document. The local study area encompasses the lower Yuba River basin, including storage and hydropower facilities located in the basin, the riparian corridor along the North Yuba River downstream of New Bullards Bar Reservoir, the lower Yuba River downstream of Englebright Reservoir to the confluence with the Feather River, the YCWA water service area, and the local groundwater basin utilized by YCWA Member Units. The local project area is located within the USGS 7.5' quadrangles of American House, Forbestown, Clipper Mills, Strawberry Valley, Rackerby, Challenge, Comptonville, Honcut, Loma Rica, Oregon House, French Corral, Yuba City, Browns Valley, Smartville, Olive Hurst, Wheatland, Camp Far West, Nicolaus and Sheridan.

The regional study area includes all surface water reservoirs, river systems and components of the SWP/CVP that may be affected by integrated operation of the SWP/CVP system under the Proposed Yuba Accord and/or cumulative conditions. Preliminarily, these facilities include but are not limited to: Shasta Reservoir, the Sacramento River from below Shasta Dam to the Delta; Oroville Reservoir; the Feather River below the Oroville Facilities to the confluence with the Sacramento River; Folsom Reservoir and the American River below Folsom Dam to the confluence with the Sacramento River; and the Delta region.

DESCRIPTION OF THE PROPOSED LOWER YUBA RIVER ACCORD

YCWA is a public agency created and existing pursuant to the provisions of the Yuba County Water Agency Act of 1959. YCWA owns and operates the Yuba Project in accordance with a Federal Energy Regulatory Commission (FERC) License, flood control rules promulgated by the U.S. Army Corps of Engineers, a Power Purchase Contract with the Pacific Gas and Electric Company, and SWRCB water rights permits.

The Proposed Yuba Accord includes the proposed Fisheries Agreement, the proposed Water Purchase Agreement and the proposed Conjunctive Use Agreements that, in order to become effective, must be fully approved and executed by the individual parties to each agreement. Additionally, implementation of the Proposed Yuba Accord would require SWRCB amendment of YCWA's water rights permits and RD-1644 as appropriate to implement the Proposed Yuba Accord. The key provisions of the Proposed Yuba Accord preliminary agreements and related actions are outlined below. The individual executed preliminary agreement documentation may be viewed at YCWA offices (see *Proposed Yuba Accord Documentation* for contact information) or found on the Internet at www.ycwa.com.

Principles of Agreement for Lower Yuba River Fisheries Agreement (Fisheries Agreement)

The signatory parties to the proposed Fisheries Agreement would be YCWA, CDFG, South Yuba River Citizens League, Friends of the River, Trout Unlimited and The Bay Institute. NMFS and USFWS, although not signatories to the Fisheries Agreement, have signed the "Statement of Support for Proposed Lower Yuba River Fisheries Agreement" and have provided critical input into the development of the Fisheries Agreement. The term of the Fisheries Agreement would be anticipated to extend until FERC issues a new Long-term License for the Yuba Project (approximately 2016), and would be consistent with the terms of the Conjunctive Use Agreement and Water Purchase Agreement.

Key elements of the Fisheries Agreement include: (1) proposed changes to lower Yuba River instream flow requirements; (2) formation of a RMT (a collaborative decision-making body made up of the signatories to the "Statement of Support for Proposed Lower Yuba River Fisheries Agreement") and a River Management Fund (RMF); (3) proposed supplemental water transfers; and (4) proposed changes to YCWA water rights permits. These elements are described below.

Lower Yuba River Instream Flow Requirement

YCWA would petition the SWRCB to amend YCWA's water right permits to authorize YCWA to operate the Yuba Project and manage lower Yuba River instream flows according to proposed revised instream flow requirements according to specific flow schedules, numbered 1 through 6, based upon water availability as presented in **Table 1** (Schedules 1 – 6) and **Table 2** (Schedules

A – B). The specific flow schedule or schedules that would be implemented at any time would be determined by the value of a new North Yuba Index (which is a proposed refinement of the Yuba River Index addressed in RD-1644) and the rules described in the Fisheries Agreement. The regional study area includes all surface water reservoirs, river systems and components of the SWP/CVP that may be affected by integrated operation of the SWP/CVP system under the Proposed Yuba Accord and/or cumulative conditions. Preliminarily, these facilities include but are not limited to: Shasta Reservoir, the Sacramento River from below Shasta Dam to the Delta; Oroville Reservoir; the Feather River below the Oroville Facilities to the confluence with the Sacramento River; Folsom Reservoir and the American River below Folsom Dam to the confluence with the Sacramento River; and the Delta region.

The North Yuba Index is an indicator of the amount of water available in the North Yuba River at New Bullards Bar Reservoir that can be utilized to achieve flows on the lower Yuba River through operations of New Bullards Reservoir.

Table 1. Proposed Yuba Accord - Lower Yuba River Instream Flow Requirements, Marysville Gage (cfs), Schedules 1 - 6

	Schedule	Oct 1-31	Nov 1-30	Dec 1-31	Jan 1-31	Feb 1-29	Mar 1-31	Apr 1-15 16-30	May 1-15 16-31	Jun 1-15 16-30	Jul 1-31	Aug 1-31	Sep 1-30	Total Annual Volume (AF)
WET	1	500	500	500	500	500	700	1,000 1,000	2,000 2,000	1,500 1,500	700	600	500	574,200
↓	2	500	500	500	500	500	700	700 800	1,000 1,000	800 500	500	500	500	429,066
	3	500	500	500	500	500	500	700 700	900 900	500 500	500	500	500	398,722
	4	400	500	500	500	500	500	600 900	900 600	400 400	400	400	400	361,944
	5	400	500	500	500	500	500	500 600	600 400	400 400	400	400	400	334,818
DRY	6	350	350	350	350	350	350	350 500	500 400	300 150	150	150	350	232,155

Indicated flows represent average volumes for the specified time period. Actual flows may vary from the indicated flows according to established criteria.
Indicated Schedule 6 flows do not include an additional 30,000 acre-feet available from groundwater substitution to be allocated according to the criteria established in the Fisheries Agreement.
cfs = cubic feet per second

Table 2. Proposed Yuba Accord – Lower Yuba River Instream Flow Requirements, Smartville Gage (cfs), Schedules A - B

Schedule	Oct 1-31	Nov 1-30	Dec 1-31	Jan 1-31	Feb 1-29	Mar 1-31	Apr 1-15 16-30	May 1-15 16-31	Jun 1-15 16-30	Jul 1-31	Aug 1-31	Sep 1-30	Total Annual Volume (AF)
A	700	700	700	700	700	700	700 **	** **	** **	** **	** **	700	**
B	600	600	550	550	550	550	600 **	** **	** **	** **	** **	500	**

Schedule A flows are to be used concurrently with Schedules 1,2,3 and 4 at Marysville.
Schedule B flows are to be used concurrently with Schedules 5 and 6 at Marysville.
** During the summer months, flow requirements at the downstream Marysville gage will always control, so no Schedule A or Schedule B flows were developed by May-August. Flows at the Smartville Gage will equal or exceed flows at Marysville.

Table 1 presents the instream flow requirements as measured at the Marysville Gage pursuant to Schedules 1 through 6. Table 2 presents the instream flow requirements at the Smartville Gage, where appropriate, pursuant to Schedules A and B. Schedules A and B of the Smartville Gage instream flow requirements would be effective concurrently with the Marysville Gage instream flow requirements during Schedules 1 through 4 and Schedules 5 and 6, respectively. For example, during November of a Schedule 1 year, the instream flow requirement at the Smartville

Gage would be 700 cfs and the instream flow requirement at the Marysville Gage would be 500 cfs.

The instream flow requirements in the Proposed Yuba Accord schedules would be measured by a five-day running average of the mean daily stream flows with instantaneous flows never less than 90 percent of the applicable flow requirements specified in the schedules. Instantaneous flows would not be less than the applicable flow requirements specified in the schedules for more than 48 consecutive hours unless CDFG concurs to a longer period of time, which may not exceed 5 days.

During the parts of September of Schedule A water years when the Narrows II Powerhouse is shut down for normal maintenance, the Smartville Gage requirements would be 700 cfs or the full release capacity of the Narrows I Powerhouse at the Englebright Reservoir level that occurs at that time, whichever is less.

In Schedule 6 water years, an additional 30,000 acre-feet of water would be made available through groundwater substitution practices during the portions of such water years when this water would be transferable under provisions of the Water Purchase Agreement. This groundwater component would be managed by the RMT to achieve maximum fisheries resource benefits during the transfer period.

Additionally, pursuant to specific rules, minor modifications to the applicable instream flow requirements in Schedules 1 through 6 may be agreed to by the RMT.

Conference Years

The Fisheries Agreement also would include provisions for conference years. Conference years are defined as water years for which the North Yuba Index is less than 500,000 acre-feet. It is anticipated that conference years would occur at a frequency of one percent or less. During such years, YCWA would operate the Yuba Project so that flows in the lower Yuba River would comply with the instream flow requirements in YCWA's FERC License, exclusive of the flow reductions authorized by that license. In general, the minimum instream flow requirements below Daguerre Point Dam specified in the 1965 YCWA/CDFG agreement were set at 245 cfs from January 1 through June 30, 70 cfs from July 1 through September 30, and 400 cfs from October 1 through December 31. In conference years, the total diversions at Daguerre Point Dam would not exceed 250,000 acre-feet per year. Additionally, the RMT may determine and agree to additional instream flows for the purposes of fisheries resources benefit.

In conference years, YCWA would meet with the parties to the Fisheries, Conjunctive Use and the Water Purchase agreements, to develop a strategic management plan to balance water supply and lower Yuba River instream flow needs for that year. The strategic management plan would state affirmative steps that YCWA and the Member Units would undertake to ensure total water diversions do not exceed 250,000 acre-feet per year. YCWA would ensure implementation and enforcement of the strategic management plan's requirements through its contracts with the participating Member Units.

River Management Team and River Management Fund

The Fisheries Agreement would include the formation of a RMT, which would have various planning and decision responsibilities, including:

- Modifying flow schedules, when necessary, according to the terms of the Fisheries Agreement;
- Scheduling additional instream flows during conference years;
- Scheduling water made available for supplemental instream flows in connection with any supplemental water transfer(s); and
- Overseeing various environmental actions for the lower Yuba River, including operation of water temperature devices, and planning and execution of fisheries monitoring and studies and habitat enhancement measures.

YCWA would utilize revenues generated by implementation of the Water Purchase Agreement to provide annual funding to the River Management Fund (RMF), in amounts and subject to the rules outlined in the Fisheries Agreement. Additionally, both YCWA and CDFG would make in-kind contributions of services and equipment to the RMF on an annual basis. The RMF would be used for various fisheries monitoring and evaluation studies and habitat enhancement measures, as described in the Fisheries Agreement.

Supplemental Water Transfers

Additional water, above the Table 1 and Table 2 flow schedules, may be made available from either surface or groundwater sources for transfer, subject to specific rules for the releases, and specific notice, planning and implementation requirements as would be included in the Fisheries Agreement.

Other Changes to YCWA Water Rights Permits

YCWA would petition the SWRCB to amend RD-1644's flow requirements and delete the water temperature and flow fluctuation provisions of RD-1644. YCWA proposes that water temperatures in the lower Yuba River instead would be addressed through the new instream flow requirements and the operations of water temperature devices. Flow fluctuations would be addressed in YCWA's FERC license, which is in the process of being amended to include new ramping rate criteria.

Outline of Proposed Principles of Agreements with YCWA Member Units in Connection with Proposed Settlement of SWRCB D-1644 (Conjunctive Use Agreements)

YCWA would enter into individual Conjunctive Use Agreements with each of the participating Member Units: Brophy Water District, Browns Valley Irrigation District, Dry Creek Mutual Water Company, Hallwood Irrigation Company, Ramirez Water District, South Yuba Water District and Wheatland Water District. The term of the Conjunctive Use Agreements between YCWA and each participating Member Unit would be anticipated to extend until FERC issues a new Long-term License for the Yuba Project (approximately 2016), and would be consistent with the terms of the Fisheries Agreement and Water Purchase Agreement.

Groundwater Pumping - Schedule 6 Water Years

In Schedule 6 water years (about 4 percent of the years of hydrologic record), each participating Member Unit would pump a specified percentage of 30,000 acre-feet of groundwater to allow for reduced use of surface water for irrigation. The reduced use of surface water for irrigation will result in additional stored water being available to supplement the minimum instream flow requirements specified in Schedule 6. The ability of a Member Unit to participate in the conjunctive use program would depend on the extent to which each Member Unit can make arrangements with landowners within its service area to provide the groundwater pumping capacity required for the conjunctive use program. The proposed groundwater pumping allocations to be set forth in the Conjunctive Use Agreements would be adjusted to reflect the ability of the individual Member Units to provide this pumping capacity.

Participation in Groundwater Substitution Water Transfer Program

YCWA anticipates that the Water Purchase Agreement with Reclamation and DWR would include the purchase of groundwater substitution transfer water when it is made available in dry and critical water years. Participating Member Units would have the first priority over non-participating Member Units to participate in YCWA groundwater substitution water transfers.

YCWA would seek agreement with state and federal fishery agencies and other RMT members on measures to mitigate instream impacts from groundwater substitution water transfers as follows:

- In Schedule 2 and 3 years, 10 percent of the groundwater substitution water would be dedicated to mitigating instream impacts.
- In Schedule 4 and 5 years, 20 percent of the groundwater substitution water would be dedicated to mitigating instream impacts.

Conference Years

In conference years, YCWA would meet with the Member Units, and the parties to the Fisheries Agreement and the Water Purchase Agreement, to develop a strategic management plan to balance water supply and lower Yuba River instream flow needs for that year.

Conjunctive Use Program

YCWA would implement a conjunctive use program including monitoring of groundwater pumping to avoid long-term impacts to the safe yield of the aquifer and impacts to domestic and municipal wells. The maximum annual amount of groundwater pumping for the Schedule 6 water year commitments, for YCWA's Sacramento Valley Water Management Program (Phase 8) settlement commitments, to mitigate for deficiencies in supplemental water supplies, and for groundwater substitution transfers would not exceed approximately 120,000 acre-feet per year.

YCWA would coordinate with the Member Units in developing a program for efficiently providing the groundwater needed to implement the conjunctive use program. YCWA also would coordinate with Member Units in the development and implementation of a program to convert certain diesel groundwater pumps to electric pumps to avoid air quality impacts associated with groundwater pumping operations.

Reasonable and Beneficial Uses of Water Supplies

In accordance with the terms of the water supply contract between YCWA and the Member Units, water deliveries to the Member Units would be limited to amounts that could be put to reasonable and beneficial use within the Member Units service areas. The Member Units would pursue water use efficiency actions to help maintain the water supply reliability.

Agreement for the Long-term Purchase of Water From Yuba County Water Agency by the Department of Water Resources and the Bureau of Reclamation (Water Purchase Agreement)

The parties to the proposed Water Purchase Agreement would be YCWA, Reclamation and DWR. This agreement provides for the purchase and delivery of water to Reclamation and DWR in quantities described below. The term of the Water Purchase Agreement would be anticipated to extend until FERC issues a new Long-term License for the Yuba Project (approximately 2016), and would be consistent with the terms of the Fisheries Agreement and Conjunctive Use Agreements. Additionally, the Water Purchase Agreement would include provisions for the continued YCWA delivery of water and DWR and Reclamation purchase of such water until December 31, 2025, based upon certain conditions to be specified in the agreement. Related to implementation of the Water Purchase Agreement and use of the transfer water, Reclamation and DWR would enter into an agreement regarding sharing of the water and related integrated operations of the SWP/CVP system (Tier 2 Agreement). Additionally, Reclamation and DWR would each enter into separate agreements with the federal and state water contractors, respectively, regarding allocation of the transfer water supply (Tier 3 Agreement).

Key elements of the Water Purchase Agreement include: (1) definition of water supply components and related pricing structures; (2) description of potential water supplies available to third parties; (3) implementation of a water accounting mechanism; (4) explanation of conference year principles; (5) definition of the proposed place of use of the water; (6) implementation of a Groundwater Monitoring and Reporting Program; and (7) specification of quantities of and pricing provisions for water during a FERC Annual License and during the FERC Long-term License. These elements are described below.

Water Supply Components

The Water Purchase Agreement identifies four water supply components (1 – 4) that would be provided based upon certain water availability conditions and subject to various pricing structures.

Component 1 Water

YCWA would make Component 1 water available to DWR and Reclamation during the first nine accounting years of the Water Purchase Agreement (January 1, 2007 through December 31, 2015). In each of these nine years, Reclamation and DWR would acquire a total of up to 60,000 acre-feet of water for use in the CALFED EWA Program to be shared according to separate agreement terms between Reclamation and DWR (Tier 2 Agreement). Over the course of the first nine accounting years, YCWA would make available and deliver a total of up to 540,000 acre-feet of Component 1 water. Payment for the Component 1 water would include: (1) an initial payment of $32,700,000; and (2) an additional payment of $2,550,000.

Component 2 Water

Implementation of the Component 2 water provisions (dry and critical water years) would involve YCWA total deliveries to Reclamation and DWR of: 15,000 acre-feet of Component 2 water during dry water years and 30,000 acre-feet of Component 2 water during critical water years. The pricing structure for Component 2 water would be $50.00 per acre-foot in dry water years and $62.50 per acre-foot in critical water years.

Component 3 Water

Component 3 water could be obtained in above normal, below normal, dry or critical water years. Delivery of the Component 3 water would be based upon projected CVP and SWP water contractor water allocations to be determined by April 21 of each water accounting year. YCWA would make available for delivery 40,000 acre-feet of Component 3 water for purchase by DWR and Reclamation for SWP contractors when water allocations are at or below 40 percent of SWP contractors water supply contract (Table A) amounts and for CVP contractors when water allocations are at or below 35 percent of CVP South of Delta agricultural contractors entitlements as of April 21. Alternatively, when allocations for SWP contractors water supply contract (Table A) amounts are at or below 60 percent and above 40 percent, and water allocations for CVP South of Delta agricultural contractors are at or below 45 percent and above 35 percent, DWR and Reclamation may request to purchase up to 40,000 acre-feet and YCWA would make available the amount of water requested for delivery.

DWR and Reclamation would pay for 40,000 acre-feet of Component 3 water reduced by an amount that reflects any reduction in the amount of groundwater pumping availability between April 21 and May 21 if the allocations as of April 21 for CVP South of Delta agricultural contractors are at or below 35 percent of their CVP contractual entitlements and for the SWP contractors are at or below 40 percent of their SWP water supply contract (Table A) amounts and they have opted to have less than 40,000 acre-feet of Component 3 water delivered.

If after April 21, but prior to May 21, water allocations to SWP contractors or CVP South of Delta agricultural contractors increase, then DWR and Reclamation may, on or before May 21, reduce their request for Component 3 water to the greater of zero or the quantity of water already delivered by YCWA plus the quantity of water already stored by YCWA through the substitution of groundwater for surface water in anticipation of Component 3 water deliveries originally requested by DWR and Reclamation.

The pricing structure for Component 3 water would vary according to water year type as follows: $50 per acre-foot in above normal water years; $75 per acre-foot in below normal water years; $100 per acre-foot in dry water years; and $125 per acre-foot in critical water years.

Component 4 Water

On or before April 10 of each year, YCWA would inform DWR and Reclamation regarding the quantity of Component 4 water available from surface and groundwater sources for that water accounting year. In return, by May 15, DWR and Reclamation would notify YCWA if they will take delivery of any or all of the offered Component 4 water. The pricing structure for Component 4 water would vary according to water year type as follows: $25 per acre-foot in wet water years; $50 per acre-foot in above normal water years; $75 per acre-foot in below normal water years; $100 per acre-foot in dry water years; and $125 per acre-foot in critical water years.

Water Supplies Available to Third Parties

In those years when YCWA offers Component 3 or Component 4 water, but DWR and Reclamation decline to take all of the water offered, YCWA may elect to sell this water to a third party. The sale of this water to a third party would only be made provided that such sale would not impair YCWA's ability to meet its obligations to deliver Components 1 through 4 water in the current or any future water accounting year under the Proposed Yuba Accord.

YCWA may elect to sell to a third party any quantity of Components 1, 3 or 4 water released by YCWA that would have been accounted for as Proposed Yuba Accord Water Purchase Agreement water supply, except for the inability of DWR and Reclamation to take delivery of that water.

Water Accounting Mechanism

The proposed water accounting mechanism requires that YCWA, DWR and Reclamation collaborate on the determination of the delivery of Water Purchase Agreement water by certain dates of each year and pursuant to specified standards and procedures.

Conference Year Principles

YCWA would not be obligated to deliver Components 1 through 4 water in a conference year or refund any part of payment received for Component 1 water in such a year. However, YCWA would deliver, in a subsequent water accounting year, subject to a schedule acceptable to DWR and Reclamation, the Component 1 water that was not delivered in a conference year.

Place of Use of Water

Water made available under the Water Purchase Agreement would not be used outside of the place of use specified in a SWRCB order approving delivery of water from YCWA to DWR and Reclamation without the written consent of YCWA and authorization by the SWRCB.

Groundwater Monitoring and Reporting Program

YCWA would implement a Groundwater Monitoring and Reporting Program (Groundwater Program) within its service area to ensure that the water supply development pursuant to the Conjunctive Use Agreements avoids long-term effects upon the local groundwater aquifers. Implementation of the Groundwater Program would apply to practices involving the conjunctive use of groundwater to enable delivery of water to DWR and Reclamation pursuant to the terms of the Water Purchase Agreement. The Groundwater Program would include the conversion of some diesel groundwater pumps to electric pumps to minimize potential air quality effects. DWR and Reclamation would pay YCWA for costs associated with implementation of certain elements of the Groundwater Program, including compensation for any annual increases in operations and maintenance costs above actual 2006 Groundwater Program expenses.

Provisions for Water After 2015

The Water Purchase Agreement would provide for the continued delivery by YCWA and purchase by DWR and Reclamation of Components 1 through 4 water during any water year beginning after September 30, 2015 through 2025, if YCWA can deliver these quantities of water consistent with the terms of a FERC Annual License or new FERC License. For water accounting years beginning after December 31, 2015, YCWA may adjust the quantities of water delivered (to no less than 20,000 acre-feet of water in each such water accounting year, other than a conference year). Additionally, the Water Purchase Agreement provides for the continuation of YCWA delivery and DWR and Reclamation purchase of Components 1 through 4 water based upon an agreement of the annual quantity of water among the agencies (no less than 20,000 acre-feet of water in each such water accounting year, other than a conference year) through December 31, 2025. Provisions for water after 2015 will not be used to limit FERC's licensing authority.

Implementation of the Proposed Yuba Accord requires implementation of the three agreements described above. YCWA's proposed operation of the Yuba Project to satisfy the instream flow requirements provisions of the Fisheries Agreement and to provide transfer water under the Water Purchase Agreement necessitates implementation of the proposed Conjunctive Use Agreements to ensure water supply reliability within Yuba County. YCWA's provision of higher instream flows, relative to the existing SWRCB requirements (RD-1644), would protect lower Yuba River Chinook salmon and steelhead habitat conditions as well as provide benefits in the Feather and Sacramento rivers and the Delta.

The purchase of transfer water by DWR and Reclamation under the Water Purchase Agreement with YCWA would provide assurances for water supply reliability and operational flexibility for the protection of fisheries resources within the Delta through the CALFED EWA Program and other venues as well as improve water supply reliability for SWP and CVP state and federal water contractors. The water transfer revenues derived from the Water Purchase Agreement would be used by YCWA to finance the conjunctive use program, local flood control projects, a long-term fisheries monitoring and study program, and other activities.

Additionally, the enhanced conservation and water use efficiency measures enabled by the conjunctive use program would contribute to economic security for local farmers and other landowners. Therefore, in order for the Proposed Yuba Accord to become effective as presently proposed, the three agreements must be fully approved and executed by the individual parties to each agreement and the SWRCB must approve YCWA's water rights petition without substantial modification. All three agreements and related actions are necessary for implementation of the Proposed Yuba Accord.

Authorization for a New YCWA Point of Diversion/Rediversion

In order to maintain no less than the proposed Yuba Accord instream flows down the lower Yuba River and past the existing YCWA point of diversion that serves south Yuba County after the expiration of the proposed Fisheries Agreement, YCWA may eventually propose to add another point of diversion/rediversion downstream from the existing points of diversion in order to meet future water service needs within south Yuba County. YCWA therefore will petition the SWRCB to amend YCWA's water rights permits to add an authorized point of diversion/rediversion on either the lower Yuba River near its confluence with the Feather River near Marysville or on the Feather River downstream of this confluence (within Yuba County), so that YCWA may divert and redivert water at this location to provide surface water for municipal, industrial and irrigation uses in South Yuba County. The full detailed design of the facilities at the new point of diversion would not be completed until YCWA determines a definitive need for such facility and no diversions or rediversions of water would be authorized to occur at this proposed facility before April 30, 2016. SWRCB approval of the requested authorized additional point of diversion/rediversion will not require YCWA to construct such diversion facilities or actually divert water there. The EIR/EIS will provide an evaluation related to YCWA's requested authorization of a new point of diversion/rediversion including an assessment of potential hydrologic effects of operating such a facility and a description of the total maximum amount of diversion. The EIR/EIS also will address potential construction-related effects based upon preliminary design considerations.

YCWA would petition the SWRCB to amend YCWA's water rights permits to add the SWP and CVP points of diversion/rediversion and places of use that are necessary to implement the Water Purchase Agreement during the term of the Water Purchase Agreement, subject to the specific reservation of SWRCB jurisdiction to revisit the additional points of diversion/rediversion and places of use and the requirement to review these changes before May 2016 or during the Clean Water Act section 401 process for the new FERC Long-Term License, whichever is earlier.

PARTICIPATING AGENCY DECISIONS

The lead, responsible, trustee, cooperating and other participating agencies will utilize the environmental analyses and conclusions presented in the EIR/EIS to make individual agency decisions regarding implementation of the Proposed Yuba Accord (i.e., execution and implementation of agreements). The following section identifies a preliminary but non-exhaustive list of agency decisions (e.g., contracts, permits, entitlements, changes in operations) associated with implementation of the Proposed Yuba Accord to be included and evaluated in the EIR/EIS.

Yuba County Water Agency – CEQA Lead Agency

Fisheries Agreement - Approval and implementation of the Fisheries Agreement, including:

- Change of YCWA Yuba Project operations to meet amended SWRCB instream flow requirements
- Creation of a Lower Yuba River Management Team and Fund

Conjunctive Use Agreements - Approval and implementation of the Conjunctive Use Agreements, including:

- Groundwater pumping and management in Yuba County as necessary to implement the Proposed Yuba Accord and as provided by the Conjunctive Use Agreements, including conversion of some diesel pumps to electric pumps.

Water Purchase Agreement - Approval and implementation of the Water Purchase Agreement, including:

- YCWA delivery of water to DWR and Reclamation pursuant to the terms of the Water Purchase Agreement, and related changes in Yuba Project operations and lower Yuba River flows to accommodate such deliveries.

Bureau of Reclamation – NEPA Lead Agency

Water Purchase Agreement - Approval and implementation of the Water Purchase Agreement, including:

- Reclamation purchase, diversion and use of water pursuant to the terms of the Water Purchase Agreement and associated changes in SWP and CVP operations.
- Execution of related agreement(s) with DWR and federal water contractors regarding use of the water and integrated operations of the SWP/CVP system.

California Department of Water Resources – CEQA Responsible Agency

Water Purchase Agreement - Approval and implementation of the Water Purchase Agreement, including:

- DWR purchase, diversion and use of water pursuant to the terms of the Water Purchase Agreement and associated changes in SWP and CVP operations.
- Execution of related agreement(s) with Reclamation and state water contractors regarding use of the water and integrated operations of the SWP/CVP system.

State Water Resources Control Board – CEQA Responsible Agency

- Approval of YCWA petitions to amend YCWA water rights and RD-1644 to:
    - Change the instream flow requirements and other provisions in accordance with the terms of the Fisheries Agreement;
    - Add an authorized point of diversion/rediversion on the lower Yuba River or Feather River in accordance with the terms of the Fisheries Agreement; and

- Add the SWP and CVP as new points of diversion/rediversion and places of use as necessary to implement the Water Purchase Agreement in accordance with the terms of the Fisheries Agreement.

California Department of Fish and Game – CEQA Responsible and Trustee Agency

Fisheries Agreement - Approval and implementation of the Fisheries Agreement, including:

- Participation on the Lower Yuba River Management Team.

YCWA Member Units – CEQA Responsible Agencies

Brophy Water District
Browns Valley Irrigation District
Ramirez Water District
South Yuba Water District
Wheatland Water District

Conjunctive Use Agreements - Approval and implementation of the Conjunctive Use Agreements, including:

- Groundwater pumping and management in Yuba County as necessary to implement the Proposed Yuba Accord and as provided by the Conjunctive Use Agreements, including conversion of some diesel pumps to electric pumps.

National Marine Fisheries Service and U.S. Fish and Wildlife Service – NEPA Cooperating Agencies (Tentative)

Fisheries Agreement – Support approval and implementation of the Fisheries Agreement.

YCWA Member Units (Private Companies)

Dry Creek Mutual Water Company
Hallwood Irrigation Company

Conjunctive Use Agreements - Approval and implementation of the Conjunctive Use Agreements, including:

- Groundwater pumping and management in Yuba County as necessary to implement the Proposed Yuba Accord and as provided by the Conjunctive Use Agreements, including conversion of some diesel pumps to electric pumps.

Non-Governmental Organizations

South Yuba River Citizens League
Friends of the River
Trout Unlimited
The Bay Institute

Fisheries Agreement - Approval and support of implementation of the Fisheries Agreement.

Federal and State Endangered Species Acts

The Proposed Yuba Accord also is subject to review and evaluation of potential effects pursuant to the federal Endangered Species Act (ESA) and California ESA (CESA). Reclamation and YCWA will pursue coordination and consultation with the following agencies:

- USFWS – Federal ESA Consultation
- NMFS – Federal ESA Consultation
- CDFG – CESA Compliance

POTENTIAL ENVIRONMENTAL EFFECTS AND CONSIDERATIONS

The EIR/EIS scoping process is designed to elicit comments from CEQA responsible, trustee and commenting agencies, NEPA cooperating and commenting agencies, other interested organizations, and the public on the scope of the potential environmental effects and issues to be addressed in the Public Review Draft EIR/EIS. Comments on potential effects will be noted and addressed as appropriate in the Public Review Draft EIR/EIS.

The Public Review Draft EIR/EIS will analyze the beneficial and adverse effects of implementing the Proposed Yuba Accord and alternatives on surface water hydrology, groundwater hydrology, water supply, hydropower, flood control, water quality, fisheries, wildlife, vegetation, special-status species, recreation, visual, cultural and Indian Trust Assets, air quality, land use, socioeconomic, growth inducement, and environmental justice resources and conditions. Alternatives to be evaluated in the Public Review Draft EIR/EIS include the No Action Alternative, Proposed Project/Action Alternative, and others as appropriate. In addition, the Public Review Draft EIR/EIS will address the indirect effects and the cumulative effects of implementation of the Proposed Yuba Accord in conjunction with other past, present and reasonably foreseeable actions.

A brief initial list of potential effects and considerations that may be attributable to the Proposed Project/Action and its alternatives and/or the cumulative condition, which will be evaluated in the EIR/EIS, is presented below.

Water Supply

Local

- Effects on YCWA water supply management and reliability
- Effects on reliability of water supply to Member Units in the YCWA service area
- Effects on surface water/groundwater interconnectivity
- Effects on groundwater sustainability/safe yield

Regional

- Effects on SWP and CVP water supply management and reliability

- Assurance of long-term water supply for the CALFED EWA Program
- Changes in the rate and timing of river flows affecting water supply of SWP/CVP and non-SWP/CVP users

Water Quality

Local

- Anticipated changes in summer river flows and associated water temperature effects
- Verification of compliance with regulatory standards and requirements

Regional

- Effects of changes in the timing and magnitude of river flows and associated changes in water constituent concentrations
- Effects of changes in the rate and timing of Delta inflows and associated changes in Delta water constituent concentrations
- Verification of compliance with regulatory standards and requirements

Fisheries Resources

Local

- Investigation of flow and water temperature related effects on various life stages of anadromous salmonids and resident fisheries resources, and overall habitat quality and quantify for aquatic organisms, from alterations in the timing, duration and/or magnitude of river flows
- Effects of changes in flow and water temperature related effects on various life stages of anadromous salmonids and resident fisheries resources from the proposed new point of diversion/rediversion

Regional

- Investigation of flow and water temperature related effects on various life stages of anadromous salmonids and resident fisheries resources, and overall habitat quality and quantify for aquatic organisms, from alterations in the timing, duration and/or magnitude of inflow and diversions
- Effects of changes in timing and magnitude of flows and associated changes in water constituent concentrations and bioavailability of heavy metals in the Feather River, Sacramento River, and the Delta
- Effects of changes in flow and other associated changes and operational changes in the Delta on various life stages of anadromous salmonids and resident fisheries resources, and overall habitat quality and quantify for aquatic organisms

Terrestrial Resources

Local

- Evaluation of groundwater/surface water hydraulic continuity between hyporheic zones, instream flows and wetland habitats

- Evaluation of potential effects on terrestrial habitat related to the proposed second point of diversion
- Effects of changes in timing and magnitude of river flows and associated changes in riparian vegetation/habitat

Regional

- Effects of changes in timing and magnitude of flows and associated changes in riparian vegetation/habitat associated with SWP/CVP system-wide reservoirs, river corridors, floodplains and the Delta

Recreation

Local

- Effects of changes in timing and magnitude of Yuba River flows, and New Bullards Bar and Englebright reservoir elevations, and associated changes on water-dependent and water-enhanced recreation opportunities

Regional

- Effects of changes in timing and magnitude of flows and reservoir elevations and associated changes in water-dependent and water-enhanced recreation opportunities within the SWP/CVP system

Air Quality

Local

- Evaluation of effects of conversion of groundwater pumps from diesel to electric

Land Use

Local

- Evaluation of potential effects on agricultural and residential land uses
- Evaluation of compliance with local and regional planning objectives

Regional

- Evaluation of potential non-Yuba Basin land use issues, effects and mitigation, tiering from relevant approved/certified environmental compliance documentation, as applicable

Socioeconomic

Local

- Improvement of water supply reliability effects upon local municipal and agricultural economy
- Revenue source for local water resources and flood control projects

Regional

- Improvement in reliability of SWP and CVP water supply contract allocations and EWA water supply source

Growth Inducement

Local

- Evaluation of the potential for the Proposed Yuba Accord related water supply availability as a growth-inducement mechanism (foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment)

Regional

- Evaluation of potential non-Yuba Basin growth-inducement issues, effects and mitigation, tiering from relevant approved/certified environmental compliance documentation, as applicable

OTHER INFORMATION TO BE PROVIDED IN THE EIR/EIS

Alternatives Analysis

Effects Found Not to Be Significant

Relationship of the Proposed Yuba Accord to Relevant Laws and Regulations

PROCESS FOR ENVIRONMENTAL REVIEW

EIR/EIS Scoping Process

YCWA and Reclamation will seek public input on topics, issues, and alternatives to be considered in the EIR/EIS during scoping meetings in July 2005.

Scoping is an open process of eliciting comment on the contents of the EIR/EIS from responsible, trustee, cooperating and reviewing agencies, and interested parties. The views of your agency, relative to the statutory responsibilities of your agency in connection with the proposed project, are being solicited in an effort to determine the scope and content of the environmental document. The Public Review Draft EIR/EIS is anticipated to be available for public review in March 2006.

Public Scoping Meetings

Dates and Locations: Four public scoping meetings will be held on the following dates and locations:

- City of Sacramento: July 19, 2005 - 1:00 p.m. and 6:30 p.m.
  Double Tree Hotel
  2001 Point West Way
  Sacramento, CA 95815

- City of Marysville: July 20, 2005 - 1:00 p.m. and 6:30 p.m.
  Yuba County Government Center
  915 8th Street
  Marysville, CA 95901

*Special Assistance***.** If you require special assistance during public meetings, please contact Carol Brown at Surface Water Resources, Inc., (916) 563-6369 or by email: brown@swri.net. Please notify Ms. Brown as far in advance of the scoping meetings as possible to enable the provision of the needed services. If a request cannot be honored, the requestor will be notified.

Response to Notice of Preparation

Written comments on the scope and content of the environmental information to be addressed in the Public Review Draft EIR/EIS, should be sent to Carol Brown, Surface Water Resources, Inc. 2031 Howe Avenue, Suite 110, Sacramento, CA, 95825 by July 20, 2005. Written comments also may be sent by e-mail to ProposedYubaAccord@swri.net.

Disclosure of Public Comments

Our practice is to make comments, including names and addresses of respondents, available for public review. Individual respondents may request that we withhold their address from public disclosure, which we will honor to the extent allowable by law. There may be other circumstances in which we would withhold a respondent's identity from public disclosure, as allowable by law. If you wish us to withhold your name and/or address, you must state this prominently at the beginning of your comment. We will make available for public disclosure all submissions, in their entirety, from organizations or businesses, and from individuals identifying themselves as representatives or officials of organizations or businesses.

Proposed Yuba Accord Documentation

Documents related to the Proposed Yuba Accord are available for public viewing at the Yuba County Water Agency (including its website http://www.ycwa.com) and the Yuba County Library. For additional information regarding viewing of related documentation contact: Jeanene Upton, Yuba County Water Agency, 1402 D Street, Marysville, CA – (530) 741-6278.

EIR/EIS Public Review

Public Review of the Draft EIR/EIS

The Public Review Draft EIR/EIS will be circulated for a 60-day public review period. Public hearings/meetings will be held during the public review period to receive comment on the Public Review Draft EIR/EIS.

Final EIR/EIS Approval Process

Approval of the Final EIR/EIS will involve a YCWA Board Meeting (to be held in Marysville, California) in which it is anticipated that the YCWA Board will certify the Final EIR, make a decision regarding the Proposed Project, adopt the Mitigation, Monitoring and Reporting Plan (MMRP) for the Proposed Project, and issue a Notice of Determination (NOD) for the CEQA process.

NEPA Compliance

Reclamation is the federal lead agency for the Proposed Yuba Accord and will be responsible for ensuring the joint EIR/EIS is prepared to satisfy the requirements of NEPA. Reclamation NEPA processes include public scoping, Public Review Draft EIR/EIS review and comment period, public meetings to receive comments on the Public Review Draft EIR/EIS, preparation of a Final EIR/EIS including responses to comments received on the Public Review Draft EIR/EIS and preparation of a Record of Decision (ROD).

This NOP has been distributed to responsible agencies, trustee agencies, involved federal agencies and other interested parties.

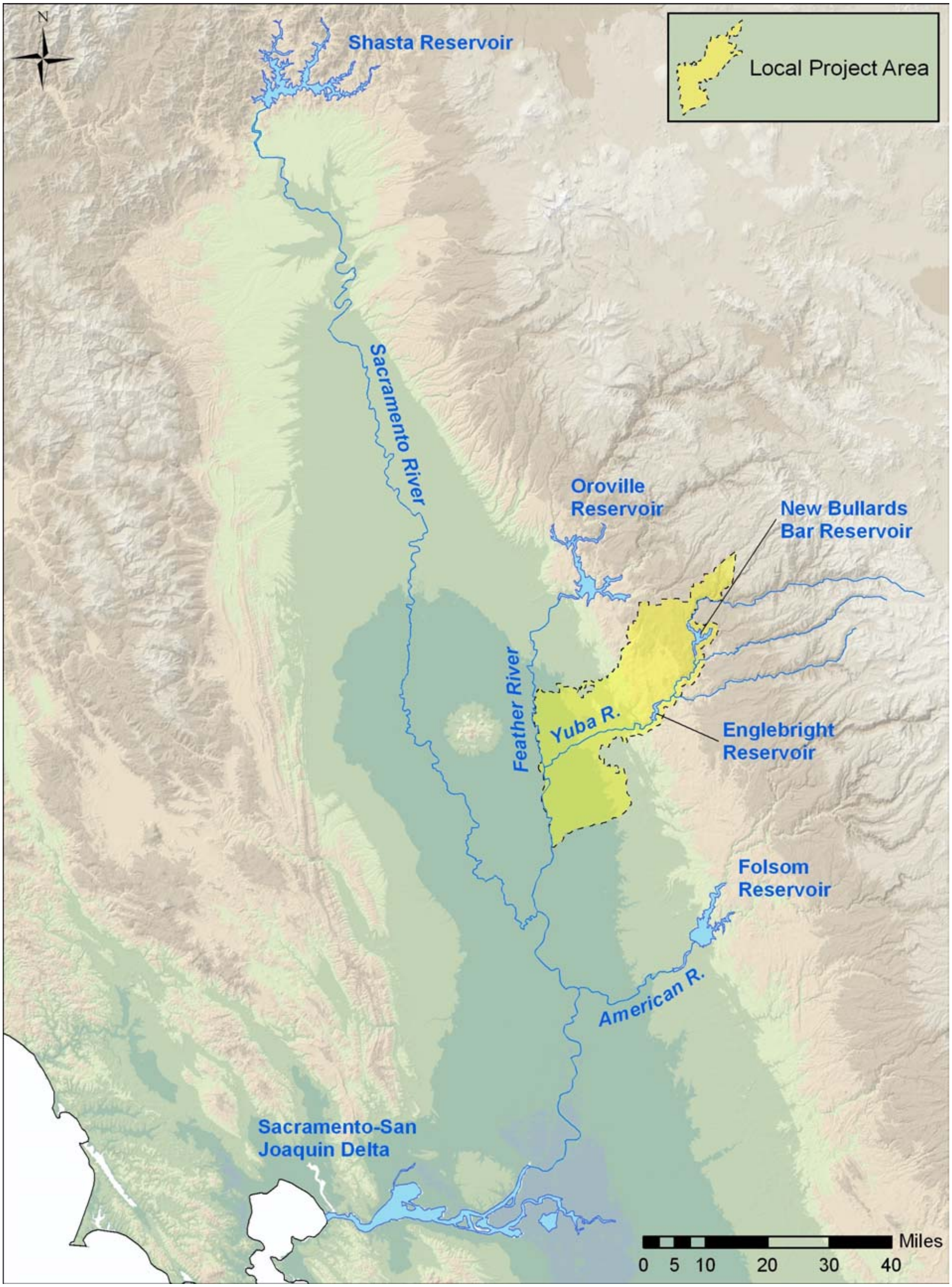

Figure 1. Proposed Yuba Accord project area.

Notice of Intent

Department of Archives and History, Historic Preservation Division, P.O. Box 571, Jackson, MS 39205, telephone (601) 576–6940, before July 20, 2005. Repatriation of the human remains and associated funerary objects to the Chickasaw Nation, Oklahoma may proceed after that date if no additional claimants come forward.

The Mississippi Department of Archives and History, Historic Preservation Division is responsible for notifying the Chickasaw Nation, Oklahoma that this notice has been published.

Dated: May 31, 2005.

Sherry Hutt,

Manager, National NAGPRA Program.

[FR Doc. 05–12029 Filed 6–17–05; 8:45 am]

BILLING CODE 4312–50–S

DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

Lower Yuba River Accord, Yuba County, CA

AGENCY: Bureau of Reclamation, Interior.

ACTION: Notice of Intent to prepare an Environmental Impact Statement/ Environmental Impact Report (EIS/EIR) and to hold public scoping meetings.

SUMMARY: Pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended, the Bureau of Reclamation (Reclamation) proposes to participate and serve as the lead agency under NEPA in the preparation of a joint EIS/EIR on the Lower Yuba River Accord (Yuba Accord). The Yuba County Water Agency (YCWA), a local public water agency, is proposing the project and will serve as the lead agency under the California Environmental Quality Act (CEQA). The purpose of the Yuba Accord is to resolve instream flow issues associated with operation of the Yuba River Development Project (Yuba Project) in a way that protects and enhances lower Yuba River fisheries and local water-supply reliability, while providing revenues for local flood-control and water-supply projects, water for the CALFED Program to use for protection and restoration of Sacramento-San Joaquin Delta (Delta) fisheries, and improvements in state-wide water supply management, including supplemental water for the Central Valley Project (CVP) and the State Water Project (SWP).

This notice is published in accordance with NEPA regulations found in 40 CFR 1501.7. The purpose of this notice is to obtain suggestions and information from other agencies and the public on the scope of issues to be addressed in the EIS/EIR. A similar notice is being published by YCWA in accordance with CEQA. Comments and participation in the scoping process are encouraged.

DATES: Four public scoping meetings will be held on the following dates:

- July 19, 2005–1 p.m., Sacramento, CA
- July 19, 2005–6:30 p.m., Sacramento, CA
- July 20, 2005–1 p.m., Marysville, CA
- July 20, 2005–6:30 p.m., Marysville, CA

ADDRESSES: The public scoping meeting locations are:

- Sacramento—Doubletree Hotel, 2001 Point West Way, Sacramento, CA
- Marysville—Yuba County Government Center, 915 8th Street, Marysville, CA

Written comments on the scope of the Yuba Accord or issues to be addressed in the EIR/EIS must be received no later than August 4, 2005. Send written comments to Mary Grim, Bureau of Reclamation, 2800 Cottage Way, MP–400, Sacramento, CA 95825. Grim, Bureau of Reclamation, 2800 Cottage Way, MP–400, Sacramento, CA 95825.

FOR FURTHER INFORMATION CONTACT: Mary Grim, Environmental Specialist, Reclamation, at the above address; telephone number 916–978–5204.

SUPPLEMENTARY INFORMATION: YCWA is a public agency created and existing pursuant to the provisions of the Yuba County Water Agency Act of 1959. YCWA owns and operates the Yuba Project, which includes New Bullards Bar Dam and Reservoir on the North Yuba River. YCWA operates the Yuba Project in accordance with a Federal Energy Regulatory Commission License, flood control rules promulgated by the U.S. Army Corps of Engineers, state water rights permit terms, and an agreement with the California Department of Fish and Game (CDFG) for instream flows.

In March of 1991, CDFG released a "Lower Yuba River Fisheries Management Plan", which contained recommendations regarding fishery protection and enhancement measures in the lower 24-mile section of the Yuba River. CDFG requested that the State Water Resources Control Board (SWRCB) consider modifying YCWA's water rights permits to implement the recommendations contained in CDFG's Plan. Based on CDFG's request, and to address various allegations raised by a coalition of non-governmental fisheries organizations (NGOs) against several water agencies in 1989 filings, the SWRCB initiated a proceeding to consider fishery protection and water right issues on the lower Yuba River in early 1992.

The SWRCB held hearings on these issues in 1992 and 2000. The SWRCB adopted Water Rights Decision 1644 (D–1644) on March 1, 2001. D–1644 established new instream flow requirements for the lower Yuba River in YCWA's water right permits, required YCWA to take actions to address potential concerns regarding water temperatures for Chinook salmon and steelhead, and required studies and consultation on various other issues.

YCWA, several local water districts in Yuba County, and a collective of fisheries NGOs all initiated legal actions challenging D–1644 on a variety of issues. After considering some new evidence, the court remanded D–1644 to the SWRCB for reconsideration in light of the new evidence. After a brief hearing in 2003, the SWRCB issued Revised Water Rights Decision 1644 (RD–1644), which contains only minor changes from D–1644. The same parties that had challenged D–1644 then initiated new legal proceedings challenging RD–1644 on most of the same issues.

Since RD–1644 was issued, the parties to the litigation and the state and Federal fisheries agencies have been engaged in a collaborative, interest-based initiative to try to resolve the flow and other fisheries issues on the lower Yuba River. The potential settlement has become known as the Yuba Accord. If implemented, the Yuba Accord would resolve issues associated with operation of the Yuba Project in a way that would protect and enhance lower Yuba River fisheries, protect local water supply reliability, provide revenues for local flood-control and water-supply projects, provide water for protection and restoration of Delta fisheries, and increase state-wide water supplies.

The Yuba Accord would include three major elements:

- The first element would be an agreement (Yuba Accord Fisheries Agreement) between YCWA, CDFG and the collective of NGOs, with the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration, National Marine Fisheries Service supporting the agreement. Under the Yuba Accord Fisheries Agreement, YCWA would revise the operation of the Yuba Project to provide higher flows in the lower Yuba River to protect and enhance fisheries and to increase downstream water supplies.

• The second element of the Yuba Accord would be an agreement between YCWA and water districts within Yuba County (Yuba Accord Conjunctive Use Agreement) for the implementation of a comprehensive program of conjunctive use of surface water and groundwater supplies and actions to improve water use efficiencies.

• The third element would be an agreement between YCWA and the California Department of Water Resources (DWR) and Reclamation (Yuba Accord Transfer Agreement), which would put water released from the Yuba Project to beneficial uses through the Environmental Water Account and in the CVP and SWP service areas.

All three of these agreements would need to be in place for the Yuba Accord to be implemented.

The draft EIS/EIR will analyze the adverse and beneficial effects of implementing the Yuba Accord on surface water hydrology, groundwater hydrology, water supply, hydropower, flood control, water quality, fisheries, wildlife, vegetation, special-status species, recreation, visual, cultural and Indian Trust Assets, air quality, land use, socioeconomic, growth inducement, and environmental justice resources and conditions. Alternatives to be evaluated in the draft EIS/EIR include the No Action Alternative, Proposed Action Alternative, and others as appropriate. In addition, the draft EIS/EIR will address the cumulative impacts of implementation of the Yuba Accord in conjunction with other past, present, and reasonably foreseeable actions.

Our practice is to make comments on a Notice of Intent, including names and home addresses of respondents, available for public review. Individual respondents may request that we withhold their home addresses from public disclosure, which we will honor to the extent allowable by law. There also may be circumstances in which we would withhold a respondent's identity from public disclosure, as allowable by law. If you wish us to withhold your name and/or address, you must state this prominently at the beginning of your comment. We will make all submissions from organizations or businesses, and from individuals identifying themselves as representatives or officials of organizations or businesses, available for public disclosure in their entirety.

Dated: June 10, 2005.

Frank Michny,

Regional Environmental Officer, Mid-Pacific Region.

[FR Doc. 05–11975 Filed 6–17–05; 8:45 am]

BILLING CODE 4310–MN–P

INTERNATIONAL TRADE COMMISSION

[Inv. No. 337–TA–542]

In the Matter of Certain DVD/CD Players and Recorders, Color Television Receivers and Monitors, and Components Thereof; Notice of Investigation

AGENCY: U.S. International Trade Commission.

ACTION: Institution of investigation pursuant to 19 U.S.C. 1337.

SUMMARY: Notice is hereby given that a complaint was filed with the U.S. International Trade Commission on May 17, 2005, under section 337 of the Tariff Act of 1930, as amended, 19 U.S.C. 1337, on behalf of BenQ Corporation of Taiwan and BenQ America Corporation of Irvine, California. The complaint alleges violations of section 337 in the importation into the United States, the sale for importation, and the sale within the United States after importation of certain DVD/CD players and recorders, color television receivers and monitors, and components thereof, by reason of infringement of claims 7–11 and 13–15 of U.S. Patent No. 5,270,821 and claims 1, 2, 4, and 5 of U.S. Patent No. 6,683,842. The complaint further alleges that an industry in the United States exists as required by subsection (a)(3) of section 337.

The complainants request that the Commission institute an investigation and, after the investigation, issue an exclusion order and a cease and desist order.

ADDRESSES: The complaint, except for any confidential information contained therein, is available for inspection during official business hours (8:45 a.m. to 5:15 p.m.) in the Office of the Secretary, U.S. International Trade Commission, 500 E Street, SW., Room 112, Washington, DC 20436, telephone 202–205–2000. Hearing impaired individuals are advised that information on this matter can be obtained by contacting the Commission's TDD terminal on 202–205–1810. Persons with mobility impairment who will need special assistance in gaining access to the Commission should contact the Office of the Secretary at 202–205–2000. General information concerning the Commission may be obtained by accessing its Internet server (*http://www.usitc.gov*). The public record for this investigation may be reviewed on the Commission's electronic docket (EDIS) at *http://edis.usitc.gov.*

FOR FURTHER INFORMATION CONTACT: Jay H. Reiziss, Esq., Office of Unfair Import Investigations, U.S. International Trade Commission, telephone 202–205–2579.

Authority: The authority for institution of this investigation is contained in section 337 of the Tariff Act of 1930, as amended, and in section 210.10 of the Commission's Rules of Practice and Procedures, 19 CFR 210.10(2004).

Scope of Investigation: Having considered the complaint, the U.S. International Trade Commission, on June 13, 2005, *ordered that*—

(1) Pursuant to subsection (b) of section 337 of the Tariff Act of 1930, as amended, an investigation be instituted to determine whether there is a violation of subsection (a)(1)(B) of section 337 in the importation into the United States, the sale for importation, or the sale within the United States after importation of certain DVD/CD players or recorders, color television receivers or monitors, or components thereof, by reason of infringement of one or more of claims 7–11 and 13–15 of U.S. Patent No. 5,270,821, or claims 1, 2, 4, or 5 of U.S. Patent No. 6,683,842, and whether an industry in the United States exists as required by subsection (a)(3) of section 337.

(2) For the purpose of the investigation so instituted, the following are hereby named as parties upon which this notice of investigation shall be served:

(a) The complainants are—

BenQ Corporation, 157 Shan-Ying Rd, Gueishan, Taoyuan 333, Taiwan.

BenQ Corporation, 53 Discovery, Irvine, California 92618.

(b) The respondent is the following company alleged to be in violation of section 337, and is the party upon which the complaint is to be served:

Thomson Inc., 10330 N. Meridian Street, Indianapolis, IN 46290–1024.

(c) Jay H. Reiziss, Esq., Office of Unfair Import Investigations, U.S. International Trade Commission, 500 E Street, SW., Suite 401, Washington, DC 20436, who shall be the Commission investigative attorney, party to this investigation; and

For the investigation so instituted, the Honorable Robert L. Barton, Jr. is designated as the presiding administrative law judge.

A response to the complaint and the notice of investigation must be

APPENDIX B

(please refer to mp400_yubaaccord_deir_eis_appendix_b

APPENDIX C

BACKGROUND REGARDING THE DEVELOPMENT OF THE PROPOSED YUBA ACCORD FISHERIES AGREEMENT

Appendix C
Background Regarding the Development of the Proposed Yuba Accord Fisheries Agreement

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Appendix C
Background Regarding the Development of the Proposed Yuba Accord Fisheries Agreement

1.0 DEVELOPMENT OF THE YUBA ACCORD

The development of the proposed agreements that comprise the Yuba Accord was a collaborative process that took place over a period of approximately two and a half years. The stakeholders that participated in the development of the Yuba Accord proposed agreements represent most of the fisheries agencies, water users, and other agencies and organizations concerned with lower Yuba River flows.[1]

The Yuba Accord was developed as an alternative to litigation over flow requirements in Revised Decision 1644 (RD-1644) of the State Water Resources Control Board (SWRCB). To accomplish a settlement of litigation, the stakeholders and participants in the discussions started with a set of objectives and criteria for the key elements of any settlement. Those objectives and criteria were ultimately carried forward as the objectives stated in Chapter 1 of this Environmental Impact Report/Environmental Impact Statement (EIR/EIS).

The initial development of the Yuba Accord focused on the development of the flow schedules for the lower Yuba River. The development of flow schedules included biological and other science-based considerations and a stressor analysis of key fisheries species and life stages, prioritized and weighted in a summary matrix. Six flow schedules, plus a conference year schedule, were developed to cover the entire range of Yuba Basin water availabilities. The flow schedules were developed to maximize fisheries benefits during wetter years, and to maintain fisheries benefits to the extent possible for drier years.

In addition to the fisheries stressor analysis, other key considerations in the development of the flow schedules included water supply demands and hydrologic constraints of the system (i.e., consumptive water use demands, flood control operations, and hydropower generation commitments). The Technical Team tasked with flow schedule development pursued a variety of analytic techniques and tools, and performed numerous evaluations of operations protocols,

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[1] Representatives of the following parties participated in various parts of the collaborative process to develop the Yuba Accord: BVID, CDFG, California Sportfishing Protection Alliance (CSPA), CID, FOR, NMFS, SYRCL, TBI, TU, USFWS, YCWA, DWR, Reclamation, PG&E, SWC, Central Valley Project Contractors Association, MWD, San Luis and Delta Mendota Water Authority, Westlands Water District, RWD, BWD, HIC, and DCMWC.

All of these entities signed an agreement providing that all documents and other information that any party prepared for the mediation or any associated settlement discussions and marked as "CONFIDENTIAL," and all associated discussions, would be treated as "Confidential Information," and that no party would disclose any Confidential Information that was prepared by any other party, except as required by applicable law.

All of these entities except for CSPA and CID have signed principles of agreement for one or more of the proposed Yuba Accord agreements. This appendix does not contain any Confidential Information that was prepared by CSPA or CID, and nothing in this appendix is based on any such Confidential Information or associated discussions. Accordingly, nothing in this appendix may be attributed to, or construed to be a position or statement of, CSPA or CID.

Except for CSPA and CID, all of the Confidential Information in this appendix was prepared by one or more of the entities that are listed above and that have consented to its public disclosure.

to mitigate and remove operational constraints that precluded providing an 'optimal' flow schedule in more years. Additionally, the development of a new Yuba Basin water availability index was required to allow a more precise determination of which flow schedule to use in the lower Yuba River during a particular water year.

After the development of the flow schedules, other technical working teams of the stakeholder collaborative undertook the codification of the flow schedules and other biological elements into the proposed Fisheries Agreement, developed the necessary supporting proposed Conjunctive Use and Water Transfer agreements, and cross-verified the 'fit' of the agreements into a total package. In many instances, elements or concepts in one agreement needed to be carefully tailored to avoid disruption of elements in another agreement; in other instances, the path to resolving an issue brought forth by a party to one agreement was found in new or modified elements in another agreement.

Throughout the nearly three year process that resulted in the Yuba Accord Alternative, all of the participating stakeholders were engaged and able to represent their own interests and perspectives. To meet all of those interests, innumerable different approaches, alternatives, concepts, and changes were described, discussed, debated, evaluated and either incorporated or discarded. For example, during development of the flow schedules as an initial component of the Fisheries Agreement, more than two dozen different flow schedule combinations were evaluated by the Technical Team. After several days of work, a dozen combinations of operational rules were evaluated to identify an approach for the proposed supplemental surface-water transfers. Notification and reporting requirements (and associated key dates) in each of the agreements went through multiple revisions, to accommodate all of the interests, to provide operational flexibility and to correspond to dates in the other agreements. The penalty and remedy provisions in each of the agreements were drawn from lists of potential provisions, and the agreements generally include different remedies for different situations that could be encountered in implementing the Yuba Accord.

In total, the aggregate number of different 'alternatives' or permutations to the final Yuba Accord Alternative that were evaluated and discarded by the technical and drafting teams numbered into the hundreds. During the entire duration of the development of the Yuba Accord Alternative, the various participants and technical teams remained mindful of the initial suite of objectives for the process. As a result, alternatives and permutations that were rejected were rejected as either technically insufficient, as failing to meet a key interest of one of the stakeholders, or as failing to meet one of the initial objectives of the process.

1.1 DEVELOPMENT OF THE FISHERIES AGREEMENT

The development of the proposed Fisheries Agreement was the first step taken in the process that led to the Yuba Accord. The Fisheries Agreement derived from a process focused on: (1) evaluating key fisheries stressors in the lower Yuba River; (2) developing new instream flow requirements; (3) developing a monitoring and evaluation program to oversee the success of the flow schedules; and (4) creating a funding mechanism to pay for monitoring and study activities and the proposed conjunctive-use program.

1.2 PURPOSE OF THIS APPENDIX

This appendix provides an overview of the development of the proposed Fisheries Agreement, including significant detail on the construction of the Stressor Matrix, evaluation, and integration of operational constraints, and the iterative process of development of flow schedules for the lower Yuba River. While this appendix does not attempt to enumerate or describe the dozens of permutations, alternatives, variations, and ideas that were put forth by all of the parties during the collaborative development of the Fisheries Agreement, this appendix does provide an overview of the Fisheries Agreement development process, and it describes the wide variety of different concepts and alternatives that were part of the establishment of the final Fisheries Agreement.

2.0 TECHNICAL TEAM WORKING GROUP

2.1 COMPOSITION OF THE TECHNICAL TEAM

The group primarily responsible for development of the biological aspects of the Fisheries Agreement was a technical working team comprised of representatives of various resource agencies (including NMFS, USFWS, and CDFG), representatives of various NGOs including Trout Unlimited, Friends of the River, South Yuba River Citizens League, and the Bay Institute. YCWA also participated in the technical working team, which became known as the Technical Team[2].

Participation in the Technical Team was voluntary, and each of the participating agencies and entities provided staff and other resources for the Technical Team. Each of the participating agencies and entities represented its own interests and provided extensive input and perspective into the process. As would be expected, there was a wide divergence of opinions on numerous issues. However, the Technical Team participants were able to reach consensus and agreement on most issues.

The Technical Team members did not have a formal mandate from their agency/organization to achieve a settlement or other agreement. However, Technical Team members were able to undertake a science-based discussion of technical issues, and an interest-based discussion of the potential solutions that ultimately did lead to a collaborative settlement.

From the earliest stages of discussion, the Technical Team recognized the following needs and challenges to developing an agreeable set of flow schedules:

- A history of sometimes acrimonious dialogues and debates over lower Yuba River operations and appropriate minimum flow requirements;
- Fisheries and aquatic habitat needs, and goals for protection and enhancement of fisheries and aquatic resources; and
- Operational constraints on the lower Yuba River system, including water delivery, power generation, flood control, and biological constraints.

To meet these needs and challenges, the Technical Team decided that it would be necessary to essentially "start over" using current science and data on the state and condition of the lower

[2] A representative of CSPA also participated in some of the Technical Team meetings. However, as discussed in footnote 1 above, CSPA has not signed the principles of agreement for the Fisheries Agreement and has not consented to the disclosure of any Confidential Information that its representative provided to the Technical Team. This appendix does not contain any confidential information provided by CSPA, and nothing in this appendix may be attributed to, or construed to be a position of, CSPA.

Yuba River. In addition, it was essential that every participant in the Technical Team clearly understand the goals and interests of each of the other participants, and have a clear and accurate understanding of the operational constraints for the lower Yuba River. As a result, considerable time and effort was expended by the Technical Team in discussing interests and operational constraints.

2.2 TECHNICAL TEAM GOALS

All of the participants in the Technical Team shared a common goal of ensuring an appropriate level of protection for various aquatic resources and fisheries species in the lower Yuba River, particularly for listed species such as Central Valley steelhead and Central Valley spring-run Chinook salmon. Additionally, all of the participants were interested in a long-term monitoring and studies program to further evaluate the effects of the Yuba Accord and the general health of the lower Yuba River.

Additionally, YCWA was interested in:

- ❑ Improving Yuba County water supply management and reliability;
- ❑ Implementing a comprehensive conjunctive use program for managing surface water and groundwater supplies within Yuba County to improve water use efficiency; and
- ❑ Developing a consistent source of revenues to fund both Yuba Accord actions (e.g., Conjunctive Use Program, River Management Team) and other YCWA projects such as Yuba County flood control and water supply improvements.

The Technical Team did not take the step of formally adopting in these specific goals and objectives during the early stages of development of what would become the Fisheries Agreement. However, these goals and objectives were a clear and pervasive thread through all of the discussions undertaken by the Technical Team.

In the process of pursuing the overarching goal of ensuring an appropriate level of protection for various aquatic resources and fisheries species in the lower Yuba River, the Technical Team worked toward achieving several subsidiary goals:

- ❑ Appropriate flows for the lower Yuba River, including development of an instream flow regime that addressed Yuba River-specific fisheries-related concerns and that enhanced the current regulatory baseline for stream flows and water temperatures, particularly for listed species such as Central Valley steelhead and Central Valley spring-run Chinook salmon;
- ❑ Operational flexibility for the lower Yuba River;
- ❑ Appropriate monitoring of conditions, flows, and the nexus between flows and species health; and
- ❑ Establishment of a collaborative river management process for New Bullards Bar Reservoir and lower Yuba River operations.

2.3 APPROACH DEVELOPED BY THE TECHNICAL TEAM

Several steps were taken to develop to the proposed Yuba Accord flow schedules:

- Develop a Stressor Matrix for key fisheries species in the lower Yuba River;
- Focus on key fish species and consider general aquatic habitat conditions and health in the lower Yuba River;
- Define general fisheries goals (e.g., maintenance, recovery, enhancement, etc.);
- Define specific fisheries-related goals of the new flow regime in terms of flow, temperature, habitat, etc.;
- Develop a comprehensive understanding of the hydrology and range of variability in hydrology for the Yuba Basin;
- Develop a comprehensive understanding of the operational constraints (regulatory, contractual, and physical) of the Yuba River Development Project (Yuba Project) and lower Yuba River, as well as an understanding of the flexibilities and inflexibilities of those constraints; and
- Develop flow regimes based on specific fisheries-related goals and water availability (as defined by operational constraints and hydrologic conditions).

3.0 DEVELOPMENT OF STRESSOR MATRICES FOR THE LOWER YUBA RIVER

The Technical Team recognized that a new flow regime for the lower Yuba River would need to achieve several objectives, including:

- Maximize the occurrence of "optimal" flows and minimize the occurrence of sub-optimal flows, within the bounds of hydrologic variation;
- Maximize occurrence of appropriate flows for Chinook salmon and steelhead immigration spawning, rearing, and emigration;
- Provide month-to-month flow sequencing in consideration of Chinook salmon and steelhead life history periodicities;
- Provide appropriate water temperatures for Chinook salmon and steelhead immigration and holding, spawning, embryo incubation, rearing and emigration.
- Promote a dynamic, resilient, and diverse fish assemblage;
- Minimize potential stressors to fish species and life stages; and
- Develop flow regimes that consider all freshwater life stages of salmonids and allocate flows accordingly.

To build a scientific basis for crafting a flow regime that would meet these objectives, the Technical Team needed a tool to be able to prioritize impacts on and benefits to the lower Yuba River aquatic resources. To meet this need, the Technical Team undertook development of a matrix of the primary "stressors" that affect anadromous salmonids in the lower Yuba River.

3.1 STRESSOR MATRIX DEVELOPMENT

While the Technical Team recognized the critical importance of having a dynamic and resilient aquatic community, the Technical Team also realized that developing a flow regime that considered the environmental and biotic requirements of each species in the entire aquatic community would not only be exceedingly complex and difficult, but probably also impossible, given the myriad of constraints (time, operations, finite water availability, water rights, conflicting requirements of aquatic species, etc.) confronting the process. The Technical Team decided that, to meet its goals, efforts would be focused on addressing "keystone" lower Yuba River species. The Technical Team agreed that a flow regime that supported key fish species such as Central Valley steelhead and Central Valley Chinook salmon generally would benefit other native fish species, recreationally important fish species such as American shad and striped bass, aquatic macroinvertebrates, and other aquatic and riparian resources. The Technical Team also realized that, above all else, the developed flow regime would be evaluated primarily on its perceived value or benefit to state and federally listed species, namely Central Valley steelhead and Central Valley spring-run Chinook salmon, and to fall-run Chinook salmon. For this reason, the lower Yuba River stressor prioritization process principally considered steelhead, spring-run Chinook salmon, and fall-run Chinook salmon. Other fish species considered, but ultimately excluded from the stressor prioritization process, were American shad, striped bass, and green sturgeon. The primary purpose of the stressor prioritization process was to provide specific input and rationale for seasonal flow regime development as well as to provide overall guidance for other management and potential restoration actions.

For the purpose of developing the lower Yuba River Anadromous Salmonid Stressor Matrix[3] — the ultimate product of the stressor prioritization process — the freshwater lifecycle for each species or race was broken up into six commonly acknowledged life stages. These life stages are: (1) adult immigration and holding; (2) spawning and egg incubation; (3) post-emergent fry outmigration (referred to as young-of-year (YOY) downstream movement/outmigration for steelhead); (4) fry rearing; (5) juvenile rearing; and (6) smolt outmigration (referred to as yearling (+) outmigration for steelhead). Each of the life stages was then assigned a temporal component reflecting the best available knowledge of the timing and duration of that life stage in the lower Yuba River.

Potential stressors (also referred to as "limiting factors") were then identified for the life stage of each species or race. Because most potential stressors were limited to a particular geographic reach or extent in the lower Yuba River, a geographical component was assigned to each stressor. The following is a listing of all of the potential stressors considered for the purpose of Stressor Matrix development.

[3] The original framework for the Stressor Matrix was developed for the Lower Yuba River Technical Fisheries Working Group's "Draft Implementation Plan for Lower Yuba River Anadromous Fish Habitat Restoration: Multi-Agency Plan to Direct Near-Term Implementation of Prioritized Restoration and Enhancement Actions and Studies to Achieve Long-Term Ecosystem and Watershed Management Goals (Implementation Plan)." The intent of the Implementation Plan is to facilitate the implementation of prioritized actions and studies that will protect, enhance, and restore: (1) the Yuba River aquatic and riparian habitats; (2) the key processes that create and maintain these habitats; and (3) the anadromous fish species that use such habitats, while increasing the understanding of ecosystem structure and function in the lower Yuba River.

- Water Temperature
- Flow Fluctuations
- Flow Dependent Habitat Availability
- Habitat Complexity and Diversity
- Predation
- Entrainment/Diversion Impacts
- Physical Passage Impediments
- Transport/Pulse Flows
- Poaching
- Spawning Substrate Availability
- Angler Impacts
- Attraction of Non-Native Chinook salmon
- Overlapping Habitat
- Physical Passage Impacts
- Lake Wildwood Operations/Deer Creek Flow Fluctuations
- Motor-powered Watercraft

The potential stressors presented were not necessarily considered to be an exhaustive list of stressors, but were the major perceived stressors, based on current information. In addition, the list of stressors included some elements that were not necessarily considered to be stressors by all Technical Team members. The stressor prioritization process was intended to serve as a tool to provide context for and assistance in the development of the flow schedules. To do this, the potential of each of these stressors to affect the particular species and life stage was evaluated; however, only five to eight of the stressors ultimately were considered to be potential limiting factors for each particular species and life stage.

Geographic and temporal considerations then were assigned to each stressor, further defining the extent of the potential stressors' effect on each species and life stage.

Several biological considerations were addressed during the evaluation of potential stressors. These considerations included: (1) the cumulative distribution of the anadromous salmonids in the lower Yuba River during different months of the year; (2) the relative contributions of the different life stages (e.g., fry vs. smolt) to the spawning population; (3) the importance of increasing initial-year-class strength of the population; (4) the degree of control over exogenous factors that may affect the environmental conditions experienced by the different life stages; (5) the duration that the examined life stage is present in the river; and (6) the temporal distribution associated with each examined life stage. The final assignments of potential stressors to each species and life stage reflect conclusions based on the above considerations. While the assignment of stressor relevance to the various life stages was generally based on the collective judgment of the Technical Team participants, there was considerable difference of opinion regarding some of the stressor relevance assignments. Thus, in many cases the relevance assignments represents a reasoned consensus of the group, rather than a unanimous decision. Overall, however, the Technical Team participants expended considerable effort to research, discuss, and otherwise work through appropriate relevance assignments to include in the Stressor Matrix.

The prioritization of stressors in the lower Yuba River consisted of a limiting factor analysis, by species and life stage, which is based on the existing hydrological and biological conditions of the river. Particular emphasis was placed on the instream conditions during the past 10 to 15 years, as recent historical information is likely reasonably representative of future hydrologic patterns, and most representative of current operational practices.

Calculation of Stressor Matrix weightings was accomplished by utilization of a decision tree with weights assigned to individual tiers within the tree. The individual tiers within the decision tree, <u>from highest to lowest,</u> are: (1) fish species/run, (2) life stage; and (3) stressor/limiting factor.

The individual tiers were related hierarchically. In other words, each variable within a tier had several associated variables at the next lower tier, except at the lowest (i.e., third) tier. The weights assigned to individual variables within each tier summed to a value of 1, and higher relative weight values were assigned *a priori* to reflect individual variables that had greater potential effects on species production. Variables were ranked relative to one another according to their biological significance. The fish species/runs were ranked in relative importance according to such considerations as ESA and population status. For example, spring-run Chinook salmon and steelhead were given an equal ranking that was higher than that of fall-run Chinook salmon because Central Valley spring-run Chinook salmon and Central Valley steelhead both are ESA threatened species and Central Valley fall-run Chinook salmon is not.

The individual life stages of each fish species/run were ranked in relative importance according to the assumed contribution of each freshwater life stage to overall population production. For example, for spring-run Chinook salmon, the spawning and egg incubation life stage was given the highest relative ranking because the Technical Team perceived this life stage to be the most important freshwater life stage in contributing to spring-run Chinook salmon production.

The individual limiting factors affecting each life stage were ranked in relative importance according to such considerations as the proportion of each life stage potentially affected, the magnitude and extent of potential adverse effects on each life stage, and the spatial or temporal occurrence of potentially limiting factors. Continuing with the example of spring-run Chinook salmon spawning and egg incubation life stage, water temperature was identified by the Technical Team as the most important limiting factor affecting this life stage and, thus was given the highest weight.

The numeric weights assigned to individual variables within each tier reflect the degree of relative importance of each variable (i.e., variables with a high relative ranking received a relatively high weight). The ranking of the individual tiers (species/run, life stage, and stressor/limiting factor) was accomplished through a "consensus" approach and was largely determined by best professional judgment. In some circumstances, a consensus represented a compromise because some individual weightings varied substantially among Technical Team members.

The stressor prioritization process consisted of developing a "composite weight" for each species, life stage, and stressor combination. The composite weight was calculated by multiplying the species weight, the life stage weight, the stressor weight, and 100. The resulting 215 species-life stage-stressor composite weights could then be summed, sorted, and ranked numerous ways depending on the specific consideration of interest. Two of the most illustrative rankings were the overall stressor ranking and the stressor ranking by month.

The sensitivity and precision of individual stressor ratings and the prioritization summary data that the Technical Team developed were limited, and were not considered to be an exact quantification of anadromous salmonid stressors in the lower Yuba River. Instead, the stressor rankings represented a broad index of relative importance, where only substantial differences between stressor ratings were considered by the Technical Team to be meaningful. A significant difference in the potential levels of stressor impacts were assumed when significant differences were illustrated in individual stressor weightings or the resulting composite totals. However, when only small differences between individual stressor weightings existed, differences in impacts were not assumed to be significant.

Table 3-1 lists the top four stressors that were determined for each month by this process, without their composite scores. These Stressor Matrix results provided the Technical Team with a quantitative context of the relative importance of stressors for each month The Technical Team members utilized the Stressor Matrix results, with, other information, for each month to help guide flow schedule development.

Table 3-1. Top Four Stressors to Anadromous Salmonids in the Lower Yuba River for Each Month

Month	Highest Ranked Stressor	2nd Highest Ranked Stressor	3rd Highest Ranked Stressor	4th Highest Ranked Stressor
January	Flow Fluctuation	Flow Dependent Habitat Availability	Habitat Complexity and Diversity	Predation
February	Flow Fluctuation	Flow Dependent Habitat Availability	Habitat Complexity and Diversity	Physical Passage Impediment
March	Flow Fluctuation	Habitat Complexity and Diversity	Flow Dependent Habitat Availability	Predation
April	Flow Fluctuation	Habitat Complexity and Diversity	Flow Dependent Habitat Availability	Predation
May	Water Temperature	Flow Fluctuation	Habitat Complexity and Diversity	Predation
June	Water Temperature	Flow Fluctuation	Habitat Complexity and Diversity	Entrainment/Diversion Impact
July	Water Temperature	Flow Fluctuation	Habitat Complexity and Diversity	Flow Dependent Habitat Availability
August	Water Temperature	Flow Fluctuation	Flow Dependent Habitat Availability	Habitat Complexity and Diversity
September	Water Temperature	Flow Fluctuation	Flow Dependent Habitat Availability	Habitat Complexity and Diversity
October	Water Temperature	Flow Fluctuation	Flow Dependent Habitat Availability	Habitat Complexity and Diversity
November	Flow Dependent Habitat Availability	Flow Fluctuation	Predation	Habitat Complexity and Diversity
December	Flow Fluctuation	Flow Dependent Habitat Availability	Habitat Complexity and Diversity	Entrainment/Diversion Impact

4.0 DEVELOPMENT OF INITIAL FLOW SCHEDULES

After the Stressor Matrix was developed, the Technical Team undertook development of an initial set of flow schedules for the lower Yuba River. A deliberate decision was made by the Technical Team to develop these flow schedules without consideration of historic or existing regulatory requirements. Essentially, this allowed a "blank paper" development of a new set of flow schedules based on scientific considerations and the Stressor Matrix, hydrologic probabilities, and basic operational constraints.

The lower Yuba River flow schedules would ultimately need to balance consideration of numerous elements, including specific biological objectives, annual variability in water availability, reservoir constraints for flood control and power generation, ramping and flow delivery constraints, water delivery obligations (contractual and by rights), and the complex interrelations among these elements. However, during initial flow schedule development efforts, the influence of anything other than hydrology, the basic physical parameters of the Yuba River Development Project, and the direction provided by the Stressor Matrix was minimized.

Although the flow schedule development process focused on anadromous salmonids, the Technical Team remained cognizant of the importance of a properly functioning river ecosystem and the aquatic resource community, including introduced species of management concern (American shad and striped bass).

The initial development of flow schedules included the following steps:

- Identify basic hydrologic conditions, physical parameters and operations objectives that influence flow;
- Development of an "optimal" flow schedule for years with virtually unlimited water availability;
- Development of a "survival" flow schedule for years with extremely low water availability; and
- Development of additional flows schedules between the high and low range, corresponding to varying the water availabilities between the very wet years and the extremely dry years.

4.1 Basic Hydrology, Physical Parameters and Operations Objectives

The hydrology of the Yuba River basin is tremendously variable, with total Yuba River system runoff ranging from 276,000 to 3.8 million acre-feet per year. The total operational storage available in the basin is less than 1 million acre-feet, less than necessary to fully attenuate the impacts of the varied hydrology. Thus, the lower Yuba River flow schedules must accommodate all conditions from extremely wet to extremely dry. During the wetter half of hydrologic years, total water supply is not an issue in the development of flow schedules – rather, flood control operations and the need to evacuate surplus water from the reservoir are key drivers in operations and planning.

Flows in the lower Yuba River are measured at the Smartville Gage (located just downstream of Englebright Dam, at the top of the lower Yuba River reach) and the Marysville Gage (located just above the confluence of the Yuba and Feather rivers, at the lower end of the lower Yuba River reach). Between these two gages, the bulk of consumptive deliveries from the lower Yuba River are diverted from the river at or near Daguerre Point Dam.

Flow schedules were developed for both the Smartville and Marysville gages. Due to the need to release flows for consumptive needs between the gages, the flow schedules may be very different for the two gages. The higher of the Smartville and Marysville requirement dictate flows in the river.

4.2 "Optimal" Flow Schedule Development

The first step in developing the flow schedules was the development of an "optimal" flow schedule that was not constrained by water availability limitations. Available information such as the Stressor Matrix results (and the species and life stage rankings, life stage periodicities, and geographical considerations developed for the Stressor Matrix), flow-habitat relationships (i.e., weighted usable area [WUA]) for Chinook salmon and steelhead spawning, and an understanding of the lower Yuba River flow-water temperature relationship was utilized. Obviously, even this flow schedule would not be "optimal" for all species and life stages that might be present in the river; however, it was the intent of the biologists on the Technical Team to construct a flow schedule that would provide the greatest benefit to the broadest suite of species and life stages.

Although the Technical Team generally was aware of the specific interim and long-term flow requirements in RD-1644, the Technical Team's goal was not to modify the RD-1644 flow requirements, but instead to develop an independent flow regime that principally considered the requirements of the species and life stages of anadromous salmonids in the lower Yuba River present during each month.

The development of the "optimal" flow schedule resulted in a "high" (Schedule 1) and a "low" (Schedule 2) range of ideal flows (**Table 4-1**). The development of the "high" and "low" range of ideal flows was representative of the variety of opinions among the Technical Team biologists. Through extensive discussion and collaboration, the Technical Team biologists and representatives came to a general agreement that the two flow schedules represented the range of the "optimal" flows.

Table 4-1. Initial Technical Team Schedule 1 and Schedule 2 Minimum Flow Requirements as Measured in cfs at the Marysville Gage

Schedule	Oct		Nov	Dec	Jan	Feb	Mar	Apr		May		Jun		Jul	Aug	Sep	Total Annual Volume (AF)
	1-15	16-31	1- 30	1-31	1-31	1-29	1-31	1-15	16-30	1-15	16-31	1-15	16-30	1-31	1-31	1-30	
1	500	500	500	500	500	500	700	1,000	1,000	2,000	2,000	1,500	1,500	600	500	500	555,984
2	500	500	500	500	500	500	700	700	800	1,000	1,000	800	400	400	400	400	408,078

Although flows were developed month by month, the year generally could be broken into three periods: (1) September through March; (2) April through June; and (3) July and August. The September through March period encompassed the entire Chinook salmon (fall-run and spring-run) spawning period and the majority of the steelhead spawning period, and spawning requirements guided flow-schedule development for this period. The April through June period is characterized by higher flows from the spring snowmelt and run-off, and is an important period for juvenile salmonid emigration. July and August are typically the warmest months of the year. During this period, juvenile anadromous salmonids are rearing and spring-run and fall-run Chinook salmon are migrating and holding in the lower Yuba River. Flows allocated during July and August were intended to provide appropriate water temperatures for these life stages. Also, development focused on the "control" period of April though November, when flows in the lower Yuba River generally were not subject to other operations requirements such as flood control, and when flows normally are controlled by reservoir releases.

4.2.1 SEPTEMBER THROUGH MARCH

The flows the Technical Team prescribed for the September through March period, which generally encompasses the spring-run Chinook salmon, fall-run Chinook salmon, and steelhead spawning periods, generally provided maximum (or near maximum) spawning habitat (as measured by flow at the Smartville Gage) as determined through instream flow incremental methodology (IFIM) physical habitat simulations (CDFG 1991) (see **Figure 4-1**). Because all of the spring-run Chinook salmon spawning (CALFED and YCWA 2005), the vast majority of the steelhead spawning, and approximately 60 percent of the fall-run Chinook salmon spawning occurs upstream of Daguerre Point Dam (SWRCB 2003), the Technical Team developed flow requirements at the Marysville Gage with the understanding that flows during the spawning periods were at least 200 cfs higher at the Smartville Gage than at the Marysville Gage during most years.

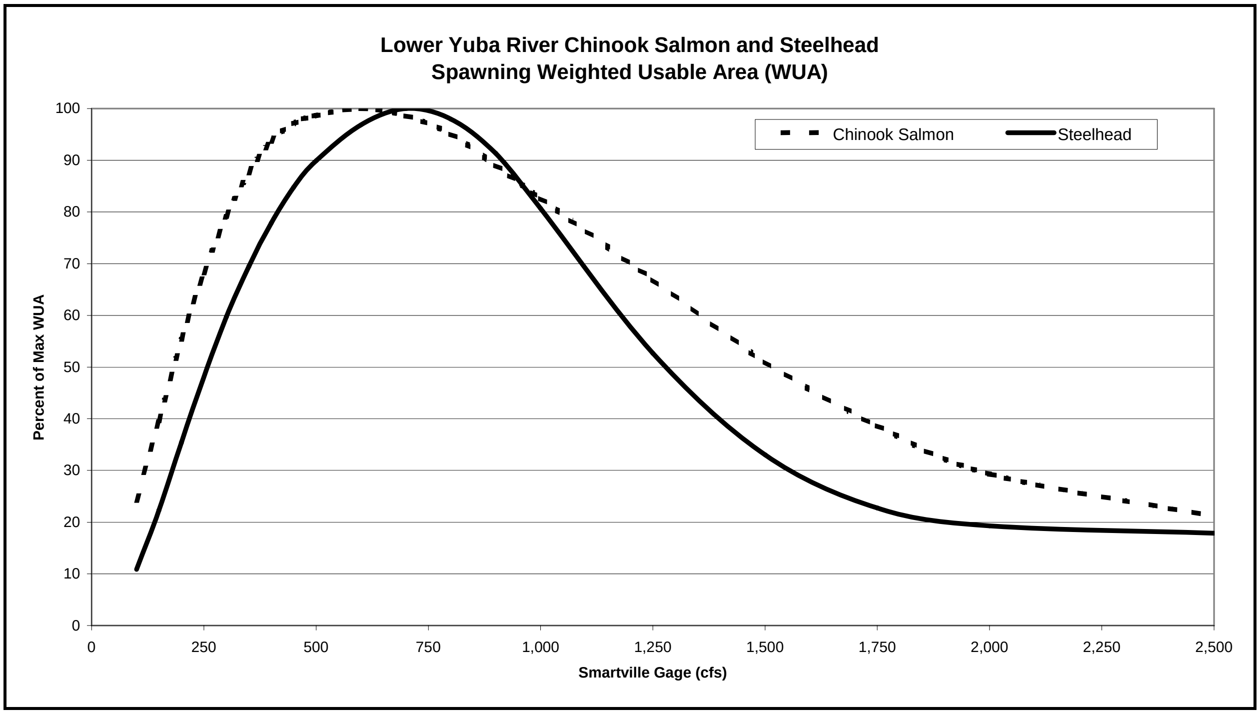


Figure 4-1. The Lower Yuba River Chinook Salmon and Steelhead Flow-Spawning Habitat Weighted Usable Area Curve

As indicated by the flow-habitat relationships developed for the lower Yuba River, a flow of 700 cfs as measured at the Smartville Gage provides 100 percent of available steelhead spawning habitat and 98.6 percent of available Chinook salmon spawning habitat (CDFG 1991). Later in the flow schedule development process, the Technical Team developed specific flow requirements for particular months for the lower Yuba River at the Smartville Gage. **Table 4-2** presents the Smartville Gage flow requirements that were developed, which are associated with the flow requirements at the Marysville Gage during Schedule 1 through 6 years.

Table 4-2. Technical Team Flow Requirements Associated with the Six Flow Schedules as Measured (in cfs) at the Smartville Gage

Schedule	Oct		Nov	Dec	Jan	Feb	Mar	Apr		May		Jun		Jul	Aug	Sep	Total Annual Volume (AF)
	1-15	16-31	1- 30	1-31	1-31	1-29	1-31	1-15	16-30	1-15	16-31	1-15	16-30	1-31	1-31	1-30	
A	700	700	700	700	700	700	700	700	0	0	0	0	0	0	0	700	--
B	600	600	600	550	550	550	550	600	0	0	0	0	0	0	0	500	--
Schedule A used with Schedules 1, 2, 3 and 4 at Marysville Schedule B used with Schedules 5 and 6 at Marysville																	

During September and October of the September through March period, water temperature, particularly for spring- and fall-run Chinook salmon immigration, holding, spawning and egg incubation life stages, also was a particular concern. Because of the water diversions that occur in the lower Yuba River in the vicinity of Daguerre Point Dam during most months of the year, the progressive downstream ambient warming that occurs during warmer months, and the inflow of relatively warm water from the Yuba Goldfields, water temperatures downstream of Daguerre Point Dam typically are considerably warmer, especially at lower flows, than temperatures upstream. The Technical Team weighed the water temperature considerations and the flow-spawning habitat relationships and determined that 500 cfs at the Marysville Gage and 700 cfs at the Smartville Gage achieved the principal biological objectives for the September through March period.

4.2.2 APRIL THROUGH JUNE

During the April through June period, minimizing flow fluctuations and mimicking the natural unimpaired hydrological patterns for juvenile rearing and emigration were of particular concern to the Technical Team. During May and June, water temperature was a very important consideration for several species/run and life stage combinations, including spring-run Chinook salmon adult immigration and holding, juvenile rearing, and smolt emigration, fall-run Chinook salmon juvenile rearing and outmigration, and steelhead embryo incubation (May only), juvenile rearing, and smolt emigration (May only). Providing flows sufficient to transport emigrating juvenile salmonids also was of concern.

Flow fluctuations resulting from Yuba Project operations were identified by the Technical Team in the Stressor Matrix as a very important limiting factor for the spawning and egg incubation life stages and the fry and juvenile life stages of the anadromous salmonids the lower Yuba River. However, flow fluctuations were not a specific consideration when developing the flow schedules because the current flow fluctuation and ramping requirements and the on-going RD-1644-mandated redd dewatering and fry stranding study were sufficient to address any flow fluctuation concerns.

The Technical Team identified April through June 15 as the primary smolt emigration period for fall-run and spring-run Chinook salmon, and October through May for yearling (+) outmigration for steelhead in the lower Yuba River. In consideration of these life stages, the Technical Team sought to develop a flow regime that mimicked the unimpaired hydrological pattern (based on the available data) during spring, provided appropriate transport flows for emigrating juveniles, and provided appropriate water temperatures for rearing and emigrating juveniles. **Figure 4-2** presents the monthly average lower Yuba River unimpaired run-off by water year type. As illustrated in Figure 4-2, peak run-off during the wetter years occurs during May, with high run-off also occurring in April and June.

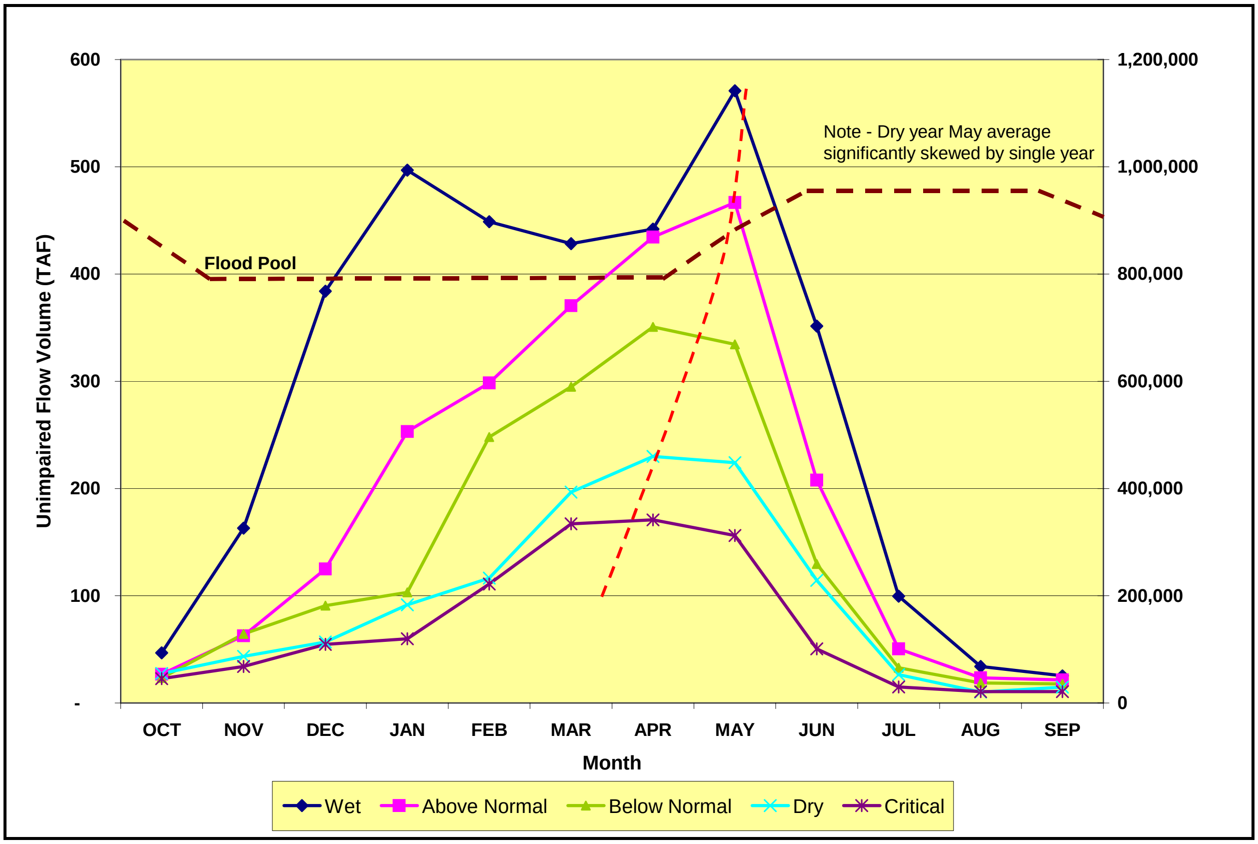


Figure 4-2. Simulated Unimpaired Monthly Flow Volume, by Water Year Type, Based on the 78-year Hydrologic Period of Record

When considering transport flows for juvenile salmonid emigration, the Technical Team was concerned with the conditions downstream of the lower Yuba River (i.e., in the Feather River, Sacramento River, and the Delta) to which juvenile Yuba River salmonids would be emigrating. The Technical Team was particularly concerned about providing "optimal" juvenile salmonid emigration conditions in the lower Yuba River and "encouraging" juvenile fish to emigrate to conditions in the lower Feather and Sacramento rivers that may be less favorable. However, the Technical Team ultimately concluded that the conditions in the lower Feather and lower Sacramento rivers, and the Delta were beyond the Technical Team's control, and therefore focused on providing anadromous salmonids the best possible conditions, under the given constraints, in the lower Yuba River.

The resulting Schedule 1 and Schedule 2 flows for April through June addressed the Technical Team's objectives of: (1) mimicking to the extent feasible the natural unimpaired hydrological run-off pattern; (2) providing sufficient transport flows for emigrating juvenile salmonids; and (3) providing appropriate water temperatures for rearing and emigrating juvenile salmonids.

4.2.3 JULY AND AUGUST

Water temperature, particularly downstream of Daguerre Point Dam, was the overriding consideration in the development of July and August flows. Anadromous salmonid life stages present in the lower Yuba River during July and August include steelhead juvenile rearing and adult immigration and holding (August only), spring-run Chinook salmon juvenile rearing and adult immigration and holding, and fall-run Chinook salmon adult immigration and holding (August only).

Although there was (and still is) much debate among Technical Team biologist regarding the water temperature requirements of specific life stages of the anadromous salmonid species in the lower Yuba River, the following water temperatures generally guided flow schedule development for Chinook salmon and steelhead:

- Over-summer Rearing: < 65°F
- Adult Holding and Pre-spawning: < 60°F
- Spawning: < 58°F
- Optimal Spawning: < 56°F

Because Daguerre Point Dam's fish ladders do not allow juvenile salmonid upstream movement, any juvenile fish that pass Daguerre Point Dam downstream would be restricted to rearing in the lower reach of the lower Yuba River (i.e., downstream of Daguerre Point Dam). Given the progressive warming that occurs in a downstream direction in the lower Yuba River during the warmer months, an important consideration for the Technical Team was that juvenile salmonids may be exposed to stressful water temperatures downstream of Daguerre Point Dam. The Technical Team concluded that the optimal high and low flow schedules (Schedules 1 and 2) would provide juvenile salmonids plenty of rearing habitat with suitably cool water temperatures downstream from Daguerre Point Dam during July and August. In addition, the Technical Team concluded that flow Schedules 1 and 2 also would provide suitable water temperatures for Chinook salmon immigration and holding.

4.3 "SURVIVAL" FLOW SCHEDULE DEVELOPMENT

The second step of the flow schedule development process was the development of a "worst case" flow schedule for years with extremely low water availability, targeting hydrologic year classes in the 5 percent of driest years. This flow schedule, which eventually became Schedule 6, was termed the "survival" flow schedule because the Technical Team sought to develop a flow regime that permitted survival of the year's cohort. The total annual Schedule 6 flow volume is approximately 174,000 acre-feet less than that in Schedule 2 years. **Table 4-3** presents the Schedule 6 flow requirements.

Table 4-3. Technical Team Schedule 6 Flow Requirements as Measured in cfs at the Marysville Gage

Schedule	Oct		Nov	Dec	Jan	Feb	Mar	Apr		May		Jun		Jul	Aug	Sep	Total Annual Volume (AF)
	1-15	16-31	1- 30	1-31	1-31	1-29	1-31	1-15	16-30	1-15	16-31	1-15	16-30	1-31	1-31	1-30	
6	300	400	400	350	350	350	350	350	450	500	500	300	150	150	150	300	234,135

Significant flow reductions from Schedule 2 were made in all months, particularly during the spring, to develop this schedule. Flows were reduced as little as possible during the fall to protect Chinook salmon spawning to the extent feasible. The Smartville Gage flow requirements (Table 4-2) are reduced during Schedule 6 years as well.

The 500 cfs requirement at Smartville during September of Schedule 6 years provides the same percent of maximum salmon spawning WUA (98.6 percent) as the 700 cfs requirement for Schedule 1 though 4 years. The October through November and April 1-15 requirement of 600 cfs provides 100 percent of maximum spawning WUA for Chinook salmon and approximately 97 percent of maximum spawning WUA for steelhead. The December through March Smartville Gage requirement of 550 cfs provides approximately 99 percent and 93 percent of maximum spawning WUA for Chinook salmon and steelhead, respectively.

4.4 REMAINING FLOW SCHEDULES DEVELOPMENT

Recognizing the year-to-year variations in lower Yuba River water availability, the Technical Team developed three additional flow schedules (Schedules 3, 4, and 5) to accommodate levels of water availability between the "optimal" flows and the "survival" flows. **Table 4-4** presents Schedules 3, 4, and 5. The step size between each successive flow schedule was adjusted to be large enough to cover the ranges of water availability without resulting in excessive jumps between flow schedules. The Technical Team considered utilizing more or fewer than a total of six flow schedules; however, it was ultimately determined that six flow schedules could adequately address nearly the entire spectrum of hydrological occurrences.

Table 4-4. Technical Team Schedule 3, Schedule 4, and Schedule 5 Flow Requirements as Measured in cfs at the Marysville Gage

Schedule	Oct		Nov	Dec	Jan	Feb	Mar	Apr		May		Jun		Jul	Aug	Sep	Total Annual Volume (AF)
	1-15	16-31	1- 30	1-31	1-31	1-29	1-31	1-15	16-30	1-15	16-31	1-15	16-30	1-31	1-31	1-30	
3	500	500	500	500	500	500	700	600	700	700	700	400	400	400	400	400	371,844
4	300	300	500	500	500	500	700	600	700	700	700	400	300	300	300	300	338,382
5	300	300	500	500	500	500	500	500	500	400	400	400	300	250	250	300	292,446

The previously presented Smartville flow schedules (Table 4-2) require that flows, as measured in cfs at the Smartville Gage, during September through April during Schedule 1, 2, 3, and 4 years must be at least 700 cfs, regardless of the requirements at the Marysville Gage. This requirement ensures that Chinook salmon and steelhead flow-related spawning habitat upstream of Daguerre Point Dam, which constitutes the majority of habitat, is protected during these years. The Smartville Gage requirements are slightly lower during Schedule 5 and 6 years to accommodate the reduced water availabilities of these years.

Flows were reduced from Schedule 2 to Schedule 3 during April, May, and the first half of June because of the overarching emphasis the Technical Team placed on summer and fall water temperatures to protect rearing juvenile salmonids and immigrating and holding Chinook salmon (particularly spring-run) and steelhead, and on fall flows for Chinook salmon spawning. When making this flow reduction, the Technical Team concluded that maintaining summer and fall flows was a top priority and that the resulting spring flows were sufficient to protect emigrating fry and juvenile salmonids.

The flow reductions from Schedule 3 to Schedule 4 resulted in lower flows from June 16 through October, while spring flows were maintained at the levels established in Schedule 3. The goal of this flow reduction was to maintain the shape of the unimpaired hydrograph (see Figure 4-2) with peak flows during the spring without sacrificing summer water temperatures. The Technical Team believed the 100 cfs reduction in flow (measured at the Marysville Gage) from June 16 through September might decrease the linear distance of river with suitable juvenile salmonid rearing water temperatures, but not to the extent that production would be dramatically compromised. The 200 cfs decrease at the Marysville Gage during October was justified because, although it can be warm, ambient temperature conditions typically cool during October. Water temperatures upstream of Daguerre Point Dam are not believed to be an issue during most Octobers.

Flow reductions from Schedule 4 to Schedule 5 resulted in lower flows during March through May and slightly lower flows during June 16 through August.

5.0 EVALUATION OF OPERATIONAL OBLIGATIONS AND CONSTRAINTS

5.1 LIMITATIONS ON THE LOWER YUBA RIVER

There are many limitations on YCWA's ability to provide flows in the lower Yuba River; chief among those is hydrologic variability. Runoff in the Yuba River Basin that ultimately flows to the lower Yuba River is highly variable, with total Yuba system runoff ranging from 276,000 to 3.8 million acre-feet per year. Even with wet year storage reservoirs to provide some inter-year flow balancing, there will still be occurrences of wet year and critically dry year classes.

In addition to hydrologic variability, there are a variety of legal, regulatory, and operational constraints that govern or dictate either storage volumes in the Yuba River Development Project reservoirs or releases to the lower Yuba River. Some of the constraints are "fixed", for which YCWA has very little ability to modify or vary from the constraint. Other constraints are more flexible.

In addition to hydrologic variation, key legal and regulatory constraints include:

- Consumptive demands, and legal requirements to meet those demands, in Yuba County that are supplied from the lower Yuba River
- Water rights of other consumptive users in the lower Yuba River
- Flood control requirements in New Bullards Bar Reservoir
- Required Releases from storage to meet power contract requirements
- Flow fluctuation and ramping constraints
- Key operational constraints include:
- Routine maintenance requirements, including periods during which facilities are shut down for maintenance
- Operations during flood control or storm runoff periods
- Maintenance of river flows in consideration of the ESA consequences (avoidance of dewatering salmon redds)

- ❑ Physical system limitations
- ❑ Reservoir carry-over requirements

Figure 5-1 graphically depicts the impacts of several New Bullards Bar Reservoir operations constraints.

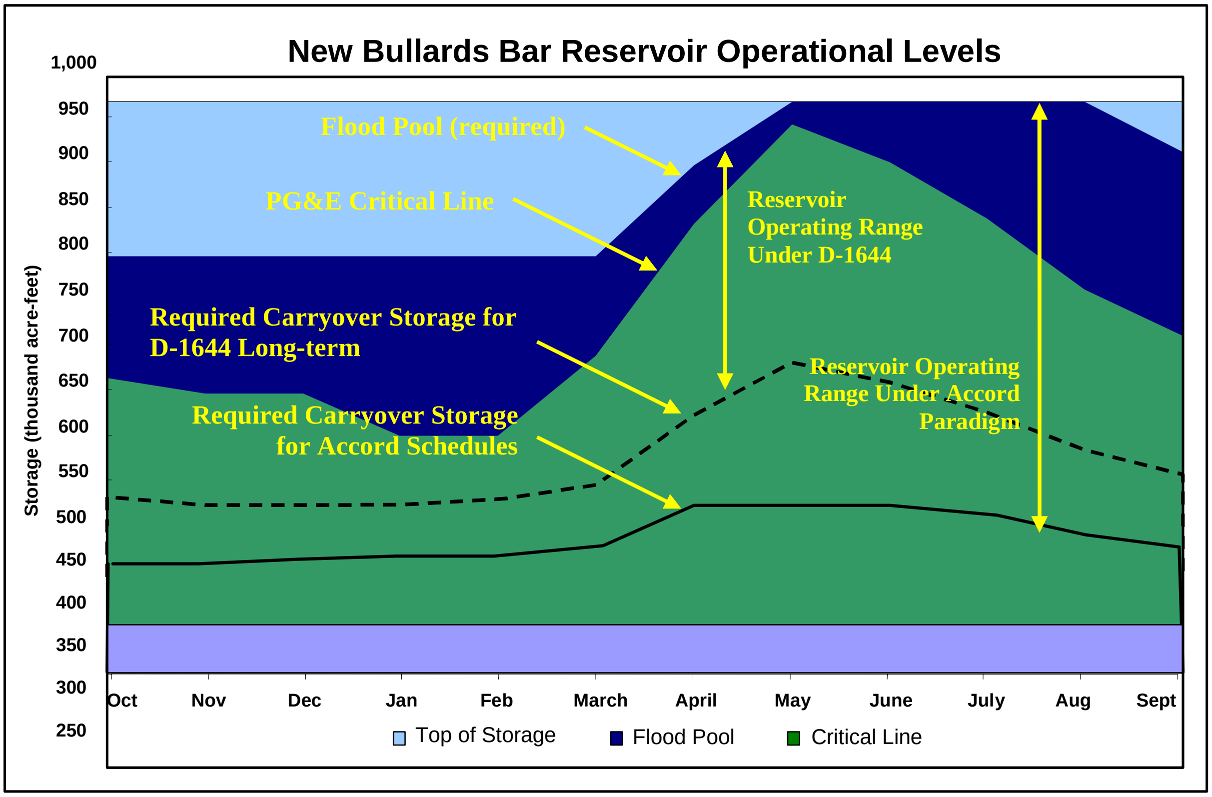


Figure 5-1. New Bullards Bar Reservoir Operations Constraints

The Technical Team spent considerable time investigating and understanding these constraints in the context of developing the flow schedules for the lower Yuba River. As mentioned previously, many of these constraints are relatively inflexible, for which YCWA has little potential to modify the constraint to facilitate a different flow release schedule. Of the relatively flexible constraints, one of the most critical to successful operations of lower Yuba River flows and diversions is the reservoir carry-over storage requirement. Given the variability of the year-to-year hydrologic conditions, it is imperative for YCWA to "carry-over" a volume of water in a New Bullards Bar Reservoir sufficient to meet the basic needs of the lower Yuba River during the subsequent (potentially dry) water year. Lack of sufficient carryover volume would result in delivery shortages in a subsequent dry year; excess carryover volume means that less water was utilized for in-river flows during the current year, and carries a higher risk of spill during the runoff season.

Two key factors affect the selection of an appropriate carryover volume: total potential demand, and a reliability target. The total potential demand includes both water required for instream flow requirements and water acquired for consumptive demands. The reliability target reflects the desire to be able to meet the potential demands without shortages. For example, a reliability target using a 1:200 dry year would still allow demands to be met in a year when inflow was in the 0.5 percent driest (1:200) of years. Historically, YCWA planned to meet the lowest flow schedule (corresponding to the driest year flow schedule), with a 1:200 reliability target.

5.2 NORTH YUBA INDEX

Once the Technical Team had developed a set of flows schedules for the lower Yuba River, it was necessary to develop a methodology for determining when the appropriate flow schedule would be utilized. It was important that the method of assigning flow schedules be responsive, a good indicator of hydrologic year class, and provide a reasonable balance between releasing water in the current year and carrying over water to meet potential future dry years. The NYI was developed as the water year hydrologic classification system to be used for determining flow schedule release requirements.

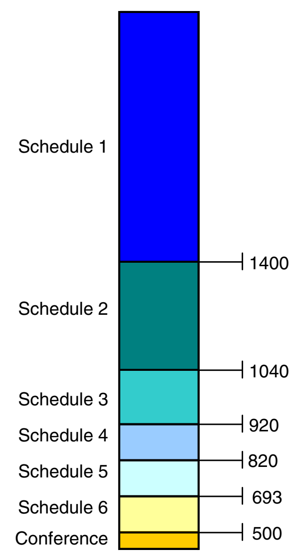
The NYI is an indicator of the amount of water available in the North Yuba River at New Bullards Bar Reservoir that can be utilized to maintain flows in the lower Yuba River through operations of New Bullards Bar Reservoir. The index is comprised of two components: (1) active storage in New Bullards Bar Reservoir for the current water year; and, (2) total inflow to New Bullards Bar Reservoir for the current water year, including diversions from the Middle Yuba River and Oregon Creek to New Bullards Bar Reservoir.

The Technical Team, with the support of YCWA and resource agency hydrologists and modelers, spent considerable time evaluating the components and 'inflection points' of the NYI, including variations on the structure of the Index (the relative inflow and reservoir influences on the index), Index inflection points for determining flow schedule assignments, and protocols for use of the Index (when the Index and corresponding flow schedule is updated during the year).

Determinations of a year's flow schedule type will be made in February, March, April, and May and for any subsequent updates. **Table 5-1** presents the North Yuba Index and resulting flow schedules. Additional detail regarding the North Yuba Index is presented in the Fisheries Agreement (Appendix E).

Table 5-1. North Yuba Index Hydrologic Classification and Flow Schedule Determination Criteria

Flow Schedule Year Type	North Yuba Index Thousand Acre-Feet (TAF)
Schedule 1	Equal to or greater than 1,400
Schedule 2	Equal to or greater than 1,040 and less than 1,400
Schedule 3	Equal to or greater than 920 and less than 1,040
Schedule 4	Equal to or greater than 820 and less than 920
Schedule 5	Equal to or greater than 693 and less than 820
Schedule 6	Equal to or greater than 500 and less than 693
Conference Year	Less than 500



5.3 PROBABILITY OF OCCURRENCE OF FLOW SCHEDULES

Once the Technical Team had developed both flows schedules and the North Yuba Index, it was then possible to statistically project the probability of occurrence of each of the flow schedules based on the historic hydrology of the Yuba River basin.

One of the Technical Team's objectives was to maximize the probability of occurrence of the higher flow schedules (1 and 2) while minimizing the probability of occurrence of the very low flow schedules (6 and Conference Year). **Table 5-2** presents the estimated probabilities of occurrence of the six flow schedules and the Conference Year[4], based on preliminary modeling of the Consensus Flow Schedules and the 78-year period of hydrologic record.

Table 5-2. Estimated Predicted Probabilities of Occurrence of the Six Flow Schedules and the Conference Year

Schedule	North Yuba Index (TAF)	Percent Occurrence	Cumulative
1	≥1,400	56%	56%
2	1,040 to 1,400	22%	78%
3	920 to 1,040	7%	85%
4	820 to 920	5%	90%
5	693 to 820	5%	95%
6	500 to 693	4%	99%
Conference	<500	1%	100%

Once the probability of occurrence of the different flow schedules was computed, the Technical Team was able to adjust the relative frequencies of the flow schedules by adjusting the volume of water in each of the flow schedules. In particular, the dry-year flow schedules had the greatest impact on the necessary carryover storage volume, and thus on the frequency of occurrence of the wetter-year flows schedules. Increasing the volume of water to be released during a Schedule 6 year therefore would reduce the frequencies the more desired Schedule 1 or 2 years, and thus would increase the frequency of the Schedule 6 year class. In subsequent phases of flows schedule development, the Technical Team was able to adjust the frequency of occurrence of the various flow schedules by adjusting the volume of water in each flow schedule.

6.0 EVALUATE OPTIONS FOR REMOVING OR LIMITING CONSTRAINTS

The Technical Team recognized the different ways in which the various constraints on the Yuba River system impacted the ability to maintain flows to the lower Yuba River. During the next phase of development of the lower Yuba River flow schedules, the Technical Team evaluated a variety of different options for removing, eliminating, or modifying constraints on the Yuba River system to allow either higher instream flows, or a higher frequency of the occurrence of those flows. Many different options for removing or minimizing constraints were identified and evaluated. Most had insufficient benefit (in terms of additional water or flexibility) for the cost (in terms of water or money), and were excluded from further evaluation. Ultimately, the Technical Team identified several key changes in operations that would yield significant

[4] Note: The Conference Year concept is discussed more fully in Section 6.3.

benefits in terms of water availability or operational flexibility for the lower Yuba River. The following sections describe some of the major changes to historic operations protocols that were developed by the Technical Team, and that will be implemented as a portion of the Yuba Accord.

6.1 CONJUNCTIVE USE OF YUBA COUNTY GROUNDWATER RESOURCES

The conjunctive use of ground water resources means that water demands within Yuba County can be met with either surface or ground water supplies. Essentially, the groundwater reservoir acts as a backup to New Bullards Bar Reservoir, allowing New Bullards Bar Reservoir to be cycled more aggressively.

Under the provisions of the flow schedules developed for the Yuba Accord, YCWA's Member Units (irrigation districts and mutual water companies within Yuba County) will be faced with the potential for shortages of surface water supply. Through conjunctive use agreements between YCWA and the Member Units, the Member Units will supplement the surface water supply provided by YCWA with groundwater pumping. Additionally, the Member Units will pump a minimum of 30,000 acre-feet of water in Schedule 6 years, making an equivalent amount of water (30,000 acre-feet) available for the lower Yuba River.[5]

6.2 MODIFICATIONS OF THE PACIFIC GAS AND ELECTRIC COMPANY POWER PURCHASE CONTRACT

Various contractual terms in the Power Purchase Contract (PPC) between YCWA and PG&E require certain minimum monthly power generation amounts, and maximum reservoir storage volumes. Since some of the terms in the PPC potentially conflict with the ability of YCWA to provide the flows schedules developed by the Technical Team, YCWA and PG&E have agreed to modify the terms of the PPC to relax some of the flow and storage obligations in the PPC.

6.3 CONFERENCE YEAR

The "Conference Year" concept was developed for the very driest water years. As discussed previously, carryover volume required to meet minimum flow requirements in the very driest year classes has a substantial impact on the ability to use a greater portion of the reservoir storage volume during normal year classes. A high instream flow requirement for extremely dry years necessitates that a large block of water be carried over to provide for those relatively high dry year flows. Conversely, if dry year flows are lower (in keeping with low runoff conditions), a smaller block of water is required to be carried over, and more water is available for use during current-year releases. The Technical Team developed a conference year concept that would apply during only the very driest 1 percent of water years. During these extremely dry years, there will be insufficient water to meet many of the demands within Yuba County.

During Conference Years, YCWA will operate the Yuba Project so that: (1) flows in the lower Yuba River comply with the instream flow requirements in YCWA's FERC License, except that YCWA will not pursue any of the flow reductions authorized by article 33(c) of that license, and

[5] It should be noted that a necessary element of this conjunctive use program will be the funding provided by the Water Purchase Agreement, which allows YCWA to compensate the Member Units for pumping in support of lower Yuba River flows.

YCWA will provide any additional instream flows agreed to by the RMT Planning Group; and (2) total diversions at Daguerre Point Dam (including Browns Valley Irrigation District's diversions into its Pumpline Canal) will not exceed 250,000 acre-feet per year.

If Conference Year conditions are present or imminent, then YCWA, in consultation with its Member Units, will prepare a strategic management plan that will state affirmative steps that YCWA and the Member Units will undertake to ensure that total diversions will not exceed 250,000 acre-feet per year. YCWA will submit this plan to the RMT as soon as practicable after the determination that Conference Year conditions are present or imminent. YCWA will provide the RMT with any updates that YCWA makes to this plan, and YCWA will provide the RMT with monthly reports on the implementation of this plan. YCWA will ensure implementation and enforcement of the plan's requirements through its contracts with its Member Units.

6.4 DEMAND LIMITS AND CONSERVATION

YCWA is obligated to provide for consumptive demands within Yuba County, and County-wide demands have continued to grow through the years. However, YCWA, in consultation with the Member Units, has structured a limit on the consumptive demand for the duration of the Yuba Accord. This upper limit will both provide greater certainty in the delivery of the Yuba Accord flow schedules (manifested in a higher probability of delivery of Schedules 1 and 2), and will provide some incentive for additional conservation by YCWA and the Member Units.

6.5 LOWER RESERVOIR CARRYOVER TARGET LEVEL

The conjunctive use program, demand limits, and conference year described above would combine to allow a lower reservoir carryover target level. Additionally, YCWA modified the reliability target for deliveries within Yuba County. Prior to the Yuba Accord, YCWA had typically planned to provide full consumptive releases even if the following year was a 1:200 dry year. To increase the reservoir operations flexibility to accommodate the Technical Team flows, YCWA modified this planning criterion to a 1:100 reliability target. The 1:100 year reservoir carryover storage requirement allows New Bullards Bar to be operated more aggressively (e.g., allows the reservoir storage to be drawn down farther) than previously, but imposes more shortage risks on YCWA.

7.0 OPTIMIZATION OF FLOW SCHEDULES

Following the initial development of flow schedules by the Technical Team, Yuba Project operations were simulated using a spreadsheet-based Yuba Basin model with 78 years of available hydrologic records, the new flow schedules, and existing operational constraints. Modeling the flow schedules allowed YCWA and the Technical Team to identify the relative frequency of each flow schedule, hydrological risk factors, and the most confining operational constraints. Key factors and constraints were further evaluated to determine how to minimize shortage risk and maximize water availability. As described in the previous section, concepts that were explored in detail and ultimately included in the Yuba Accord include: (1) modifying the reservoir storage carryover requirement; (2) developing a new water availability index, eventually termed the North Yuba Index; (3) identifying a plan for the very driest, "Conference Years"; and (4) developing a conjunctive use program.

Even with the relaxation of some of the operational constraints on the Yuba River system, some flow schedule tradeoffs were still necessary. Fundamental flows tradeoffs included:

- ❑ Higher flows during drier years require higher reservoir carryover, making less water available for the current water year, and reducing the incidence of the higher flow schedules. As described in Sections 5.1 and 6.5, generally lower flow requirements in drier year classes allow more of the reservoir to be used in all years, because the carryover target is calculated based on the need to deliver the driest-year flow volumes during driest-year conditions.
- ❑ High spring flows (particularly during the months of May and June) often require the use of releases from storage, reducing the amount of water available for temperature mitigation during the warmer months and spawning flows in the dry fall months. As can be seen in Figure 4-2, peak runoff occurs earlier in dry year classes. If high spring flows are required later than the peak of the runoff cycle, there is a high likelihood that those spring flows would need to be released from storage, rather than being provided directly from the natural runoff.
- ❑ It is important to strike a balance between use of water in the current year and prudent carryover volumes, with a successful balance benefiting both fisheries and consumptive users. Excessive releases in the current water year, whether for consumptive or fisheries needs, would have the potential to result in shortages in subsequent dry years. Conversely, excessively cautious operations and high carryover volumes would make less water available in the current year, and increase the likelihood of spills in a subsequent wet year.

Once the Technical Team fully understood the operational constraints and flow tradeoffs, the team was able to reconsider the flow schedules to: (1) make use of the flexibilities discovered in some of the operational constraints, and (2) find an optimal balance in inter-month and inter-year flow tradeoffs.

7.1 AUGMENTED FLOW SCHEDULE DEVELOPMENT

The "second pass" of flow schedule development by the Technical Team yielded what was known within the Team as the Augmented Flow Schedules. The Augmented Flow Schedules are shown in **Table 7-1**. Flow modifications that resulted in the Augmented Flow Schedules were concentrated during the summer and fall months, which the Technical Team considered to be critical periods for lower Yuba River anadromous salmonid production.

Table 7-1. Augmented Flow Schedules

Schedule	Oct		Nov	Dec	Jan	Feb	Mar	Apr		May		Jun		Jul	Aug	Sep	Total Annual Volume (AF)
	1-15	16-31	1- 30	1-31	1-31	1-29	1-31	1-15	16-30	1-15	16-31	1-15	16-30	1-31	1-31	1-30	
1	500	500	500	500	500	500	700	1,000	1,000	2,000	2,000	1,500	1,500	600	600	600	574,002
2	500	500	500	500	500	500	700	700	800	1,000	1,000	800	500	500	500	500	429,264
3	500	500	500	500	500	500	700	600	700	700	700	500	500	500	500	500	396,000
4	400	400	500	500	500	500	700	600	700	700	700	400	400	400	400	400	365,706
5	350	350	500	500	500	500	500	500	500	400	400	400	400	400	400	350	322,839
6	325	325	350	350	350	350	350	350	450	500	500	300	150	150	150	300	229,532

Under the Augmented Flow Schedules, as measured at the Marysville Gage:

- Flows were increased by 100 cfs during June 1-15 in Schedule 3 years;
- Flows were increased by 100 cfs during June 16-30 in Schedule 2, 3, 4 and 5 years;
- Flows were increased by 100 cfs during July in Schedule 2, 3, and 4 years, and by 150 cfs in Schedule 5 years;
- Flows were increased by 100 cfs during August in Schedule 1, 2, 3, and 4 years, and by 150 cfs in Schedule 5 years;
- Flows were increased by 100 cfs during September in Schedule 1, 2, 3, and 4 years, and by 50 cfs in Schedule 5 years;
- Flows were increased by 100 cfs during October in Schedule 4 years, by 50 cfs in Schedule 5 years, and by 25 cfs during October 1-15 in Schedule 6 years;
- Flows were decreased by 75 cfs during October 16-31, and by 50 cfs during November, in Schedule 6 years; and
- The Smartville Gage flows were not changed.

The modifications resulting in the Augmented Flow Schedules were anticipated to: (1) provide higher flows and lower water temperatures during summer and early fall for adult salmonid immigration, holding, and spawning, and for juvenile salmonid rearing; and (2) provide higher flows and lower water temperatures during late spring for spring-run Chinook salmon immigration and holding, and for juvenile salmonid emigration. The small reductions in flows during October 16-31 and November in Schedule 6 years were acceptable given the aforementioned increase in flows during other years.

A concept that gained increasing importance throughout the flow schedule development process was that of probability of occurrence (e.g., the percentage of years which a particular Flow Schedule is expected to be implemented, based on the 78-year lower Yuba River hydrologic period of record). The Technical Team opted to develop a regime in which the schedules that resulted in the highest instream flows (i.e., Schedules 1 and 2) had a relatively high probability of occurrence. A probability of occurrence of approximately 75 percent for the “Optimal” Flow Schedules (1 and 2) was acceptable to the Technical Team. The trade-off of this approach was that the Schedules 1 and 2 flows could not be too high, which would have resulted in a reduced probability of occurrence.

7.2 FINAL TUNING OF FLOW SCHEDULES

The final step in the flow schedule development process was further refinement of the Augmented Flow Schedules to produce the Consensus Flow Schedules, which were ultimately adopted as the Yuba Accord flow schedules. The final series of refinements focused on further alleviating perceived lower Yuba River stressors, achieving additional biological enhancements, and providing month-to-month flow sequencing that was consistent with salmonid life history periodicities.

At this point, the Yuba River Index development was completed and the monthly flow volumes in the flow schedules could be adjusted to achieve the desired probabilities of occurrence. Additionally, conjunctive use concepts were further defined and could be used to reduce risk and make additional flow available.

7.2.1 CONSENSUS/YUBA ACCORD FLOW SCHEDULES

Table 7-2 presents the Consensus Flow Schedules. The changes in flows under the Consensus Flow Schedules were concentrated during the spring, but some modifications were made during the summer and fall.

Table 7-2. Consensus Flow Schedules

Schedule	Oct		Nov	Dec	Jan	Feb	Mar	Apr		May		Jun		Jul	Aug	Sep	Total Annual Volume (AF)
	1-15	16-31	1- 30	1-31	1-31	1-29	1-31	1-15	16-30	1-15	16-31	1-15	16-30	1-31	1-31	1-30	
1	500	500	500	500	500	500	700	1,000	1,000	2,000	2,000	1,500	1,500	700	600	500	574,200
2	500	500	500	500	500	500	700	700	800	1,000	1,000	800	500	500	500	500	429,066
3	500	500	500	500	500	500	500	700	700	900	900	500	500	500	500	500	398,722
4	400	400	500	500	500	500	500	600	900	900	600	400	400	400	400	400	361,944
5	400	400	500	500	500	500	500	500	600	600	400	400	400	400	400	400	334,818
6	350	350	350	350	350	350	350	350	500	500	400	300	150	150	150	150	232,155

Under the Consensus Flow Schedules, as measured at the Marysville Gage:

- Flows were decreased by 200 cfs during March in Schedule 3 and 4 years;
- Flows were increased by 100 cfs during April 1-15 in Schedule 3 years;
- Flows were increased by 200 cfs, 100 cfs, and 50 cfs during April 16-30 in Schedule 4, 5, and 6 years, respectively;
- Flows were increased by 200 cfs during May 1-15 in Schedule 3, 4, and 5 years, and during May 16-31 in Schedule 3 years;
- Flows were decreased by 100 cfs during May 16-31 in Schedule 4 and 6 years;
- Flows were increased by 100 cfs during July in Schedule 1 years;
- Flows were decreased by 100 cfs during September in Schedule 1 years;
- Flows were increased by 50 cfs during September in Schedule 5 and 6 years;
- Flows were increased by 50 cfs and 25 cfs during October 1-15 and 16-31, respectively, in Schedule 5 and 6 years; and
- The Smartville Gage flows were not changed.

The primary flow modifications occurred during the spring. The Technical Team attempted to mimic the form of the natural unimpaired run-off pattern (Figure 5-1) by providing peak flows during Mays of wetter years (Schedules 1, 2 and 3) and during the last half of April and first half of May during drier years (Schedule 4, 5, and 6). This patterning was implemented primarily to provide juvenile salmonid emigration flows.

7.2.2 SEPTEMBER THROUGH MARCH

During September through April 15, the Smartville Gage flow requirements (Table 4-2) ensure that appropriate Chinook salmon and steelhead flows will be provided upstream of Daguerre Point Dam, where the majority of salmonid spawning occurs. The 700 cfs requirement during September through April 15 in Schedules 1, 2, 3, and 4 equates to approximately 99 percent of maximum Chinook salmon spawning WUA and 100 percent of maximum steelhead spawning WUA. The Smartville Gage requirements in Schedules 4 and 5 provide:

- 98.6 percent of maximum Chinook salmon spawning WUA during September;
- 100 percent of maximum Chinook salmon spawning WUA during October through November;
- 99 percent of maximum Chinook salmon spawning WUA during December;
- 93 percent of maximum steelhead spawning WUA during January through March; and
- 97 percent of maximum steelhead spawning WUA during April 1-15.

Water temperature, particularly for Chinook salmon immigration, holding, spawning, and egg incubation, also was a primary consideration in developing the flow schedules during September and October.

7.2.3 April through June

During the April through June period, minimizing flow fluctuations and mimicking the natural unimpaired hydrological patterns for juvenile rearing and emigration were of particular concern to the Technical Team. Within this period, water temperature was a very important consideration during May and June for several anadromous salmonid life stages, including juvenile rearing and smolt emigration. Providing flows sufficient to transport emigrating juvenile salmonids, particularly yearling and older fish, including smolts, also was of concern.

Annual instream flow requirements are highest during the April through June period, reflecting the objective of maintaining the natural unimpaired hydrograph pattern to the extent feasible. Peak flow requirements in May during Schedule 1, 2, and 3 years, shifting to April 16-30 and May 1-15 during Schedule 4, 5, and 6 years, follow the pattern of shifting peak flows progressively earlier under progressively drier water years (Figure 5-1).

7.2.4 July and August

Water temperature, particularly downstream of Daguerre Point Dam, was the overriding consideration in the development of July and August flows. Important anadromous salmonid life stages present in the lower Yuba River during July and August include steelhead juvenile rearing and adult immigration (August only), spring-run Chinook salmon juvenile rearing and adult immigration, and fall-run Chinook salmon adult immigration (August only).

For additional detail on the month-by-month flow development considerations, Section 4.0, Development of Initial Flow Schedules.

7.2.5 Additional Flows for Schedule 6

Through the development of the Consensus Flow Schedules, the Technical Team remained concerned with the Schedule 6 year flows. In particular, the 150 cfs flow requirement for June 16 through August 31 potentially could result in warm water temperatures, particularly downstream from Daguerre Point Dam. To address the Technical Team's concern, YCWA will operate a groundwater-substitution program in water years when Schedule 6 is in effect, which will result in an additional 30,000 acre-feet of water not shown in Schedule 6 flowing in the lower Yuba River at the Marysville Gage during the portions of such years when this water is transferable. Subject to the preceding requirement of transferability, the RMT, through a decision by its Planning Group, will determine the flow schedule for the 30,000 acre-feet during each Schedule 6 year. This flow schedule will be set to achieve maximum fish benefit during the transfer period. The transferable period is anticipated to be quite broad during this very dry year class, and it is anticipated that the additional water will be discharged during the lowest flow period (mid-June through August).

7.2.6 PROBABILITY OF OCCURRENCE OF FLOW SCHEDULES

One of the Technical Team's objectives was to maximize the probability of occurrence of the higher flow schedules (1 and 2) while minimizing the probability of occurrence of the very low flow schedules (6 and Conference Year). **Table 7-3** presents the estimated probabilities of occurrence of the six flow schedules and the Conference Year, based on preliminary modeling of the Consensus Flow Schedules and the 78-year period of hydrologic record.

Table 7-3. Estimated Predicted Probabilities of Occurrence of the Six Flow Schedules and the Conference Year

Schedule	North Yuba Index (TAF)	Percent Occurrence	Cumulative
1	≥1,400	56%	56%
2	1,040 to 1,400	22%	78%
3	920 to 1,040	7%	85%
4	820 to 920	5%	90%
5	693 to 820	5%	95%
6	500 to 693	4%	99%
Conference	<500	1%	100%

As presented in Table 7-3, the Technical Team's objectives of implementing the "optimum" flows (Schedule 1 and 2) at least 75 percent of the time and the "survival" flows (Schedule 6) 5 percent or less of the time were achieved.

8.0 DEVELOPMENT OF THE REMAINDER OF THE FISHERIES AGREEMENT

Once the Technical Team had completed its work on the flow schedules and modifications to the operational constraints on the lower Yuba River, all of the members of the Technical Team took the resulting work products to their respective managements for review and consultation. This management review step included peer review, scientific and technical scrutiny, verification of modeling results, and other investigations and scrutiny seeking to identify any potential flaws or problems with the technical work put forth by the Technical Team.

After the management and peer review, the entities that had participated in the Technical Team (resource agencies, NGOs, and YCWA) established a Drafting Team to turn the technical work of the Technical Team into a proposed formal agreement among all of the parties. The work of the Drafting Team took over 12 months to complete, and involved yet another layer of careful review and scrutiny of the work of the Technical Team. As with the Technical Team, all of the parties were represented on the Drafting Team, and were able to put forth and represent their own interests and ideas. As during the course of the discussions of the Technical Team, the Drafting Team considered numerous alternatives, permutations, variations and ideas both for the terms of the legal document that was being crafted, and as a 'test' and reconsideration of the work put forward by the Technical Team[6].

[6] On many occasions, members of the Technical Team were asked about the decisions and intent of various provisions of the flow schedules and NYI. Conversely, on many occasions Technical Team members reviewed the

In addition to codifying the work of the Technical Team, the Drafting Team crafted and developed several other key aspects of the Fisheries Agreement and of the Yuba Accord. Three of the key elements of the Fisheries Agreement developed by the Drafting Team included:

- ❑ Structuring a River Management Team for operational input, decision making, and direction for monitoring studies for the lower Yuba River;
- ❑ Establishing a River Management Fund, to pay for focused studies and monitoring work on the lower Yuba River; and
- ❑ Developing a comprehensive set of rights and remedies that will ensure the adherence to, and performance of, the Fisheries Agreement.

8.1 RIVER MANAGEMENT TEAM

The River Management Team (RMT) was established to provide a forum for dispute resolution, input into lower Yuba River operations, and oversight of studies and monitoring work under the terms of the Yuba Accord. The RMT includes both an Operations Group and a Planning Group, the duties of each of which is spelled out in the Fisheries Agreement. The RMT will include representatives of the participants in the Fisheries Agreement, plus the other participants in the Yuba Accord.

The Planning Group's authority is specified in the Fisheries Agreement includes setting the flow schedule for the 30,000 acre-feet of additional water that will occur in Schedule 6 years, developing and implementing studies of lower Yuba River fish or fish habitat, and making decisions to spend money in the RMF for any authorized purpose. The Planning Group may convene a Technical Working Group, which will include such members as the Planning Group may appoint.

The Operations Group's actions and efforts are time sensitive and will often be made in real-time or near real-time situations. The Operations Group will provide specific guidance to YCWA for YCWA's implementation of actions specified in the Fisheries Agreement, including the flow schedule set by the Planning Group for the 30,000 acre-feet of additional water during Schedule 6 years, any Planning Group decisions regarding the operations of the upper and lower outlets from New Bullards Bar Dam into the New Colgate Penstock or any temperature adjustment device that is constructed at Englebright Dam, and any other recommendations or directions from the Planning Group to the Operations Group.

8.2 RIVER MANAGEMENT FUND AND STUDY PROGRAM

The Fisheries Agreement will create a River Management Fund (RMF). The RMF is intended to provide a source of funding for ongoing monitoring and focused studies in the lower Yuba River.

The Technical Team developed a framework for prioritizing the monitoring and evaluation funding from the RMF to ensure reasonable and prudent disbursement of funds. Goals and priorities include monitoring and evaluating the effectiveness of the implementation of the flow schedules, obtaining baseline information for future application, and completing habitat

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work of the Drafting Team, to ensure that the intent and biological basis of various elements of the flow schedules were correctly captured in the Fisheries Agreement.

improvement actions and activities. The Technical Team's monitoring framework is composed of a core monitoring program, which is designed to assess long-term individual and population responses of fish in the lower Yuba River to implementation of the flow schedules, and a focused study program, which is designed to address specific, more proximate, objectives. Among other specific actions further detailed in the Fisheries Agreement, the RMF will be used for:

- Evaluating the condition of fish resources in the lower Yuba River;
- Evaluating the viability of lower Yuba River fall-run Chinook salmon and any subpopulations of the Central Valley steelhead and spring-run Chinook salmon ESUs that may exist in the lower Yuba River; and
- Implementing habitat improvement and non-flow enhancement actions and activities.
- YCWA will make contributions of $550,000 per year to the General Account of the RMF.

YCWA also will make a one-time contribution of $300,000 to the Restoration Projects Account of the RMF. Money from the Restoration Account may be used to provide parts of the costs of pilot projects for: (1) side channel restoration; (2) riparian habitat; and (3) woody debris. Any such projects must be simple, robust, and self-sustaining and demonstrate, verify or test some specific benefit.

Only the parties to the Fisheries Agreement, NMFS, and the USFWS will participate in making RMF decisions. Such decisions will be made by unanimous consent of all such parties and entities, or will be made pursuant to specific alternative dispute resolution process detailed in the Fisheries Agreement.

8.3 Rights and Remedies in the Fisheries Agreement

The Fisheries Agreement contains a comprehensive suite of rights and remedies for the various parties. These provisions are intended to ensure adherence to, and compliance with, the Fisheries Agreement by all of the parties to the Agreement. The focus of the remedies provisions is on ensuring the appropriate flows in the lower Yuba River. Key elements of the remedies provisions include:

- Dispute resolution provisions for the various aspects of the Fisheries Agreement. Different elements of the Fisheries Agreement may have different dispute resolution provisions.
- Remedies for minor and substantitive flow violations. There are also provisions for evaluating whether flow violations were accidental or deliberate.
- Provisions that seek to ensure continued collaboration, sharing of scientific data, and participation in the process of managing the lower Yuba River.

9.0 LITERATURE CITED

CALFED and YCWA. 2005. Draft Implementation Plan for Lower Yuba River Anadromous Fish Habitat Restoration. Prepared on Behalf of the Lower Yuba River Fisheries Technical Working Group by SWRI.

CDFG. 1991. Lower Yuba River Fisheries Management Plan.

SWRCB. 2003. Revised Water Right Decision 1644 in the Matter of Fishery Resources and Water Right Issues of the Lower Yuba River.

APPENDIX D

PROPOSED LOWER YUBA RIVER ACCORD MODELING TECHNICAL MEMORANDUM

Proposed Lower Yuba River Accord

Modeling Technical Memorandum

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1.0 INTRODUCTION

This memorandum provides detailed information regarding the modeling tools, primary modeling assumptions, model inputs, and methodologies that are used to evaluate potential effects on reservoir operations, stream flow, water quality, water temperature, and salmon mortality under the various scenarios that are analyzed in the Proposed Yuba Accord EIR/EIS. Implementation of one of these scenarios would result in changes in operations of: (1) YCWA's Yuba Project; (2) YCWA Member Units' groundwater pumping within the Yuba Groundwater Basin; (3) the DWR Oroville-Thermalito complex of the SWP; (4) CVP/SWP Delta facilities; and (5) CVP/SWP San Luis Reservoir. This memorandum is included as Appendix D to the Draft EIR/EIS.

2.0 IMPACT ANALYSIS FRAMEWORK

This section describes the impact analysis framework to evaluate potential flow and water temperature related changes on surface water supplies, surface water quality, hydropower, and aquatic and riparian habitat utilized by listed species that would be expected to occur with implementation of the various alternatives analyzed in the Draft EIR/EIS.

Modeling scenarios were developed to represent existing and future hydrologic conditions with and without implementation of the alternatives considered for the Proposed Yuba Accord (i.e., Yuba Accord Alternative and Modified Flow Alternative) to enable an evaluation of potential environmental impacts for CEQA, NEPA and water rights purposes.

These scenarios include: (1) CEQA Existing Condition; (2) CEQA No Project Alternative; (3) CEQA Yuba Accord Alternative; (4) CEQA Modified Flow Alternative; (5) NEPA No Action Alternative; (6) NEPA Yuba Accord Alternative; and (7) NEPA Modified Flow Alternative. In addition to these scenarios, baseline conditions for the accounting of Released Transfer Water for the two characterizations (CEQA and NEPA) of the Yuba Accord Alternative are determined, but not directly used in any of the impact analyses. The hydrologic modeling and related post-processing of outputs is used to simulate the YCWA, Reclamation, and DWR water project operations associated with implementation of the alternatives.

Comparison of model results for the different scenarios is used in the discussions of environmental effects in the following resource chapters of the Draft EIR/EIS:

- Chapter 5 - Surface Water Supply and Management
- Chapter 6 - Groundwater Resources
- Chapter 7 – Power Production and Energy Consumption
- Chapter 8 - Flood Control
- Chapter 9 - Surface Water Quality
- Chapter 10 - Fisheries and Aquatic Resources
- Chapter 11 - Terrestrial Resources
- Chapter 12 – Recreation

- Chapter 13 - Visual Resources
- Chapter 14 - Cultural Resources
- Chapter 18 - Growth Inducement

2.1 IMPACT ANALYSIS APPROACH

The impact analysis compares modeling outputs from one modeling scenario with outputs from another scenario to determine the potential for changes in hydrologic and environmental conditions. Parameters represented by the modeling outputs include: reservoir storages and water surface elevations, river flows, reservoir and river water temperatures, early life stage Chinook salmon mortalities, and Delta water quality (EC).

The alternatives considered involve changes in surface water and groundwater management within the Yuba River and Yuba groundwater subbasins, changes in operations of the SWP Oroville-Thermalito complex, and modifications of CVP/SWP export operations in the Delta. Changes in San Luis Reservoir storage also are evaluated for certain resources, as appropriate.

The evaluation of environmental impacts is performed using the impact indicators and significance criteria developed for each resource topic (presented in resource chapters of the EIR/EIS). Simulation comparisons to be evaluated in the Draft EIR/EIS are presented in **Table 2-1**.

For purposes of addressing potential impact considerations of interest to the SWRCB and to satisfy CEQA requirements, modeling simulations for the alternatives evaluated in this EIR/EIS are compared to both the Existing Condition and the No Project Alternative. For CEQA impact assessment purposes, the alternatives (i.e., Yuba Accord, Modified Flow and No Project) are compared to the Existing Condition, which includes RD-1644 Interim instream flow requirements and current demands at Daguerre Point Dam (see Section 4.0, CEQA/NEPA Model Scenarios). To provide additional information to address SWRCB water rights issues, the action alternatives (i.e., Yuba Accord and Modified Flow) also are compared to the No Project Alternative, which includes RD-1644 Long-term instream flow requirements and additional demands at Daguerre Point Dam (see Section 4.0). Demands at Daguerre Point Dam are increase by an additional 40 TAF under the No Project Alternative, relative to the Existing Condition, due to the expected implementation of the Wheatland Project.

To satisfy NEPA requirements, modeling simulations for the Yuba Accord Alternative and the Modified Flow Alternative are compared to the No Action Alternative.

Cumulative impact analyses are required by both CEQA and NEPA regulations and are an important component of the environmental documentation and approval process. Model output for the Yuba Accord Alternative and the Modified Flow Alternative are used to provide an indication of the potential incremental contributions of the Yuba Accord Alternative and the Modified Flow Alternative to cumulative impacts.

Table 2-1. Summary of Required CEQA and NEPA Comparative Scenarios to be Evaluated

Statute	Base Scenarios		Compared Scenarios		Purpose of Comparison
CEQA	Scenario 1	CEQA Existing Condition	Scenario 3	CEQA Yuba Accord Alternative [a]	To evaluate potential impacts of the Proposed Project and Alternatives scenarios, relative to the Existing Condition
			Scenario 4	CEQA Modified Flow Alternative	
			Scenario 2	CEQA No Project Alternative	
NEPA	Scenario 5	NEPA No Action Alternative	Scenario 6	NEPA Yuba Accord Alternative [a]	To evaluate potential impacts of the Proposed Action and Alternatives, relative to the No Action Alternative
			Scenario 7	NEPA Modified Flow Alternative	
Water Rights	Scenario 2	CEQA No Project Alternative	Scenario 3	CEQA Yuba Accord Alternative	To evaluate potential impacts of the SWRCB action.
			Scenario 4	CEQA Modified Flow Alternative	

[a] The Yuba Accord Alternative is the CEQA Proposed Project Alternative and the NEPA Proposed Action Alternative.

2.2 PROJECT STUDY AREA

The project study area is described in four regions: (1) the Yuba Region; (2) the CVP/SWP Upstream of the Delta Region; (3) the Delta Region; and (4) the Export Service Area[1]. Operations of Trinity River, Clear Creek, Shasta Reservoir and the upper Sacramento River[2], Folsom Reservoir and the lower American River will not be affected by implementation of the alternatives considered, as discussed below. Simulation of these facilities is not included in the comparative impact analysis.

2.2.1 CHARACTERIZATION OF TRINITY RIVER AND CLEAR CREEK OPERATIONS

The CVP consists of seven divisions located within the Central Valley Basin and two out-of-basin divisions (i.e., the Trinity River Division and the San Felipe Division). The Trinity River Division is the only out-of-basin division that imports water into the Central Valley (i.e., the Sacramento River Basin). Water is transported from the Trinity River Basin via the Clear Creek Tunnel to Whiskeytown Reservoir. From Whiskeytown Reservoir, Trinity River water can be transported either via a second tunnel (i.e., Spring Creek Conduit) to Keswick Reservoir or released into Clear Creek, which flows into the Sacramento River. Reclamation conducts integrated operations between the CVP Trinity River and Shasta divisions.

The Trinity River does not naturally flow into the Sacramento River Basin but is connected by the Clear Creek Tunnel and the Spring Creek Conduit to the Sacramento River system and contributes to CVP water supply. Trinity River flows enter the Sacramento River below Keswick Dam via Clear Creek, however, Sacramento River flows below Keswick Dam do not influence or re-enter the Trinity River Basin. The Trinity River and Clear Creek systems are unlike other river systems (e.g., the Sacramento, Feather, and lower American) evaluated by CALSIM II modeling because project-related changes in flow, water temperature, or reservoir storage in those systems do not alter conditions affecting the availability, rate, timing, magnitude or duration of flows in the Trinity River Basin. The flow regime established in the Trinity River ROD is the only requirement for CVP water downstream of Lewiston Dam and is

[1] For modeling purposes, the Export Service Area includes San Luis Reservoir.

[2] For analytical purposes of this EIR/EIS, the upper Sacramento River includes those reaches of the Sacramento River that are located between Keswick Dam and the Feather River confluence with the Sacramento River.

not altered by the Proposed Yuba Accord. Diversions from the Trinity River to the Sacramento River occur at Lewiston Lake and CVP operators have expressed their intent to maintain diversions consistent in magnitude and temporal distribution with those that have occurred historically.

Based on the CVP system configuration described above, and upon confirmation that the Proposed Yuba Accord would not directly or indirectly affect Trinity River resources through review of hydrologic and water temperature modeling results, the Trinity River system does not require detailed study in the Draft EIR/EIS. However, Trinity, Whiskeytown, and Folsom reservoirs are included in the water temperature modeling because including them is necessary to assess Sacramento River water temperatures.

2.2.2 CHARACTERIZATION OF FOLSOM RESERVOIR AND LOWER AMERICAN RIVER OPERATIONS

Reclamation does not anticipate modifying Folsom Reservoir, Folsom Dam, or lower American River operations as a result of the Proposed Yuba Accord for the following reasons: (1) average annual inflow to Folsom Reservoir is about 2.7 MAF, slightly more than 2.5 times the active storage in the reservoir; (2) the inflow to storage ratio is so large that Folsom Dam and Reservoir is operated as an annual reservoir with typically little or no opportunity to store water assets outside of naturally occurring inflow; (3) in a case when water assets might potentially be stored in Folsom Reservoir, the likelihood that assets would be spilled due to required flood control operations would be high; and (4) lower American River flow operations are highly sensitive to, and regulated by, fishery considerations such that changes to flow regimes are undesirable and unlikely if alternative operations can accomplish CVP objectives. For these reasons, CVP operators have expressed their intention to maintain lower American River releases below Nimbus Dam consistent in magnitude and temporal distribution with those that have occurred historically. Flow and water temperature output values for Folsom Reservoir and the lower American River are automatically calculated as part of the CALSIM II and post-processing modeling runs. As part of the modeling quality assurance and quality control process, a review of the preliminary model output for the scenarios presented in Table 2-1 was conducted to verify that project-related actions would not influence or change conditions in Folsom Reservoir and the lower American River.

Based on the known operational limitations to the American River system described above, and review of the model output, the American River system does not require detailed study in the Draft EIR/EIS. However, the American River is included in the water temperature modeling application because it is required to assess Sacramento River water temperatures.

2.2.3 CHARACTERIZATION OF SHASTA RESERVOIR AND THE SACRAMENTO RIVER UPSTREAM OF THE FEATHER RIVER CONFLUENCE

According to the modeling assumptions, flows on the Sacramento River upstream of the confluence with the Feather River would not change with the implementation of the Proposed Project/Action and alternatives. Due to institutional difficulties in implementing a program allowing increases in Yuba River flow at Marysville to offset a portion of Shasta Reservoir releases, thus increasing Shasta Reservoir storage, modeling of the Proposed Project/Action and alternatives did not include this option. According to modeling rules:

- Increases in Yuba River flow at Marysville can result in increased Oroville Reservoir storage, increased Delta exports, or increased Delta outflow.
- Decreases in Yuba River flow at Marysville in wet, above normal, or below normal years when the Delta is in balanced conditions, will be offset by an increase in releases from Oroville Reservoir.
- Decreases in Yuba River flow at Marysville in dry or critical years when the Delta is in balanced conditions, will be offset by a reduction in Banks pumping.
- Decreases in Yuba River flow at Marysville when the Delta is in excess conditions will be offset by a decrease in Delta outflow.

The only case in which Shasta Reservoir storage and Sacramento River flows upstream of the confluence with the Feather River could be affected by changes in Yuba River flow at Marysville is in the second case described above. Rather than by just increasing releases from Oroville Reservoir, a portion of the decrease could be offset by increases in Shasta Reservoir releases. But, an evaluation of the occurrence of these conditions indicates they are extremely unlikely (occurring in less than 2.5 percent of months during the 72-year simulation period for the Proposed Project/Action), and are relatively small compared to the total flow in the Sacramento River, particularly when divided according to the COA rules (55 percent CVP, 45 percent SWP). Accordingly, modeling assumed all operational changes would occur in the Feather River and Oroville Reservoir. In addition, conversations with SWP operations staff indicated that, with appropriate notice from YCWA to the SWP, changes in Yuba River flow could be accommodated by Oroville Reservoir releases, and included in the real-time COA accounting between the CVP and SWP.

3.0 MODELS USED FOR THE IMPACT ANALYSIS

Computer simulation models of water systems provide a means for evaluating changes in system characteristics such as reservoir storage, stream flow, and hydropower generation, as well as the effects of these changes on environmental parameters such as water temperature, water quality, and early life stage Chinook salmon survival. The models and post-processing tools used to simulate conditions with and without implementation of the Proposed Project/Action and alternatives include the following:

- Reclamation and DWR simulation model of the integrated CVP and SWP system operations (CALSIM II);
- Spreadsheet-based Yuba Project Model (YPM);
- Lower Yuba River Water Temperature Model (LYRWTM);
- Lower Yuba River Outflow Routing Tool;
- Reclamation Trinity, Shasta, Whiskeytown, Oroville, and Folsom reservoir water temperature models;
- Reclamation Feather, and Sacramento river water temperature models;
- Reclamation Feather, and Sacramento river early life stage Chinook salmon mortality models;
- Graphical and Tabular Analysis for Environmental Resources (GATAER) Tool
- DWR Delta hydrodynamic and water quality model (DSM 2);

- Sacramento-San Joaquin Delta Fish Salvage Analyses; and
- CVP and SWP (Project) Hydropower Production and Delta Export Pumping Power Demand Analysis

The CALSIM II model provides baseline monthly simulation of the CVP and SWP water operations (reservoir inflows, releases, and storage; river flow; and other operating parameters such as CVP/SWP pumping and Delta operations) without implementation of the Proposed Yuba Accord. The YPM provides the Yuba River outflow resulting from the Proposed Yuba Accord operations in the Yuba River Basin. Output from these two models is used as input to the Proposed Yuba Accord Routing Tool to develop the system-wide Yuba Accord operations and to produce a modified or "*virtual*" CALSIM II output database. This database contains the final Proposed Yuba Accord operations as if they had been computed in the CALSIM II model. This step allows the use of the current interface between the CALSIM II model and other models used in the simulation process.

The virtual CALSIM II output databases is used to generate the inputs required for the DSM2, water temperature, fish salvage, and power models. Output from LYRWTM is used as a boundary condition for the temperature models. The water temperature models output is subsequently used to generate the inputs to the early life stage Chinook salmon mortality models. The output or results, of all these models is used to generate a model simulation database. Finally, the GATAER tool is used to generate the information needed for the impact analysis in the form of tables and graphs of model results. These models and related post-processing tools are described in detail in the following sections.

A diagram of the modeling and post-processing applications is presented in **Figure 3-1**.

3.1 CALSIM II MODEL

CALSIM II was jointly developed by Reclamation and DWR for planning studies relating to CVP and SWP operations. The primary purpose of CALSIM II is to evaluate the water supply reliability of the CVP and SWP at current or future levels of development (e.g. 2001, 2020), with and without various assumed future facilities, and with different modes of facility operations.

Geographically, the model covers the drainage basin of the Delta, and SWP exports to the San Francisco Bay Area, Central Coast, and Southern California.

CALSIM II typically simulates system operations for a 73-year period using a monthly time-step. The model assumes that facilities, land use, water supply contracts, and regulatory requirements are constant over this period, representing a fixed level of development (e.g., 2001 or 2020). The historical flow record of October 1921 to September 1994, adjusted for the influence of land use change and upstream flow regulation, is used to represent the possible range of water supply conditions. It is assumed that past hydrologic conditions are a good indicator of future hydrologic conditions. Major Central Valley rivers, reservoirs, and CVP/SWP facilities are represented by a network of arcs and nodes. CALSIM II uses a mass balance approach to route water through this network.

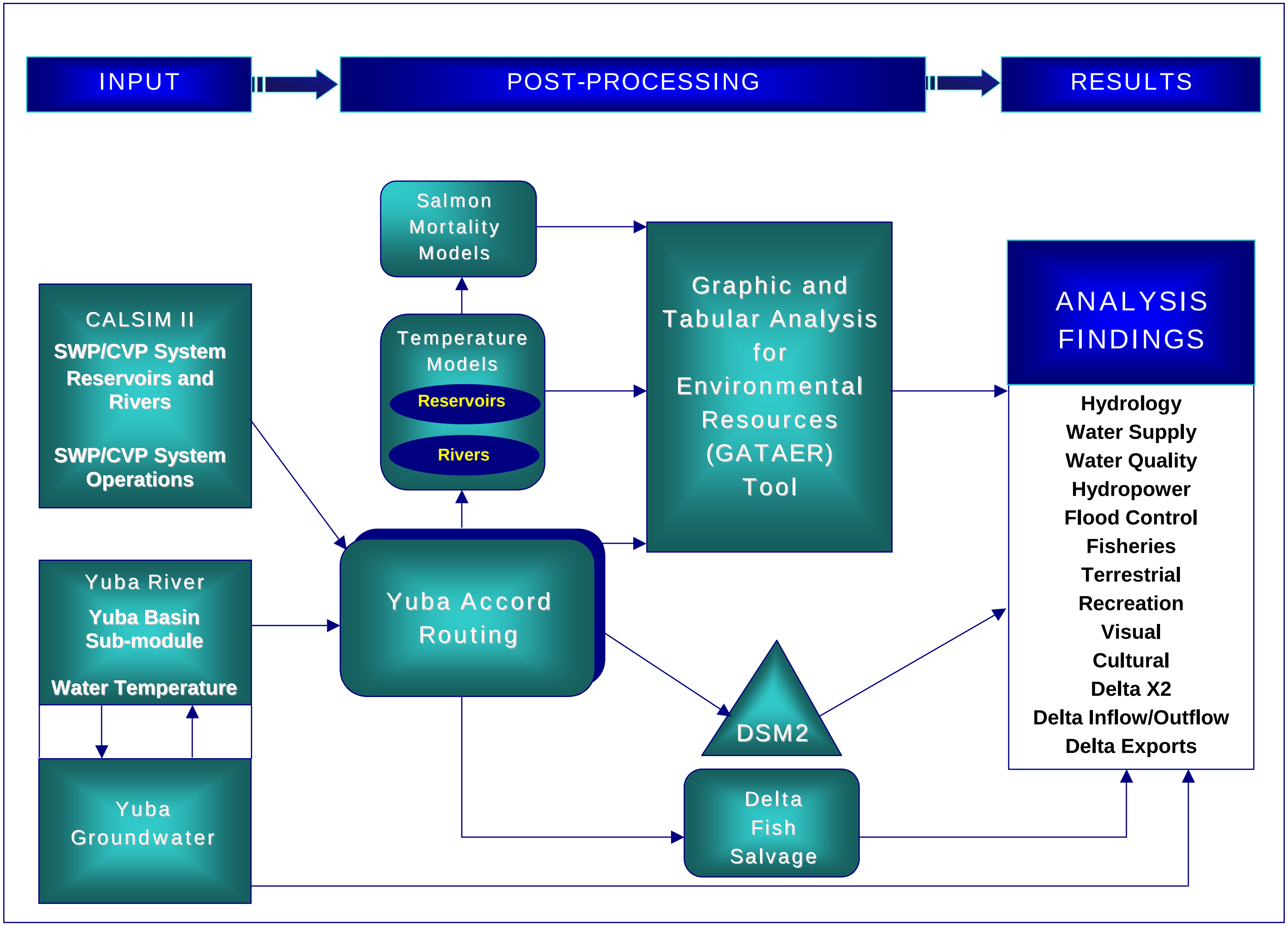

Figure 3-1. Modeling and Post-Processing Procedures

The model simulates one month of operation at a time, with the simulation passing sequentially from one month to the next, and from one year to the next. Each determination that the model makes regarding stream flow is the result of defined operational priorities (e.g. delivery priorities to water right holders, and water contractors), physical constraints (e.g., storage limitations, available pumping and channel capacities), and regulatory constraints (flood control, minimum instream flow requirements, Delta outflow requirements). Certain decisions, such as the definition of water year type, are triggered once a year, and affect water delivery allocations and specific stream flow requirements. Other decisions, such as specific Delta outflow requirements, vary from month to month. CALSIM II output contains estimated flows and storage conditions at each node for each month of the simulation period. Simulated flows are mean flows for the month, reservoir storage volumes correspond to end-of month storage.

CALSIM II models a complex and extensive set of regulatory standards and operations criteria. Descriptions of both are contained in Chapter 8 of the OCAP BA (Reclamation 2004b), and in the Benchmark Studies Assumptions Document (Reclamation and DWR 2002).

CALSIM II simulates monthly operations of the following water storage and conveyance facilities:

- Trinity, Lewiston, and Whiskeytown reservoirs (CVP);
- Spring Creek and Clear Creek tunnels (CVP);
- Shasta and Keswick reservoirs (CVP);
- Oroville Reservoir and the Thermalito Complex (SWP);
- Folsom Reservoir and Lake Natoma (CVP);
- New Melones Reservoir (CVP);
- Millerton Lake (CVP);
- Jones (CVP), Contra Costa (CVP) and Banks (SWP) pumping plants; and
- San Luis Reservoir (shared by CVP and SWP).

To varying degrees, nodes also define CVP/SWP conveyance facilities including the Tehama-Colusa, Corning, Folsom-South, and Delta-Mendota canals and the California Aqueduct. Other non-CVP/SWP reservoirs or rivers tributary to the Delta also are modeled in CALSIM II, including:

- New Don Pedro Reservoir;
- Lake McClure; and
- Eastman and Hensley lakes.

For this EIS/EIR, CALSIM II is used to establish baseline flow conditions in the Sacramento River, Feather River, and Delta, and the availability of pumping capacity at Banks and Jones pumping plants. CALSIM II output includes average monthly X2 (2 parts per thousand [ppt] near bottom salinity isohaline) location, Net Delta Outflow, and Delta export-to-inflow (E/I) ratio.

CALSIM II modeling undertaken for Reclamation's OCAP BA is used to provide the foundation for CVP/SWP system-wide baseline conditions (stream flow, storage, and diversions) used to represent the Existing Condition (CEQA basis of comparison) and the future No Action Alternative (NEPA basis of comparison). OCAP model simulations were rerun (OCAP Study 3 and OCAP Study 5) with updated inputs for lower Yuba River outflow to the Feather River, lower Yuba River diversions at Daguerre Point Dam, and Trinity River instream flow requirements downstream of Lewiston Dam.

3.2 YUBA PROJECT MODEL

The spreadsheet-based YPM simulates operations of New Bullards Bar and Englebright dams, diversions at Daguerre Point Dam, and flows in the lower Yuba River between Englebright Dam and its confluence with the Feather River. The model is a volumetric mass balance accounting tool, which simulates reservoir operations according to a set of pre-defined operating rules and to meet downstream water demands and instream flow requirements on the lower Yuba River.

A schematic of the model is presented in **Figure 3-2**. Additional details are presented in Attachment A.

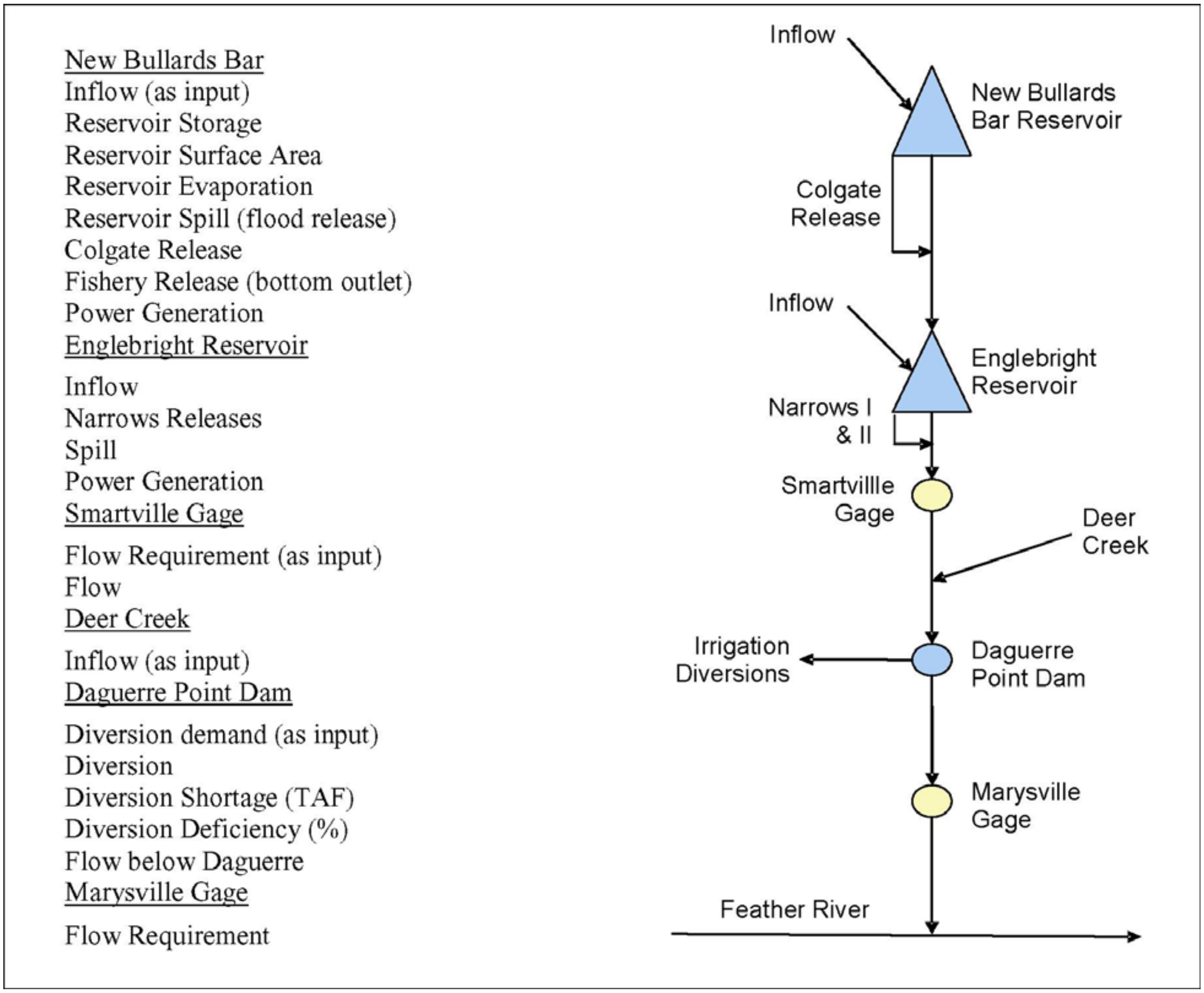

Figure 3-2. Lower Yuba River Model Network Schematic and Output

3.3 LOWER YUBA RIVER WATER TEMPERATURE MODEL

Due to limited available water temperature and meteorological data, a statistical rather than a physically based water temperature model was developed to evaluate the potential impacts of the alternatives considered in the Draft EIR/EIS. The statistical model is used to estimate the effects of various New Bullards Bar Reservoir storage regimes, flow releases, and diversions at

Daguerre Point Dam on water temperatures in the lower Yuba River. The statistical model is used to compare water temperatures between alternatives. The statistical model is not used to predict absolute water temperatures in the lower Yuba River.

The Proposed Yuba Accord modeling approach relies on further developing the statistical model utilized for the 2000 SWRCB Lower Yuba River Hearings. The statistical relationships previously developed for calculating predicted water temperatures were enhanced through extension of the historical data set used for model calibration. The statistical relationships used in the model developed for the 2000 SWRCB Lower Yuba River Hearings were based on historical data collected between 1990 and 1999. Now, five more years of data are available and have been incorporated into the revised model.

The statistical model consists of five sub-models that can be used to calculate water temperatures at the following locations:

- New Bullards Bar Dam low-level outlet
- New Colgate Powerhouse release
- Narrows I and II powerhouse release (assumed equal to water temperatures at the Smartville Gage)
- Daguerre Point Dam
- Marysville Gage

Additional information is provided in Attachment B**.**

3.4 LOWER YUBA RIVER OUTFLOW ROUTING TOOL

The lower Yuba River outflow routing tool is an Excel-based post-processing tool that uses output from CALSIM II and the YPM to simulate how changes in Yuba River flow at Marysville effect downstream flows in the Feather River, lower Sacramento River and Delta.

The starting point for the routing tool are CALSIM II simulations of CVP and SWP operations under the Yuba Accord accounting baseline, as defined in the Water Purchase Agreement. The Accord accounting baseline is used to determine Released Transfer Water under the Water Purchase Agreement, and includes RD-1644 interim instream flow requirements on the lower Yuba River, and FERC License 2246 instream flow requirements of 400 cfs at the Marysville Gage for the period October 1 to 14. Two CALSIM II simulations are performed, one for a present level of development based on OCAP Study 3 used for the CEQA analysis, one for a future level of development based on OCAP Study 5 used for the NEPA analysis. Input to the routing tool from a CALSIM II simulation includes Oroville reservoir storage, Feather River and lower Sacramento River flows, and Delta inflows, exports, and outflow.

The YPM is used to simulate flows in the lower Yuba River for each modeling scenario. Input to the routing tool from a YPM simulation is the lower Yuba River flow at the Marysville Gage.

The routing tool subsequently adjusts releases from Oroville Reservoir and CVP/SWP Delta exports to account for the changes in the lower Yuba River outflow under a specific scenario (e.g. CEQA Yuba River Accord) compared to the accounting baseline condition (RD-1644 Interim flows requirements). The modified reservoir storage, river flows, and Delta inflows, exports and outflow from the routing tool are stored in DSS so creating the virtual CALSIM II output database that is used by other post-processing tools.

The lower Yuba River outflow routing tool is a very efficient method of modeling the Proposed Project/Action and alternatives. The tool is necessary because the CALSIM II model is not presently configured to simulate the range of actions contemplated and evaluated in the Draft EIR/EIS. CVP and SWP operators have acknowledged their ability to limit the effects of the Yuba Accord to the Feather River, lower Sacramento River, and Delta through the use of forecasting, real-time accounting, and adjustment of the COA balance. CALSIM II is not set up to model this operational flexibility.

3.5 BUREAU OF RECLAMATION WATER TEMPERATURE MODELS

Reclamation has developed water temperature models for the Sacramento, Feather, and American rivers. The models have both reservoir and river components to simulate water temperatures in five major reservoirs (Trinity, Whiskeytown, Shasta, Oroville, and Folsom); four downstream regulating reservoirs (Lewiston, Keswick, Thermalito, and Natoma); and three main river systems (Sacramento, Feather, and American).

The following sections provide additional detail regarding the reservoir and river components of the water temperature models, respectively. Additional details regarding Reclamation's water temperature models are well documented in the CVPIA "*Draft Programmatic EIS (PEIS) Technical Appendix, Volume Nine*" (Reclamation 1997). These water temperature models also are documented in the report titled: "*U.S. Bureau of Reclamation Monthly Temperature Model Sacramento River Basin*" (Reclamation 1990).

3.5.1 BUREAU OF RECLAMATION'S RESERVOIR WATER TEMPERATURE MODELS

Reclamation's reservoir models simulate monthly water temperature profiles in five major reservoirs: Trinity, Whiskeytown, Shasta, Oroville, and Folsom. The vertical water temperature profile in each reservoir is simulated in one dimension using monthly storage, inflow and outflow water temperatures and flow rates, evaporation, precipitation, solar radiation, and average air temperature. The models also compute the water temperatures of dam releases. Release water temperature control measures in reservoirs, such as the penstock shutters in Folsom Reservoir and the temperature control device in Shasta Reservoir, are incorporated into the models.

Reservoir inflows, outflows, and end-of-month storage calculated by CALSIM II and post-processing applications are input into the reservoir water temperature models. Additional input data include meteorological information and monthly water temperature targets that are used by the model to select the level from which reservoir releases are drawn. Water temperature control devices, such as the outlet control device in Shasta Dam, the temperature curtains in Whiskeytown Dam, and the penstock shutters in Folsom Dam are incorporated into the simulation. Model output includes reservoir water temperature profiles and water temperatures of the reservoir releases. The reservoir release water temperatures are then used in the downstream river water temperature models, as described in the next section.

Trinity, Whiskeytown, and Folsom reservoirs are included in the modeling application because they are required to assess Sacramento River water temperatures; however, these reservoirs are not individually analyzed because there would be no change in CVP/SWP project operations due to implementation of the Proposed Project/Action or an alternative, relative to the bases of comparison (see Section 6.1).

3.5.2 BUREAU OF RECLAMATION'S RIVER WATER TEMPERATURE MODELS

Reclamation's river water temperature models utilize the calculated temperatures of reservoir releases, much of the same meteorological data used in the reservoir models, and CALSIM II and post-processing application outputs for river flow rates, gains and water diversions. Mean monthly water temperatures are calculated at multiple locations on the Sacramento, Feather, and American rivers.

Reservoir release rates and water temperatures are the boundary conditions for the river water temperature models. The river water temperature models compute water temperatures at 52 locations on the Sacramento River from Keswick Dam to Freeport, and at multiple locations on the Feather and American rivers. The river water temperature models also calculate water temperatures within Lewiston, Keswick, Thermalito, and Natoma reservoirs. The models are used to estimate water temperatures in these reservoirs because they are relatively small bodies of water with short residence times; thereby, on a monthly basis, the reservoirs act as if they have physical characteristics approximating those of riverine environments.

The American River is included in the modeling application because it is required to assess Sacramento River water temperatures. However, Folsom Reservoir and the lower American River are not included in post-processing modeling because of the annual high refill and spill potential at Folsom Reservoir; therefore, the modeling assumes no change in Folsom Reservoir storage/elevations or lower American River flows with implementation of the Proposed Project/Action or an alternative, relative to the bases of comparison (see Section 6.1).

3.6 BUREAU OF RECLAMATION'S EARLY LIFE STAGE CHINOOK SALMON MORTALITY MODELS

Water temperatures calculated for specific reaches of the Sacramento and Feather rivers are used as inputs to Reclamation's Early Life Stage Chinook Salmon Mortality Models (Salmon Mortality Models) to estimate annual mortality rates of Chinook salmon during specific early life stages. For the Sacramento River analyses, the model estimates mortality for each of the four Chinook salmon runs: fall, late fall, winter, and spring. For the Feather River analyses, the model[3] produces estimates of fall-run Chinook salmon mortality. Because hydrologic conditions in the Yuba River are not characterized in Reclamation's current Salmon Mortality Models, it is not possible to estimate changes in early life stage mortality for Chinook salmon in the lower Yuba River.

The Salmon Mortality Models produce a single estimate of early life stage Chinook salmon mortality in each river for each year of the simulation. The overall salmon mortality estimate consolidates estimates of mortality for three separate Chinook salmon early life stages: (1) pre-spawned (in utero) eggs; (2) fertilized eggs; and (3) pre-emergent fry. The mortality estimates

[3] For the purposes of improved technical accuracy and analytical rigor, simulated Chinook salmon early life stage survival estimates specific to the Feather River are derived from a revised version of Reclamation's Salmon Mortality Model (2004), which incorporates new data associated with: (1) temporal spawning and pre-spawning distributions; and (2) mean daily water temperature data in the Feather River. Although the updated Feather River information serving as input into the model deviates slightly from that which was used in Reclamation's OCAP BA, both versions of the model are intended for planning purposes only, and thus should not be used as an indication of actual real-time in-river conditions. Because a certain level of bias is inherently incorporated into these types of planning models, such bias is uniformly distributed across all modeled simulations, including both the Proposed Project/Action and alternatives and the bases of comparison, regardless of which version of the model is utilized.

are computed using output water temperatures from Reclamation's water temperature models as inputs to the Salmon Mortality Models. Thermal units (TUs), defined as the difference between river water temperatures and 32°F, are used by the Salmon Mortality Models to track life stage development, and are accounted for on a daily basis. For example, incubating eggs exposed to 42°F water for one day would experience 10 TUs. Fertilized eggs are assumed to hatch after exposure to 750 TUs. Fry are assumed to emerge from the gravel after being exposed to an additional 750 TUs following hatching.

Because the models are limited to calculating mortality during early life stages, they do not evaluate potential impacts to later life stages, such as recently emerged fry, juvenile out-migrants, smolts, or adults. Additionally, the models do not consider other factors that may affect early life stage mortality, such as adult pre-spawn mortality, instream flow fluctuations, redd superimposition, and predation. Because the Salmon Mortality Models operate on a daily time-step, a procedure is required to convert the monthly water temperature output from the water temperature models into daily water temperatures. The Salmon Mortality Models compute daily water temperatures based on the assumption that average monthly water temperature occurs on the 15th of each month, and interpolate daily values from mid-month to mid-month. Output from the Salmon Mortality Models provide estimates of annual (rather than monthly mean) losses of emergent fry from egg potential (i.e., all eggs brought to the river by spawning adults) (Reclamation 2003).

A similar water temperature based mortality model for steelhead in the Sacramento, Feather and Yuba rivers currently is not available. However, because the temporal and spatial spawning distributions of steelhead and late fall-run Chinook salmon are similar, it can be assumed that water temperature changes and resultant losses of steelhead eggs and fry would be similar to those estimated for late fall-run Chinook salmon using the Salmon Mortality Models, where available.

3.6.1 LOWER FEATHER RIVER EARLY LIFE STAGE CHINOOK SALMON MORTALITY MODEL REVISIONS

During March 2004, Reclamation's Salmon Mortality Model was revised to include updated information regarding the temporal distribution of Chinook salmon spawning activity in the lower Feather River. The revised Feather River Salmon Mortality Model estimates the water temperature-induced early life stage mortality using updated pre-spawning and spawning temporal distributions, which were derived from estimated daily carcass distributions. Estimated daily carcass distributions were derived from daily observations of Chinook salmon carcasses during the 2002 spawning period. Additional information regarding the use of carcass survey data as a basis for development of pre-spawning and spawning temporal distributions in the Feather River, is described in the Oroville Facilities Relicensing, FERC Project 2100, Study Plan F-10 – "*Task 2C: Evaluation of the Timing, Magnitude, and Frequency of Water Temperatures and Their Effects on Chinook Salmon Egg and Alevin Survival*" (DWR 2004).

While the revised Feather River Salmon Mortality Model utilizes updated pre-spawning and spawning temporal distributions as bases from which to calculate early life stage mortality, the remaining model assumptions, computations, and input variables remain unchanged from Reclamation's Feather River Early Life Stage Chinook Salmon Mortality Model.

3.6.2 OTHER SALMON MORTALITY MODEL CONSIDERATIONS

Three separate reviews of the NMFS October 2004 BO on the Long-term CVP and SWP OCAP (NMFS 2004) have been conducted to determine whether NMFS (2004) used the best available scientific and commercial information (2005).

McMahon (2006) acknowledged that a lack of information on how water operations related habitat alterations affect Central Valley salmonid populations exists. In this context, McMahon (2006) concluded that, "*…the Biological Opinion (BO) appears to be based on best available information with regards to temperature effects on survival of salmonid embryos and early fry in the upper Sacramento River and major tributaries…*".

Maguire (2006) reported two general concerns related to the salmon mortality model. First, Maguire (2006) stated, "*The mean monthly temperature may in fact be of little predictive value for mortality estimation without knowing (using) the variability and duration of variability.*" Second, Maguire (2006) suggested that the salmon mortality model is of limited usefulness because it does not evaluate potential impacts on emergent fry, smolts, juvenile emigrants, or adults, and the model only considers water temperature as a source of mortality.

With respect to the application of the salmon early life stage mortality model in NMFS (NMFS 2004), three concerns were reported within the California Bay-Delta Authority (CBDA) report (California Bay-Delta Authority 2005). First, CBDA (2005) questioned the use of water temperature predictions that were developed by linear interpolation between monthly means without accounting for variation. Second, water temperature at the time of spawning was taken as an index of pre-spawning water temperature exposure, which reportedly may be an unsatisfactory approach for spring-run Chinook salmon, which may hold in the river throughout the summer. Lastly, and reportedly the expert panel's most serious concern, "*…the data used to develop the relationships between temperature and mortality on eggs, alevins, and especially gametes was not the best available.*"

To address these three concerns, the expert panel recommended that NMFS should: (1) perform a thorough analysis of the data, relationships, and calculations of the salmon mortality model; (2) investigate how variation around monthly mean water temperatures would affect salmon mortality model results; and (3) suggest or make improvements to the model. It is uncertain whether NMFS will accept these recommendations and undertake these efforts to address the concerns raised with technical details of the salmon mortality model. At this time, this process has not been undertaken and salmon mortality model improvements have not been identified and incorporated into the model. Therefore, the existing salmon mortality model is the best available model for comparing the potential water temperature related effects of the Proposed Project/Action and alternatives on Chinook salmon early life stages to those of the basis of comparison.

3.7 GRAPHIC AND TABULAR ANALYSIS OF ENVIRONMENTAL RESOURCES TOOL

The GATAER Tool produces figures and tables for the analysis of output from CALSIM II, the water temperature models, salmon mortality models, and other post-processing applications. Data are loaded from these models into a DSS database, which is then used as input to a series of spreadsheets that generate the figures and tables for use in the environmental resource analyses. The figures and tables generated for the evaluation of specific resource topics and impacts is included in Appendix F4, *Graphical and Tabular Analysis of Environmental Resources – Summary and Technical Output*, of the Draft EIR/EIS.

3.8 DELTA SIMULATION MODEL 2

The Delta Simulation Model 2 (DSM2) is a branched one-dimensional model for simulation of hydrodynamics, water quality and particle tracking in a network of riverine or estuarine channels (DWR 2002). The hydrodynamic module can simulate channel stage, flow and water velocity. The water quality module can simulate the movement of both conservative and non-conservative constituents. The model is used by DWR to perform operational and planning studies of the Delta.

Impact analysis for planning studies of the Delta is typically performed for a 16-year period 1976 to 1991. In model simulations, EC is typically used as a surrogate for salinity. Results from CALSIM II and the post-processing analysis (i.e., Yuba River Outflow Routing Tool) are utilized to define Delta boundary inflows. CALSIM II derived boundary inflows include the Sacramento River flow at Hood, the San Joaquin River flow at Vernalis, inflow from the Yolo Bypass, and inflow from the Eastside streams. In addition, the Net Delta Outflow from CALSIM II is used to calculate the salinity boundary at Martinez.

Details of the model, including source codes and model performance, are available from the DWR, Bay-Delta Office, Modeling Support Branch Web site (http://modeling.water.ca.gov /delta/models/dsm2/index.html). Documentation on model development is discussed in the annual reports to the SWRCB, *Methodology for flow and salinity estimates in the Sacramento-San Joaquin Delta and Suisun Marsh* of the Delta Modeling Section of DWR.

3.9 SACRAMENTO-SAN JOAQUIN DELTA FISH SALVAGE EVALUATION

The CVP and SWP export facilities (including the Skinner Fish Facility and the Tracy Fish Collection Facility) that pump water from the Delta can directly affect fish mortality in the Delta through entrainment and associated stresses resulting from CVP/SWP export pumping operations. This section describes the methodology and assumptions that is used to evaluate these potential impacts. The evaluation uses historical fish salvage data from the CVP and SWP pumping plants to evaluate the overall effect of changes in Delta exports.

3.9.1 SALVAGE

Salvage operations at the CVP and SWP export facilities are performed to reduce the number of fish adversely affected by entrainment (direct loss). Salvage estimates are defined as the number of fish entering a salvage facility and subsequently returned to the Delta through a trucking and release operation. Because the survival of species that are sensitive to handling is believed to be low for most fish species, increased salvage is considered an adverse impact and decreased salvage is considered a beneficial impact on Delta fisheries resources.

Historical salvage records provide data for delta smelt, Chinook salmon, steelhead, and striped bass at both the CVP and SWP facilities. These data were used to develop estimates of salvage loss. During the historical period, 1993 to 2003, the CVP and SWP facilities were operated under Delta water quality, flow, and export constraint requirements that varied over the period and were different than the Delta requirements in place today. This suggests that the historical fish salvage was likely higher than it would be if the 1993 to 2003 period reoccurred with the CVP/SWP facilities operated under today's Delta requirements, as is assumed in this analysis.

Consistent with prior Reclamation assumptions (Reclamation 2004b), it is assumed that changes in salvage are directly proportional to changes in the amount of water pumped (i.e., doubling the amount of water exported doubles the number of fish salvaged). Salvage analyses are performed for winter-run Chinook salmon, spring-run Chinook salmon, steelhead, striped bass, and delta smelt to develop estimates of the relative impacts of CVP and SWP pumping operations under the various modeling scenarios. The evaluation uses historical fish salvage data from the CVP and SWP pumping plants to evaluate changes in Delta exports (increased pumping) and the resultant changes in salvage for various fish species in the Delta. The available historical salvage data extends from 1993 to 2003 for delta smelt, Chinook salmon, steelhead, and striped bass. The salvage data prior to 1993 does not sufficiently represent the current conditions in the Delta due to operational changes. Since 1993, the salvage data provides daily densities, in numbers of fish salvaged per thousand acre-feet pumped at the CVP Jones Pumping Plant and the SWP Banks Pumping Plant.

Populations of some of the listed species, such as winter-run Chinook salmon, are continuously variable and the geographical and temporal distribution of the population can be different today from what they were during the 1993 to 2003 period. Because of this, neither the timing, duration, nor the quantity of water needed for most export curtailments can be accurately estimated until shortly before an action is scheduled.

In response to NMFS issuance of a final rule (71 FR 17757 (2006)) listing the Southern DPS of North American green sturgeon as threatened under the ESA, Reclamation is in the process of developing a methodology for calculating green sturgeon salvage estimates at the CVP and SWP export pumping facilities in the Delta. If a methodology is developed prior to completion of the EIR/EIS for the Proposed Yuba Accord, it is anticipated that salvage estimates for green sturgeon also would be conducted.

3.9.2 MODELING

Salvage analyses is performed to develop an indication of the relative changes in CVP and SWP pumping operations under the various modeling scenarios evaluated in the Draft EIR/EIS. Salvage densities are developed for the purposes of evaluating the incremental effects of potential operations on the direct losses at the Delta export facilities. Calculations of salvage at the CVP and SWP facilities, as a function of changes in the seasonal volume of water diverted, have been used as an indicator of potential effects resulting from changes in water project operations. The magnitude of direct salvage resulting from export operations is a function of the magnitude of monthly water exports from each facility and the density (number per acre-foot) of fish susceptible to entrainment at the facilities.

Data selected for use in these analyses extended over a period from 1993 to 2003. The salvage densities are derived using historic records of species-specific salvage at the CVP and SWP facilities, which are used to calculate average monthly density (number of fish per thousand acre-feet), and then are multiplied by the calculated CVP and SWP monthly exports (in thousand acre-feet) obtained from the hydrologic modeling output to estimate direct salvage. The salvage estimates are calculated separately for the CVP and SWP export operations for all modeling scenarios.

Average monthly salvage densities for each species are calculated from daily salvage records over the period from 1993 to 2003 (pers. comm. M. Chotkowski, Reclamation *in* (Reclamation 2004a). Based on the daily salvage, expanded for sub-sampling effort, a daily density estimate is calculated using the actual water volume diverted at each of the two export facilities. The daily density estimates are averaged to calculate an average monthly density. For consistency, the average monthly density of each of the individual target species are used to calculate the estimated salvage using hydrologic modeling results for each modeling scenario. After calculating the monthly salvage estimates for each species, the baseline (or basis of comparison scenario) estimate are subtracted from the monthly salvage estimate for each species to determine the net difference in salvage estimates for the various scenarios.

Results of the hydrologic modeling provide estimates of the average monthly Delta export operations for both the CVP and SWP. Because hydrologic conditions may affect salvage densities, the average salvage densities are calculated separately for wet years (i.e., wet and above normal water years using the Sacramento Valley 40-30-30 Index) and dry years (i.e., below normal, dry, and critical water years using the Sacramento Valley 40-30-30 Index). Estimates of direct salvage from CVP and SWP facilities are calculated for Chinook salmon, steelhead, delta smelt, and striped bass, and then are used to determine the incremental benefits (reduced salvage) and impacts (increased salvage) calculated for each modeling scenario.

Despite the inaccuracies within the analyses caused by assuming historical fish salvage at the pumping plants, the evaluations are performed to provide an approximate quantification of the overall potential impacts with implementation of the alternatives, using the best available data. Without some quantification, the discussion and analyses of potential changes in fish salvage and the cost of exporting water would have to be qualitative and based solely on scientific opinion. Therefore, the results provided by the analyses must be considered as only part of the information (quantitative and qualitative) that are used to evaluate the potential effects in the Delta.

3.10 PROJECT HYDROPOWER PRODUCTION AND DELTA EXPORT PUMPING POWER DEMAND EVALUATION

CVP project hydropower impacts are assessed using the LongTermGen Model, which is a CVP power model developed to estimate the CVP power generation, capacity, and project use based on the operations defined by a CALSIM II simulation. Created using Microsoft's Excel spreadsheet with extensive Visual Basic programming, the LongTermGen Model computes monthly generation, capacity, and project use (pumping power demand) for each CVP power facility for each month of the CALSIM II simulation.

The LongTermGen model does not compute hydropower production for Oroville Reservoir or pumping power use for SWP pumping plants. To assess any changes in Oroville power production, equations were developed relating reservoir storage and release to generation and capacity, using historical data. These relationships were incorporated into an Excel 2000 spreadsheet that uses CALSIM II (or post-processing tool) output data as input.

Although the LongTermGen Model can calculate export pumping power demand for the CVP pumping plant at the Jones Pumping Plant, it does not calculate SWP export pumping power demand at the Banks Pumping Plant. Water pumped at Banks Pumping Plant can gravity flow to O'Neill Forebay, but water pumped at Jones Pumping Plant requires an additional lift at O'Neill Pumping Plant. The combined pumping power requirement at Jones and O'Neill is approximately equal to that of Banks Pumping Plant. For this reason, and because CVP or SWP water may be pumped at either Delta export facility, the Banks, and Jones plus O'Neill, pumping power demand was calculated using a plant requirement of 298 kilowatthours/acre-foot times the volume of water pumped at either facility. An Excel spreadsheet is used to calculate the resultant pumping power demand using input from the CALSIM II (or post-processing tool) simulations.

3.11 MODEL LIMITATIONS

Reclamation's OCAP BA outlines the limitations of three of the models that were used in the assessment conducted for the most recent Section 7 consultations on the OCAP, which led to NMFS and USFWS BOs for winter-run and spring-run Chinook salmon, steelhead, and delta smelt. These models (i.e., CALSIM II, water temperature, and salmon mortality) are the same models used to conduct the modeling analysis presented in the Draft EIR/EIS for the Proposed Yuba Accord. The following discussion regarding the model limitations used in the modeling analysis is taken directly from the CVP and SWP OCAP BA.

> "*The main limitation of CALSIM II and the temperature models used in the study is the time-step. Mean monthly flows and temperatures do not define daily variations that could occur in the rivers due to dynamic flow and climatic conditions. However, monthly results are still useful for general comparison of alternatives. The temperature models are also unable to accurately simulate certain aspects of the actual operations strategies used when attempting to meet temperature objectives, especially on the upper Sacramento River. To account for the short-term variability and the operational flexibility of the system to respond to changing conditions, cooler water than that indicated by the model is released in order to avoid exceeding the required downstream temperature target. There is also uncertainty regarding performance characteristics of the Shasta TCD [temperature control device]. Due to the hydraulic characteristics of the TCD, including leakage, overflow, and performance of the side intakes, the model releases are cooler than can be achieved in real-time operations; therefore, a more conservative approach is taken in real-time operations that is not fully represented by the models.*
>
> *The salmon model is limited to temperature effects on early life stages of Chinook salmon. It does not evaluate potential direct or indirect temperature impacts on later life stages, such as emergent fry, smolts, juvenile out-migrants, or adults. Also, it does not consider other factors that may affect salmon mortality, such as in-stream flows, gravel sedimentation, diversion structures, predation, ocean harvest, etc. Since the salmon mortality model operates on a daily time-step, a procedure is required to utilize the monthly temperature model output. The salmon model computes daily temperatures based on linear interpolation between the monthly temperatures, which are assumed to occur on the 15th day of the month.*
>
> *CALSIM II cannot completely capture the policy-oriented operation and coordination the 800,000 of dedicated CVPIA 3406 (B)(2) water and the CALFED EWA. Because the model is set up to run each step of the 3406(B)(2) on an annual basis and because the WQCP and ESA actions are set on a priority basis that can trigger actions using 3406(b)(2) water or EWA assets, the model will exceed the dedicated amount of 3406(b)(2) water that is available. Moreover, the 3406(b)(2) and EWA operations in CALSIM II are just one set of plausible actions aggregated to a monthly representation and modulated by year type. However, they do not fully account for the potential weighing of assets versus cost or the dynamic influence of biological factors on the timing of actions. The monthly time-step of CALSIM II also requires day-weighted monthly averaging to simulate minimum instream flow levels, VAMP actions, export reductions, and X2-based operations that occur within a month. This averaging can either under- or over-estimate the amount of water needed for these actions.*

> *Since CALSIM II uses fixed rules and guidelines results from extended drought periods might not reflect how the SWP and CVP would operate through these times. The allocation process in the modeling is weighted heavily on storage conditions and inflow to the reservoirs that are fed into the curves mentioned previously in the Hydrologic Modeling Methods section beginning on page 8-1 and does not project inflow from contributing streams when making an allocation. This curve based approach does cause some variation in results between studies that would be closer with a more robust approach to the allocation process*" (Reclamation 2004).

Because both the lower Yuba River outflow routing tool and DSM2 use output from CALSIM II planning studies, they share the same limitations as the CALSIM II model. The routing tool uses fixed operating rules to make decisions regarding CVP/SWP reservoir releases and changes to Delta exports. These rules were reviewed by Reclamation and DWR for consistency with CVP/SWP operator decisions. However, the fixed rules cannot capture the flexible and adaptive management of CVP/SWP operators.

Model assumptions and results are generally believed to be more reliable for comparative purposes than for absolute predictions of conditions. All of the assumptions are the same for both the with-project and without-project model runs, except assumptions associated with the action itself, and the focus of the analysis is the differences in the results. For example, model outputs for the Proposed Project/ Action can be compared to that of the CEQA No Project and NEPA No Action simulations. Results from a single simulation may not necessarily correspond to actual system operations for a specific month or year, but are representative of general water supply conditions. Model results are best interpreted using various statistical measures such as long-term and year-type average, and probability of exceedance.

4.0 CEQA/NEPA MODEL SCENARIOS

The full suite of CEQA and NEPA modeling scenarios developed to represent existing and future hydrologic conditions expected to occur with and without implementation of the alternatives considered for the Proposed Yuba Accord (i.e., Yuba Accord Alternative and Modified Flow Alternative) and evaluated in the Draft EIR/EIS are presented in **Table 4-1**. Because Reclamation's OCAP Study 3 and Study 5 are used as foundational studies, these studies also are presented in Table 4-1, so that the reader may compare specific assumptions that have been modified for each of the CEQA and NEPA modeling scenarios developed for the Proposed Yuba Accord. Details on the assumptions included in each of the scenarios are included in footnotes after the table. The assumptions for groundwater pumping and other aspects of Yuba Project operations are described in detail in Attachment A.

Yuba River operations must abide by the conditions that have been established in the Yuba County Water Agency Act, water rights permits and licenses administered by the SWRCB, FERC License #2246 for the Yuba River Development Project, FERC 1993 License to Pacific Gas and Electric Company (PG&E) for continued operation at the Narrows I Power House, Section 7 of the Flood Control Act of 1944 (at New Bullards Bar Dam and Reservoir), and the 1966 Power Purchase Contract between YCWA and PG&E (YCWA 2001).

Table 4-1. Yuba Accord CEQA AND NEPA Modeling Scenario Assumptions Matrix

Row			CEQA Scenarios					NEPA Scenarios		
1.	Scenario No.	-	1	2	3	4	-	5	6	7
2.	Description	Foundation Study OCAP Study 3 [p]	Existing Condition	No Project Alternative	Yuba Accord Alternative	Modified Flow Alternative	Foundation Study OCAP Study 5 [p]	No Action Alternative	Yuba Accord Alternative	Modified Flow Alternative
3.	Time Frame	2001	2005	2007-2025	2007-2025	2007-2025	2020	2007-2025	2007-2025	2007-2025
4.	**Lower Yuba River Basin**	**Assumption**	**Assumption**	**Assumption**	**Assumption**	**Assumption**	**Assumption**	**Assumption**	**Assumption**	**Assumption**
5.	**Lower Yuba River Operations**	Derived from DWR HEC-3 model	Updated using YPM [k]	Updated using YPM [k]	Updated using YPM [k]	Updated using YPM [k]	Derived from DWR HEC-3 model	Updated using YPM [k]	Updated using YPM [k]	Updated using YPM [k]
6.	**Maximum Demand at Daguerre Point Dam**	N/A [a]	298 TAF - wet, above normal years, 304 TAF below normal, dry, and critical years	338 TAF - wet, above normal years, 344 TAF below normal, dry, and critical years [b]	338 TAF - wet, above normal years, 344 TAF below normal, dry, and critical years [b]	338 TAF - wet, above normal years, 344 TAF below normal, dry, and critical years [b]	N/A [a]	338 TAF - wet, above normal years, 344 TAF below normal, dry, and critical years [b]	338 TAF - wet, above normal years, 344 TAF below normal, dry, and critical years [b]	338 TAF - wet, above normal years, 344 TAF below normal, dry, and critical years [b]
7.	**Carryover Storage Target for YCWA Deliveries to Member Units**	N/A [a]	Maximum 50% shortage for 1 in 100 year drought event in the following year	Maximum 50% shortage for 1 in 100 year drought event in the following year	Carryover storage targets inherent in flow schedules	Maximum 50% shortage for 1 in 100 year drought event in the following year	N/A [a]	Maximum 50% shortage for 1 in 100 year drought event in the following year	Carryover storage targets inherent in flow schedules	Maximum 50% shortage for 1 in 100 year drought event in the following year
8.	**Yuba Groundwater Basin Conjunctive Use**	N/A [a]	Groundwater use to compensate for surface water supply shortages at Daguerre Point Dam	Groundwater use to compensate for surface water supply shortages at Daguerre Point Dam	Groundwater use to compensate for surface water supply shortages at Daguerre Point Dam	Groundwater use to compensate for surface water supply shortages at Daguerre Point Dam	N/A [a]	Groundwater use to compensate for surface water supply shortages at Daguerre Point Dam	Groundwater use to compensate for surface water supply shortages at Daguerre Point Dam	Groundwater use to compensate for surface water supply shortages at Daguerre Point Dam
9.	**New Bullards Bar Reservoir End of September Maximum Target Storage**	N/A [a]	705 TAF [d]	705 TAF [d]	650 TAF [e]	705 TAF [d]	N/A [a]	705 TAF [d]	650 TAF [e]	705 TAF [d]
10.	**Carryover Storage Criteria for Stored Water Transfers for Use Outside of Yuba County**	N/A [a]	No shortages for 1 in 100 year drought event in the following year	No shortages for 1 in 100 year drought event in the following year	Stored water transfers inherent in flow schedules and New Bullards Bar Reservoir target operating line	No shortages for 1 in 100 year drought event in the following year	N/A [a]	No shortages for 1 in 100 year drought event in the following year	Stored water transfers inherent in flow schedules and New Bullards Bar Reservoir target operating line	No shortages for 1 in 100 year drought event in the following year
11.	**Stored Water Transfers to SWP, CVP and EWA**	N/A [a]	Stored water transfers. Transfers capped at recent maximum historical amounts [f]	No stored water transfers	Modeled per schedules 1-6, A-B, and New Bullards Bar Reservoir target operating line [n] [s]	Stored water transfers [f]	N/A [a]	No stored water transfers	Modeled per schedules 1-6, A-B, and New Bullards Bar Reservoir target operating line [n] [s]	Stored water transfers [f]
12.	**Groundwater Substitution Transfers to SWP, CVP and EWA**	N/A [a]	Groundwater substitution pumping. Transfers capped at recent maximum historical amounts [f] Total transfer limited to maximum of 164 TAF/year [r]. Groundwater substitution transfer limited to 85 TAF/year [l]	Groundwater substitution pumping [f]. Groundwater substitution pumping limited to 70 TAF/year, and 140 TAF/yr in any 3 consecutive years	Groundwater substitution pumping. 15 TAF groundwater pumping in Schedule 6 years. Groundwater substitution pumping limited to 90 TAF/year, and 180 TAF/yr in any 3 consecutive years	Groundwater substitution pumping. Groundwater substitution pumping limited to 70 TAF/year, and 140 TAF/yr in any 3 consecutive years [f]	N/A [a]	Groundwater substitution pumping. Groundwater substitution pumping limited to 70 TAF/year, and 140 TAF/yr in any 3 consecutive years [f]	Groundwater substitution pumping. 15 TAF groundwater pumping in Schedule 6 years. Groundwater substitution pumping limited to 90 TAF/year, and 180 TAF/yr in any 3 consecutive years	Groundwater substitution pumping. Groundwater substitution pumping limited to 70 TAF/year, and 140 TAF/yr in any 3 consecutive years [f]
13.	**Yuba River Development Project Power Generation**	N/A [a]	1966 PG&E Power Purchase Contract as modified by practice/agreement	1966 PG&E Power Purchase Contract as modified by practice/agreement	1966 PG&E Power Purchase Contract as modified by practice/agreement, as further modified for Proposed Yuba Accord	1966 PG&E Power Purchase Contract as modified by practice/agreement	N/A [a]	1966 PG&E Power Purchase Contract as modified by practice/agreement	1966 PG&E Power Purchase Contract as modified by practice/agreement, as further modified for Proposed Yuba Accord	1966 PG&E Power Purchase Contract as modified by practice/agreement

Row			CEQA Scenarios					NEPA Scenarios		
1.	Scenario No.	-	1	2	3	4	-	5	6	7
2.	Description	Foundation Study OCAP Study 3 [p]	Existing Condition	No Project Alternative	Yuba Accord Alternative	Modified Flow Alternative	Foundation Study OCAP Study 5 [p]	No Action Alternative	Yuba Accord Alternative	Modified Flow Alternative
14.	Lower Yuba River Instream Flow Requirements	1965 YCWA-DFG Agreement	SWRCB RD-1644 Interim	SWRCB RD-1644 Long-term	Proposed Yuba Accord flow schedules	SWRCB RD-1644 Interim with Conference Year provisions	1965 YCWA-DFG Agreement	SWRCB RD-1644 Long-term	Proposed Yuba Accord flow schedules	SWRCB RD-1644 Interim with Conference Year provisions
15.	Other Projects and Programs	Assumption	Assumption	Assumption	Assumption	Assumption	Assumption	Assumption	Assumption	Assumption
16.	Trinity River Flows [g]	369 – 453 TAF	Trinity ROD flows	Trinity ROD flows	Trinity ROD flows	Trinity ROD flows	Trinity ROD flows	Trinity ROD flows	Trinity ROD flows	Trinity ROD flows
17.	Freeport Regional Water Project [h]	Not included	Not Included	Not Included	Not Included	Not Included	Included	Included	Included	Included
18.	CVP/SWP Intertie [i]	Not included	Not Included	Not Included	Not Included	Not Included	Included	Included	Included	Included
19.	CVPIA 3406 (b)(2)	Included	Included	Included	Included	Included	Included	Included	Included	Included
20.	EWA [m]	Included	As modeled in OCAP Study 3	As modeled in OCAP Study 3	As modeled in OCAP Study 3, except C1 water may exceed OCAP Upstream of Delta purchases for EWA in some years	As modeled in OCAP Study 3	Included [t]	As modeled in OCAP Study 5	As modeled in OCAP Study 5, except C1 water may exceed OCAP Upstream of Delta purchases for EWA in some years	As modeled in OCAP Study 5
21.	CVP/SWP Integration [j]	Not included	Not included	Not included	Not included	Not included	Not included	Included [j]	Includedd [j]	Included [j]
22.	South Delta Improvement Program	Not included	Not included	Not included	Not included	Not included	Included	Included	Included	Included

Matrix Footnotes

[a] CALSIM II modeling for OCAP represents the lower Yuba River as an inflow to the Feather River (arc C211) and a diversion at Daguerre Point Dam (arc D211). New Bullards Bar Dam and Englebright Dam are not modeled explicitly. Yuba River flows at Daguerre Point Dam are an input to CALSIM II. These inflows are derived from a DWR HEC-3 model of the Yuba Basin.

[b] Demands at Daguerre Point Dam increase by 40 TAF/year compared to existing conditions due to implementation of the Wheatland Project.

[d] Reservoir target operating line (TAF): Oct -705, Nov -680, Dec - 650, Jan - 610, Feb - 680, Mar - 750, Apr - 890, May - 960, Jun - 920, Jul – 840, Aug - 745, Sep – 705. The target end of September storage is 705 TAF, less stored water transfer amount.

[e] Reservoir target operating line (TAF): Oct -650, Nov -650, Dec - 650, Jan - 600, Feb - 650, Mar - 750, Apr - 850, May - 960, Jun - 920, Jul - 820, Aug - 695, Sep – 650. The target end of September storage is 650 TAF, less stored water transfer amount.

[f] Variable single-year transfer amount depending on water supply availability, transfer demand, and limited by E/I ratio, available conveyance capacity at Banks and Jones pumping plants and periods of Delta balanced conditions.

[g] The December 19, 2000, ROD on the Trinity River Main Stem Fishery Restoration EIS/EIR adopted a variable annual requirement of 369 TAF to 815 TAF.

[h] The Freeport Regional Water Project is a joint venture of the Sacramento County Water Agency and East Bay Municipal Utility District to supply water from the Sacramento River to customers in Sacramento County and the East Bay. Final EIR has been certified, The Final EIS has been released, and on January 4, 2005, Reclamation issued the ROD.

[i] The Delta-Mendota Canal to California Aqueduct Intertie is part of the CALFED conveyance program and consists of construction and operation of a 400 cfs pumping plant and pipeline connection between the DMC and the California Aqueduct. Reclamation and the San Luis & Delta-Mendota Water Authority completed a Finding of No Significant Impact/Negative Declaration and Draft Environmental Assessment/Initial Study in 2004.

[j] The CVP/SWP Integration is dependent on an increase in the permitted inflow to Clifton Court Forebay from 6,680 cfs to 8,500 cfs.

[k] YPM - Yuba Project Model

[l] The maximum historical YCWA groundwater substitution transfer of 85 TAF occurred in 1991.

[m] CALSIM II modeling for OCAP does not specify the source of water for EWA purchases upstream of the Delta

[n] Export of stored water transfers not limited by E/I ratio. When the E/I ratio is controlling, the incremental increase in exports resulting from Proposed Yuba Accord Released Transfer Water amount is the Delivered Transfer amount. It is assumed that YCWA will opt to pay carriage water cost if Released Transfer Water would otherwise be lost as surplus Delta outflow.

[p] Modeling foundations are in accordance with the relevant modeling studies conducted for the Long-term CVP OCAP Biological Assessment/Biological Opinions.

[r] The maximum YCWA annual water transfer, after inception of the EWA program in 2001, is 164 TAF and occurred in 2001. This transfer included 50 TAF sale to EWA, and 114 TAF sale to DWR's Dry Year Purchase Program.

[s] Water for EWA preferentially transferred from July to September using 500 cfs dedicated capacity. Transfer to EWA includes 60 TAF/year commitment of Component 1 water plus any previous year undelivered Component 1 water in wet, above normal, and below normal years. Additional delivery of Component 4 water to EWA using July – September dedicated capacity.

[t] The OCAP BA assumed that future operation of EWA would be similar to the Short-term EWA Program. The OCAP BA modeling assumptions regarding water purchases for the "*Future EWA*" are identical to those of the "*Today EWA*". These assumptions may differ from those being developed as part of the Long-term EWA Program EIR/EIS.

A description of YCWA's water supply management practices, including instream flow requirements related to protection of fishery benefits in the lower Yuba River, provision of surface water supplies to YCWA Member Units and related water demands, groundwater pumping practices, and other operational and regulatory considerations are presented in the Chapter 3, Proposed Project/Action and Alternatives, of the Draft EIR/EIS.

4.1 FOUNDATION STUDIES

The foundations studies are CALSIM II planning studies that have been developed by Reclamation in association with DWR for the OCAP BA. These studies are used as the basis for all hydrologic modeling.

4.1.1 OCAP STUDY 3

The environmental setting, or existing condition, represents the current conditions at the time a project is proposed. For CEQA purposes, the existing condition is defined as the time at which the notice of preparation is published (CEQA Guidelines Section 15125). The existing condition represents the current regulatory and physical conditions, which are used as a baseline to evaluate the significance of potential impacts associated with implementation of the alternatives considered in the Draft EIR/EIS.

OCAP Study 3, "*Today EWA*" was developed by Reclamation as part of the OCAP BA to evaluate the current EWA program (Reclamation 2004). OCAP Study 3 represents existing conditions, and therefore most correctly characterizes the modeling assumptions applied to the CEQA modeling scenarios evaluated in the Draft EIR/EIS.

No water transfers are modeled in OCAP Study 3, other than as part of the EWA program. Total North of Delta and South of Delta EWA purchases of water (referred to as assets) include fixed water purchases of 250 TAF per year in wet, above normal, and below normal water years, 230 TAF in dry water years, and 210 TAF in critical water years (Sacramento Valley 40-30-30 Index).

In OCAP Study 3, targets for upstream of Delta purchases varies from zero in a wet year, to approximately 47 TAF in above normal and below normal years, to 106 TAF in a dry year, and to 153 TAF in a critical year. Variable assets include use of 50 percent JPOD export capacity, acquisitions of 50 percent of any CVPIA 3406(b)(2) releases pumped by SWP, and dedicated 500 cfs pumping capacity at Banks from July through September, which is the preferred transfer period for EWA actions. EWA transfers are limited by Delta conditions and the availability of export capacity. Fixed assets are transferred during the July through September period. The OCAP BA does not identify the sellers of this water.

OCAP Study 3 assumptions associated with the EWA actions include: (1) reducing total exports by 50 TAF per month, relative to total exports without EWA, in December through February; (2) VAMP SWP export restrictions from April 15 through May 16; (3) Post VAMP SWP export restrictions from May 16 through May 31 (and potentially CVP export restrictions if b(2) post-VAMP action is not taken); and (4) export ramping in June.

CALSIM II does not simulate operations of the Yuba Project. Flow upstream of and diversions at Daguerre Point Dam are inputs to the model.

4.1.2 FOUNDATION STUDY OCAP STUDY 5

In contrast to the CEQA Guidelines, NEPA requirements focus on reasonable foreseeable actions that may occur at any time during the life of the project, rather than just near-term future actions. For NEPA purposes, the No Action Alternative is used as the basis of comparison for evaluating potential impacts due to implementation of the alternatives considered in the Draft EIR/EIS. The No Action Alternative is defined in the Reclamation NEPA Handbook (2000) as "*a projection of current conditions to the most reasonable future responses or conditions that could occur during the life of the project without any action alternatives being implemented.*"

OCAP Study 5, "*Future EWA*" was developed by Reclamation as part of the OCAP BA to evaluate a future EWA program, and was used to evaluate the effects of projects and actions included in the early consultation (Reclamation 2004). OCAP Study 5 accounts for future foreseeable projects/actions, and therefore most correctly characterizes the modeling assumptions applied to the NEPA modeling scenarios evaluated in the Draft EIR/EIS.

The hydrology and level of development used for NEPA modeling simulations is assumed to be the 2020 level of development, as forecasted by DWR in Bulletin 160-98. Assumptions under OCAP Study 5 are similar to OCAP Study 3. However, OCAP Study 5 includes the following additional projects or actions that are not included in OCAP Study 3:

- South Delta Improvements Program;
- CVP/SWP Integration;
- Freeport Regional Water Project; and
- California Aqueduct/Delta-Mendota Canal Intertie.

4.2 CEQA SCENARIOS

For CEQA purposes, model scenarios are based on OCAP Study 3, modified to account for (1) the Trinity River ROD flows; and (2) lower Yuba River operations under the Baseline Condition, as defined in Article 4, section 3 of the Water Purchase Agreement (RD-1644 Interim Yuba River flow requirements) and present level demands at Daguerre Point Dam as simulated by the YPM. Output from the resulting CALSIM II model simulation was subsequently modified using the lower Yuba River outflow routing tool to create simulations for the CEQA Existing Condition (Scenario 1), the CEQA No Project Alternative (Scenario 2), the CEQA Yuba Accord Alternative (Scenario 3) and the CEQA Modified Flow Alternative (Scenario 4).

4.2.1 CEQA EXISTING CONDITION (SCENARIO 1)

This simulation represents current hydrologic, operational and regulatory considerations within the Study Area as described in the Chapter 2, Description of Environmental Setting and Existing Condition, of the Draft EIR/EIS.

The Yuba River is subject to instream flow requirements according to SWRCB Decision 1644 (RD-1644), which came into effect on March 1, 2001. The intent of these requirements is to provide protection for fishery resources and other issues relating to water use and diversion activities in the lower Yuba River (the Yuba River below Englebright Dam). To characterize existing conditions, this scenario includes implementation of RD-1644 Interim flow requirements on the lower Yuba River. For the CEQA Existing Condition, two types of Yuba River water transfers are modeled: (1) stored water transfers from releases from New Bullards

Bar Reservoir, and (2) groundwater substitution transfers made by YCWA in cooperation with its Member Units. It is assumed that all transfers are sold to the CVP, SWP or EWA, and are used in the export service area south of the Delta. Assumptions regarding the magnitude and timing of these transfers are discussed in Attachment A. Stored water transfers are possible when the resulting end-of-September storage in New Bullards Bar Reservoir is at or greater than the required carryover storage to provide 100 percent deliveries in the following year for dry hydrologic conditions with a 1 in 100 year return period. Both stored water and groundwater substitution transfers are capped at their maximum historical amount since the inception of the EWA Program.

For modeling the CEQA Existing Condition, EWA actions are based on the OCAP Study 3 assumptions which include the purchase and conveyance of North of Delta water through Banks Pumping Plant during July to September for EWA purposes [4].

For modeling purposes, the portion of Yuba transfer water that is made available for EWA purchase is assumed to be part of the EWA North-of-Delta purchases included in OCAP Study 3. Therefore, these EWA transfers do not result in increased Delta exports beyond that already identified and simulated in OCAP Study 3. In some years, Yuba transfer water for EWA may exceed the volume of North-of-Delta purchases included in OCAP Study 3, and therefore represent an additional EWA transfer.

The portion of Yuba transfer water made available for EWA is determined as follows:

- If the SWP end-of-May Table A allocation, as determined in CALSIM II, is greater than 60 percent, all YCWA transfers are attributed to EWA.
- If the SWP end-of-May agricultural allocation from CALSIM II is between 40 percent and 60 percent, YCWA transfers are split evenly between EWA and DWR and Reclamation.
- If the SWP end-of-May agricultural allocation from CALSIM II is less than 40 percent, all YCWA transfers are attributed to DWR and Reclamation.

4.2.2 CEQA No Project Alternative (Scenario 2)

The CEQA No Project Alternative represents current environmental conditions plus future operational and environmental conditions anticipated to occur in the foreseeable future pursuant to existing physical and regulatory environmental conditions in the absence of the Proposed Project or other action alternative.

This scenario includes implementation of RD-1644 Long-term flow requirements on the lower Yuba River. Additionally, the CEQA No Project Alternative differs from the CEQA Existing Condition because it assumes a future level of development, and additional irrigation demand at Daguerre Point Dam due to implementation of the Wheatland Project.

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[4] For the months of July, August, and September, the EWA Program has 500 cfs of dedicated conveyance capacity at the Banks Pumping Plant. EWA actions and CVPIA (b)(2) actions restrict pumping at Banks and Jones pumping plants in April, May and June, during which months the maximum allowable E/I ratio under D-1641 is 0.35. In April and May export at the Jones Pumping Plant is restricted to 3,000 cfs in accordance with D-1485 criteria to protect striped bass. EWA Transfer capacity under the JPOD also may be limited in October due to water quality impacts in the Delta. June EWA actions typically restrict pumping at Banks by ramping from post-VAMP May shoulder to June E/I ratio restrictions. Transfer capacity under the JPOD also may be limited in October due to water quality impacts in the Delta.

YCWA's ability to make stored water transfers under RD-1644 Long-term flow requirements is discussed in detail in Attachment C. No stored water transfers are possible. Groundwater substitution transfers are modeled in a similar manner to water transfers under the CEQA Existing Condition, except that YCWA water transfers are not capped at the maximum historical transfer amount. The maximum annual volume of groundwater substitution transfer is limited to 70 TAF. Additionally, it is assumed the maximum amount of groundwater pumping over any 3-year period is 140 TAF and over any 2-year period is 120 TAF. Also, because of institutional difficulties in implementing a groundwater substitution transfer, the modeling assumes that groundwater substitution transfers will be limited to critical and dry years, and below normal years when SWP Table A allocations less than 60 percent.

4.2.3 CEQA YUBA ACCORD ALTERNATIVE (SCENARIO 3)

The Yuba Accord Alternative includes three separate but interrelated agreements that would result in integrated operation of YCWA and Member Units water supply resources within Yuba County, as well as provide Reclamation and DWR with increased operational flexibility for the protection of Delta fisheries resources and the provision of supplemental water supplies to state and federal water contractors.

Under the Yuba Accord Alternative, YCWA, DWR, and Reclamation would be parties to the proposed Water Purchase Agreement. This agreement provides for the purchase and delivery of water to EWA, Reclamation, and DWR. Key elements of the Water Purchase Agreement include definition of water supply components, water accounting mechanism, and explanation of Conference Year principles. Under the Water Purchase Agreement, YCWA would have an obligation to provide specific quantities of transfer water (Component 1, Component 2, and Component 3) and would have the option to provide additional transfer water (Component 4) depending on supply availability and demand (see Attachment A). It also is assumed that 60 TAF of Component 1 water would be provided to the EWA Program regardless of water year type because of EWA Program demands and the availability of dedicated capacity at the CVP/SWP pumping facilities in the Delta, which have the ability to accommodate a minimum of 60 TAF of EWA asset acquisitions on an annual basis. The portion of Component 4 transfers allocated to EWA for the purpose of displacing a portion of the EWA North-of-Delta purchases as determined in CALSIM II is calculated using the same methodology as the CEQA Existing Condition and the CEQA No Project Alternative.

For modeling purposes, the preferred transfer period is July through September. In Reclamation's OCAP BA, the July through September period is identified as the primary transfer period for the EWA Program, and a large component of water from the Yuba Accord Alternative also would be transferred during these months. Because YCWA, Reclamation and DWR would like to maintain as much operational flexibility as possible, the modeling assumes that water could be transferred in all months, except for June, depending on: (1) available Delta export capacity; (2) compliance with the E/I ratio; and (3) the transfer would occur on a "*fish-friendly*" basis consistent with the provisions identified in Reclamation's OCAP BA (Reclamation 2004b).

The maximum annual volume of groundwater substitution transfer is limited to 90 TAF. Additionally, it is assumed the maximum amount of groundwater pumping over any 3-year period is 180 TAF and over any 2-year period is 150 TAF.

During some months, Yuba River flows at the Marysville Gage may be lower under the Yuba Accord Alternative compared to baseline conditions due to changes in instream flow requirements (e.g., RD-1644 Interim requirements compared to the Yuba Accord Alternative flow schedules), or due to New Bullards Bar Reservoir refill impacts. For modeling purposes, reductions in flow at the Marysville Gage that occur during Delta balanced water conditions are offset by either: (1) reduced CVP and/or SWP export pumping, or (2) increased releases from project storage (e.g., Oroville and Shasta reservoirs). Model assumptions regarding CVP/SWP operations are discussed in Section 5.

4.2.4 CEQA MODIFIED FLOW ALTERNATIVE (SCENARIO 4)

The Modified Flow Alternative includes implementation of flows characterized by SWRCB RD-1644 Interim flow requirements, and the conference year provisions that are proposed for the Yuba Accord Alternative. Stored water transfers are modeled in a similar manner to water transfers under the Existing Condition. However, transfers are not capped at their historical level. Groundwater substitution transfers are modeled in a similar manner to water transfers under the CEQA No Project Alternative.

For modeling purposes, the allocation of Yuba transfer water to EWA, DWR and Reclamation are as described for the CEQA Existing Condition.

4.3 NEPA SCENARIOS

For NEPA purposes, OCAP Study 5 is used to characterize the modeling scenarios representing the No Action Alternative, Yuba Accord Alternative, and the Modified Flow Alternative. Additionally, OCAP Study 5 characterizes the Cumulative Condition, which is used for both CEQA and NEPA cumulative impact analyses. For NEPA purposes, model scenarios are based on OCAP Study 5, modified to account for lower Yuba River operations under the Baseline Condition, as defined in Article 4, section 3 of the Water Purchase Agreement (RD-1644 Interim Yuba River flow requirements) and future level demands at Daguerre Point Dam as simulated by the YPM. Output from the resulting CALSIM II model simulation was subsequently modified using the lower Yuba River outflow routing tool to create simulations for the NEPA No Action Alternative (Scenario 5), the NEPA Yuba Accord Alternative (Scenario 6) and the NEPA Modified Flow Alternative (Scenario 7).

4.3.1 NEPA NO ACTION ALTERNATIVE (SCENARIO 5)

The principal elements of the NEPA No Action Alternative would generally be the same as those previously described for the CEQA No Project Alternative. The primary differences between the No Project and No Action alternatives are assumptions relating to land use development and the implementation of reasonably foreseeable programs and actions. The CEQA No Project Alternative considers conditions without the proposed project imposed upon an existing condition framework [current hydrologic operations, water demands, and level of land development, characterized by OCAP Study 3], while the NEPA No Action Alternative considers conditions without the proposed project in a future condition framework [future hydrologic operations, water demands, and level of land development, characterized by OCAP Study 5].

Because several of the conditions specific to RD-1644 are currently being contested and undergoing litigation, they may be subject to revision. Until those proceedings are finalized, the original conditions described in the SWRCB's decision apply and are incorporated as part of the hydrologic modeling assumptions. Therefore, this scenario includes implementation of RD-1644 Long-term flow requirements on the lower Yuba River. Lower Yuba River operations in OCAP

Study 5 have been modified to be consistent with operations under RD-1644 Long-term flow requirements.

No stored water transfers are possible under the No Action Alternative. Groundwater substitution transfers are modeled as for the No Project Alternative.

For the Draft EIR/EIS, OCAP Study 5 was modified to account for updated flows and diversions at Daguerre Point Dam, so as to provide consistency with the YPM. Similar to the approach used for the 2004 OCAP BA, EWA North-of-Delta purchases are considered to be part of the No Action Alternative, and are transferred to the export service area south of the Delta during the July through September period. However, the source water for these purchases is not represented explicitly in the modeling.

For modeling purposes, it is assumed a portion of the YCWA transfers are for EWA purchase. Accordingly, a portion of the EWA North-of-Delta purchases included in OCAP Study 5 are "displaced" by the corresponding Yuba River outflow. The portion of YCWA transfers made available for EWA for the purposes of determining the volume of EWA North-of-Delta purchases displaced by the YCWA transfers is as described for the CEQA Existing Condition.

The SVWMP is under development and in the process of completing separate environmental documentation for CEQA, NEPA and ESA regulatory compliance purposes. Under the proposed SVWMP Short-term Program, upstream water districts would make additional water available to the CVP and SWP in below normal, dry, and critical water years. Water in above normal years will be made available on request. Under the terms of the SVWMP, upstream water users would not be obligated to provide water to the CVP/SWP if providing water might have a negative impact on the upstream users' ability to meet their commitment in below normal, dry, or critical years.

The SVWMP is not included in OCAP Study 5, and in general is not included in the analyses for the Draft EIR/EIS that concern future conditions. However, for evaluation of impacts to the Yuba groundwater basin, YCWA's commitment to provide up to 15 TAF annually is considered.

4.3.2 NEPA YUBA ACCORD ALTERNATIVE (SCENARIO 6)

The NEPA Proposed Action scenario includes implementation of the Yuba Accord Alternative, as previously discussed above, and presented in Chapter 3, Proposed Project/Action and Alternatives, of the Draft EIR/EIS. Modeling assumptions are as described for Scenario 3.

Yuba Project operations under the NEPA analysis differ from operations under the CEQA analysis due to changes in the available pumping capacity at Banks and Tracy pumping plants. The simulated available pumping capacity to support transfers is primarily affected by increased demands in the export service area, and the assumed implementation of the SDIP, and the associated increase in the permitted capacity at Clifton Court to 8,500 cfs.

4.3.3 NEPA MODIFIED FLOW ALTERNATIVE (SCENARIO 7)

The NEPA Modified Flow Alternative includes implementation of flows characterized by SWRCB RD-1644 Interim flow requirements, and the conference year provisions that are proposed for the Yuba Accord Alternative. Modeling assumptions are as described for Scenario 4.

5.0 ASSUMPTIONS REGARDING CVP/SWP OPERATIONS

For modeling purposes, the following assumptions and operational constraints are applied to the CALSIM II post-processing applications used to simulate CVP/SWP reservoir and export operations. These assumptions were developed through an iterative process involving collaboration with Reclamation and DWR. The assumptions listed below are designed to address project considerations related to CVP/SWP exports and fisheries protections in the Delta.

5.1 WATER TRANSFERS

Cross-Delta water transfers are limited by Delta conditions[5], prevailing operational constraints, such as the E/I ratio, and available conveyance capacity.

Parties to the transfer are responsible for providing any incremental flows (i.e., carriage water) to protect Delta water quality standards. For modeling purposes, a carriage water cost of 20 percent of the released transfer water is assumed, so that a 75 TAF purchase of water upstream of the Delta would result in an export of 60 TAF, and an additional Delta outflow of 15 TAF.

The available conveyance capacity at Banks Pumping Plant for water transfers includes 500 cfs dedicated capacity for EWA at Banks Pumping Plant from July through September.

Stored water transfers are not possible when RD-1644 Long-term flow-requirements are governing Yuba River operations due to the associated carryover-storage requirement at New Bullards Bar Reservoir. A detailed description of this limitation is included in Attachment C. No such limit exists on groundwater substitution transfers.

5.2 NO TRANSFER PERIOD

For modeling purposes it is assumed that no Yuba transfer water will be pumped during the month of June. Typically CVP/SWP ability to pump transfer water in June is limited by fishery considerations. In addition, exports of Proposed Yuba Accord water are limited in April and May due to assumed (b)2 and EWA actions, and VAMP restrictions imbedded in the modeling logic: April 15 and June 15 due to VAMP[6], post-VAMP shoulder and June ramping[7].

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[5] Cross-Delta transfers can only occur during Delta balanced conditions, as defined by the Coordinated Operations Agreement (COA).

[6] As reported in Reclamation's OCAP BA (Reclamation 2004b), the VAMP program has two distinct components, including a flow objective and an export restriction. The export restriction involves a combined federal and state pumping limitation on the Delta pumps during April and May. Combined export targets for the 31-day pulse flow period of VAMP are specified in the San Joaquin River Agreement (U.S.Department of Interior *et al.* 1999).

[7] As reported in Reclamation's OCAP BA (Reclamation 2004b), additional export restrictions also occur during the post-VAMP shoulder and June ramping periods, which are extensions of VAMP-related export restrictions associated with the use of b(2) water.

Actual operations of the Delta pumping facilities are adjusted on a near real-time basis, using daily data, input and decisions by CVP and SWP operators in consultation with resource agency representatives from USFWS, NMFS and CDFG. CVP and SWP pumping rates may be adjusted on a weekly or daily basis in response to changing conditions, environmental actions and resource agency instructions. As a result, on some occasions CVP and SWP operations may increase to full authorized pumping rates during the month of June, and it may be possible to transfer some small amount of Yuba Accord water in the June of some years. Water transfers associated with the Yuba Accord would occur in June only when: (1) the Delta is in balance; (2) capacity exists at the CVP and SWP export facilities to pump the transfer water; (3) the E/I ratio and other potential delta constraints do not prevent the transfer; and (4) the ESA agencies allow pumping at Delta facilities that would include Yuba Accord transfer volumes. Because these occasions are expected to rarely occur, the modeling assumes that no export of Yuba Accord water would occur in June.

5.3 PROPOSED YUBA ACCORD WATER FOR THE CENTRAL VALLEY PROJECT

For modeling purposes, it is assumed that all Proposed Yuba Accord water for the CVP would be exported to service areas south of the Delta.

5.4 PROPOSED YUBA ACCORD WATER FOR THE STATE WATER PROJECT

Full Table A amounts for the SWP total 4.173 MAF. Table A amounts for SWP long-term contractors upstream of the Delta (not including North Bay Aqueduct) total approximately 37.1 TAF (0.9 percent). Table A amounts for SWP long-term contractors served by the North Bay Aqueduct total 76.78 TAF (1.9 percent). Because these percentages are relatively small compared to the full Table A amounts, it is assumed for modeling purposes that all Yuba Accord water for the SWP would be exported to service areas south of the Delta.

5.5 CHARACTERIZATION OF CVP/SWP RESPONSE TO DECREASES IN LOWER YUBA RIVER OUTFLOW

During some months flows in the lower Yuba River at the Marysville Gage may be lower under the Yuba Accord Alternative compared to the baseline conditions[8] due to changes in instream flow requirements (i.e., RD-1644 Interim requirements vs. Yuba Accord flow schedules), or due to New Bullards Bar Reservoir refill impacts.

For modeling purposes, reductions in flow at the Marysville gage that occur during Delta balanced water conditions are offset by either: (1) reduced export pumping; or (2) increased releases from project storage (Oroville Reservoir). When decreases in the lower Yuba River flow at the Marysville Gage occur in dry and critical water years during balanced water conditions, or when reductions in lower Yuba River flow at the Marysville Gage would result in balanced conditions in the Delta, CVP/SWP exports are reduced to offset the reduction in flows at the Marysville Gage. The reduction in export was assumed to occur at Banks Pumping Plant[9].

[8] As defined in Exhibit 4, Section 2 of the Water Purchase Agreement

[9] Reduction in pumping at Banks can be expected to occur when the SWP is wheeling water for the CVP, or the SWP is pumping unused federal share. At other times a reduction in export based on COA sharing formula might be more appropriate (55:45 CVP:SWP split if there is unstored water for export, 75:25 CVP:SWP split if there is in-basin use), but not considered significant for modeling purposes.

- If the E/I ratio is controlling, then the reduction in export will be equal to the E/I ratio times the reduction in flow at Marysville. Delta outflow is reduced.
- If water quality standards are controlling, then the reduction in export is equal to the 0.8 times the reduction in flow at Marysville (i.e. an assumed carriage water cost of 20 percent). Delta outflow is reduced by 0.2 times the reduction in flow at Marysville.
- If Delta outflow standard is controlling, then the reduction in export is equal to the reduction in flow at Marysville. No change in Delta outflow.

For modeling purposes, when decreases in the lower Yuba River flow at the Marysville Gage occur in wet, above normal and below normal years during balanced conditions in the Delta, or when decreases in Yuba River flow at the Marysville Gage would result in balanced conditions in the Delta, exports are maintained and storage releases from Oroville and Shasta reservoirs are increased by an amount equal to the reduction in flow at the Marysville Gage.

For modeling purposes, when decreases in the lower Yuba River flow at the Marysville Gage occur during excess conditions in the Delta, or when decreases in Yuba River flow would not result in the Delta going into balanced conditions, neither additional releases nor decrease in exports are made. Instead, the amount of surplus Delta outflow is reduced.

For modeling purposes, when decreases in the lower Yuba River flow at the Marysville Gage would result in a violation of the Feather River flow requirement below the confluence with the Yuba River, storage releases from Oroville Reservoir are increased by an amount required to ensure compliance with applicable flow requirements.

5.6 PUMPING PRIORITIES: BANKS PUMPING PLANT VS. JONES PUMPING PLANT

Surplus pumping capacity available for transfers varies considerably. The CVP has little surplus capacity, except under drier hydrologic conditions. The SWP has greatest capacity in dry and critical years, less under average conditions, and some surplus in wetter years when demands may be lower because contractors have alternate supplies. Export of transfer water is divided between the Banks Pumping Plant and the Jones Pumping Plant according to the following rules:

- Water is transferred through the Banks Pumping Plant and the Jones Pumping Plant when the Delta is in balanced conditions. Transfers are constrained by the permitted pumping capacity, downstream channel capacity in the Delta-Mendota Canal, and the E/I ratio (unless YCWA elects to pay for carriage water costs).
- In practice, limited or no Jones pumping capacity is expected to be available. Accordingly, modeling assumes that in wet and above normal years, all transfers are exported through the Banks Pumping Plant until all capacity, including the dedicated EWA capacity, is used. Any remaining transfers are exported through available capacity at the Jones Pumping Plant.
- It is more likely that Jones pumping capacity is available during dry periods. Therefore, modeling assumes that during below normal, dry, and critical years, transfers are split evenly between the Banks Pumping Plant and the Jones Pumping Plant as long as export capacity is available. Once either plant reaches capacity, any remaining transfers are exported through the remaining capacity at the other pumping plant.

5.7 REREGULATION OF YUBA RIVER WATER IN OROVILLE RESERVOIR

When Delta conditions constrain the export of increased Yuba River flow at the Marysville Gage, it may be possible for the SWP to reduce releases from Oroville Reservoir, resulting in an increase of storage for later release and export. Oroville Reservoir releases from storage can be reduced if:

- Feather River flows are greater than the flow requirement below the Thermalito Afterbay Outlet, but upstream of the Yuba River confluence. If Oroville Reservoir is operating to meet a minimum instream flow requirement, no reductions in releases are possible.
- An increase in Oroville Reservoir storage would not result in an encroachment into reserved flood control space.

Increased storage in Oroville Reservoir resulting from increases in Yuba River flow at the Marysville Gage is subsequently released from storage:

- During flood control operations.
- When the Delta is in balanced conditions, and there is export capacity at either the Banks or Jones pumping plant.
- To meet instream flow requirements on the Feather River downstream of the confluence with the Yuba River due to a decrease in Yuba River flow at the Marysville Gage.

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Attachment A

Yuba Project Model

Attachment A
Yuba Project Model

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Attachment A
Yuba Project Model

A.1 INTRODUCTION

The surface water resources of the Yuba Region are described in Chapter 5, Surface Water Supply and Management, of the Draft EIR/EIS. This attachment describes how these resources are modeled to determine possible environmental impacts and environmental consequences of the Proposed Project and alternatives. In particular, this attachment describes reservoir operations modeling for the Yuba Project and modeling of flows in the lower Yuba River downstream of Englebright Reservoir.

This attachment is divided into four sections. This Section briefly describes the Yuba Project and facilities and operations on the lower Yuba River. Section A.2 describes the structure of the YPM and elements of the model that are common to all modeling scenarios considered in this EIR/EIS. Section A.3 describes elements of the YPM that differ between scenarios (e.g., instream flow requirements for the lower Yuba River). Finally, Section A.4 discusses modeling of water transfers that require the use of other models to characterize conditions in the Delta.

A.1.1 THE YUBA RIVER BASIN

The Yuba River Basin encompasses an area of about 1,339 square miles and rises from an elevation of about 88 feet above msl at the Marysville Gage, near the Yuba River's confluence with the Feather River, to about 8,590 feet above msl in the upper basin. The estimated annual unimpaired runoff of the Yuba River at Smartville has ranged from a low of 0.4 MAF in 1977 to a high of 4.9 MAF in 1982, with an average of about 2.4 MAF per year (1901-2005)[1]. In general, the runoff is nearly equally divided between runoff from rainfall during October through March and runoff from snowmelt during April through September.

The Yuba Region is one of four regions that make-up the project study area. It encompasses storage and hydropower facilities of the Yuba Project, the Yuba River downstream from New Bullards Bar Reservoir, the lower Yuba River downstream from Englebright Reservoir to the confluence with the Feather River, the YCWA Member Unit water service areas, the local groundwater basins, and lands overlying the groundwater basins.

Figure A-1 shows the principal streams and facilities of the Yuba Region. Daguerre Point Dam and Englebright Dam were originally constructed by the California Debris Commission, a unit of the Corps for debris control, and now are operated and maintained by the Corps. The Yuba Project, operated by YCWA, is a multiple-use project that provides flood control, power generation, irrigation, recreation, and protection and enhancement of fish and wildlife. It includes New Bullards Bar Dam and Reservoir, New Colgate Powerhouse and Narrows II Powerhouse. Englebright Dam and Reservoir and Daguerre Point Dam are not part of the Yuba Project. However, Englebright Dam and Reservoir are used to regulate the power peaking releases from the New Colgate Powerhouse and Daguerre Point Dam is used by YCWA to

[1] The forecasted seasonal unimpaired flow at Smartville is estimated each year by DWR and reported monthly in Bulletin 120, *Water Conditions in California*.

divert water to its Member Units[2]. The elements of the Yuba Project are described in more detail in the following subsections.

A.1.2 NEW BULLARDS BAR DAM, RESERVOIR AND NEW COLGATE POWERHOUSE

New Bullards Bar Reservoir, located on the North Yuba River, is the major storage facility of the Yuba Project. The reservoir has a total storage capacity of 966 TAF with a required minimum pool of 234 TAF (as required by YCWA's FERC Project License), thus leaving 732 TAF of capacity that can be regulated. A portion of this regulated capacity, 170 TAF, normally must be held empty from September through April for flood control.

The North Yuba River inflow to New Bullards Bar Reservoir is augmented by diversions from the Middle Yuba River to Oregon Creek via the Lohmann Ridge Tunnel, and by diversions from Oregon Creek into the reservoir via the Camptonville Tunnel. The average combined inflow to New Bullards Bar Reservoir from the North Yuba River and the diversions from the Middle Yuba River and Oregon Creek is about 1.2 MAF per year[3]. Releases from New Bullards Bar Reservoir are made through the New Colgate Powerhouse, which has a capacity of 3,700 cfs, the dam's bottom outlet, the Fish Release Powerhouse, or a gated spillway.

The Fish Release Powerhouse is so named because it generates power from the water released at the base of the New Bullards Bar Dam for fishery maintenance on the river. This facility was added by YCWA in 1986. If there is a power outage at the dam, this tiny powerhouse can be used to operate the massive spillway gates of New Bullards Bar Dam.

A.1.2.1 ENGLEBRIGHT RESERVOIR AND NARROW I AND II POWERHOUSES

Englebright Reservoir is situated downstream of New Bullards Bar Reservoir, at the confluence of the Middle and South Yuba rivers. The average annual inflow to Englebright Reservoir, excluding releases from New Bullards Bar Dam, is approximately 400 TAF. Englebright Reservoir has a total storage capacity of 70 TAF, but provides limited conservation storage as the reservoir is used to attenuate power peaking releases from the New Colgate Powerhouse and tributary inflows.

Water from Englebright Reservoir is released for generation at the Narrows I (owned by PG&E) and Narrows II powerhouses. The Narrows I Powerhouse has limited capacity and typically is used for low flow reservoir releases (less than 700 cfs), or to supplement the Narrows II Powerhouse capacity for high flow reservoir releases. The combined release capacity of the Narrows I and II powerhouses is 4,190 cfs. Narrows II Powerhouse is typically shut-down for annual maintenance at the beginning of September for a 2 to 3 week period.

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[2] YCWA provides surface water to its Member Units: Brophy Water District, Browns Valley Irrigation District, Cordua Irrigation District, Dry Creek Mutual Water Company, Hallwood Irrigation Company, Ramirez Water District, and the South Yuba Water District. YCWA also provides surface water to the city of Marysville for Lake Ellis, and YCWA will provide surface water in the future to the Wheatland Water District.

[3] Based on model simulations of current facilities for the 1922 to 1994 period, and estimated historical inflows for the 1995 to 2005 period.

Figure A-1. Lower Yuba River Basin

Under existing water rights and agreements, PG&E may release up to 45 TAF from Englebright Reservoir storage, although only about 10 TAF of storage normally are used. Fluctuations in Englebright Reservoir storage principally occur for daily or weekly regulation of winter inflows and New Colgate Powerhouse releases. Because of recreational and power generation needs, the storage level within the reservoir seldom drops below 50 TAF.

A.1.2.2 LOWER YUBA RIVER

The lower Yuba River refers to the 24-mile section of the river between Englebright Dam and the confluence with the Feather River south of Marysville. This stretch of the Yuba River is shown in **Figure A-2**. Instream flow requirements are specified for the lower Yuba River at the Smartville Gage (RM 23.6), approximately 2,000 feet downstream from Englebright Dam, and at the Marysville Gage (RM 6.2). Below the Smartville Gage, accretions, local inflow, and runoff contribute, on average, approximately 200 TAF per year to the lower Yuba River. Deer Creek flows into the Yuba River at approximately RM 22.7. Dry Creek flows into the Yuba River at RM 13.6, approximately two miles upstream of Daguerre Point Dam. The flow in Dry Creek is regulated by BVID's operation of Merle Collins Reservoir, located on Dry Creek about eight miles upstream of its confluence with the Yuba River.

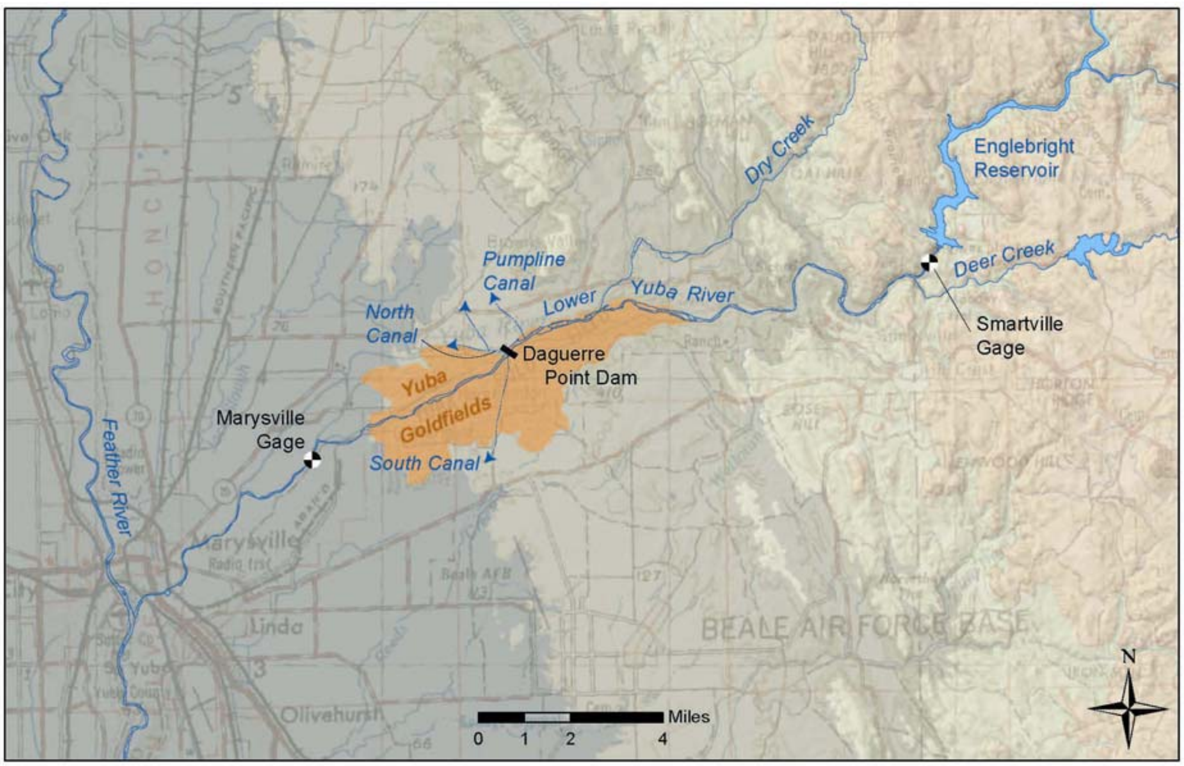

Figure A-2. Lower Yuba River

BVID diverts water at its Pumpline Diversion Facility, approximately one mile upstream from Daguerre Point Dam. Daguerre Point Dam, located at RM 11.6, controls water elevations for irrigation diversions. CID, HIC, and RWD receive water via the Hallwood-Cordua Canal (North Canal) from the north side of the Yuba River just upstream from the north abutment of the dam. BWD, SYWD, and DCMWC receive water via the South Yuba Canal (South Canal) from the south side of the Yuba River just upstream from the south abutment of the dam.

A.2 MODELING THE LOWER YUBA RIVER

This section presents an overview of the YPM, and describes elements of the model that are common to all modeling scenarios considered in this Draft EIR/EIS.

The first model of the Yuba Basin was developed by DWR's Division of Planning (now named the Bay-Delta Office) using the HEC-3 program to generate inflows for DWR's planning model DWRSIM for the SWP (Yuba River Watershed Model, DWR 1985). Between 1988 and 2002, Bookman-Edmonston Engineering, Inc. (B-E), on behalf of YCWA, collaborated with DWR to further refine and develop this model. B-E moved the model from the HEC-3 to the HEC-5 software platform, and modified operational parameters and criteria to better characterize YCWA operations. The HEC-5-based Yuba River Basin Model simulates the entire Yuba River watershed, including facilities outside of YCWA's operational control. Detailed information regarding the HEC-5 model is presented in the Yuba River Basin Model: Operations and Simulation Procedures Report prepared for the SWRCB 2000 Lower Yuba River Hearings.

In 2002, MWH developed the YPM, a spreadsheet model of the Yuba Project and lower Yuba River. Inflows to New Bullards Bar and Englebright reservoirs, and flows from Deer Creek to the lower Yuba River were obtained from the output of the HEC-5 Yuba River Basin Model. The YPM was subsequently used to determine operations of New Bullards Bar Reservoir to meet instream flow requirements, diversion demands, and reservoir operational requirements for the 2006 and 2007 Yuba Accord Pilot Program. Figure 3-2 of Appendix D, Modeling Technical Memorandum, shows the YPM network schematic and lists model output.

A.2.1 YUBA PROJECT MODEL

The YPM simulates system operations for a multi-year period using a monthly time-step. The model assumes that facilities, land use, water supply contracts, and regulatory requirements are constant over the simulation period, representing a fixed level of development (e.g., 2001 or 2020). The historical flow record from October 1921 to September 1994[4], adjusted for the influence of land use changes and upstream flow regulation, is used to represent the possible range of water supply conditions (this approach is standard practice for planning models, though projects with a long planning horizon are considering climate change scenarios). For example, model results for 1976 to 1977 do not try to represent the historical flow conditions that actually occurred in 1976 to 1977, but rather represent the flow conditions that would occur with operation of the current (or future) facilities under current (or future) regulatory conditions during a repeat of the 1976 to 1977 two-year drought.

[4] Hydrologic inputs for the Yuba Project Model have been developed for the period October 1921 to September 2005. However, the shorter period October 1921 to September 1994 was used for modeling for this Draft EIR/EIS to conform to the simulation period used by the CALSIM II model.

A.2.1.1 INFLOWS

In general, inflow data for the YPM are derived from the HEC-5 based Yuba River Basin Model (model run YRBMS 18-99). The HEC-5 Yuba River Basin Model yields a time series of monthly simulated system flows for a 73-year period with a repeat of the 1922 to 1994 historical hydrologic conditions. Inflows for the 1922 to 1994 period account for upstream impairments at Jackson Meadows Reservoir, Bowman Reservoir, Fordyce Lake, and Lake Spaulding. These inflows also account for exports from the South Yuba River to Deer Creek, the American River Basin, and Bear River Basin, and exports from Slate Creek to the Feather River Basin.

For modeling purposes, inflows to New Bullards Bar Reservoir are aggregated into a single time series. This inflow incorporates flows from the North Yuba River, Oregon Creek, and the Middle Yuba River via the Camptonville and Lohman Ridge tunnels. Similarly, inflows to Englebright Reservoir are aggregated into a single time series representing combined inflow from the South Yuba River, Middle Yuba River, Canyon Creek, and Oregon Creek.

Deer Creek flows into the Yuba River below the Smartville Gage. Deer Creek has upstream impairments, with diversions into the Bear River and American River watersheds. Modeled inflows from 1922 through 1994 account for these upstream impairments, and calculated inflows to the lower Yuba River are corrected for accretions and depletions along Deer Creek.

In the YPM, inflows from Dry Creek into the lower Yuba River are not considered in reservoir release decisions to meet downstream flow and diversion requirements. Flows in Dry Creek are regulated by Merle Collins Reservoir, which is outside of YCWA's operational control. Inflows from Dry Creek are not included in the model's flow balance at the Marysville Gage for meeting regulatory requirements. However, Dry Creek flows are included in the lower Yuba River outflow to the Feather River that is input into the CALSIM II model.

A.2.1.2 RESERVOIR EVAPORATION

Reservoir storage is adjusted for evaporation for each month in the period of simulation using an area-capacity curve and monthly evaporation factors. The monthly evaporation factors for New Bullards Bar and Englebright reservoirs are presented in **Table A-1**.

Table A-1. Monthly New Bullards Bar and Englebright Reservoir Evaporation Factors

Reservoir	Evaporation Rate (ft/month)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
New Bullards Bar	0.36	0.16	0.11	0.09	0.13	0.19	0.28	0.35	0.53	0.64	0.60	0.44
Englebright	0.42	0.16	0.10	0.09	0.16	0.24	0.31	0.40	0.63	0.76	0.71	0.50

A.2.2 NEW BULLARDS BAR RESERVOIR OPERATIONS

New Bullards Bar Reservoir operations are primarily driven by downstream demands (instream flow requirements and diversion requirements), power generation considerations, and requirements for annual carryover storage.

A.2.2.1 RESERVOIR RULE CURVES

Reservoir rule curves, or target operating lines, define reservoir target storage for each month. These different rule curves are discussed below.

The New Bullards Bar Reservoir critical line is based on the terms of the 1966 PG&E Power Purchase Contract, as described in Chapter 5 of the Draft EIR/EIS. Under the Power Purchase Contract, PG&E has a right to require YCWA to release up to 3,700 cfs through New Colgate Powerhouse to bring the end-of-month storage in New Bullards Bar to the critical line each month. Storage is allowed to exceed the monthly power storage critical line when releases from New Bullards Bar Reservoir would result in Englebright Reservoir releases exceeding the combined capacity of Narrows I and Narrows II powerhouses, causing reductions in total system power generation. The New Bullards Bar Reservoir critical line is not used in the YPM, and is discussed here for reference only.

For modeling purposes, the FERC-required minimum pool for New Bullards Bar Reservoir of 234 TAF line establishes the minimum reservoir storage. Similarly, the target operating line establishes the maximum reservoir storage for a given month, except under two conditions:

- New Bullards Bar Reservoir releases to achieve the target storage line would exceed the release capacity of the New Colgate Powerhouse
- New Bullards Bar Reservoir releases to achieve the target storage line would cause releases at Englebright Dam to bypass Narrows I and Narrows II due to the combination of large releases from New Bullards Bar Reservoir and high inflows from the South Yuba and Middle Yuba rivers.

A target operating line is established for each based on the carryover storage requirements described in Section A.3.2.3.

A.2.2.2 FLOOD CONTROL

New Bullards Bar Dam must be operated from September 16 to May 31 to comply with flood control regulations. Under the contract between the United States and YCWA entered into on May 9, 1966, YCWA agreed to reserve up to 170 TAF of storage space for flood control. The YPM specifies an end-of month flood control space, as presented in **Table A-2**. This flood control space does not vary from year to year. The YPM makes controlled releases through New Colgate Powerhouse and New Bullards Bar Dam bottom outlet, and uncontrolled releases through the spillway to maintain the flood control space.

Table A-2. New Bullards Bar Reservoir Flood Storage Space Allocation

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Storage (TAF)	170	170	170	170	170	170	70	0	0	0	0	56

A.2.2.3 POWER GENERATION

In the YPM, power generation from New Colgate Powerhouse is calculated each month based on reservoir surface water elevation, flow-dependent tailwater elevation, and an assumed efficiency of 90 percent. The maximum capacity of the powerhouse is assumed to be 3,700 cfs. The minimum power generation per month from New Colgate Powerhouse is assumed to be 18,500 MWh, as stated in the 1966 PG&E Power Purchase Contract. The Fish Release Powerhouse is not included in the YPM power generation calculation.

A.2.2.4 ANNUAL CARRYOVER STORAGE TARGET

New Bullards Bar Reservoir is operated to meet minimum carryover storage requirements (end-of-September storage) designed to ensure that instream flow requirements and anticipated surface water deliveries to YCWA member units will be met during the next year. The carryover storage requirement is a drought protection measure. Reservoir carryover storage is used to make up the difference between the available surface water supply and system demands (diversion demands, instream flow requirements, and system operational losses) under dry conditions. For modeling purposes, the determination of the yearly carryover storage requirement is based on several factors: the drought protection level (return period); Member Unit water demands; instream flow requirements; minimum percentage delivery during the next year; and forecasted unimpaired flows. The drought protection level is designed to provide full instream flow requirements and 50 percent of diversion requirements during the following water year, if that water year were to have the specified return period (assumed for this modeling to be 1 in 100 years, that is, if the next year is a 1-in-100 driest year). The 50 percent delivery corresponds approximately to no deliveries of supplemental water, a 50 percent cut in deliveries of base project water, and full deliveries of all pre-1914 water rights settlement water.

For modeling purposes, the delivery carryover storage requirement is calculated as:

Carryover storage requirement

= Annual diversion requirement for member units (with 50 percent deficiency)

\+ Annual instream flow requirement

\+ Annual system operational loss

\+ Annual evaporation (27 TAF)

\+ Operation buffer (50 TAF)

\+ Minimum pool (234 TAF)

\- Available water for the lower Yuba River during the following year, if it were to have a specified hydrological condition (assumed to be 1-in-100 driest year)

System operational losses are present because the lower Yuba River is not completely controlled by the existing facilities (e.g., inflows from Deer Creek and Dry Creek). The following two relationships have been developed based on model simulations. The development of system loss is focused on the simulation results for drier water years, when the carryover storage requirements affect the water supply available for deliveries.

Water Available Annually for the Lower Yuba River

$= 0.00005045\,(\text{Annual total unimpaired flow of Yuba River Basin})^2$

$+ 0.6446\,(\text{Annual total unimpaired flow of Yuba River Basin})$

System Operational Loss

$= 6.2619\,(\text{Annual total unimpaired flow of Yuba River Basin})^{3.04736}$

To simplify the demand and instream flow requirements in the calculation of the annual carryover storage requirement, the diversion and instream fishery flow requirements for the period from October to March used for the above calculation are the requirements for above normal water years, which results in smaller diversion requirements and higher instream fishery flow requirements. Before the new year type classification is determined, the operation should follow the year type defined in the previous year; however, this refinement is not considered necessary for the precision of modeling.

The carryover storage requirement is relaxed when it would result in a delivery shortage of more than 50 percent in the current year. This is because YCWA would not operate the Yuba Project so as to impose deficiencies of 50 percent or greater in the current year to protect against the risk of a 50 percent curtailment in the following year.

The annual and multi-year inflows and associated exceedance probabilities, and the minimum observed inflow during the historical period 1922 to 1994 are presented in **Table A-3.** Exceedance probabilities are based on an assumed log-Pearson distribution of flows. The 1977 unimpaired flow corresponds approximately to a 1 in 167 year drought event. The 1976 to 1977 2-year unimpaired flow corresponds to a 1 in 300 year drought event. The 1987 to 1992 6-year unimpaired flow corresponds approximately to a 1 in 100 year drought event.

Table A-3. Exceedance Probability and Historical Minimum River Unimpaired Flow

Exceedance Probability	1-Year Flow	2-Year Flow	3-Year Flow	4-Year Flow	5-Year Flow	6-Year Flow	7-Year Flow
Historical Flow (TAF)							
Historical Minimum	370 [a]	1,174 [b]	3,323	4,821	6,430	7,341 [c]	9,891
Corresponding Exceedance	99.40%	99.67%	97.96%	98.07%	97.89%	98.98%	97.91%
Calculated Flow For a Given Exceedance (TAF)							
99.5%	350	1,277	2,745	4,082	5,407	6,754	8,461
99.0%	432	1,482	3,005	4,435	5,863	7,325	9,108
98.5%	490	1,621	3,179	4,667	6,160	7,694	9,525
98.0%	537	1,730	3,313	4,845	6,387	7,975	9,840

[a] 1977
[b] 1976 to 1977
[c] 1987 to 1992

Carryover storage requirements for water transfers are calculated in the same manner as carryover storage requirements for delivery drought protection, except that the requirement for water transfers is calculated so there is sufficient water to provide 100 percent deliveries to Member Units in the following year for a 1-in-100 year drought event. This difference is necessary because YCWA may transfer only water that is surplus to that needed for local uses. Attachment C describes these carryover storage requirements in more detail.

A.2.2.5 FLOW REQUIREMENTS BELOW NEW BULLARDS BAR DAM

The 1963 FERC license, as amended in 1966, contains reservoir release and instream flow requirements. YCWA is obligated to operate the Yuba Project to meet minimum instream flows throughout the year below New Bullards Bar Dam, Englebright Dam and Daguerre Point Dam. The minimum release to the North Yuba River from New Bullards Bar Reservoir is 5 cfs year-round. The YPM specifies a minimum 5 cfs release from the bottom outlet of New Bullards Bar Dam through the Fish Release Powerhouse.

A.2.3 ENGLEBRIGHT RESERVOIR OPERATIONS

The YPM does not simulate storage operations at Englebright Reservoir. Within the model, storage is held constant from month to month. Each month's release equals reservoir inflow less reservoir evaporation. The maximum controlled release from Englebright Reservoir is 4,190 cfs through the Narrows I and Narrows II powerhouses. The release capacities of the Narrows I and Narrows II powerhouses are used as part of the release criteria for New Bullards Bar Reservoir to avoid spilling at Englebright Reservoir. However, because Englebright Reservoir also receives uncontrolled inflows from the South Yuba and Middle Yuba rivers, spilling of Englebright Reservoir at some times is unavoidable.

A.2.3.1 POWER GENERATION

In the YPM, power generation at Narrows I and II is not an operational constraint. However, it is calculated to estimate the total system power generation. There are no considerations for maximizing power generation other than through avoiding spills at Englebright Reservoir. Power generation from the Narrows I and II powerhouses is calculated each month based on an assumed reservoir surface water elevation of 530 feet, flow-dependent tailwater elevation, and an assumed efficiency of 90 percent.

A.2.3.2 FLOW REQUIREMENTS BELOW ENGLEBRIGHT DAM

YCWA's FERC license specifies minimum release schedules to be met, except for flood control operations and release of uncontrolled inflows from tributary streams. Stream flow fluctuation and ramping criteria specified in the 1966 FERC license have since been superseded by a more restrictive set of requirements established on November 22, 2005.

Flow requirements in the 1993 Narrows I Powerhouse FERC license are not modeled in the YPM for the following reasons: (1) the 1993 FERC license flow requirements have only a limited impact on the operation of New Bullards Bar and Englebright reservoirs because flow requirements usually are satisfied by operations for Daguerre Point Dam diversion requirements and instream flow requirements below Daguerre Point Dam under YCWA's 1966 FERC license, (2) the 1993 FERC license flow requirements have been shown to be constantly met under the Yuba Accord Alternative, and (3) YPM cannot explicitly incorporate the conditions specifying when the 1993 Narrows I licensee will maintain the schedule of daily average flows. The volume accounting procedure required in the FERC license could be implemented through iterative YPM simulations. However, a preliminary study showed that the limited impact of these requirements does not warrant such an elaborate effort; rather, a post-processing spreadsheet analysis provides a satisfactory check that these requirements are met.

Flow Stability Criteria below Englebright Dam have been established to avoid dewatering Chinook salmon redds and causing other fishery related impacts. For modeling purposes, the flow in October is established as an additional modified flow requirement for November through January.

Because the ramping criteria are characterized by 5-day averages, and the YPM uses a monthly time step, literal application of the ramping criteria in modeling would unrealistically restrict operations of New Bullards Bar Reservoir. Accordingly, the modeling uses a simplified ramping criterion, where changes in monthly releases from Englebright Dam under non-spill conditions are not allowed to exceed 200 cfs between October and January.

A.2.4 DIVERSION REQUIREMENTS

All diversions on the lower Yuba River are modeled using an aggregate diversion at Daguerre Point Dam. The aggregate diversion includes diversions to serve areas north and south of the lower Yuba River, riparian diversions to the Dantoni Area downstream of Daguerre Point Dam, diversions to the City of Marysville and seepage losses.

Agricultural diversion requirements for the YCWA service area have been estimated for present and projected full level of development conditions in Yuba County (SWRCB Lower Yuba River Hearings 2000, Exhibit S-YCWA-15: Lower Yuba River diversion requirements: Present and full development). The 12-month schedules of diversion requirements are based on crop acreages and applied crop water rates within the service area (as limited by contract allocations). The diversion requirements also account for fall flooding of rice fields for waterfowl habitat and rice straw decomposition. The present level of demands presented in **Table A-4** are for water purveyors that have existing contracts with YCWA and developed or developing distribution systems to convey Yuba River water to the purveyor's service area. The table also includes 400 AF per month for seepage losses from the lower Yuba River upstream of the Marysville Gage. The post-2007 agricultural demands on the lower Yuba River (after implementation of the Wheatland Project) are presented in **Table A-5**. The service area for the post-2007 demands includes the present YCWA service area and the Wheatland Water District[5].

Table A-4. Irrigation Demand at Daguerre Point Dam, Present Level Development

Water Year Type (YRI)	Irrigation Demand (AF)												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Wet	18,692	10,441	5,210	400	400	1,226	13,055	59,187	54,170	63,869	53,743	17,705	298,098
Above Normal	18,692	10,441	5,210	400	400	1,226	13,055	59,187	54,170	63,869	53,743	17,705	298,098
Below Normal	18,692	10,441	5,210	400	400	2,753	17,311	59,187	54,170	63,869	53,743	17,705	303,881
Dry	18,692	10,441	5,210	400	400	2,753	17,311	59,187	54,170	63,869	53,743	17,705	303,881
Critical	18,692	10,441	5,210	400	400	2,753	17,311	59,187	54,170	63,869	53,743	17,705	303,881

Table A-5. Irrigation Demand at Daguerre Point Dam, Projected Full Development

Water Year Type (YRI)	Irrigation Demand (AF)												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Wet	20,543	10,717	5,338	400	400	2,191	17,625	65,600	62,174	72,780	60,519	20,201	338,488
Above Normal	20,543	10,717	5,338	400	400	2,191	17,625	65,600	62,174	72,780	60,519	20,201	338,488
Below Normal	20,543	10,717	5,338	400	400	3,835	22,230	65,600	62,174	72,780	60,519	20,201	344,736
Dry	20,543	10,717	5,338	400	400	3,835	22,230	65,600	62,174	72,780	60,519	20,201	344,736
Critical	20,543	10,717	5,338	400	400	3,835	22,230	65,600	62,174	72,780	60,519	20,201	344,736

[5] The first phase of the Wheatland Project is estimated to have a total annual demand at Daguerre Point Dam of 29 TAF. This demand will not all come online in 2008; a reasonable estimate is that 60 percent of this demand will be served in 2008, 80 percent in 2009 and 100 percent in 2010. After the completion of the second phase of the project, it is estimated that the total annual demand of the Wheatland Water District will be 40 TAF.

The estimated demands have been refined to adjust for water year type classifications based on the Yuba River Index. This refinement reflects an estimated reduction of demand in wet and above normal years resulting from higher than normal soil moisture at the start of the irrigation season and reduced pre-irrigation water requirements. Water demands for grains, pastures, and orchards are reduced by 0.4 feet during March and April in these water year types.

Figure A-3 compares the estimated annual present level development demands used for modeling purposes with historical deliveries by YCWA to its Member Units. The present level development demands shown in Figure A-3 do not include estimated demands for riparian diverters within the Dantoni Area, or demands for the City of Marysville, or the estimated seepage losses. The figure shows that since 1998 surface water deliveries have been consistent with the assumed present level of demand presented in **Table A-4**.

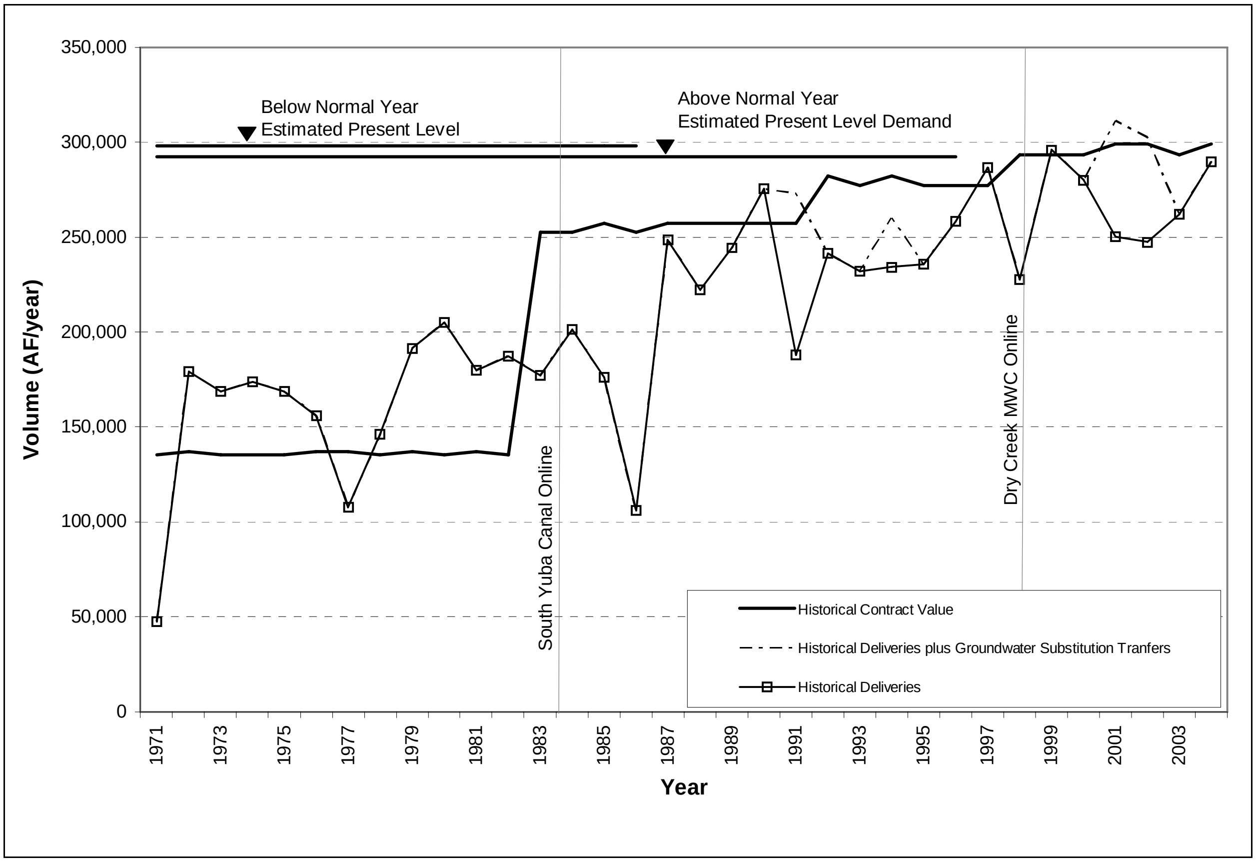

Figure A-3. Historical Deliveries to YCWA Member Units Compared to Estimated Present Level of Demands

A.2.5 DELIVERY SHORTAGE CALCULATIONS

The YPM meets the full diversion demand at Daguerre Point Dam, if the resulting end-of-September carryover storage in New Bullards Bar Reservoir is above the delivery carryover storage required for the specified level of drought protection (1 in 100 years). Delivery deficiencies of up to 50 percent are allowed by the model to maintain delivery carryover storage requirements. Delivery shortages, when required, are applied uniformly (as a fixed percent of demand) from April through to the following March. If a 50 percent deficiency is reached, then

New Bullards Bar Reservoir is drawn down below the carryover storage requirement, as necessary to prevent deficiencies from exceeding 50 percent during that year.

A.2.6 WATER TRANSFERS

Two types of water transfers are modeled using the YPM: (1) stored water transfers, and (2) groundwater substitution transfers. For a stored water transfer, the monthly transfer volume is added to the system demands downstream of Daguerre Point Dam. The diversions at Daguerre Point Dam are maintained and the additional water (transfer volume) flows into the Feather River. Stored water transfers for the Yuba Accord Alternative are implicit in the Accord flow schedules and New Bullards Bar Reservoir target operating line so do not require this adjustment.

Modeling groundwater substitution transfers requires two modifications to the YPM: (1) the diversion demand at Daguerre Point Dam is proportionally uniformly decreased over the irrigation season, typically April to September by the amount of the groundwater substitution transfer, and (2) the system demand downstream from Daguerre Point Dam is increased. The seasonal volume of increased demands downstream of Daguerre Point Dam is equal to the decrease in irrigation deliveries. However, the temporal mismatch from month to month is balanced through regulation of New Bullards Bar Reservoir releases. Reduced releases from New Bullards Bar Reservoir prior to the transfer result in additional storage, or backing-up water, in New Bullards Bar Reservoir. The start of groundwater substitution operations requires that New Bullards Bar Dam is under water management operations and is not operating to meet flow requirements at the Smartville Gage.

In an iterative modeling procedure, the annual volume of groundwater substitution transfer is determined by considering the available pumping capacity at Banks and Jones pumping plants, and rules developed to protect the Yuba groundwater basin from excessive drawdown. Subsequently, the YPM is rerun, and surface water deliveries in any year are reduced by the amounts of any groundwater substitution pumping to achieve the transfer volume.

A.2.7 GROUNDWATER MODELING

The YPM includes a simple routine for simulating combined storage in the North Yuba and South Yuba groundwater subbasins. Groundwater modeling is limited to simple mass balance accounting of changes in annual storage from existing conditions. The two subbasins are treated as a single basin. Changes in storage from existing conditions are based on: (1) the net observed historical rate of groundwater recharge, (2) deficiency groundwater pumping to make-up for any surface water delivery shortages, and (3) groundwater substitution pumping. The net observed historical rate of groundwater recharge is the average annual historical change in groundwater storage after removing the effects of historical groundwater substitution transfers. A detailed analysis of historical groundwater conditions is presented in Chapter 6, Groundwater Resources, of the Draft EIR/EIS. The average annual recharge rate for the North Yuba Subbasin is estimated to be about 10 TAF per year. The average annual recharge rate for the South Yuba Subbasin is estimated to be about 20 TAF per year. The change in storage is calculated as the net observed historical rate of groundwater recharge, minus simulated deficiency pumping, minus simulated groundwater substitution pumping. Changes in induced groundwater recharge due to changes in groundwater levels are ignored in this approach.

With implementation of the Wheatland Project, additional groundwater pumping capacity will be available in the South Yuba Subbasin. Water users in the Wheatland Water District have historically pumped groundwater to meet all their agricultural water demands. After 2007, YCWA will deliver surface water from the Yuba River to the Wheatland Water District to meet a total future projected annual agricultural water demand of approximately 40 TAF. As a result, the Wheatland Project will have a positive effect on the South Yuba Subbasin groundwater storage. So as to achieve a conservative analysis, the beneficial effect of the Wheatland Project on groundwater storage and recharge has not been accounted for.

A.3 MODELING SCENARIOS

The Existing Condition and four alternatives are considered in detail for this Draft EIR/EIS. The alternatives considered are as follows:

- No Project Alternative (as defined by CEQA)
- No Action Alternative (as defined by NEPA)
- Yuba Accord Alternative (Proposed Project/Action)
- Modified Flow Alternative

These alternatives are described in detail in Chapter 3 of the Draft EIR/EIS. A total of seven model scenarios are considered:

- Scenario 1: CEQA Existing Condition
- Scenario 2: CEQA No Project Alternative
- Scenario 3: CEQA Yuba Accord Alternative
- Scenario 4: CEQA Modified Flow Alternative
- Scenario 5: NEPA No Action Alternative
- Scenario 6: NEPA Yuba Accord Alternative
- Scenario 7: NEPA Modified Flow Alternative

These modeling scenarios are discussed in Section 4 and Section 5 of the Modeling Technical Memorandum. The assumptions for the different modeling scenarios are summarized in Table 3-1 of the Modeling Technical Memorandum. This section describes how the different scenarios are modeled with respect to New Bullards Bar Reservoir target operating line, New Bullards Bar Reservoir carryover storage target, and Yuba River instream flow requirements. Section A.4 discusses the water transfer assumptions for each scenario.

A.3.1 NEW BULLARDS BAR RESERVOIR OPERATING LINE

Simulated New Bullards Bar Reservoir target operating lines are presented in **Figure A-4** and **Table A-6** for the various model scenarios. Reservoir storage levels presented in Table A-6 are maximum amounts; actual reservoir storage may be significantly less in some years due to dry hydrological conditions.

The critical line, described in Section A.2.2.1, is the maximum target storage defined under the 1966 Power Purchase Contract. It is included here for reference only. Target Operating Line 1 represents current practice, agreed to by YCWA and PG&E on a year-to-year basis. Under Target Operating Line 1, YCWA can hold more water in storage than under the critical line. However, both Target Operating Line 1 and the PG&E critical line designate 705 TAF as the end-of-September maximum reservoir surface water elevation. Target Operating Line 1 is the

New Bullards Bar Reservoir target storage for the Existing Condition, the CEQA No Project Alternative, the NEPA No Action Alternative and the Modified Flow Alternative. Target Operating Line 2 is the target storage for the Yuba Accord Alternative.

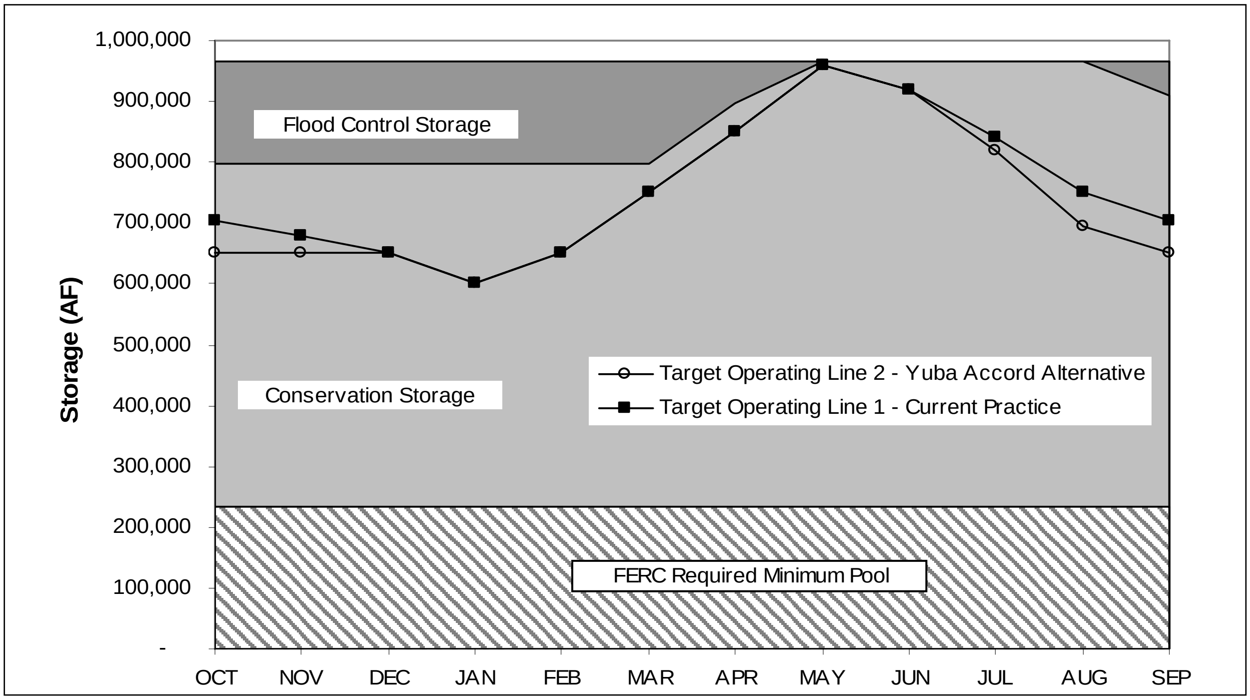

Figure A-4. New Bullards Bar Reservoir Target Operating Lines

Table A-6. New Bullards Bar Reservoir Operational Storage Targets

Target	End-of-Month Storage Target (TAF)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Inactive Storage	234	234	234	234	234	234	234	234	234	234	234	234
Critical Line	660	645	645	600	600	685	825	930	890	830	755	705
Target Operating Line 1 [a]	705	680	650	600	650	750	850	960	920	840	750	705
Target Operating Line 2 [b]	650	650	650	600	650	750	850	960	920	820	695	650
Flood Control	796	796	796	796	796	796	896	966	966	966	966	910

[a] Target Storage Line 1 represents current operational practice, and proposed operations under the Modified Flow Alternative.
[b] Target Storage Line 2 represents proposed operations under the Yuba Accord Alternative.

A.3.2 LOWER YUBA RIVER INSTREAM FLOW REQUIREMENTS

Instream flow requirements on the lower Yuba River were originally specified in the September 2, 1965 agreement between YCWA and CDFG. These requirements were incorporated into the 1966 FERC license which specified minimum releases from Englebright Dam. In 1993, FERC issued a new license to PG&E for the continued operation of the Narrows I Powerhouse. Contained within this license is a new set of instream flow requirements for fisheries resources downstream of Englebright Dam as measured at the Smartville Gage. SWRCB in Revised Decision-1644 (RD-1644), adopted July 16, 2003, specified both interim and long-term instream flow requirements for the lower Yuba River at the Smartville and Marysville gages. The Yuba Accord Alternative would implement three agreements relating to operation of the Yuba Project. Changes in facility operations under the Yuba Accord Alternative would primarily be triggered by proposed new instream flow schedules at the Smartville and Marysville gages. The proposed instream flows are described in Exhibit 1 of the Lower Yuba River Fisheries Agreement.

The 1966 FERC flow requirements, RD-1644 flow requirements and the proposed Yuba Accord flow schedules are described in Chapter 5 of the Draft EIR/EIS. This section describes how these instream flow requirements are modeled in the YPM. Regulatory flow requirements at the Smartville and Marysville gages are sometimes specified for parts of some months. These flow requirements must be approximated for use in a model that uses a monthly timestep.

Several water supply indices have been developed for the Yuba Basin. These indices are used to specify minimum instream flow requirements and water supply contract obligations. Flow requirements under RD-1644 are defined by the Yuba River Index. Flow requirements for the Yuba Accord Alternative are defined by the North Yuba Index.

The Yuba River Index was developed in 2000 for the SWRCB Lower Yuba River Hearings to describe the hydrology of the lower Yuba River. This index is a measure of the unimpaired river flows at Smartville. The Yuba River Index is used to determine the water year types and the corresponding instream flow requirements under RD-1644.

The North Yuba Index was developed in conjunction with the Proposed Yuba Accord. This index provides a measure of available water in the North Yuba River that can be used to meet instream flow requirements and delivery requirements to Member Units on the lower Yuba River. The Yuba River Index is based on unimpaired flows at Smartville, and thus does not accurately represent the water available for storage by YCWA. The North Yuba Index comprises two components: (1) active storage in New Bullards Bar Reservoir at the start of the current water year (October 1), and (2) total actual and forecasted inflow into New Bullards Bar Reservoir for the current water year, including diversions from the Middle Yuba River and Oregon Creek to New Bullards Bar Reservoir. The definition and calculation of the North Yuba Index is presented in Exhibits 4 and 5 of the Proposed Yuba Accord Lower Yuba River Fisheries Agreement.

In the YPM instream flow requirements are applied based on the water year type from April through March. The Yuba River Index was reconstructed from 1922 to 1994 using results from the HEC-5 based Yuba River Basin Model. The North Yuba Index is calculated dynamically in the YPM based on New Bullards Bar Reservoir storage and forecasted inflow. The YPM assumes perfect knowledge of future inflows to forecast the North Yuba Index in April.

A.3.2.1 SMARTVILLE GAGE

The Smartville Gage is located approximately 2,000 feet downstream from Englebright Dam, and upstream from the Deer Creek inflow. In the YPM, flow at this gage is simulated as the total outflow from Englebright Dam. The various instream flow requirements for the Smartville Gage, as modeled, are presented in **Table A-7**.

Table A-7. Modeled Yuba River Instream Flow Requirements at the Smartville Gage

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1966 YCWA FERC License												
All Water Year Types [e]	527 [a]	620	620	818 [a]	620	620	0	0	0	0	0	0
SWRCB RD-1644 Interim (cfs)												
Water Year Type (Yuba River Index)	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Wet	700	700	700	700	700	700	800 [b]	0	0	0	0	490 [b]
Above Normal	700	700	700	700	700	700	800 [b]	0	0	0	0	490 [b]
Below Normal	632 [a]	700	700	700	700	700	767 [b]	0	0	0	0	410 [b]
Dry	555 [a]	600	600	600	600	600	533 [b]	0	0	0	0	383 [b]
Critical	510 [a]	600	600	600	600	600	490 [b]	0	0	0	0	260 [b]
SWRCB RD-1644 Long-term (cfs)												
Water Year Type (Yuba River Index)	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Wet	700	700	700	700	700	700	800 [b]	0	0	0	0	490 [b]
Above Normal	700	700	700	700	700	700	800 [b]	0	0	0	0	490 [b]
Below Normal	700	700	700	700	700	700	800 [b]	0	0	0	0	490 [b]
Dry	555 [a]	600	600	600	600	600	733 [b]	0	0	0	0	383 [b]
Critical	510 [a]	600	600	600	600	600	733 [b]	0	0	0	0	330 [b]
Extremely Critical	510 [a]	600	600	600	600	600	567 [b]	0	0	0	0	330 [b]
Yuba Accord Alternative (cfs)												
Water Year Type (North Yuba Index) [c]	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
1	700	700	700	700	700	700	850 [b]	0	0	0	0	700
2	700	700	700	700	700	700	750 [b]	0	0	0	0	700
3	700	700	700	700	700	700	700 [b]	0	0	0	0	700
4	700	700	700	700	700	700	800 [b]	0	0	0	0	700
5	600	600	550	550	550	550	600 [b]	0	0	0	0	500
6	600	600	550	550	550	550	550 [b]	0	0	0	0	500
Conference [d]	527	620	620	818	620	620	0	0	0	0	0	0

[a] Indicated flow represents average flow rate for the month. Actual flow requirements vary during the month.
[b] Indicated flow represents average flow rate for the month. Actual flow requirements vary during the month. Where the actual flow requirement is zero for part of the month, the flow requirement for modeling purposes is based on the flow requirement at the Marysville Gage.
[c] For the Yuba Accord Alternative, Schedule 1 years are years with the NYI > 1,400 TAF, Schedule 2 are years with NYI > 1,040 TAF, Schedule 3 are years with NYI > 920 TAF, Schedule 4 are years with NYI > 820 TAF, Schedule 5 are years with NYI > 693 TAF, Schedule 6 are years with NYI > 500 TAF, and Conference Years are years with NYI < 500 TAF.
[d] In Conference Years under the Yuba Accord Alternative, YCWA would operate the Yuba Project so that flows in the lower Yuba River comply with the instream flow requirements of YCWA's 1966 FERC license, except that YCWA would not pursue any of the flow reductions authorized by Article 33(c) of that license.
[e] Flow schedules include a buffer of 2.5 percent + 5 cfs. The buffer is required because the minimum instream flow specified in the 1966 FERC license is a daily required flow.

In April and September, flow requirements under RD-1644 and the Yuba Accord Alternative at the Smartville Gage are specified only for part of the month. For modeling purposes, the instream flow requirement for Marysville, for the part of the month for which no Smartville requirement is specified, is used to calculate the monthly average flow requirement at the Smartville Gage. This step has been taken to so that the Smartville flow requirement controls New Bullards Bar Reservoir operations when appropriate. For example, the required flow at the Smartville Gage under the Yuba Accord Alternative under Schedule A is 700 cfs for April 1 to 15, and is not specified for April 16 to 30. For Schedule 2 years, the required flow at Marysville is 700 cfs Apr 1 to 15 and 800 cfs for April 16 to 30. For modeling purposes, the required flow at the Smartville Gage for Schedule 2 years is calculated as 700 cfs for 15 days and 800 cfs for 15 days, resulting in a monthly average flow of 750 cfs.

A.3.2.2 MARYSVILLE GAGE

The Marysville Gage is the lower of the two flow requirement compliance points. For modeling purposes, the Marysville Gage flow is calculated as the flow over Daguerre Point Dam; no accretions or depletions are simulated below the dam. The flow over Daguerre Point Dam is calculated as the flow at Smartville, plus the inflow from Deer Creek, minus the Daguerre Point Dam diversion. The various instream flow requirements for the Marysville Gage are presented in **Table A-8**.

Several months (April, June, July, and September) have different flow requirements for different parts of the month. Because the YPM operates on a monthly timestep, the weighted average monthly flow for each month is used. For example, if the minimum instream flow requirement for April requires 20 days at 500 cfs and 10 days at 1,000 cfs, the modeled monthly requirement is (500 cfs * 20 days + 1,000 cfs * 10 days)/(20 days + 10 days) = 667 cfs.

A.4 WATER TRANSFERS

This section presents the water transfer assumptions for the different modeling scenarios, relating to operation of the Yuba Project and the export of transfer water from the south Delta through Banks and Jones pumping plants. Since 1987 water transfers have been an important element in YCWA's operation of the Yuba Project. For modeling purposes, it is assumed that YCWA transfers are cross-Delta transfers and all transfer water, less carriage water, is moved through Banks or Jones pumping plants. Simulated transfers are limited to periods of Delta balanced water conditions, by the availability of surface water and groundwater water from the Yuba Region, and the availability of conveyance at Banks and Jones pumping plants.

For modeling purposes, the preferred transfer period is from July 1 to September 30. For the months of July, August, and September, EWA has 500 cfs dedicated conveyance capacity at Banks Pumping Plant. EWA actions and the Central Valley Project Improvement Act (CVPIA) (b)(2) actions typically restrict pumping at Banks and Jones pumping plants in April, May, and June, during which months the maximum allowable E/I ratio under D-1641 is 0.35. Transfer capacity under the JPOD may be limited in October due to water quality impacts in the Delta. Release of transfer water is also limited by the scheduled maintenance of Narrow II power plant during the beginning of September.

It is assumed that water transfers, whether derived from storage releases or groundwater substitution pumping, are scheduled so as to achieve maximum fish benefit even if some supplemental instream flows cannot be transferred. Released transfer water that cannot be exported, is not backed-up into CVP/SWP storage, but contributes to Delta outflow.

Table A-8. Modeled Yuba River Instream Flow Requirements at the Marysville Gage

1966 YCWA FERC License [a]												
Water Year Type	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
f>50%	415	415	415	256	256	256	256	256	256	77	77	70
f < 50%	353	353	353	218	218	218	218	218	218	65	65	65
f < 45%	332	332	332	205	205	205	205	218	218	65	65	65
f < 40%	291	291	291	179	179	179	179	218	218	65	65	65
SWRCB RD-1644 Interim Flows (cfs)												
Water Year Type (Yuba River Index)	**Oct** [b]	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Wet	387[c]	500	500	500	500	500	667[c]	1,500	808[c]	265[c]	250	250
Above Normal	387[c]	500	500	500	500	500	667[c]	1,500	808[c]	265[c]	250	250
Below Normal	387[c]	500	500	500	500	500	633[c]	1,500	808[c]	265[c]	250	250
Dry	332[c]	400	400	400	400	400	400[c]	500	400[c]	251[c]	250	250
Critical	332[c]	400	400	400	400	400	357[c]	270	245[c]	103[c]	100	127[c]
SWRCB RD-1644 Long-Term Flows (cfs)												
Water Year Type (Yuba River Index)	**Oct** [c]	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Wet	387[c]	500	500	500	500	500	667[c]	1,500	808[c]	265[c]	250	250
Above Normal	387[c]	500	500	500	500	500	667[c]	1,500	808[c]	265[c]	250	250
Below Normal	387[c]	500	500	500	500	500	667[c]	1,500	808[c]	265[c]	250	250
Dry	332[c]	400	400	400	400	400	600[c]	1,500	808[c]	265[c]	250	250
Critical	332[c]	400	400	400	400	400	600[c]	1,100	800	265[c]	250	250
Extremely Critical	332[c]	400	400	400	400	400	433[c]	500	500	263[c]	250	250
Yuba Accord Alternative (cfs)												
Water Year Type (North Yuba Index) [d]	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
1	500	500	500	500	500	700	1,000	2,000	1,500	700	600	500
2	500	500	500	500	500	700	750[c]	1,000	650[c]	500	500	500
3	500	500	500	500	500	500	700	900	500	500	500	500
4	400	500	500	500	500	500	750[c]	745[c]	400	400	400	400
5[e]	400	500	500	500	500	500	550[c]	497[c]	400	400	400	400
6	350	350	350	350	350	350	425[c]	448[c]	225[c]	350[f]	350[f]	450[f]
Conference [g]	400	400	400	245	245	245	245	245	245	70	70	70

[a] Flow schedules include a buffer of 2.5 percent + 5 cfs. The buffer is required because the minimum instream flow specified in the 1966 FERC license is a daily required flow.

[b] The FERC License 2246 instream flow requirement of 400 cfs applies to the period October 1 to October 14.

[c] Indicated flow represents average flow rate for the month. Actual flow requirements vary during the month.

[d] For the Yuba Accord Alternative, Schedule 1 years are years with the NYI > 1,400 TAF, Schedule 2 are years with NYI > 1,040 TAF, Schedule 3 are years with NYI > 920 TAF, Schedule 4 are years with NYI > 820 TAF, Schedule 5 are years with NYI > 693 TAF, Schedule 6 are years with NYI > 500 TAF, and Conference Years are years with NYI < 500 TAF.

[e] For the Yuba Accord Alternative in Schedule 5 years, the instream flow requirement is adjusted when carryover storage in New Bullards Bar Reservoir is below 400 TAF. If the September 30 New Bullards Bar Reservoir storage is below 400 TAF, the Marysville Gage instream flow requirement is 400 cfs from October 1 until the next February Bulletin 120 forecast is available. For modeling purposes, the adjustment is made for the months of October to January. If the September 30 New Bullards Bar Reservoir storage is below 450 TAF, but above 400 TAF the River Management Team may decide to adjust the Marysville Gage instream flow requirement of 400 cfs from October 1 until the next February Bulletin 120 forecast is available. For modeling purposes, this second adjustment is not made.

[f] Includes 30 TAF Schedule 6 year groundwater pumping commitment – modeled as 200 cfs in July and August and 100 cfs in September. The actual flow schedule for the 30 TAF would be determined by the River Management Team according to when the water is transferable to the Transfer Agreement transferees, and to achieve maximum fish benefits.

[g] In Conference Years, YCWA would operate the Yuba Project so that flows in the lower Yuba River comply with the instream flow requirements in YCWA's 1966 FERC license, except that YCWA would not pursue any of the flow reductions authorized by Article 33(c) of that license.

A.4.1 MODELING PROCEDURE

The modeling procedure is broken down into a series of steps. Step 1 and Step 2, described below, are required to establish a set of baseline flows from which the flow and storage conditions subsequently are determined for each of the modeling scenarios. Steps 3 to 6 describe an iterative modeling process using the YPM and the lower Yuba River outflow routing tool (described in Section 3.4 of Appendix D) to simulate YCWA water transfers.

1. The YPM is run to simulate Yuba Project operations for the Yuba Accord accounting baseline (i.e., RD-1644 Interim instream flow requirements, no stored water or groundwater transfers)

2. The CALSIM II model is run to establish a set of baseline conditions for: (a) the CEQA analysis; and (b) the NEPA analysis[6], which are consistent with the lower Yuba River outflow and Daguerre Point Dam diversions established in Step 1.

3. The YPM is run to simulate Yuba Project operations under the Existing Condition and for each alternative in the absence of stored water transfers (except for the Yuba Accord Alternative for which transfers are implicit in the Accord flow schedules and New Bullards Bar Reservoir target operating line), and in the absence of groundwater substitution transfers.

4. Based on CALSIM II output from Step 2, the lower Yuba outflow routing tool is used to adjust flow and storage conditions for all model scenarios due to changes in the lower Yuba River outflow from Step 3 compared to Step 1. Subsequently, for each scenario, Delta conditions are determined (excess or balanced water conditions), and the available pumping capacity at Banks and Jones pumping plants for water transfers calculated.

5. The YPM is rerun to simulate any stored water transfers and/or groundwater substitution transfers.

6. Using the lower Yuba outflow routing tool, the additional outflow from the lower Yuba River from Step 5, is used to adjust Feather and lower Sacramento river flows, Delta inflow, Delta exports, and Delta outflow.

A.4.2 STORED WATER TRANSFERS

In the 18 years between 1987 and 2004, YCWA transferred water in 12 years, averaging about 120 TAF in each transfer year. The details of the individual transfers are presented in Table 5-5 in Chapter 5. Stored water transfers were made by YCWA from storage releases from New Bullards Bar Reservoir in all of the transfer years except for 1994. The majority of transferred water has been exported at Banks and Jones pumping plants for use in service areas south of the Delta.

Single-year stored water transfers may occur when the projected end-of-September carryover storage in New Bullards Bar Reservoir, without the transfer, is greater than the storage required to ensure 100 percent deliveries to Member Units in the following year under a drought event with a 1 in 100 year return period. Carryover storage requirements for local deliveries and carryover storage requirements for stored-water transfers for the various modeling scenarios are presented in **Table A-9**. Values given in the table, except for the Yuba Accord Alternative, are based on a 1-in-100 year level of protection against critically dry conditions in the following year. The reduced carryover storage requirement under the Yuba Accord Alternative is made possible by inclusion of carryover storage in the North Yuba Index which is used to specify the

[6] The CALSIM II model run for the CEQA analysis is based on OCAP Study 3. The CALSIM II model run for the NEPA analysis is based on OCAP Study 5.

following year Yuba Accord flow schedules. Dry hydrologic conditions may result in New Bullards Bar Reservoir carryover storage, before any transfer, below the end of September maximum target storage of 705 TAF. Except under these conditions, the volume of stored water transfer is measured as the differences between 705 TAF and the carryover storage required to ensure full deliveries to YCWA Member Units in the following year.

Table A-9. Carryover Storage Requirements for New Bullards Bar Reservoir

Scenario			Demand (TAF)		Lower Yuba River Flow Requirements	Carryover Storage Requirement (TAF)	
No.	Act	Description	Above Normal Years	Below Normal Years		For Local Deliveries	Stored Water Transfers
1	CEQA	Existing Condition	298	304	RD-1644 Interim	477	610
2/5	CEQA/NEPA	No Project/No Action Alternative	338	344	RD-1644 Long-Term	558	710 [a]
3/6/8	CEQA/NEPA	Yuba Accord Alternative	338	344	Accord Flow Schedules	540 [b]	[c]
4/7/9	CEQA/NEPA	Modified Flow Alternative	338	344	RD-1644 Interim	497 [d]	648 [d]

[a] No stored water transfers are possible because the carryover storage requirement exceeds the Target Operating Line 1 value of 705 TAF for September 30 (see Table A-7).

[b] Value given is based on Schedule 6 instream flow requirements in the following year (April-March). Carryover storage requirement for local deliveries for a conference year (~1:100 year exceedance) is 495 TAF for deliveries.

[c] Because stored-water transfers are inherent in the Yuba Accord Alternative flow schedules and operational parameters, carryover storage requirements for stored water transfers are not used in modeling of Scenarios 3, 6, and 8. The calculated carryover storage requirements for stored water transfers for the Yuba Accord Alternative are 647 TAF for a 1-in-100 Conference Year and 692 TAF for a 1-in-100 Schedule 6 Year.

[d] Values given are based on critical year instream flow requirements in the following year (April-March). Carryover storage requirements for a conference year (~1:100 year exceedance) are 486 TAF for deliveries and 638 TAF for water transfers.

For modeling of the CEQA Existing Condition, the maximum single-year YCWA transfer is capped at 164 TAF, which is the historical maximum YCWA water transfer since inception of the EWA. This transfer occurred in 2002, and included sales to DWR and EWA.

Implementation of RD-1644 Long-term flow requirements and additional irrigation demand at Daguerre Point Dam due to implementation of the Wheatland Project would reduce available storage in New Bullards Bar Reservoir. Carryover storage requirements for water transfers under RD-1644 Long-term exceed the September target operating storage of 705 TAF. Therefore, no stored water transfers are possible for the No Project Alternative and the No Action Alternative.

For the Yuba Accord, stored water is made available through the Yuba Accord flow schedules and through the New Bullards Bar Reservoir Target Operating Line that specifies a target end-of-September storage of 650 TAF (compared to 705 TAF for the Existing Condition, the No Project Alternative, the No Action Alternative, and the Modified Flow Alternative). No additional stored water transfers are modeled.

Attachment C of the Modeling Technical Appendix describes carryover storage requirements for water transfers in greater detail.

A.4.3 GROUNDWATER SUBSTITUTION TRANSFERS

Groundwater substitution transfers were made by YCWA in coordination with its Member Units in 1991, 1994, 2001, and 2002, and are included in all scenarios. For modeling purposes, it is assumed that groundwater substitution pumping occurs in dry and critical years (Sacramento Valley 40-30-30 Index), and in below normal years when the allocations to the SWP are less than 60 percent.

Under the Existing Condition, single-year transfer amounts are capped at 61 TAF, which is the historical maximum YCWA groundwater substitution transfer since inception of the EWA. Similarly, under the Existing Condition, back-to-back groundwater substitution transfers are limited to two successive years and to a maximum total transfer of 116 TAF, which corresponds to the combined 2001 and 2002 transfer.

Analysis of the 2001 and 2002 water transfer data and estimates of historical changes in groundwater storage suggests a third year of transfer of a similar volume could have been conducted without inducing any detrimental decline in groundwater levels in the Yuba Basin and without drawing groundwater levels to the historical low levels seen in 1991. Recent surveys conducted by YCWA with potential participants in the groundwater substitution program indicated a maximum groundwater substitution pumping volume of approximately 90 TAF per year could be implemented.

For the Yuba Accord Alternative, groundwater substitution transfer modeling assumes a maximum 3-year total groundwater pumping volume of 180 TAF. An additional constraint of a maximum 2-year groundwater substitution transfer pumping volume of 120 TAF is applied to prevent transfers of 90 TAF in two consecutive years, followed by a year without any groundwater substitution pumping. The resulting 3-year pattern for maximum annual groundwater substitution pumping is 90 TAF for the first year, 60 TAF for the second year, and 30 TAF for the third year. With implementation of the Wheatland Project, the maximum available groundwater pumping capacity for groundwater substitution transfers and groundwater pumping to make-up for deficiencies in surface water deliveries is assumed to be 120 TAF.

While these constraints establish reasonable maximum groundwater pumping levels for the Yuba Accord Alternative, institutional difficulties in implementing a single-year groundwater substitution transfer program require that additional restrictions on pumping be used to simulate operations for the No Project Alternative, No Action Alternative and the Modified Flow Alternative. Accordingly, groundwater substitution pumping in the absence of a long-term water purchase agreement is limited to a maximum volume of 140 TAF over 3 years. The resulting 3-year pattern for the maximum annual groundwater substitution pumping is 70 TAF in the first year, 50 TAF in the second year, and 20 TAF in the third year.

For the NEPA analysis, groundwater substitution transfers have been further limited by consideration of the volumes of groundwater pumping that may occur in support of the Sacramento Valley Water Management Program.

Limits on the maximum annual volume of groundwater substitution pumping are distributed monthly assuming the following percentages for May through September: 20 percent, 20 percent, 25 percent, 25 percent, and 10 percent respectively. These percentages are based upon experiences from the 2001 and 2002 groundwater substitution transfers. The start of groundwater substitution pumping is dictated by New Bullards Bar Reservoir operations as simulated by the YPM. Water can be backed up in storage when releases from New Bullards Bar Dam are controlled by irrigation requirements at Daguerre Point Dam or instream flow requirements at the Marysville Gage. No groundwater substitution pumping was modeled after the end of September.

For modeling purposes, groundwater pumping is limited so that the long-term average annual groundwater pumping, including deficiency pumping, is at or less than 30 TAF, which is the net observed historical rate of groundwater recharge. Groundwater substitution pumping is also limited so that the simulated groundwater storage remains above the 1991 level.

A.4.4 YUBA ACCORD ALTERNATIVE

Under the Yuba Accord Alternative, YCWA, Reclamation and DWR would be parties to the proposed Water Purchase Agreement. This agreement provides for the purchase and delivery of water to EWA, Reclamation and DWR. Key elements of the Water Purchase Agreement include definition of water supply components, water accounting mechanism, and explanation of Conference Year principles.

Under the Water Purchase Agreement, YCWA would have an obligation to provide specific quantities of transfer water (Component 1, Component 2, and Component 3) and would have the option to provide additional transfer water (Component 4) depending on supply availability and demand. **Table A-11** summarizes YCWA's water transfer commitments under the Water Purchase Agreement. In the first 8 years of the agreement (2007 through December 31, 2015), Reclamation and DWR would purchase 60 TAF per year of Component 1 water, for a total of 480 TAF. YCWA's obligation to supply Component 2 water is year-type dependent. YCWA's obligation to supply Component 3 water would be dependent on CVP/SWP contract allocations and CVP/SWP requests for the water. Component 1 water would be surface water made available through the Yuba Accord flow schedules and New Bullards Bar Reservoir target operating line. Component 2, 3, and 4 water would be made available through a mix of the Accord flow schedules and groundwater substitution pumping.

Table A-10. Summary of Proposed Yuba Accord Water Purchase Agreement

CVP Allocation	SWP Allocation	Water Year Type	Transfer Type	Transfer Amount (TAF)	Source
N/A	N/A	All	Component 1	60	Stored water only [e]
N/A	N/A	Dry	Component 2	15	Stored water and groundwater substitution pumping
N/A	N/A	Critical	Component 2	30	Stored water and groundwater substitution pumping
< 35%	< 40%	N/A	Component 3a	40	Stored water and groundwater substitution pumping
35% - 45%	40% - 60%	N/A	Component 3b	40 [a]	Stored water and groundwater substitution pumping
N/A	N/A	All	Component 4 [c]	Supply Limited [b]	Stored water and groundwater substitution pumping [d]

[a] For modeling purposes, it is assumed that the CVP/SWP will request 40 TAF of Component 3b water when allocations for the CVP or SWP are within the percentages shown. Under the Draft Water Purchase Agreement, there is no commitment by either the CVP or SWP to request this water.
[b] For modeling purposes, it is assumed that YCWA transfer amount is limited only by supply, by Delta conditions, and by conveyance capacity at Banks and Jones pumping plants during the transfer period.
[c] For modeling purposes, it is assumed that, except in dry and critical years, YCWA will delivered previous years undelivered Component 1 water prior to making Component 4 water available to the CVP/SWP.
[d] For modeling purposes it is assumed that that the price of water would not support groundwater substitution transfers in wet and above normal years.
[e] Stored water refers to water made available through the Yuba Accord flow schedules and New Bullards Bar Reservoir target operating line that has an end-of-September target of 650 TAF.

A.4.4.1 SCHEDULE 6 YEAR PUMPING COMMITMENT

As part of the Yuba Accord Alternative, YCWA would enter into agreements with its Member Units (Conjunctive Use Agreements) to implement a program for the conjunctive use of surface water and groundwater. Under these agreements, participating Member Units would agree to pump specified percentages of 30 TAF of groundwater in Schedule 6 years. Through exchanges with surface water deliveries, these agreements would provide 30 TAF to supplement flows at Marysville, over and above the Accord flow schedules for Schedule 6 years.

Schedule 6 year groundwater substitution transfers are modeled through a uniform percentage reduction in the Daguerre Point Dam diversion demand, typically from April to September. The water that would have been diverted at Daguerre Point Dam is backed up in New Bullards Bar Reservoir, and then later released to the Delta on a pattern that allows the CVP/SWP to export the released transfer water. New Bullards Bar Reservoir storage is not affected by Schedule 6 groundwater pumping, after the transfer is complete, because no net storage withdrawal occurs to support the groundwater substitution transfer.

For modeling purposes, storage releases to support the groundwater substitution transfers in Schedule 6 years are assumed to normally provide an increase in flow at Marysville of 200 cfs in July and August, and 100 cfs in September. The release schedule is modified in some years based on CALSIM II model results to account for Delta conditions and available Delta export capacity.

A.4.4.2 GROUNDWATER SUBSTITUTION PUMPING

Accounting rules for water transfers under the Yuba Accord Alternative are presented in *Exhibit 4 – Accounting, and Exhibit 5 – Refill Accounting of the proposed agreement for the Long-term purchase of water from YCWA* of Appendix B. Released Transfer Water is calculated based on baseline flow conditions and flow conditions under the Yuba Accord Alternative, as measured at the Marysville Gage. Delivered Transfer Water is defined as the Released Transfer Water that is accounted as being exported by the Buyers. Transfer accounting determines YCWA need to implement groundwater substitution transfers to provide Component 2 and Component 3 water. Baseline conditions for Released Transfer Water are calculated using the YPM, and are based on RD-1644 interim instream flow requirements and FERC License 2246 instream flow requirements of 400 cfs at the Marysville Gage for the period October 1 to 14.

For modeling purposes, groundwater substitution transfers under the Yuba Accord Alternative are determined based on the following factors:

- Groundwater pumping constraints, described in Section A4.3, formulated to protect the Yuba groundwater basin from overdraft
- Delta conditions and the availability of export capacity at Banks and Jones pumping plants
- YCWA commitment to provide Reclamation and DWR with 15 TAF of Component 2 water in dry years and 30 TAF of Component 2 water in critical years (Sacramento Valley 40-30-30 Index)
- YCWA commitment to provide Reclamation and DWR up to 40 TAF of Component 3 water depending on CVP and SWP contract allocations.

The schedule for the release of groundwater substitution water is determined through post-processing of CALSIM II output. Transfer water is released during periods of Delta balanced water conditions, when there exists: (1) CVP/SWP pumping capacity to export the transfer water, and (2) the E/I ratio is not controlling Delta exports. However, in Schedule 2 and 3 years, 10 percent of the transfer water is dedicated to mitigating instream flows, even if this water is not transferable. In Schedule 4 and 5 years this percentage is 20 percent.

Attachment B

Lower Yuba River Water Temperature Evaluation

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Lower Yuba River Water Temperature Evaluation

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Attachment B
Lower Yuba River Water Temperature Evaluation

B.1 INTRODUCTION

The Yuba River has been developed for water supply, hydropower generation, flood control, sedimentation control, and recreation over a period extending back to the Gold Rush in the mid-1800s. These developments have varied and have resulted in complex impacts to the water temperature regime of the Yuba River.

The lower Yuba River is the 24-mile reach stretching from Englebright Dam to the confluence with the Feather River, south of Marysville. The construction of the Yuba River Development Project, and specifically New Bullards Bar Reservoir in 1970, has played a significant role in reducing the lower Yuba River water temperature in the spring, summer, and fall. Inflows from tributaries intermix with releases from reservoirs to develop the water temperature profile within the river channel. The flows emanating from Englebright Reservoir and Narrows I and II powerhouses provide the base flow of cold water in the upper reaches of the lower Yuba River. During certain periods of the year, inflows from Deer Creek (RM 22.7) near Smartville, and Dry Creek (RM 13.6) have significant effects on the heat gain of the river. During the irrigation season, a portion of the river flow is diverted at Daguerre Point Dam (RM 11.6).

Example of the average temperature regime of the lower Yuba River, from New Bullards Bar Reservoir to Marysville for May and August, is shown in **Figure B-1**.

B.1.1 COLDWATER POOL SYSTEM

Other than weather, the greatest factor that affects water temperatures in the lower Yuba River is the temperature of water released from the Narrows I and II powerhouses, which are located immediately downstream of Englebright Dam. Because Englebright Reservoir has a relatively small capacity (70 TAF), the temperature of water released from the Narrows I and Narrows II powerhouses are primarily governed by:

- Temperature of releases from New Bullards Bar Dam through New Colgate Powerhouse
- Air temperature
- Middle Yuba and South Yuba rivers' inflow rates and water temperatures

B.1.1.1 NEW BULLARDS BAR RESERVOIR

New Bullards Bar Reservoir is a 966,000 acre-foot capacity reservoir, which in most years has a significant coldwater pool supply. A cross-section of the dam is shown in **Figure B-2**. The reservoir outlet control gates provide the ability to release water from different levels at the dam, from a high elevation of 1,956 feet above msl to a low elevation of 1,638 feet above msl (at the low-level outlet). The upper intake is fitted with slide gates, so that flows from the upper 150 feet of the reservoir can be regulated.

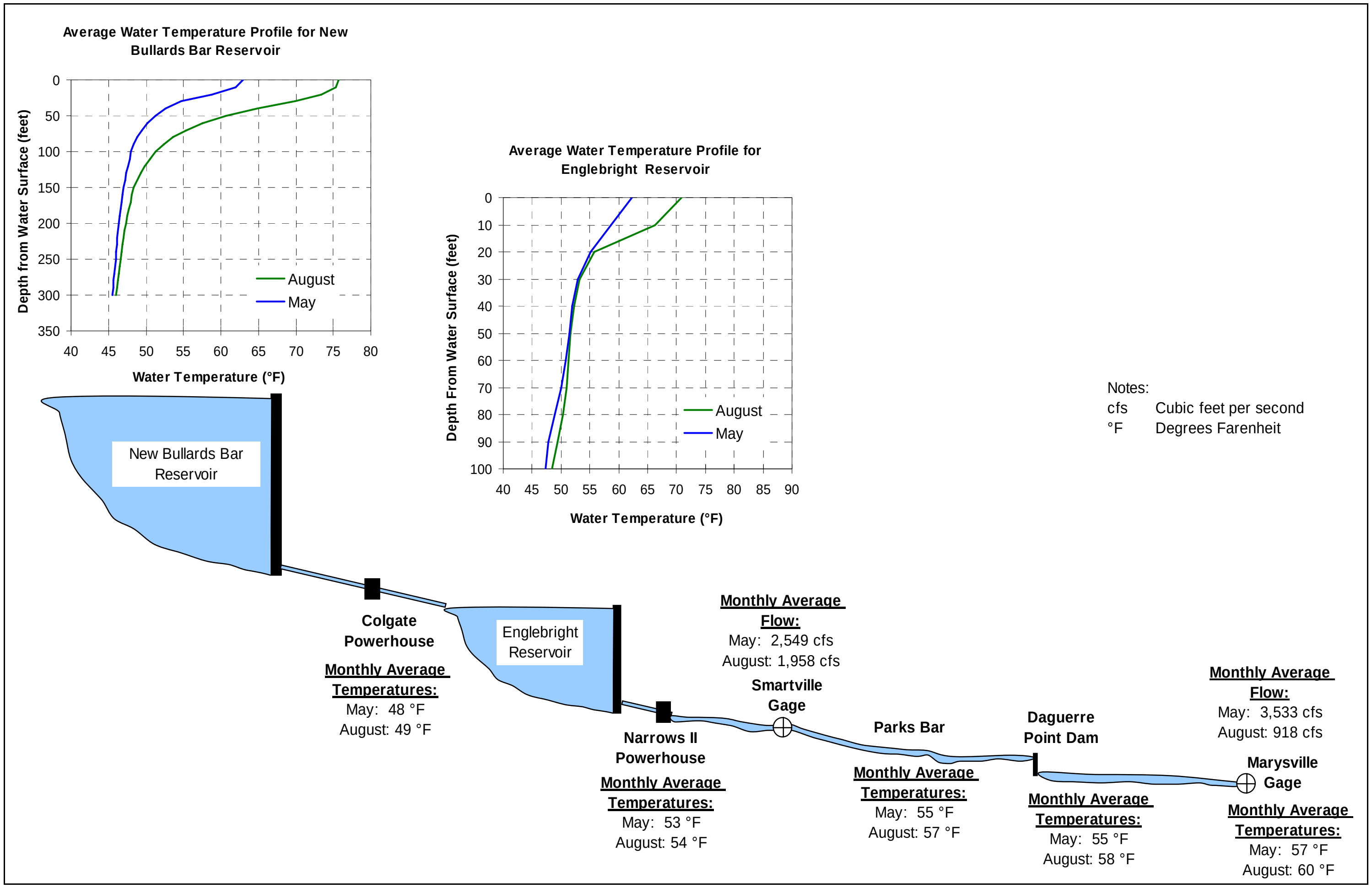

Figure B-1. Average Monthly Water Temperature Profile in the Lower Yuba River for May and August for the Period 1999 to 2004[1]

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1 Flow data is from U.S. Geological Survey (USGS) gages 11421000 (Marysville) and 11418000 (Smartville). Water temperature data is from YCWA.

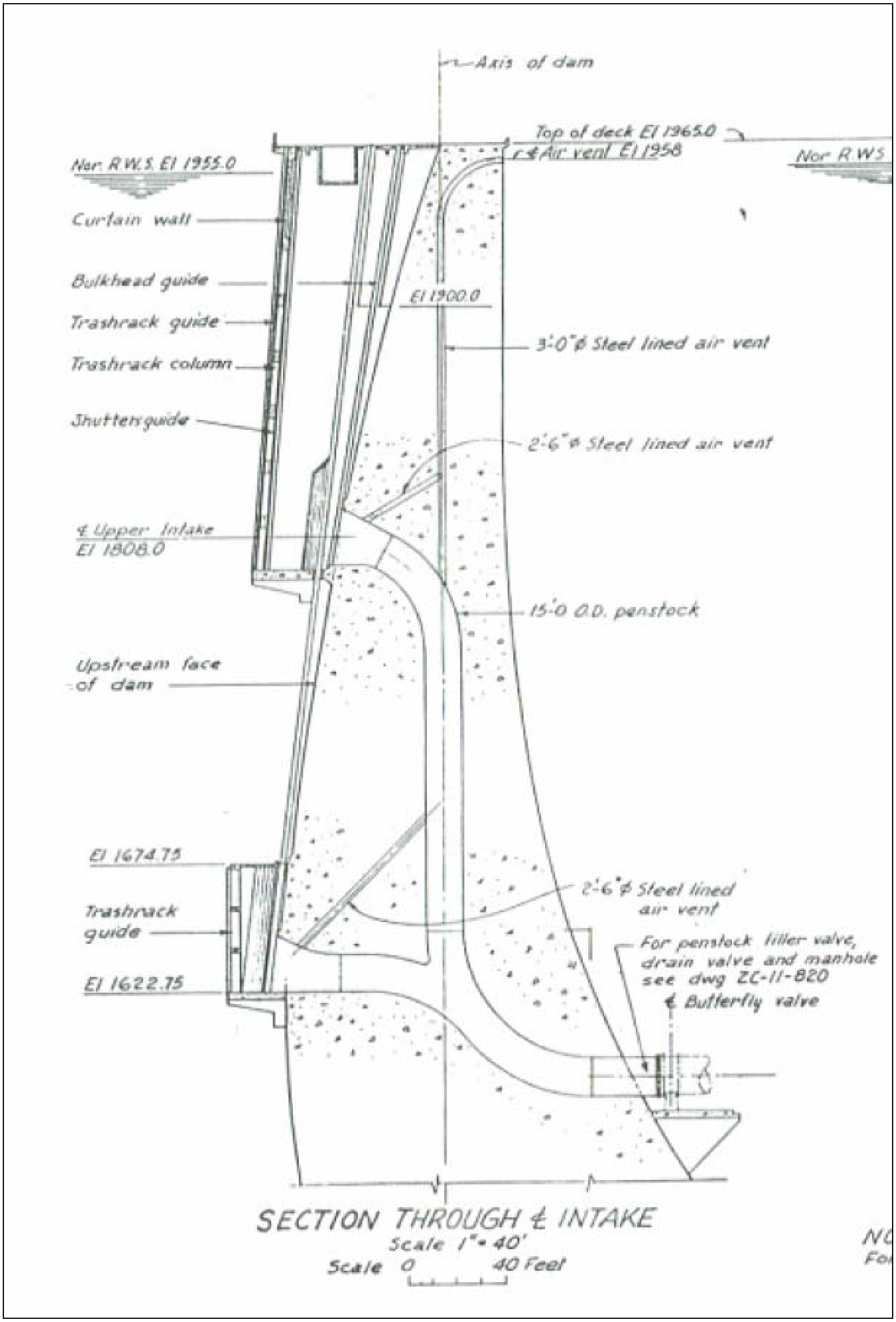

Figure B-2. Section Through New Bullards Bar Dam

Under current operating conditions, the coldwater pool in New Bullards Bar Reservoir is normally not exhausted and coldwater releases are made throughout the year. Current YCWA operating procedures call for use of the low-level outlet throughout the year, as recommended by a temperature advisory committee, which was convened by YCWA in 1993 with representatives from CDFG and USFWS. The low-level outlet has been used for all controlled releases from the dam since September 1993. The minimum pool for operating the low-level outlet is at an elevation of 1,734 feet above msl, 96 feet above the low-level outlet.

Analysis of water temperature profiles in New Bullards Bar Reservoir, for the recorded period of 1990 to 2005, indicate strong seasonal behavior of the water temperature profile within the reservoir (**Figure B-3**). The consistent shape and narrow range of water temperature profiles suggest that temperature in New Bullards Bar Reservoir is primarily controlled by solar radiation and air temperature. The seasonal trends in average monthly water temperature profiles are shown in **Figure B-4** and **Figure B-5**, which shows the warming and cooling cycles of reservoir temperature, respectively.

Additional analysis of the water temperature profiles shows that fluctuations of surface water elevations do not typically impact the water temperature profiles. Available water temperature profiles show surface water elevation variations between 1,818 feet and 1,957 feet above msl, which is equivalent to 440 TAF and 970 TAF of reservoir storage. The consistent monthly water temperature profiles appear to be independent of surface water elevations, over the observed range of elevations.

B.1.1.2 ENGLEBRIGHT RESERVOIR

Recreation activities on Englebright Reservoir are dependent upon a stable reservoir level. Therefore, the active storage in Englebright Reservoir is maintained at a steady elevation of 515 feet (approximately 45 TAF of storage), except during the flood season. As a result, the flow through the Narrows II Powerhouse at Englebright Dam is primarily governed by the water temperature releases from New Colgate Powerhouse, air temperature, and the Middle Yuba and South Yuba rivers’ inflow rates and water temperatures. The intake structure at Englebright Dam is located approximately 448 feet above msl.

Analysis of temperature profiles in Englebright Lake, for the period of 1990 to 2005, shows a seasonal behavior of the temperature profiles in the lake (**Figure B-6**). The warming and cooling water temperature cycles in Englebright Lake are shown in **Figure B-7** and **Figure B-8.**

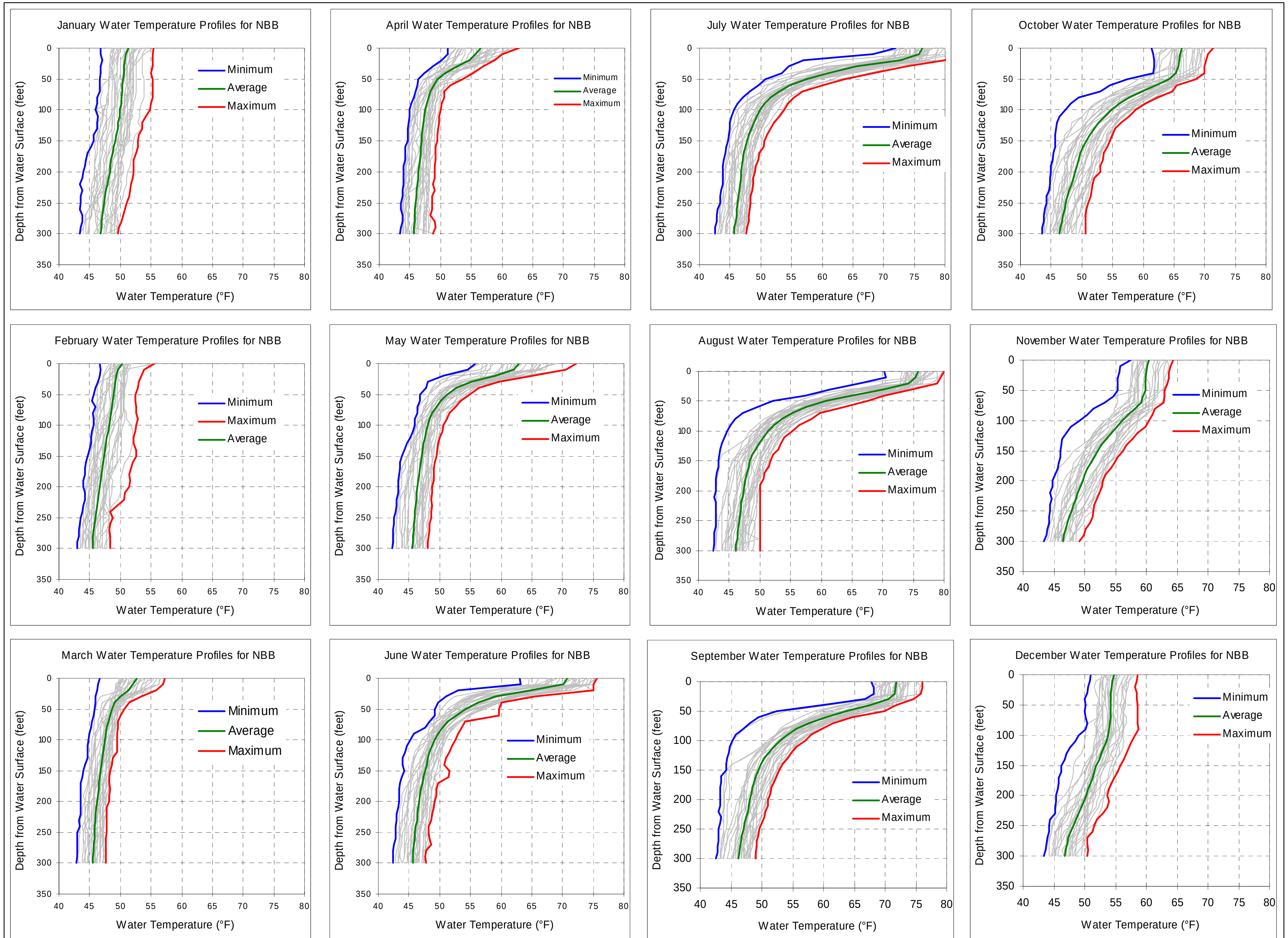

Figure B-3. Monthly Water Temperature Profiles of New Bullards Bar Reservoir

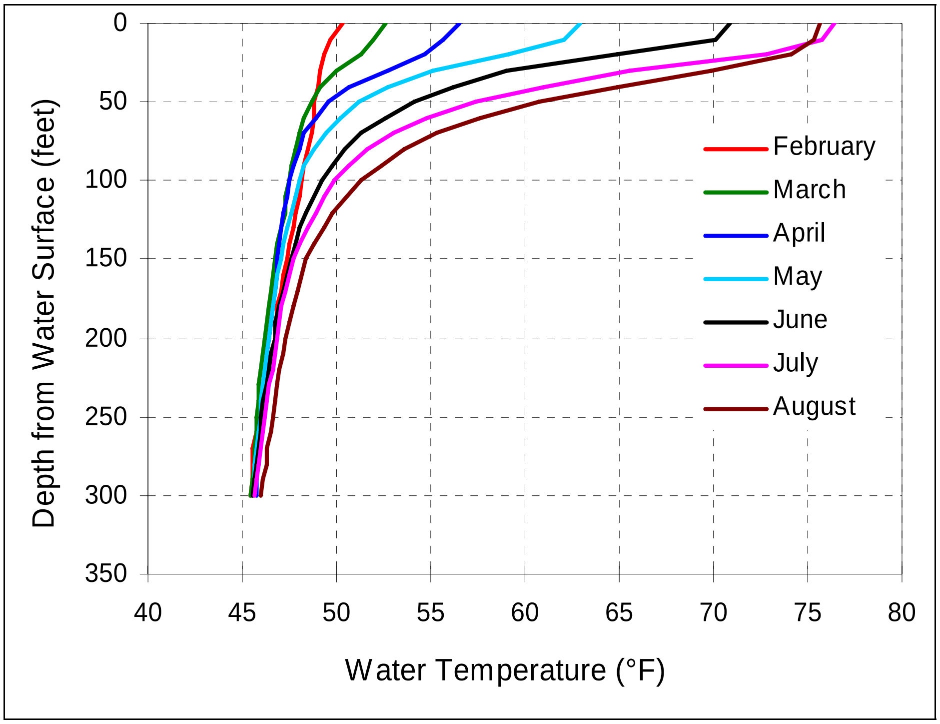

Figure B-4. New Bullards Bar Reservoir Average Monthly Water Temperature Profile, February to August Warming Cycle

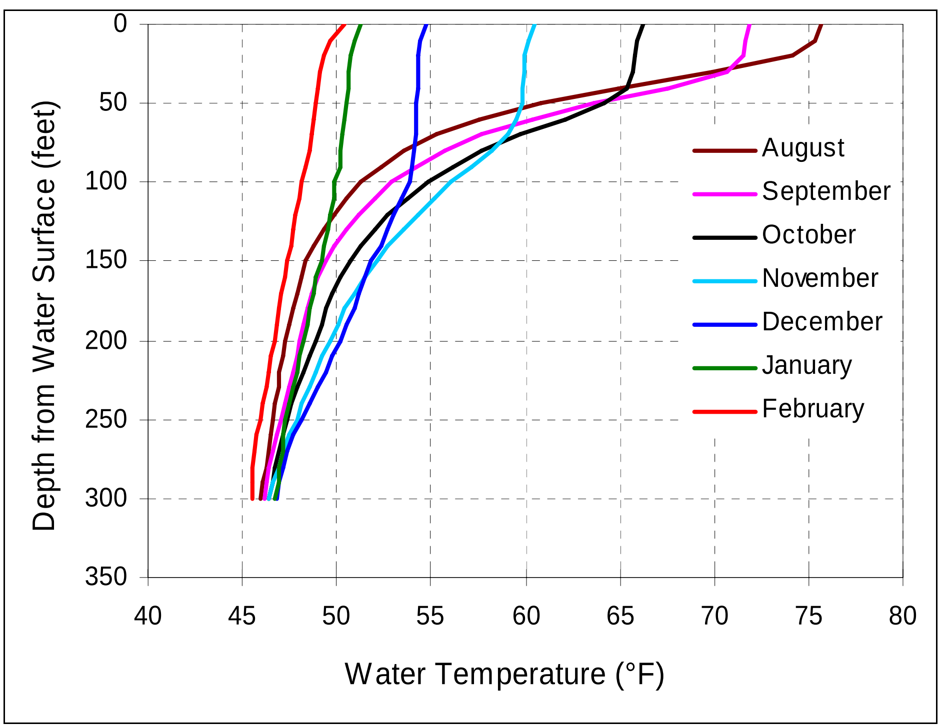

Figure B-5. New Bullards Bar Reservoir Average Monthly Water Temperature Profile, August to February Cooling Cycle

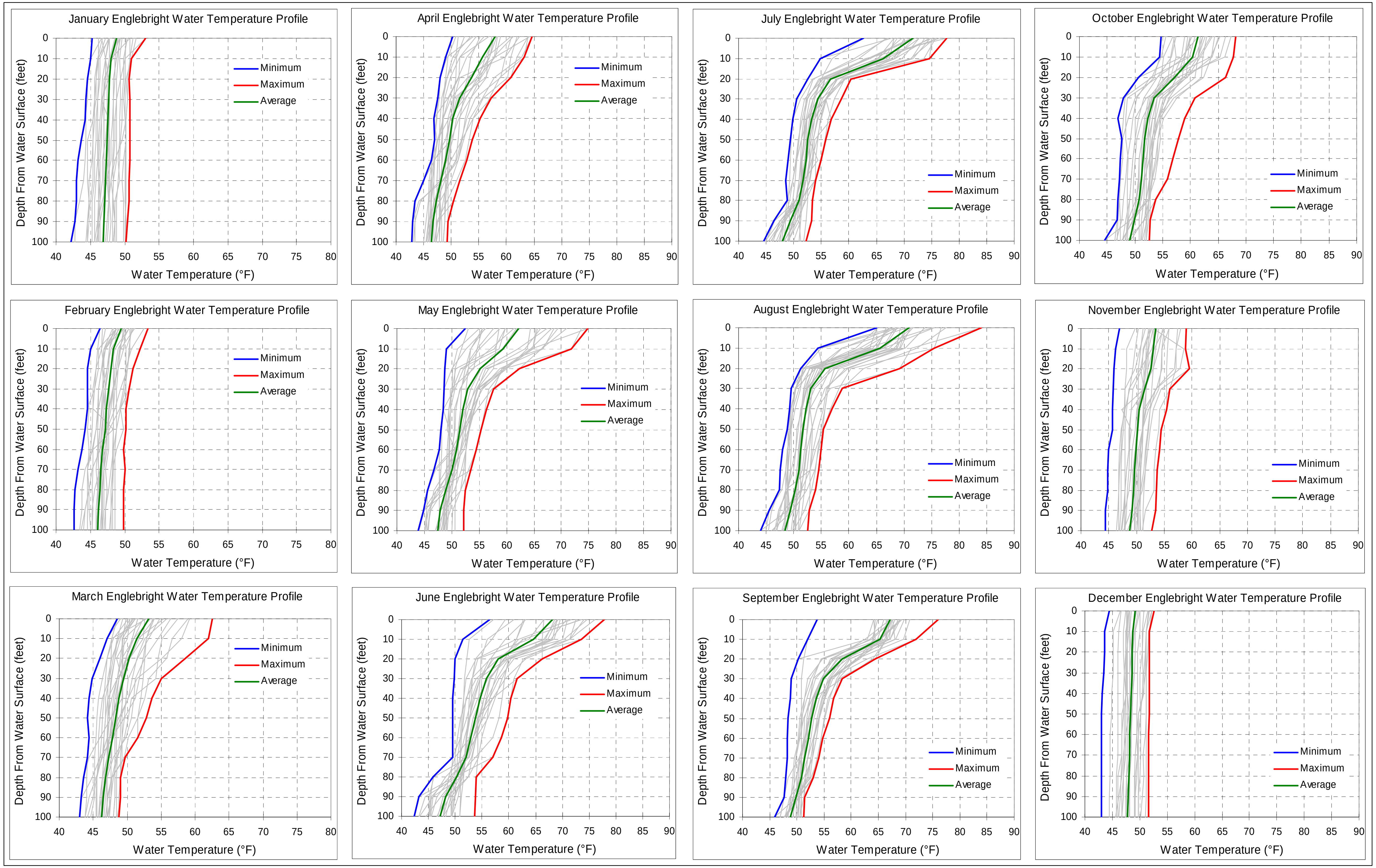

Figure B-6. Monthly Water Temperature Profiles of Englebright Lake

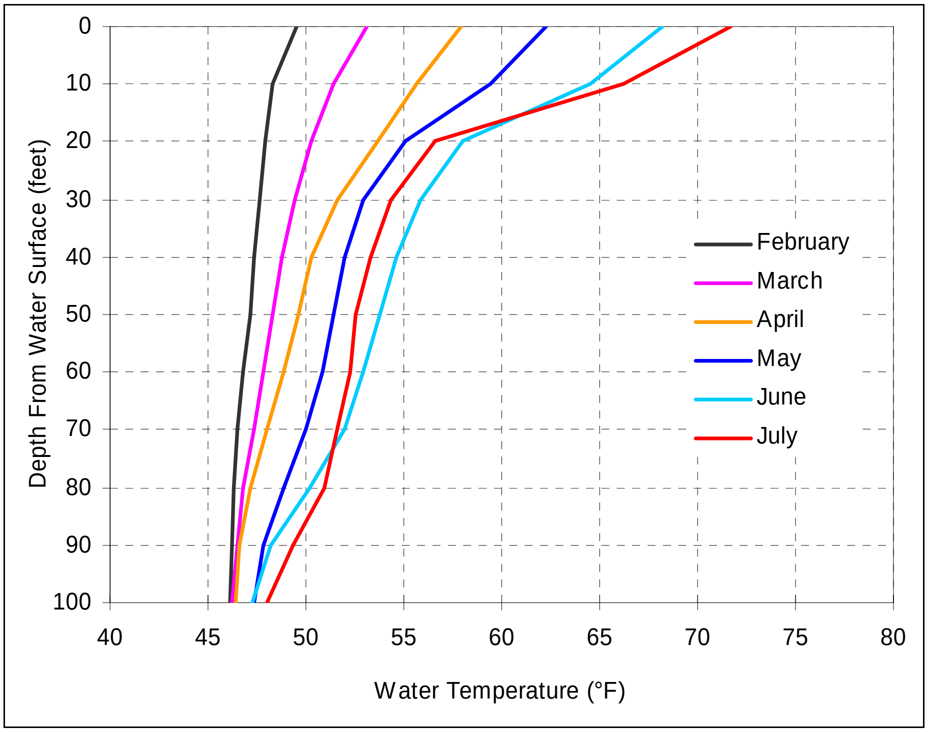

Figure B-7. Englebright Average Monthly Water Temperature Profile, February to August Warming Cycle

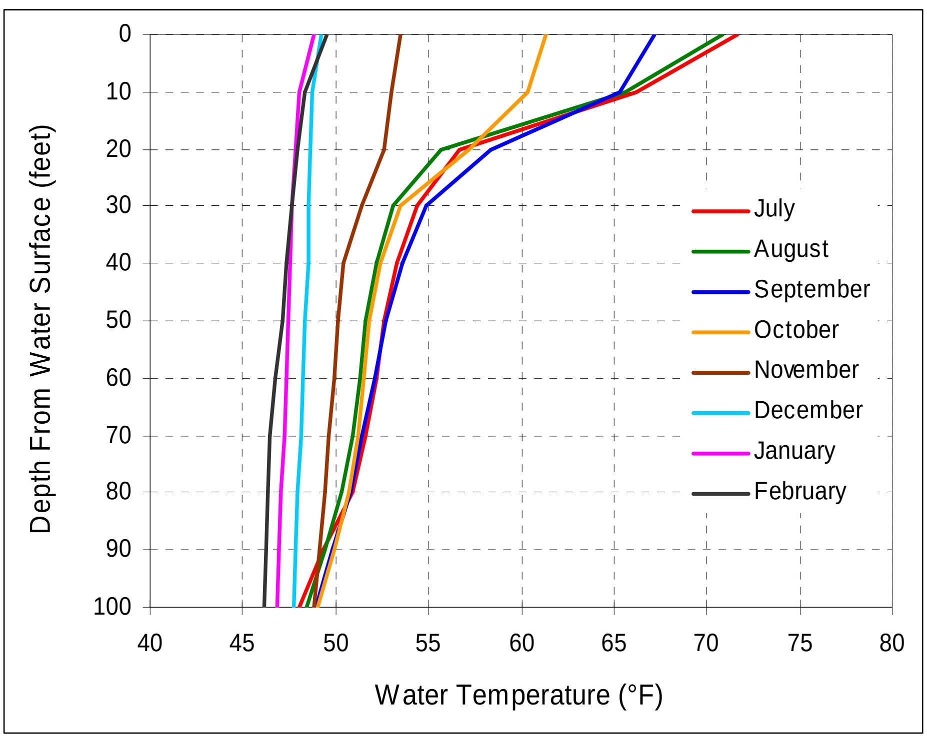

Figure B-8. Englebright Average Monthly Water Temperature Profile, August to February Cooling Cycle

B.1.2 LOWER YUBA RIVER

Figure B-9 shows the monthly average of daily mean water temperatures of the lower Yuba River, at the Marysville Gage, during the three periods, for which water temperature data are available.

- Pre-Yuba project period from 1965 to 1968 (two wet and two below normal years[2])
- Post-Yuba project period from 1974 to 1977 (two wet and two critical years)
- Modified operations in the Yuba Project period from 1993 to 2005[3] (five wet, four above normal, one below normal, one dry, and two critical years)

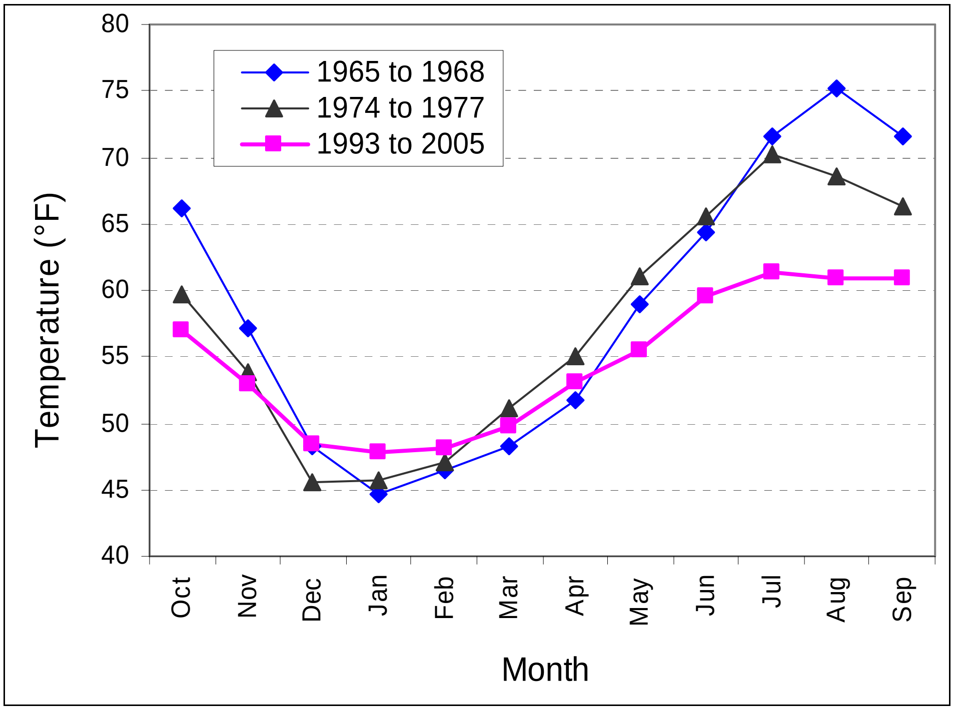

Figure B-9. Monthly Average of Daily Yuba River Water Temperatures at Marysville Gage for Periods of Pre- and Post-Yuba River Development Project

The monthly average of daily mean water temperatures, during the 1974 to 1977 period, also show reductions in summer water temperatures compared to the 1965 to 1968 period, even though the 1974 to 1977 period included the most severe drought (1976-1977) that the Yuba River Basin has experienced in recorded history. This shows the effect of Yuba-project on reducing summer temperature in the Yuba River.

Operation of the Yuba Project was modified in 1993. Therefore, the monthly average water temperatures for the 1993 to 2005 period are more representative of current conditions in the Yuba River. Compared to the period of 1965 to 1968, the monthly averages of daily mean water temperatures were substantially lower during the 1993 to 2005 period, from mid-summer into

[2] Water year types are defined by the Yuba River Index (B-E, *Yuba River Index: Water Year Classifications for Yuba River*, 2000).

[3] Water temperature data is available for 1989 to 2005. However, since September 1993, the low-level outlet of New Bullards Bar Reservoir has consistently been used to release water for power generation at New Colgate Powerhouse to assist in the management of water temperatures in the lower Yuba River.

the fall, with the average August temperature over 10°F lower. The reduction in summer and fall water temperatures was greatly influenced by the continued releases of water from the coldwater pool in New Bullards Bar Reservoir, resulting from the modified operations in the Yuba Project.

B.1.2.1 MECHANISM OF HEAT TRANSFER

For most of the lower Yuba River below Englebright Dam, the river channel is wide and flat, with little or no bank shading. Thus, the entire river channel is exposed to the warm Sacramento Valley air, which produces substantial heat transfer to the water surface. Additionally, water temperatures are influenced by solar radiant heating of the river and riverbed. Many of the Sierra foothill rivers have well defined, moderate to highly incised channels, which provide for low surface width-to-flow ratios. The Yuba River, however, is characterized by a wide, shallow channel (i.e., high surface width-to flow ratio) that receives a substantial amount of solar radiant heating. An aerial photograph of the lower Yuba River at Daguerre Point Dam is shown in **Figure B-10**. As can be seen in the photograph, a substantial portion of the river bottom is covered at very modest flow.

Figure B-10. Photograph of the Yuba River at Daguerre Point Dam Looking Upstream

A cross section of the Yuba River, downstream of Daguerre Point Dam, is presented in **Figure B-11.** Water surface elevations also are plotted within this figure to demonstrate potential water surface elevations over a range of flows (i.e., 250 to 1250 cfs). The figure shows that flow above 500 cfs result in greater surface water width of the river, for each additional increment of flow, compared to flow rates below 500 cfs. Typically, there is a dramatic increase in surface water width once the capacity of the low flow channel is exceeded.

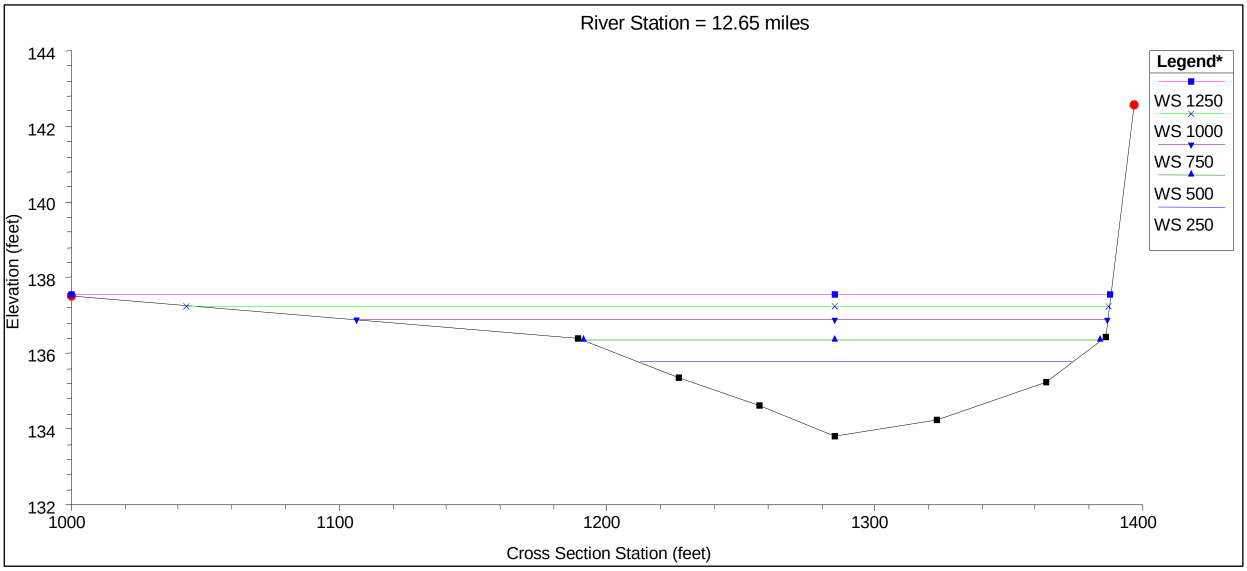

Figure B-11. Yuba River Cross Section at River Mile 12.65 with Flow Stages (e.g., WS 750: Water Surface Elevation at a Flow of 750 cfs)

Figure B-12 shows the range of daily minimum and maximum water temperatures for August 2004. During the summer months, the lower Yuba River experiences a diurnal water temperature variation of approximately 10°F. This extreme diurnal water temperature variation can be mainly attributed to the river geometry and intense warm weather. The mechanism of heat transfer for warming of river water temperatures is governed by air-to-water contact at the water surface and solar radiant heating of the river and riverbed. The air-to-water heat transfer is driven by the difference between the air temperature and the water temperature, and humidity. Solar radiant heating is affected by the time of the year, cloud cover, surface area, water depth, and solar radiation absorption of the riverbed. The lower Yuba River is unprotected from both heating mechanisms and, compared with other foothill rivers, has a greater relative heat load due to its channel geometry. Water temperatures in the lower Yuba River can increase more than 12°F between Englebright Dam and Marysville.

Although significant warming of river temperature occurs in the lower Yuba River, **Figure B-13** shows that considerable warming of cold water releases from New Bullards Bar Dam occurs upstream the Englebright Dam. During the period from March to July, warming upstream of Englebright Dam account for more than 50 percent of the increase in water temperature between New Bullards Bar Dam and Marysville. However, during late summer and fall, August through November, warming in the lower Yuba River, below Englebright Dam, accounts for more than 60 percent of temperature gain between New Bullards Bar Dam and Marysville. Different heat transfer mechanisms control warming of water temperature upstream of Englebright Dam and in the lower Yuba River, which result in seasonal variations of warming rates in the two sections of the river. The rate of warming in Englebright Reservoir is generally controlled by air temperature and solar radiation, and rate and temperature of inflows from Middle and South Yuba rivers. However, the rate of warming in the lower Yuba River is controlled by air temperature and solar radiation, and volume of the flow in the river.

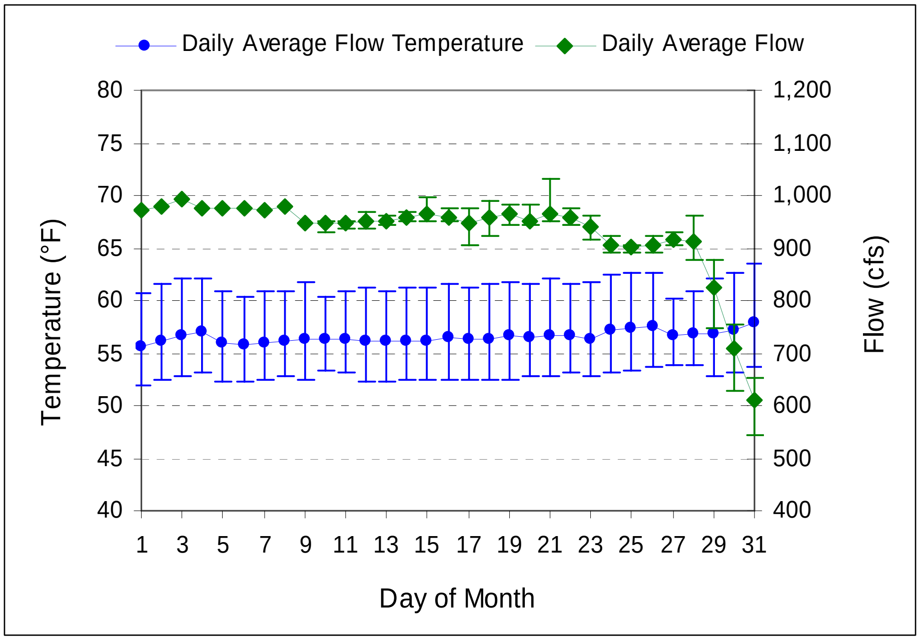

Figure B-12. Lower Yuba River Water Temperature at the Marysville Gage in August 2004

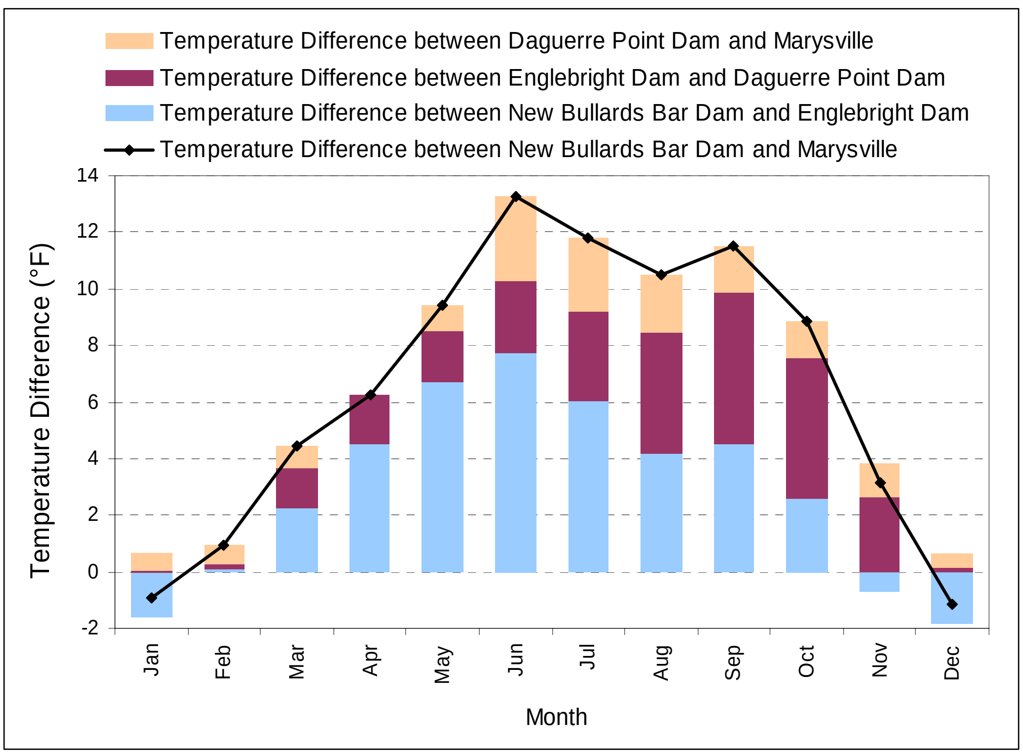

Figure B-13. Average Monthly Water Temperature Differences in the Lower Yuba River (1990 to 2005)

B.2 TEMPERATURE MODELING APPROACH

Temperature models for stream and reservoir applications can be broadly classified as physically based, empirical, or a mix of the two. Physically based models use governing equations for heat transport, flow, and climatic conditions to estimate water temperatures. A physically based model is capable of estimating water temperature under a variety of circumstances that may not be present in the existing system or data set, such as extreme flow conditions or reservoir reoperation. Typically, physically based models are one-dimensional, describing the one-dimensional vertical water temperature profile in a reservoir or the one-dimensional horizontal profile along a stream.

One-dimensional reservoir water temperature models that have previously been used to simulate Central Valley reservoir water temperature profiles include HEC/Reclamation[4], HEC-5Q, WQRRS, and RMA. One-dimensional river water temperature models that have previously been applied to streams in the Central Valley include HEC/Reclamation, HEC-5Q, QUAL2E, WQRRS, and RMA. A disadvantage to using a physically based model is the effort required to build and calibrate the model. In order to simulate a full period of record, meteorological inputs, such as solar radiation and wind, and information about the water temperature for accretions and depletions to the system, are needed. Additionally, atmospheric data is needed for a meaningful prediction.

In contrast, an empirical model (e.g., statistical model) characterizes the statistical relationships between water temperatures and one or more observed characteristic of the system. The simplest example of this type of model is a linear regression relationship between observed flow and water temperature. The advantage of a statistically based model is its ease of use and development. Confidence limits (or error bands) on water temperature results are readily available. However, the model is limited to making predictions regarding future conditions based on available historic data, and such a model cannot evaluate potential outcomes outside of the range of these data. A statistically based water temperature model was used in the 2000 SWRCB Lower Yuba River Hearings (2000 Hearings).

Due to limited available data, statistical water temperature models are used to evaluate the potential impacts of the Proposed Project/Action and alternatives. The statistical models can be used to estimate the effects of different New Bullards Bar Reservoir storage regimes and flow releases, and diversions at Daguerre Point Dam on water temperatures in the lower Yuba River. The statistical models should be used only in a comparative analysis to predict differences in water temperature for a particular action alternative compared to the CEQA No Project Alternative. The statistical models should not be used to predict absolute temperatures in the lower Yuba River.

B.2.1 PERIOD OF SIMULATION

Monthly simulation of the Sacramento-San Joaquin Delta water system is available for the 72-year period of record. The Yuba Project Model (YPM) is capable of simulating operations of New Bullards Bar and Englebright dams, and flows in the lower Yuba River for the period 1922

[4] HEC (1972) was modified and adapted by J. Rowell to provide temperature simulation capability throughout the Sacramento River basin. This collection of sub-models was ultimately referred to as the "Sacramento River Basin Model" and included Trinity, Whiskeytown, Shasta, Oroville, and Folsom reservoirs; Lewiston, Keswick, Thermalito, and Natoma re-regulating reservoirs; and the Sacramento, Feather, and American rivers. Also see Rowell (1990).

to 2004. However, lack of simulated Delta conditions and simulated through-Delta conveyance capacity for transfers restricts modeling of the lower Yuba River to the 1922 to 1994 period. Thus, temperature modeling for the lower Yuba River is restricted to the 1922 to 1994 period.

Climatic data (e.g., air temperature at Marysville) are required as independent variable(s) in some of the statistical temperature models developed for the lower Yuba River. Historical air temperature data for Marysville is available from 1948 to present. This further restricts the simulation period for temperature modeling using historical monthly air temperature to the 1948 to 1994 period. However, the period of 1922 to 1948 could be included by using historical monthly averages.

B.2.2 TIME STEP

Reservoir storage and flow inputs for the water temperature model are obtained from the YPM. The YPM is run using a monthly time step; therefore, water temperature modeling also is conducted using a monthly time step.

B.2.3 LOCATION

The statistical water temperature model is used to estimate changes in monthly water temperatures of New Colgate releases, Narrows II releases (assumed same as river temperature at the Smartville Gage), Daguerre Point Dam, and Marysville Gage.

B.2.4 CALIBRATION DATA

The data available for calibration of the temperature model is presented in **Table B-1**. More data are available for the period of 1989 to present compared to previous periods, because YCWA is recording water temperature at more locations in the lower Yuba River with greater frequency. The recent data record is more representative of the current operation of the Yuba Project. The water temperature measurement locations in the Yuba River are: New Bullards Bar Reservoir, New Colgate Powerhouse, Englebright Reservoir, Narrows II Powerhouse, Parks Bar, Daguerre Point Dam, and Marysville.

Table B-1. Available Historical Data for Water Temperature Model Calibration

Location	Data Type	Start Date	End Date	Data Type	Frequency
New Colgate PH	Air temperature	1/1/1979	Present	Max, Min	Daily
New Colgate PH	Water temperature	4/6/2000	Present	Max, Min, Avg	Daily
Daguerre	Water temperature	9/1/1999	Present	Obs	Hourly
Deer Creek	Flow	9/1/1969	Present	Avg	Daily
Englebright	Air temperature	1/9/1990	Present	Obs	~Bi-weekly
Englebright	Reservoir profile	1/9/1990	Present	Obs	~Weekly
Englebright	Storage	1/1/1970	Present	Obs	Daily
Marysville	Air temperature	1/1/1951	Present	Max, Min, Obs	Daily
Marysville	Air temperature	July 1948	Present	Max, Min, Avg	Monthly
Marysville	Flow	9/1/1969	Present	Avg	Daily
Marysville	Water temperature	9/16/1999	Present	Obs	Hourly
Marysville	Water temperature	10/1/1989	5/11/1999	Max, Min, Avg	Daily
Narrows II	Water temperature	1/9/1990	Present	Obs	~Weekly
Narrows II	Water temperature	8/24/1999	Present	Max, Min, Avg	Daily
New Bullards Bar	Reservoir profile	1/24/1990	Present	Obs	Monthly
New Bullards Bar	Storage	1/15/1969	Present	Obs	Daily
Parks Bar	Water temperature	9/1/1999	Present	Obs	Hourly
Smartville	Flow	9/1/1969	Present	Avg	Daily
Smartville	Water temperature	9/3/1999	Present	Obs	Hourly

Notes: PH = Powerhouse, Obs = Observation, Max = Maximum, Min = Minimum, Avg = Average

B.3 PREVIOUS STUDIES

Two previous studies have developed water temperature models for the lower Yuba River in 1992 and 2000. The 1992 model was developed to evaluate the Lower Yuba River Fisheries Management Plan proposed by CDFG. The 2000 model was developed for the 2000 Hearings.

B.3.1 1992 WATER TEMPERATURE MODEL OF THE LOWER YUBA RIVER

The development of a water temperature model of the lower Yuba River is reported in *Water Temperature Modeling on the Yuba River* (B-E 1992). The developed temperature model consists of four sub-models:

- One-dimensional physical model of New Bullards Bar Reservoir (CE-QUAL-R1)
- Statistical, multiple-linear regression model of New Colgate Powerhouse release temperature, as a function of reservoir temperature and air temperature
- Statistical multiple linear regression model of water temperature at the Smartville Gage, as a function of New Colgate Powerhouse release temperature and air temperature
- One-dimensional physical model of the lower Yuba River (HEC-5Q)

The water temperature data used in the study were collected from 1974 through 1977.

B.3.2 2000 ASSESSMENT OF PROPOSED WATER TEMPERATURE REQUIREMENTS

A statistical temperature model was developed for the resumption of the 2000 Hearings. The model development and application is described in *Lower Yuba River: Assessment of Proposed Water Temperature Requirements* (YCWA 2001). Three separate, multivariate linear regression relationships were developed to relate water temperatures in different parts of the system:

- Narrows II Powerhouse release temperature, as a function of New Colgate Powerhouse release temperature and Marysville air temperature
- Water temperature at Marysville Gage, as a function of Narrows II Powerhouse release temperature, Marysville air temperature, and the flow at the Marysville Gage.
- Yuba River temperature at Daguerre Point Dam, as a function of Narrows II Powerhouse release temperature, Marysville air temperature, and the flow at the Marysville Gage.

Solar radiation and ambient air temperature are important factors that affect the flow-water temperature relationship in the lower Yuba River because of the flat geometry of the riverbed. Thus, in developing water temperature relationships, the daily mean air temperatures at Marysville were used as a surrogate for solar radiation, ambient temperature, and other climate-related factors. The relative importance of these controlling factors varies from month to month. Therefore, statistical temperature relationships were established for each month using daily data for that month. The analysis showed that the water temperature at the Marysville Gage is most affected by the Narrows II Powerhouse release temperature and then by the air temperature at Marysville.

Application of the temperature modeling for the 2000 Hearings was based on historical average monthly water temperature of releases from New Colgate Powerhouse (to provide the upstream boundary condition) and historical average monthly air temperature at Marysville.

B.4 PROPOSED TEMPERATURE MODEL

The modeling approach adopted for the Proposed Yuba Accord is to further develop the statistical model developed for the 2000 Hearings. The statistical relationships previously developed for calculating temperatures can be enhanced, through extension of the historical data set used for calibration, to include more recent data. The statistical relationships for the 2000 Hearings were based on historical data collected between 1990 and 1999. Five more years of data now are available.

In addition, under the Yuba Accord Alternative, New Bullards Bar Reservoir storage will be significantly lower in many years. Additional analysis on the effect of reduced reservoir storage on the New Colgate Powerhouse release temperature is needed to understand the impacts of the Proposed Project/Action and alternatives on lower Yuba River temperatures. New Colgate Powerhouse release temperature is an input to the statistical model for calculating the Narrows II Powerhouse release temperatures and, subsequently, the water temperature at Daguerre Point Dam and at the Marysville Gage.

The proposed statistical model consists of five sub-models that can be used to predict water temperature at the following locations:

- New Colgate Powerhouse release
- Narrows II Powerhouse release (assumed to equal the water temperature at the Smartville Gage
- Daguerre Point Dam
- Marysville Gage

B.4.1 NEW COLGATE POWERHOUSE RELEASE TEMPERATURE

The consistent monthly temperature profiles in New Bullards Bar Reservoir (Figure B-3) allows for development of a reasonable estimate of water temperature at New Bullards Bar low-level outlet. The estimated water temperature at the low-level outlet can then be used to estimate release temperature through New Colgate Powerhouse by accounting for water warming through the powerhouse. The temperature model for New Colgate Powerhouse release temperature consists of two components: (1) low-level outlet temperature component and (2) release temperature component.

Model Description

The low-level outlet temperature model assumes an average temperature profile for each month, which is developed using the historical record of temperature profiles in New Bullards Bar Reservoir (Figure B-3). Water temperature at the low-level outlet is estimated from the monthly temperature profile corresponding to the depth of the low-level outlet from the water surface. Depending on the volume of the release, the thickness of the intake zone for the low-level outlet will vary. Water temperature at the low-level outlet is adjusted to account for thickness of intake zone.

The release temperature model uses a multi-linear regression relationship to predict the temperature of the New Colgate Powerhouse water release. This relationship uses three independent variables:

- Estimated average monthly water temperature at New Bullards Bar low-level outlet

- Average monthly release rate from New Colgate powerhouse
- Average monthly air temperature at Marysville

This model accounts for both the warming through the powerhouse and the seasonal variability in low-level outlet temperature. Because water temperature at the low-level outlet is estimated using long-term average monthly temperature profiles, monthly air temperature and release rates are used to account for seasonal variability. Marysville air temperature is used in the relation as a surrogate for climatic conditions.

Model Calibration

The New Colgate release temperature model was developed using data spanning the period of 1994 to present. Data sets prior to 1994 were excluded because it wasn't until after 1994 that all New Colgate releases were made from the low-level outlet at New Bullards Bar Dam. The regression equation for New Colgate release temperature is:

$$NCT = 9.88 + 0.7801 * NBT - 0.000547 * NCR + 0.0401 * Air$$

Where

NCT = Release temperature of New Colgate Powerhouse (°F)
NBT = Estimated water temperature of the low-level outlet at New Bullards Bar Dam (°F)
NCR = Release rate of New Colgate (cfs)
AIR = Air temperature at Marysville (°F)

Comparison between observed and predicted release temperature at New Colgate Powerhouse is shown in **Figure B-14**. The comparison shows a general good performance of the developed model for New Colgate release temperature (**Table B-2**). Although the fit between the observed and predicted is not complete, the observed release temperature falls well within the 99 percentile confidence limits of model predictions. As reported in **Table B-3**, statistical tests confirm the significance of all the parameters used in the temperature equation for New Colgate release.

Table B-2. Performance Statistics for the New Colgate Release Temperature Equation

Statistic	Value
R-Square	0.674
Mean absolute error (°F)	0.69
Standard deviation of error (°F)	0.88

Table B-3. Statistical Significance Tests for the Parameters of the New Colgate Release Temperature Equation

Parameter	P-value[5]
Intercept	3.7 E-03
NBT	2.8 E-23
NCR	2.8 E-08
AIR	1.6 E-06

[5] P-value tests whether each individual variable has a significant contribution to the relationship. If p-value is less than 0.05, then its corresponding variable is a significant predictor in the relationship.

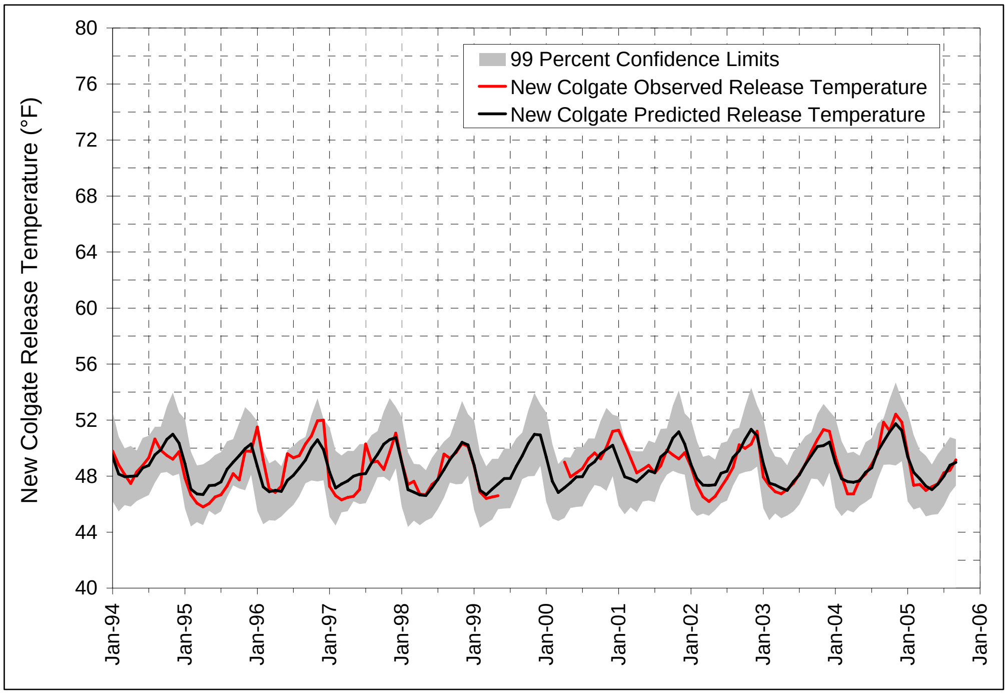

Figure B-14. Predicted and Observed Release Temperature at New Colgate Powerhouse for the Period 1994 to 2005

The coefficients of the regression equation for New Colgate release temperature specifies the sensitivity of release temperature to each independent variable. A one degree increase in release temperature can be caused by an increase in low-level temperature of 1.3 degrees, a decrease in New Colgate release of 1,800 cfs, or a 25-degree increase in average monthly air temperature of at Marysville.

Model Validation

Under the Yuba Accord Alternative, New Bullards Bar Reservoir storage would be significantly lower than the levels experienced in recent years. Therefore, it is important to validate the developed temperature model for New Colgate for reduced reservoir storage conditions. The observed release temperature at New Colgate during the historical low storage conditions of 1976 and 1977 and data for 1981 were used to validate the developed model. **Figure B-15** shows the time series of New Bullards Bar Reservoir storage.

Figure B-16 compares the observed and predicted release temperature for New Colgate during 1976, 1977, and 1981. It should be noted that observed release temperature is only shown for periods when release is made from the low-level outlet at New Bullards Bar Dam. Figure B-16 shows a reasonable match between observed and predicted release temperature. Observed temperature remained largely within the 99 percentile confidence limits of model prediction, except during 1976. Although the prediction error during 1976 was high (3 degrees on average), the model correctly predicted the trend of release temperature. Figure B-16 also shows that model predicted release temperature is generally warmer than the observed release temperature. This can be explained by the fact that New Colgate releases prior to 1994 were generally made from the upper-level outlet at New Bullards Bar Dam, while the low-level outlet is used when reservoir storage is low. This means that during that period cold water pool has been exercised less regularly than in recent years, which can explain the conservative model predictions of release temperature.

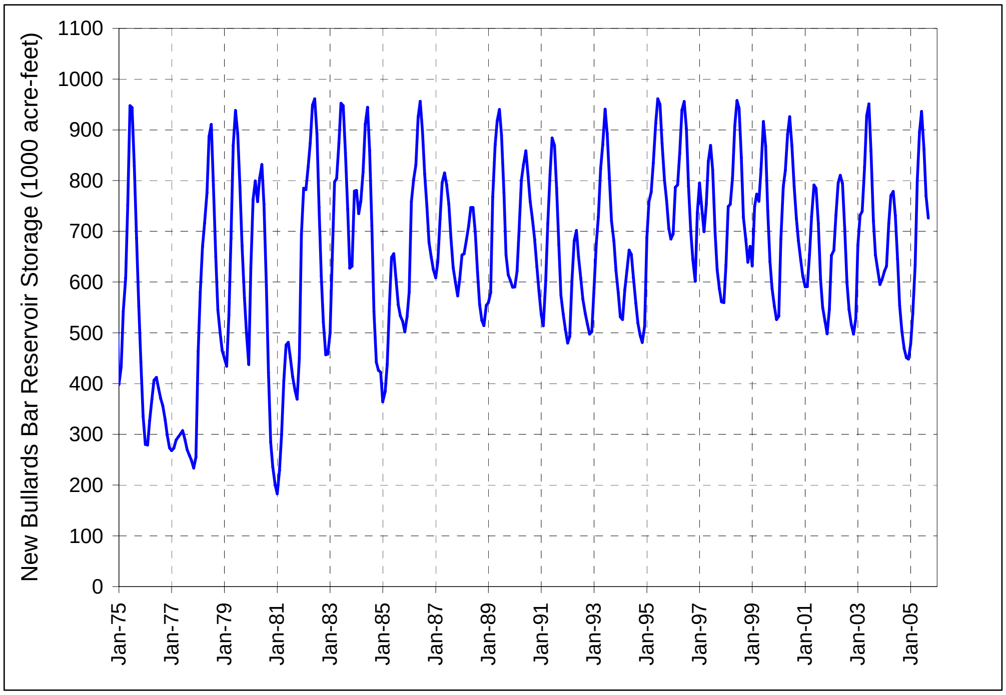

Figure B-15. New Bullards Bar Reservoir Monthly Storage Time Series

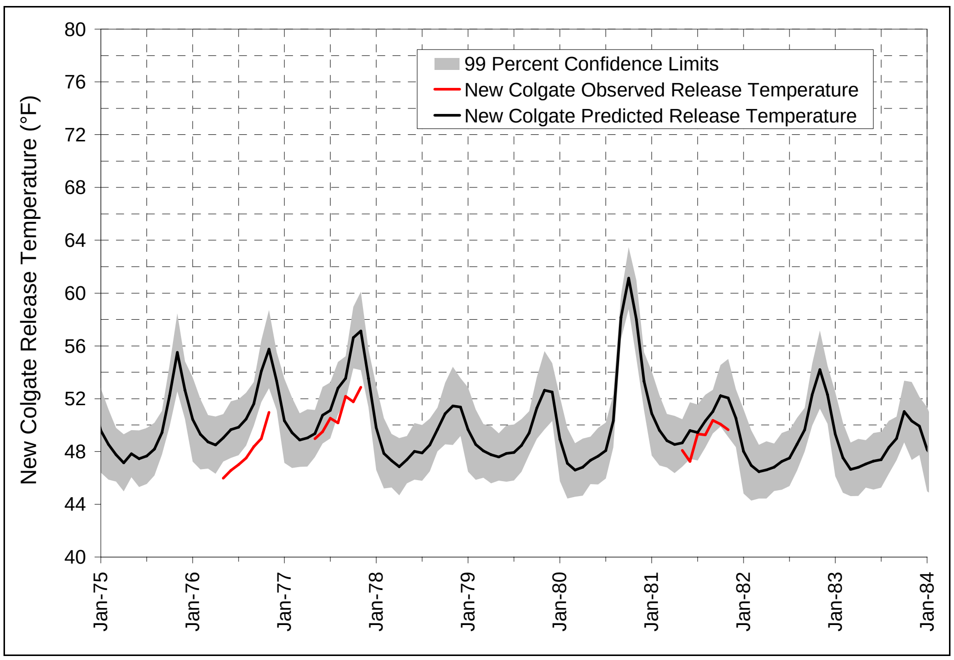

Figure B-16. Validation of New Colgate Release Temperature Model using Observed Release Temperature during 1976, 1977, and 1981[6]

[6] Observed release temperature is only shown at periods when release is made from the low-level outlet at New Bullards Bar Dam.

Model Comparison to Previous Studies

The statistical temperature model developed for the 2000 Hearings did not include a component to model New Colgate release temperature. However, a temperature model for New Colgate releases was developed in 1992 *(Water Temperature Modeling on the Yuba River, B-E 1992)*. That model used a similar concept to the model developed in this analysis, where temperature in the reservoir is modeled to predict water temperature at the low-level outlet, which is then used to estimate New Colgate release temperature. The main difference between the two approaches is that the 1992 model used a one-dimensional physical model to predict the temperature profile in the reservoir (CE-QUAL-R1), while the approach used in this study used average monthly temperature profiles of the reservoir. Another significant difference is the time step used in each model; the 1992 model used daily time step, while the current model uses monthly time step.

It has been determined that the one-dimensional physical model with daily time steps is not appropriate for the purpose of this analysis. This is primarily due to the large metrological data requirements of the one-dimensional model, which restricts its application over the complete period of analysis. Moreover, the New Colgate release temperature statistical model, developed in this analysis, has demonstrated adequate performance in predicting release temperature.

Impact of Reservoir Geometry on Temperature Profiles

Due to the three-dimensional (3-D) geometry of the New Bullards Bar Reservoir, as the elevation of water surface drops, the thickness of a water layer of certain volume will expand because of reduction in the plan area of the reservoir. This phenomenon could modify the temperature profile in the reservoir. However, analysis of the available historical record of temperature profiles did not support the presence of this effect. The available record of temperature profiles (1990 to 2005) documented surface water elevation variations of 139 feet (between 1,957 and 1,818 feet). Further analysis was undertaken based on conservation of warm water volumes as the reservoir elevation is reduced. Under this assumption, the upper temperature profile becomes elongated. However, changes in the temperature profile and the estimated water temperature at the low-level outlet were not significant compared to the observed variation in water temperature profiles from year to year for any given month. Therefore, distortion of the temperature profiles due to impacts of the reservoir 3-D geometry is not modeled.

B.4.2 NARROWS II POWERHOUSE RELEASE TEMPERATURE

Narrows II Powerhouse release temperature is modeled using a statistical relationship between Narrows II release temperature and temperature and volume of the inflows to Englebright Lake, as well as the effects of solar radiation and heat exchange with the overlaying warm air. This model relates the release temperature of Narrows II Powerhouse to changes in New Bullards Bar operations and to changes in New Colgate release temperature. Since Englebright Reservoir storage is maintained at a steady level during its normal operations, impact of reservoir elevation on release temperature is not modeled.

Model Description

Narrows II Powerhouse release temperature model is a multi-linear regression relationship that uses four independent variables:

- Average monthly New Colgate release temperature
- Average monthly Air temperature at Marysville
- Average monthly Englebright Lake inflows from New Bullards Bar
- Average monthly Englebright Lake inflows from sources other than New Bullards Bar Dam (i.e., Middle Yuba and South Yuba rivers)

Model Calibration

The Narrows II release temperature model is developed using data spanning the period of 1990 to present (data sets prior to 1990 were generally incomplete). The equation for Narrows II release temperature is:

$$N2 = 15.69 + 0.448^{*}\ NCT + 0.236^{*}\ AIR - 0.00064^{*}\ NBI + 0.00056^{*}\ YRI$$

Where

N2 = Release temperature of Narrows II Powerhouse (°F)
NCT = Release temperature of New Colgate Powerhouse (°F)
AIR = Air temperature at Marysville (°F)
NBI = Inflows to Englebright Lake from New Bullards Bar Dam (cfs)
YRI = Inflows to Englebright Lake from Middle Yuba and South Yuba river (cfs)

Comparison between observed and predicted release temperature at Narrows II Powerhouse is shown in **Figure B-17**. The comparison shows a good performance of the developed model for Narrows II release temperature (**Table B-4**). Although the fit between the observed and predicted is not complete, the observed release temperature falls well within the 99 percentile confidence limits of model predictions. In addition, model predictions closely match the seasonal trend in observed release temperature. As reported in **Table B-5**, statistical tests confirm the significance of all the parameters used in the temperature equation for Narrows II release.

The coefficients of the regression equation for Narrows II release temperature specifies the sensitivity of release temperature to each independent variable. A one degree increase in release temperature can be caused by an increase in New Colgate release temperature of 2.2 degrees, an increase in average monthly air temperature of 4.2 degrees at Marysville, a decrease in New Bullards Bar release of 1,600 cfs, or an increase of 1,800 cfs in the inflows from Middle and South Yuba rivers.

It should be noted that the maximum release capacity of New Colgate Powerhouse is about 3,500 cfs. Therefore, the relationships for the reservoir temperature model do not hold for flood control operations that require a release rate greater than 3,500 cfs. However, temperatures in the lower Yuba River are not a concern during flood control operations.

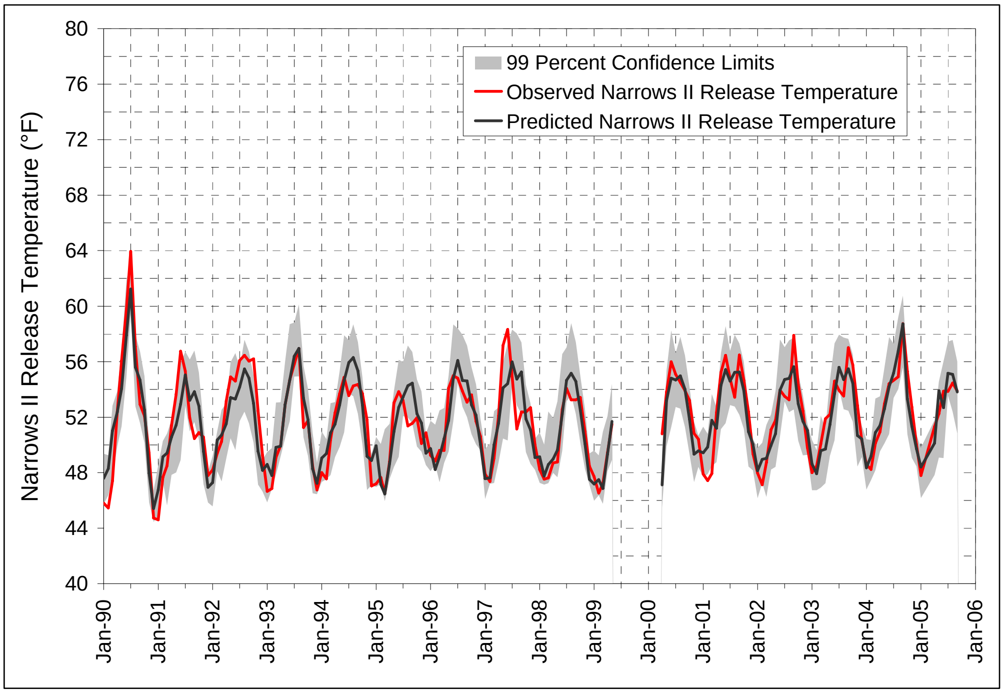

Figure B-17. Predicted and Observed Release Temperature at Narrows II Powerhouse for the period 1990 to 2005 (Calibration Results)

Table B-4. Performance Statistics for the Narrows II Release Temperature Equation

Statistic	Value
R-Square	0.792
Mean absolute error (°F)	1.18
Standard deviation of error (°F)	1.49

Table B-5. Statistical Significance Tests for the Parameters of the Narrows II Release Temperature Equation

Parameter	P-Value[7]
Intercept	3.1 E-08
NCT	5.1 E-14
AIR	3.1 E-53
NBI	2.4 E-06
YRI	6.0E-04

Model Validation

Figure B-18 compares the 1976 to 1984 observed and predicted release temperature for Narrows II. This period of the record is used for validation because it was not part of the calibration data set (1990 to 2005). Note that model predictions are only provided during periods when observed New Colgate release temperature is available.

[7] P-value tests whether each individual variable has a significant contribution to the relationship. If p-value is less than 0.05, then its corresponding variable is a significant predictor in the relationship.

Figure B-18 shows that predicted release temperature reasonable matched the general monthly trend of observed temperature. Although observed temperature fell below the 99 percentile confidence limits of model prediction during some periods, average absolute prediction error for the validation test was about 2.6°F.

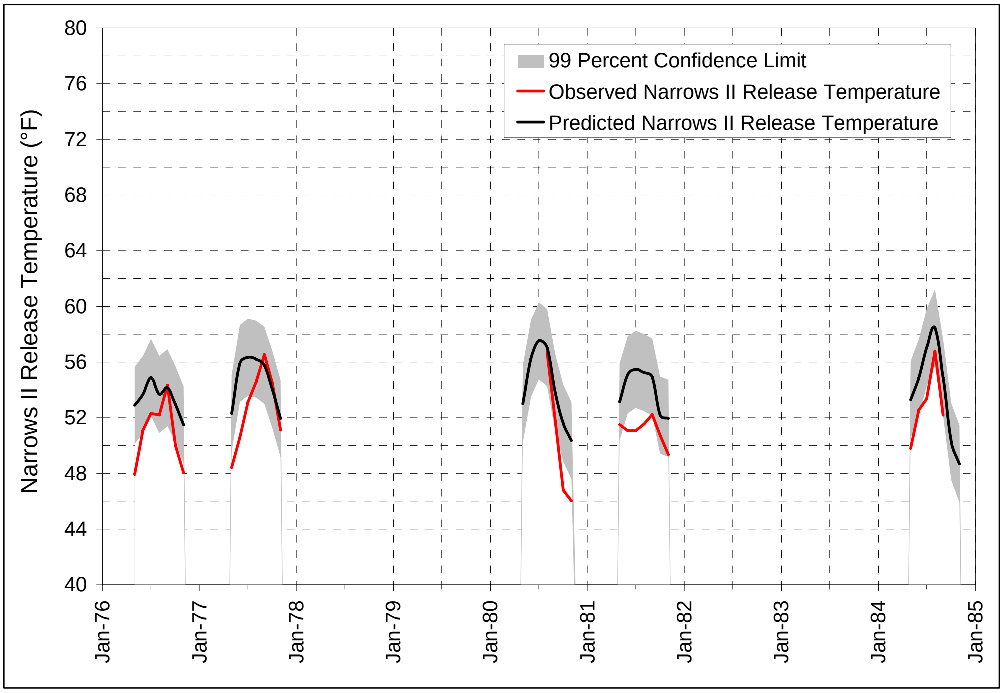

Figure B-18. Validation of Narrows II Release Temperature Model Using Observed Release Temperature at Narrows II Powerhouse for the Period 1976 to 1985

Model Comparison to Previous Studies

Two statistical temperature models were developed previously for water temperature below Englebright Dam: the temperature model for the 2000 Hearings and the temperature model developed in 1992 (*Water Temperature Modeling on the Yuba River, B-E 1992*). All models for water temperature below Englebright Dam, including the one developed in this study, used a multi-linear regression approach. The two previous models used two independent variables: (1) New Colgate release temperature and (2) average monthly air temperature at Marysville. The model developed under this analysis extends the previous two models by including flow terms in the regression equation, in addition to the temperature terms; it uses four independent variables: (1) New Colgate release temperature, (2) average monthly air temperature at Marysville, (3) Englebright Lake inflows from New Bullards Bar, and (4) Englebright Lake inflows from sources other than New Bullards Bar Dam (i.e., Middle Yuba and South Yuba river).

In this study, temperature relation for Narrows II is developed using monthly average temperature and inflows to Englebright Lake to account for detention time in the lake. This agrees with the approach adopted by the 1992 temperature model, where 20-day running average temperature was used to account for the effects of detention in Englebright Lake. In addition to a monthly temperature relation, the 2000 Hearings study also developed daily flow temperature relations, by month, for water temperature below Englebright Dam. These daily relations had noticeably lower R-square values compared to the monthly relation. This again emphasizes the need to account for effects of detention in Englebright Lake.

Inclusion of flow terms into the regression relation has improved the overall performance of the temperature model, where its R-Square improved from 0.64 in the 2000 Hearing model to 0.79 under the new model. This is an additional evidence of the significance of the flow terms in the regression relationship, which has been confirmed by the statistical tests (Table B-5). Moreover, including the flow terms in the regression equation allows for evaluating the impact of changed release pattern in New Bullards Bar Dam on temperature in lower Yuba River.

B.4.3 DAGUERRE POINT DAM WATER TEMPERATURE

Daguerre Point Dam is approximately 12 miles downstream of Englebright Dam. The terrain for this reach of the river varies significantly from a steep, narrow gorge near Englebright Dam to a wide, flat, open area near Daguerre Point. Also, there are multiple accretions and depletions between Englebright Dam and Daguerre Point, including Deer Creek, Dry Creek, and the Yuba River Goldfields. While there is a flow gage at the mouth of Deer Creek, there are limited temperature data for any of these locations and there are no flow gages below Deer Creek, except for the Marysville Gage.

Factors controlling Yuba River temperature at Daguerre Point include temperature of the releases form Englebright Dam and heat exchange in the river, which is affected by both climatic conditions and volume of the flow in the river. The impacts of inflows from Deer Creek on river temperature at Daguerre Point is not modeled because of the scarcity of temperature data for these inflows, in addition to their small volumes compared to the flows in Yuba River.

Model Description

The Daguerre Point Dam temperature model is a multi-linear regression relation that uses three independent variables:

- Narrows II release temperature
- Flow at Smartville
- Air temperature at Marysville

Two separate models are developed and compared for Daguerre Point, a single-relation model and a monthly-relations model. The monthly-relations model estimates water temperature at Daguerre Point using a set of unique coefficients for each month. The monthly relations are developed to assess the relative influence of the independent variable on a monthly basis.

Model Calibration

The Daguerre Point temperature models are developed using data spanning the periods of 1976, 1977, and 2000 to 2005. Additional available data set between 1997 and 2000 was reserved for model validation purposes. Although the temperature models developed in this study use monthly time-steps, calibration of Daguerre Point temperature model is carried-out using daily data. Use of daily data for calibration provides a larger data set for calibration compared to using monthly average data. This is especially important because of the short available temperature record at Daguerre Point. Moreover, because of the short travel time between Englebright Dam and Daguerre Point Dam, using daily data for calibration of models that uses monthly time-steps is considered appropriate.

Observation of the relation between flows and temperature shows a reduction in the influence on water temperature as flows increase, while influence increase for lower flows. Therefore, a linear relationship between flow and temperature will tend to overestimate predicted water temperature at higher flows and underestimate water temperature at low flows. To capture this nonlinear effect a logarithmic relationship between flows and temperature is used in place of the linear relationship. Daguerre Point water temperature representative equation has the form:

$$DGP = A + B^* N2 + C^* AIR + D^* Ln (SMF)$$

Where

DGP = Water temperature at Daguerre Point Dam (°F)
N2 = Release temperature of Narrows II powerhouse (°F)
AIR = Air temperature at Marysville (°F)
SMF = Yuba River Flow at Smartville gage (cfs)
A, B, C, D = Coefficients
Ln ( ) = the natural logarithm

Table B-6 presents the regression coefficients for the two models of Daguerre Point water temperature. **Figure B-19** and **Figure B-20** compare the observed and predicted water temperature at Daguerre Point using the monthly-relations model for the periods 2000 to 2005 and 1976 to 1977, respectively. The comparison shows a good performance of the developed monthly-relation model for Daguerre Point water temperature. The observed water temperatures fall well within the 99 percentile confidence limits of model predictions.

Table B-6. Model Coefficients of Water Temperature at Daguerre Point Dam

	Coefficients			
	A	B	C	D
Single-Relation	37.3	0.353	0.277	-2.636
Monthly-Relations				
January	21.6	0.345	0.170	0.180
February	8.0	0.653	0.179	-0.080
March	15.9	0.708	0.135	-1.030
April	53.2	0.108	0.126	-1.738
May	46.7	0.281	0.183	-2.363
June	57.1	0.271	0.108	-2.836
July	83.9	0.090	0.082	-4.948
August	86.4	0.066	0.037	-4.728
September	83.2	-0.067	0.116	-4.274
October	52.9	0.274	0.135	-2.895
November	2.5	0.877	0.148	-0.585
December	29.6	0.274	0.148	-0.221

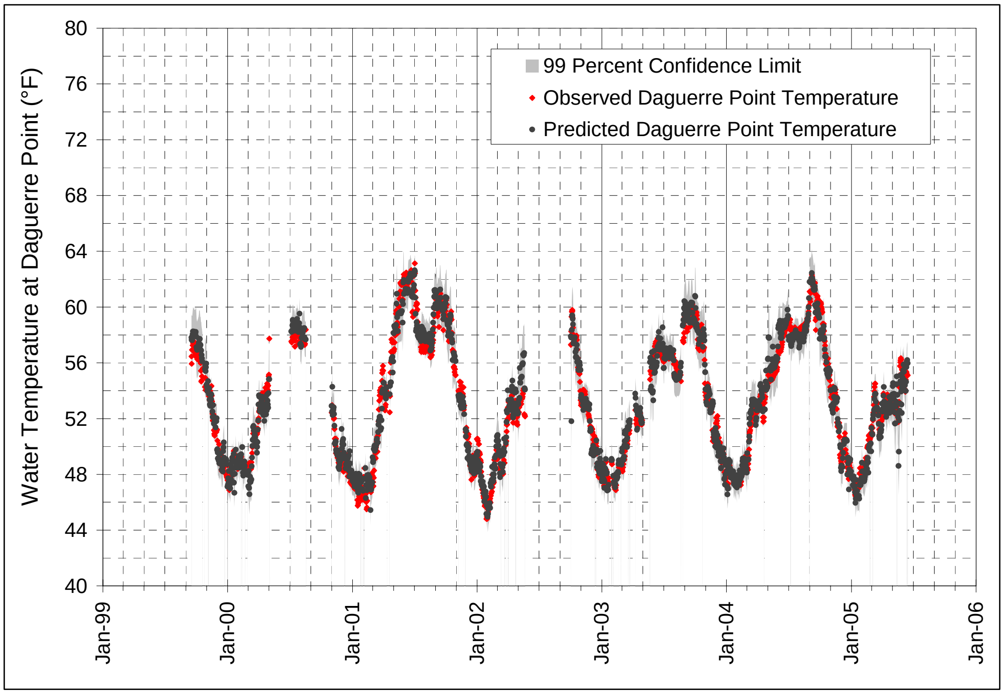

Figure B-19. Predicted and Observed Release Temperature at Daguerre Point Dam for the Period 1999 to 2005 (Calibration Results)

Note: Temperature Predictions are developed using the monthly-relations model.

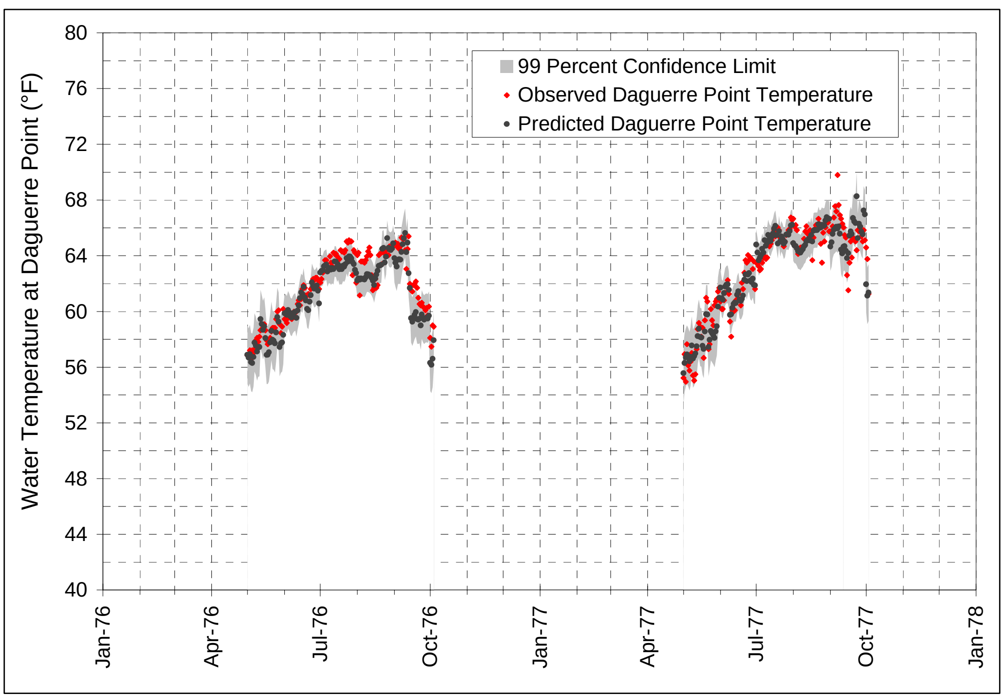

Figure B-20. Predicted and Observed Release Temperature at Daguerre Point Dam for the Period 1976 to 1977 (Calibration Results)

Note: Temperature Predictions are developed using the monthly-relations model.

Table B-7 reports the performance statistics of the developed single-relation and monthly-relation models for Daguerre Point water temperature. Performance statistics show an overall improved performance of the monthly-relations model over the single-relations model. This is caused by the additional degrees of freedom provided in the monthly-relations model, which has a total of 48 coefficients compared to 4 coefficients for the single-relation model. In addition, the monthly-relations model has the ability to capture effects of seasonal controls on river temperature that are not captured by the three independent variables, e.g., inflows from Deer Creek and Dry Creek.

Table B-7. Performance Statistics for the Daguerre Point Dam Water Temperature Models

Statistics	Single-Relation Model	Monthly-Relations Model	Percent Change
R-Square	0.861	0.971	+13%
Mean absolute error (°F)	1.57	0.68	-57%
Standard deviation of error (°F)	1.97	0.90	-54%

The coefficients of the regression equation specify the sensitivity of water temperature to each independent variable. Based on the single-relation model, a one degree increase in water temperature at Daguerre Point can be caused by an increase in release temperature in Narrows II of 2.8°F, an increase in Maysville air temperature of 3.6 °F, or a 46 percent decrease in river flow at Smartville. However, the sensitivity of water temperature to these factors varies from month to month.

Table B-8 shows the results of statistical significance tests for Daguerre Point temperature models. The tests confirm the significance of all the parameters used in the single-relation temperature equation. However, results of the significance test were not consistent for the monthly-relations model. The coefficients corresponding to Marysville air temperature were all significant predicators in the model. On the other hand, the coefficients corresponding to Narrows II release temperatures were insignificant predicators during the months of April, July, and August. The coefficients corresponding to Smartville flows were insignificant predicators during the months of January, February, and December. These monthly coefficients were reported insignificant because the historical record used for calibration showed limited influence of their corresponding variables on river temperature during the specified months.

Model Validation

To validate the developed models for water temperature at Daguerre Point, the data set for the period 1997 to 2000, which was not part of the calibration data set, was used. The validation test was carried-out at monthly time-steps because the developed models will be applied to estimate average monthly temperature in lower Yuba River. **Figure B-21** shows the comparison between the observed and predicted monthly water temperature at Daguerre Point for the period 1997 to 2000. It shows that predicted water temperatures, from both the single-relation and monthly-relations model, reasonably matched the observed temperature. The average absolute prediction errors in the validation test for the single-relation and monthly-relations models are 1.7 °F and 0.8 °F, respectively. This is additional evidence in favor of the monthly-relations model over the single-relation model.

Table B-8. Statistical Significance Tests for the Parameters of the Daguerre Point Dam Water Models

	P-Value[8]			
	A	B	C	D
Single-Relation	1E-237	8.1E-72	0	2E-296
Monthly-Relations				
January	2.1E-15	3.7E-09	1.9E-28	1.3E-01
February	5.5E-03	8.4E-19	2.4E-21	3.4E-01
March	8.4E-09	1.0E-25	6.3E-22	2.8E-18
April	1.5E-21	1.8E-01	5.5E-27	1.2E-19
May	3.9E-58	2.8E-09	9.4E-22	2.2E-50
June	4.0E-78	1.2E-13	9.2E-21	1.5E-72
July	3.8E-76	1.1E-01	3.9E-13	2E-121
August	2.5E-64	3.3E-01	4.0E-03	5E-117
September	8.8E-91	1.3E-02	2.2E-15	1.2E-66
October	1.1E-24	5.0E-05	2.4E-14	5.2E-15
November	4.9E-01	1.0E-26	9.6E-25	6.5E-04
December	3.0E-23	7.2E-09	6.4E-21	1.2E-01

* P-values highlighted in red correspond to coefficients that are statistically insignificant.

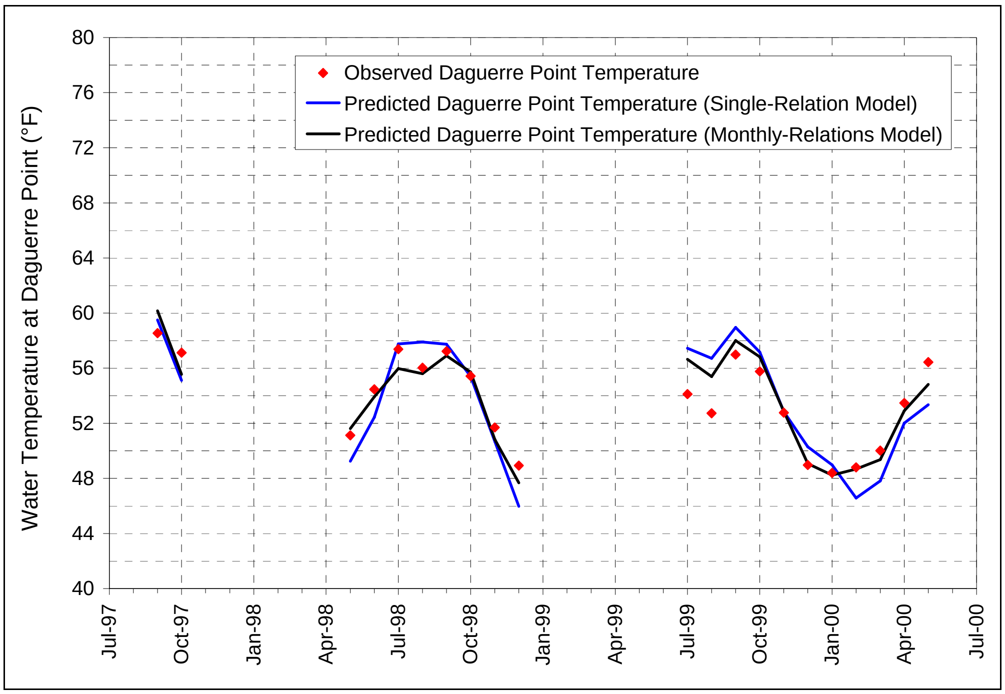

Figure B-21. Predicted and Observed Release Temperature at Daguerre Point Dam for the Period 1997 to 2000 (Validation Results)

Model Comparison to Previous Studies

Two temperature models were developed previously for water temperature at Daguerre Point Dam: (1) the statistical temperature model for the 2000 Hearings and (2) the one-dimensional physical temperature model (HEC-5Q) developed in 1992 (*Water Temperature Modeling on the Yuba River, B-E 1992*). The model developed under this analysis extends the statistical model

[8] P-value tests whether each individual variable has a significant contribution to the relationship. If p-value is less than 0.05, then its corresponding variable is a significant predictor in the relationship.

developed for the 2000 Hearings. The physical approach (HEC-5Q) is not used because of the large data input requirements, which include continuous metrological and flow data, as well as river cross sections information.

Because of the limited calibration data, the 2000 Hearings model developed a regression relationship for temperature at Daguerre Point using river temperature at Marysville, in addition to Marysville air temperature and Yuba River flow at the Marysville Gage. An additional relationship was also developed that replaced Marysville water temperature with release temperature at New Colgate. Similar to the approach used in this analysis, the 2000 Hearings model developed single-relation and monthly-relations models that were calibrated using daily data.

For the purpose of this study, additional five years of continuous daily temperature data is made available at Daguerre Point Dam (2000 to 2005). This additional data set allowed for the development of direct relationship between temperature of releases from Englebright Dam (Narrows II release temperature) and river temperature at Daguerre Point. Additionally, the temperature relationships developed in this study used flow at Smartville as an independent variable in place of flow at Marysville. The relationship between flow and temperature is also changed from a linear to a logarithmic relation to capture the observed behavior of flow and temperature relation in the calibration data set.

B.4.4 WATER TEMPERATURE AT MARYSVILLE GAGE

The Marysville Gage is approximately six miles downstream of Daguerre Point Dam. The river in this reach is relatively wide and flat, with very little cover or shade. There are few accretions or depletions in this reach. While the Yuba Goldfields have an influence on water temperatures, they are relatively high in the reach, and the flow reaches equilibrium with the Goldfield return flow temperature by the time it reaches the Marysville Gage. Therefore, the impact of Goldfield is not explicitly modeled.

Factors controlling Yuba River temperature at Marysville include temperature of the releases form Englebright Dam and heat exchange in the river, which is affected by both climatic conditions and volume of the flow in the river. The volume of the flow in the Yuba River is a function of both Englebright releases and diversions at Daguerre Point Dam.

Model Description

The Marysville water temperature model is a multi-linear regression relation that uses four independent variables:

- Narrows II release temperature
- Air temperature at Marysville
- Flow at Marysville
- Flow at Smartville

Yuba River flows in both Marysville and Smartville are used in order to capture the impacts of water diversions at Daguerre Point Dam. Two separate models are developed and compared for Marysville, a single-relation model and a monthly-relations model. The monthly-relations model estimates water temperature at Marysville using a set of unique coefficients for each month. The monthly relations are developed to assess the relative influence of the independent variable on a monthly basis.

Model Calibration

The Daguerre Point temperature models are developed using data spanning the periods of 1976, 1977, and 2000 to 2005. Additional available data set between 1990 and 2000 was reserved for model validation purposes. Although the temperature models developed in this study use monthly time-steps, calibration of Marysville temperature model is carried-out using daily data because it provides a larger data set for calibration compared to using monthly average data.

Similar to the models developed for Daguerre Point water temperature, a logarithmic relationship between flows and temperature is used. Marysville water temperature representative equation has the form:

$$MAR = A + B^* N2 + C^* AIR + D^* Ln(MRF) + E^* Ln(SMF)$$

Where

MAR = Water temperature at Marysville (°F)
N2 = Release temperature of Narrows II powerhouse (°F)
AIR = Air temperature at Marysville (°F)
MRF = Yuba River Flow at Marysville Gage (cfs)
SMF = Yuba River Flow at Smartville Gage (cfs)
A, B, C, D = Coefficients
Ln ( ) = the natural logarithm

Table B-9 presents the regression coefficients for the two models of Marysville water temperature. **Figure B-22** and **Figure B-23** compare the observed and predicted water temperature at Marysville using the monthly-relations model for the periods 2000 to 2005 and 1976 to 1977, respectively. The comparison shows a good performance of the developed monthly-relations model for Marysville water temperature. The observed water temperatures fall well within the 99 percentile confidence limits of model predictions.

Table B-10 reports the performance statistics of the developed single-relation and monthly-relation models for Marysville water temperature. Performance statistics show an overall improved performance of the monthly-relations model over the single-relations model. This is caused by the additional degrees of freedom provided in the monthly-relations model, which has a total of 60 coefficients compared to 5 coefficients for the single-relation model. In addition, the monthly-relations model has the ability to capture effects of seasonal controls on river temperature that are not captured by the four independent variables.

Table B-9. Model Coefficients of Water Temperature at Marysville

	Coefficients				
	A	B	C	D	E
Single-Relation	47.97	0.197	0.300	-4.873	1.723
Monthly-Relations					
January	2.57	0.778	0.120	0.321	0.033
February	11.12	0.870	0.145	1.662	-3.252
March	16.33	0.843	0.116	1.439	-3.238
April	49.33	-0.144	0.075	-0.493	1.393
May	53.64	0.085	0.237	-3.590	1.203
June	67.63	0.243	0.167	-3.313	-1.161
July	93.21	0.245	0.111	-3.311	-4.139
August	117.53	-0.496	0.099	-4.529	-0.962
September	97.30	-0.173	0.092	-4.380	-0.666
October	63.83	0.202	0.214	-2.454	-2.155
November	3.36	0.842	0.226	0.094	-0.999
December	36.27	0.141	0.141	-0.801	0.683

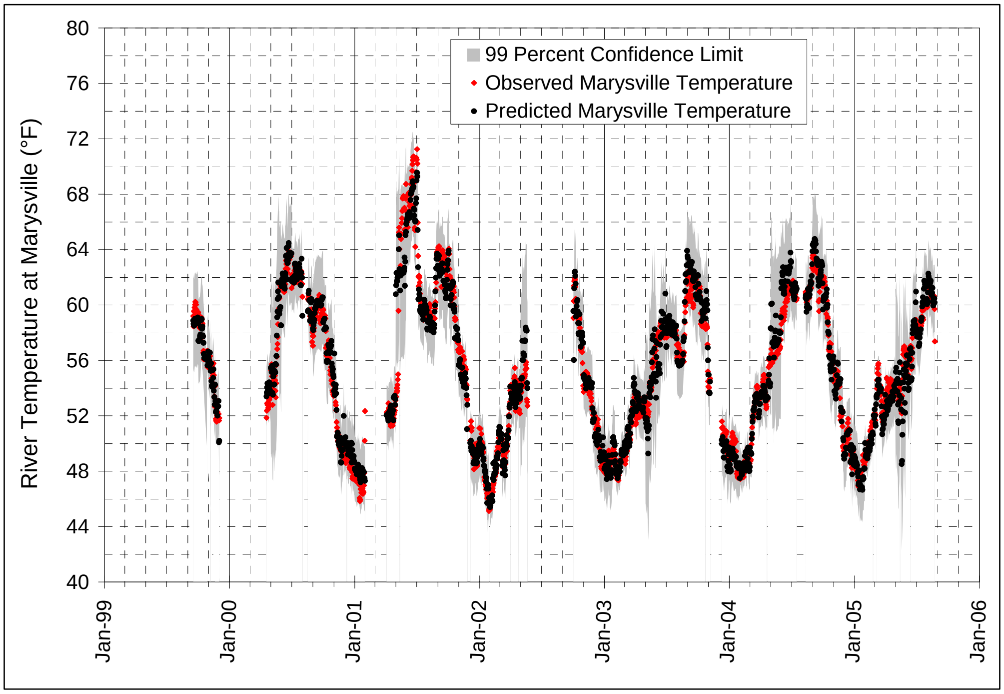

Figure B-22. Predicted and Observed Release Temperature at Marysville for the period 1999 to 2005 (Calibration Results)

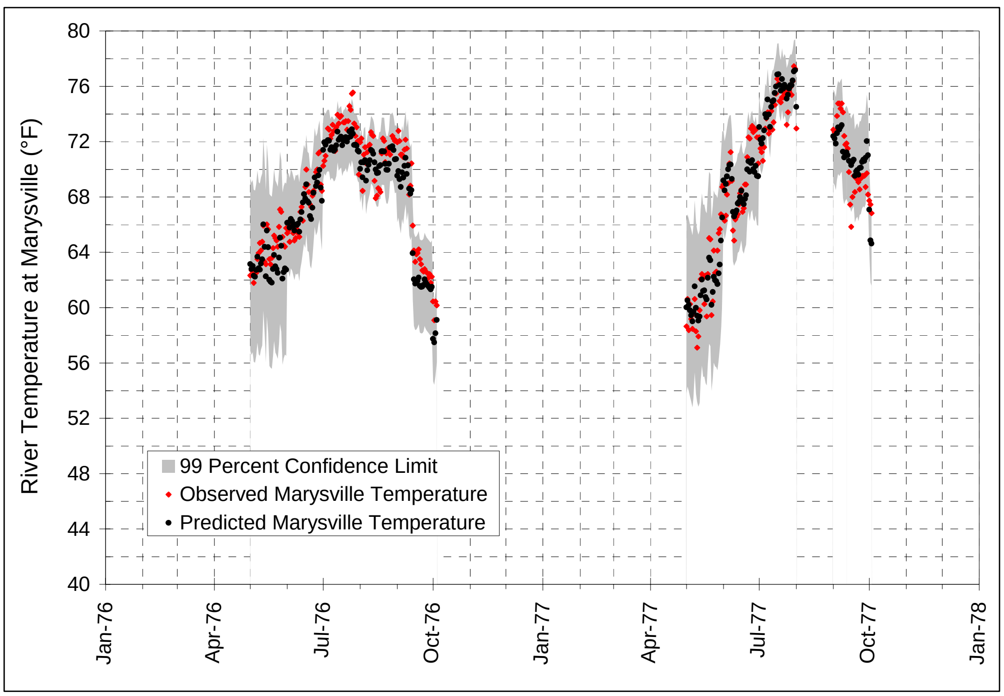

Figure B-23. Predicted and Observed Release Temperature at Marysville for the Period 1976 to 1977 (Calibration Results)

Table B-10. Performance Statistics for the Marysville Water Temperature Models

Statistics	Single-Relation Model	Monthly-Relations Model	Percent Change
R-Square	0.870	0.964	+11%
Mean absolute error (°F)	1.93	0.85	-56%
Standard deviation of error (°F)	2.48	1.26	-49%

The coefficients of the regression equation specify the sensitivity of water temperature to each independent variable. Based on the single-relation model, a one degree increase in water temperature at Marysville can be caused by an increase in release temperature in Narrows II of 5.1°F, an increase in Maysville air temperature of 3.3°F, or a 22 percent decrease in river flow at Marysville. However, the sensitivity of water temperature to these factors varies from month to month.

Table B-11 shows the results of statistical significance tests for Marysville temperature models. The tests confirm the significance of all the parameters used in the single-relation temperature equation. However, results of the significance test were not consistent for the monthly-relations model. Similar to Daguerre Point models, the coefficients corresponding to Marysville air temperature were all significant predicators in the model in all months. On the other hand, the coefficients corresponding to Narrows II release temperatures were insignificant predicators during the months of April and May. The coefficients corresponding to Marysville flows were insignificant predicators during the months of January, April, and November. The coefficients corresponding to Smartville flows were insignificant predicators during the months of January, May, June, August, and September. These monthly coefficients were reported insignificant because the historical record used for calibration showed limited influence of their corresponding variables on river temperature during the specified months.

Table B-11. Statistical Significance Tests for the Parameters of the Marysville Water Temperature Models

	P-Value[9]				
	A	B	C	D	E
Single-Relation	6E-221	1.8E-15	0	1E-186	2.4E-16
Monthly-Relations					
January	6.2E-01	2.6E-09	5.9E-08	4.6E-01	9.4E-01
February	8.9E-05	1.4E-26	7.3E-16	1.5E-05	3.9E-11
March	5.1E-06	1.6E-24	1.8E-19	2.9E-03	9.0E-09
April	6.6E-14	1.5E-01	1.3E-08	1.1E-01	6.6E-05
May	5.0E-34	2.4E-01	1.4E-15	2.7E-06	2.4E-01
June	2.6E-37	4.5E-06	7.1E-22	1.7E-05	3.0E-01
July	7.3E-54	5.8E-04	1.4E-16	3.5E-24	2.0E-15
August	8.8E-52	4.4E-05	3.2E-08	1.9E-32	5.1E-02
September	2.1E-97	6.2E-08	2.2E-09	2.6E-20	2.4E-01
October	1.6E-32	1.7E-03	3.3E-31	9.9E-11	4.3E-07
November	4.7E-01	3.0E-17	5.2E-29	7.3E-01	5.6E-06
December	5.0E-21	1.7E-02	3.5E-13	2.2E-04	7.8E-03

* P-values highlighted in red correspond to coefficients that are statistically insignificant

[9] P-value tests whether each individual variable has a significant contribution to the relationship. If p-value is less than 0.05, then its corresponding variable is a significant predictor in the relationship.

Model Validation

To validate the developed models for water temperature at Marysville, the data set for the period 1990 to 2000, which was not part of the calibration data set, was used. The validation test was carried-out at monthly time-steps because the developed models will be applied to estimate average monthly temperature in lower Yuba River. **Figure B-24** shows the comparison between the observed and predicted monthly water temperature at Marysville Point for the period 1990 to 2000. It shows that predicted water temperatures, from both the single-relation and monthly-relations model, reasonable matched the observed temperature. The average absolute prediction errors in the validation test for the single-relation and monthly-relations models are 1.9 °F and 1.5 °F, respectively.

Model Comparison to Previous Studies

Two temperature models were developed previously for water temperature at Marysville: (1) the statistical temperature model for the 2000 Hearings and (2) the one-dimensional physical temperature model (HEC-5Q) developed in 1992 (*Water Temperature Modeling on the Yuba River, B-E 1992*). The model developed under this analysis extends the statistical model developed for the 2000 Hearings. The physical approach (HEC-5Q) is not used because of the large data input requirements that restrict the use of the model over the complete simulating period.

The 2000 Hearings model used a regression relationship for temperature at Marysville using release temperature at Englebright Dam, Marysville air temperature, and Yuba River flow at Marysville Gage. Similar to the approach used in this analysis, the 2000 Hearings model developed single-relation and monthly-relations models that were calibrated using daily data.

The model developed for this analysis extends this relationship by adding a fourth independent variable, flow at Smartville. The use of two flow terms in the equation, flows at Marysville and Smartville, allows for capturing the effect of water diversions at Daguerre Point Dam. However, the relationship between flow and temperature has changed from a linear to a logarithmic relation to capture the observed behavior of flow and temperature relation in the calibration data set.

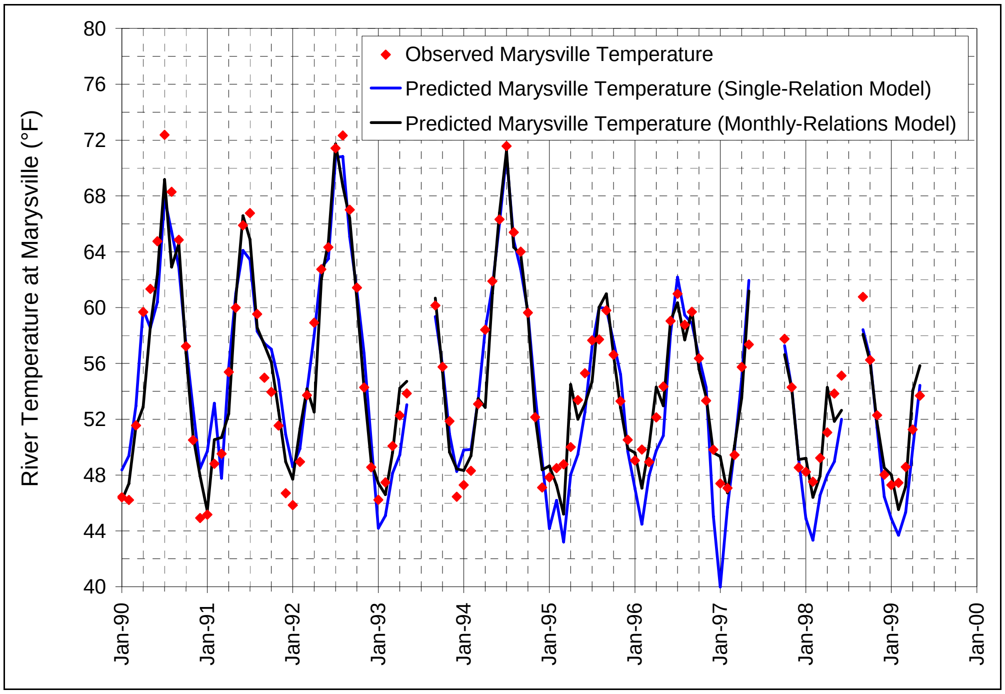

Figure B-24. Predicted and Observed Release Temperature at Marysville for the Period 1990 to 2000 (Calibration Results)

B.4.5 PREDICTION UNCERTAINTY OF TEMPERATURE MODELS

Error margins for the predictions of a certain model are determined by the standard deviation of calculated errors during model calibration. Standard devotions of calibration errors for the four model components for the lower Yuba River are reported in Table B-2, Table B-4, Table B-7, and Table B-10. Error margin corresponding to 99 percent confidence level is:

Error Margin = ± 2.56 * STD

Where

STD = standard deviation of calibration errors

Because of the linkage between the four components of lower Yuba River temperature model, prediction uncertainty of a certain component is carried over into the other models that depend on its output. **Table B-12** summarizes the prediction uncertainty of lower Yuba River temperature model that also accounts for the carry-over of errors. It should be noted that Table B-12 represents the upper bound on the expected errors of model predictions.

Table B-12. Upper Bound of Prediction Uncertainty of Lower Yuba River Water Temperature Model at 99 Percent Confidence Level

	Single-Relation Model	Monthly-Relations Model
New Colgate Release Temperature Model	± 2.3 °F	-
Narrows II Release Temperature Model	± 4.8 °F	-
Daguerre Point Temperature Model	± 6.7 °F	± 4.0 °F
Marysville Gage Temperature Model	± 8.1 °F	± 4.9 °F

B.5 REFERENCES

Bookman Edmonston Engineering, Inc. 1992. Water Temperature Modeling on the Yuba River.

YCWA. 2001. Lower Yuba River: Assessment of Proposed Water Temperature Requirements. Testimony of Stephen Grinnell, P.E., Yung-Hsin Sun, Ph.D., and Stuart Robertson, P.E. Prepared by Bookman-Edmonston Engineering, Inc.

Attachment C

Carry-over Storage for Water Transfers

Attachment C

Carry-over Storage for Water Transfers

Table of Contents

Attachment C
Carry-over Storage for Water Transfers

C.1 MECHANISMS FOR YCWA WATER TRANSFERS

YCWA has two mechanisms for transferring water: groundwater-substitution transfers and stored-water transfers. This attachment describes YCWA's ability to make these two types of transfers under RD-1644 Long-Term flow requirements and under the Yuba Accord Alternative, and the carry-over storage requirements[1] that are associated with these transfers.

C.1.1 GROUNDWATER SUBSTITUTION TRANSFERS

The quantities of water that YCWA and its Member Units can provide through groundwater-substitution transfers are not directly affected by the applicable instream-flow requirements. This is because groundwater substitutions create an additional water supply (which is provided locally at the farms in the service areas of YCWA's Member Units) and, as a result, do not create additional demands on surface water in the Yuba River. For the same reason, groundwater-substitution transfers do not affect the amount of carry-over storage that remains in New Bullards Bar Reservoir at the end of the water year during which the transfer occurs.

C.1.2 STORED WATER TRANSFERS

YCWA stored-water transfers are made with water surplus to the local needs for water from the Yuba River. Historically, YCWA has transferred water from storage in New Bullards Bar Reservoir because the volume of water in storage, in the absence of a transfer, has been greater than that needed locally for use within Yuba County plus the stored water needed at the end of the water year for drought protection for the upcoming year. However, if the volume of stored water needed for a given year for local water uses within Yuba County plus the volume of carry-over storage for drought protection for the next year exceeds the volume of water stored in New Bullards Bar Reservoir at the end of the water year without the transfer, YCWA would not be able to transfer any water from storage. Under these circumstances, YCWA would not have any stored water surplus to the volume needed for use within Yuba County and drought protection for the next year.

In almost all years when the annual runoff is greater than the average annual runoff, the volume of water needed for local use is less than the total volume of water released from storage for power generation plus the volume of uncontrolled runoff from the Middle and South Yuba rivers. In such years, without a transfer, New Bullards Bar Reservoir would be drawn down to an end-of-water-year storage of 705 TAF, the maximum September 30 storage volume specified in the 1966 YCWA/PG&E Power Purchase Contract.

Since YCWA is contractually obligated to PG&E to release a sufficient volume of water to reduce New Bullards Bar Reservoir storage to 705 TAF on September 30 of each year, water released to reach this storage level is not transferable. Transfers are only credited from releases

[1] In California, (annual) carry-over storage refers to the volume of water in storage at the end of the water year (September 30).

of stored water reducing September 30 storage to a level below 705 TAF. Therefore, the maximum amount of stored water that can be transferred in wetter years will normally be the difference between 705 TAF and the volume required on September 30 to meet all local water supply demands in the following year assuming the next year is very dry and runoff alone is not sufficient to meet all local demands for water in that year[2]. In drier years, when September 30 storage in the absence of a transfer would be less than 705 TAF, the maximum amount of stored water that may be transferred will normally be the difference between the September 30 storage volume occurring without the transfer and the storage amount required on September 30 in case the following year is very dry.

C.2 CARRY-OVER STORAGE FOR LOCAL DELIVERIES AND CARRY-OVER STORAGE FOR WATER TRANSFERS

As discussed in Section A.3.2.3 of Attachment A to the Modeling Technical Memorandum, modeling scenarios assume that New Bullards Bar Reservoir will be operated to meet a minimum carry-over storage volume to ensure minimum instream flow requirements and anticipated surface water deliveries to YCWA Member Units will be met the next year. If the next year is very dry, this reservoir carry-over storage will be used to make up the difference between the available surface water supply and total system demands for that year. Total system demands include local diversion demands, instream-flow requirements, and system operational losses.

The carry-over storage requirement varies depending on whether it is used to determine: (a) the stored water that may be released for local uses in the current year; or (b) the stored water that is available for water transfer during the current year. In the discussion below and in Attachment A to the Modeling Technical Memorandum, the first type of carry-over storage is referred to as “carry-over storage for local deliveries” and the second type of carry-over storage is referred to as “carry-over storage for water transfers.”

C.2.1 CARRY-OVER STORAGE FOR LOCAL DELIVERIES

Carry-over storage for local deliveries is the amount of carry-over storage required for YCWA to meet the applicable instream flow requirements and 50 percent of anticipated surface water demands of YCWA’s Member Units in the next water year, given a water year of a specified return period. For example, a 1-in-100-year return period means that the next year will be a 1-in-100 driest year. The value of 50 percent of anticipated surface water demands is used in modeling to provide a reasonable balance between supplying water for local uses in the current year and providing sufficient end-of-year storage for deliveries in the next year, in case the next year is very dry.

[2] Storage volumes can also be adjusted to a limited extent within a year, reducing reservoir releases during Delta excess water conditions and increasing reservoir releases during Delta balanced water conditions, with no change in end of September storage. This reoperation can generate additional water transfers.

With these provisions, Carry-over Storage for Local Deliveries is calculated as follows:

Carry-over Storage for Local Deliveries

= Annual diversion requirement with 50 percent deficiency

+ Annual instream flow requirement

+ Annual system operational loss

+ Annual evaporation (27 TAF)

+ Operation buffer (50 TAF)

+ Minimum pool (234 TAF)

- Available water for the lower Yuba River during the following year, if it were to have a specified hydrological condition, assumed in modeling to be a 1-in-100 driest year[3]

C.2.2 CARRY-OVER STORAGE FOR WATER TRANSFERS

The calculation of carry-over storage for water transfers is the same as the calculation of carry-over storage for local deliveries, except that carry-over storage for water transfers is calculated with retention of sufficient water to provide 100 percent deliveries to Member Units in the following year rather than 50 percent. This greater retention is necessary because YCWA may only transfer water surplus to the volume needed for local use, including the volume needed for local use in the next year if the next year is very dry. Thus, Carry-over Storage for Water Transfers is calculated as follows:

Carry-over Storage for Water Transfers

= Annual diversion requirement with 100 percent deliveries

+ Annual instream flow requirement

+ Annual system operational loss

+ Annual evaporation (27 TAF)

+ Operation buffer (50 TAF)

+ Minimum pool (234 TAF)

- Available water for the lower Yuba River during the following year, if it were to have a specified hydrological condition, assumed in modeling to be a 1-in-100 driest year

Since sufficient storage to provide 100 percent deliveries in the next year are required for carry-over storage for water transfers, it exceeds the volume of carry-over storage for local deliveries by 50 percent of the annual diversion requirement.

An increase in YCWA Member Units' total demand for surface water from YCWA will occur in the next few years when a new canal is constructed to convey surface water from the Yuba River to the Wheatland Water District. Construction of this canal is planned for construction in

[3] When calculating carry-over storage for local deliveries, the model does not maintain carry-over storage to meet 50 percent deliveries in the next year if maintaining that level of carry-over storage would require YCWA to impose deficiencies in its deliveries to its Member Units of more than 50 percent in the current year. This is because YCWA would not operate the Yuba Project so as to impose deficiencies of greater than 50 percent in the current year to protect against the risk of a curtailment of less than 50 percent in the next year.

2007, and deliveries to this area are planned to start in 2008 and to increase by blocks in subsequent years as distribution canals are added. The first phase of the Wheatland Water District Project (Wheatland Project) is estimated to have a total annual demand of 29 TAF. This demand will not all come online in 2008; a reasonable estimate is that 60 percent of this demand will be served in 2008, 80 percent in 2009 and 100 percent in 2010. The projected annual diversion requirements for calculation of carry-over storage amounts will be approximately 304 TAF for 2007, 321 TAF for 2008, 327 TAF for 2009 and 333 TAF for 2010 and subsequent years. After the completion of the second phase of the project, it is estimated that the total annual demand of the Wheatland Water District will be 40 TAF, and` the projected annual diversion requirements for calculation of carry-over storage amounts will be 344 TAF[4].

C.3 CARRY-OVER STORAGE FOR WATER TRANSFERS UNDER RD-1644 LONG-TERM INSTREAM-FLOW REQUIREMENTS

Combining YCWA's projected schedule of demands, protection for a 1-in-100-year return period drought event, the RD-1644 Long Term instream-flow requirements, and the Wheatland Water District demands described above, the carry-over storage for water transfers will be 670 TAF in 2007, 687 TAF in 2008, 693 TAF in 2009, 699 TAF in 2010 and 710 TAF after the second phase of the Wheatland Project is completed.

Subtracting these amounts from the September 30 maximum storage volume of 705 TAF specified in the 1966 YCWA/PG&E Power Purchase Contract indicates, if RD-1644 Long Term instream-flow requirements were in place, then 35 TAF of surface-water transfers could occur in 2007, 18 TAF in 2008, 12 TAF in 2009 and 6 TAF in 2010. Because the required carry-over storage for water transfers after the completion of the second phase of the Wheatland Project will be 710 TAF, exceeding the 705 TAF September 30 maximum storage volume in the 1966 Power Purchase Contract, YCWA would not be able to make stored-water transfers if the RD-1644 Long-Term instream-flow requirements were in place.

C.4 CARRY-OVER STORAGE FOR WATER TRANSFERS UNDER THE YUBA ACCORD ALTERNATIVE

If the Yuba Accord Alternative is in place, the required carry-over storage for water transfers will be lower; the total amount of water needed to meet instream flow-requirements in a 1-in-100 Conference Year is lower than the total amount of water needed to meet the RD-1644 Long-Term instream-flow requirements in a 1-in-100 Extreme Critical Year. With the Yuba Accord instream-flow requirements and YCWA Member Unit demands, including the second phase of the Wheatland Project, of 344 TAF per year, carry-over storage for water transfers is 648 TAF[5]. This is consistent with the target carry-over storage of 650 TAF for operations under the Yuba Accord Alternative.

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[4] The carry-over storage for local deliveries is calculated assuming that there will be a normal year during the following October through March and a critical water year during the subsequent April through September. This calculation results in a carry-over storage for local deliveries of 343,093 acre-feet.

[5] For calculation of the available water in the lower Yuba River it is assumed that a 1:100 year Conference Year corresponds to a 1:100 year unimpaired flow in the Yuba River (see Attachment A).

As noted in Table A-9, if the volume of carry-over storage for water transfers was calculated based on the driest type of Schedule 6 water year, then this amount would be 692 TAF[6]. This amount is higher than the 648 TAF for Conference Years because the total amount of water needed for Schedule 6 instream-flow requirements exceeds the total amount of water needed for Conference Year instream-flow requirements by 45 TAF, while the total unimpaired flow in the driest type of Schedule 6 year would equal the total unimpaired river flow in a 1-in-100 Conference Year.

To determine the feasibility of water transfers under the Yuba Accord, YCWA is using the carry-over storage for water transfers amount based on a 1-in-100 Conference Year, with the understanding that if a very dry Schedule 6 year were to occur, YCWA and its Member Units would have to address resulting deficiencies.

[6] There is a 5 percent probability that the North Yuba Index will be less than the value that marks the break between Schedule 5 and Schedule 6 years.

APPENDIX E

FISHERIES RESOURCES

ANALYTICAL APPROACH AND ANALYSES

APPENDIX E1

ANADROMOUS SALMONID SPAWNING HABITAT – FLOW ANALYSES

Appendix E1

Anadromous Salmonid Spawning Habitat – Flow Analyses

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Appendix E1
Anadromous Salmonid Spawning Habitat – Flow Analyses

1.0 INTRODUCTION

The potential flow-related effects of the Proposed Project/Action, relative to the Environmental Baseline, on the adult spawning life stage of anadromous salmonids in the lower Yuba River and the lower Feather River are evaluated through the analysis of spawning habitat available to each run/species throughout their spawning seasons.

Available spawning habitat for fall-run Chinook salmon in the lower Yuba River is expressed as a scaled composite weighted usable area that corresponds to the particular species available spawning habitat under the monthly flows throughout the spawning season. The scaled composite weighted usable area (i.e., $\widehat{CWUA}_Y$) is calculated as the sum of the weighted usable areas that correspond to the monthly flows during the species spawning season within various reaches, multiplied by a spatial weighting coefficient that represents the average relative spawning intensity in a particular reach, and by a temporal weighting coefficient that represents the average relative spawning intensity in a particular month, divided by the sum of the maximum weighted usable area (WUA) of each reach multiplied by their corresponding spatial and temporal weighting coefficients.

For a hypothetical salmonid run that spawns within 3 distinct reaches, during 4 months of a particular year or season *Y*, the scaled composite weighted usable area (i.e., $\widehat{CWUA}_Y$) is expressed by the following formula:

$$\widehat{CWUA}_Y = \frac{\sum_{m=1}^{4}\sum_{k=1}^{3} WUA_k\left(Q_{m,Y}\right) \times w_k \times w_m}{\sum_{m=1}^{4}\sum_{k=1}^{3} \max\left(WUA_k\right) \times w_k \times w_m} \qquad \textbf{(1)}$$

where $WUA_k\left(Q_{m,Y}\right)$ is the weighted usable area (WUA) of reach *k* at the monthly flow $Q_{m,Y}$ obtained from the WUA-flow relationships developed by the most recent IFIM studies performed in the spawning areas of the particular species. The maximum weighted usable area of reach *k* over the flow range for which the WUA-flow relationships were developed is expressed as $\max\left(WUA_k\right)$, and w_k and w_m are the spatial and temporal weighting coefficients for the species being analyzed.

For anadromous salmonids in the lower Feather River, and for spring-run Chinook salmon and steelhead in the lower Yuba River, available spawning habitat is expressed by a scaled weighted usable area that corresponds to the species particular available spawning habitat under the monthly flows during the spawning season. The scaled weighted usable area (i.e., $\widehat{WUA}_Y$) is calculated as the sum of the weighted usable areas that correspond to the monthly flows during the species spawning season within various reaches divided by the sum of the maximum WUA of each reach.

For a hypothetical salmonid run that spawns within 3 distinct reaches, during 4 months of a particular year or season *Y*, the scaled weighted usable area (i.e., $\widehat{WUA}_Y$) is expressed by the following formula:

$$\widehat{WUA}_Y = \frac{\sum_{m=1}^{4}\sum_{k=1}^{3} WUA_k\left(Q_{m,Y}\right)}{\sum_{m=1}^{4}\sum_{k=1}^{3} \max\left(WUA_k\right)} \qquad \textbf{(2)}$$

The scaled composite weighted usable area (equation 1) is utilized in the lower Yuba River for fall-run Chinook salmon, but not on the Feather River, or for steelhead or spring-run Chinook salmon in the lower Yuba River, for the following reasons. First, because the Proposed Project/Action includes implementing the lower Yuba River Accord flow schedules, there is a greater emphasis regarding potential changes to salmonid spawning habitat availability in the lower Yuba River than in the Feather River. Thus, an examination of salmonid spawning habitat availability that incorporates species/run-specific spatial and temporal distributions of spawning is assumed to be appropriate for application on the lower Yuba River. Second, data describing run-specific spatial and temporal distributions for steelhead in the lower Yuba River, and for steelhead and Chinook salmon in the Feather River, are somewhat limited relative to the data available for fall-run Chinook salmon in the lower Yuba River. For example, in the Feather River, only four years (i.e., 2000-2003) of fall-run Chinook salmon escapement survey data are available to develop temporal weighting coefficients, compared to 14 years (i.e., 1991-2004) of Chinook salmon escapement data available on the lower Yuba River (YCWA 1992; YCWA 1994; YCWA 1995; YCWA 1996; YCWA 1997; YCWA 1998; YCWA 1999; YCWA 2000; YCWA 2001; YCWA 2002; YCWA 2003; YCWA 2006a; YCWA 2006b).

Table 1-1 summarizes the use of $\widehat{CWUA}_Y$ (equation 1) and $\widehat{WUA}_Y$ (equation 2) in the calculation of annual spawning habitat availability by river and species, specifying the months (*m*) and river reaches (*k*) over which the summations are performed.

The following sections describe the data and calculations utilized to develop the main components of $\widehat{CWUA}_Y$ (equation 1) and $\widehat{WUA}_Y$ (equation 2):

1) WUA-flow relationships per river and species/run ($WUA_k\left(Q\right)$);

2) Spatial weighting coefficients (W_k); and

3) Temporal weighting coefficients (W_m).

Table 1-1. Summary of Calculations of Annual Spawning Habitat Availability Indexes by River and Species

River	Species	WUA Equation	Months (*m*)	Reaches (*k*)
Feather	Chinook salmon (Spring- + Fall-run)	2	4 (Sep - Dec)	2 (Upstream and downstream Thermalito Afterbay Outlet)
	Steelhead		5 (Dec – Apr)	
Yuba	Spring-run Chinook salmon	2	3 (Sep - Nov)	1 (Upstream Daguerre Point Dam)
	Fall-run Chinook salmon	1	4 (Oct – Jan)	2 (Upstream and Downstream Daguerre Point Dam)
	Steelhead	2	4 (Jan – Apr)	1 (Upstream Daguerre Point Dam)

2.0 WUA-FLOW RELATIONSHIPS

The weighted usable area of a given reach *k* at a monthly flow $Q_{m,Y}$ (i.e., $WUA_k(Q_{m,Y})$ in equations 1 and 2) is obtained from the WUA-flow relationships developed by the most recent IFIM studies performed in the spawning grounds of the particular species/run being analyzed. For each species/run spawning in a particular river, the monthly flow is developed from the modeled monthly flows for the upper boundary of a reach *k* for which there is a WUA-flow relationship and is used to ascertain the corresponding weighted usable area value ($WUA_k(Q_{m,Y})$).

Because the WUA-flow relationships developed by the most recent IFIM studies present WUA values within particular flow ranges at particular variable steps (e.g., in the lower Yuba River the WUA-flow relationships were developed for a flow range of 100 – 2,500 cfs, with flow increasing steps of 50 cfs, 100 cfs, 250 cfs and 500 cfs), it is often the case that the monthly flow $Q_{m,Y}$ for a particular reach *k* falls between two flows for which there are WUA values. In these cases, the $WUA_k(Q_{m,Y})$ value is determined by linear interpolation between the available WUA values for the flows immediately below and above the target flow $Q_{m,Y}$. If $Q_{m,Y}$ is lower than the lowest flow value on the WUA-flow relationship, $WUA_k(Q_{m,Y})$ is determined by linear interpolation between the origin (i.e., zero flow and zero WUA) and the WUA at the lowest flow on the WUA-flow relationship. Conversely, the WUA for the highest flow value on the WUA-flow relationship is assigned for all $Q_{m,Y}$ values higher than the highest flow value on the WUA-flow relationship.

2.1 LOWER FEATHER RIVER

The WUA-flow relationships developed for salmonids spawning in the lower Feather River were obtained from DWR (DWR 2004). This recent IFIM study for the lower Feather River generated WUA-flow relationships for two reaches: reach 1, referred to as the Low Flow Channel (LFC); and reach 2, referred to as the High Flow Channel (HFC), as shown in **Table 2-1**.

Table 2-1. Locations of Lower Feather River Reaches with WUA-Flow Relationships Developed by DWR (2004)

Reach *k*	Upstream Limit	RM	Downstream Limit	RM	CALSIM Model Channel
1	Fish Barrier Dam	67.25	Thermalito Afterbay Outlet	59	C200-A
2	Thermalito Afterbay Outlet	59	Honcut Creek	44	C203

The WUA-flow relationships developed by DWR (2004) are based upon the merging of IFIM data collected by DWR in 1992 and reviewed by DWR (DWR 2002), with new depth, velocity, substrate and cover data collected along supplemental PHABSIM cross-section transects in 2002 and 2003.

2.1.1 CHINOOK SALMON

The WUA-flow relationships developed for spawning Chinook salmon (**Figure 2-1)** were based on habitat suitability index (HSI) curves obtained from depth and velocity data collected on 212 Chinook salmon redds measured in October 1991, and on 205 Chinook salmon redds measured in the fall of 1995. In addition to these data, 200 measurements of depth and velocity at "unoccupied" locations within the search area were taken to represent the "availability" of habitat conditions that were not selected by spawners for redd construction. Substrate habitat suitability criteria for the analysis were created from the October 1991 data.

2.1.2 STEELHEAD

The WUA-flow relationships developed for spawning steelhead (**Figure 2-2**) were based on habitat suitability index (HSI) curves obtained from depth, velocity and substrate data collected on 76 steelhead redds in late winter 2002 (DWR 2003).

2.2 LOWER YUBA RIVER

The analysis for the lower Yuba River utilized the WUA-flow relationships developed by a CDFG IFIM study (CDFG 1991) to describe the habitat available for fall-run Chinook salmon spawning. CDFG (1991) divided the lower Yuba River into four study reaches (**Table 2-2**).

Reach 1, also termed the Narrows reach, consists of 11,400 feet of river with steep-walled canyon topography, dominated by deep pools, and bedrock and large boulder substrate. This reach is believed to be an important site for spring-run Chinook salmon holding during late spring, summer, and fall. This reach has never been sampled for Chinook salmon redds or carcasses. The spawning WUA-flow relationships developed for Chinook salmon and steelhead at this uppermost reach showed zero WUA values for flows between 100 cfs and 2,500 cfs. The 56,400-foot long reach 2, known as the Garcia Gravel Pit reach, and the 41,400-ft reach 3, known as the Daguerre Point Dam reach, are believed to have good spawning potential for Chinook salmon.

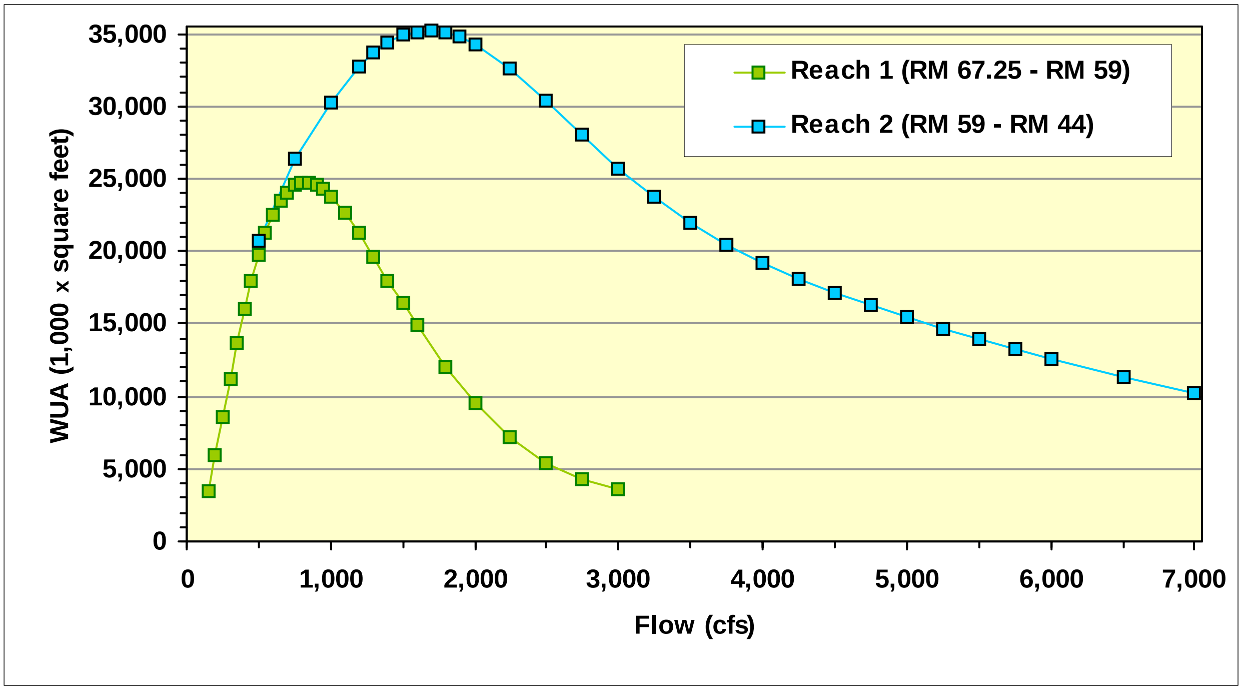

Figure 2-1. Relationship Between Spawning Habitat Availability (Expressed as WUA) and Flow for Lower Feather River Chinook Salmon

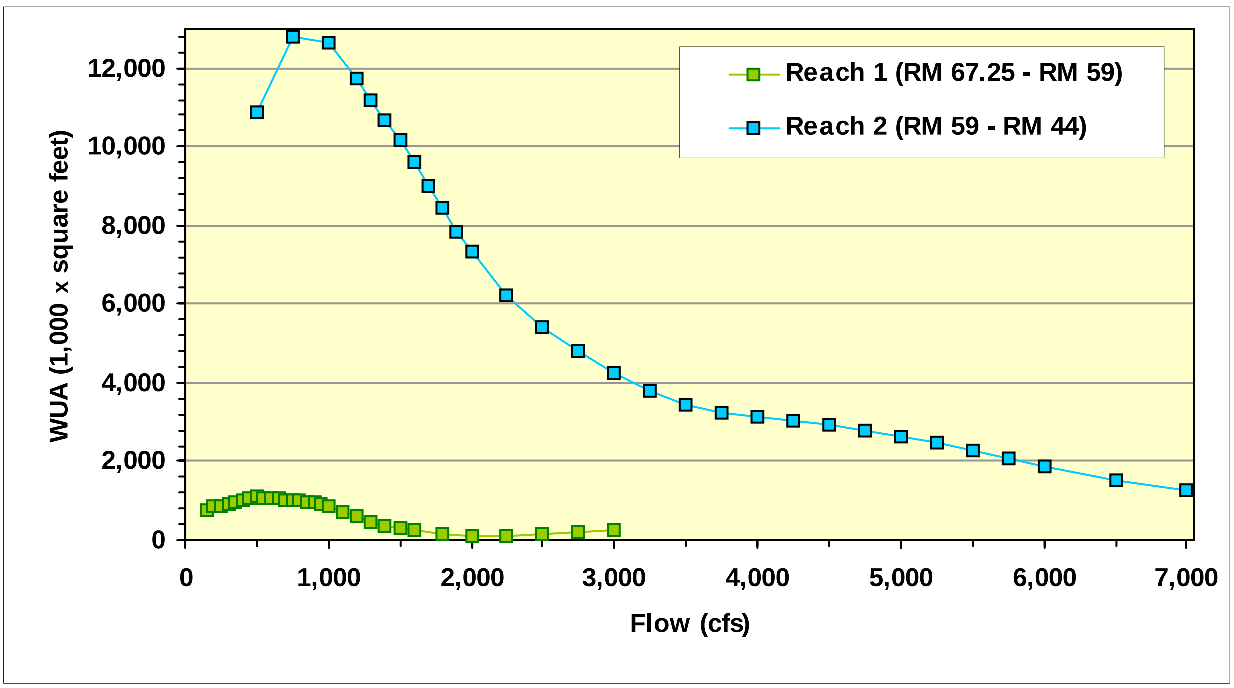

Figure 2-2. Relationship Between Spawning Habitat Availability (Expressed as WUA) and Flow for Lower Feather River Steelhead

Table 2-2. Locations of Lower Yuba River Reaches with WUA-Flow Relationships Developed by CDFG (1991)

Reach *k*	Upstream Limit	RM	Downstream Limit	RM
1	Englebright Dam	23.9	Terminus of the Narrows	21.5
2	Terminus of the Narrows	21.5	Daguerre Point Dam	11.4
3	Daguerre Point Dam	11.4	Terminus of Feather River Backwater Influence	3.5
4	Terminus of Feather River Backwater Influence	3.5	Feather River Confluence	0

Both reaches, which have been customarily sampled during the annual fall-run Chinook salmon carcass surveys performed by CDFG and YCWA, consist of repeating segments of long, deep pools, shallow pools, run/glide, and long low-gradient riffles, with fewer riffles and more pools in reach 3. Finally, reach 4, named the Simpson Lane reach, consists of 18,500 feet of river with low gradient and water velocities, characterized by deep pools under the influence of Feather River waters. This reach has been normally sampled, but not differentiated from reach 3, during the CDFG and YCWA fall-run Chinook salmon carcass surveys, and is believed to have limited potential for Chinook salmon spawning.

2.2.1 CHINOOK SALMON

The fall-run Chinook salmon spawning habitat use data were collected November 17-22, 1986 at three locations:

1) Below and near Highway 20 Bridge crossing (i.e., at RM 18 in reach 2);

2) Below and within one-quarter mile of Daguerre Point Dam (i.e., approximately at RM 11.4 at the upstream end of reach 3); and

3) Near Plantz Road (i.e., at RM 5.3 in reach 3).

A total of 154 redds were observed at these three sites. At each redd location, measurements of mean column water velocity, total depth, and substrate were conducted to provide the basic habitat data used to build the HSI curves. These HSI curves were incorporated into PHABSIM to generate reach-specific WUA-flow relationships for spawning fall-run Chinook salmon (**Figure 2-3)**.

Because spring-run Chinook salmon that spawn in the lower Yuba River are not differentiated from fall-run Chinook salmon during annual carcass surveys, and spring-run Chinook salmon redds cannot be separated from those built by fall-run Chinook salmon during redd surveys, the WUA-flow relationship developed for fall-run Chinook salmon spawning is assumed to reasonably represent the WUA-flow relationship for spring-run Chinook salmon spawning. The WUA-flow relationships in Figure 2-3 were used to calculate the scaled composite weighted usable area (i.e., $\widehat{CWUA}_Y$) for the fall-run Chinook salmon spawning period extending from October into January.

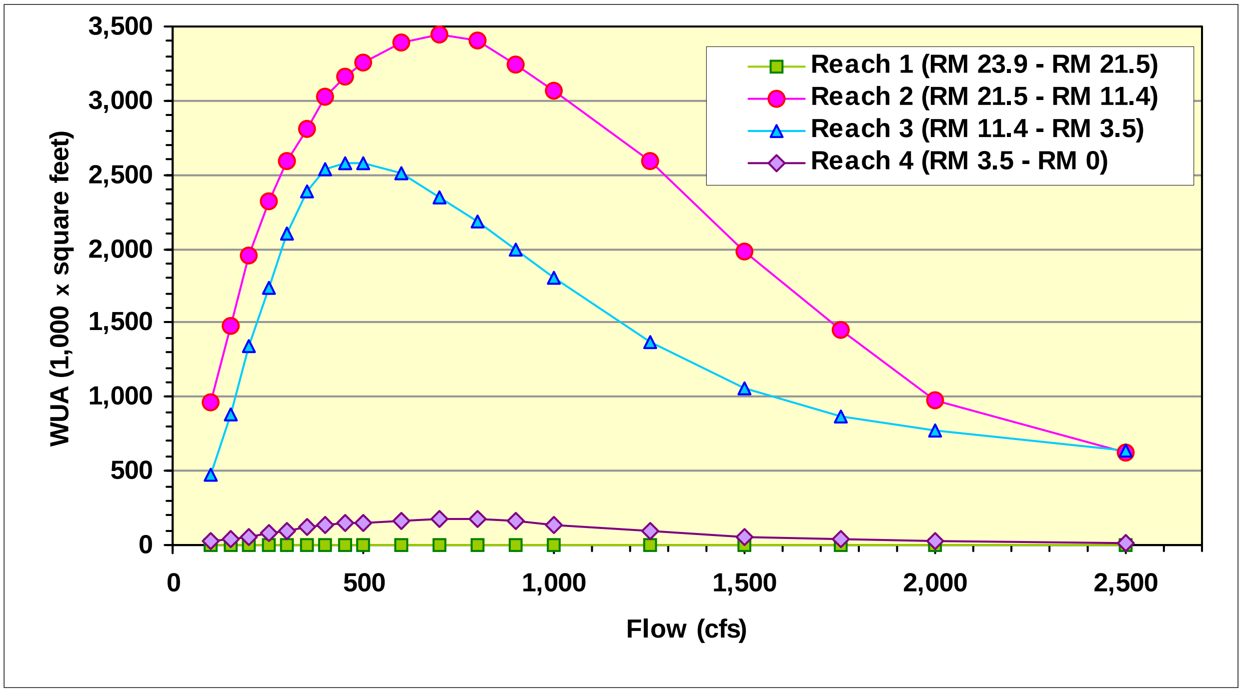

Figure 2-3. Relationship Between Spawning Habitat Availability (Expressed as WUA) and Flow for Lower Yuba River Chinook Salmon

For spring-run Chinook salmon, the annual scaled weighted usable area (i.e., $\widehat{WUA}_Y$) was calculated over a spawning period extending from September through November. For analytical purposes, September through November was assumed to represent the period of spring-run Chinook salmon spawning, although considerable temporal and spatial overlap in spawning occurs between spring-run and fall-run Chinook salmon. Because lower Yuba River spring-run Chinook salmon primarily spawn above Daguerre Point Dam (CALFED and YCWA 2005), the WUA-flow analysis for spring-run Chinook salmon was restricted to those reaches above Daguerre Point Dam (reaches 1 and 2, in Figure 2-3). Additionally, the scaled weighted usable area for the month of September of each year is calculated to compare the potential impacts of the Proposed Project/Action, relative to the Environmental Baseline, on the only month of the spring-run Chinook salmon spawning period that is assumed to not temporally overlap with fall-run Chinook salmon spawning (CDFG 1991).

2.2.2 STEELHEAD

CDFG (1991) steelhead WUA-flow relationships (**Figure 2-4**) were developed from suitability habitat criteria recommended by Bovee (1978). Although the criteria are not specific to the lower Yuba River, the steelhead spawning WUA-flow relationship described in CDFG (1991) is used for this analysis because it is the best available tool for evaluating how flow changes may affect steelhead spawning in the lower Yuba River. The USFWS is in the process of developing a new WUA-flow relationship for steelhead spawning in the lower Yuba River, but this relationship was not finalized or available at the time of the preparation of this BE.

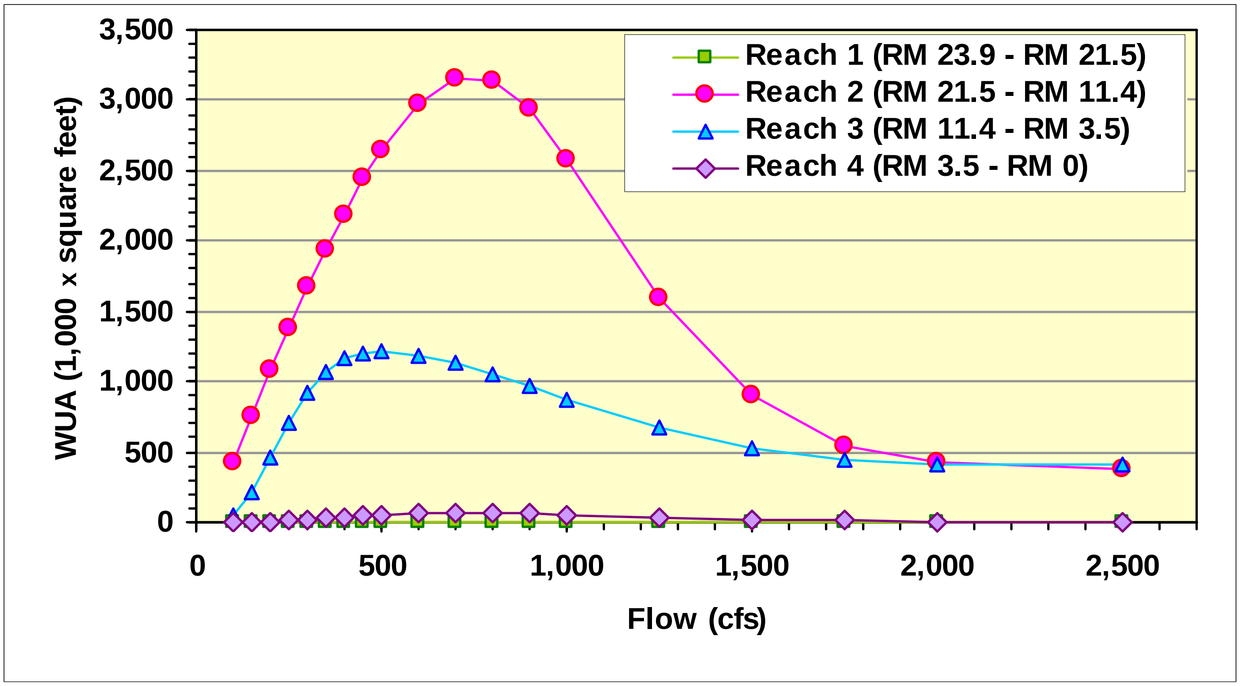

Figure 2-4. Relationship Between Spawning Habitat Availability (Expressed as WUA) and Flow for Lower Yuba River Steelhead

Because the steelhead spawning period in the Yuba River generally extends from January through April, and most of steelhead spawning activity is believed to take place in the lower Yuba River upstream of Daguerre Point Dam, the annual scaled composite weighted usable area for steelhead spawning utilized only the WUA-flow relationship developed for the reaches upstream of Daguerre Point Dam (Reaches 1 and 2, in Figure 2-4), applied to the months of January through April.

3.0 SPATIAL WEIGHTING COEFFICIENTS

Because $\widehat{CWUA}_Y$ is a scaled composite weighted usable area for a species' spawning area that may be comprised of more than one IFIM river reach, and because not all the IFIM reaches may be equally used by the species during its spawning period, the spatial weighting coefficients w_k were incorporated into equation 1 to account for the average relative spawning intensity in particular reaches k. The coefficients w_k of a particular species were developed from in-river Schaefer escapement estimates. Each w_k is a proportion with a value between 0 and 1, so that for a given species and river their sum over all studied IFIM river reaches is equal to 1.

3.1 LOWER YUBA RIVER

Ten years of Schaefer spawning escapement estimates (i.e., 1994 and 1996 to 2004) were utilized in the calculations of spatial weighting coefficients, because only in those ten years was reach 2 sampled to its maximum extent by including Rose Bar (YCWA 1992; YCWA 1994; YCWA 1995; YCWA 1996; YCWA 1997; YCWA 1998; YCWA 1999; YCWA 2000; YCWA 2001; YCWA 2002; YCWA 2003; YCWA 2006a; YCWA 2006b). Because the estimation of fall-run Chinook salmon escapement to the lower Yuba River are based upon two carcass-survey reaches, one extending from Rose Bar, 0.1 river miles downstream of the mouth of the Narrows to Daguerre Point Dam, and another extending from Daguerre Point Dam to Marysville E street bridge (RM 1), spatial weighting coefficients were developed only for IFIM reaches 2, and 3 + 4 (**Table 3-1**). IFIM reach 1, extending from Englebright Dam to the terminus of the Narrows, displayed 0 WUA values for fall-run Chinook spawning, and was never sampled for fall-run Chinook salmon redds or carcasses. Consequently, it was not considered in the calculations of $\widehat{CWUA}_Y$ for fall-run Chinook salmon spawning in the lower Yuba River. The spatial weighting coefficients used for Chinook salmon spawning in the lower Yuba River at IFIM reaches 2, and 3 + 4 are displayed in Table 3-1.

Table 3-1. Spatial Weighting Coefficients Used for Chinook Salmon Spawning in the Lower Yuba River IFIM Reaches 2 and 3+4

Year	IFIM Reach *k*	Upstream Limit	RM	Downstream Limit	RM	Schaefer Escapement	Spawning (%)
1994	2	Rose Bar	21.4	Daguerre Point Dam	11.4	8,801	82.32%
	3 + 4	Daguerre Point Dam	11.4	E Street Bridge	1	1,890	17.68%
1996	2	Rose Bar	21.4	Daguerre Point Dam	11.4	18,892	68.65%
	3 + 4	Daguerre Point Dam	11.4	E Street Bridge	1	8,628	31.35%
1997	2	Rose Bar	21.4	Daguerre Point Dam	11.4	16,951	65.76%
	3 + 4	Daguerre Point Dam	11.4	E Street Bridge	1	8,827	34.24%
1998	2	Rose Bar	21.4	Daguerre Point Dam	11.4	18,306	59.43%
	3 + 4	Daguerre Point Dam	11.4	E Street Bridge	1	12,496	40.57%
1999	2	Rose Bar	21.4	Daguerre Point Dam	11.4	12,392	53.72%
	3 + 4	Daguerre Point Dam	11.4	E Street Bridge	1	10,675	46.28%
2000	2	Rose Bar	21.4	Daguerre Point Dam	11.4	10,435	70.26%
	3 + 4	Daguerre Point Dam	11.4	E Street Bridge	1	4,417	29.74%
2001	2	Rose Bar	21.4	Daguerre Point Dam	11.4	17,059	76.21%
	3 + 4	Daguerre Point Dam	11.4	E Street Bridge	1	5,325	23.79%
2002	2	Rose Bar	21.4	Daguerre Point Dam	11.4	16,838	72.57%
	3 + 4	Daguerre Point Dam	11.4	E Street Bridge	1	6,364	27.43%
2003	2	Rose Bar	21.4	Daguerre Point Dam	11.4	20,924	72.41%
	3 + 4	Daguerre Point Dam	11.4	E Street Bridge	1	7,973	27.59%
2004	2	Rose Bar	21.4	Daguerre Point Dam	11.4	9,477	64.97%
	3 + 4	Daguerre Point Dam	11.4	E Street Bridge	1	5,109	35.03%
Spatial Weighting Coefficients							
2		Rose Bar	21.4	Daguerre Point Dam	11.4	68.63%	
3 + 4		Daguerre Point Dam	11.4	E Street Bridge	1	31.37%	
					Totals	100%	

4.0 TEMPORAL WEIGHTING COEFFICIENTS

Because $\widehat{CWUA}_Y$ in equation 1 is a scaled composite weighted usable area for a species spawning over various months of its spawning season, and because the species' spawning intensity does not remain constant throughout the spawning season, the temporal weighting coefficients w_m were incorporated into equation 1 to account for the average relative spawning intensity in a particular month. Each w_m is a proportion with a value between 0 and 1, so that for a given species and river their sum over the commonly accepted spawning period of the species is equal to 1.

The daily cumulative proportions of fresh carcasses reported in available annual surveys were fitted to a common asymmetric logistic function through non-linear least squares. The asymmetric logistic function has the following expression:

$$Y_D = \left(\frac{1}{1 + \exp(\alpha + \beta \times D)} \right)^{1/\delta}, \quad (3)$$

where Y_D is the expected cumulative proportion of fresh carcasses through day D, and α, β and δ are parameters that determine the shape of the curve. The variable D is a continuous variable that indicates the day number at which new fresh carcasses were observed during a particular annual survey, counting from a particular starting date. Once equation 3 was fitted to the data available for a particular species, the fitted curve was rescaled to the commonly accepted spawning period of the species, and the monthly temporal weighting coefficients w_m were calculated by subtraction. For example, if $\hat{Y}_D$ is the value of the fitted asymmetric logistic curve at a given day D, for a species that spawns from April through August, the temporal weighting coefficient for May (i.e., w_{May}) is calculated as $w_{\text{May}} = \left(\hat{Y}_{6/01} - \hat{Y}_{5/01}\right) / \left(\hat{Y}_{9/01} - \hat{Y}_{4/01}\right)$. The following sections present the fitted asymmetric curves and the temporal weighting coefficients for lower Yuba River fall-run Chinook salmon.

4.1 LOWER YUBA RIVER

The temporal weighting coefficients used for fall-run Chinook salmon spawning in the lower Yuba River are derived from the latest 14 fall-run Chinook carcass survey reports (YCWA 1992; YCWA 1994; YCWA 1995; YCWA 1996; YCWA 1997; YCWA 1998; YCWA 1999; YCWA 2000; YCWA 2001; YCWA 2002; YCWA 2003; YCWA 2006a; YCWA 2006b). Different common asymmetric curves were fitted to the annual cumulative carcass proportions obtained from the fresh carcasses observed from RM 21.4 through RM 11.4 (i.e., IFIM reach 2), and to those obtained from the fresh carcasses observed from RM 11.4 through RM 1 (i.e., roughly IFIM reaches 3 + 4).

In the lower Yuba River, extending from RM 21.4 through RM 11.4, the 1991-2004 Chinook salmon carcass surveys produced a total of 231 daily cumulative proportions for the fitting of the common asymmetric logistic function (**Figure 4-1**). The resulting fitted curve had the following expression:

$$\hat{Y}_D = \left(\frac{1}{1 + \exp(7.0720 - 0.1113 \times D)} \right)^{1/1.2444}, \quad (4)$$

where D is the day number at which new fresh carcasses were observed during a particular annual survey, counted from midnight of August 31 of each year. The mean square error of this fit was 0.1044. Fitted equation 4 was rescaled to the spawning period of Chinook salmon in the lower Yuba River (i.e., September into January) to obtain the final monthly weighting coefficients displayed in **Table 4-1**.

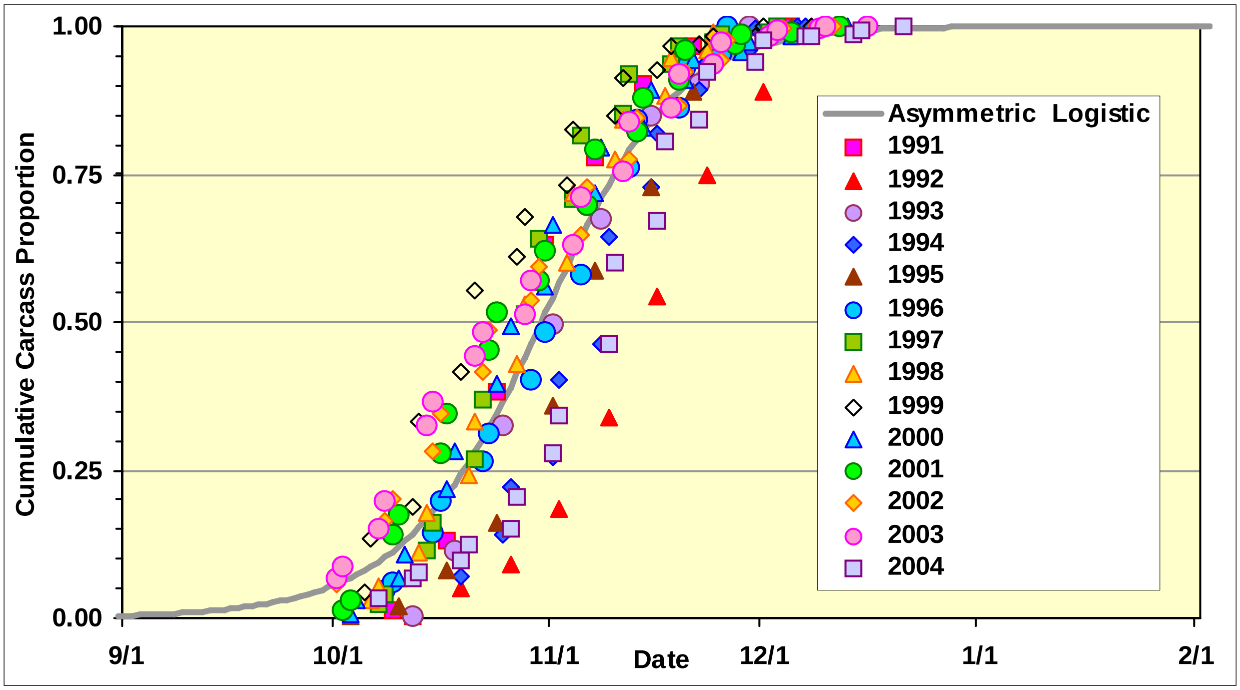

Figure 4-1. Cumulative Proportions of Fresh Chinook Salmon Carcasses in the Lower Yuba River Reach Extending from RM 21.4 Through RM 11.4, during the 1991-2004 Spawning Seasons, and Fitted Asymmetric Logistic Curve

Table 4-1. Temporal Weighting Coefficients Used for Chinook Salmon Spawning in the Lower Yuba River IFIM Reach 2

Month	Asymmetric Logistic	Temporal Weighting Coefficient
October	48.41%	0.513423
November	42.70%	0.452845
December	3.08%	0.032657
January	0.10%	0.001075
Totals	94.28%	1

In the lower Yuba River reach extending from RM 11.4 through RM 1, the 1991-2004 Chinook salmon carcass surveys produced a total of 124 daily cumulative proportions for the fitting of the common asymmetric logistic function (**Figure 4-2**). The resulting fitted curve had the following expression:

$$\hat{Y}_D = \left(\frac{1}{1 + \exp(10.2105 - 0.1356 \times D)} \right)^{1/1.7495}, \qquad (5)$$

where D is the day number at which new fresh carcasses were observed during a particular annual survey, counted from midnight of August 31 of each year. The mean square error of this fit was 0.1687. Fitted equation 5 was rescaled to the spawning period of Chinook salmon in the lower Yuba River (i.e., September into January) to obtain the final monthly weighting coefficients displayed in **Table 4-2**.

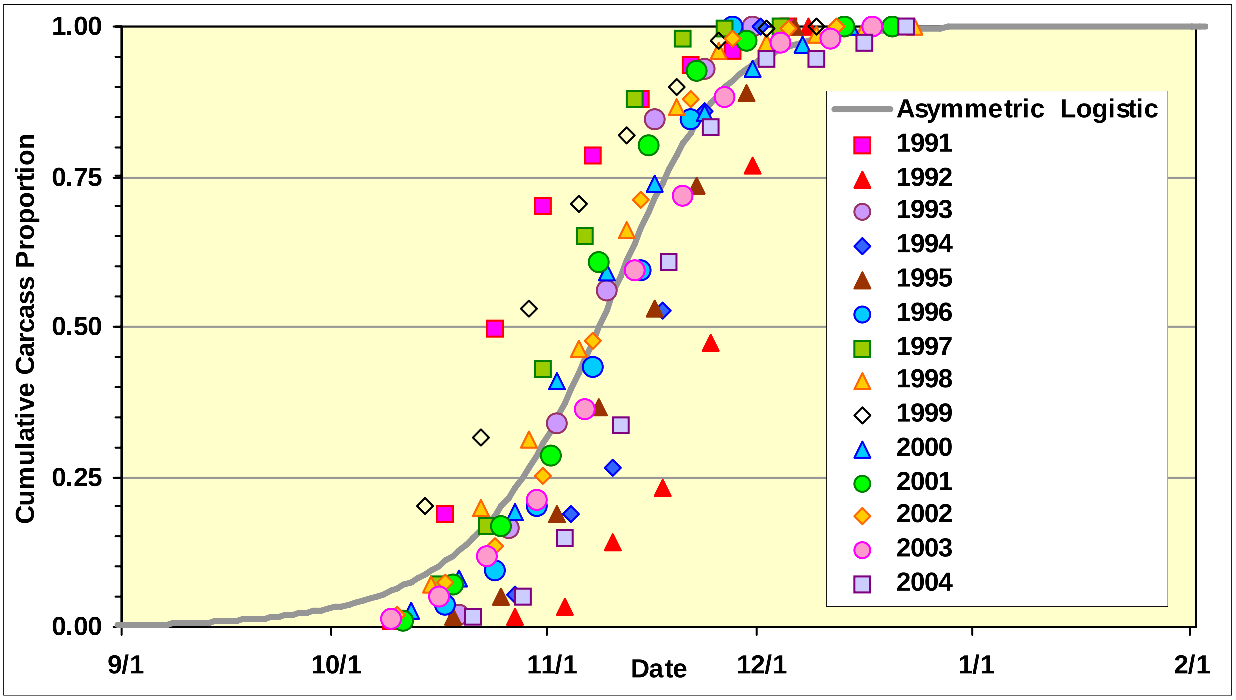

Figure 4-2. Cumulative Proportions of Fresh Chinook Salmon Carcasses in the Lower Yuba River Reach Extending from RM 11.4 Through RM 1, during the 1991-2004 Spawning Seasons, and Fitted Asymmetric Logistic Curve

Table 4-2. Temporal Weighting Coefficients Used for Chinook Salmon Spawning in the Lower Yuba River IFIM Reaches 3+4

Month	Asymmetric Logistic	Temporal Weighting Coefficient
October	29.45%	0.304355
November	61.82%	0.638822
December	5.41%	0.055919
January	0.09%	0.000904
Totals	96.78%	1

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APPENDIX E2

WATER TEMPERATURE INDEX VALUES FOR TECHNICAL EVALUATION GUIDELINES

Appendix E2
Water Temperature Index Values for Technical Evaluation Guidelines

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Appendix E2
Water Temperature Index Values for Technical Evaluation Guidelines

1.0 INTRODUCTION

Water temperature is one of the most important environmental parameters affecting the distribution, growth, and survival of fish populations. Lethal water temperatures affect fish populations by directly reducing population size, while sub-lethal water temperatures affect fish populations via indirect physiologic influences. Water temperatures may particularly regulate fish populations that are near their latitudinal distributional extremes, because environmental conditions (e.g., water temperature) at distributional extremes also may be near the boundaries of conditions that allow the populations to persist. For example, California's Central Valley is at the southern limit of Chinook salmon distribution, and studies have demonstrated that direct effects of high water temperatures are an important source of juvenile Chinook salmon mortality in the Central Valley (Baker *et al.* 1995).

Myrick and Cech, Jr. (2001) suggested that the primary cause for declines in Central Valley salmon and steelhead populations is the extensive construction of dams on rivers and streams used by salmonids for spawning and freshwater rearing. Dam construction has restricted Central Valley salmonids to less than 80 percent of their historical spawning habitat (Moyle 2002), and has altered the natural flow and water temperature regimes in the river sections that remain available to spawning and rearing salmonids.

State and federal protection of salmonid resources requires effects assessment for projects that could potentially affect species listed as threatened or endangered under the federal ESA, as well as species managed under the MSA. Technical evaluation guidelines have been developed to assess potential effects of water diversion and water use projects in a consistent and effective manner. Specifically, salmonid life stages have been explicitly defined, and life stage specific water temperature index values derived from comprehensive literature reviews have been established. In order to successfully evaluate the effects of water temperature regimes on a given salmonid life stage or the entire life cycle, it is necessary to gain a broad understanding of how salmonids respond to water temperature regimes. This Technical Appendix presents the results of a literature review that was conducted to: (1) clearly define each salmonid life stage; (2) provide logical and biologically sound rationale for each life stage definition and/or combination of life stages; (3) interpret the literature on the effects of water temperature on the various life stages of Chinook salmon and steelhead; (4) consider the effects of short-term and long-term exposure to constant or fluctuating temperatures; and (5) establish biologically defensible water temperature index values to be used as guidelines for effects assessment.

2.0 METHODS

Water temperature index values were established from a comprehensive literature review to reflect an evenly spaced range of water temperatures, from reported "optimal" to "lethal" water temperatures, for each life stage of Chinook salmon and steelhead. Types of literature examined include scientific journals, Master's theses and Ph.D. dissertations, literature reviews, and agency publications (see Section 4.0, References). With respect to water temperature, the primary concern in the Central Valley relates to water temperatures that may exceed upper salmonid tolerance limits rather than lower limits; therefore, index values were only established for water temperatures at and above the warmer tolerance zone. Water temperature index values were determined by placing emphasis on the results of laboratory experiments that examined how water temperature affects Central Valley Chinook salmon and steelhead, as well as by considering regulatory documents such as biological opinions from NMFS. Studies on fish from outside the Central Valley were used to establish index values when local studies were unavailable. To avoid unwarranted specificity, only whole integers were selected as index values, thus support for index values was, in some cases, partially derived from literature supporting a water temperature that varied from the resultant index value by several tenths of a degree. For example, Combs and Burrows (1957) reported that constant incubation temperatures between 42.5°F and 57.5°F resulted in normal development of Chinook salmon eggs, and their report was referenced as support for a water temperature index value of 58°F. Rounding for the purposes of selecting index values is appropriate because the daily variation of experimental treatment temperatures is often high. For example, temperature treatments in Marine (1997) consisted of control (55.4°F to 60.8°F), intermediate (62.6°F to 68.0°F), and extreme (69.8°F to 75.2°F) treatments that varied daily by several degrees.

For Chinook salmon, water temperature index values were developed to separately evaluate the following life stages or, where appropriate, combinations of life stages: (1) adult immigration and holding; (2) adult spawning and embryo incubation; and (3) juvenile rearing and smolt emigration. For steelhead, water temperature index values were developed to separately evaluate the following life stages, or where appropriate, combinations of life stages: (1) adult immigration and holding; (2) adult spawning and embryo incubation; (3) juvenile rearing; and (4) smolt emigration.

Inspection of the available literature on the effects of water temperature on salmonids revealed the need to interpret each document with caution and to verify the appropriateness of statements supported by references to other literature. Often source studies are cited incorrectly, and sometimes repeatedly. For example, Hinze (1959) actually examines the effects of water temperature on incubating Chinook salmon eggs, yet Hinze (1959); Marine (1992); and NMFS (1997b) in statements regarding the effects of water temperature on holding Chinook salmon adults. Boles *et al.* (1988) and Marine (1992) were then further cited by McCullough *et al.* (2001) in support of a section detailing how water temperature affects the viability of gametes developing in adults.

Most of the literature on salmonid water temperature requirements refers to “stressful,” “tolerable,” “preferred,” or “optimal” water temperatures or water temperature ranges. (Spence *et al.* 1996) defined the tolerable water temperature range as the range at which fish can survive indefinitely. Thermal stress to fish is any water temperature change that alters the biological functions of the fish and which decreases probability of survival (McCullough 1999). Optimal water temperatures provide for feeding activity, normal physiological response, and behavior void of thermal stress symptoms (McCullough 1999). Preferred water temperature ranges are those that are most frequently selected by fish when allowed to freely choose locations along a thermal gradient (McCullough 1999). Properly functioning condition (PFC) is an additional term that will be used in the present document as defined by NMFS in (McElhany *et al.* 2000). McElhany *et al.* (2000) suggests that defining PFC is an ongoing process and the term will undergo further revision, but based on currently available knowledge, PFC defines the "…freshwater spawning and rearing conditions necessary for the long-term survival of Pacific salmon populations."

Finally, as a comparative tool, life stage-specific water temperature effects indicator values to be used as evaluation guidelines have been developed for Chinook salmon and steelhead, the basis of which are described herein. The water temperature index values are not meant to serve as significance thresholds, but instead serve as a mechanism by which to compare the Proposed Action to an Environmental Baseline. Thus, water temperature index values represent a gradation of potential effects, from reported optimal water temperatures increasing through the range of represented index values for each life stage. Differences in the frequency of exceeding a particular water temperature index value between the Proposed Action and Environmental Baseline will not necessarily constitute an effect. Effects determinations will be based on consideration of all evaluated impact indicators for all life stages for a particular species.

3.0 RESULTS

3.1 CHINOOK SALMON

It has been suggested that separate water temperatures standards should be developed for each run-type of Chinook salmon. For example, McCullough (1999) states that spring-run Chinook salmon immigrate in spring and spawn in 3rd to 5th order streams and, therefore, face different migration and adult holding temperature regimes than do summer- or fall-run Chinook salmon, which spawn in streams of 5th order or greater. However, to meet the objectives of the current literature review, run-types will not be separated because: (1) there is a paucity of literature specific to each life stage of each run-type; (2) there is an insufficient amount of data available in the literature suggesting that Chinook salmon run-types respond to water temperatures differently; (3) the water temperature index values derived from all the literature pertaining to Chinook salmon that provide PFC for a particular life stage will be sufficiently protective of that life stage for each run-type; and (4) all run-types overlap in timing of adult immigration and holding and in some cases are not easily distinguished (Healey 1991).

3.1.1 ADULT IMMIGRATION AND HOLDING

3.1.1.1 LIFE STAGE DESCRIPTION

After spending three to four years in the ocean, Chinook salmon begin their return to freshwaters to spawn (Moyle 2002). Chinook salmon show considerable temporal variation in the timing of their spawning migrations, which is evident in the classification of Chinook salmon by run-type (i.e., fall-run, late fall-run, winter-run, and spring-run). In the Central Valley, the upstream migration of adult Chinook salmon generally occurs from October to April for the late fall-run, from December to July for the winter-run, from March to September for the spring-run, and from June to December for the fall-run (Fisher 1994). The holding period extends from the time that adult Chinook salmon enter their natal stream until the onset of spawning site selection. In the Sacramento River, the adult immigration and holding life stage for Chinook salmon generally lasts from December through July for the winter-run (Moyle 2002; USFWS 1995b), from February through September for the spring-run (time period derived from (Moyle 2002; CDFG 1998; Lindley *et al.* 2004; Vogel and Marine 1991), from August through November for the fall-run (time period derived from (Snider *et al.* 1999; Vogel and Marine 1991)), and from October through April for late fall-run (Moyle 2002). In the Feather River, the adult immigration and holding period generally lasts from March through October for spring-run Chinook salmon, and from mid-July through December for fall-run Chinook salmon (Moyle 2002; DWR 2003a; Eaves 1982; 64 FR 50394 (1999); Sommer *et al.* 2001). In the American River, the adult immigration and holding period for fall-run Chinook salmon generally lasts from September through November (time period derived from (CDFG 1995; Snider and McKewan 1992).

The adult immigration and adult holding life stages will be evaluated together, because it is difficult to determine the thermal regime that Chinook salmon have been exposed to in the river prior to spawning and in order to be sufficiently protective of pre-spawning fish, water temperatures that provide high adult survival and high egg viability must be available throughout the entire pre-spawning freshwater period. Although studies examining the effects of thermal stress on immigrating Chinook salmon are generally lacking, it has been demonstrated that thermal stress during the upstream spawning migration of sockeye salmon negatively affected the secretion of hormones controlling sexual maturation causing numerous reproductive impairment problems (McCullough *et al.* 2001).

3.1.1.2 INDEX VALUE SELECTION RATIONALE

One set of adult immigration and holding water temperature index values was established for all Chinook salmon run-types. The water temperature index values are evenly spaced across the range of conditions from those reported as "optimal" to those reported as "lethal" for adult Chinook salmon during upstream spawning migrations and holding. The water temperature index values established to evaluate the Chinook salmon adult immigration and holding life stage are 60°F, 64°F, and 68°F (**Table 3-1**). Although 56°F is referenced in the literature frequently as the upper "optimal" water temperature limit for upstream migration and holding, the references are not foundational studies and often are inappropriate citations. For example, many of the references to 56°F are based on Hinze (1959), which is a study examining the effects of water temperature on incubating Chinook salmon eggs. Boles *et al.* (1988), Marine (1992), and NMFS (1997b) all cite Hinze (1959) in support of recommendations for a water temperature of 56°F for adult Chinook salmon immigration. Because 56°F is not strongly supported in the literature for adult Chinook salmon immigration and holding, it was not established as an index value.

The lowest water temperature index value established was 60°F, because in the NMFS biological opinion for the proposed operation of the Central Valley Project (CVP) and State Water Project (SWP), 59°F to 60°F is reported as…"*The upper limit of the optimal temperature range for adults holding while eggs are maturing*" (NMFS 2000). Also, NMFS (1997b) states…"*Generally, the maximum temperature of adults holding, while eggs are maturing, is about 59°F to 60°F*" …and… "*Acceptable range for adults migrating upstream range from 57°F to 67°F*." ODEQ (1995) reports that "*…many of the diseases that commonly affect Chinook become highly infectious and virulent above 60°F*." The 60°F water temperature index value established for the Chinook salmon adult immigration and holding life stage is the index value generally reported in the literature as the upper limit of the optimal range, and is within the reported acceptable range. Increasing levels of thermal stress to this life stage may reportedly occur above the 60°F water temperature index value.

Table 3-1. Chinook Salmon Adult Immigration and Holding Water Temperature Index Values and the Literature Supporting Each Value

Index Value	Supporting Literature
60°F [a]	Maximum water temperature for adults holding, while eggs are maturing, is approximately 59ºF to 60ºF (NMFS 1997b). Acceptable water temperatures for adults migrating upstream range from 57ºF to 67ºF (NMFS 1997b). Upper limit of the optimal water temperature range for adults holding while eggs are maturing is 59°F to 60°F (NMFS 2000). Many of the diseases that commonly affect Chinook salmon become highly infectious and virulent above 60ºF (ODEQ 1995). Mature females subjected to prolonged exposure to water temperatures above 60°F have poor survival rates and produce less viable eggs than females exposed to lower water temperatures (USFWS 1995b).
64°F	Acceptable range for adults migrating upstream is from 57ºF to 67ºF (NMFS 1997b). Disease risk becomes high at water temperatures above 64.4°F (EPA 2003b). Latent embryonic mortalities and abnormalities associated with water temperature exposure to pre-spawning adults occur at 63.5ºF to 66.2°F (Berman 1990).
68°F	Acceptable range for adults migrating upstream range from 57°F to 67ºF (NMFS 1997b). For chronic exposures, an incipient upper lethal water temperature limit for pre-spawning adult salmon probably falls within the range of 62.6°F to 68.0°F (Marine 1992). Spring-run Chinook salmon embryos from adults held at 63.5ºF to 66.2°F had greater numbers of pre-hatch mortalities and developmental abnormalities than embryos from adults held at 57.2ºF to 59.9°F (Berman 1990). Water temperatures of 68°F resulted in nearly 100 percent mortality of Chinook salmon during columnaris outbreaks (Ordal and Pacha 1963).

[a] The 60°F water temperature index value established for the Chinook salmon adult immigration and holding life stage is the index value generally reported in the literature as the upper limit of the optimal range, and is within the reported acceptable range. Increasing levels of thermal stress to this life stage may reportedly occur above the 60°F water temperature index value.

An index value of 64°F was established because Berman (1990) suggests effects of thermal stress to pre-spawning adults are evident at water temperatures near 64°F. Berman (1990) conducted a laboratory study to determine if pre-spawning water temperatures experienced by adult Chinook salmon influenced reproductive success, and found evidence suggesting latent embryonic abnormalities associated with water temperature exposure to pre-spawning adults occurs at 63.5°F to 66.2°F. Also, 64°F represents a mid-point value between the water temperature index values of 60°F and 68°F. An index value of 68°F was established because the literature suggests that thermal stress at water temperatures greater than or equal to 68°F is pronounced, and severe adverse effects to immigrating and holding pre-spawning adults, including mortality, can be expected (Berman 1990; Marine 1997; NMFS 1997b). Because potential effects to immigrating and holding adult Chinook salmon reportedly occur at water temperatures greater than or equal to 68°F, index values higher than 68°F were not established.

3.1.2 SPAWNING AND EMBRYO INCUBATION

3.1.2.1 LIFE STAGE DESCRIPTION

In the Sacramento River, Chinook salmon spawning and embryo incubation generally occurs from April through October for the winter run (Vogel and Marine 1991), from September through February for both the spring-run (Moyle 2002; DWR 2004) and the fall-run (time period derived from (Moyle 2002; Snider *et al.* 1999; Vogel and Marine 1991)), and from December through June for late fall-run (time period derived from (Reclamation 1991; Vogel and Marine 1991)). In the Feather River, adult spawning and embryo incubation reportedly occurs from September through February for both spring-run and fall-run Chinook salmon (DWR 2004). In the lower American River, fall-run Chinook salmon spawning and embryo incubation generally occurs from October through February (SWRI 2001).

The duration of embryo incubation is dependent on water temperature and can be variable (NMFS 2002a). In Butte and Big Chico creeks, emergence of spring-run Chinook salmon generally occurs from November through January (NMFS 2002b). In Mill and Deer creeks, colder water temperatures delay emergence to January through March (CDFG 1998).

The adult spawning and embryo (i.e., eggs and alevins) incubation life stage includes redd construction, egg deposition, and embryo incubation. Potential effects to the adult spawning and embryo incubation life stages will be evaluated together using one set of water temperature index values because it is difficult to separate the effects of water temperature between life stages that are closely linked temporally, especially considering that studies describing how water temperature affects embryonic survival and development based on varying water temperature treatments on holding adults often report similar results to water temperature experiments conducted on fertilized eggs (Marine 1992; McCullough 1999; Seymour 1956).

3.1.2.2 Index Value Selection Rationale

Water temperature index values were selected from a comprehensive literature review for Chinook salmon eggs during spawning and incubation (**Table 3-2**). Relative to the large body of literature pertaining to water temperature effects on Chinook salmon embryos, few laboratory experiments specifically examine Chinook salmon embryo survival under different constant or fluctuating water temperature treatments, only one of which is recent (Combs and Burrows 1957; Hinze 1959; Johnson and Brice 1953; Seymour 1956; USFWS *et al.* 1999). In large part, supporting evidence for index value selections was derived from the aforementioned laboratory studies and from regulatory documents (NMFS 1993b; NMFS 1997b; NMFS 2002a). Field studies reporting river water temperatures during spawning also were considered (Dauble and Watson 1997; Groves and Chandler 1999).

Table 3-2. Chinook Salmon Spawning and Embryo Incubation Water Temperature Index Values and the Literature Supporting Each Value

Index Value	Supporting Literature
56°F [a]	Less than 56°F results in a natural rate of mortality for fertilized Chinook salmon eggs (Reclamation Unpublished Work). Optimum water temperatures for egg development are between 43°F and 56°F (NMFS 1993b). Upper value of the water temperature range (i.e., 41.0ºF to 56.0°F) suggested for maximum survival of eggs and yolk-sac larvae in the Central Valley of California (USFWS 1995b). Upper value of the range (i.e., 42.0ºF to 56.0°F) given for the preferred water temperature for Chinook salmon egg incubation in the Sacramento River (NMFS 1997a). Incubation temperatures above 56°F result in significantly higher alevin mortality (USFWS 1999). 56.0°F is the upper limit of suitable water temperatures for spring-run Chinook salmon spawning in the Sacramento River (NMFS 2002a). Water temperatures averaged 56.5°F during the week of fall-run Chinook salmon spawning initiation on the Snake River (Groves and Chandler 1999).
58°F	Upper value of the range given for preferred water temperatures (i.e., 53.0ºF to 58.0°F) for eggs and fry (NMFS 2002a). Constant egg incubation temperatures between 42.5°F and 57.5°F resulted in normal development (Combs and Burrows 1957). The natural rate of mortality for alevins occurs at 58°F or less (Reclamation Unpublished Work).
60°F	100 percent mortality occurs during yolk-sac stage when embryos are incubated at 60°F (Seymour 1956). An October 1 to October 31 water temperature criterion of less than or equal to 60°F in the Sacramento River from Keswick Dam to Bend Bridge has been determined for protection of late incubating larvae and newly emerged fry (NMFS 1993b). Mean weekly water temperature at first observed Chinook salmon spawning in the Columbia River was 59.5°F (Dauble and Watson 1997). Consistently higher egg losses resulted at water temperatures above 60.0°F than at lower temperatures (Johnson and Brice 1953).
62°F	100 percent mortality of fertilized Chinook salmon eggs after 12 days at 62°F (Reclamation Unpublished Work). Incubation temperatures of 62ºF to 64°F appear to be the physiological limit for embryo development resulting in 80 to 100 percent mortality prior to emergence (USFWS 1999). 100 percent loss of eggs incubated at water temperatures above 62°F (Hinze 1959). 100 percent mortality occurs during yolk-sac stage when embryos are incubated at 62.5°F (Seymour 1956)

[a] The 56°F water temperature index value established for the Chinook salmon spawning and embryo incubation life stage is the index value generally reported in the literature as the upper limit of the optimal range for egg development and the upper limit of the range reported to provide maximum survival of eggs and yolk-sac larvae in the Central Valley of California. Increasing levels of thermal stress to this life stage may reportedly occur above the 56°F water temperature index value.

The water temperature index values selected to evaluate the Chinook salmon spawning and embryo incubation life stages are 56ºF, 58ºF, 60ºF, and 62ºF. Some literature suggests that water temperatures must be less than or equal to 56°F for maximum survival of Chinook salmon embryos (i.e., eggs and alevins) during spawning and incubation. (NMFS 1993b) reported that optimum water temperatures for egg development are between 43°F and 56°F. Reclamation (unpublished work) reports that water temperatures less than 56°F results in a natural rate of mortality for fertilized Chinook salmon eggs. USFWS (1995a) reported a water temperature range of 41.0ºF to 56.0°F for maximum survival of eggs and yolk-sac larvae in the Central Valley of California. 42.0ºF to 56.0°F was suggested as the preferred water temperature for Chinook salmon egg incubation in the Sacramento River (NMFS 1997a). Alevin mortality is reportedly significantly higher when Chinook salmon embryos are incubated at water temperatures above 56°F (USFWS 1999). NMFS (2002a) reported 56.0°F as the upper limit of suitable water temperatures for spring-run Chinook salmon spawning in the Sacramento River. The 56°F water temperature index value established for the Chinook salmon spawning and embryo incubation life stage is the index value generally reported in the literature as the upper limit of the optimal range for egg development and the upper limit of the range reported to provide maximum survival of eggs and yolk-sac larvae in the Central Valley of California. Increasing levels of thermal stress to this life stage may reportedly occur above the 56°F water temperature index value.

High survival of Chinook salmon embryos also has been suggested to occur at incubation temperatures at or near 58.0°F. For example, (Reclamation Unpublished Work) reported that the natural rate of mortality for alevins occurs at 58°F or less. Combs (1957) concluded constant incubation temperatures between 42.5°F and 57.5°F resulted in normal development of Chinook salmon eggs, and NMFS (2002a) suggests 53.0°F to 58.0°F is the preferred water temperature range for Chinook salmon eggs and fry. Johnson (1953) found consistently higher Chinook salmon egg losses resulted at water temperatures above 60.0°F than at lower temperatures. In order to protect late incubating Chinook salmon embryos and newly emerged fry NMFS (1993a) has determined a water temperature criterion of less than or equal to 60.0°F be maintained in the Sacramento River from Keswick Dam to Bend Bridge from October 1 to October 31. However, Seymour (1956) provides evidence that 100 percent mortality occurs to late incubating Chinook salmon embryos when held at a constant water temperature greater than or equal to 60.0°F. The literature largely agrees that 100 percent mortality will result to Chinook salmon embryos incubated at water temperatures greater than or equal to 62.0°F (Hinze 1959; Seymour 1956; USFWS 1999), therefore, it was not necessary to select index values above 62°F. Similarly, mortality to spawning adult Chinook salmon prior to egg deposition (Berman 1990; Marine 1992) reportedly occurs at water temperatures above those at which embryo mortality results (i.e., 62°F) (Hinze 1959; Reclamation 2003; Seymour 1956; USFWS 1999); therefore, an index value above 62°F was not required.

3.1.3 JUVENILE REARING AND SMOLT EMIGRATION

3.1.3.1 LIFE STAGE DESCRIPTION

The juvenile life stage is comprised of fry, fingerlings, and smolts; the parr stage is included in the fingerling category. Chinook salmon are considered to be fry from the time when they leave the gravel of the spawning redd to swim up into the water column as a free-swimming fish, until skeletal development is complete, at which point it reaches the fingerling stage (Bovee *et* *al*. 1998). Chinook salmon fry transition to the fingerling stage at approximately 45 to 60 mm (DWR 2003b; NMFS 1997b; NMFS 2003). Fingerling Chinook salmon become smolts when physiological changes occur that allow the juvenile to survive the transition from freshwater to saltwater during seaward migration. In addition to physiological changes, morphological changes also take place during smolting (Hoar 1988). Salmonid smolts can be distinguished from pre-smolts by their silvery appearance and relatively slim, streamlined body (Hoar 1988).

In the Sacramento River Basin, the duration that juvenile Chinook salmon rear in natal streams varies according to run-type. Winter-run juveniles reportedly emerge from the spawning substrate as free-swimming fry from July to October and rear for 5 to 10 months (Fisher 1994). Spring-run juveniles emerge from the spawning substrate as free-swimming fry from November to March and rear for 3 to 15 months (Fisher 1994). Fall-run juveniles emerge from the spawning substrate as free-swimming fry from December to March and rear for 1 to 7 months (Fisher 1994). Late fall-run juveniles emerge from the spawning substrate as free-swimming fry from April to June and rear in their natal stream for 7 to 13 months (Fisher 1994). Recent studies from the American and Feather rivers indicate that most juvenile Chinook salmon move downstream as fry shortly after they emerge from the spawning gravel (DWR 2002; Snider and Titus 2000). In the Sacramento River, juvenile Chinook salmon move downstream during all months, as both fry and smolts (Moyle 2002).

Water temperature is a major limiting factor for juvenile Chinook salmon, as it strongly affects survival and growth. Water temperatures that are too high can be lethal or cause sub-lethal effects such as reduced appetite and growth, increased incidence of disease, increased metabolic costs, and decreased ability for predator avoidance. The scientific literature indicates that a similar range of water temperatures provides positive growth and high survival for Chinook salmon fry, fingerlings, and smolts. Because Chinook salmon juveniles can be found in their natal stream rearing and moving downstream year-round as fry, fingerlings, or smolts, and the scientific literature indicates that a similar range of water temperatures that are important for fry also are important for fingerlings and smolts, potential effects to each phase of the juvenile life stage can be evaluated using a single set of water temperature index values.

3.1.3.2 INDEX VALUE SELECTION RATIONALE

Water temperature index values were selected from a comprehensive literature review for juvenile rearing and smolt emigration (**Table 3-3**). The lowest index value of 60°F was chosen because regulatory documents as well as several source studies, including ones recently conducted on Central Valley Chinook salmon fry, fingerlings, and smolts, report 60°F as an optimal water temperature for growth (Banks *et al.* 1971; Brett *et al.* 1982; Marine 1997; NMFS 1997b; NMFS 2000; NMFS 2001a; NMFS 2002a; Rich 1987b). Water temperatures below 60°F also have been reported as providing conditions optimal for fry and fingerling growth, but were not selected as index values, because the studies were conducted on fish from outside of the Central Valley (Brett 1952; Seymour 1956). Studies conducted using local fish may be particularly important because *Oncorhynchus* species show considerable variation in morphology, behavior, and physiology along latitudinal gradients (Myrick 1998; Taylor 1990b; Taylor 1990a). More specifically, it has been suggested that salmonid populations in the Central Valley prefer higher water temperatures than those from more northern latitudes (Myrick and Cech 2000).

Table 3-3. Chinook Salmon Juvenile Rearing and Smolt Emigration Water Temperature Index Values and the Literature Supporting Each Value

Index Value	Supporting Literature
60°F [a]	Optimum water temperature for Chinook salmon fry growth is between 55.0°F and 60°F (Seymour 1956). Water temperature range that produced optimum growth in juvenile Chinook salmon was between 54.0°F and 60.0°F (Rich 1987b). Water temperature criterion of less than or equal to 60.0°F for the protection of Sacramento River winter-run Chinook salmon from Keswick Dam to Bend Bridge (NMFS 1993b). Upper optimal water temperature limit of 61°F for Sacramento River fall-run Chinook salmon juvenile rearing (Marine 1997; Marine and Cech 2004). Upper water temperature limit of 60.0°F preferred for growth and development of spring-run Chinook salmon fry and fingerlings (NMFS 2000; NMFS 2002a). To protect salmon fry and juvenile Chinook salmon in the upper Sacramento River, daily average water temperatures should not exceed 60°F after September 30 (NMFS 1997b). A water temperature of 60°F appeared closest to the optimum for growth of fingerlings (Banks *et al.* 1971). Optimum growth of Nechako River Chinook salmon juveniles would occur at 59°F at a feeding level that is 60 percent of that required to satiate them (Brett *et al.* 1982). In a laboratory study, juvenile fall-run Chinook salmon from the Sacramento River reared in water temperatures between 70°F and 75°F experienced significantly decreased growth rates, impaired smoltification indices, and increased predation vulnerability compared with juveniles reared between 55°F and 61°F (Marine 1997; Marine and Cech 2004). Indirect evidence from tagging studies suggests that the survival of fall-run Chinook salmon smolts decreases with increasing water temperatures between 59°F and 75°F in the Sacramento-San Joaquin Delta (Kjelson and Brandes 1989).
63°F	Acceleration and inhibition of Sacramento River Chinook salmon smolt development reportedly may occur at water temperatures above 63°F (Marine 1997; Marine and Cech 2004). Laboratory evidence suggest that survival and smoltification become compromised at water temperatures above 62.6°F (Zedonis and Newcomb 1997). Juvenile Chinook salmon growth was highest at 62.6°F (Clarke and Shelbourn 1985).
65°F	Water temperatures between 45°F to 65°F are preferred for growth and development of fry and juvenile spring-run Chinook salmon in the Feather River (NMFS 2002a). Recommended summer maximum water temperature of 64.4°F for migration and non-core rearing (EPA 2003b). Water temperatures greater than 64.0°F are considered not "properly functioning" by NMFS in Amendment 14 to the Pacific Coast Salmon Plan (NMFS 1995). Fatal infection rates caused by *C. columnaris* are high at temperatures greater than or equal to 64.0°F (EPA 2001). Disease mortalities diminish at water temperatures below 65.0°F (Ordal and Pacha 1963). Fingerling Chinook salmon reared in water greater than 65.0°F contracted *C. columnaris* and exhibited high mortality (Johnson and Brice 1953). Water temperatures greater than 64.9°F identified as being stressful in the Columbia River Ecosystem (Independent Scientific Group 1996). Juvenile Chinook salmon have an optimum temperature for growth that appears to occur at about 66.2°F (Brett *et al.* 1982). Juvenile Chinook salmon reached a growth maximum at 66.2°F (Cech and Myrick 1999). Optimal range for Chinook salmon survival and growth from 53.0°F to 64.0°F (USFWS 1995b). Survival of Central Valley juvenile Chinook salmon declines at temperatures greater than 64.4°F (Myrick and Cech 2001). Increased incidence of disease, reduced appetite, and reduced growth rates at 66.2 ± 1.4 (Rich 1987b)
68°F	Sacramento River juvenile Chinook salmon reared at water temperatures greater than or equal to 68.0°F suffer reductions in appetite and growth (Marine 1997; Marine and Cech 2004). Significant inhibition of gill sodium ATPase activity and associated reductions of hyposmoregulatory capacity, and significant reductions in growth rates, may occur when chronic elevated temperatures exceed 68°F (Marine 1997; Marine and Cech 2004). Water temperatures supporting smoltification of fall-run Chinook salmon range between 50°F to 68°F, the colder temperatures represent more optimal conditions (50°F to 62.6°F), and the warmer conditions (62.6°F to 68°F) represent marginal conditions (Zedonis and Newcomb 1997). Juvenile spring-run Chinook salmon were not found in areas having mean weekly water temperatures between 67.1°F and 71.6°F (Burck *et al.* 1980; Zedonis and Newcomb 1997). Results from a study on wild spring-run Chinook salmon in the John Day River system indicate that juvenile fish were not found in areas having mean weekly water temperatures between 67.1°F and 72.9°F (McCullough 1999; Zedonis and Newcomb 1997).
70°F	No growth at all would occur for Nechako River juvenile Chinook salmon at 70.5°F (Brett *et al.* 1982; Zedonis and Newcomb 1997). Juvenile spring-run Chinook salmon were not found in areas having mean weekly water temperatures between 67.1°F and 71.6°F (Burck *et al.* 1980; Zedonis and Newcomb 1997). Results from a study on wild spring-run Chinook salmon in the John Day River system indicate that juvenile fish were not found in areas having mean weekly water temperatures between 67.1°F and 72.9°F (McCullough 1999; Zedonis and Newcomb 1997). Increased incidence of disease, hyperactivity, reduced appetite, and reduced growth rates at 69.8 ±1.8 (Rich 1987b). In a laboratory study, juvenile fall-run Chinook salmon from the Sacramento River reared in water temperatures between 70°F and 75°F experienced significantly decreased growth rates, impaired smoltification indices, and increased predation vulnerability compared with juveniles reared between 55°F and 61°F (Marine 1997; Marine and Cech 2004).

Table 3-3. (continued)

Index Value	Supporting Literature
75°F	For juvenile Chinook salmon in the lower American River fed maximum rations under laboratory conditions, 75.2ºF was determined to be 100 percent lethal due to hyperactivity and disease (Rich 1987b; Zedonis and Newcomb 1997). Lethal temperature threshold for fall-run juvenile Chinook salmon between 74.3 and 76.1°F (McCullough 1999). In a laboratory study, juvenile fall-run Chinook salmon from the Sacramento River reared in water temperatures between 70°F and 75°F experienced significantly decreased growth rates, impaired smoltification indices, and increased predation vulnerability compared with juveniles reared between 55°F and 61°F (Marine 1997; Marine and Cech 2004).

[a] The 60°F water temperature index value established for the Chinook salmon juvenile rearing and smolt emigration life stage is the index value generally reported in the literature as the upper limit of the optimal range for fry and juvenile growth and the upper limit of the preferred range for growth and development of juvenile Chinook salmon. Increasing levels of thermal stress to this life stage may reportedly occur above the 60°F water temperature index value.

The 60°F water temperature index value established for the Chinook salmon juvenile rearing and smolt emigration life stage is the index value generally reported in the literature as the upper limit of the optimal range for fry and juvenile growth and the upper limit of the preferred range for growth and development of spring-run Chinook salmon fry and fingerlings. Increasing levels of thermal stress to this life stage may reportedly occur above the 60°F water temperature index value.

Laboratory experiments suggest that water temperatures at or below 62.6°F provide conditions that allow for successful transformation to the smolt stage (Clarke and Shelbourn 1985; Marine 1997; Zedonis and Newcomb 1997). 62.6ºF was rounded and used to support an index value of 63ºF. 65°F was selected as an index value because it represents an intermediate value between 64.0°F and 66.2°F, at which both adverse and beneficial effects to juvenile salmonids have been reported to occur. For example, at temperatures approaching and beyond 65°F, sub-lethal effects associated with increased incidence of disease reportedly become severe for juvenile Chinook salmon (EPA 2003a; Johnson and Brice 1953; Ordal and Pacha 1963; Rich 1987a). Conversely, numerous studies report that temperatures between 64.0°F and 66.2°F provide conditions ranging from suitable to optimal for juvenile Chinook salmon growth (Brett *et al.* 1982; Cech and Myrick 1999; EPA 2003a; Myrick and Cech 2001; NMFS 2002a; USFWS 1995a). 68°F was selected as an index value because, at water temperatures above 68°F, sub-lethal effects become severe such as reductions in appetite and growth of juveniles, as well as prohibiting successful smoltification (Marine 1997; Rich 1987a; Zedonis and Newcomb 1997). Chronic stress associated with water temperature can be expected when conditions reach the index value of 70°F. For example, growth becomes drastically reduced at temperatures close to 70.0°F and has been reported to be completely prohibited at 70.5°F (Brett *et al.* 1982; Marine 1997). 75°F was chosen as the highest water temperature index value because high levels of direct mortality to juvenile Chinook salmon reportedly result at this water temperature (Rich 1987b). Other studies have suggested higher upper lethal water temperature levels (Brett 1952; Orsi 1971), but 75°F was chosen because it was derived from experiments using Central Valley Chinook salmon and it is a more rigorous index value representing a more protective upper lethal water temperature level. Furthermore, the lethal level determined in Rich (Rich 1987b) was derived using slow rates of water temperature change and, thus, is ecologically relevant. Additional support for an index value of 75°F is provided from a study conducted by (Baker *et al.* 1995) in which a statistical model is presented that treats survival of Chinook salmon smolts fitted with coded wire tags in the Sacramento River as a logistic function of water temperature. Using data obtained from mark-recapture surveys, the statistical model suggests a 95 percent confidence interval for the upper incipient lethal water temperature for Chinook salmon smolts as 71.5°F to 75.4°F.

3.2 STEELHEAD

3.2.1 ADULT IMMIGRATION AND HOLDING

3.2.1.1 LIFE STAGE DESCRIPTION

Most Central Valley steelhead spend 1 to 2 years in the ocean before entering freshwater in August, with an immigration peak from early fall (i.e., September) to early winter (i.e., December). Movements of adult steelhead from freshwater holding areas to spawning grounds can occur any time from December to March, with peak activities reportedly occurring in January and February (Moyle 2002). In the Sacramento River, the adult immigration and holding time period for steelhead generally lasts from September through March (McEwan 2001). In the Feather River, the adult immigration and holding time period for steelhead generally lasts from September through mid-April, with peak migration extending from October through November (Moyle 2002; pers. comm., Cavallo 2004; McEwan 2001; S.P. Cramer & Associates 1995). In the American River, steelhead adult immigration and holding reportedly occurs from November through March (SWRI 2001).

The adult immigration and adult holding life stages will be evaluated together, because it is difficult to determine the thermal regime that steelhead have been exposed to in the river prior to spawning and in order to be sufficiently protective of pre-spawning fish, water temperatures that provide high adult survival and high egg viability must be available throughout the entire pre-spawning freshwater period. Although studies examining the effects of thermal stress on immigrating steelhead are lacking, it has been demonstrated that thermal stress during the upstream spawning migration of sockeye salmon negatively affected the secretion of hormones controlling sexual maturation causing numerous reproductive impairment problems (McCullough *et al.* 2001).

3.2.1.2 INDEX VALUE SELECTION RATIONALE

Water temperatures can control the timing of adult spawning migrations and can affect the viability of eggs in holding females. Few studies have been published that examine the effects of water temperature on either steelhead immigration or holding, and none have been recent (Bruin and Waldsdorf 1975; McCullough *et al.* 2001). The available studies suggest that adverse effects occur to immigrating and holding steelhead at water temperatures exceeding the mid 50°F range, and that immigration will be delayed if water temperatures approach approximately 70°F (**Table 3-4**). Water temperature index values of 52°F, 56°F, and 70°F were chosen because: (1) they incorporate a range of values that provide PFC to conditions that are highly adverse; and (2) the available literature provided the strongest support for these values. Because of the paucity of literature pertaining to steelhead adult immigration and holding, an evenly spaced range of water temperature index values could not be achieved. 52°F was selected as a water temperature index value because it has been referred to as a "recommended" (Reclamation 2003), "preferred" (NMFS 2002a), and "optimum" (Reclamation 1997a) water temperature for steelhead adult immigration. Increasing levels of thermal stress to this life stage may reportedly occur above the 52°F water temperature index value.

Table 3-4. Steelhead Adult Immigration and Holding Water Temperature Index Values and the Literature Supporting Each Value

Index Value	Supporting Literature
52°F [a]	Preferred range for adult steelhead immigration of 46.0°F to 52.0°F (NMFS 2000; NMFS 2001a; SWRCB 2003). Optimum range for adult steelhead immigration of 46.0°F to 52.1°F (Reclamation 1997a). Recommended adult steelhead immigration temperature range of 46.0°F to 52.0°F (Reclamation 2003).
56°F	To produce rainbow trout eggs of good quality, brood fish must be held at water temperatures not exceeding 56.0°F (Leitritz and Lewis 1980). Rainbow trout brood fish must be held at water temperatures not exceeding 56°F for a period of 2 to 6 months before spawning to produce eggs of good quality (Bruin and Waldsdorf 1975). Holding migratory fish at constant water temperatures above 55.4°F to 60.1°F may impede spawning success (McCullough *et al.* 2001).
70°F	Migration barriers have frequently been reported for pacific salmonids when water temperatures reach 69.8°F to 71.6°F (McCullough *et al.* 2001). Snake River adult steelhead immigration was blocked when water temperatures reached 69.8 (McCullough *et al.* 2001). A water temperature of 68°F was found to drop egg fertility in vivo to 5 percent after 4.5 days (McCullough *et al.* 2001).

[a] The 52°F water temperature index value established for the steelhead adult immigration and holding life stage is the index value generally reported in the literature as the upper limit of either the recommended, preferred, or optimum range for steelhead immigration. Increasing levels of thermal stress to this life stage may reportedly occur above the 52°F water temperature index value.

56°F was selected as a water temperature index value because 56°F represents a water temperature above which adverse effects to migratory and holding steelhead begin to arise (Leitritz and Lewis 1980; McCullough *et al.* 2001; Smith *et al.* 1983). 70°F was selected as the highest water temperature index value because the literature suggests that water temperatures near and above 70.0°F present a thermal barrier to adult steelhead migrating upstream (McCullough *et al.* 2001).

3.2.2 SPAWNING AND EMBRYO INCUBATION

3.2.2.1 LIFE STAGE DESCRIPTION

Steelhead spawning includes the time period from redd construction until spawning is completed with the deposition and fertilization of eggs. The embryo incubation period extends from egg deposition until emergence from the substrate as a free-swimming fry. In the Central Valley, steelhead spawning reportedly occurs from October through June (McEwan 2001) and embryo (i.e., eggs and alevins) incubation generally lasts 2 to 3 months after deposition (Moyle 2002; McEwan 2001; Myrick and Cech 2001). The steelhead spawning and embryo incubation life stage generally occurs from December through May in the Sacramento River (time period derived from McEwan (2001) and Busby (1996), in the Feather River (Moyle 2002; Busby *et al.* 1996; pers. comm., Cavallo 2004; Interagency Ecological Program Steelhead Project Work Team 1998), and in the American River (time period derived from McEwan (2001) and Busby (1996)).

Like Chinook salmon, the steelhead embryo life stage is highly vulnerable to water temperature. Because the initial embryo incubation water temperatures are a function of spawning water temperatures, one set of water temperature index values was established to evaluate spawning adults and incubating embryos.

3.2.2.2 INDEX VALUE SELECTION RATIONALE

Few studies have been published regarding the effects of water temperature on steelhead spawning and embryo incubation (Redding and Schreck 1979; Rombough 1988). Because anadromous steelhead and non-anadromous rainbow trout are genetically and physiologically similar, studies on non-anadromous rainbow trout also were considered in the development of water temperature index values for steelhead spawning and embryo incubation (Moyle 2002; McEwan 2001). From the available literature, water temperatures in the low 50°F range appear to support high embryo survival, with substantial mortality to steelhead eggs reportedly occurring at water temperatures in the high 50°F range and above (**Table 3-5**).

Table 3-5. Steelhead Spawning and Embryo Incubation Water Temperature Index Values and the Literature Supporting Each Value

Index Value	Supporting Literature
52°F [a]	Rainbow trout from Mattighofen (Austria) had highest egg survival at 52.0°F compared to 45.0°F, 59.4°F, and 66.0°F (Humpesch 1985). Water temperatures from 48.0°F to 52.0°F are suitable for steelhead incubation and emergence in the American River and Clear Creek (NMFS 2000; NMFS 2001a; NMFS 2002a). Optimum water temperature range of 46.0°F to 52.0°F for steelhead spawning in the Central Valley (USFWS 1995b). Optimum water temperature range of 46.0°F to 52.1°F for steelhead spawning and 48.0°F to 52.1°F for steelhead egg incubation (Reclamation 1997a). Upper limit of preferred water temperature of 52.0°F for steelhead spawning and egg incubation (SWRCB 2003).
54°F	Big Qualicum River steelhead eggs had 96.6 percent survival to hatch at 53.6°F (Rombough 1988). Highest survival from fertilization to hatch for *Salmo gairdneri* incubated at 53.6°F (Kamler and Kato 1983). Emergent fry were larger when North Santiam River (Oregon) winter steelhead eggs were incubated at 53.6°F than at 60.8°F (Redding and Schreck 1979). The upper optimal water temperature regime based on constant or acclimation water temperatures necessary to achieve full protection of steelhead is 51.8°F to 53.6°F (EPA 2001). From fertilization to hatch, rainbow trout eggs and larvae had 47.3 percent mortality (Timoshina 1972). Survival of rainbow trout eggs declined at water temperatures between 52.0 and 59.4°F (Humpesch 1985). The optimal constant incubation water temperature for steelhead occurs below 53.6°F (McCullough *et al.* 2001).
57°F	From fertilization to 50 percent hatch, Big Qualicum River steelhead had 93 percent mortality at 60.8°F, 7.7 percent mortality at 57.2°F, and 1 percent mortality at 47.3°F and 39.2°F (Velsen 1987). A sharp decrease in survival was observed for rainbow trout embryos incubated above 57.2°F (Kamler and Kato 1983).
60°F	From fertilization to 50 percent hatch, Big Qualicum River steelhead had 93 percent mortality at 60.8°F, 7.7 percent mortality at 57.2°F, and 1 percent mortality at 47.3°F and 39.2°F (Velsen 1987). From fertilization to 50 percent hatch, rainbow trout eggs from Ontario Provincial Normendale Hatchery had 56 percent survival when incubated at 59.0°F (Kwain 1975).

[a] The 52°F water temperature index value established for the steelhead spawning and embryo incubation life stage is the index value generally reported in the literature as the upper limit of the optimal range for steelhead spawning, embryo incubation, and fry emergence. Increasing levels of thermal stress to this life stage may reportedly occur above the 52°F water temperature index value.

Water temperature index values of 52°F, 54°F, 57°F, and 60°F were selected for two reasons. First, the available literature provided the strongest support for water temperature index values at or near 52°F, 54°F, 57°F, and 60°F. Second, the index values reflect an evenly distributed range representing reported optimal to lethal conditions for steelhead spawning and embryo incubation. Although some literature suggests water temperatures ≤ 50°F are optimal for steelhead spawning and embryo survival (Myrick and Cech 2001; Timoshina 1972), a larger body of literature suggests optimal conditions occur at water temperatures ≤ 52°F (Humpesch 1985; NMFS 2000; NMFS 2001a; NMFS 2002a; Reclamation 1997b; SWRCB 2003; USFWS 1995a). Therefore, 52°F was selected as the lowest water temperature index value. Increasing levels of thermal stress to the steelhead spawning and embryo incubation life stage may reportedly occur above the 52°F water temperature index value.

54°F was selected as the next index value, because although most of the studies conducted at or near 54.0°F report high survival and normal development (Kamler and Kato 1983; Redding and Schreck 1979; Rombough 1988), some evidence suggests that symptoms of thermal stress arise at or near 54.0°F (Humpesch 1985; Timoshina 1972). Thus, water temperatures near 54°F may represent an inflection point between properly functioning water temperature conditions, and conditions that cause negative effects to steelhead spawning and embryo incubation. 57°F was selected as an index value because embryonic mortality increases sharply and development becomes retarded at incubation temperatures greater than or equal to 57.0°F. Velsen (1987) provided a compilation of data on rainbow trout and steelhead embryo mortality to 50 percent hatch under incubation temperatures ranging from 33.8°F to 60.8°F that demonstrated a two-fold increase in mortality for embryos incubated at 57.2°F, compared to embryos incubated at 53.6°F. In a laboratory study using gametes from Big Qualicum River, Vancouver Island, steelhead mortality increased to 15 percent at a constant temperature of 59.0°F, compared to less than 4 percent mortality at constant temperatures of 42.8°F, 48.2°F, and 53.6°F (Rombough 1988). Also, alevins hatching at 59.0°F were considerably smaller and appeared less well developed than those incubated at the lower temperature treatments. From fertilization to 50 percent hatch, Big Qualicum River steelhead had 93 percent mortality at 60.8°F, 7.7 percent mortality at 57.2°F, and 1 percent mortality at 47.3°F and 39.2°F (Velsen 1987).

3.2.3 JUVENILE REARING

3.2.3.1 LIFE STAGE DESCRIPTION

The juvenile life stage is comprised of fry, fingerlings, and smolts. Steelhead are considered to be fry from the time they emerge from the gravel of the spawning redd to swim up into the water column as a free swimming fish until skeletal development is complete, at which point it reaches the fingerling stage (Bovee *et al.* 1998). Steelhead fry transition to the fingerling stage at approximately 45 to 60 mm (Moyle 2002; Bovee *et al.* 1998; DWR 2003b; NMFS 1997b). After Central Valley steelhead emerge from the gravel, juveniles remain in freshwater for 1 to 3 years before smolting and migrating to saltwater (Myrick and Cech 2001). Shapovalov (Shapovalov and Taft 1954) suggest that most Waddell Creek, California, steelhead rear in freshwater for two years.

3.2.3.2 INDEX VALUE SELECTION RATIONALE

Like other salmonids, growth, survival, and successful smoltification of juvenile steelhead are controlled largely by water temperature. The duration of freshwater residence for juvenile steelhead is long relative to that of Chinook salmon, making the juvenile life stage of steelhead more susceptible to the influences of water temperature, particularly during the over-summer rearing period. Central Valley juvenile steelhead have high growth rates at water temperatures in the mid 60°F range, but reportedly require lower water temperatures to successfully undergo the transformation to the smolt stage (**Table 3-6** and **Table 3-7**). Water temperature index values of 65°F, 68°F, 72°F, and 75°F were selected to represent an evenly distributed range of index values for steelhead juvenile rearing. The lowest water temperature index value of 65°F was established because NMFS (2002a) reported 65°F as the upper limit preferred for growth and development of Sacramento and American River juvenile steelhead. Also, 65°F was found to be within the preferred water temperature range (i.e., 62.6°F to 68.0°F) and supported high growth of Nimbus strain juvenile steelhead (Cech and Myrick 1999). Increasing levels of thermal stress to this life stage may reportedly occur above the 65°F water temperature index value. For example, Kaya *et al.* (1977) reported that the upper avoidance water temperature for juvenile rainbow trout was measured at 68°F to 71.6°F. Cherry *et al.* (1977) observed an upper preference water temperature near 68.0°F for juvenile rainbow trout, duplicating the upper preferred limit for juvenile steelhead observed in Cech (1999). Because of the literature describing 68.0°F as both an upper preferred and an avoidance limit for juvenile *Oncorhynchus mykiss*, 68°F was established as a water temperature index value.

Table 3-6. Steelhead Juvenile Rearing Water Temperature Index Values and the Literature Supporting Each Value

Index Value	Supporting Literature
65°F [a]	Upper limit of 65°F preferred for growth and development of Sacramento River and American River juvenile steelhead (NMFS 2002a). Nimbus juvenile steelhead growth showed an increasing trend with water temperature to 66.2°F, irrespective of ration level or rearing temperature (Cech and Myrick 1999). The final preferred water temperature for rainbow fingerlings was between 66.2 and 68°F (Cherry *et al.* 1977). Nimbus juvenile steelhead preferred water temperatures between 62.6°F and 68.0°F (Cech and Myrick 1999). Rainbow trout fingerlings preferred or selected water temperatures in the 62.6°F to 68.0°F range (McCauley and Pond 1971).
68°F [a]	Nimbus juvenile steelhead preferred water temperatures between 62.6°F and 68.0°F (Cech and Myrick 1999). The final preferred water temperature for rainbow trout fingerlings was between 66.2°F and 68°F (Cherry *et al.* 1977). Rainbow trout fingerlings preferred or selected water temperatures in the 62.6°F to 68.0°F range (McCauley and Pond 1971). The upper avoidance water temperature for juvenile rainbow trout was measured at 68°F to 71.6°F (Kaya *et al.* 1977).
72°F	Increased physiological stress, increased agonistic activity, and a decrease in forage activity in juvenile steelhead occur after ambient stream temperatures exceed 71.6°F (Nielsen *et al.* 1994). The upper avoidance water temperature for juvenile rainbow trout was measured at 68°F to 71.6°F (Kaya *et al.* 1977). Estimates of upper thermal tolerance or avoidance limits for juvenile rainbow trout (at maximum ration) ranged from 71.6°F to 79.9°F (Ebersole *et al.* 2001).
75°F	The maximum weekly average water temperature for survival of juvenile and adult rainbow trout is 75.2°F (EPA 2002). Rearing steelhead juveniles have an upper lethal limit of 75.0°F (NMFS 2001a). Estimates of upper thermal tolerance or avoidance limits for juvenile rainbow trout (at maximum ration) ranged from 71.6 to 79.9°F (Ebersole *et al.* 2001).

[a] The 65°F and 68°F water temperature index values established for the steelhead juvenile rearing life stage are the index values generally reported in the literature as the upper limits of the preferred range for juvenile steelhead. However, because 68°F also has been reported as an avoidance temperature for juvenile rainbow trout, 65°F may provide more suitable conditions for steelhead juvenile rearing than 68°F. Therefore, increasing levels of thermal stress to this life stage may reportedly occur above the 65°F water temperature index value.

Table 3-7. Steelhead Smolt Emigration Water Temperature Index Values and the Literature Supporting Each Value

Index Value	Supporting Literature
52°F [a]	Steelhead successfully smolt at water temperatures in the 43.7°F to 52.3°F range (Myrick and Cech 2001). Steelhead undergo the smolt transformation when reared in water temperatures below 52.3°F, but not at higher water temperatures (Adams *et al.* 1975). Optimum water temperature range for successful smoltification in young steelhead is 44.0°F to 52.3°F (Rich 1987a).
55°F	ATPase activity was decreased and migration reduced for steelhead at water temperatures greater than or equal to 55.4°F (Zaugg and Wagner 1973). Water temperatures should be below 55.4°F at least 60 days prior to release of hatchery steelhead to prevent premature smolting and desmoltification (Wedemeyer *et al.* 1980). In winter steelhead, a temperature of 54.1°F is nearly the upper limit for smolting (McCullough *et al.* 2001; Zaugg and Wagner 1973). Water temperatures less than or equal to 54.5°F are suitable for emigrating juvenile steelhead (EPA 2003b). Water temperatures greater than 55°F prevent increases in ATPase activity in steelhead juveniles (Hoar 1988). Water temperatures greater than 56°F do not permit smoltification in summer steelhead (Zaugg *et al.* 1972)
59°F	Yearling steelhead held at 43.7°F and transferred to 59°F had a substantial reduction in gill ATPase activity, indicating that physiological changes associated with smoltification were reversed (Wedemeyer *et al.* 1980).

[a] The 52°F water temperature index value established for the steelhead smolt emigration life stage is the index value generally reported in the literature as the upper limit of the water temperature range that provides successful smolt transformation thermal conditions. Increasing levels of thermal stress to this life stage may reportedly occur above the 52°F water temperature index value.

A water temperature index value of 72°F was established because symptoms of thermal stress in juvenile steelhead have been reported to arise at water temperatures approaching 72°F. For example, physiological stress to juvenile steelhead in Northern California streams was demonstrated by increased gill flare rates, decreased foraging activity, and increased agonistic activity as stream temperatures rose above 71.6°F (Nielsen *et al.* 1994). Also, 72°F was selected as a water temperature index value because 71.6°F has been reported as an upper avoidance water temperature (Kaya *et al.* 1977) and an upper thermal tolerance water temperature (Ebersole *et al.* 2001) for juvenile rainbow trout. The highest water temperature index value of 75°F was established because NMFS and EPA report that direct mortality to rearing juvenile steelhead results when stream temperatures reach 75.0°F (EPA 2002; NMFS 2001b).

3.2.4 Smolt Emigration

3.2.4.1 Life Stage Description

Fingerling steelhead become smolts when physiological changes occur that allow the juvenile to survive the transition from freshwater to saltwater during seaward migration. In addition to physiological changes, morphological changes also take place during smolting (Hoar 1988). Salmonid smolts can be distinguished from pre-smolts by their silvery appearance and relatively slim, streamlined body (Hoar 1988). Steelhead smolts migrate out to sea at 1 to 3 years of age, at 10 to 25 cm FL (Moyle 2002). Steelhead smolt emigration generally occurs from January through June in the Sacramento River (time period derived from (USFWS 1999); (Snider and Titus 2000); (McEwan 2001); and Newcomb (2001)), the Feather River, (pers. comm., Cavallo 2004) (Newcomb and Coon 2001); (Snider and Titus 2000); (USFWS 1995a)), and the American River (McEwan 2001; Newcomb and Coon 2001; Snider and Titus 2000; USFWS 1995a).

3.2.4.2 Index Value Selection Rationale

Laboratory data suggest that smoltification, and therefore successful emigration of juvenile steelhead is directly controlled by water temperature (Adams *et al.* 1975). Water temperature index values of 52°F and 55°F were selected to evaluate the steelhead smolt emigration life stage, because most literature on water temperature effects on steelhead smolting suggest that water temperatures less than 52°F (Adams *et al.* 1975; Myrick and Cech 2001; Rich 1987a); or less than 55°F (EPA 2003a; McCullough *et al.* 2001; Wedemeyer *et al.* 1980; Zaugg and Wagner 1973) are required for successful smoltification to occur. (Adams *et al.* 1973) tested the effect of water temperature (43.7°F, 50.0°F, 59.0°F or 68.0°F) on the increase of gill microsomal Na^+-, K^+-stimulated ATPase activity associated with parr-smolt transformation in steelhead and found a two-fold increase in Na^+-, K^+-ATPase at 43.7 and 50.0°C, but no increase at 59.0°F or 68.0°F. In a subsequent study, the highest water temperature where a parr-smolt transformation occurred was at 52.3°F (Adams *et al.* 1975). The results of Adams *et al.* (1975) were reviewed in Myrick and Cech (2001) and Rich (1987b), which both recommended that water temperatures below 52.3°F are required to successfully complete the parr-smolt transformation. The 52°F water temperature index value established for the steelhead smolt emigration life stage is the index value generally reported in the literature as the upper limit of the water temperature range that provides successful smolt transformation thermal conditions. Increasing levels of thermal stress to this life stage may reportedly occur above the 52°F water temperature index value.

Zaugg and Wagner (1973) examined the influence of water temperature on gill ATPase activity related to parr-smolt transformation and migration in steelhead and found ATPase activity was decreased and migration reduced when juveniles were exposed to water temperatures of 55.4°F or greater. In a technical document prepared by the EPA to provide temperature water quality standards for the protection of Northwest native salmon and trout, water temperatures less than or equal to 54.5°F were recommended for emigrating juvenile steelhead (EPA 2003b).

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APPENDICES F - G

(due to size limitations, Appendices F and G are not provided

APPENDIX H

MITIGATION MONITORING AND REPORTING PLAN/ENVIRONMENTAL COMMITMENTS PLAN

To be provided in the Final EIR/EIS

APPENDIX I

RESPONSES TO COMMENTS RECEIVED ON THE PUBLIC DRAFT EIR/EIS

To be provided in the Final EIR/EIS

APPENDIX J

STATE AND FEDERAL ENDANGERED SPECIES ACT COMPLIANCE DOCUMENTATION

To be provided in the Final EIR/EIS

APPENDIX K

FISH AND WILDLIFE COORDINATION ACT COMPLIANCE

To be provided in the Final EIR/EIS