Biological Assessment

for the

U. S. Army Corps of Engineers Authorized Operations and Maintenance of Existing Fish Passage Facilities at Daguerre Point Dam on the Lower Yuba River

US Army Corps
of Engineers ®
Sacramento District

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1.0 Introduction and Background

1.1 Introduction

The U. S. Army Corps of Engineers, Sacramento District (Corps), as the Action Agency, is submitting this Biological Assessment (BA) to the National Marine Fisheries Service (NMFS) as part of a consultation process pursuant to Section 7(a)(2) of the Endangered Species Act (ESA). This BA was prepared in accordance with legal requirements set forth in Section 7 of the ESA (16 U.S.C. 1536; see also 50 CFR Part 402), as well as in the NMFS and the United States Fish and Wildlife Service (USFWS) Endangered Species Act Consultation Handbook, Procedures for Conducting Consultation and Conference Activities under Section 7 of the Endangered Species Act (USFWS and NMFS 1998). This BA defines and evaluates the potential effects of the Corps' limited ongoing discretionary activities at Daguerre Point Dam on threatened and endangered species and their designated critical habitats in the lower Yuba River. Specifically, the Corps' discretionary activities at Daguerre Point Dam are: (1) the operation and maintenance of the fish ladders; (2) an outgrant to the California Department of Fish and Wildlife (CDFW) [formerly California Department of Fish and Game] for VAKI Riverwatcher operations; and (3) a license to Cordua Irrigation District for flashboard operations. These activities constitute the Proposed Action for purposes of this consultation.

Although previous consultations have been conducted addressing various Corps activities in the lower Yuba River, this BA has been prepared to more clearly define and deconstruct the Proposed Action, and potential effects on listed species and their designated critical habitats attributed to the Proposed Action, in response to the considerations presented below regarding the background associated with the Proposed Action. There are many Corps actions on the lower Yuba River. This BA provides detailed information regarding the Corps' authorities and describes the Proposed Action for which the Corps is currently seeking Section 7 consultation, and also describes other actions that are not covered by the BA for clarification. To help illustrate the deconstruction of Corps' lower Yuba River activities (refer to Figure 1-1 in Section 1.3), the following categories have been created: (1) future actions requiring separate ESA consultation; (2) non-discretionary actions; (3) discretionary actions with no effect; (4) Englebright Dam and Reservoir discretionary actions that are not likely to adversely affect listed species, and are included in a separate informal ESA consultation; and (5) operations and maintenance (O&M) of existing fish passage facilities at Daguerre Point Dam included in the formal ESA consultation for this Proposed Action.

1.2 Background

The Section 7 ESA consultation process between the Corps and NMFS associated with Corps activities in the lower Yuba River extend back to 2000. Biological opinions (BOs) were issued by NMFS in 2002, 2007, and 2012. This section presents a description of the project history and an overview of the consultation history related to the NMFS BOs.

1.2.1 Consultation History

1.2.1.1 2002 Consultation

The Corps' proposed action that was evaluated in the 2000 Corps BA and the 2002 NMFS BO included the following actions:

ENGLEBRIGHT DAM

- ☐ O&M of Englebright Dam.
- ☐ Administration of License No. DACW05-9-95-604 to the Pacific Gas & Electric Company (PG&E) granting access for the Narrows I powerhouse near Englebright Dam. Narrows I is operated and maintained under Federal Energy Regulatory Commission (FERC) License No. 1403.
- ☐ Administration of Easement No. DACW05-2-75-716 to the Yuba County Water Agency (YCWA) granting a right-of-way for the Narrows II near Englebright Dam. Narrows II is operated and maintained under FERC License No. 2246.

- ☐ Administration of the March 28, 1994 Agreement with PG&E for the operation and maintenance of the Narrows I FERC licensed hydroelectric project. The 1994 Agreement states that the Corps is responsible for maintaining Englebright Dam and the outlet facilities in good order and repair, while PG&E is responsible for the O&M of the FERC licensed hydroelectric facility.

Although recreation at Englebright Reservoir was briefly mentioned in both the 2000 Corps BA and the 2002 NMFS BO, detailed descriptions of the Corps' specific operations and maintenance activities pertaining to recreation at Englebright Reservoir were not presented in the proposed action.

DAGUERRE POINT DAM

- ☐ O&M of Daguerre Point Dam and the North and South fish ladders.
- ☐ Administration of License No. DAW05-3-97-549 issued to the Hallwood Irrigation Company for a diversion in the vicinity of Daguerre Point Dam.
- ☐ Administration of License No. DACW05-3-85-537 granting a right-of-way for access to the South Yuba/Brophy Diversion Canal and Facilities in the vicinity of Daguerre Point Dam.

Although generally identified, specific Corps operations and maintenance activities pertaining to Daguerre Point Dam, including work with CDFW to maintain the two fish ladders at Daguerre Point Dam by clearing debris, were not presented in detail in the proposed action.

The following is a chronology of key events in the ESA consultation history that culminated with the 2002 BO.

- ☐ *June 22, 2000.* The Corps prepared a BA titled "*Biological Assessment of the Effects of Operations of Englebright Dam/Englebright Lake and Daguerre Point Dam on Central Valley ESU Spring-Run Chinook Salmon and Steelhead Trout*".
- ☐ *December 18, 2000.* The Corps prepared a revised BA titled Biological Assessment of the Effects of Operations of Englebright Dam and Reservoir and

Daguerre Point Dam on Central Valley ESU Spring-Run Chinook Salmon and Steelhead Trout.

- *March 27, 2002.* NMFS issued a non-jeopardy 5-year interim BO that analyzed the effects of the Corps' operation of Englebright Dam and Daguerre Point Dam on the threatened Central Valley spring-run Chinook salmon (*Oncorhynchus tshawtscha*), Central Valley steelhead (*O. mykiss*), and the respective designated critical habitats for these species. The 2002 NMFS BO concluded that the project was not likely to jeopardize the continued existence of the listed species, and was not likely to destroy or adversely modify designated critical habitat for these species, over the 5-year time period.

After 5 years, the Corps was required to reinitiate formal consultation on the effects of operations of Englebright Dam and Daguerre Point Dam on any species listed at that time.

The reason for the establishment of the 5-year time limit in the 2002 NMFS BO was that several programs and investigative studies (e.g., Daguerre Point Dam Preliminary Fish Passage Improvement Study (Corps 2001), Upper Yuba River Studies Program[1] (DWR 2007)) were underway, which were anticipated to provide new information affecting the Yuba River water management operations and the status of Yuba River fisheries resources (e.g., Chinook salmon and steelhead). In addition, the 2002 NMFS BO stated that recent changes to operational procedures as well as the physical structures associated with Englebright and Daguerre Point dams have provided a level of improvement to the situation for listed salmonids and their critical habitat within the lower Yuba

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[1] Since 2008, the CALFED Ecosystem Restoration Program and the Fish Passage Improvement Program have been unable to fund continued work on the Upper Yuba River Studies Program (DWR 2011a).

River, and that additional actions planned for implementation within the next year were expected to further improve conditions for listed salmonids and their critical habitat. NMFS (2002) concluded that it is reasonable to expect that the recent and near-term improvements will at least stabilize population levels if not slightly increase them during the 5-year term of the BO as a result of decreases in the chronic effects of reduced survival of these species under past operations. NMFS (2002) therefore determined that the level of impacts over the 5-year period covered by the BO is unlikely to reduce the population numbers, reproductive success or the distribution of listed salmonids in the Yuba River to the point of reducing these populations' likelihood of survival and recovery. NMFS (2002) also concluded that the proposed action will not diminish the value of designated critical habitat for the survival and recovery of the Central Valley steelhead and spring-run Chinook salmon. The 2002 NMFS BO expired on March 27, 2007.

1.2.1.2 2007 Consultation

The Corps' proposed action that was evaluated during the 2007 Corps BA and the 2007 NMFS BO included the following actions:

ENGLEBRIGHT DAM

☐ O&M of Englebright Dam.

☐ Administration of Outgrant No. DACW05-9-95-604 to PG&E granting access for the Narrows I powerhouse near Englebright Dam. Narrows I is operated and maintained under FERC License No. 1403.

☐ Administration of Easement No. DACW05-2-75-716 to YCWA granting a right-of-way for the Narrows II powerhouse near Englebright Dam. Narrows II is operated and maintained under FERC License No. 2246.

☐ Administration of the March 28, 1994 Agreement with PG&E for the operation and maintenance of the Narrows I FERC licensed hydroelectric project. The 1994 Agreement states that the Corps is responsible for maintaining Englebright Dam and the outlet facilities in good order and repair, while PG&E is responsible for the O&M of the FERC licensed hydroelectric facility.

Recreation at Englebright Reservoir was not included in the 2007 Corps BA or the 2007 NMFS BO as part of the proposed action.

DAGUERRE POINT DAM

- ☐ O&M of Daguerre Point Dam and the North and South fish ladders.
- ☐ Administration of License No. DAW05-3-97-549 issued for access to the Hallwood-Cordua diversion in the vicinity of Daguerre Point Dam.

Although License No. DACW05-3-85-537, granting access to the South Yuba/Brophy Diversion Canal and Facilities in the vicinity of Daguerre Point Dam was discussed, it was unclear to what extent, if any, administration of this license was included in the proposed action. Also, although generally identified, specific Corps operations and maintenance activities pertaining to Daguerre Point Dam, including work with CDFW to maintain the two fish ladders at Daguerre Point Dam by clearing debris, were not presented in detail in the proposed action.

The following is a chronology of key events in the ESA consultation history that culminated with the 2007 NMFS BO.

- ☐ *April 7, 2006.* NMFS issued a Final Rule to list the Southern DPS of North American green sturgeon (*Acipenser medirostris*) as a threatened species under the ESA.
- ☐ *February 28, 2007.* The Corps requested reinitiation of consultation for the species listed in the previous 2002 NMFS BO, and extension of the incidental take statement in the 2002 BO. The Corps also requested an incidental take statement for the Southern DPS of North American green sturgeon until NMFS issued a new BO and incidental take statement.
- ☐ *March 23, 2007.* The Corps delivered an initiation package including a cover letter requesting the initiation of formal consultation under Section 7 of the ESA for the proposed action along with a new BA and an Essential Fish Habitat (EFH) assessment for the proposed action to NMFS. Included in the Corps' March 23, 2007 cover letter was a request for the extension of the timeframe covered by the

2002 NMFS BO to maintain coverage for the proposed action until the current consultation could be completed and a final, long-term BO issued.

- ☐ *April 27, 2007*. NMFS issued a non-jeopardy BO that analyzed the effects of continuation of operation of the project for a period of up to one year.
- ☐ *November 21, 2007*. NMFS issued a non-jeopardy long-term BO (2007 NMFS BO) that analyzed the effects of operations of Englebright Dam and Daguerre Point Dam on threatened Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley steelhead (*O. mykiss*), the respective designated critical habitats for these salmonid species, as well as the threatened Southern DPS of North American green sturgeon. The long-term BO superseded the April 27, 2007 NMFS BO and was intended to be the final BO for the project.

NMFS (2007) stated that it would be likely that the facilities and operational procedures used in the past, if left uncorrected, would cause continued declines in population viability of these species and in the conservation value of critical habitat. However, NMFS also stated that there had been several recent changes to the facilities (e.g., fish screens at the Hallwood-Cordua diversion) and operational procedures (e.g., flashboard management, regular inspections and maintenance of the fish ladders, sediment management) at Daguerre Point Dam related to the Corp's Yuba River operations which were expected to improve conditions for Yuba River fisheries. Additionally, NMFS (2007) stated that recent salmonid monitoring data, while insufficient to allow detection of definite trends, did not suggest any significant, ongoing decline of salmonid populations or habitat variables in the lower Yuba River.

The 2007 NMFS BO concluded that the level of effects caused by Corps operations would be unlikely to cause a reduction in the population numbers, reproductive success or the distribution of listed fish in the Yuba River to the point of appreciably reducing these populations' likelihood of survival into the future. NMFS also concluded that there were several other actions and programs which were at varying stages of planning and implementation that were intended to produce significant improvements to the accessibility and quality of the habitat and viability of the populations of listed species on the Yuba River, and if fully implemented, would greatly increase the likelihood of significant recovery of these populations. Thus, the 2007 NMFS BO concluded that it was reasonable to expect that the Corps' proposed operations on the Yuba River should at least maintain, if not slightly improve the value of critical habitat for the conservation of spring-run Chinook salmon and steelhead above the value that was present when critical habitat was designated on the Yuba River in 2005.

However, review of the 2007 Corps BA and the 2007 NMFS BO suggests that effects of the proposed action were confused with effects of the environmental baseline.

The environmental baseline was accurately defined in the 2007 NMFS BO, based on the ESA regulations, to include "*the past and ongoing human and natural factors leading to the current status of the species and designated critical habitat within the action area*." The 2007 NMFS BO explained that the environmental baseline comprises all past impacts, including the effects of the proposed action up to the present.

The 2007 NMFS BO further explained that the assessment of "future" effects of the proposed action, by contrast to environmental baseline effects, should "*include the impacts to listed species and their critical habitat which will continue to be caused by operations of the projects in the future*." In the view of the Corps, effects of Englebright and Daguerre Point dams, that were due to the mere existence of the dams and not a result of the Corps' proposed action, should have been part of the environmental baseline and not attributed to the Corps proposed action. The 2007 NMFS BO did not distinguish between the future effects caused by the operations and maintenance of Englebright and Daguerre Point dams, and the future effects caused by the continued presence of the dams.

The 2007 NMFS BO discussion of critical habitat takes a similar approach, and described effects resulting from the continued presence of both dams in the analysis of the effects of the proposed action on critical habitat.

The 2007 NMFS BO included the existence of the dams and water diversions as effects of the proposed action. In the Corps' view, this approach to effects assessment was not consistent with the ESA regulations, ESA guidance, or the environmental baseline approached by NMFS in BOs for other ongoing water projects such as the New Hogan Dam and Lake BO dated December 5, 2002, the FERC Yuba River Development Amendment BO dated November 4, 2005, and the Central Valley Project/State Water Project BO dated June 4, 2009.

The 2007 NMFS BO determined that many future effects solely attributable to the presence of Englebright and Daguerre Point dams also were effects of the proposed action, which was not correct. In summary, the species-specific effects resulting from the presence of Englebright Dam, which the 2007 NMFS BO previously attributed to the Corps' operation and maintenance of Englebright Dam, should be included in the environmental baseline. Similarly, most of the effects that the 2007 NMFS BO previously attributed to the Corps' operation and maintenance of Daguerre Point Dam, as well as the associated fish ladders, should be included in the environmental baseline. Only those effects of Corps facilities that the Corps has the authority to change through its discretionary operation and maintenance activities at Englebright and Daguerre Point dams and the fish ladders at Daguerre Point Dam should be included in the effects of the proposed action. For these and other reasons (see below), the Corps voluntarily reinitiated consultation during 2011.

Two environmental groups, South Yuba River Citizen's League (SYRCL) and Friends of the River (FOR), sued NMFS, the Corps, and YCWA, alleging that NMFS' BO was arbitrary and capricious and that the Corps' operations of Englebright and Daguerre Point dams are causing take of protected salmon and steelhead. The *SYRCL v. NMFS* case was filed in the United States District Court, Eastern District of California, Case No. Civ. S-06-2845 LKK/JFM.

On June 16, 2010, the court entered a stipulated settlement order dismissing all the claims and relief sought against YCWA.

On July 8, 2010, the court issued an order, which concluded that NMFS acted arbitrarily and capriciously in reaching the BO's no-jeopardy and no adverse modification conclusions, and in issuing the incidental take statement. On April 29, 2011, the Court ordered that the 2007 Biological Opinion be remanded to NMFS and a new Biological Opinion be prepared.

On July 26, 2011, the Court granted, in part, Plaintiffs' Motion for Final Remedies ordering the Corps to take several actions, including: (1) develop a flashboard management plan; (2) conduct weekly inspections of the fish ladders at Daguerre Point Dam and removal of accumulated debris; (3) inspect and manage sediment accumulation in the channel upstream of Daguerre Point Dam after high flow events; and (4) install locking metal grates over the Daguerre Point Dam fish ladders.

On February 29, 2012, the Federal Defendants (NMFS) filed a notice of completion and issued a new Biological Opinion to the Corps. On May 31, 2012, the Court terminated the case.

1.2.1.3 2012 Consultation

The Corps voluntarily reinitiated formal consultation with NMFS on the Corps' ongoing operation and maintenance of Englebright Dam and Daguerre Point Dam and associated facilities in October 2011 with transmission of a draft BA to NMFS. In January 2012, a final BA (referred to herein as the 2012 BA) was prepared to, among other things, describe the proposed action and analyze the effects of that action on listed species and designated critical habitat.

As discussed in the 2012 BA, the Corps' responsibilities, as well as its ability to conduct operations- and maintenance-related actions at Englebright Dam and Reservoir and at Daguerre Point Dam, are primarily governed by each of the facilities' respective authorizations and appropriations. Consequently, the Corps' actions that were proposed and evaluated in the 2012 BA, which could potentially affect listed fish species in the lower Yuba River, were more clearly defined and limited relative to the previous two consultations. Additionally, review of Corps and NMFS documents previously prepared in association with the 2002 and 2007 consultation processes suggests that several issues pertaining to the characterization of the Corps' proposed action and other environmental baseline considerations potentially affecting listed fish species in the action area were inadvertently conflated during the previous two consultation processes.

By contrast to the assessments presented in the 2002 and 2007 consultation documents, a different approach was undertaken for the 2012 BA. Primarily, the analysis provided in the 2012 BA attempted to more clearly distinguish between the potential effects to listed fish species that are attributable to the environmental baseline (see Chapter 6.0 in the 2012 BA), compared to those that are expected to occur as a result of the proposed action (see Chapter 8.0 in the 2012 BA). The 2012 BA also provided information that the United States District Court, Eastern District of California identified as inadequacies in the 2007 NMFS BO.

The July 8, 2010 order of the United States District Court, Eastern District of California, in Case No. Civ. S-06-2845 LKK/JFM, held that the 2007 NMFS BO failed to address five stressors related to the Corps' proposed action: (1) effects in the action area from the Feather River Fish Hatchery (FRFH); (2) effects in the action area from conditions in the Delta; (3) effects based on the species overall viability; (4) effects in the action area from global warming; and (5) effects in the action area from poaching.

The 2012 BA addressed whether the Corps has authority to reduce the future effects from these potential stressors through its operation and maintenance activities. With the possible exceptions of effects related to poaching, and effects of fish ladder performance that are associated with authorized routine maintenance activities, the Corps determined that it did not have the ability to lessen other stressors associated with the Corps facilities. Therefore, the 2012 BA determined that many of the ongoing and future effects from the identified stressors were associated with the environmental baseline, and not the proposed action.

The 2012 BA attributed species-specific effects resulting from the presence of Englebright Dam, which the 2007 NMFS BO previously attributed to the Corps' operation and maintenance of Englebright Dam, to the environmental baseline. Also, in the 2012 BA, the anticipated potential direct and indirect effects associated with the

South Yuba/Brophy diversion were considered in the effects assessment for the proposed action, to the extent that the Corps has authority to mitigate these effects through conditions specified in the easement proposed at that time.

Additionally, several changed conditions had occurred since 2007 when the earlier consultation with NMFS was completed, including:

- ☐ *March 2008.* The State Water Resources Control Board (SWRCB) approved the petitions to change the water right permits of YCWA that were necessary to implement the Yuba Accord.
- ☐ *June 2009.* YCWA entered into Settlement Agreement with Plaintiffs (SYRCL and FOR) in their lawsuit against NMFS et al., which resulted in improvements to the maintenance and operations of the South Yuba/Brophy Diversion Canal and Facilities.
- ☐ *June 2009.* NMFS issued its Biological Opinion and Conference Opinion on the Long-term Operations of the Central Valley Project (CVP) and State Water Project (SWP).
- ☐ *October 2009.* NMFS issued the Draft Recovery Plan for the ESUs of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon, and the DPS of Central Valley Steelhead.
- ☐ *October 2009.* NMFS issued its final rulemaking to designate critical habitat for the threatened Southern DPS of North American green sturgeon.

Because the aforementioned changed conditions have the potential to influence the status of listed fish species and their habitats throughout each species' respective ESU (Evolutionary Significant Unit) or DPS (Distinct Population Segment), as well as within the action area, each of these changed conditions was considered in the Corp's 2012 BA, as appropriate.

The following is a chronology of key events in the ESA consultation history that culminated with the 2012 BO.

- ☐ *October 9, 2009.* NMFS issued a Final Rule designating critical habitat for the Federally threatened Southern DPS of North American green sturgeon.

- ☐ *June 2, 2010.* NMFS issued a Final ESA Section 4(d) Rule establishing take prohibitions for the Federally threatened Southern DPS of North American green sturgeon.
- ☐ *December 17, 2010.* The Corps and YCWA met to discuss the proposed ESA consultation approach, components of the proposed action, the environmental baseline, as well as the general content and organizational format of the revised BA.
- ☐ *January 5, 2011.* The Corps and YCWA met to discuss components of the proposed action, the environmental baseline and other ESA compliance issues.
- ☐ *February 10, 2011.* Coordination meeting between the Corps and NMFS to discuss current activities regarding the status of the terms and conditions of the 2007 BO and updates for the 2012 BA.
- ☐ *March 24, 2011.* Coordination meeting between the Corps and NMFS to discuss current activities regarding the status of the terms and conditions of the 2007 BO and updates for the 2012 BA.
- ☐ *April 13, 2011.* The Corps and YCWA met to discuss environmental baseline considerations and other effects of YCWA's facilities associated with Daguerre Point Dam and Englebright Dam, and YCWA's request for an easement for the South Yuba/Brophy Diversion Canal and Facilities.
- ☐ *April 28, 2011.* Coordination meeting between the Corps and NMFS to discuss current activities regarding the status of the terms and conditions of the 2007 BO and updates for the 2012 BA.
- ☐ *May 9, 2011.* YCWA submitted a letter to the Corps describing YCWA's view of the legal requirements for ESA consultation on Englebright Dam and Daguerre Point Dam.
- ☐ *June 28, 2011.* YCWA submitted a letter to the Corps requesting non-Federal applicant status for the Yuba River consultation.

- ☐ *June 29, 2011.* Coordination meeting between the Corps and NMFS to discuss current activities regarding the status of the terms and conditions of the 2007 BO and updates for the 2012 BA.
- ☐ *July 28, 2011.* Coordination meeting between the Corps and NMFS to discuss current activities regarding the status of the terms and conditions of the 2007 BO and updates for the 2012 BA.
- ☐ *August 25, 2011.* Coordination meeting between the Corps and NMFS to discuss current activities regarding the status of the terms and conditions of the 2007 BO, updates for the 2012 BA, and status of the Corps' implementation of the interim measures required by the District Court's July 26, 2011 Order.
- ☐ *September 22, 2011.* Coordination meeting between the Corps and NMFS to discuss current activities regarding the status of the terms and conditions of the current BO, updates for the 2012 BA, and status of the Corps' implementation of the interim measures required by the District Court's July 26, 2011 Order.
- ☐ *October 5, 2011.* NMFS wrote a letter to the Corps requesting that the Corps expedite preparation of the draft BA.
- ☐ *October 17, 2011.* The Corps transmitted to NMFS the draft BA for the U.S. Army Corps of Engineers' Ongoing Operation and Maintenance of Englebright Dam and Reservoir and Daguerre Point Dam on the lower Yuba River.
- ☐ *October 27, 2011.* Coordination meeting between the Corps and NMFS to discuss current activities regarding the status of the Corps' compliance with the terms and conditions of the 2007 BO incidental take statement and issues related to completion of the 2012 BO.
- ☐ *December 2, 2011.* NMFS sent a letter to the Corps identifying what NMFS believed to be deficiencies in the Corps draft BA.
- ☐ *January 10, 2012.* NMFS provided the Corps draft versions of the "action area" and "project description" portions of the 2012 BO for review and comment.
- ☐ *January 12, 2012.* Coordination meeting between the Corps and NMFS to discuss issues related to completion of the 2012 BO.

- ☐ *January 19, 2012.* The Corps provided comments to NMFS on the draft versions of the "action area" and "project description" portions of the 2012 BO.

- ☐ *January 27, 2012.* A meeting was held among the Corps, YCWA and NMFS regarding the ESA consultation for the Corps' operations on the lower Yuba River.

- ☐ *January 27, 2012.* The Corps responds to NMFS's December 2, 2011 letter and requests initiation of formal consultation on the proposed action. As part of the consultation request, the Corps submits the final 2012 BA to NMFS.

- ☐ *February 1, 2012.* NMFS provides the Corps with draft Reasonable and Prudent Alternative (RPA) options for review and comment.

- ☐ *February 2, 2012.* NMFS and the Corps meet to discuss Corps comments on NMFS draft project description for the BO.

- ☐ *February 8, 2012.* YCWA submits comments to NMFS on the Corps' final BA, requests a copy of the draft BO. YCWA also requests that the Corps ask that NMFS modify the present consultation schedule to allow sufficient time for YCWA to meaningfully participate in the consultation as well as review and offer comments on the draft BO.

- ☐ *February 27, 2012.* NMFS provides a draft BO to the Corps and YCWA, and allows a 24-hour period for review and comment on the draft BO.

- ☐ *February 28, 2012.* The Corps submits comments to NMFS on the draft BO.

- ☐ *February 28, 2012.* YCWA submits comments to NMFS on the draft BO.

- ☐ *February 29, 2012.* NMFS issued its Final BO (2012 BO) regarding the effects of Englebright Dam and Daguerre Point Dam on the Yuba River in Yuba and Nevada Counties, California on threatened Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley steelhead (*O. mykiss*), the threatened Southern distinct population segment of North American green sturgeon (*Acipenser medirostris*), and their designated critical habitat in accordance with Section 7(a)(2) of the ESA of 1973, as amended (16 U.S.C. 1531 et seq.).

The February 29, 2012 Final BO concluded that the operation and maintenance of these two dams would likely jeopardize the continued existence of spring-run Chinook salmon, steelhead, and green sturgeon, and result in the adverse modification of critical habitat for each of these species. The BO includes an RPA that modified the proposed action to avoid jeopardizing the species and adversely modifying their critical habitat. The RPA was divided into eight categories containing almost 60 specific actions to be implemented by the Corps (NMFS 2012).

The 2012 NMFS BO provided a summary of the authorities NMFS believed would allow the Corps to implement the various measures described in the 2012 NMFS BO RPA. However, in many instances, the 2012 NMFS BO failed to acknowledge or mention the significant constraints associated with the cited authorities that might have precluded immediate action by the Corps. See **Appendix A** for a discussion/explanation of the Corps' Authorities.

1.2.1.4 2013 Consultation

On July 3, 2012 the Corps transmitted a letter to NMFS memorializing the Corps' concerns regarding the 2012 BO. The Corps' concerns regarding the 2012 BO were related to the description of the proposed action and action area, NMFS' approach to baseline effects, the scientific basis for the analysis and conclusions, the scope and breadth of the RPA and the Reasonable and Prudent Measures (RPMs) associated with the incidental take statement, and the limitations of the Corps' authorities (Corps 2012b). This letter is attached as **Appendix B**.

On February 26, 2013, the Corps notified NMFS of its intent to reinitiate consultation with NMFS to address the impacts of the Corps' discretionary activities on Central Valley spring-run Chinook salmon, Central Valley steelhead, North American green sturgeon and their associated critical habitats. The Corps' February 26, 2013 letter stated that reinitiation of consultation is appropriate when *"…new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered," as well as when "…the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion*." 50 CFR §402.16(b)-(c). The Corps' letter further stated that reinitiation of consultation is appropriate in order for the Corps to provide NMFS with additional information and clarification on subjects that include the following:

1. The scope of the Corps' authorities and discretion, for purposes both of appropriately defining the proposed action and ensuring that any RPMs or RPA are "within the scope of the [Corps'] legal authority and jurisdiction." *See* 50 C.F.R. §402.02.
2. The scope of the action area and the determination of which other activities are interrelated and interdependent with the proposed action.
3. Additional information regarding the nature of the Corps' proposed activities at Englebright and Daguerre Point dams.
4. Scientific and technical information regarding the listed species and the effects of the proposed action on them.

The Corps' stated that it would prepare a revised BA to support the reinitiation of consultation. The following is a chronology of key events leading up to, and contributing to the consultation history for the 2013 ESA consultation process.

- ☐ *March 14, 2012.* Meeting to discuss the February 29, 2012 Final BO with NMFS, the Corps, YCWA and Pacific Gas and Electric Company (PG&E).
- ☐ *May 29, 2012.* Clarification Workshop No. 1 regarding the February 29, 2012 Final BO with NMFS, the Corps, YCWA and PG&E.
- ☐ *June 22, 2012.* The Corps and NMFS meet to discuss the content and conclusions presented in the February 29, 2012 Final BO.
- ☐ *June 25, 2012.* The Corps submits technical comments to NMFS on the February 29, 1012 Final BO.
- ☐ *June 29, 2012.* YCWA submits comments and requested clarifications to NMFS on the February 29, 2012 Final BO.
- ☐ *July 3, 2012.* The Corps sends a letter to NMFS acknowledging receipt of the February 29, 2012 Final BO. Although the Corps conditionally accepted the RPA

described in the Final BO, the Corps expressed serious concerns about various aspects of the BO that need to be resolved.

- ☐ *July 12, 2012.* PG&E submits comments to NMFS on the February 29, 2012 Final BO.
- ☐ *July 19, 2012.* Clarification Workshop No. 2 regarding the February 29, 2012 Final BO with NMFS, the Corps, YCWA and PG&E.
- ☐ *September 11, 2012.* Coordination meeting between the Corps and NMFS to discuss the status of revising the BA and reinitiating consultation.
- ☐ *September 19, 2012.* Clarification Workshop No. 3 regarding the February 29, 2012 Final BO with NMFS, the Corps, YCWA and PG&E.
- ☐ *September 25, 2012.* YCWA submits a letter to NMFS regarding the Yuba River BO clarification process and the status of NMFS's responses to comments submitted by the Corps, YCWA and PG&E.
- ☐ *October 4, 2012.* Corps submits a letter to NMFS requesting schedule adjustments pertaining to the implementation of certain actions of the RPA described in the February 29, 2012 Final BO.
- ☐ *October 30, 2012.* Yuba River BO Technical Meeting No. 1 with representatives from NMFS, the Corps, YCWA and PG&E.
- ☐ *November 16, 2012.* Yuba River BO Technical Meeting No. 2 with representatives from NMFS, the Corps, YCWA and PG&E.
- ☐ *November 27, 2012.* NMFS responds to the Corps' October 4, 2012 letter regarding implementation of certain RPA actions, and recognizes that several of measures in the RPA contain deadlines that cannot be met for practical reasons, such as a lack of appropriations, the length of time required to comply with the National Environmental Policy Act (NEPA), and other implementation challenges. The NMFS letter also extends the required implementation dates of several of the measures in the RPA.

☐ *November 29, 2012.* Yuba River BO Technical Meeting No. 3 was held among representatives from NMFS, the Corps, YCWA and PG&E.

☐ *December 11, 2012.* Yuba River BO Technical Meeting No. 4 was cancelled per NMFS's request.

☐ *January 24, 2013.* Yuba River BO Technical Meeting No. 5 was cancelled per NMFS's request.

☐ *February 26, 2013.* The Corps submits a request to NMFS advising of the Corps' intent to reinitiate consultation for the Corps' discretionary activities on the Yuba River.

☐ *April 11, 2013.* NMFS responds to the Corps February 26, 2013 request for reinitiation of consultation under Section 7 of the ESA (16 U.S.C. 1536(a) and the Magnuson-Stevens Fishery Conservation and Management Act (Public Law 94-541). To meet the requirements of CFR 402.14(c) to initiate formal consultation, and 50 CFR 402.l4(d) to provide the best scientific and commercial data available, NMFS recommended that the Corps develop an updated BA to evaluate the potential effects of the action on listed species and designated critical habitat, pursuant to 50 CFR 402.12.

☐ *April 17, 2013.* YCWA submits a letter to the Corps requesting non-Federal applicant status due to its pending June 28, 2011 application for a new easement related to operation and maintenance of the South Yuba/Brophy Diversion Canal and Facilities.

☐ *July 18, 2013.* The Corps and NMFS meet to discuss the characterization of the Proposed Action, the Action Area, the Environmental Baseline and the project schedule.

☐ *July 25, 2013.* The Corps, NMFS and YCWA meet to discuss YCWA's applicant status regarding the South Yuba/Brophy Diversion Canal and Facilities.

☐ *August 30, 2013.* The Corps and NMFS meet to discuss comments on the draft status of the species chapter and the draft effects assessment methodology chapter of the Corps' BA.

- ☐ *September 26, 2013*. The Corps and NMFS meet to discuss the scope of the Corps' authorities, as well as non-discretionary actions and discretionary actions within the scope of those authorities.

1.3 Deconstruction of Corps Activities

NMFS uses a series of sequential analyses to assess the effects of Federal actions on endangered and threatened species and designated critical habitat (NMFS 2009a). According to the document titled *An Assessment Framework for Conducting Jeopardy Analyses Under Section 7 of the Endangered Species Act* (NMFS 2004c), one of the early steps in NMFS evaluation process is to "deconstruct" the Proposed Action into its constituent parts. As part of the 2013 consultation between the Corps and NMFS, it was agreed that this BA would undertake a "deconstruction" process to more clearly define the Proposed Action, and distinguish the Proposed Action from other Corps' activities in the Yuba River Basin, to assist NMFS in its jeopardy analysis.

Given the suite of Corps activities in the Yuba River Basin and perplexity associated with the previous consultations, the "deconstruction" step in this BA clearly distinguishes between discretionary actions that may affect listed species and their critical habitat in the lower Yuba River and: (1) future actions requiring separate ESA consultation; (2) non-discretionary actions; (3) discretionary actions with no effect; and (4) Englebright Dam and Reservoir discretionary actions that are not likely to adversely affect listed species (**Figure 1-1**). Appropriately, this BA does not include consultation on future actions requiring separate ESA consultation and non-discretionary actions. Also, the Corps is not required to consult with NMFS on actions that have no effect on listed species and critical habitat. Englebright Dam and Reservoir discretionary actions that are not likely to adversely affect listed species or critical habitat concludes with informal consultation, and are addressed in a separate ESA consultation. Discretionary actions in the lower Yuba River that are likely to adversely affect listed species or critical habitat are carried forward for formal consultation in this BA. Each of these categories of actions in the Yuba River Basin is described below.

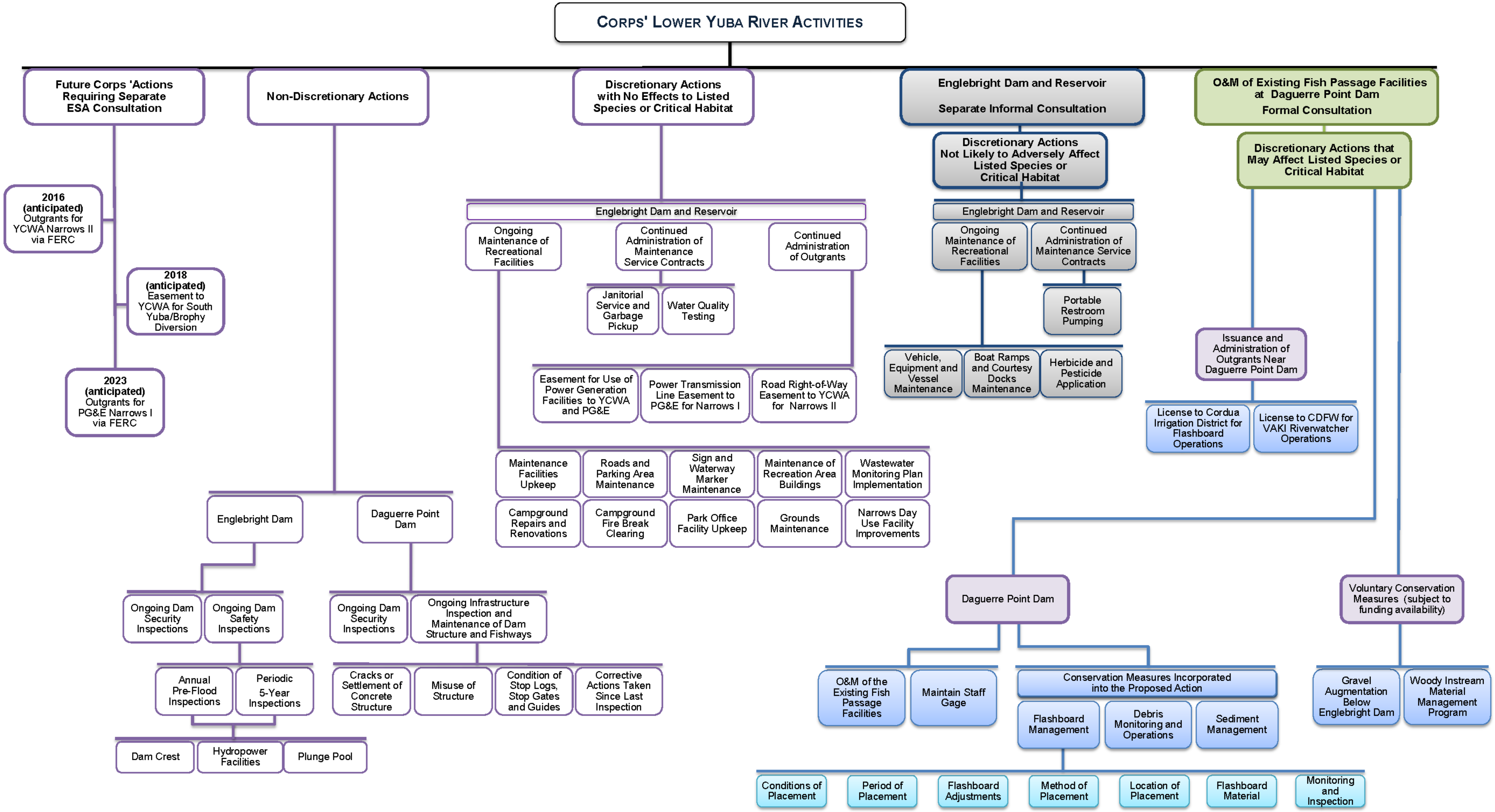

Figure 1-1. Deconstruction of the Corps' lower Yuba River activities and the Proposed Action (i.e., discretionary actions that may affect listed species).

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1.3.1 Corps Non-Discretionary Activities Not Subject to ESA Consultation

One of the key considerations emanating from the 2012 consultation process was the need for clear distinctions between Corps discretionary and non-discretionary actions regarding Englebright and Daguerre Point dams. As stated in 50 CFR §402.03, "*Section 7 and the requirements of this part apply to all actions in which there is discretionary Federal involvement or control*". Therefore, non-discretionary activities at Englebright and Daguerre Point dams are not subject to ESA consultation.

The responsibility to maintain Civil Works structures so that they continue to serve their Congressionally authorized purposes is inherent in the authority to construct them and is therefore non-discretionary. Only Congressional actions to de-authorize the structures can alter or terminate this responsibility and thereby allow the maintenance of the structures to cease. Congress authorized Englebright and Daguerre Point dams on the Yuba River to prevent hydraulic mining debris from washing downstream and blocking the navigation channel of the Sacramento River. The Corps inspects Englebright and Daguerre Point dams to ensure their safety and integrity, and to take the minimal maintenance actions needed to ensure that the dams can continue to serve their Congressionally authorized purposes. Corps non-discretionary activities and associated authorities pertinent to Englebright and Daguerre Point dams on the lower Yuba River are described below.

1.3.1.1 Background Regarding Corps' Authorities Related to Dam Inspections and Hydropower Facilities on Federal Lands

NATIONAL DAM INSPECTION ACT OF 1972

In the early 1970s, several dam failure events prompted the passage of legislation aimed at establishing a national program to protect human life and property from the hazards of improperly constructed or poorly maintained dams (GAO 1977). Consequently, the U. S. Congress enacted Public Law 92-367, which is known as the National Dam Inspection Act of 1972. Under this law, the Secretary of the Army, acting through the Corps of

Engineers, was directed to inspect all dams in the United States except: (1) dams under the jurisdiction of the Bureau of Reclamation, the Tennessee Valley Authority, and the International Boundary and Water Commission; (2) dams constructed pursuant to licenses issued under the authority of the Federal Power Act; (3) dams that had been inspected by a State agency within the 12-month period immediately preceding the enactment of the law and for which the Governor of the respective State requested exclusion; and (4) dams that the Secretary of the Army determined do not pose any threat to human life and property (GAO 1977).

Public Law 92-367 defined the term "dam" to mean any artificial barrier, including appurtenant works, which impounds or diverts water, and which: (1) is twenty-five feet or more in height from the natural base of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation; or (2) has an impounding capacity at maximum water storage elevation of fifty acre-feet (AF) or more.

For the purpose of determining whether a dam (including the waters impounded by such dam) constitutes a danger to human life or property, the law states that the Secretary of the Army shall take into consideration the possibility that the dam might be endangered by overtopping, seepage, settlement, erosion, sediment, cracking, earth movement, earthquakes, failure of bulkheads, flashboard, gates on conduits, or other conditions which exist or which might occur in any area in the vicinity of the dam (Public Law 92-367).

The law also states that as soon as practicable after inspection of a dam, the Secretary of the Army shall notify the Governor of the State in which such dam is located the results of such investigation. The Secretary of the Army shall immediately notify the Governor of any hazardous conditions found during an inspection. The Secretary of the Army shall provide advice to the Governor, upon request, relating to timely remedial measures necessary to mitigate or obviate any hazardous conditions found during an inspection (Public Law 92-367).

NATIONAL DAM SAFETY PROGRAM ACT OF 1996

The National Dam Safety Program Act was signed into law on October 12, 1996 as part of the Water Resources Development Act of 1996 (PL 104-303) and authorized the Secretary of the Army to undertake a national program of inspection of dams.

The objectives of the National Dam Safety Program (Program) are to: (1) ensure that new and existing dams are safe through the development of technologically and economically feasible programs and procedures for national dam safety hazard reduction; (2) encourage acceptable engineering policies and procedures to be used for dam site investigation, design, construction, operation and maintenance, and emergency preparedness; (3) encourage the establishment and implementation of effective dam safety programs in each State based on State standards. The Federal element of the Program shall incorporate the activities and practices carried out by Federal agencies under Section 7 of the Act to implement the Federal Guidelines for Dam Safety.

Public Law 109–460 (December 22, 2006; 109th Congress) amended the National Dam Safety Program Act to reauthorize the National Dam Safety Program. Section 6 of Public Law 109–460 states "*The Secretary of the Army shall maintain and update information on the inventory of dams in the United States. Such inventory of dams shall include any available information assessing each dam based on inspections completed by either a Federal agency or a State dam safety agency.*"

The Corps continues to implement its dam safety program under Engineer Regulation (ER) 1110-2-1156.

1.3.1.2 Englebright Dam Non-Discretionary Activities

Englebright Dam and Reservoir are located downstream of New Bullards Bar Dam on the Yuba River and is part of the Sacramento River and Tributaries project, which was authorized by the Rivers and Harbors Act of August 30, 1935 (P. L. 409, 74th Congress, 1st Session, 49 Stat. p. 1028-1049). The Sacramento River and Tributaries project was constructed by the California Debris Commission in 1941. The Rivers and Harbors Act of 1935 also authorized the development of power at Englebright Dam.

Englebright Dam is 260 feet high, and the storage capacity of Englebright Reservoir was 69,700 AF at the time of construction, as estimated by the U.S. Geological Survey (USGS) using a pre-dam elevation model (Childs et al. 2003 as cited in YCWA 2010). However, due to sediment buildup since construction, the gross storage capacity was more recently estimated at approximately 50,000 AF (USGS 2003).

Upon decommissioning of the California Debris Commission by Section 1106 of the 1986 Water Resources Development Act (P. L. 99-662, 99th Congress, 2nd Session, November 7, 1986), administration of Englebright Dam was assumed by the Corps.

Because Englebright Dam was constructed as a sediment retention facility (debris dam) it does not contain a low-level outlet. Unregulated flood flows spill over Englebright Dam. Following construction of Englebright Dam in 1941 and extending until approximately 1970, controlled flow releases from Englebright Dam were made through the PG&E Narrows I hydropower facilities. Since about 1970 to the present, controlled flow releases from Englebright Reservoir into the lower Yuba River have been made from the PG&E Narrows I and the YCWA Narrows II power plants, both FERC licensed facilities.

The Corps' ongoing activities of Englebright Dam infrastructure pertain to dam maintenance, safety and security. The Corps does not have authority or discretion to control Narrows I, Narrows II, or Englebright Reservoir operations regarding water releases. The water stored in Englebright Reservoir provides recreation and hydroelectric power, and YCWA and PG&E administer water releases for hydroelectric power, irrigation, and other beneficial uses (e.g., instream flow requirements).

ONGOING INFRASTRUCTURE INSPECTION AND SECURITY AT ENGLEBRIGHT DAM

Ongoing infrastructure inspections and security at Englebright Dam includes dam safety and dam security inspections, as described below.

DAM INSPECTION

The Corps' general responsibilities and activities associated with dam maintenance and safety, which are applicable to Englebright Dam, are described in the document titled USACE - Engineering and Design Safety of Dams – Policy and Procedure ER 1110-2-1156 Regulation No. 1110-2-1156 (Corps 2003). The Corps conducts two different types of regular inspections: (1) annual pre-flood inspections; and (2) periodic inspections every 5 years. These inspections are conducted to address the legal requirement that the Corps shall maintain in good order and repair Englebright Dam and outlet facilities in accordance with its authorized purposes.

The purpose of the Corps' periodic inspections is to evaluate the condition of the critical components of Englebright Dam in order to assure the safety, continuing structural integrity, and operational adequacy of the structure (Corps 2004). Periodic inspections conducted from 1970 to date include the inspections described in the following reports.

- Periodic Inspection and Continuing Evaluation Report No. 1, November 1970
- Periodic Inspection and Continuing Evaluation Report No. 2, December 1975
- Periodic Inspection and Continuing Evaluation Report No. 3, June 1981
- Periodic Inspection and Continuing Evaluation Report No. 4, March 1985
- Periodic Inspection and Continuing Evaluation Report No. 5, August 1987
- Periodic Inspection and Continuing Evaluation Report No. 6, December 1993
- Periodic Inspection and Continuing Evaluation Report No. 7, July 1999
- Periodic Inspection and Continuing Evaluation Report No. 8, June 2004

The Corps also conducts Pre-flood Inspections for Englebright Dam. A report of the most recent of these inspections was published in 2012.

At the onset of each inspection, Englebright Reservoir water surface elevation and the maximum pool elevation attained during the season, as well as mean total outflow, weather conditions and air temperature, are recorded. Based upon Corps observations and information provided from past inspections (Corps 2004; Corps 2008a; Corps 2012), examples of the Englebright Dam facilities and appurtenant features addressed as part of the Pre-flood Inspection process generally include the following:

Crest

- Overflow and non-overflow sections of the crest are checked for signs of distress, surface delamination, concrete deterioration and movement of the training wall.

- The downstream face of the dam is inspected for signs of cracking, seepage, and other structural problems that could affect the structural integrity of the dam.
- Upstream and downstream areas of the left and right abutments are checked for notable movement, instability, seepage and debris.
- Corps gatehouse interior and gate chamber, and the bulkhead gate are inspected for signs of concrete deterioration, distress, and misalignment.
- The adit portal, including internal and external examination of the concrete bulkhead wall, the projecting conduit and the riveted dished head closure of the projecting conduit are inspected for possible structural or corrosion problems.
- The reservoir rim is inspected from a Corps patrol boat.
- New and/or previously identified relief landslides are located, photographed, compared to aerial photos and occasionally identified for further monitoring to determine whether a landslide has the potential to present a hazard to the dam from slope-failure induced seiches or to affect nearby roadways.

Hydropower Facilities

- The PG&E Narrows I Hydropower Project intake structure, trash rack, and the first 700 feet of the conduit are regularly inspected on a 5-year cycle by the Corps.

  The Corps' inspections are limited to: (1) the Narrows I intake structure; (2) the trash rack; and (3) the first 700 feet of the conduit because these three components are owned and maintained by the Corps. These three components extend to the structure known as the "adit". The remaining portion of the conduit, extending from the adit to the Narrows I power plant, including all appurtenances in the plant, is owned and maintained by PG&E. PG&E conducts separate inspections of its Narrows I facility for hydropower purposes.
- Because the Narrows II penstock extends through the abutment of the dam, the Corps also inspects the YCWA Narrows II hydropower penstock on a 5-year cycle to ensure that the penstock is in good condition and will not threaten the

stability and safety of Englebright Dam. YCWA conducts separate inspections of its Narrows II facility for hydropower purposes.

Plunge Pool

- ☐ A visual inspection of the plunge pool and downstream overflow sections at Englebright Dam are conducted periodically. It was recommended that the Corps map the plunge pool area (Corps 2008a), which will be accomplished after receiving appropriations by Congress.

Based on the above criteria, the overall condition of Englebright Dam was rated as **Very Good** during the Corps' 2012 Pre-flood Inspections.

Project Safety Plan and Hazard Communication Program

In addition to dam safety, the Englebright Project Safety Plan (Corps 2008b) provides a safety plan for the Englebright Reservoir recreation area to: (1) minimize employee, volunteer, contractor and visitor accidents by establishing procedures and responsibilities relative to safety; (2) assist employees, volunteers, contractors and visitors in the development of a safety attitude; and (3) identify precautionary measures to be taken to eliminate unsafe conditions. The Hazard Communication Program (Corps 2007b) ensures that all field offices within the Sacramento District of the Corps comply with the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard as defined by Title 29 CFR Part 1910.1200. This program provides information for the use of Material Safety Data Sheets, chemical product labeling, handling and storage, training, documentation, and record keeping requirements.

If a need for maintenance repairs or other corrective actions is identified during the inspection process, authorization and funding to conduct the repairs or corrective actions will be included in the Corps' budget two years later.

DAM SECURITY

The baseline security posture for Corps dams will be based on the completion of project specific Vulnerability and Risk Assessments which take into account project criticality, threat (criminal or terrorist), current physical security posture, and law enforcement response capabilities. Once established, the baseline security posture will become the norm (Corps 1992).

All dams will have project-specific Physical Security Plans. The format for these plans should follow the format detailed in Appendix F of the USACE Engineering and Design Safety of Dams – Policy and Procedure ER 1110-2-1156 Regulation No. 1110-2-1156 (Corps 2003).

Inspections are conducted when no prior physical security inspection exists, at regularly scheduled intervals, and when directed by competent authority. Whenever possible, security should be included in annual, periodic, and special inspections of projects. In addition, Corps dams will have dam security systems, which also are inspected during regular dam safety inspections. Dam security inspections are conducted to determine whether the features are safe from vandalism, sabotage, acts of terrorism, or any other acts that could cause the project to fail to function properly and safely for its intended purpose.

In addition to dam security, the 2008 Englebright Lake Security Plan (Corps 2008c) provides for the physical security of Englebright Reservoir during normal operations, and during periods of increased security. Physical security threats include terrorism, natural disasters, civil disturbances, theft and vandalism.

These Corps dam safety and security activities are Federally mandated actions, and are not subject to ESA consultation. Activities conducted as part of the Corps' regular inspections of infrastructure maintenance at Englebright Dam are restricted to the physical facilities at Englebright Dam and do not extend downstream to the lower Yuba River. Additionally, the continuation of these activities will have no effect on listed fish species or critical habitat in the lower Yuba River.

1.3.1.3 Daguerre Point Dam Non-Discretionary Activities

ONGOING INFRASTRUCTURE INSPECTION AND SECURITY AT DAGUERRE POINT DAM

Ongoing infrastructure inspections at Daguerre Point Dam include dam safety and dam security inspections. Specific inspection activities at Daguerre Point Dam are specified in the Corps' O&M Manual, Yuba River Debris Control Project" (Corps 1966), which is used in conjunction with Corps' Engineering Manuals EM 1130-2-203 - Project Operation Maintenance Guide, and EM 385-1-1 - General Safety Requirements.

INSPECTION AND MAINTENANCE

The Daguerre Point Dam O&M Manual states that periodic inspections shall be made as required, to determine maintenance measures necessary to insure serviceability of the facility during flood conditions. Such inspections shall be made immediately prior to the beginning of the flood season, and immediately after each high water period. Immediate steps shall be taken to correct dangerous conditions observed during such inspections, and regular maintenance repair measures shall be accomplished during the appropriate season as determined by the Corps. The ongoing non-discretionary inspection and maintenance activities address the following.

DAGUERRE POINT DAM STRUCTURE

☐ Condition of the concrete (e.g., erosion, pop-out, movement and vibration, cracks in or settlement of concrete in overflow and non-overflow sections).

☐ Excessive abrasion of concrete.

☐ Rock and derrick stone backfills.

☐ Foundation and backfill drainage. The outlets of all drains shall be inspected when river stages permit access to them, and shall be cleaned a minimum of every 5 years or more often if required. At other times the drainage manholes at either end of the overflow section shall be inspected and cleaned a minimum of every 3 years or more often if required.

☐ Record water level in drainage manholes, and check drainage pipe outlets, if accessible.

☐ Roadways and parking areas (e.g., condition of pavement, shoulders and ditches, sloughing, slides).

☐ Corrective action taken since the last inspection.

DAGUERRE POINT DAM FISHWAYS

- ☐ Cracks or settlement of concrete structures.
- ☐ Misuse of structures, such as burning of debris in them.
- ☐ Condition of the stop logs, stop gates and guides.
- ☐ Corrective action taken since the last inspection.

If dam safety and dam security maintenance repairs are necessary, the Corps' Chief, Construction-Operations Division will request the Corps' Chief, Engineering Division, to prepare plans, specifications, and cost estimates for the repairs. All dam safety and dam security maintenance cost estimates will be submitted to the State of California for approval. After approval, the Corps' Construction-Operations Division will accomplish the maintenance work, and the cost of the work will be shared equally by the Government and the State of California.

These Corps safety and security activities at Daguerre Point Dam are Federally mandated actions, and are not subject to ESA consultation.

1.3.2 Corps' Discretionary Activities that have No Effects to Listed Species or Critical Habitat

Another key consideration emanating from the 2012 consultation process was the need to clearly identify Corps discretionary actions that have no effects to listed species or critical habitat. The Action Area for this consultation (see Chapter 3) is determined considering the extent of the direct and indirect effects of the Proposed Action. The Action Area is defined as "*all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action*" (50 CFR § 402.02).

The Corps conducts discretionary activities upstream of the Action Area. These activities are conducted in locations that are not occupied by any of the listed species addressed in this BA, and are not designated as critical habitats. Although these discretionary Corps activities occur upstream of the Action Area, they are evaluated to demonstrate that they do not have the potential to transmit effects downstream to the lower Yuba River.

These discretionary activities upstream of the Action Area are those associated with maintenance of recreational facilities and continued administration of maintenance service contracts on and around Englebright Reservoir, and continued administration of outgrants at or near Englebright Dam. The Corps is not required to consult with NMFS on actions that have no effect on listed species and critical habitat (USFWS 2013; USFWS and NMFS 1998). For clarification, these discretionary activities that have no effects to listed species or critical habitat are described below.

1.3.2.1 Englebright Dam and Reservoir Discretionary Activities

ONGOING MAINTENANCE OF RECREATIONAL FACILITIES ON AND AROUND ENGLEBRIGHT RESERVOIR

Recreation-related operations and maintenance activities on and around Englebright Reservoir, as identified and described in the 2007 Harry L. Englebright Lake Operational Management Plan (Corps 2007) are discretionary actions. The types of discretionary ongoing activities described in the 2007 Harry L. Englebright Lake Operational Management Plan (Corps 2007) include:

- ☐ Maintenance Facilities Upkeep
- ☐ Sign and Waterway Marker Maintenance
- ☐ Narrows Day Use Facility Improvements
- ☐ Wastewater Monitoring Plan Implementation
- ☐ Park Office Facility Upkeep
- ☐ Grounds Maintenance
- ☐ Roads and Parking Area Maintenance
- ☐ Maintenance of Recreation Area Buildings
- ☐ Campground Repairs and Renovations
- ☐ Campground Fire Break Clearing

Along the 24 miles of Englebright Reservoir’s shoreline, the Corps has developed facilities including: (1) 96 campsites; (2) 9 picnic sites; (3) 1 group picnic shelter with 4 tables; (4) 2 boat launching ramps (Narrows and Joe Miller Ravine) maintained by the Corps; (5) a private marina operated by a concessionaire; and (6) 5 parking lots containing a total of 163 parking spaces. During the May 1 to September 30 recreation season, daily maintenance/safety inspections are conducted in all developed recreation areas. Facilities receiving consistent use and open to the public outside this time frame are also inspected daily (Corps 2007). The Corps also inspects these recreation facilities during the October 1 to April 30 off-season to determine whether it needs to make repairs or rehabilitate campsites during this period.

The 800-acre Englebright Reservoir attracts large numbers boaters and campers during the summer months and has an excellent year-round trout fishery[2] (Corps 2007). Even though there are ten other reservoirs within a 50-mile radius, the boat-in-only style of camping and the scenic steep canyons make it a popular destination. Unlike most area reservoirs that are affected by summer draw-downs, Englebright Reservoir water surface levels remain fairly constant throughout the year. This results in an influx of park users during the late summer months, especially during drought years (Corps 2007).

The Narrows and Joe Miller Recreation Areas are the primary visitor access points to the lake. Both have launch ramps, restrooms, and parking areas, but only Narrows has a picnic area with individual tables and a reservable group shelter. Privately-owned Skipper's Cove Marina is situated adjacent to these areas, and provides mooring to hundreds of houseboats and pleasure craft at its facility (Corps 2007).

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[2] Englebright Reservoir is currently managed as a cold water and warm water fishery under the direction of CDFW, and the fish stocking program at Englebright Reservoir is conducted and directed by CDFW, or by PG&E in coordination with CDFW. The Corps does not conduct or direct fish stocking at Englebright Reservoir.

CONTINUED ADMINISTRATION OF MAINTENANCE SERVICE CONTRACTS AT ENGLEBRIGHT DAM AND RESERVOIR

According to the 2007 Harry L. Englebright Lake Operational Management Plan (Corps 2007), the types of maintenance service contracts currently in use at Englebright Reservoir include the following:

- ☐ Garbage Pickup
- ☐ Janitorial Service
- ☐ Water Quality Testing

CONTINUED ADMINISTRATION OF OUTGRANTS DESCRIBED IN THE 2007 HARRY L. ENGLEBRIGHT LAKE MANAGEMENT PLAN

According to the 2007 Harry L. Englebright Lake Operational Management Plan (Corps 2007), the Corps administers outgrants, which include permits, licenses, leases, and easements on project lands used to maintain public utilities and for right-of-way purposes. The administration of ongoing outgrants include:

- ☐ Road Right-of-Way Easement to YCWA for Narrows II
- ☐ Power Transmission Line Easement to PG&E for Narrows I
- ☐ Easements for Use of Power Generation Facilities to YCWA and PG&E

For the purposes of this BA, the "*administration of existing permits, licenses, leases and easements*" is defined as the activities related to the safety and inspection of facilities by the Corps.

ASSESSMENT OF THE CORPS' DISCRETIONARY ACTIVITIES AT AND AROUND ENGLEBRIGHT DAM AND RESERVOIR THAT HAVE NO EFFECTS TO LISTED SPECIES OR CRITICAL HABITAT

The proposed action evaluated in the Corps' 2012 BA included the Corps' discretionary activities associated with Englebright Dam and Reservoir. However, further review of the effects analysis presented in the Corps 2012 BA indicates that several discretionary activities have no effect on listed fish species or critical habitat in the lower Yuba River. Consequently, these activities are not carried forward for Section 7 consultation because they have no effects on the listed species. Each of these activities is further discussed below.

ONGOING MAINTENANCE OF RECREATIONAL FACILITIES ON AND AROUND ENGLEBRIGHT RESERVOIR

Recreation-related operations and maintenance activities conducted by the Corps on and around Englebright Reservoir are restricted to the 800-acre Englebright Reservoir, the 24 miles of Englebright Reservoir shoreline, and various upland campsite areas in the vicinity of the reservoir.

Project maintenance is accomplished by using service contracts, maintenance staff and ranger staff in a variety of ways, including: (1) service contract specifications; (2) scheduled inspections of facilities, equipment, grounds, and resources; (3) specific job assignments to park staff; (4) specific assignments to park staff for inspection of contractor performance and maintenance/safety inspections; and (5) general project inspections by all employees during the course of daily activities. Work areas are cleaned at the end of each workday, with tools and materials put in their proper place. Clean, safe, and properly stored and maintained tools represent an important step toward efficient maintenance facilities.

During the May 1 to September 30 recreation season each year, daily maintenance/safety inspections are conducted by the Corps in all developed recreation areas around Englebright Reservoir. Facilities are cleaned, serviced, repaired, or replaced as applicable in order to maintain them in proper working condition. Facilities receiving consistent use and open to the public outside this time frame also are inspected daily.

Corps maintenance staff are responsible for miscellaneous repairs to existing roadways. Potholes, depressions and sub-grade failures to pavements are repaired promptly. With the recent addition of the computerized road inventory program at Englebright Reservoir, all roadways are inspected annually and minor repairs made and major overlay needs reported.

Campground repairs and renovations are periodically needed at the campsites around Englebright Reservoir. Common types of improvements include site leveling and pad enlargement, tie replacement, table and fire ring replacement, installing stairs, trail improvement, tree removal, and bulletin board replacement. Occasionally, campground fire breaks also need to be cleared of trees and vegetation.

With respect to grounds maintenance, most areas are mowed to minimize and prevent fire danger in and around recreation areas. Day use areas are also mowed and trimmed for visitor use and aesthetics. The Corps conducts periodic inspections of turf areas during the recreation season and maintenance is scheduled as needed for repair of holes, ruts, depressions, erosion, bare areas, overuse, weeds, disease, debris, and litter.

The Corps also conducts a project sign inventory each fall to determine signage needs for the following year. All signs are inspected for damage, vandalism, deterioration, fading, placement, secure fastening, and appropriateness. Repairs and replacements are made as necessary.

The foregoing activities are primarily conducted in upland areas around Englebright Reservoir and have limited or no potentiality to affect aquatic habitat in the reservoir. These maintenance activities do not have the potential to transmit physical habitat alteration effects downstream to the lower Yuba River. Listed fish species do not inhabit Englebright Reservoir and there is no fisheries-related critical habitat designated in or around the reservoir. The continuation of the Corps' ongoing maintenance of recreational facilities on and around Englebright Reservoir will have no effect on listed fish species or critical habitat in the lower Yuba River. Consequently, these activities are not carried forward for Section 7 consultation because they have no effects on the listed species.

CONTINUED ADMINISTRATION OF MAINTENANCE SERVICE CONTRACTS AT ENGLEBRIGHT DAM AND RESERVOIR

The Corps' discretionary activities include administration of the following maintenance service contracts at Englebright Reservoir: (1) garbage pickup; (2) janitorial service; and (3) water quality testing. Maintenance activities associated with these contracts would occur at and around Englebright Reservoir and at various upland campsite areas in the vicinity of the reservoir.

The administration of these maintenance service contracts constitutes ministerial actions, and not activities that have the potential to affect listed species or their critical habitats in the lower Yuba River. Any potential effects associated with the conduct of these activities would be locally constrained, and would not extend to the lower Yuba River. These maintenance activities are primarily conducted in upland areas around Englebright Reservoir and have limited or no potentiality to affect aquatic habitat in the reservoir. These maintenance activities do not have the potential to transmit physical habitat alteration effects downstream to the lower Yuba River. The Corps' continuation of the maintenance of service contracts at and around Englebright Reservoir would have no effect on listed fish species or critical habitat in the lower Yuba River. Consequently, these activities are not carried forward for Section 7 consultation because they have no effects on the listed species.

CONTINUED ADMINISTRATION OF OUTGRANTS DESCRIBED IN THE 2007 HARRY L. ENGLEBRIGHT LAKE MANAGEMENT PLAN

The Corps' discretionary activities include the continued administration of permits, licenses, leases, and easements related to the Corps' outgrants for project lands used to maintain public utilities and right-of-way purposes. Outgrants have been issued to various entities, examples of which include: (1) road right-of-way permits and easements; (2) telephone line license; (3) power transmission line easements; and (4) concessionaire lease at the Englebright Dam marina.

The Corps conducts annual compliance inspections on outgranted lands, including lands outgranted for commercial concessions. Major purposes of the inspections are to establish a good liaison with outgrantee, to provide assistance to outgrantee handling problems and planning, and to ascertain outgrantee compliance with terms of the outgrant (Corps 2007). These inspections constitute administrative actions, and not activities that have the potential to affect listed species or their critical habitats in the lower Yuba River. Moreover, inspection activities conducted by the Corps are restricted to locations that do not extend to the lower Yuba River. Therefore, the Corps' continued administration of permits, licenses, leases, and easements is anticipated to have no effect on listed fish species or critical habitat in the lower Yuba River. Consequently, these activities are not carried forward for Section 7 consultation because they have no effects on the listed species.

1.3.3 Corps' Discretionary Activities at and around Englebright Dam and Reservoir that May Affect but are Not Likely to Adversely Affect Listed Species or Critical Habitat

The proposed action evaluated in the Corps' 2012 BA included the Corps' discretionary activities associated with Englebright Dam and Reservoir. However, further review of Corps' authorizations and the effects analysis presented in the Corps 2012 BA indicates that the discretionary activities at Englebright Dam and Reservoir identified below may affect, but are not likely to adversely affect listed species or critical habitat in the lower Yuba River. The "*may affect, but is not likely to adversely affect*" conclusion is appropriate when effects to the species or critical habitat are expected to be beneficial, discountable, or insignificant. The Corps has prepared a separate BA for their discretionary activities at and around Englebright Dam and Reservoir. In that BA, the Corps has determined that their activities are not likely to adversely affect listed species or critical habitat. If NMFS agrees with that determination, informal consultation on these activities can be concluded with a concurrence letter. For clarification purposes, each of these activities are briefly discussed below.

The Corps conducts discretionary actions at and around Englebright Dam and Reservoir that have a remote possibility of transmitting contaminants downstream to the lower Yuba River. The types of discretionary ongoing activities described in the 2007 Harry L. Englebright Lake Operational Management Plan (Corps 2007) with the potential to transmit contaminants downstream include:

- ☐ Vehicle, Equipment and Vessel Maintenance
- ☐ Boat Ramps and Courtesy Docks Maintenance
- ☐ Herbicide and Pesticide Application

Additionally, nine separate buoy lines are located on the lake surface at Englebright Reservoir. Maintenance and repair of these waterway markers are performed by the Corps, as needed.

The Corps engages in some activities associated with herbicide and pesticide application, and also administers contracts for application. Thus, potential effects associated with herbicide and pesticide application are briefly summarized below in the next section titled "*Continued Administration of Maintenance Service Contracts at Englebright Dam and Reservoir*".

1.3.3.1 Ongoing Maintenance of Recreational Facilities on and around Englebright Reservoir

Maintenance of recreational facilities on and around Englebright Reservoir only has the potential to impact the lower Yuba River through the inadvertent release of contaminants into Englebright Reservoir. Recreation-related areas in the vicinity of Englebright Reservoir that may be subject to a contaminant spill include: (1) areas with high public visitation such as campgrounds, marinas, and launch ramps; (2) petroleum products storage and delivery points; (3) water intake points; and (4) septic distribution, pumping, and treatment systems.

Corps personnel are required to perform a walk-a-round inspection of their vehicle at least once a day and also to check oil, water, battery and tires when fueling the vehicle or at the start of their shift each day. When not in use, vehicles are parked inside the Corps' secure Maintenance Shop Facility compound. Maintenance of all vehicles operated by the Corps is accomplished off-site at an authorized dealer. The maintenance of gasoline and diesel powered equipment is conducted by Corps' contractor personnel, maintenance staff and equipment operators. All equipment is scheduled for routine maintenance by Corps maintenance personnel at prescribed intervals. Equipment operations are required to conduct equipment inspections prior to operating equipment at each use. Corps maintenance personnel also conduct periodic equipment inspections for quality of operation and safety purposes. The Corps also maintains three 20-21 foot aluminum jet boats and one 40-foot aluminum utility barge.

Boat ramps at Englebright Reservoir are located at the Narrows and Joe Miller Recreation Areas. Each boat ramp has a courtesy dock adjacent to it for visitor convenience. These ramps are inspected daily by the Corps, and kept clean of debris, driftwood and sediment. All parts are inspected and replaced or repaired as needed including decking, framing, flotation, fasteners, cables, and anchors. Docking is maintained with a slip-free surface. After flood waters recede, all launch ramps are inspected for damage or undercut concrete and repaired as needed. Signs are maintained at each boat ramp to prohibit parking on the ramps and swimming in their vicinity. The courtesy docks are repaired by the Corps, as necessary.

There have been few recreation-related hazardous materials release incidents at Englebright Reservoir. However, there have been minor instances including vehicles ending up in the lake during boat launching, and sinking boats. Notable spill incidents are as follows:

- ☐ On July 3, 1996, a water line on a boat broke while it was being trailered at the boat launch. The boat sank and released several quarts of oil that was contained with spill containment booms.
- ☐ On July 25, 1996, gasoline was spilled from a leaking fuel delivery line at the private marina's fuel float. Emergency shut-off valves were quickly closed which limited the spill to approximately one gallon.
- ☐ On August 27, 1999, a Nevada County sanitation truck leaked hydraulic oil on the boat ramp and into the reservoir. Marina personnel who were first to arrive at the scene successfully deployed absorbent pads and containment booms.

Vehicle and equipment maintenance activities generally occur in the Corps' Maintenance Shop Facility compound, which is not proximal to Englebright Reservoir. Although vessel maintenance, and boat ramp and courtesy dock maintenance have a remote potential for hazardous materials or other hydrocarbon-based contaminants to be released and enter Englebright Reservoir, it is reasonable to expect that potential spills would be locally constrained, and the volume of contaminants resulting from a spill would be relatively minor in comparison to the total volume of water in the reservoir. For example and contextual purposes, given the descriptions of the above occurrences of minor contamination incidences, one gallon of contaminant spilled into Englebright Reservoir with an estimated storage capacity of about 50,000 AF would result in a concentration of less than about 1 part per 16 billion.

Long-term sublethal effects of oil pollution refer to interferences with cellular and physiological processes such as feeding and reproduction, and do not lead to immediate death of an organism (EPA 1986). Disruption of such behavior apparently can result from petroleum product concentrations in the range of 10 to 100 ug/L (EPA 1986). In addition to sublethal effects reported at the 10 to 100 ug/L level, it has been shown that petroleum products can harm aquatic life at concentrations as low as 1 ug/L (Jacobson and Boylan 1973 in EPA 1986).

For comparison purposes, 1 part per billion (ppb) is a microgram (µg or ug), or 1/1,000,000th of a gram, of a contaminant present in one liter of water or one kilogram of soil (ADEC 2009). Therefore, a petroleum product concentration of less than 1 part per 16 billion is considerably below the EPA (1986) thresholds of: (1) 10 to 100 ug/L (i.e., 10 to 100 ppb) that has been identified as having the potential to cause sublethal (e.g., behavioral) disruptions to aquatic life; and (2) 1 ug/L (1 ppb) shown to potentially harm aquatic life.

Additionally, Corps employees working at Englebright Reservoir are routinely trained in the storage and handling of hazardous materials. The Corps also implements the Harry L. Englebright Lake Operational Management Plan (Corps 2007) for Englebright Reservoir, which includes a Hazardous Materials Plan and a Spill Prevention and Response Plan to address potential hazards associated with the accidental release of hydrocarbons into aquatic habitat in Englebright Reservoir. Although contaminants accidentally entering Englebright Reservoir would be subject to dilution, the containment procedures were developed to further restrict the movement of a spill to soil or water. Therefore, it is not reasonable to suggest that adverse effects to listed species in the lower Yuba River would occur as a result of Corps activities related to: (1) vehicle, equipment, and vessel maintenance; and (2) boat ramps and courtesy docks maintenance.

Overall, although the possibility is extremely remote given all of the above considerations, the continuation of these Corps' activities associated with ongoing maintenance of recreational facilities on and around Englebright Reservoir do have the potential to transmit contaminants downstream to the lower Yuba River. For this reason, the Corps has determined through a separate ESA consultation process that these activities may affect, but are not likely to adversely affect, listed fish species and critical habitat in the lower Yuba River.

1.3.3.2 Continued Administration of Maintenance Service Contracts at Englebright Dam and Reservoir

The Corps' discretionary activities include administration of: (1) portable restroom pumping; and (2) herbicide application maintenance service contracts in areas surrounding Englebright Reservoir. These maintenance activities have a remote possibility to impact the lower Yuba River, as discussed below.

Sewage from portable restroom pumping around the lake is recognized in the Englebright Operations Management Plan as a common hazardous material found on Corps' project lands (Corps 2007), which could pose a threat to public and environmental health. For these reasons, portable restroom pumping is managed as part of the Corps' Wastewater Monitoring Plan, which addresses the management of wastewater from Corps' maintained facilities and monitoring of wastewater generated by houseboats on Englebright Reservoir. As described in Corps (2007), the Corps has established a Hazardous Materials Plan and a Spill Prevention and Response Plan that provide spill response guidance and containment procedures to be implemented in the event of an emergency at or around Englebright Reservoir. Although wastewater accidentally entering Englebright Reservoir would be subject to dilution, the containment procedures were developed to further restrict the movement of a spill to soil or water.

Poison oak is a problem in day use areas, campgrounds, trails, roadsides, and operations areas. Because the presence of poison oak in high-use recreation and operations areas is an unacceptable nuisance and health hazard, exposure must be controlled or eliminated to reduce risk to visitors and Corps employees. Annual and perennial grasses, as well as assorted noxious herbaceous weeds, also are common to the area. This vegetation has the potential to grow very tall, blocking facilities, harboring insects in recreation sites and creating an extreme fire hazard when dry. Consequently, herbicide application is conducted, on an as-needed basis, around Englebright Reservoir, primarily at campsites, firebreaks and nature trails.

The areas of herbicide and pesticide application are generally located in more upland areas not proximal to Englebright Reservoir. Moreover, herbicides are applied in relative dilute quantities that would not represent significant contributions affecting water quality in Englebright Reservoir. Annual herbicide application around Englebright Reservoir is relatively minor. For example, a usage report dated January 29, 2008 indicates that 2 gallons of herbicide were used on 8 acres of land, and 3 gallons used on 10 acres of recreation and operation areas to control weeds, grasses and poison oak. Thus, any potential effects associated with the conduct of these activities would be locally constrained, and would not extend to the lower Yuba River. Also, the Corps Operations Management Plan for Englebright Reservoir includes a Hazardous Materials Plan and a Spill Prevention and Response Plan to address potential hazards associated with herbicide application. Given the minor amounts and upland areas of herbicide application, it is reasonable to conclude that adverse effects to listed species in the lower Yuba River would not occur.

Overall, the Corps has determined through a separate ESA consultation process that the continuation of activities associated with administration of maintenance service contracts at Englebright Dam and Reservoir that have the potential to transmit contaminants downstream to the lower Yuba River may affect, but are not likely to adversely affect listed fish species or critical habitat in the lower Yuba River.

1.3.4 Future Corps Actions in the Yuba River Basin Requiring Separate ESA Consultation

Future Corps' actions in the Yuba River Basin requiring separate ESA consultation have been identified in this BA for clarification and informational purposes. Within the foreseeable future, the Corps has identified three projects that are expected to occur within the Yuba River Basin, as follows.

- ☐ Corps' Issuance of a right-of-way to PG&E for access to the PG&E Narrows I via a separate FERC Relicensing Process (anticipated to occur in 2023)

- ☐ Corps' Issuance of a right-of-way to YCWA for access to the YCWA Narrows II via a separate FERC Relicensing Process (anticipated to occur in 2016)
- ☐ Corps' Issuance of right-of-way to YCWA for access to the South Yuba/Brophy Diversion Canal and Facilities (anticipated to occur in 2018)

Once the technical investigations and regulatory compliance documentation for these projects are completed, these projects would likely require a Federal approval from the Corps. At this time, however, none of these three projects are at the appropriate level of completion to allow the Corps to become involved through the appropriate mechanism associated with each respective regulatory compliance process (e.g., FERC relicensing, 404 permitting). Hence, these three projects represent future actions requiring separate ESA consultation, and are not included in the consultation for this Proposed Action.

1.3.4.1 Hydroelectric Generation Facilities in the Vicinity of Englebright Dam

Besides flood flow spills over the top of Englebright Dam, releases from Englebright Reservoir are made through two FERC licensed hydroelectric power facilities, one of which (YCWA's Yuba River Development Project (YRDP) Narrows II) is located just below the base of the dam, and the other of which (PG&E's Narrows I) is located approximately 0.2 mile downstream (Corps 2007; NMFS 2007) (**Figure 1-2**).

NARROWS I

PG&E's operations of Narrows I are authorized by a license for these facilities issued by FERC under the Federal Power Act.

On February 11, 1993, PG&E received License No. 1403-004 from the FERC, which grants PG&E the right to conduct the continued operation and maintenance of the Narrows I Hydroelectric Project.

On March 28, 1994, the Corps issued a right-of-way (license) No. DACW05-9-95-604 to PG&E for Narrows I, granting access to the FERC licensed powerhouse and for PG&E to utilize Corps outlet facilities and storage space between elevation 450 and 527 in Englebright Reservoir. The 1994 agreement (assigned License No. DACW05-9-95-604

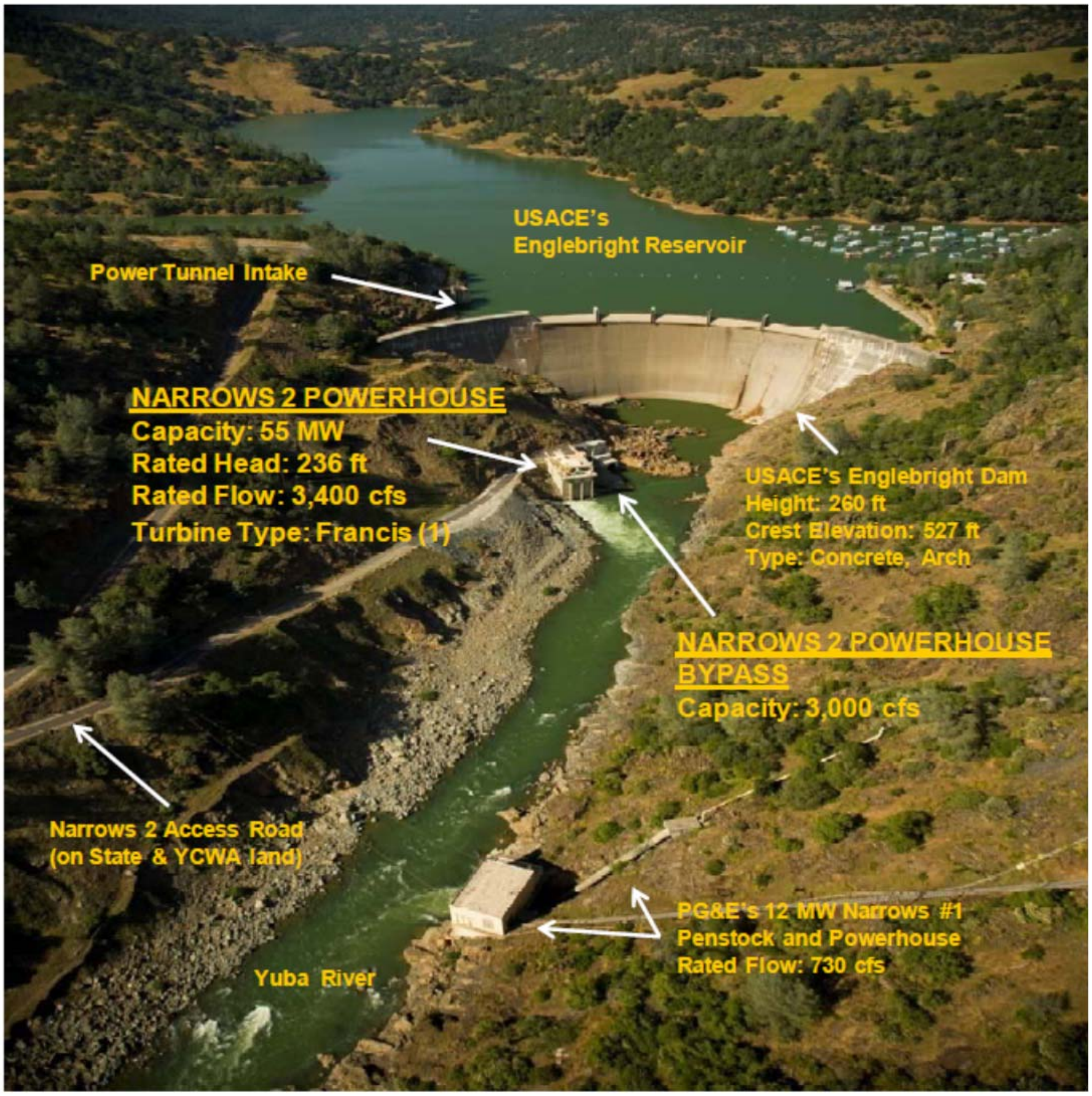

Figure 1-2. Hydroelectric generation facilities in the vicinity of Englebright Dam.

by the Corps) between the Corps and PG&E for access to the Narrows I Hydroelectric Project states that the Corps is responsible for maintaining Englebright Dam and the outlet facilities, including the first 700 feet of the outlet tunnel (Corps and PG&E 1994), in good order and repair, while PG&E is responsible for the operation and maintenance of the hydroelectric facility (Corps 2007).

The Corps also has issued a right-of-way (easement) No. DACW05-2-95-587 making lands available for PG&E's electric transmission lines that run from the Corps' gatehouse (where the control for the bulkhead gate is located) to the Narrows 1 substation, and right-of-way No. DACW05-2-69-102 to PG&E for power transmission lines that run from the Narrows I substation to Narrows II.

Related to ongoing operations and maintenance responsibilities for the power transmission line easements, Corps personnel perform compliance inspections on outgranted lands pursuant to Engineer Regulation 405-1-12, Chapter 8. The compliance inspections are performed on an annual basis, or more often if circumstances dictate. Corps personnel also perform interim inspections on outgrants in connection with day-to-day administration, and instances of unsatisfactory outgrantee performance are noted and reported immediately. Corrective actions will be immediately taken if emergency health or safety is involved (Corps 2007).

NARROWS II

YCWA's operations of Narrows II are authorized by a license for these facilities issued by FERC pursuant to the Federal Power Act.

On February 14, 1966, the Corps entered into an agreement (Contract No. DA-04-167-CIVENG-66-95) with YCWA regarding the use of Englebright Dam and Reservoir for the generation of power at the Narrows II powerplant. The term of the 1966 Agreement extends through the term of the license for FERC Project No. 2246 (April 30, 2016), and may be extended annually according to the conditions and provisions included in the agreement.

The 1966 Agreement specifies that operations and maintenance of the intake works, tunnel, power plant, access roads and appurtenances are the responsibility of YCWA, and are not the responsibility of the Corps.

In 1975, the Corps issued a right-of-way (easement) No. DACW05-2-75-716 to YCWA for access to the construction site of the Narrows II powerplant, intake works and tunnel which is associated with the FERC license. The term of this easement is for a fifty-year period beginning August 14, 1967 and ending August 13, 2017. Also, in 1975, the Corps issued right-of-way (easement) No. DACW05-2-75-715 to YCWA for access to the construction site, use and maintenance of access roads, including culverts and other drainage facilities, associated with the FERC license. The term of this easement is for a fifty-year period beginning August 14, 1967 and ending August 13, 2017. The Corps has no ongoing operation and maintenance responsibilities associated with these two easements (D. Grothe, Corps, pers. comm. 2011).

In 2005, the Corps issued a Right of Entry (No. DACW05-9-06-510) to YCWA for the construction of the Narrows II Full Flow Bypass, which is associated with the FERC license. In 2006, YCWA constructed a full-flow bypass on Narrows II powerhouse which allows approximately 3,000 cfs (or 88 percent of the full 3,400 cfs capacity of the powerhouse) to be bypassed around the power generation facilities to maintain river flows during emergencies, maintenance, and accidental shut-downs of the powerhouse. Although emergency and maintenance shutdowns occur infrequently, the full-flow bypass was designed to eliminate most flow fluctuations that would result from such shutdowns. Since the flow bypass system was installed in 2006, YCWA has been able to more consistently operate the Narrows II facility to reduce most short-term flow fluctuations by providing nearly instantaneous restoration of flows to the lower Yuba River. The full-flow bypass has resulted in an overall improvement in conditions for listed anadromous salmonids and green sturgeon by reducing the potential for severe flow reductions and fluctuations to adversely affect these species in the lower Yuba River (FERC 2005). The Corps has no ongoing operation and maintenance responsibilities associated with this Right of Entry.

Presently, the Corps is simply administering the existing rights-of-way associated with FERC licenses to PG&E for the Narrows I facility and to YCWA for the Narrows II facility. At the time of this consultation, the Corps is not proposing to take any actions related to the aforementioned, pre-existing rights-of-way, and these rights-of-way will remain in effect until the existing FERC licenses for both the PG&E and YCWA FERC hydropower projects expire in 2023 and 2016, respectively.

An example of a license article that FERC has recently included in FERC project licenses that would use Corps' facilities (T. Mansholt, FERC Office of the General Counsel – Energy Projects, pers. comm. 2013) is:

> *"Article 309. Agreement with Corps. The licensee shall within 90 days from the issuance date of the license, enter into an agreement with the*

> *U.S. Army Corps of Engineers (Corps) to coordinate its plans for access to and site activities on lands and property administered by the Corps so that the authorized purposes, including operation of the Federal facilities, are protected…"*

The Corps will re-evaluate the rights-of-way during the FERC relicensing processes. These evaluations will be conducted as part of separate, future ESA consultations, and are not included in the consultation for the Proposed Action.

1.3.4.2 Right-of-Way to YCWA for the South Yuba/Brophy Diversion Canal and Facilities Near Daguerre Point Dam

Approximately 1,000 feet upstream of Daguerre Point Dam on the south side of the Yuba River, the South Yuba/Brophy Diversion Canal and Facilities divert water through an excavated channel from the Yuba River's south bank. The South Yuba/Brophy diversion facility includes a 450-foot long porous rock weir fitted with a fine-mesh barrier (geotextile cloth) within the weir, intended to protect juvenile fish from becoming entrained into the canal (Corps 2007). Over the years, various rights-of-way (permits, licenses, easements) have been issued to provide access to the diversion facilities.

The Corps issued a right-of-way (license), No. DACW05-3-83-593, to Brophy Water District on August 29, 1983. This license is no longer in force because it was discovered to be a duplicate. License No. DACW05-3-85-537 was issued to South Yuba Water District on March 15, 1985, for the South Yuba/Brophy diversion. This license is currently in a hold-over status, because it expired in March 2000.

The Corps issued a 50-year right-of-way (easement), No. DACW05-2-98-612, to YCWA on October 19, 1998. The Corps subsequently retracted this easement in March 1999 because of land administration issues associated with Bureau of Land Management (BLM) lands (Corps 2000).

A BLM right-of-way (Serial No. CACA 44390) to YCWA was issued by BLM on June 24, 2002. It grants YCWA the right to operate, maintain, and terminate an existing canal on public lands until December 31, 2031 (30-year term). YCWA's activities under the grant are limited to operations and maintenance of the existing facilities.

Although the diversion structure addressed CDFW fish screening requirements at the time of construction in 1985, fish screening requirements have changed over time and the diversion structure does not meet current NMFS and CDFW screening criteria. The potential replacement or modification of the rock gabion fish screen at the South Yuba/Brophy Diversion Canal and Facilities has been under consideration for many years. A collaborative process to undertake a feasibility assessment was initiated by YCWA and CDFW in late 2005. A final feasibility study titled *"Feasibility Study for the South Canal Fish Screen"* (Feasibility Study) was issued in April 2009.

In August 2009, YCWA initiated the environmental review process pursuant to the California Environmental Quality Act (CEQA) for the South Diversion Canal Screening Project. For a variety of reasons (including uncertainty regarding various aspects of the litigation regarding Daguerre Point Dam), YCWA suspended the CEQA process in July 2010.

Since July 2010, YCWA has worked with local stakeholders, water users and water right holders to address concerns about the cost and reliability of a new water diversion structure. YCWA has engaged a consultant team to undertake an Enhanced Feasibility Assessment, to expand on the feasibility work previously completed by YCWA and CDFW. YCWA will re-initiate the CEQA process, as well as a parallel NEPA process with the Corps after completion of the Enhanced Feasibility Assessment. Final permitting and final design work for the preferred alternative will be undertaken after the completion of the full CEQA/NEPA process.

At such time as YCWA develops the final plan for a new water diversion structure and completes any required permitting (including 404) and ESA consultation, the Corps plans to issue a right-of-way (easement) to YCWA for access to the diversion facilities and canal, located near Daguerre Point Dam. The Corps will have no responsibility for designing such facilities, or operating or maintaining the South Yuba/Brophy Diversion Canal and Facilities. This project represents a future action that may require separate ESA consultation(s), and is not included the Corps' consultation for this Proposed Action.

2.0 Description of the Proposed Action

The Corps' identification and definition of an "action" must comply with the procedural and substantive requirements of the ESA. A comprehensive project description is vital to determining the scope of the proposed action. The ESA Section 7 regulations define "action" as: *"…all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas. Examples include, but are not limited to: …(d) actions directly or indirectly causing modifications to the land, water, or air"* (50 CFR 402.02).

The Corps' authorized O&M and planning activities associated with the Proposed Action includes making minor modifications to the fish ladders at Daguerre Point Dam. The Corps' O&M of the fish ladders at Daguerre Point Dam does not include major ladder reconfigurations or reconstruction. According to the Corps Regulation (No. 1165-2-119) titled "Modifications to Completed Projects" (Corps 1982), such activities would require additional Congressional authorization and appropriation of necessary funding. Consequently, the Proposed Action is comprised of O&M of the existing fish passage facilities at Daguerre Point Dam, and specified conservation measures.

When used in the context of the ESA, "conservation measures" represent actions pledged in the project description that the action agency (in this case, the Corps) will implement to further the recovery of the species under review (USFWS and NMFS 1998). Such measures should be closely related to the action, and should be achievable within the authority of the action agency. For the present consultation, such measures correspond to the "Protective Conservation Measures" described below.

Because conservation measures are part of a proposed action, their implementation is required under the terms of the consultation. However, NMFS can make conservation recommendations, which are discretionary suggestions for consideration by the Corps. For the present consultation, the "Voluntary Conservation Measures for Habitat Enhancement Purposes" generally correspond to conservation recommendations, because although these measures are planned for implementation, they are subject to funding availability.

The beneficial effects of conservation measures are taken into consideration for both jeopardy and incidental take analyses by NMFS. However, USFWS and NMFS (1998) caution that… *"the objective of the incidental take analysis under section 7 is minimization, not mitigation. If the conservation measure only protects off-site habitat and does not minimize impacts to affected individuals in the action area, the beneficial effects of the conservation measure are irrelevant to the incidental take analysis."*

2.1 Proposed Action Components

The formal Section 7 consultation, for which this BA has been prepared, includes Corps discretionary actions pertaining to O&M of the fish passage facilities at Daguerre Point Dam, including administration of outgrants associated with O&M of the facilities, and conservation measures. The Proposed Action is consistent with the Congressional authorization (Rivers and Harbors Act of 1935) for Daguerre Point Dam, and consists of the following components:

- ☐ Operation and maintenance of the fish passage facilities at Daguerre Point Dam
- ☐ Maintenance of the staff gage at Daguerre Point Dam
- ☐ Administration of a right-of-way (license) issued to CDFW for VAKI Riverwatcher operations at Daguerre Point Dam
- ☐ Administration of a right-of-way (license) issued to Cordua Irrigation District for flashboard installation, removal and maintenance at Daguerre Point Dam

Protective Conservation Measures (annual funding availability and ongoing implementation is reasonably certain to occur based on past operations).

- ☐ Implementation of the Daguerre Point Dam Fish Passage Sediment Management Plan
- ☐ Administration of a long-term Flashboard Management Plan at Daguerre Point Dam
- ☐ Implementation of a Debris Monitoring and Maintenance Plan at Daguerre Point Dam

Voluntary Conservation Measures for Habitat Enhancement Purposes (planned for implementation, but less certain and subject to funding availability).

- ☐ Gravel Injection in the Englebright Dam Reach of the lower Yuba River
- ☐ Large Woody Material Management Program

In addition, Corps discretionary activities also include the review of requests for temporary right-of-ways (permits) or use of portions of Corps owned right-of-ways associated with Daguerre Point Dam. All requests for permits for temporary right-of-ways or use of portions of the Government owned right-of-ways are carefully reviewed to determine that such use will not adversely affect maintenance operations, or the safety and functioning of the project structures (Corps 1966). Each request is processed on a case-by-case basis. No specific requests are presently identified, and the Corps review of such requests is not included in formal consultation for this BA.

It also is important to note that, for this consultation, the Corps has no water rights or authority to regulate water rights on the Yuba River. Because water right issues on the Yuba River are not within the Corps' authority or discretion to regulate, they are not part of the Proposed Action.

2.1.1 Operation and Maintenance of the Fish Passage Facilities at Daguerre Point Dam

Daguerre Point Dam (**Figure 2-1**) is located on the lower Yuba River approximately 11.5 River Miles (RM) upstream from the confluence of the lower Yuba and lower Feather rivers. Concrete fish ladders are located on both the North and South abutments of the Dam **(Figure 2-2, Figure 2-3).** The park personnel of the Corps administer the operation and maintenance of the fish ladders, in coordination with CDFW.

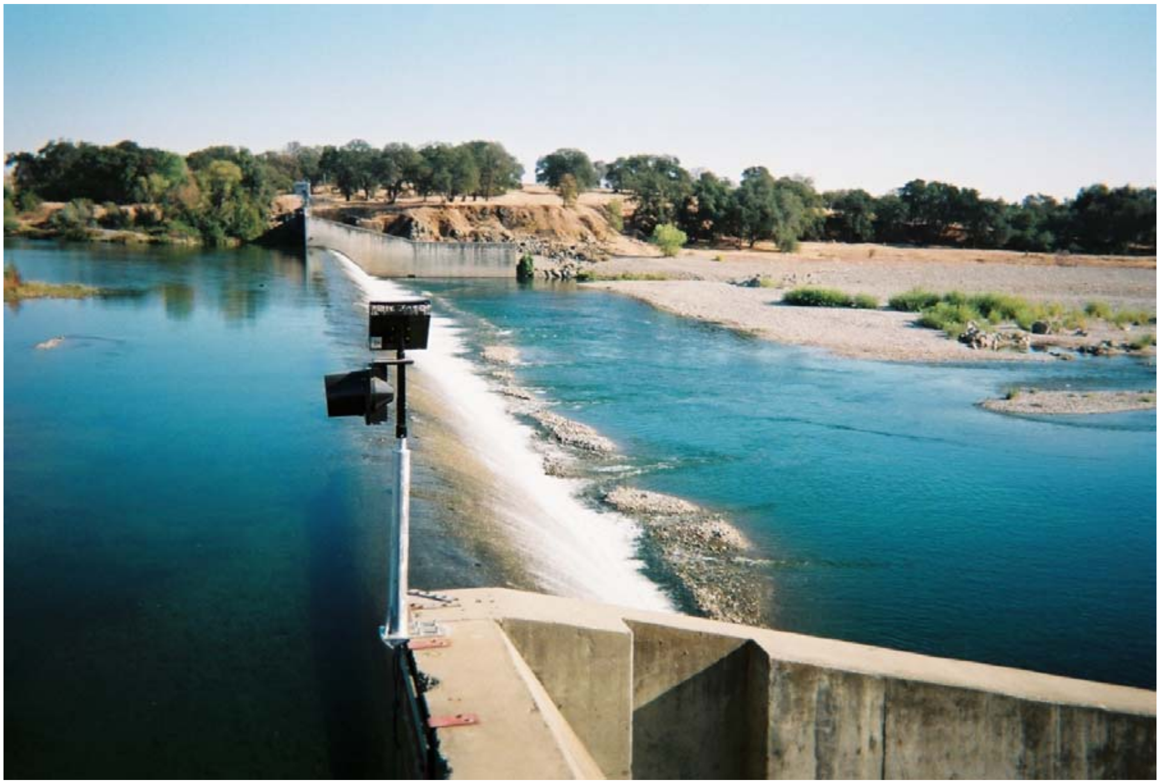

Figure 2-1. Daguerre Point Dam (photo by D. Simodynes, October 9, 2009).

2.1.1.1 Fish Ladder Operations

Fish ladder operations consist of adjusting the fishway gates, within-ladder flashboards, and the fish ladder gated orifices. Fishway gates allow water to enter the fish ladders, and the fish ladder gated orifices regulate the point where upstream migrating fish can most easily enter the ladders (Corps 1966). Within-ladder flashboards influence flow hydraulics within the bays of the ladders.

The Corps continues to operate the fish ladders at Daguerre Point Dam to improve fish passage. The Corps' past operational criteria required that the fish ladders at Daguerre Point Dam be physically closed when water elevations reached 130 feet, or when flows were slightly less than 10,000 cfs (SWRCB 2003), and to keep them closed until the water recedes to an elevation of 127 feet (CALFED and YCWA 2005). Presently, the Corps is collaborating with resource agencies (CDFW, NMFS) and the Yuba Accord River Management Team (RMT) to improve fish passage by keeping the ladders open at

Figure 2-2. North fish ladders at Daguerre Point Dam (Corps 2012c).

Figure 2-3. South fish ladders at Daguerre Point Dam (Corps 2012c).

all river elevations. The Proposed Action includes continuation of this collaboration, and keeping the ladders open.

Within-ladder flashboards were installed in the lower bays of the south fish ladder during June 2010 by CDFW. Adjustment of these within-ladder flashboards influence hydraulics and have been shown to improve adult anadromous salmonid attraction flows to the south ladder (Grothe 2011). The Proposed Action includes the continued collaboration with CDFW regarding adjustment of these within-ladder flashboards.

2.1.1.2 Fish Passage Facility Maintenance

The Corps coordinates with CDFW and NMFS to determine when maintenance of the fish passage facilities at Daguerre Point Dam is to be conducted, which is when it is least stressful to fish. Corps and CDFW joint maintenance activities include cleaning the bays of the fish ladders, cleaning the grates covering the fish ladder bays, and other minor maintenance activities. Since the spring of 2010, the Corps and NMFS have been holding monthly meetings to coordinate regarding maintenance activities and other issues pertaining to the lower Yuba River. The Proposed Action includes the continuation of the Corps-NMFS coordination meetings.

CDFW is responsible for inspecting and clearing debris from the upper portion of the ladders containing the VAKI Riverwatcher devices (see Section 2.1.3), and the Corps is responsible for all other parts of the ladders. Presently, Pacific States Marine Fisheries Commission (PSMFC) staff, in collaboration with CDFW, operating the VAKI Riverwatcher devices make observations of the fish ladders on an approximately daily basis, and the Corps coordinates with them regarding observations of debris or blockages, and/or adult salmonid upstream passage observations. Any debris that could affect fish passage is removed as soon as possible when personnel can safely access the area. Since August 2010, the Corps has also conducted sub-surface inspections of the ladders, after NMFS advised the Corps of the possibility of sub-surface blockage. The Proposed Action includes continuation of the routine maintenance of removal of debris from the fish ladders.

2.1.1.3 Daguerre Point Dam Fish Passage Sediment Management Plan

The Corps routinely removes the gravel and sediment that accumulates upstream of Daguerre Point Dam. The Corps, through collaboration with NMFS, CDFW, and USFWS, developed an updated Daguerre Point Dam Fish Passage Sediment Management Plan in February 2009 (Corps 2009). The purpose of the plan is to describe the methods used to manage the sediment that accumulates upstream of Daguerre Point Dam in order to improve flows to the ladders at Daguerre Point Dam, to provide suitable adult salmonid migratory habitat conditions upstream of the Daguerre Point Dam fish ladders, and to provide attraction to the ladders downstream of Daguerre Point Dam. Details of the plan include the following.

Upstream of Daguerre Point Dam, adequate water depth will be maintained across the upstream face of the dam to allow unimpeded fish passage from the ladders to the main channel of the lower Yuba River upstream from Daguerre Point Dam. An adequate water depth is defined as a “channel” at least 30 feet wide when measured from the face of the dam upstream, and 3 feet deep when measured from the crest of the dam to the riverbed.

Water depth measurements will be taken across the upstream face of the dam to determine the depth of the channel during June of each year. If the flows are too high in June to take the measurements, they will be taken as soon as conditions are safe. If the water depth measurements show that the channel is still at least 30 feet wide by 3 feet deep, no sediment removal is required for that year. If the water depth measurements show that sediment has encroached and the channel has filled in to less than 30 feet wide by 3 feet deep, sediment removal will be conducted during the month of August. During sediment removal, the channel will be widened to 45 feet and deepened to 5 feet.

A tracked excavator will be used to remove the sediment/gravel (**Figure 2-4**). The excavator will be cleaned of all oils and greases, and will be inspected and re-cleaned daily as necessary to insure no contaminants are released into the lower Yuba River. All hydraulic hoses and fittings also will be inspected to insure there are no leaks in the hydraulic system.

Figure 2-4. Excavator removing sediment above Daguerre Point Dam during August 2011.

Material removed shall be managed in one of two ways. If all required permits can be obtained (expected to occur during the summer of years when excavation is necessary), then it is anticipated that the excavated material will be placed on a downstream bank of the lower Yuba River approximately ¼ mile downstream of Daguerre Point Dam (Grothe, Corps, pers. comm. 2013). Materials will be placed in a location that will provide an opportunity for the gravel to be mobilized by the river during high flow conditions and transported downstream to augment downstream spawning gravels. If permits cannot be obtained or conditions do not allow for the downstream placement, then the material will be removed and stored above the ordinary high water mark until both permits are obtained and it can be moved downstream to a location where the gravel can be mobilized by the river during high flow conditions and transported downstream.

The Proposed Action includes continued implementation of the Daguerre Point Dam Fish Passage Sediment Management Plan.

2.1.2 Staff Gage Maintenance

Hydrologic facilities consist of a staff gage on the right abutment of Daguerre Point Dam. As described in the Daguerre Point Dam O&M Manual (Corps 1966), the Corps' Engineering Division is responsible for maintaining, reading, and filing all records obtained from this gage. The Proposed Action includes continuation of the routine maintenance activities associated with the staff gage.

2.1.3 Administration of a License Issued to CDFW for VAKI Riverwatcher Operations at Daguerre Point Dam

The Corps administers a license to CDFW (DACW05-3-03-550) to install and operate electronic fish counting devices, referred to as a VAKI Riverwatcher infrared and photogrammetric system, in the fish ladders at Daguerre Point Dam and is revocable at will by the Corps (Amendment 2 to License DACW05-3-03-550). The Proposed Action includes continued administration of this license, which remains in effect until 2018.

The license specifies that CDFW shall pay the cost, as determined by the Corps, of producing and/or supplying any utilities and other services furnished by the Government or through Government-owned facilities for the use of CDFW, including CDFW's proportionate share of the cost of operation and maintenance of the Government-owned facilities by which such utilities or services are produced or supplied. The Government is under no obligation to furnish utilities or services.

The license further specifies that CDFW shall keep the premises in good order and in a clean, safe condition by and at the expense of CDFW. CDFW is responsible for any damage that may be caused to property of the United States by CDFW activities and shall exercise due diligences in the protection of all property located on the premises against fire or damage from any and all other causes.

The Proposed Action includes continued administration of the license to CDFW to operate the VAKI Riverwatcher infrared and photogrammetric system in the fish ladders at Daguerre Point Dam.

2.1.4 Administration of a License Issued to Cordua Irrigation District for Flashboard Installation, Removal and Maintenance at Daguerre Point Dam

To benefit listed fish species by improving the ability of the fish to locate the fish ladders and migrate upstream to spawning and rearing habitats the Corps, in coordination with CDFW and NMFS, developed and implemented a Daguerre Point Dam Flashboard Management Plan in 2011. The Plan addresses the use, placement, monitoring and removal of flashboards at Daguerre Point Dam. To improve management of the flashboards at Daguerre Point Dam on a long-term basis, the Flashboard Management Plan was incorporated into the September 27, 2011 license amendment issued by the Corps to Cordua Irrigation District. The Proposed Action includes continued administration of the license issued to Cordua Irrigation District which incorporates the Flashboard Management Plan, until the license expires in 2016.

Installation of these flashboards directs some sheet flow from over the top of Daguerre Point Dam into the fish ladders. In accordance with the terms of the 2011 amended license, which will continue to be administered by the Corps as part of the Proposed Action, Cordua Irrigation District will install, remove and maintain the anchoring system, supporting brackets and flashboards and must coordinate its activities with the Corps, NMFS, and CDFW. These agencies will work with Cordua Irrigation District to direct the placement, timing and configuration of the flashboards to best manage flows to benefit fish (Grothe 2011). The long-term flashboard operations plan developed by the Corps includes the following.

- ☐ Conditions of Placement. Flashboards will be used in periods of low flow to direct water toward the fish ladders to provide optimal flow conditions. Because there is no recorded flow information at this time to set a flow-based trigger, the flashboards will be set in place when the flows recede to a point that only part of the dam has water flowing over it. Flows will be recorded at the time of placement to determine the flow rate trigger for future placement.

- ☐ Period of Placement. Flashboards and brackets will be installed as described above, but only after April 15 and will be removed before November 1 of each year. Further, flashboards will be removed within 24 hours, if directed by the Corps, NMFS or CDFW.

- ☐ Flashboard Adjustments. Flashboards will be closely monitored in accordance with monitoring and inspection activities (see below) to ensure they have been placed in a manner that leads to actual improvement in fish passage and will be adjusted accordingly based on such monitoring. All adjustments will be coordinated with NMFS and CDFW. Any recommended adjustments will be made within 24 hours of notification unless flow conditions prohibit them. In that case, the adjustments will be made as soon as conditions allow.

- ☐ Method of Placement. Flashboards will be installed using metal brackets that are attached to the dam with anchor bolts. The brackets will be fabricated of material that is light enough that it will break away if the flows increase too rapidly before the brackets can be removed.

- ☐ Location of Placement. When flashboard placement is required, they will be placed in the center portion of the dam in such a way that the flows are directed toward both fish ladders. This will ensure adequate flows through the fish ladders to promote optimal flow conditions and attraction flows to the fish ladders. The number of boards placed and the exact location will be determined based upon flow conditions and channel position. Adjustments will be made as necessary to provide optimal fish attraction and passage. All adjustments will be coordinated with NMFS and CDFW.

- ☐ Flashboard Material. Flashboard material will be 2” x 10” Douglas Fir or equal material. Material will be free of preservatives and other contaminants – no pressure treated material will be used.

- ☐ Monitoring and Inspection. Once the flashboards have been placed, fish passage will be closely monitored for the first week after placement to confirm that the flashboard installation improves fish passage. This monitoring will be conducted via the VAKI in coordination with the RMT. Additionally, during the period that flashboards are installed in accordance with this plan, the flashboards will be monitored at least once per week to make sure that the flashboards have not collected debris that might contribute to juvenile fish mortality. The flashboards will be cleared within 24 hours of finding a blockage, or as soon as it is safe to clear them.

- ☐ <u>Updates.</u> The Corps will update and adjust this plan as required based upon new information generated through monitoring efforts.

As part of future Cordua Irrigation District license renewal and approval processes after 2016, the Corps will refine the description of specific operations addressing the placement, timing and configuration of the flashboards at Daguerre Point Dam and incorporate changes to the Flashboard Management Plan into the terms and conditions for the Corps license to be re-issued to Cordua Irrigation District (Grothe 2011), and Cordua Irrigation District will remain responsible for implementing the flashboard operations.

In addition to the aforementioned description of the long-term flashboard operations developed by the Corps, additional refinements for the license may include the following.

- ☐ The flow conditions in the lower Yuba River flow that will prompt the placement and removal of the flashboards.
- ☐ The responsibility of Cordua Irrigation District for monitoring the flashboards at least once a week to make sure that they have not collected debris that might contribute to juvenile fish mortality.
- ☐ The responsibility of Cordua Irrigation District for monitoring the effects of the flashboards on juvenile salmonids and the potential for direct mortality due to entrainment or concentrating juveniles in a manner that promotes predation.

If the Corps does not renew the license to Cordua Irrigation District or another entity when it expires in 2016, then the Corps will assume responsibility for implementing the operations and maintenance activities addressing the placement, timing and configuration of the flashboards at Daguerre Point Dam that are described in the Flashboard Management Plan on a long-term basis.

2.1.5 Protective Conservation Measures

The ESA mandates Federal agencies to utilize their authorities to carry out programs for the conservation and survival of Federally-listed endangered and threatened species (Corps 1996).

The Corps has committed to incorporate several conservation measures into its activities for this Proposed Action (**Appendix C**). These measures are intended to improve conditions for listed salmonids in the lower Yuba River. The Corps will implement the following protective conservation measures under the Corps' obligation to Section 7(a)(1) of the ESA for the conservation of threatened and endangered species.

2.1.5.1 Implementation of the Daguerre Point Dam Fish Passage Sediment Management Plan

The Proposed Action includes continued implementation of the 2009 Fish Passage Sediment Management Plan (see Section 2.1.1.3). The Corps considers the Fish Passage Sediment Management Plan to be a protective conservation measure because it includes activities beyond those specified in the Daguerre Point Dam O&M Manual (Corps 1966).

2.1.5.2 Management of a Long-term Flashboard Program at Daguerre Point Dam

The Proposed Action includes implementation of the Flashboard Management Plan (see Section 2.1.4) through the administration of a license issued to Cordua Irrigation District. If the Corps does not renew the license to Cordua Irrigation District, or another entity, when it expires in 2016, then the Corps will assume responsibility for implementing the operations and maintenance activities addressing the placement, timing and configuration of the flashboards at Daguerre Point Dam that are described in the Flashboard Management Plan on a long-term basis.

2.1.5.3 Implementation of a Debris Monitoring and Maintenance Plan at Daguerre Point Dam

Through coordination with CDFW and NMFS, the Corps will implement the Debris Monitoring and Maintenance Plan for clearing accumulated debris and blockages in the fish ladders at Daguerre Point Dam. This plan specifies that CDFW is responsible for inspecting and clearing the portion of the ladders containing the VAKI device, and that the Corps is responsible for all other parts of the ladders. Inspections will include sub-surface inspections of the ladders. The Corps will conduct weekly inspections of the Daguerre Point Dam fish ladders for surface and subsurface debris. The Corps also will routinely inspect the fish ladder gates to ensure that no third parties close them. Routine inspections shall occur at least weekly, and may be conducted under agreement with CDFW. This plan also specifies that routine inspection and clearing of debris from the two fish ladders at Daguerre Point Dam may be conducted by CDFW pursuant to agreement with the Corps, or by other parties (e.g., PSMFC) under CDFW direction. Routine inspections and debris clearing will occur weekly, although more frequent inspections and debris clearing activities may be conducted by CDFW, or other parties (e.g., PSMFC) under CDFW direction.

When river flows are 4,200 cfs or greater, the Corps or other designated parties as described above, will conduct daily manual inspections of the Daguerre Point Dam fish ladders. Upon discovering debris in the ladders, the debris will be removed within twelve hours, even if the Corps or CDFW determines that flow levels are adequate for fish passage. If conditions do not allow for safe immediate removal of the debris, the debris will be removed within twelve hours after flows have returned to safe levels.

The Corps will reconsider the need for specific provisions, and may modify the Debris Monitoring and Maintenance Plan upon issuance by NMFS of a BO for the Proposed Action.

2.1.6 Corps' Voluntary Conservation Program

With respect to the conservation of Federally-listed endangered and threatened species on existing Corps' project lands, the Corps' Environmental Stewardship and Maintenance

Guidance and Procedures (Corps 1996) state that identified conservation activities will be accomplished when funds are available through the budget priority process presented in the Annual O&M Budget Guidance. Therefore, conservation measures contained within the Corps' Voluntary Conservation Program are subject to the availability of funding. Limited financial resources are presently available for the Corps to proceed with implementing the Voluntary Conservation Program measures described below. In the past, the Corps has been successful in obtaining the additional funding as it places a high priority on these measures. These voluntary conservation measures were previously identified in the Corps' 2012 BA, and the Corps will continue to diligently seek opportunities for future implementation, subject to available funding (**Appendix D**).

2.1.6.1 Gravel Injection in the Englebright Dam Reach of the Lower Yuba River

The Corps has been injecting a mixture of coarse sediment in the gravel (2-64 mm) and cobble (64-256 mm) size ranges into the lower Yuba River below Englebright Dam, as part of their voluntary conservation measures associated with ESA consultations regarding Daguerre Point Dam. Four separate gravel injection efforts have been undertaken from 2007-2013, with approximately 15,500 tons of gravel/cobble placed into the Englebright Dam Reach.

Future gravel injections are anticipated as one of the Corps voluntary conservation measures associated with the current ESA consultation. The Corps' Gravel Augmentation Implementation Plan (GAIP) provides guidance for a long-term gravel injection program to provide Chinook salmon spawning habitat in the bedrock canyon downstream of Englebright Dam. The Corps has contracted bathymetric survey monitoring to compare volumetric differences between pre- and post- gravel injection distributions, to further evaluate the disposition of the injected gravels. Additionally, the Corps has funded PSMFC to conduct redd surveys in the Englebright Dam Reach to investigate whether Chinook salmon and steelhead are utilizing areas where gravel placement occurred. If the monitoring suggests alterative locations or gravel injection methods, then the Corps will continue the long-term gravel injection program accordingly. In addition, the frequency of gravel injection will be dependent upon annual monitoring results.

The GAIP (Pasternack 2010) describes present and proposed future gravel injection efforts, based on information available in 2010. The long-term plan calls for continuing gravel/cobble injection into the Englebright Dam Reach until the estimated coarse sediment storage deficit for the reach is eradicated, and then it calls for subsequent injections as needed to maintain the sediment storage volume in the event that floods export material downstream of the reach. The Corps does not currently have the authority to completely eradicate the deficit created by various causes in one placement, nor is that the intent of the Corps gravel injection program.

2.1.6.2 Large Woody Material Management Program

The Corps has prepared the Large Woody Material Management Plan (LWMMP), which includes the implementation of a Pilot Study in order to enhance rearing conditions for spring-run Chinook and Central Valley steelhead (Corps 2012d). The Corps proposed to initiate a pilot study to determine an effective method of replenishing the supply of large woody material (LWM) back into the lower Yuba River. As described in the LWMMP, the Pilot Study will use LWM from existing stockpiles at New Bullards Bar Reservoir for placement at selected sites along the lower Yuba River. The Pilot Study would include monitoring of placed materials, and used to assess the effectiveness of LWM placement in the lower Yuba River in order to develop a long-term program (Corps 2012d).

As part of this conservation measure, the Corps will: (1) refine the draft plan that was prepared for management of LWM, consistent with recreation safety needs; (2) conduct a pilot project to identify suitable locations and evaluate the efficacy of placing large in-stream woody material to modify local flow dynamics to increase cover and diversity of instream habitat for the primary purpose of benefitting juvenile salmonid rearing; and (3) based upon the outcomes of the pilot program, develop and implement a long-term large woody material management plan for the lower Yuba River, anticipated to occur within one year following completion of the pilot program, and subject to available funding.

2.2 Interrelated Actions

Interrelated actions are those that are part of a larger action and depend on the larger action for their justification (50 C.F.R. 402.02). There are no anticipated interrelated actions associated with the Proposed Action.

2.3 Interdependent Actions

Interdependent actions are those that have no independent utility apart from the action under consideration (50 C.F.R. 402.02). There are no anticipated interdependent actions associated with the Proposed Action.

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3.0 Description of the Action Area

3.1 Action Area Definition and Description

The regulations governing consultations under the federal ESA define the "action area" as "*all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action*" (50 CFR §402.02). Direct effects are defined as "*the direct or immediate effects of the project on the species or its habitat*" (USFWS and NMFS 1998). Indirect effects are defined as "*those [effects] that are caused by the proposed action and are later in time, but still are reasonably certain to occur*" (50 CFR §402.02).

Consistent with 50 CFR 402.02, the Action Area for this consultation is determined considering the extent of the direct and indirect effects of the Proposed Action. As described in Chapter 2, the Proposed Action includes the Corps' authorized discretionary O&M of the fish passage facilities at Daguerre Point Dam and specified conservation measures. O&M activities of the Proposed Action would indicate that the Action Area would be restricted to the immediate vicinity adjacent to Daguerre Point Dam. Similarly, administration of the licenses to CDFW and Cordua Irrigation District also would be restricted to the immediate vicinity adjacent to Daguerre Point Dam. However, the conservation measures in the Proposed Action have a broader geographic extent of potential direct and indirect effects.

The LWMMP does not specifically indicate the upstream and downstream boundaries for potential wood placement in the lower Yuba River. By contrast, the gravel augmentation project specifies that the gravel placement site is located within the first 300-feet downstream of Englebright Dam, downstream of the Narrows II Powerhouse. The project site is less than one-acre and is confined to the river channel within the Englebright Dam Reach, a 0.89-mile long bedrock reach starting at Englebright Dam and ending at the junction with Deer Creek.

The Daguerre Point Dam Fish Passage Sediment Management Plan includes excavation of sediment immediately upstream of Daguerre Point Dam and placement of excavated materials on a downstream bank of the lower Yuba River approximately ¼ mile downstream of Daguerre Point Dam. Materials will be placed in a location that will provide an opportunity for the gravel to be mobilized by the river during high flow conditions and transported downstream to augment downstream spawning gravels. Although fate and transport studies of the excavated materials have not been conducted, it is reasonable to assume that some of these materials may be transported as far downstream as the confluence with the lower Feather River.

Therefore, the Action Area for this Proposed Action includes the lower Yuba River starting at the upstream extent of where in-river gravel placement has occurred, an area which is located within the first 300 feet downstream of Englebright Dam (39°14'18"N, 121°16'07"W, Yuba River (RM 23.9), downstream to the confluence with the lower Feather River (39°07'46"N, 121°35'56"W, Yuba River mile 0) (**Figure 3-1**).

The descriptions that follow identify prominent features and characteristics of the Action Area. Specific information related to physical habitat conditions and species-specific utilization within the Action Area, as well as throughout the respective ESU/DPS is provided in Chapter 4.0 – Status of the Species and in Chapter 5.0 – Environmental Baseline.

3.1.1 Daguerre Point Dam

Daguerre Point Dam is located about ten miles east of Marysville, California, in the Yuba Goldfields (Figure 3-1). The dam is located on a bedrock bench in the piedmont plain of the ancestral Yuba River. A cut 600 feet wide and 25 feet deep was dug in the bedrock bench for the footing of the dam, which was completed in 1910 (Hunerlach et al. 2004). The current configuration of Daguerre Point Dam is an overflow concrete ogee (“s-shaped”) spillway with concrete apron and concrete abutments. The ogee spillway section is 575 feet wide and 24 feet tall. The purpose of Daguerre Point Dam was to retain hydraulic mining debris. This purpose was later modified to include diversion of

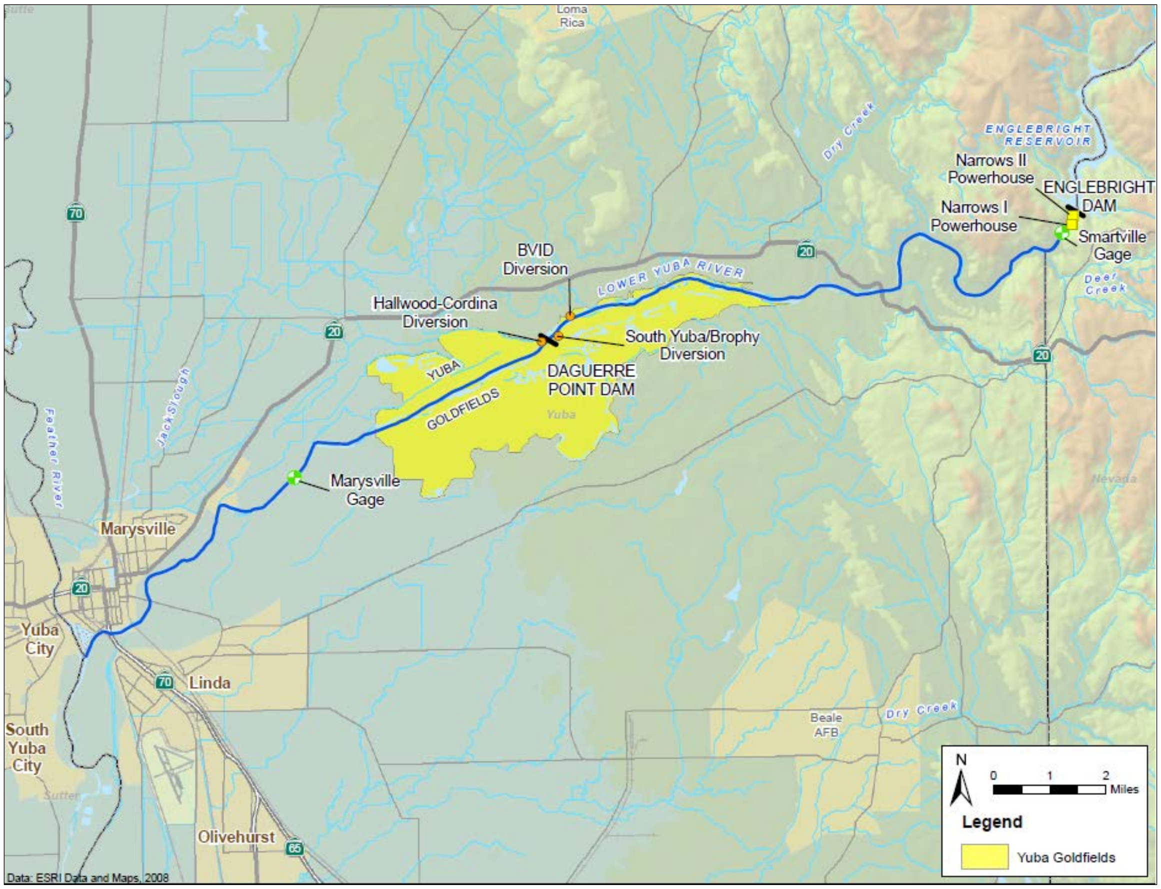

Figure 3-1. The lower Yuba River including the Action Area, which extends from downstream of the Narrows II Powerhouse, downstream to the lower Yuba River confluence with the lower Feather River.

water for irrigation purposes. The dam is not operated for flood control and there is no water storage capacity as the entire reservoir has been filled with hydraulic mining debris and sediments.

3.1.2 Lower Yuba River

The lower Yuba River consists of the approximately 24-mile stretch of river extending from Englebright Dam, downstream to the confluence with the Feather River near Marysville.

Recently, the RMT (2013) conducted specific studies to rigorously investigate spatial structure in the lower Yuba River by developing an approach to identify the fluvial-geomorphologic dynamics affecting: (1) adult spatial structure components, including the availability of fish habitat for immigrating, holding, and spawning adult salmonids; and

(2) the seasonal availability of rearing habitat for juvenile salmonids. The RMT (2013) morphological unit and mesohabitat classification studies: (1) identified morphological units throughout the lower Yuba River; (2) evaluated the quality, number, size and distribution of mesohabitats for various lifestages of adult and juvenile anadromous salmonids; and (3) evaluated the maintenance of watershed processes in the lower Yuba River. Part of the RMT (2013) process included the identification of morphological reaches in the lower Yuba River, identified and described in **Table 3-1**.

Table 3-1. Morphological reaches and delineating transparent geomorphic features in the lower Yuba River.

Reach Name	Reach Description
Englebright Dam Reach	Englebright Dam to confluence with Deer Creek
Narrows Reach	Deer Creek to onset of emergent gravel floodplain
Timbuctoo Bend Reach	Emergent gravel floodplain to upstream of Blue Point Mine
Parks Bar Reach	Upstream of Blue Point Mine to Highway 20 Bridge
Dry Creek Reach	Highway 20 Bridge to Yuba River confluence with Dry Creek
Daguerre Reach	Yuba River confluence with Dry Creek downstream to Daguerre Point Dam
Hallwood Reach	Daguerre Point Dam downstream to Eddie Drive aims at Slope Break
Marysville Reach	Eddie Drive aims at Slope Break downstream to the mouth of the lower Yuba River
Source: RMT 2013	

3.2 Other Aquatic Habitat Areas Affecting the Species' Status in the ESU/DPS

The discussion of the status of each species includes appropriate information on the species' life history, current known range and habitat use, distribution, and other data regarding factors necessary to the species' survival (USFWS and NMFS 1998). Because many listed species are declining throughout their range, the overall population trend of a species has implications for new proposals that could result in additional effects on the species (USFWS and NMFS 1998). The trends of the remaining populations of listed species form the basis for evaluating the effects of a proposed action on that species. USFWS and NMFS (1998) further state that "*Unless a species' range is wholly contained within the action area, this analysis* [describing the status of a species within the action area] *is a subset of the preceding rangewide status discussion*."

Because the listed fish species (i.e., spring-run Chinook salmon, steelhead and green sturgeon) that inhabit the lower Yuba River are anadromous, they do not reside in the lower Yuba River for their entire lifecycles. On an ESU/DPS scale, aquatic habitat conditions throughout each species' range, including the Feather River, the Sacramento River, and the Sacramento-San Joaquin Delta (Delta) affect spring-run Chinook salmon, steelhead, and green sturgeon (**Figure 3-2**). Although these areas are not contained within the Action Area, they are briefly described here to provide context regarding the lower Yuba River.

3.2.1 Feather River

The Feather River Basin encompasses an area of about 5,900 square miles (DWR 2007). The Feather River is considered to be a major tributary to the Sacramento River and provides about 25 percent of the flow[1] in the Sacramento River (DWR 2007). The lower Feather River extends from the Fish Barrier Dam (RM 67.25) near Oroville Reservoir downstream to the confluence of the Feather and Sacramento rivers (RM 0) (Figure 3-2).

Flows in the lower Feather River are influenced by releases from Oroville Dam and Reservoir, which is operated by the California Department of Water Resources (DWR) as part of the SWP). Downstream of Oroville Dam, water is diverted in several directions to: (1) the Thermalito Complex; (2) the Feather River Fish Hatchery (FRFH); and (3) the Low Flow Channel. The sources combine below the Thermalito Afterbay, creating the High Flow Channel. The Low Flow Channel is highly regulated and contains the majority of the anadromous salmonid spawning habitat. The Yuba and Bear rivers are both tributaries to the Feather River. The Yuba River flows into the Feather River near the

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[1] As measured at Oroville Dam.

Figure 3-2. Other aquatic habitat areas affecting Yuba River spring-run Chinook salmon, steelhead and green sturgeon throughout the ESU/DPS (Source: YCWA et al. 2007).

City of Marysville, 39 RM downstream of the City of Oroville. The Bear River flows into the Feather River about 55 RM downstream of the City of Oroville. Approximately 67 RM downstream of the City of Oroville, the Feather River flows into the Sacramento River near the town of Verona (DWR 2007).

3.2.2 Sacramento River

The Sacramento River (Figure 3-2) is the largest river system in California, yielding 35 percent of the state's water supply. Most of the Sacramento River flow is controlled by Reclamation's Shasta Dam and Reservoir, and river flow is augmented by transfer of Trinity River water through Clear and Spring Creek tunnels to Keswick Reservoir. Immediately below Keswick Dam, the river is deeply incised in bedrock with very limited riparian vegetation.

The upper Sacramento River is often defined as the portion of the river from Princeton (RM 163; downstream extent of salmonid spawning in the Sacramento River) to Keswick Dam (the upstream extent of anadromous fish migration and spawning). The Sacramento River is an important corridor for anadromous fishes moving between the ocean and Delta and upstream river and tributary spawning and rearing habitats. The upper Sacramento River is differentiated from the river's "headwaters" which lie upstream of Shasta Reservoir. The upper Sacramento River provides a diversity of aquatic habitats, including fast-water riffles and shallow glides, slow-water deep glides and pools, and off-channel backwater habitats (Reclamation et al. 2004).

The lower Sacramento River is generally defined as the portion of the river from Princeton to the Delta at approximately Chipps Island (near Pittsburg). The lower Sacramento River is predominantly channelized, leveed and bordered by agricultural lands. Aquatic habitat in the lower Sacramento River is characterized primarily by slow water glides and pools, is depositional in nature, and has lower water clarity and habitat diversity, relative to the upper portion of the river.

3.2.3 Sacramento-San Joaquin Delta

The Delta is a vast, low-lying inland region located east of the San Francisco Bay Area, at the confluence of the Sacramento and San Joaquin Rivers. Geographically, this region forms the eastern portion of the San Francisco estuary, which includes San Francisco, San Pablo, and Suisun Bays (Figure 3-2). An interconnected network of water channels and man-made islands, the Delta stretches nearly 50 miles from Sacramento south to the City of Tracy, and spans almost 25 miles from Antioch east to Stockton (Public Policy Institute of California 2007). The Delta is a complex area for both anadromous fisheries production and distribution of California water resources for numerous beneficial uses. The Delta also includes the federal CVP Jones Pumping Plant and the SWP Banks Pumping Plant in the south Delta (export pumps). Water withdrawn from the Delta provides for much of California's water needs, including both drinking water and water for agricultural irrigation purposes.

4.0 Status of Listed Species and Critical Habitat

4.1 Physical Features and Habitat Conditions

4.1.1 Hydrology

Historically, the Yuba River supported large numbers of spring-run Chinook salmon, fall-run Chinook salmon, and steelhead. Extensive hydraulic mining in the late 1800s resulted in the massive influx of mining sediments that filled the lower river valleys and profoundly changed the physical character of the lower Yuba River (Moir and Pasternack 2008). The resulting habitat degradation followed by the construction of a series of impassable debris dams from the early to mid-1900s likely caused major reductions in salmon and steelhead populations in the Yuba River Basin (Mitchell 2010). Loss of access to much of their historic spawning and rearing habitat in the upper basin likely had particularly severe impacts on spring-run Chinook salmon and steelhead populations, which depended on the upper basin for successful summer holding and rearing (Yoshiyama et al. 1998; 2001).

The Yuba River suffered perhaps the most significant damage from hydraulic mining of any California river. Approximately 1.5 billion cubic yards of mining debris were washed into the Central Valley from five rivers, with the Yuba River accounting for 40 percent of that total (Mount 1995). Gilbert (1917) as cited in Yoshiyama et al. (2001) estimates that "*…during the period 1849-1909, 684 million cubic yards of gravel and debris due to hydraulic mining were washed into the Yuba River system – more than triple the volume of earth excavated during the construction of the Panama Canal*", and Beak Consultants, Inc. (1989) states "*The debris plain ranged from about 700 feet wide and up to 150 feet thick near the edge of the foothills to nearly 3 miles wide and 26 feet tall near Marysville*" (Beak Consultants, Inc. 1989). In addition to eliminating much of the riparian vegetation corridor along the lower Yuba River (NMFS 2005b), the hydraulic mining debris probably had devastating impacts on salmonids because the sediments in these debris would have suffocated incubating eggs and pre-emergent fry (NMFS 2001). Even by the 1870s and 1880s, the Yuba River salmon runs had been greatly diminished by hydraulic mining debris effects (Yoshiyama et al. 2001). In addition, because mercury was used to extract gold from mining debris, mercury exists in the Yuba River system, and this mercury can be extremely toxic to salmonids (NMFS 2001). Cyanide also was used in hard-rock mining to recover gold from the finely ground ore (Sumner and Smith 1940). Along the South Fork of the Yuba River, it was reported that *"An occasional heavy dose of the cyanide would kill of fish and their food, even though a stream might otherwise remain unpolluted."* (Sumner and Smith 1939).

The hydrology of the Yuba River has been altered by a series of reservoirs and water conveyance facilities that are operated for water supply, hydropower production, and flood control (Mitchell 2010). Three projects export significant amounts of water from the Yuba River watershed. South Feather Water and Power Agency (formerly Oroville-Wyandotte Irrigation District) diverts water from Slate Creek (a tributary to the North Yuba River) to the South Fork Feather River via its South Feather Power Project. PG&E's South Yuba Canal diverts water from the South Yuba River, some of which is consumptively used by the Nevada Irrigation District (NID) and some of which is released into the Bear River watershed. These diversions also support NID's Yuba-Bear Hydroelectric Project. PG&E's Drum-Spaulding Project diverts water from the South Yuba watershed, via the Drum Canal, to the Drum Forebay. If that water is used at PG&E's Drum Powerhouse, it is released to the Bear River watershed. If the water is not used there, it is released to Canyon Creek (a tributary of the north fork of the North Fork American River), where it is eventually used for consumptive purposes by Placer County Water Agency and other entities.

The amount of water that these projects collectively export from the Yuba River watershed ranges between 589,000 acre-feet (17.3 percent of unimpaired runoff in wet years) and 267,000 acre-feet (31.1 percent of unimpaired runoff) in critical years[1] (SWRI et al. 2000). The impairment of the runoff in the lower Yuba River resulting from these

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[1] Water year types are defined by the Yuba River Index of SWRCB Decision 1644.

diversions is particularly high during the April through September period during snowmelt runoff, reaching an average of 43.2 percent of the runoff in critical years and an estimated 50.7 percent during hydrologic conditions like those that occurred in 1931 (SWRI et al. 2000).

Located upstream of the Action Area, New Bullards Bar Reservoir was constructed by YCWA on the North Yuba River in the late 1960s, and is the largest water storage reservoir in the watershed. This reservoir is operated for flood control, power generation, irrigation, recreation, and protection and enhancement of fish and wildlife. Since 1970, operation of New Bullards Bar Reservoir has modified the seasonal distribution of flows in the lower Yuba River by reducing spring flows and increasing summer and fall flows. However, the Yuba River below Englebright Dam still experiences a dynamic flood regime because of frequent uncontrolled winter and spring flows (Moir and Pasternack 2008).

Although not part of the Action Area for this ESA consultation, New Bullards Bar Reservoir operations are discussed below in recognition that water released from New Bullards Bar Reservoir flows into Englebright Reservoir and water is then released into the lower Yuba River. The magnitude and timing of water releases controlled by YCWA's operation of New Bullards Bar Reservoir influence flow and water temperature conditions in the lower Yuba River.

Operations of New Bullards Bar Reservoir can be described in terms of: (1) water management operations (i.e., baseflow operations); (2) storm runoff operations; and (3) flood control operations (NMFS 2009). Baseflow operations describe normal reservoir operations when system flows are controlled through storage regulation. These operations occur outside periods of flood control operations, spilling, bypassing uncontrolled flows into Englebright Reservoir, and outside periods of high unregulated inflows from tributary streams downstream from Englebright Dam (NMFS 2009). Flood control space in New Bullards Bar Reservoir is addressed through a Water Management Group, which was developed by YCWA. During flood control operations, the seasonal flood pool specified in the Corps flood operation manual for New Bullards Bar Reservoir is kept evacuated for flood protection, and to avoid unnecessary flood control releases.

Storm runoff operations occur during the storm season (typically between October and May), but reservoir releases may be required to maintain flood control space between September 15 and June 1 (YCWA et al. 2007). The Corps does not regulate the operations of New Bullards Bar Reservoir and Englebright Dam and Reservoir, which influence flow and water temperature conditions downstream in the lower Yuba River.

Water from Englebright Dam is released through either the Narrows I Powerhouse or the Narrows II Powerhouse or, if Englebright Reservoir is full, over the top of the dam (FERC 1992). Controlled releases are made through the Narrows I and Narrows II powerhouses at total rates of up to about 4,200 cfs; above that rate, releases are made over the spillway at the top of Englebright Dam and are essentially uncontrolled (JSA 2008). Englebright Dam has no low-level outlet.

Narrows I Powerhouse, owned by PG&E, is a 12 MW FERC-licensed facility, with a discharge capacity of approximately 730 cfs and a bypass flow capacity (when the generator is not operating) of 540 cfs. Narrows II, which is part of YCWA's YRDP, is a 50 MW FERC-licensed facility, with a discharge capacity of approximately 3,400 cfs and a bypass flow capacity of 3,000 cfs. Annual maintenance requires the Narrows II Powerhouse to be shut down for a two- to three-week period, or longer if major maintenance is performed. Maintenance is typically scheduled for mid-September each year. Outflows from Englebright Reservoir pass through either the Narrows II full-flow bypass or through Narrows I during Narrows II maintenance activities.

YCWA and PG&E coordinate the operations of Narrows I and II for hydropower efficiency and to maintain relatively stable flows in the lower Yuba River. The Narrows I Powerhouse typically is used for low-flow reservoir releases (less than 730 cfs), or to supplement the Narrows II Powerhouse capacity during high flow reservoir releases (JSA 2008).

4.1.1.1 PG&E Narrows I

PG&E built the Narrows I Powerhouse in the 1940s (NMFS 2005a). Several times during the 1950s, PG&E drew water from storage in Englebright Reservoir to generate power at the Narrows I Powerhouse during October, when adult Chinook salmon were returning to the Yuba River to spawn (Wooster and Wickwire 1970). PG&E's releases attracted adult Chinook salmon in the lower Yuba River, but most of them were stranded, and subsequently died when PG&E reduced its releases, and there was very little water left in the lower Yuba River (Wooster and Wickwire 1970). In 1960, several parties, including PG&E and CDFW, reached an agreement to prevent similar fish losses in future years. Under that agreement, CDFW agreed to install a temporary barrier across the lower Yuba River's mouth before September 7th to prevent Chinook salmon from entering the Yuba River "*until October 15, when adequate transportation and spawning flows are provided*" (Wooster and Wickwire 1970). While this measure may have helped protect fall-run Chinook salmon, it would not have provided protection for spring-run Chinook salmon, because these fish would have entered the river long before September 7th, and would therefore have been exposed to all of the adverse conditions that occurred in the river during the late summer and fall (NMFS 2005a). These practices were halted following the construction of New Bullards Bar Dam and Reservoir, because the new reservoir provided enough water storage to ensure adequate fall flows during most years (NMFS 2005a).

As previously discussed, the Corps does not regulate or control water rights or releases. Although the Corps does coordinate with PG&E, the Corps does not have the authority to require Narrows I operations-related changes, nor does the Corps control water operations in the upper Yuba River Basin or inflows into Englebright Reservoir.

4.1.1.2 YCWA Narrows II

The Narrows II Powerhouse, located about 400 feet downstream of Englebright Dam, was constructed in 1970 as part of the Yuba Project (FERC No. 2246). Narrows II includes one power tunnel and penstock, and one powerhouse. The penstock has a maximum capacity of 3,400 cfs.

YCWA's maintenance activities at Narrows II include generator brush replacement, which requires a 6-hour shut down 2 to 3 times per year, and annual maintenance, which typically requires a 2 to 3 week shut down, but may be longer if major maintenance is needed (NMFS 2005a). During annual maintenance prior to 2006, the 650 cfs Narrows II bypass valve usually could not be opened, and Narrows I was used to maintain instream flows in the lower Yuba River. Consequently, in the absence of water spilling over the top of Englebright Dam, flows in the lower Yuba River were reduced to a maximum of 650 cfs for several days to several weeks, depending on the type of maintenance (NMFS 2005a). YCWA schedules annual maintenance activities at Narrows II from late August to mid-September.

FLOW FLUCTUATIONS AND POWERHOUSE SHUTDOWNS

In addition to regularly scheduled maintenance outages, low-flow shutdowns (outages) at the Narrows II Powerhouse used to occur when streamflows in the lower Yuba River were below 650 cfs. During such times, YCWA's and PG&E's coordinated operation of Narrows I and Narrows II Powerhouses resulted in releases to the lower Yuba River being made exclusively by the Narrows I Powerhouse (NMFS 2005a).

Short-term emergency outages at the Narrows II Powerhouse typically resulted from electrical transmission line faults (e.g., birds, trees, lightning strikes, storms) or plant malfunctions. Depending on the cause of the outage, the Narrows II Powerhouse release could be reduced to somewhere between 0 and 650 cfs (the capacity of the Narrows II Powerhouse bypass) for a period of minutes to one or more hours. In the past, the frequency of these types of outages ranged from none to several in a year, with an annual average of about two per year.

In 2006, YCWA constructed a full-flow bypass on the Narrows II Powerhouse, which allows approximately 3,000 cfs (or 88%), of the 3,400 cfs capacity of the powerhouse to be bypassed around the power generation facilities to maintain river flows during emergencies, maintenance, and accidental shut-downs of the powerhouse (NMFS 2007). This bypass minimizes the possibility that emergencies or other events requiring that the Narrows II Powerhouse be taken offline will cause significant flow fluctuations in the lower Yuba River, and thereby minimizes the possibility that such fluctuations will strand juvenile spring-run Chinook salmon and steelhead, or dewater redds of those species (NMFS 2005a).

Before this bypass was completed, flow reductions resulting from emergency and accidental shutdowns of the Narrows II Powerhouse were a major concern due to adverse flow and water temperature effects on listed spring-run Chinook salmon and steelhead.

The ability to manage releases during maintenance and emergency operations was limited by the design of Englebright Dam and the bypass capability of the Narrows II Powerhouse which was previously only able to bypass 650 cfs (or approximately 20%) of the 3,400 cfs capacity of the powerhouse. In the past, uncontrolled flow reductions due to unexpected outages at Narrows II adversely affected spawning redds and fry/juvenile rearing areas (FERC 2001). However, with the completion of the full-flow bypass in 2006, adverse effects to listed species due to emergencies, maintenance, and accidental shut-downs of the powerhouse have been virtually eliminated.

4.1.2 Fluvial Geomorphology

According to Pasternack (2010), no known records of conditions prior to placer gold mining in the mid-nineteenth century are available that describe the hydrologic conditions in the river reach of the canyon where Englebright Dam and Reservoir are located. During the era of placer gold mining, Malay Camp on the northern bank of the lower Yuba River near the confluence of Deer Creek served as a base of operations for miners working Landers Bar, an alluvial deposit in the nearby canyon. The historical records of the existence of this camp and placer-mining site proves that coarse sediment was stored in the canyon prior to hydraulic mining in a large enough quantity to produce emergent alluvial bars (Pasternack 2010).

During the period of hydraulic gold mining, vast quantities of sand, gravel, and cobble entered the Yuba River (Gilbert 1917 as cited in Yoshiyama et al. 2001) and deposited throughout the system. This human impact completely transformed the river. Historical photos from 1909 and 1937 document that the canyon was filled with alluvial sediment with an assemblage of river features including riffles (Pasternack et al. 2010). Conditions downstream of the canyon during that period were described by James et al. (2009). Even though Daguerre Point Dam was built on the valley floor to prevent the transport of hydraulic mining debris in 1906, it is too small to block sediment migration during floods (Pasternack 2010).

Following the construction of Englebright Dam, historic photographs show that the amount of alluvium in the entire lower Yuba River, including the canyon, decreased

(Pasternack et al. 2010). At the Marysville gaging station, the river incised about 20 feet from 1905-1979, while 0.5 miles downstream of the Highway 20 Bridge it incised about 35 feet over the same period (Beak Consultants, Inc., 1989). Landform adjustments continue to occur - as illustrated by Pasternack (2008), who estimated that about 605,000 yds^3 of sediment (primarily gravel and cobble) were exported out of Timbuctoo Bend from 1999 to 2006. Further investigations of landform and sediment-storage changes are on-going.

The reported changes conform with the expected, natural response of a river to blockage of downstream sediment passage (e.g. Williams and Wolman 1984). For most rivers, such geomorphic changes represent a harmful human impact on a river, but here, where there is a pre-existing, unnatural condition of the river corridor influenced by mining debris, the dam is actually contributing to the restoration of the river toward its historical geomorphic condition, in the truest meaning of the term – going back to the pre-existing state prior to hydraulic gold mining (Pasternack 2010).

Despite evidence that Timbuctoo Bend is undergoing significant sediment export and river-corridor incision, White et al. (2010) reported that eight riffles persisted in the same locations over the last 26 years, and possibly longer. Most of these persistent riffles are positioned in the locally wide areas in the valley, while intervening pools are located at valley constrictions. Thus, incision and sediment export do not necessarily translate into harmful degradation of fluvial landforms.

The lower Yuba River has been subjected to harmful in-channel human activities that further altered it. The greatest impact came from dredgers processing and re-processing most of the alluvium in the river valley in the search for residual gold and to control the river (James et al. 2009). First, there was the formation of the approximately 10,000-acre Yuba Goldfields in the ancestral migration belt. Subsequently, there was the relocation of the river to the Yuba Goldfield's northern edge and its isolation from most of the Goldfields by large "gravel berms" of piled-up dredger spoils. Dredger-spoil gravel berms also exist further upstream in Timbuctoo Bend away from the Yuba Goldfields; these berms provide no flood-control benefit (Pasternack 2010).

Although no gravel berms exist in the canyon downstream of Englebright Dam, mechanized gold mining facilitated by bulldozers, beginning in about 1960, completely reworked the alluvial deposits in the vicinity of the confluence with Deer Creek, changing the lower Yuba River geomorphology (Pasternack et al. 2010). Prior to mechanized mining, glide-riffle transitions were gradual, enabling fish to select among a diverse range of local hydraulic conditions. Bulldozer debris constricted the channel significantly, induced abrupt hydraulic transitioning, and caused the main riffle at the apex of the bar to degrade into a chute. In addition, mining operations evacuated the majority of alluvium at the mouth of Deer Creek, and the 1997 flood caused angular hillside rocks and "shot rock" debris from the canyon bottom to be deposited on top of the hydraulic-mining alluvium in the canyon (Pasternack 2010).

Physical habitat conditions related to salmonids downstream of Englebright Dam have been studied over the years. With respect to the spawning lifestage, Fulton (2008) investigated salmon spawning habitat conditions in the canyon below Englebright Dam and found the conditions to be very poor to nonexistent. No rounded river gravels/cobbles, suitable for spawning, were present in the canyon immediately downstream of Englebright Dam and Sinoro Bar, which is located near the confluence with Deer Creek, until a small amount (500 tons) of gravel was injected artificially by the Corps in November 2007 (see Chapter 2 for additional discussion).

Farther downstream, spawning habitat does not appear to be limited by an inadequate supply of gravel in the lower Yuba River due to ample storage of mining sediments in the banks, bars, and dredger-spoil gravel berms (RMT 2013).

4.1.2.1 Englebright Dam Effects

Englebright Dam was not constructed for fish passage and therefore blocks access by anadromous salmonids to the historically utilized habitat located upstream above the dam. Consequently, spring-run Chinook salmon, fall-run Chinook salmon and steelhead in the lower Yuba River are restricted to the 24 miles extending from Englebright Dam to the mouth of the lower Yuba River.

Historically, spring-run and fall-run Chinook salmon were reproductively isolated due to spatial and temporal segregation. Under historic natural conditions, spring-run Chinook salmon migrated during spring high-flow conditions into the upper reaches of the Yuba River watershed, held over the summer in relatively deep coldwater pools, and then spawned in the late summer beginning in early to mid-September (Campbell and Moyle 1990). Fall-run Chinook salmon entered the lower Yuba River later in the year, were generally unable to reach the upper reaches of the Yuba River watershed due to fall low-flow conditions, and are believed to have spawned in areas located farther downstream than those used by spawning spring-run Chinook salmon (NMFS 2007).

The existence of Englebright Dam blocks the migration of spring-run fish, resulting in some overlaps in the temporal and spatial distributions of spawning fall-run and spring-run Chinook salmon in the lower Yuba River. The resultant reduction in reproductive isolation is believed to have resulted in interbreeding and genetic dilution of the genetics of the much smaller spring-run Chinook salmon population (NMFS 2007). There is also the potential, in areas heavily used by spawning fall-run Chinook salmon, for the later spawning fall-run to superimpose their redds onto previously constructed spring-run redds, thereby disrupting the spring-run redds and reducing the survival of eggs in those redds (NMFS 2007).

Another potential adverse effect resulting from the existence of Englebright Dam is that it requires anadromous salmonids to complete their freshwater lifestages in the lower Yuba River without the benefit of (historically available) smaller tributaries, which can provide some level of refuge in the event of catastrophic events such as chemical spills or massive flood events (NMFS 2007). Major catastrophic events are rare, but have the potential to occur in any given year.

Nonetheless, because of the loss of historical spawning and rearing habitat above Englebright Dam, resultant loss of reproductive isolation and subsequent hybridization with fall-run Chinook salmon, restriction of spatial structure and associated vulnerability to catastrophic events, the existence of Englebright Dam represents a very high stressor to Yuba River spring-run Chinook salmon.

4.2 Central Valley Spring-run Chinook Salmon ESU

4.2.1 ESA Listing Status

On September 16, 1999, NMFS listed the Central Valley ESU of spring-run Chinook salmon (*Oncorhynchus tshawytscha*) as a "threatened" species (64 FR 50394). On June 14, 2004, following a five-year species status review, NMFS proposed that the Central Valley spring-run Chinook salmon remain listed as a threatened species based on the Biological Review Team strong majority opinion that the Central Valley spring-run Chinook ESU is ''likely to become endangered within the foreseeable future'' due to the greatly reduced distribution of Central Valley spring-run Chinook salmon and hatchery influences on the natural population. On June 28, 2005, NMFS reaffirmed the threatened status of the Central Valley spring-run Chinook salmon ESU, and included the FRFH spring-run Chinook salmon population as part of the Central Valley spring-run Chinook salmon ESU (70 FR 37160).

Section 4(c)(2) of the ESA requires that NMFS review the status of listed species under its authority at least every five years and determine whether any species should be removed from the list or have its listing status changed. In August 2011, NMFS completed a second 5-year status review of the Central Valley spring-run Chinook salmon ESU. Prior to making a determination on whether the listing status of the ESU should be uplisted (i.e., threatened to endangered), downlisted, or remain unchanged, NMFS considered: (1) new scientific information that has become available since the 2005 status review (Good et al. 2005); (2) an updated biological status summary report (Williams et al. 2011) intended to determine whether or not the biological status of spring-run Chinook salmon has changed since the 2005 status review was conducted (referred to as the "viability report"); (3) the current threats to the species; and (4) relevant ongoing and future conservation measures and programs.

Based on a review of the available information, NMFS (2011a) recommended that the Central Valley spring-run Chinook salmon ESU remain classified as a threatened species. NMFS' review also indicates that the biological status of the ESU has declined since the previous status review in 2005 and, therefore, NMFS recommended that the ESU's status be reassessed in 2 to 3 years if it does not respond positively to improvements in environmental conditions and management actions. As part of the 5-year review, NMFS also re-evaluated the status of the FRFH stock and concluded that it still should be considered part of the Central Valley spring-run Chinook salmon ESU.

In addition to Federal regulations, the California Endangered Species Act (CESA, Fish and Game Code Sections 2050 to 2089) establishes various requirements and protections regarding species listed as threatened or endangered under state law. California's Fish and Game Commission is responsible for maintaining lists of threatened and endangered species under CESA. Spring-run Chinook salmon in the Sacramento River Basin, including the lower Yuba River, was listed as a threatened species under CESA on February 2, 1999.

4.2.2 Critical Habitat Designation

Critical habitat was designated for the Central Valley spring-run Chinook salmon ESU on September 2, 2005 (70 FR 52488), and includes stream reaches of the Feather and Yuba rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the Sacramento River, and portions of the northern Delta (NMFS 2009a). On the lower Yuba River, critical habitat is designated from the confluence with the Feather River upstream to Englebright Dam. This critical habitat includes the stream channels in the designated stream reaches and their lateral extents, as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series; Bain and Stevenson 1999; 70 FR 52488, September 2, 2005).

4.2.2.1 Primary Constituent Elements

In designating critical habitat, NMFS (2009a) considers the following requirements of the species: (1) space for individual and population growth, and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3)

cover or shelter; (4) sites for breeding, reproduction, or rearing offspring; and, generally, (5) habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species [see 50 CFR 424.12(b)]. In addition to these factors, NMFS also focuses on the key physical and biological features within the designated area that are essential to the conservation of the species and that may require special management considerations or protection. Specifically, primary constituent elements (PCEs) of critical habitat are those physical and biological features essential to the conservation of a species for which its designated or proposed critical habitat is based on.

Within the range of the spring-run Chinook salmon ESU, the PCEs of the designated critical habitat include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore and offshore marine areas. The following summary descriptions of the current conditions of the freshwater PCEs for the Central Valley spring-run Chinook salmon ESU were taken from NMFS (2009a), with the exception of new or updated information regarding current habitat conditions.

FRESHWATER SPAWNING HABITAT

Freshwater spawning sites are areas with appropriate water quantity, water quality and substrate for successful spawning, egg incubation, and larval development. Spring-run Chinook salmon have been reported to spawn in the mainstem Sacramento River between Red Bluff Diversion Dam (RBDD) and Keswick Dam, although little spawning activity has been reported in recent years. Spring-run Chinook salmon primarily spawn in Sacramento River tributaries such as Mill, Deer, and Butte creeks. Operations of Shasta and Keswick dams on the mainstem Sacramento River are confounded by the need to provide water of suitable temperature for adult winter-run Chinook salmon migration, holding, spawning and incubation, as well as for spring-run Chinook salmon embryo incubation in the mainstem Sacramento River.

FRESHWATER REARING HABITAT

Freshwater rearing sites are areas with: (1) water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility;

(2) water quality and forage supporting juvenile development; and (3) habitat complexity characterized by natural cover such as shade, submerged and overhanging LWM, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids. The channelized, leveed, and rip-rapped river reaches and sloughs that are common in the Sacramento River system typically have low habitat complexity, relatively low production of food organisms, and offer little protection from either fish or avian predators. However, some complex, productive habitats with floodplains remain in the system (e.g., Sacramento River reaches with setback levees (i.e., primarily located upstream of the City of Colusa)) and flood bypasses (i.e., Yolo and Sutter bypasses). Juvenile lifestages of salmonids are dependent on the function of this habitat for successful survival and recruitment.

FRESHWATER MIGRATION CORRIDORS

Freshwater migration corridors provide upstream passage for adults to upstream spawning areas, and downstream passage of outmigrant juveniles to estuarine and marine areas. Migratory corridors are downstream of the spawning areas and include the lower reaches of the spawning tributaries, the mainstem of the Sacramento River and the Delta.

Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (i.e., hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. RBDD, completed in 1964, features a series of 11 gates that, when lowered, provide for gravity diversion of irrigation water from the Sacramento River into the Tehama-Colusa and Corning Canals for potential delivery to the Sacramento Valley National Wildlife Refuge and to approximately 140,000 acres of irrigable lands along the Interstate 5 corridor between Red Bluff and Dunnigan, California (Reclamation 2008b). The RBDD has been a serious impediment to upstream and downstream fish migration, and a significant portion of the Sacramento River spawning habitat for Chinook salmon and steelhead occurs upstream of the dam. Until recently, the RBDD created an upstream migratory barrier in the mainstem Sacramento River during its May 15 through September 15 “gates in” configuration. In response to the NMFS (2009) BO, the RBDD gates were permanently raised in September 2011 and thus, fish passage conditions have likely improved at the RBDD. The Red Bluff Fish Passage Improvement Project, which included construction of a pumping plant to allow for diversion of water from the Sacramento River without closing the RBDD gates, was completed in 2012 (Tehama-Colusa Canal Authority 2012).

Both the Sacramento River flow, and many juvenile spring-run Chinook salmon, enter the Delta Cross Channel (when the gates are open) and Georgiana Slough, and subsequently the central Delta, especially during periods of increased water export pumping from the Delta. Mortality of juvenile salmon entering the central Delta is higher than for those continuing downstream in the Sacramento River. This difference in mortality could be caused by a combination of factors, including: the longer migration route through the central Delta to the western Delta; exposure to higher water temperatures; higher predation rates; exposure to seasonal agricultural diversions; water quality impairments due to agricultural and municipal discharges; and a more complex channel configuration that makes it more difficult for salmon to successfully migrate to the western Delta and the ocean. In addition, the State and Federal pumps and associated fish facilities increase mortality of juvenile spring-run Chinook salmon through various means, including entrainment into the State and Federal canals, and salvage operations.

ESTUARINE HABITAT AREAS

The current condition of the estuarine habitat in the Delta has been substantially degraded from historic conditions. Over 90% of the fringing fresh, brackish, and salt marshes have been lost due to human activities. This loss of the fringing marshes reduces the availability of forage species and eliminates the cycling of nutrients from the marsh vegetation into the water column of the adjoining waterways.

The channels of the Delta have been modified by the raising of levees and armoring of the levee banks with riprap, which has decreased habitat complexity by reducing the incorporation of woody material and vegetative material into the nearshore area, minimizing and reducing local variations in water depth and velocities, and simplifying the community structure of the nearshore environment.

Heavy urbanization and industrial actions have lowered water quality and introduced persistent contaminants to the sediments surrounding points of discharge (i.e., refineries in Suisun and San Pablo bays, creosote factories in Stockton, etc.)

Delta hydraulics have been modified as a result of federal CVP and state SWP actions. Within the central and southern Delta, net water movement is towards the pumping facilities, altering the migratory cues for emigrating fish in these regions. Spring-run Chinook salmon smolts are drawn to the central and south Delta as they outmigrate, and are subjected to the indirect effects (e.g., predation, contaminants) and direct effects (e.g., salvage, loss) in the Delta and the CVP and SWP fish facilities.

The area of salinity transition, the low salinity zone (LSZ), is an area of high productivity. Historically, this zone fluctuated in its location in relation to the outflow of water from the Delta and moved westwards with high Delta inflow (i.e., floods and spring runoff) and eastwards with reduced summer and fall flows. This variability in the salinity transition zone has been substantially reduced by the operations of the CVP/SWP. The CVP/SWP long-term water diversions also have contributed to reductions in the phytoplankton and zooplankton populations in the Delta, as well as to alterations in nutrient cycling within the Delta ecosystem.

NEARSHORE COASTAL MARINE AND OFFSHORE MARINE AREAS

Spring-run Chinook salmon reside in the Pacific Ocean from one to four years. The first few months of a salmon's ocean life has been identified as the period of critical climatic influences on survival which, in turn, suggests that coastal and estuarine environments are key areas of biophysical interaction (NMFS 2009). Juvenile salmon grow rapidly as they feed in the highly productive currents along the continental shelf (Barnhart 1986).

Most climate factors affect the entire West Coast complex of salmonids. This is particularly true in their marine phase, because the California populations are believed to range fairly broadly along the coast and intermingle, and climate impacts in the ocean occur over large spatial scales (Schwing and Lindley 2009). Salmon and steelhead residing in coastal areas where upwelling is the dominant process are more sensitive to climate-driven changes in the strength and timing of upwelling (NMFS 2009).

Oceanic and climate conditions such as sea surface temperatures, air temperatures, strength of upwelling, El Niño events, salinity, ocean currents, wind speed, and primary and secondary productivity affect all facets of the physical, biological and chemical processes in the marine environment. Some of the conditions associated with El Niño events include warmer water temperatures, weak upwelling, low primary productivity (which leads to decreased zooplankton biomass), decreased southward transport of subarctic water, and increased sea levels (Pearcy 1997 as cited in NMFS 2009). Strong upwelling is probably beneficial because it causes greater transport of smolts offshore, beyond major concentrations of inshore predators (Pearcy 1997 as cited in NMFS 2009).

The California Current Ecosystem (CCE) is designated by NMFS as one of eight large marine ecosystems within the United States Exclusive Economic Zone. The California Current begins at the northern tip of Vancouver Island, Canada and ends somewhere between Punta Eugenia and the tip of Baja California, Mexico (NMFS 2009). The northern end of the current is dominated by strong seasonal variability in winds, temperature, upwelling, plankton production and the spawning times of many fishes, whereas the southern end of the current has much less seasonal variability (NMFS 2009). The primary issue for the CCE is the onset and length of the upwelling season, that is when upwelling begins and ends (i.e., the “spring” and “fall” transitions). The biological transition date provides an estimate of when seasonal cycles of significant plankton and euphausiid production are initiated (NMFS 2009).

4.2.3 Summary of Past and Ongoing Fisheries Studies on the Lower Yuba River

As stated in YCWA (2010), the Yuba River downstream of Englebright Dam is one of the more thoroughly studied rivers in the Central Valley of California. A description of existing information regarding salmonid populations in the lower Yuba River downstream of Englebright Dam is contained in Attachment 1 to YCWA (2010), which is provided in **Appendix E** of this BA. Appendix E summarizes the available literature for spring-run Chinook salmon where specifically identified, Chinook salmon in general where runs are not specifically identified, and *O. mykiss*. Much of the referenced information discusses both runs of Chinook salmon and *O. mykiss,* and therefore is presented in its entirety in Appendix E. The appendix describes available field studies and data collection reports, other relevant documents, and ongoing data collection, monitoring and evaluation activities including the Yuba River Accord Monitoring and Evaluation Program (M&E Program) and other data collection and monitoring programs. Appendix E summarily describes 21 available field studies and data collection reports, 20 other relevant documents (e.g., plans, policies, historical accounts and regulatory compliance), 14 ongoing data collection, monitoring and evaluation activities for the M&E Program, and 4 other data collection and monitoring programs.

4.2.4 Historical Abundance and Distribution

Spring-run Chinook salmon were once the most abundant run of salmon in the Central Valley (Campbell and Moyle 1990) and were found in both the Sacramento and San Joaquin drainages. The Central Valley drainage as a whole is estimated to have supported annual runs of spring-run Chinook salmon as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). More than 500,000 spring-run Chinook salmon were reportedly caught in the Sacramento-San Joaquin commercial fishery in 1883 alone (Yoshiyama et al. 1998). Before the construction of Friant Dam (completed in 1942), nearly 50,000 adults were counted in the San Joaquin River (Fry 1961). The San Joaquin populations were essentially extirpated by the 1940s, with only small remnants of the run that persisted through the 1950s in the Merced River (Hallock and Van Woert 1959; Yoshiyama et al. 1998).

Annual run sizes of spring-run Chinook salmon are reported in “GrandTab”, a database administered by CDFW for the Central Valley that includes reported run size estimates from 1960 through 2012, although mainstem Sacramento River estimates are not available for years before 1969 (CDFW 2013). The Central Valley spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance. Estimates of spring-run Chinook salmon in the Sacramento River and its tributaries (not including the lower

Yuba and Feather rivers because GrandTab does not distinguish between fall-run and spring-run Chinook salmon in-river spawners, and not including the FRFH) have ranged from 1,404 in 1993 to 25,890 in 1982.

The average abundance for the Sacramento River and its tributaries (excluding the lower Yuba and Feather rivers – see above) was 11,646 for the period extending from 1970 through 1979, 14,240 for the period 1980 through 1989, 5,825 for the period 1990 through 1999, and 14,055 for the period 2000 through 2009. Since 1995, spring-run Chinook salmon annual run size estimates have been dominated by Butte Creek returns. Since carcass survey estimates have been available in Butte Creek in 2001 through 2012, Butte Creek returns have averaged 10,874 fish. The estimated spring-run Chinook salmon run size was 18,511 for 2012, of which Butte Creek returns (based on the carcass survey) accounted for 16,140 fish (CDFW 2013).

Historically, spring-run Chinook salmon occurred in the headwaters of all major river systems in the Central Valley where natural barriers to migration were absent, and occupied the middle and upper elevation reaches (1,000 to 6,000 feet) of most streams and rivers with sufficient habitat for over summering adults (Clark 1929). Excluding the lower stream reaches that were used as adult migration corridors (and, to a lesser degree, for juvenile rearing), it has been estimated that at least 72% of the original Chinook salmon spawning and holding habitat in the Central Valley drainage is no longer available due to the construction of non-passable dams (Yoshiyama et al. 2001). Adult migrations to the upper reaches of the Sacramento, Feather, and Yuba rivers were eliminated with the construction of major dams during the 1940s, 1950s and 1960s. Naturally spawning populations of spring-run Chinook salmon have been reported to be restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Mill Creek, Feather River, and the Yuba River (CDFG 1998).

Historically, the Yuba River watershed reportedly was one of the most productive habitats for runs of Chinook salmon and steelhead (Yoshiyama et al. 1996). Although it is not possible to estimate the numbers of spawning fish from historical data, CDFG

(1993) suggested that the Yuba River "*historically supported up to 15% of the annual run of fall-run Chinook salmon in the Sacramento River system*" (Yoshiyama et al. 1996).

By the late 1800s, anadromous fish populations were experiencing significant declines, primarily because of mining activities and resultant extreme sedimentation following flood events (McEwan 2001; Yoshiyama et al. 2001). As an example, the flood of 1861–1862 buried much of the bottomlands along the lower Yuba River under sand deposits averaging two to seven feet deep (Kelley 1989). By 1876 the channel of the lower Yuba River reportedly had become completely filled, and what remained of the adjoining agricultural lands was covered with sand and gravel (Kelley 1989; CDFG 1993) — a marked deterioration of the river as salmon habitat (Yoshiyama et al. 2001).

To control flooding and the downstream movement of sediment, construction of several man-made instream structures on the Yuba River occurred during the early 1900s. A structure referred to as Barrier No. 1, built in 1904 and 1905, was located 1 mile below Parks Bar Bridge near Smartsville and was destroyed by flood waters in March 1907 (Sumner and Smith 1939). This barrier probably hindered salmon upstream movement (Sumner and Smith 1939). In 1906, the California Debris Commission, a partnership between the Federal Government and the State of California, constructed Daguerre Point Dam, specifically to hold back mining debris. In 1910, the Yuba River was diverted over the new dam. This approximately 24-foot high dam retained the debris, but made it difficult for spawning fish to migrate upstream, although salmon reportedly did surmount the dam in occasional years because they were reportedly observed in large numbers in the North Yuba River at Bullards Bar during the early 1920s (Yoshiyama et al. 2001). Two fishways, one for low water and the other for high water, were constructed at Daguerre Point Dam prior to the floods of 1927-1928 (Clark 1929), when the fish ladders were destroyed, and were not replaced until 1938, leaving a 10-year period when upstream fish passage at Daguerre Point Dam was blocked (CDFG 1991). A fish ladder was constructed at the south end of Daguerre Point Dam in 1938 and was generally ineffective (CDFG 1991), but during the fall of 1938, *"several salmon were reported seen below the Colgate Head Dam on the North Fork of the Yuba, 35 miles above Daguerre Point Dam."* (Sumner and Smith 1939).

Upstream of Daguerre Point Dam, the 260-foot-high Englebright Dam was authorized in 1935 to hold back hydraulic mining debris, and was constructed in 1941 by the California Debris Commission. Englebright Dam was not authorized to provide fish passage, therefore it has no fish ladders and blocks anadromous fish access to all areas upstream of the dam (Eilers 2008; PG&E 2008; DWR 2009). The dam restricts anadromous fish to the lower 24 miles of the Yuba River.

There is limited information on the historical population size of spring-run Chinook salmon in the Yuba River. Historical accounts indicate that “large numbers” of Chinook salmon may have been present as far upstream as Downieville on the North Fork Yuba River (Yoshiyama et al. 1996). Due to their presence high in the watershed, Yoshiyama et al. (1996) concluded that these fish were spring-run Chinook salmon.

For the Middle Fork Yuba River, Yoshiyama et al. (2001) concluded that direct information was lacking on historic abundance and distribution of salmon, and they conservatively considered the 10-foot falls located 1.5 miles above the mouth of the Middle Fork Yuba River was the upstream limit of salmon distribution.

Yoshiyama et al. (2001) report that little is known of the original distribution of salmon in the South Fork Yuba River where the Chinook salmon population was severely depressed and upstream access was obstructed by dams when CDFW began surveys in the 1930s. Sumner and Smith (1939) stated that the “*South Fork of the Yuba is not considered an angling stream in its 24 miles below the mouth of Poorman Creek, where slickens* (pulverized rock) from the Spanish Mine turns the river a muddy grey*.” They also reported that in “*Poorman Creek, cyanide poisoning may have done more harm than the slickens… It was evident that some strong poison was entering the stream with the tailings. An occasional heavy dose of cyanide would kill off fish and fish food…*” Yoshiyama et al. (2001) consider the cascade, with at least a 12-foot drop, located 0.5 mile below the juncture of Humbug Creek, which was as essentially the historical upstream limit of salmon during most years of natural streamflows.

Clark (1929) reported that the salmon spawning grounds extended from the mouth of the lower Yuba River upstream to the town of Smartsville, but that very few salmon (evidently spring-run) went farther upstream past that point. Sumner and Smith (1940) report that salmon ascended in considerable numbers up to Bullard's Bar Dam on the North Fork Yuba River while it was being constructed (1921-1924). In their 1938 survey of Yuba River salmon populations, Sumner and Smith (1940) stated that the height of the dams in the Yuba River blocked all potential salmon and steelhead runs upstream of the barriers (Sumner and Smith 1940). However, Sumner and Smith (1940) describe the ladders as "*a rather ineffectual fishway... That few fish have been able to use it...is testified to by the almost universal belief among local residents that at present no fish ever come above the dam*." In addition, the fall-run Chinook salmon run was reportedly destroyed at least temporarily, and many miles of streams rendered unfit for trout (Sumner and Smith 1939).

In 1951, two functional fish ladders were installed by the State of California and it was stated that *"With ladders at both ends, the fish have no difficulty negotiating this barrier at any water stage."* (CDFG 1953).

CDFG (1991) reports that a small spring-run Chinook salmon population historically occurred in the lower Yuba River but the run virtually disappeared by 1959, presumably due to the effects of water diversion and hydraulic developments on the river (Fry 1961). As of 1991, a remnant spring-run Chinook salmon population reportedly persisted in the lower Yuba River downstream of Englebright Dam, maintained by fish produced in the lower Yuba River, fish straying from the Feather River, or fish previously and infrequently stocked from the FRFH (CDFG 1991).

In the 1990s, relatively small numbers of Chinook salmon that exhibit spring-run phenotypic characteristics were observed in the lower Yuba River (CDFG 1998). Although precise escapement estimates are not available, the USFWS testified at the 1992 SWRCB lower Yuba River hearing that "…*a population of about 1,000 adult spring-run Chinook salmon now exists in the lower Yuba River*" (San Francisco Bay RWQCB 2006 as cited in NMFS 2009).

4.2.5 General Life History and Habitat Requirements

This section presents a general overview of lifestage-specific information (e.g., adult immigration and holding, adult spawning, embryo incubation, juvenile rearing and outmigration) for the Central Valley spring-run Chinook salmon ESU. Then, this section specifically focuses and provides information on lifestage specific temporal and spatial distributions for spring-run Chinook salmon in the lower Yuba River. Recently, the RMT developed representative temporal distributions for specific spring-run Chinook salmon lifestages through review of previously conducted studies, as well as recent and currently ongoing data collection activities of the M&E Program (**Table 4-1**). The resultant lifestage periodicities encompass the majority of activity for a particular lifestage, and are not intended to be inclusive of every individual in the population (RMT 2010; RMT 2013).

Four distinct runs of Chinook salmon spawn in the Sacramento-San Joaquin River system, with each run named for the season when the majority of the run enters freshwater as adults. The primary characteristic distinguishing spring-run Chinook salmon from the other runs of Chinook salmon is that adult spring-run Chinook salmon enter their natal streams during the spring, and hold in areas downstream of spawning grounds during the summer months until their eggs fully develop and become ready for spawning.

Table 4-1. Lifestage-specific periodicities for spring-run Chinook salmon in the lower Yuba River (Source: RMT 2013).

Lifestage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring-run Chinook Salmon												
Adult Immigration and Holding	☐☐	☐☐	☐☐	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	☐☐	☐☐	☐☐
Spawning	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	▨▨	▨☐	☐☐	☐☐
Embryo Incubation	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	▨▨	▨▨	▨▨	▨▨
Fry Rearing	▨▨	▨☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐▨	▨▨
Juvenile Rearing	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨
Juvenile Downstream Movement	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	☐☐	☐☐	☐☐	☐☐	☐▨	▨▨
Smolt (Yearling+) Emigration	▨▨	▨▨	▨▨	▨▨	▨☐	☐☐	☐☐	☐☐	☐☐	▨▨	▨▨	▨▨

4.2.5.1 Adult Immigration and Holding

Adult spring-run Chinook salmon immigration and holding in California's Central Valley has been reported to occur from mid-February through September (CDFG 1998; Lindley et al. 2004). Spring-run Chinook salmon are known to use the Sacramento River primarily as a migratory corridor to holding and spawning areas located in upstream tributaries. For the mainstem Sacramento River, all of the potential spring-run Chinook salmon holding habitat is located upstream from the Red Bluff Diversion Dam and downstream of Keswick Dam (CDFG 1998).

Suitable water temperatures for adult upstream migration reportedly range between 57ºF and 67ºF (NMFS 1997). In addition to suitable water temperatures, adequate flows are required to provide migrating adults with olfactory and other cues needed to locate their spawning reaches (CDFG 1998). The primary characteristic distinguishing spring-run Chinook salmon from the other runs of Chinook salmon is that adult spring-run Chinook salmon hold in areas downstream of spawning grounds during the summer months until their eggs fully develop and become ready for spawning. NMFS (1997) states, "*Generally, the maximum temperature for adults holding, while eggs are maturing, is about 59-60°F, but adults holding at 55-56°F have substantially better egg viability*."

For the lower Yuba River, adult spring-run Chinook salmon immigration and holding has previously been reported to primarily occur from March through October (Vogel and Marine 1991; YCWA et al. 2007), with upstream migration generally peaking in May (SWRI 2002). The RMT's examination of preliminary data obtained since the VAKI Riverwatcher infrared and videographic sampling system has been operated (2003 – present) found variable temporal modalities of Chinook salmon ascending the fish ladders at Daguerre Point Dam. The RMT (2013) identified the spring-run Chinook salmon adult immigration and holding period as extending from April through September.

Previously, it has been reported that spring-run Chinook salmon in the lower Yuba River hold over during the summer in the deep pools and cool water downstream of the Narrows I and Narrows II powerhouses, or further downstream in the Narrows Reach (CDFG 1991; SWRCB 2003), where water depths can exceed 40 feet (YCWA et al.

2007). Congregations of adult Chinook salmon (approximately 30 to 100 fish) have been observed in the outlet pool at the base of the Narrows II Powerhouse, generally during late August or September when the powerhouse is shut down for maintenance. During this time period, the pool becomes clear enough to see the fish (M. Tucker, NMFS, pers. comm. 2003; S. Onken, YCWA, pers. comm. 2004). While it is difficult to visually distinguish spring-run from fall-run Chinook salmon in this situation, the fact that these fish are congregated this far up the river at this time of year indicates that some of them are likely to be spring-run Chinook salmon (NMFS 2007).

Past characterizations of spring-run Chinook salmon distributions from available literature on the lower Yuba River have provided some anecdotal references to behavioral run details (such as migration timing and areas of holding and spawning), but the referenced information has not provided or referenced the basis for these descriptions. Spring-run Chinook salmon have been reported to migrate immediately to areas upstream of the Highway 20 Bridge after entering the lower Yuba River from March through October (Vogel and Marine 1991; YCWA et al. 2007), and then over-summer in deep pools located downstream of the Narrows 1 and 2 powerhouses, or further downstream in the Narrows Reach through the reported spawning period of September through November (CDFG 1991; SWRCB 2003).

The RMT's (2013) examination of preliminary data obtained since the VAKI Riverwatcher infrared and videographic sampling system has been operated (2003 – present) found variable temporal modalities of Chinook salmon ascending the fish ladders at Daguerre Point Dam. The RMT's 3-year acoustic telemetry study of adult spring-run Chinook salmon tagged downstream of Daguerre Point Dam during the phenotypic adult upstream migration period has provided new information to better understand adult spring-run Chinook salmon temporal and spatial distributions in the lower Yuba River. The results from the Vaki Riverwatcher monitoring, and particularly from the acoustic telemetry study found past characterizations of temporal and spatial distributions to be largely unsupported, as phenotypic adult spring-run Chinook salmon were observed to exhibit a much more diverse pattern of movement, and holding locations in the lower Yuba River were more expansive than has been previously reported (RMT 2013).

Although some of the acoustically-tagged spring-run Chinook salmon were observed to adhere to other previously reported characterizations, observations from the telemetry study also identified that a large longitudinal extent of the lower Yuba River was occupied by the tagged phenotypic adult spring-run Chinook salmon during immigration and holding periods (**Figure 4-1**). Figure 4-1 displays all individual fish detections obtained during the RMT's mobile acoustic tracking surveys conducted from May 2009 until November 2011 (RMT 2013).

Also, temporal migrations to areas upstream of Daguerre Point Dam occurred over an extended period of time (**Figure 4-2**). The tagged phenotypic adult spring-run Chinook salmon in the lower Yuba River actually migrated upstream of Daguerre Point Dam from May through September, and utilized a broad expanse of the lower Yuba River during the summer holding period, including areas as far downstream as Simpson Lane Bridge (i.e., ~RM 3.2), and as far upstream as the area just below Englebright Dam. A longitudinal analysis of acoustic tag detection data indicated that distributions were non-random, and that the tagged spring-run Chinook salmon were selecting locations for holding.

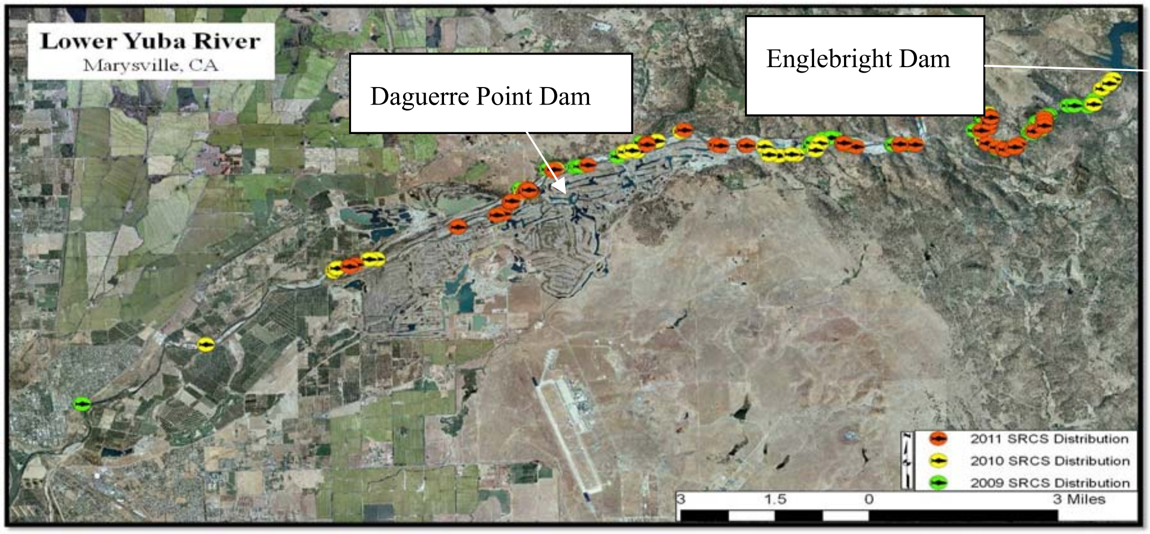

Figure 4-1. Spatial distribution of all individual acoustically-tagged adult phenotypic spring-run Chinook salmon (SRCS) detections obtained from the mobile tracking surveys conducted during 2009, 2010 and 2011 (Source: RMT 2013).

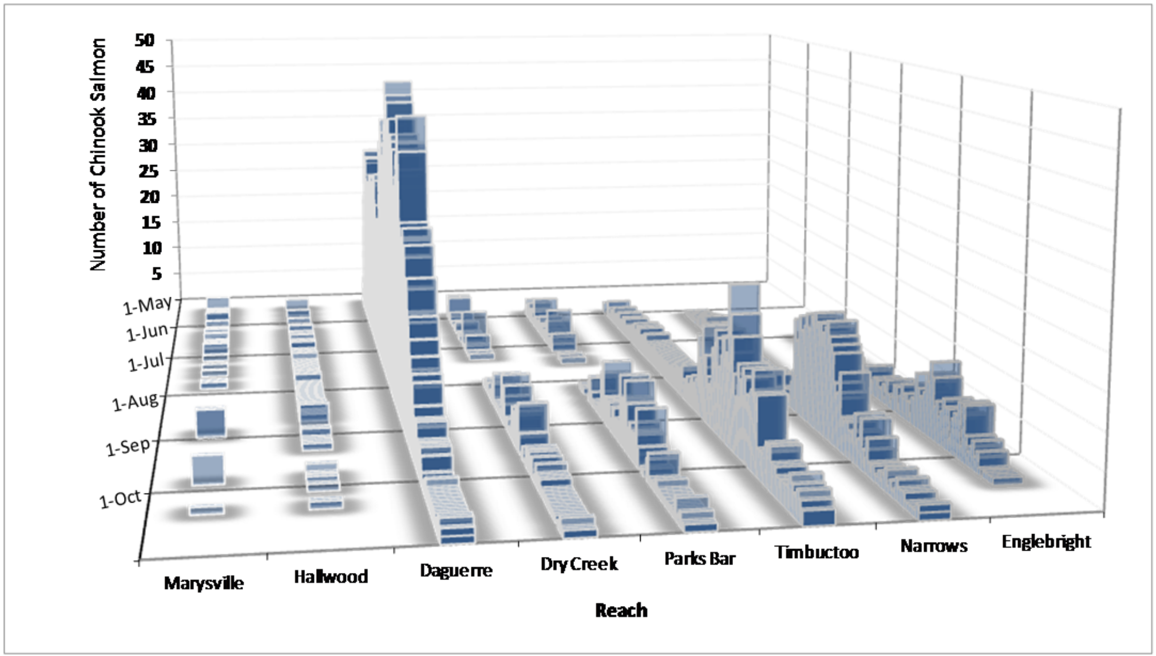

Figure 4-2. Spatial and temporal distribution of all individual acoustically-tagged adult phenotypic spring-run Chinook salmon detected from the mobile tracking surveys conducted during 2009, 2010 and 2011 in the lower Yuba River (Source: RMT 2013).

The area of the river between Daguerre Point Dam and the Highway 20 Bridge was largely used as a migratory corridor by the tagged adult spring-run Chinook salmon during all three years of the study (RMT 2013). Telemetry data in this area demonstrated relatively brief periods of occupation, characterized by sequential upstream detections as individually-tagged fish migrated through this area. By contrast, frequent and sustained detections were observed from the Highway 20 Bridge upstream to Englebright Dam (RMT 2013).

Examination of individual detection data indicated that tagged phenotypic adult spring-run Chinook salmon that moved upstream of Daguerre Point Dam had generally passed through the Daguerre Point Dam fish ladders by the end of September during all three years (RMT 2013). Acoustic tag detection data were used to discern tagged spring-run Chinook salmon residing in holding areas during June, July and August, and shifting to spawning areas during September into early October. This observation was repeated during all three years of the study, and in all occupied reaches. Telemetry data demonstrated that the majority of tagged phenotypic adult spring-run Chinook salmon that ascended the ladders at Daguerre Point Dam also continued to move farther upstream to the Timbuctoo, Narrows, and Englebright Dam reaches during September, coincident with the initiation of spawning activity (RMT 2013).

YCWA (2013) used the RMT's 2009-2011 acoustic tagging study data to evaluate movements of the individual acoustically-tagged spring-run Chinook salmon and potential relationships between changes in flow. Visual examination of the time series plots of daily locations of individual acoustically-tagged Chinook salmon and mean daily flows at the Smartsville Gage showed highly variable behavior among individuals on a daily basis within and among years. However, several general patterns of fish movement in relationship to flow are apparent.

- ☐ Abrupt upstream movement coinciding with an increase in flow
- ☐ Abrupt upstream movement coinciding with a decrease in flow
- ☐ Abrupt downstream movement coinciding with a decrease in flow
- ☐ Abrupt upstream movement occurring after an increase in flow

YCWA (2013) found that most of the individual movements of acoustically-tagged spring-run Chinook salmon potentially associated with a change in Smartsville flow were abrupt upstream movements occurring concurrently with a noticeable decrease in flow. Additional notable observations included some individuals that abruptly moved upstream in the days following a reduction in flow.

Observed movements of individual spring-run Chinook salmon identified during 2009 generally occurred within the time period from about mid-May to early September, and generally occurred over a period ranging from one to nine days. Most of the observed movements identified during 2010 occurred during early to mid-June, with a few movements occurring during August, and generally occurred over a period ranging from about one to seven days. The identified movements during 2011 generally occurred during late August into early September, and generally occurred over a period ranging from about one to five days. Because spring-running Chinook salmon immigrated into the lower Yuba River later in 2011 than during 2009 and 2010, and were not captured and acoustically-tagged until July, no potential relationships between fish movement and flow reductions during the spring months could be evaluated for 2011.

More than half (40 out of 60) of the identified movements of Chinook salmon over the three years that were potentially associated with a concurrent change in flow consisted of upstream movements coinciding with a large decrease in flow (measured at the Smartsville Gage). Most of the identified upstream movements occurring coincident to a decrease in flow occurred when flow decreased substantially during a 1 to 2 week period in late August to early September and/or during a 1 to 2 week period during May or June, depending on the year. In other words, the most common potential relationship identified between spring-run Chinook salmon movement and flow was an abrupt and continued movement upstream to the upper reaches during a large reduction in mean daily Smartsville flow (38 to 68% reduction in flow) occurring over about 1 to 2 weeks.

4.2.5.2 Adult Spawning

In the Central Valley, spawning has been reported to primarily occur from September to November, with spawning peaking in mid- September (DWR 2004c; Moyle 2002; Vogel and Marine 1991). Within the ESU, spring-run Chinook salmon spawn in accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Mill Creek, Feather River, and the Yuba River (CDFG 1998).

All of the potential spring-run Chinook salmon spawning habitat in the mainstem Sacramento River is located upstream from the Red Bluff Diversion Dam and downstream of Keswick Dam (CDFG 1998). It has been reported that in some years high water temperatures would prevent spring-run Chinook salmon egg and embryo survival (USFWS 1990 as cited in CDFG 1998). During years of low storage in Shasta Reservoir and under low flow releases, water temperatures exceed 56°F downstream of Keswick Dam during critical months for spring-run Chinook salmon spawning and egg incubation (YCWA et al. 2007).

In general, Central Valley spring-run Chinook salmon have been reported to spawn at the tails of holding pools (Moyle 2002; NMFS 2007). Redd sites are apparently chosen in part by the presence of subsurface flow. Chinook salmon usually seek a mixture of gravel and small cobbles with low silt content to build their redds. Characteristics of spawning habitats that are directly related to flow include water depth and velocity. Chinook salmon spawning reportedly occurs in water velocities ranging from 1.2 feet/sec to 3.5 feet/sec, and spawning typically occurs at water depths greater than 0.5 feet (YCWA et al. 2007).

For the lower Yuba River, the spring-run Chinook salmon spawning period has been reported to extend from September through November (CDFG 1991; YCWA et al. 2007). Limited reconnaissance-level redd surveys conducted by CDFW since 2000 during late August and September have detected spawning activities beginning during the first or second week of September. They have not detected a bimodal distribution of spawning activities (i.e., a distinct spring-run spawning period followed by a distinct fall-run Chinook salmon spawning period), and instead have detected a slow build-up of spawning activities starting in early September and transitioning into the main fall-run spawning period.

The RMT's (2013) examination of the 2009, 2010 and 2011 acoustically-tagged spring-run Chinook salmon data revealed a consistent pattern in fish movement. In general, acoustically-tagged spring-run Chinook salmon exhibited an extended holding period, followed by a rapid movement into upstream areas (upper Timbuctoo Reach, Narrows Reach, and Englebright Reach) during September. Then, a period encompassing approximately one week was observed when fish held at one specific location, followed by rapid downstream movement. The approximate one-week period appeared to be indicative of spawning events, which ended by the first week in October. These observations, combined with early redd detections and initial carcasses appearing in the carcass surveys (see below), suggest that the spring-run Chinook salmon spawning period in the lower Yuba River may be of shorter duration than previously reported, extending from September 1 through mid-October (RMT 2013).

The earliest spawning (presumed to be spring-run Chinook salmon) generally occurs in the upper reaches of the highest quality spawning habitat (i.e., below the Narrows pool) and progressively moves downstream throughout the fall-run Chinook salmon spawning season (NMFS 2007). Spring-run Chinook salmon spawning in the lower Yuba River is believed to occur upstream of Daguerre Point Dam. USFWS (2007) collected data from 168 Chinook salmon redds in the lower Yuba River on September 16-17, 2002 and

September 23-26, 2002, considered to be spring-run Chinook salmon redds. The redds were all located above Daguerre Point Dam. During the pilot redd survey conducted from the fall of 2008 through spring of 2009, the RMT (2010a) report that the vast majority (96%) of fresh Chinook salmon redds constructed by the first week of October 2008, potentially representing spring-run Chinook salmon, were observed upstream of Daguerre Point Dam. Similar distributions were observed during the 2010 and 2011 redd surveys, when weekly redd surveys were conducted. About 97 and 96% of the fresh Chinook salmon redds constructed by the first week of October were observed upstream of Daguerre Point Dam during 2009 and 2010, respectively (RMT 2013).

4.2.5.3 Embryo Incubation

The spring-run Chinook salmon embryo incubation period encompasses the time period from egg deposition through hatching, as well as the additional time while alevins remain in the gravel while absorbing their yolk sacs prior to emergence.

The length of time for spring-run Chinook salmon embryos to develop depends largely on water temperatures. In well-oxygenated intragravel environs where water temperatures range from about 41ºF to 55.4°F embryos hatch in 40 to 60 days and remain in the gravel as alevins for another 4 to 6 weeks, usually after the yolk sac is fully absorbed (NMFS 2009). In Butte and Big Chico creeks, emergence occurs from November through January, and in the colder waters of Mill and Deer creeks, emergence typically occurs from January through as late as May (Moyle 2002).

In the lower Yuba River, the RMT (2013) concluded that spring-run Chinook salmon embryo incubation period generally extends from September through December.

4.2.5.4 Juvenile Rearing and Outmigration

After emerging, Chinook salmon fry tend to seek shallow, nearshore habitat with slow water velocities and move to progressively deeper, faster water as they grow. However, fry may disperse downstream, especially if high-flow events correspond with emergence (Moyle 2002). Spring-run juveniles may emigrate as fry soon after emergence, rear in their natal streams for several months prior to emigration as young-of-the-year, or remain in their natal streams for extended periods and emigrate as yearlings. Information regarding the duration of rearing and timing of emigration of spring-run Chinook salmon in the Central Valley is summarized in NMFS (2009), much of which is presented herein.

Upon emergence from the gravel, juvenile spring-run Chinook salmon may reside in freshwater for 12 to 16 months, but some migrate to the ocean as young-of-the-year fish in the winter or spring months within eight months of hatching (CALFED 2000). The average size of fry migrants (approximately 40 mm between December and April in Mill, Butte and Deer creeks) reflects a prolonged emergence of fry from the gravel (Lindley et al. 2004).

The timing of juvenile emigration from the spawning and rearing grounds varies among the tributaries of origin, and can occur during the period extending from October through April (Vogel and Marine 1991). Studies in Butte Creek (Ward et al. 2003) found the majority of spring-run migrants to be fry, moving downstream primarily during December, January and February, and that these movements appeared to be influenced by flow. Small numbers of spring-run juveniles remained in Butte Creek to rear and migrate later in the spring. Some juveniles continue to rear in Butte Creek through the summer and emigrate as yearlings from October to February, with peak yearling emigration occurring in November and December (CDFG 1998). Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creek juveniles typically exhibit a later young-of-the-year migration and an earlier yearling migration (Lindley et al. 2004). In contrast, data collected on the Feather River suggests that the bulk of juvenile emigration occurs during November and December (Painter et al. 1977). Seesholtz et al. (2003) speculate that because juvenile rearing habitat in the Low Flow Channel of the Feather River is limited, juveniles may be forced to emigrate from the area early due to competition for resources.

In general, juvenile Chinook salmon have been collected by electrofishing and observed by snorkeling throughout the lower Yuba River, but with higher abundances above Daguerre Point Dam (Beak 1989; CDFG 1991; Kozlowski 2004). This may be due to larger numbers of spawners, greater amounts of more complex, high-quality cover, and lower densities of predators such as striped bass and American shad, which reportedly are restricted to areas below the dam (YCWA et al. 2007). During juvenile rearing and outmigration, salmonids prefer stream margin habitats with sufficient depths and velocities to provide suitable cover and foraging opportunities. Juvenile Chinook salmon reportedly utilize river channel depths ranging from 0.9 feet to 2.0 feet, and most frequently are in water with velocities ranging from 0 feet/sec to 1.3 feet/sec (Raleigh et al. 1986).

Juvenile snorkeling surveys conducted in the lower Yuba River during 2012 indicate that juvenile Chinook salmon in the lower Yuba River initially prefer slower, shallower habitat, and move into faster and deeper water as they grow. RMT (2013) reported that the vast majority of observations of juvenile Chinook salmon in the lower Yuba River occurred in water velocities and depths indicative of slackwater and slow glide mesohabitats. Juvenile Chinook salmon are known to prefer slower water habitats than many other members of Oncorhynchus (Quinn 2005), and have been previously reported to actively seek out slow backwaters, pools, or floodplain habitat for rearing (Sommer et al. 2001; Jeffres et al. 2008). The snorkeling data collected by the RMT during 2012 are generally consistent with other data available for multiple rivers (Bjornn and Reiser 1991). Juvenile Chinook salmon in the 30-50 mm size class tended to occupy shallower habitats than larger (and presumably older) individuals, which is consistent with other observations of salmonids (e.g., Bjornn and Reiser 1991). Similarly, juvenile Chinook salmon showed a clear preference for faster water (up to an average of about 1.8 ft/s) as they grew, consistent with trends found with salmonids in other rivers (Bjornn and Reiser 1991).

Based upon review of available information, the RMT (2010b) recently identified the spring-run Chinook salmon fry rearing period as extending from mid-November through March, the juvenile rearing period extending year-round, and the young-of-year (YOY) emigration period extending from November through mid-July. Associated with the previously described shortened duration of spring-run Chinook salmon spawning, the fry rearing period is estimated to extend from mid-November through mid-February (RMT 2013). Updated characterization of the juvenile (YOY) emigration (i.e., downstream movement) period extends from mid-November through June (RMT 2013).

In the lower Yuba River, CDFW has conducted juvenile salmonid outmigration monitoring by operating rotary screw traps (RSTs) near Hallwood Boulevard, located approximately 6 RM upstream from the city of Marysville. CDFW's RST monitoring efforts generally extended from fall (October or November) through winter, and either into spring (June) or through the summer (September) annually from 1999 to 2006. The RMT took over operation of the year-round RST effort in the fall of 2006, and continued operations through August 2009 (RMT 2013).

Analyses of CDFW RST data indicate that most Chinook salmon juveniles move downstream past the Hallwood Boulevard location prior to May of each year. For the 5 years of data included in the analyses, 97.5 to 99.2% of the total numbers of juvenile Chinook salmon were captured by May 1 of each year. The percentage of the total juvenile Chinook salmon catch moving downstream past the Hallwood Boulevard location each year ranged from 0.4 to 1.3% during May, and 0 to 1.2% during June (YCWA et al. 2007). During the 2007/2008 sampling period, 95% of all juvenile Chinook salmon were captured by June 2, 2008 (Campos and Massa 2010a). Analysis of the fitted distribution of weekly juvenile Chinook salmon catch at the Hallwood Boulevard RST site from survey year 1999 through 2008 revealed that most emigration occurred from late-December through late-April in each survey year (RMT 2013). Approximately 95% of the observed catch across all years based on the fitted distribution occurred by April 30 (RMT 2013).

Overall, most (about 84%) of the juvenile Chinook salmon were captured at the Hallwood Boulevard RSTs soon after emergence from November through February, with relatively small numbers continuing to be captured through June. Although not numerous, captures of (oversummer) holdover juvenile Chinook salmon ranging from about 70 to 140 mm FL, primarily occurred from October through January with a few individuals captured into March (Massa 2005; Massa and McKibbin 2005). These fish likely reared in the river over the previous summer, representing an extended juvenile rearing strategy characteristic of spring-run Chinook salmon. During the 2007/2008 sampling period, 33 Chinook salmon that met this criterion were observed at the Hallwood Boulevard RST site from mid-December through January. Juvenile Chinook salmon captured during the fall and early winter (October-January) larger than 70 mm are likely exhibiting an extended rearing strategy in the lower Yuba River (Campos and Massa 2010a).

For the sampling periods extending from 2001 to 2005, CDFW identified specific runs based on sub-samples of lengths of all juvenile Chinook salmon captured in the RSTs by using the length-at-time tables developed by Fisher (1992), as modified by S. Greene (DWR 2003b). Although the veracity of utilization of the length-at-time tables for determining the run type of Chinook salmon in the Yuba River has not been ascertained, based on the examination of run-specific determinations, in the lower Yuba River the vast majority (approximately 94%) of spring-run Chinook salmon were captured as post-emergent fry during November and December, with a relatively small percentage (nearly 6%) of individuals remaining in the lower Yuba River and captured as YOY from January through March. Only 0.6%of the juvenile Chinook salmon identified as spring-run was captured during April, and only 0.1% during May, and none were captured during June (YCWA et al. 2007). The above summary of juvenile Chinook salmon emigration monitoring studies in the Yuba River is most consistent with the temporal trends of spring-run Chinook salmon outmigration reported for Butte and Big Chico creeks (YCWA et al. 2007).

4.2.5.5 Smolt Emigration

For the Central Valley, it has been reported that while some spring-run Chinook salmon emigrate from natal streams soon after emergence during the winter and early-spring (NMFS 2004a), some may spend as long as 18 months in freshwater and move downstream as smolts during the first high flows of the winter, which typically occur from November through January (CDFG 1998; USFWS 1995). In the Sacramento River drainage, spring-run Chinook salmon smolt emigration reportedly occurs from October through March (CDFG 1998). In Butte Creek, some juvenile spring-run Chinook salmon rear through the summer and emigrate as yearlings from October to February, with peak yearling emigration occurring in November and December (CDFG 1998). In the Feather River, some spring-run Chinook salmon smolts reportedly emigrate from the Feather River system from October through June (B. Cavallo, DWR, pers. comm. 2004).

Although it has been previously suggested that spring-run Chinook salmon smolt emigration generally occurs from November through June in the lower Yuba River (CALFED and YCWA 2005; CDFG 1998; SWRI 2002), recent (1999-2005), CDFW monitoring data indicate that the vast majority of spring-run Chinook salmon emigrate as post-emergent fry during November and December. There were some captures of (over-summer) holdover juvenile Chinook salmon ranging from about 70 to 140 mm FL, which primarily occurred from October through January with a few individuals captured into March (Massa 2005; Massa and McKibbin 2005). These fish likely reared in the river over the previous summer, representing an extended juvenile rearing strategy characteristic of spring-run Chinook salmon. During the 2007/2008 sampling period, 33 Chinook salmon that met this criterion were observed at the Hallwood Boulevard RST site from mid-December through January. Juvenile Chinook salmon captured during the fall and early winter (October-January) larger than 70 mm are likely exhibiting an extended rearing strategy in the lower Yuba River (Campos and Massa 2010a).

Based upon review of available information, the RMT (2013) recently identified the spring-run Chinook salmon smolt (yearling+) outmigration period as extending from October through mid-May.

4.2.5.6 Lifestage-Specific Water Temperature Suitabilities

During November 2010, the RMT prepared a technical memorandum (RMT 2010b) to review the appropriateness of the water temperature regime associated with implementation of the Yuba Accord using previously available data and information, updated in consideration of recent and ongoing monitoring activities conducted by the RMT since the pilot programs were initiated in 2006. The RMT's objectives for that memorandum were to review and update the lifestage periodicities of target species in the lower Yuba River, identify the appropriate thermal regime for target fish species taking into account individual species and lifestage water temperature requirements, identify water temperature index values, assess the probability of occurrence that those water temperature index values would be achieved with implementation of the Yuba Accord, and to evaluate whether alternative water temperature regimes are warranted.

Since November 2010, additional water temperature monitoring and life history investigations of anadromous salmonids in the lower Yuba River have been conducted by the RMT. An update to the water temperature suitability evaluation in RMT (2010) was recently conducted by RMT (2013). The water temperature suitability evaluation conducted for this BA incorporates additional water temperature monitoring data from what was presented in RMT (2013).

Through review of previously conducted studies, as well as recent and currently ongoing data collection activities of the M&E Program, the RMT (2013) developed the following representative lifestage-specific periodicities and primary locations for water temperature suitability evaluations. The locations used for water temperature evaluations correspond to Smartsville, Daguerre Point Dam, and Marysville.

- ☐ Adult Immigration and Holding (April through September) – Smartsville, Daguerre Point Dam, and Marysville
- ☐ Spawning (September through mid-October) – Smartsville
- ☐ Embryo Incubation (September through December) – Smartsville
- ☐ Juvenile Rearing and Outmigration (Year-round) – Daguerre Point Dam and Marysville
- ☐ Smolt (Yearling+) Emigration (October through mid-May) – Daguerre Point Dam and Marysville

Lifestage-specific water temperature index values used as evaluation guidelines for spring-run Chinook salmon were developed based on the information described in Attachment A to RMT (2010b), as well as additional updated information provided in Bratovich et al. (2012). These documents present the results of literature reviews that were conducted to: (1) interpret the literature on the effects of water temperature on the various lifestages of Chinook salmon and steelhead; (2) consider the effects of short-term and long-term exposure to constant or fluctuating temperatures; and (3) establish water temperature index (WTI) values to be used as guidelines for evaluation. Specifically, the RMT (2013) evaluation adopted the approach established by Bratovich et al. (2012) which uses the lifestage and species-specific upper tolerance WTI values. These WTI values were not meant to be significance thresholds, but instead provide a mechanism by which to compare the suitability of the water temperature regimes associated with implementation of the Yuba Accord. Spring-run Chinook salmon lifestage-specific WTI values are provided in **Table 4-2**. The lifestages and periodicities presented in Table 4-2 differ from those presented in Table 4-1 due to specific lifestages that have the same or distinct upper tolerable WTI values.

Table 4-2. Spring-run Chinook salmon lifestage-specific upper tolerance WTI values.

Lifestage	Upper Tolerance WTI	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult Migration	68°F							■	■	■	■	■	■	■	■	■	■	■	■						
Adult Holding	65°F							■	■	■	■	■	■	■	■	■	■	■	■						
Spawning	58°F																	■	■	■					
Embryo Incubation	58°F																	■	■	■	■	■	■	■	■
Juvenile Rearing and Downstream Movement	65°F	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Smolt (Yearling+) Emigration	68°F	■	■	■	■	■	■	■	■	■										■	■	■	■	■	■

Recent water temperature monitoring data in the lower Yuba River are available for the period extending from 2006 into June 2013, during which time operations have complied with the Yuba Accord. In general, the lowest water temperatures in the lower Yuba River are observed during January and February, and water temperatures steadily increase until mid-June or July, remain at relatively high values through September andsteadily decrease thereafter. The coldest water temperatures are observed upstream at the Smartsville Gage, intermediate water temperatures occur at Daguerre Point Dam, and the warmest temperatures are observed downstream at the Marysville Gage for most months of the year. The least amount of spatial variation in water temperature is observed during late fall through winter months (i.e., late November through February), when water temperatures are similar at the three monitoring locations.

Figure 4-3 displays daily water temperature monitoring results from October 2006 through late June 2013 at the Smartsville, Daguerre Point Dam, and Marysville water temperature gages, superimposed with spring-run Chinook salmon lifestage-specific

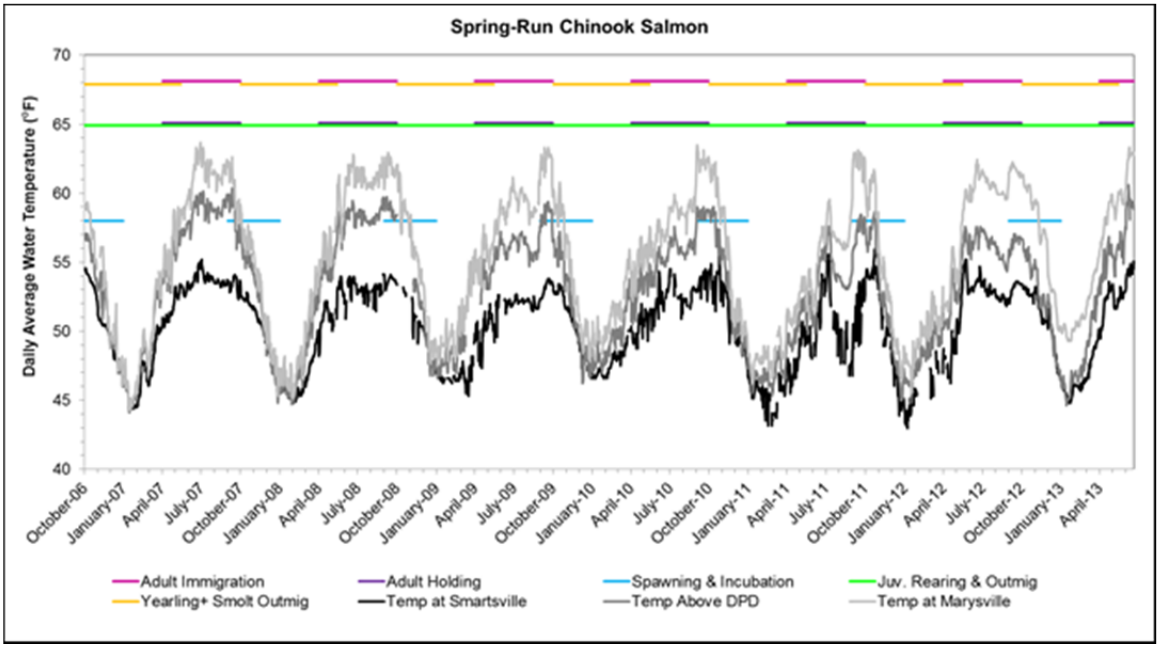

Figure 4-3. Monitored lower Yuba River water temperatures and spring-run Chinook salmon upper tolerance WTI values.

upper tolerance WTI values. Water temperatures at all three gages during the period evaluated are always below the upper tolerance WTI values for smolt (yearling+) outmigration, juvenile rearing and outmigration, and adult immigration and holding. The upper tolerance spawning and embryo incubation WTI value is never exceeded at Smartsville, which is the only location evaluated for spring-run Chinook salmon spawning and embryo incubation.

4.2.6 Limiting Factors, Threats and Stressors

Limiting factors and threats supporting the listing of the Central Valley spring-run Chinook salmon ESU are presented in two documents. The first is titled ‘‘*Factors for Decline: A Supplement to the Notice of Determination for West Coast Steelhead*’’ (NMFS 1996). That report concluded that all of the factors identified in section 4(a)(1) of the ESA have played roles in the decline of steelhead and other salmonids, including Chinook salmon. The report identifies destruction and modification of habitat, overutilization of fish for commercial and recreational purposes, and natural and human-made factors as being the primary reasons for the declines of west coast steelhead and other salmonids including Chinook salmon. The second document is a supplement to the document referred to above. This document is titled *‘‘Factors Contributing to the Decline of West Coast Chinook Salmon: An Addendum to the 1996 West Coast Steelhead Factors for Decline Report’’* (NMFS 1998a).

At the ESU level, more recent descriptions of limiting factors, threats and stressors are provided in the CVP/SWP OCAP BA (Reclamation 2008), the CVP/SWP OCAP BO (NMFS 2009a), and the Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead (NMFS Draft Recovery Plan) (NMFS 2009). In addition to the ESU-level discussions, limiting factors, threats and stressors specifically addressing spring-run Chinook salmon in the lower Yuba River are discussed in the NMFS Draft Recovery Plan (NMFS 2009). These documents are incorporated by reference into this BA, and brief summaries of limiting factors, threats and stressors to spring-run Chinook salmon at the ESU level, and in the lower Yuba River specifically, are provided below. These brief summaries provide additional detail, explanation or clarification of limiting factors, threats and stressors in the lower Yuba River.

4.2.6.1 ESU

According to the NMFS Draft Recovery Plan (NMFS 2009), threats to Central Valley spring-run Chinook salmon are in three broad categories: (1) loss of historical spawning habitat; (2) degradation of remaining habitat; and (3) threats to the genetic integrity of the wild spawning populations from the FRFH spring-run Chinook salmon production program. As stated in the NMFS (2009), the Central Valley spring-run Chinook salmon ESU continues to be threatened by habitat loss, degradation and modification, small hydropower dams and water diversions that reduce or eliminate instream flows during migration, unscreened or inadequately screened water diversions, excessively high water temperatures, and predation by non-native species. The potential effects of long-term climate change also may adversely affect spring-run Chinook salmon and their recovery. The 2009 NMFS OCAP BO (2009a), summarized below, identified the factors that have lead to the current status of the species to be habitat blockage, water development and diversion dams, water conveyance and flood control, land use activities, water quality, hatchery operations and practices, over-utilization (e.g., ocean commercial and sport harvest, inland sport harvest), disease and predation, environmental variation (e.g., natural environmental cycles, ocean productivity, global climate change), and non-native invasive species.

HABITAT BLOCKAGE

Hydropower, flood control, and water supply dams of the CVP, SWP, and other municipal and private entities have permanently blocked or hindered salmonid access to historical spawning and rearing grounds. As a result of migrational barriers, spring-run Chinook salmon (as well as winter-run Chinook salmon and steelhead) populations have been confined to lower elevation mainstems that historically only were used by these species for migration and rearing. Population abundances have declined in these streams due to decreased quantity, quality, and spatial distribution of spawning and rearing habitat (Lindley et al. 2009). Higher temperatures at these lower elevations during late-summer and fall are also a major stressor to adult and juvenile salmonids.

Juvenile downstream migration patterns have been altered by the presence of dams. Juvenile spring-run Chinook salmon (as well as winter-run) on the mainstem Sacramento River generally outmigrate earlier than they did historically because they are hatched considerably farther downstream and now have less distance to travel. Therefore, smolts in the Sacramento River under present conditions must rear for a longer period of time in order to reach sizes comparable to those of smolts that historically reared in upstream reaches above the dams. However, for several months of the year, habitat conditions in the mainstem Sacramento River do not provide the necessary features for listed anadromous fish species, especially for an extended period of time.

WATER DEVELOPMENT

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have altered the natural hydrologic cycles on which juvenile and adult salmonids historically based their migration patterns upon (NMFS 2009a). As much as 60% of the natural historical inflow to Central Valley watersheds and the Delta has been diverted for human uses. Dams have contributed to lower flows, higher water temperatures, lower dissolved oxygen (DO) levels, and decreased recruitment of gravel and LWM. More uniform flows year round have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands exist throughout the Central Valley. Thousands of small and medium-size water diversions exist along the Sacramento River, its tributaries and the Delta. Although efforts have been made in recent years to screen some of these diversions, many remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions have the potential to entrain many lifestages of aquatic species, including juvenile salmonids.

The Anderson-Cottonwood Irrigation District (ACID) operates a diversion dam across the Sacramento River about 5 miles downstream of Keswick Dam, which is one of the three largest diversions on the Sacramento River. Operated from April through October, the installation and removal of the diversion dam flashboards requires close coordination between Reclamation and ACID. Because substantial reductions (limited to 15% in a 24-hour period and 2.5% in any 1 hour) in Keswick Dam releases are necessary to install or remove the flashboards, the ACID diversion dam operations have the potential to impact various lifestages of Chinook salmon (e.g., redd dewatering, juvenile stranding and exposure to elevated water temperatures). Redd dewatering primarily affects spring- and fall-run Chinook salmon during October. Although flow reductions are usually of a short-term duration (i.e., lasting less than 8 hours), these short-term flow reductions may cause mortality through desiccation of incubating eggs and loss of stranded juveniles.

Located 59 miles downstream of Keswick Dam, RBDD is owned and operated by Reclamation. Historically, RBDD impeded adult salmonid passage throughout its May 15 through September 15 “gates in” period. Although there are fish ladders at the right and left banks, and a temporary ladder in the middle of the dam, they were not very efficient at passing fish because it was difficult for fish to locate the entrances to the ladders. Water released from RBDD flows through a small opening under each of the 11 gates in the dam cause turbulent flows that confused fish and keep them from finding the ladders. The effects resulting from upstream migrational delays at RBDD ranged from delayed but eventually successful spawning, to pre-spawn mortality and the complete loss of spawning potential in that fraction of the population. The fish ladders are not designed to allow a sufficient amount of flow through them to attract adult salmonids, and previous studies have shown that salmon could be delayed up to 20 days in passing the dam. These delays had the potential to reduce the fitness of adults that expend their energy reserves fighting the flows beneath the gates, and increase the chance of pre-spawn mortality. Passage delays of a few days up to a week were believed to prevent timely movement of adult spring-run Chinook salmon upstream to enter the lower reaches of Sacramento River tributaries (e.g., Cottonwood Creek, Cow Creek) above the RBDD, which dry up or warm up during the spring. These passage delays prevented adult spring-run Chinook salmon from accessing summer holding pools in the upper reaches of these tributaries. As previously discussed, the RBDD gates were permanently raised in September 2011 and, thus, many of the historical migration-related stressors associated with this location have likely been eliminated due to the improved fish passage conditions.

Outmigrant juvenile salmonids in the Delta have been subjected to adverse environmental conditions created by water export operations at the CVP and SWP facilities. Specifically, juvenile salmonid survival has been reduced by: (1) water diversions from the mainstem Sacramento River into the Central Delta through the Delta Cross Channel (DCC); (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways; (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay; and (4) increased exposure to introduced, non-native predators such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and sunfishes (*Centrarchidae spp.*) within the waterways of the Delta.

WATER CONVEYANCE AND FLOOD CONTROL

More than 1,600 miles of levee construction in the Central Valley has constricted river channels, disconnected floodplains from active river channels, reduced riparian habitat, and reduced natural channel function, particularly in lower reaches of the Sacramento River and the Delta (NMFS 2009a). The development of the water conveyance system in the Delta also has resulted in the construction of armored, rip-rapped levees on more than 1,100 miles of channels and diversions to increase channel elevations and flow capacity of the channels (Mount 1995 as cited in NMFS 2009a).

Levee development in the Central Valley has affected anadromous salmonid spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitats. Many of the levees use angular rock (riprap) to armor the banks from erosive forces. The effects of channelization and rip-rapping include the alteration of river hydraulics and vegetative cover along the banks as a result of changes in bank configuration and structural features (Stillwater Sciences 2006 as cited in NMFS 2009a). These changes affect the quantity and quality of nearshore habitat for juvenile salmonids and have been thoroughly studied (USFWS 2000; Schmetterling et al. 2001 as cited in NMFS 2009a; Garland et al. 2002). Simple slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than those that occur along natural banks. Higher water velocities typically inhibit deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and to escape from fast currents, deep water, and predators (Stillwater Sciences 2006 as cited in NMFS 2009a). In addition, the armoring and revetment of stream banks tend to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney et al. 2004). As a result of river narrowing, benthic habitat decreases and the number of macroinvertebrates (e.g., stoneflies, mayflies) per unit channel length decreases, affecting salmonid food supply.

LWM is a functionally important component of many streams (NMFS 1996). LWM influences stream morphology by affecting channel pattern, position, and geometry, as well as pool formation (Keller and Swanson 1979; Bilby 1984; Robison and Beschta 1990). Reduction of wood in the stream channel, either from past or present activities, generally reduces pool quantity and quality, alters stream shading which can affect water temperature regimes and nutrient input, and can eliminate critical stream habitat needed for both vertebrate and invertebrate populations. Removal of vegetation also can destabilize marginally stable slopes by increasing the subsurface water load, lowering root strength, and altering water flow patterns in the slope. During the 1960s and early 1970s, it was common practice among California fishery management agencies to remove LWM thought to be a barrier to fish migration (NMFS 1996). However, it is now recognized that too much LWM was removed from streams in past decades, resulting in a loss of salmonid habitat. The large scale removal of LWM prior to 1980 is believed to have had major, long-term adverse effects on juvenile salmonid rearing habitat in northern California (NMFS 1996). Aquatic habitat areas that were subjected to the removal of LWM are still limited in the recovery of salmonid stocks, and NMFS (2009) expects that this limitation could persist for 50 to 100 years.

LAND USE ACTIVITIES

Land use activities continue to have large-scale impacts on salmonid habitat in the Central Valley. According to Lindley et al. (2009), "*Degradation and simplification of freshwater and estuary habitats over a century and a half of development have changed the Central Valley Chinook salmon complex from a highly diverse collection of numerous wild populations to one dominated by fall Chinook salmon from four large hatcheries*."

Until about 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation extending outward for 4 or 5 miles (California Resources Agency 1989). Starting with the gold rush, vast riparian forests were cleared for building materials, fuel, and to open land for farming along the banks of the river. The clearing of the riparian forests also removed a vital source of snags and driftwood in the Sacramento River Basin. The removal of in-river snags and obstructions for navigational safety has further reduced the presence of LWM in the Sacramento River and the Delta (see LWM discussion above). The degradation and fragmentation of riparian habitat continued with extensive flood control and bank protection projects, together with the conversion of the fertile riparian lands to agriculture. By 1979, riparian habitat along the Sacramento River diminished to about 2% (i.e., 11,000 to 12,000 acres) of historic levels (McGill and Price 1987).

Land use activities associated with road construction, urban development, logging, mining, agriculture, and recreation have significantly altered fish habitat quantity and quality through the alteration of streambank and channel morphology, alteration of ambient water temperatures, degradation of water quality, elimination of spawning and rearing habitat, fragmentation of available habitats, elimination of downstream recruitment of LWM, and removal of riparian vegetation, resulting in increased streambank erosion (Meehan 1991 as cited in NMFS 2009a). Urban stormwater and agricultural runoff may be contaminated with herbicides and pesticides, petroleum products, sediment, etc. Agricultural practices in the Central Valley have eliminated large trees and logs and other woody debris that would otherwise be recruited into the stream channel (NMFS 1998a).

Increased sedimentation resulting from agricultural and urban practices is one of the primary causes of salmonid habitat degradation in the Central Valley (NMFS 1996). Sedimentation can adversely affect salmonids during all freshwater lifestages by clogging or abrading gill surfaces, adhering to eggs, hampering fry emergence (Phillips and Campbell 1961 as cited in NMFS 2009a), burying eggs or alevins, scouring and filling in pools and riffles, reducing primary productivity and photosynthesis activity (Cordone and Kelley 1961), and affecting intergravel permeability and DO levels. Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival (Waters 1995 as cited in NMFS 2009a).

River channel dredging to enhance inland maritime trade and to provide raw material for levee construction also has altered the natural hydrology and function of the Central Valley rivers. Since the mid-1800s, the Corps and others have straightened and artificially deepened river channels to enhance shipping commerce, consequently reducing the natural river meander and the formation of pool and riffle segments. In the early 1900s, the Sacramento Flood Control Project ushered in large scale Corps actions for reclamation and flood control purposes along the Sacramento River and in the Delta. The creation of levees and the deep shipping channels reduced the natural tendency of the Sacramento River to create floodplains along its banks during seasonal inundation periods (e.g., spring snow melt). The annual inundations provided necessary juvenile rearing and foraging habitat that became available in conjunction with seasonal flooding processes. The armored riprapped levee banks and active maintenance actions of Reclamation Districts precluded the establishment of ecologically important riparian vegetation, introduction of valuable LWM from these riparian corridors, and the productive intertidal mudflats characteristic of the undisturbed Delta habitat.

Since the 1850s, reclamation of wetlands for urban and agricultural development has resulted in the cumulative loss of tidal marsh habitat downstream (79%) and upstream (94%) of Chipps Island (Conomos et al. 1985; Nichols et al. 1986; Wright and Phillips 1988 as cited in NMFS 2009a; Monroe et al. 1992 as cited in NMFS 2009a; Goals Project 1999). Little of the extensive tracts of wetland marshes that existed prior to 1850 along the Central Valley river systems and within the natural flood basins exist today. Most wetland and marsh areas have been "reclaimed" for agricultural purposes, leaving only small remnant patches of available habitat. In the Delta, juvenile salmonids are exposed to increased water temperatures during the late spring and summer due to the loss of riparian shading and thermal inputs from municipal, industrial, and agricultural discharges. Studies by DWR on water quality in the Delta over the last 30 years show a steady decline in food resources available for juvenile salmonids, as well as an increase in the clarity of the water due to a reduction in phytoplankton and zooplankton. These conditions are believed to have contributed to increased juvenile Chinook salmon and steelhead mortality as fish move through the Delta.

WATER QUALITY

Over the past 150 years, the water quality of the Delta has been adversely affected by increased water temperatures, decreased DO levels, and increased turbidity and contaminant loads, which have degraded the quality of the aquatic habitat for the rearing and migration of salmonids. Historic and ongoing point and nonpoint source discharges impact surface waters, and portions of major rivers and the Delta are impaired, to some degree, by discharges from agriculture, mines, urban areas and industries (California RWQCB 1998). Pollutants include effluents from wastewater treatment plants and chemical discharges (e.g., dioxin from San Francisco Bay petroleum refineries) (McEwan and Jackson 1996). Agricultural drain water, another possible source of contaminants, can contribute up to 30% of the total inflow into the Sacramento River during drier conditions (Reclamation 2008a).

According to NMFS (2009a), the California RWQCB (1998; 2001) has identified the Delta as an impaired waterbody having elevated levels of chlorpyrifos, dichlorodiphenyltrichlor (i.e. DDT), diazinon, mercury, Group A pesticides (e.g., aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexanes (including lindane), endosulfan and toxaphene), organic enrichment, as well as low DO. In general, water degradation or contamination can lead to either acute toxicity, resulting in death when concentrations are sufficiently elevated, or more typically, when concentrations are lower, to chronic or sublethal effects that reduce the physical health of the organism, and lessens its survival over an extended period of time. Mortality may become a secondary effect due to compromised physiology or behavioral changes that lessen the organism's ability to carry out its normal activities. For listed species, these effects may occur directly to the listed fish or to its prey base, which reduces the forage base available to the listed species.

In the aquatic environment, most anthropogenic chemicals and waste materials, including toxic organic and inorganic chemicals eventually accumulate in sediment (Ingersoll 1995 as cited in NMFS 2009a). Direct exposure to contaminated sediments may cause deleterious effects if a fish swims through a plume of the re-suspended sediments or rests on contaminated substrate and absorbs the toxic compounds via dermal contact, ingestion, or uptake across the gills. Although sediment contaminant levels can be significantly higher than the overlying water column concentrations (EPA 1994), the more likely means of exposure is through the food chain when fish feed on organisms that are contaminated with toxic compounds. Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself. Therefore, the degree of exposure to the salmonids depends on their trophic level and the amount of contaminated forage base consumed. Salmonid biological responses to contaminated sediments are similar to those resulting from waterborne exposures once a contaminant has entered the body of the fish.

HATCHERY OPERATIONS AND PRACTICES

CDFW is currently operating 10 salmon and steelhead hatchery facilities in California. Eight of these 10 facilities (i.e., Iron Gate, Trinity River, Warm Springs, Feather River, Nimbus, Mokelumne River, and Merced River Hatcheries and the Coyote Valley Fish Facility) were constructed below dams on major rivers as mitigation for loss of access to anadromous fish habitat upstream of the dams. The Thermalito Annex, which is not located below a dam, supports the mitigation and enhancement programs that include Chinook and coho salmon for the FRFH.

Five hatcheries currently produce Chinook salmon in the Central Valley, and four of these also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to wild Chinook salmon and steelhead stocks through genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). The genetic impacts of artificial propagation programs in the Central Valley are primarily caused by straying of hatchery fish and the subsequent interbreeding of hatchery fish with wild fish. In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels (USDOI 1999, as cited in NMFS 2009a).

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between spring- and fall-run Chinook salmon have led to the hybridization and homogenization of some subpopulations (CDFG 1998). As early as the 1960s, Slater (1963) observed that spring-run and early fall-run were competing for spawning sites in the Sacramento River below Keswick Dam, and speculated that the two runs may have hybridized. Spring-run Chinook salmon from the FRFH have been documented as straying throughout the Central Valley for many years (CDFG 1998), and may have contributed to hybridization. In the Feather River, the lack of physical separation has led to hybridization of spring- and fall-run Chinook salmon.

The relatively low number of spawners needed to sustain a hatchery population can result in high harvest-to-escapements ratios in waters where fishing regulations are set according to hatchery population. This can lead to over-exploitation and reduction in the size of wild populations existing in the same system as hatchery populations due to incidental by-catch (McEwan 2001).

Hatcheries also can have some positive effects on salmonid populations. Spring-run Chinook salmon produced in the FRFH are considered part of the spring-run Chinook salmon ESU. Artificial propagation has been shown to be effective in bolstering the numbers of naturally spawning fish in the short term under specific scenarios. Artificial propagation programs can also aid in conserving genetic resources and guarding against catastrophic loss of naturally spawned populations at critically low abundance levels (IMST 2001, as cited in NMFS 2004).

OVERUTILIZATION

OCEAN COMMERCIAL AND SPORT HARVEST

Extensive ocean recreational and commercial troll fisheries for Chinook salmon exist along the Northern and Central California coast, and an inland recreational fishery exists in the Central Valley for Chinook salmon and steelhead. The Central Valley Index (CVI) is an annual index of abundance of all Central Valley Chinook salmon stocks combined, and is defined as the calendar year sum of ocean fishery Chinook harvests in the area south of Point Arena, California (where 85% of Central Valley Chinook salmon are caught), plus the Central Valley adult Chinook spawning escapement (Lindley et al. 2009). Since 1991, the PFMC's Salmon Technical Team (comprised of scientists from NMFS, USFWS, and state fisheries agencies from OR, WA, and CA) has used a linear regression of the CVI on the previous year's Central Valley age-2 return to forecast the CVI (BDCP 2009). The CVI harvest rate index is an annual index of the ocean harvest rate on all Central Valley Chinook stocks combined, and is defined as the ocean harvest landed south of Point Arena, California, divided by the CVI (Lindley et al. 2009).

There are no Pacific Coast Salmon Fisheries Management Plan (FMP) objectives in place specifically regulating the harvest of spring-run Chinook salmon, except that the FMP will manage ocean fisheries consistent with NMFS ESA consultation standards (BDCP 2009). The current FMP harvest constraints on winter-run Chinook salmon serve as proxy for Central Valley spring-run Chinook salmon (BDCP 2009). Spring-run Chinook salmon CVI harvest rate index ranged from 0.55 to nearly 0.80 between 1970 and 1995, when harvest rates were adjusted for the protection of winter-run Chinook salmon (NMFS 2003). The decline in the CVI harvest rate index to 0.27 in 2001 as a result of high fall-run Chinook salmon escapement also resulted in reductions to the authorized harvest of spring-run Chinook salmon (NMFS 2003).

FRFH spring-run Chinook salmon provide indices of harvest of natural spring-run. Maturing age-3 and age-4 spring-run Chinook salmon are vulnerable to the early portion of the recreational and commercial season, whereas fall-run Chinook salmon are exposed to an entire harvest season (BDCP 2009). Inferences drawn from coded-wire tag recoveries indicate that 44% of the spring-run Chinook salmon are taken prior to May 1, the start of the commercial fishing season (BDCP 2009). Ocean fisheries have affected the age structure of spring-run Chinook salmon through targeting large fish for many years and reducing the numbers of 4- and 5-year-old fish (CDFG 1998). As a result of very low returns to the Central Valley in 2007, there was a complete closure of the commercial and recreational ocean Chinook salmon fishery in 2008 and 2009. Due to improved ocean salmon numbers, a severely restricted commercial season and short recreational season opened in 2010 (Bacher 2011). On April 13, 2011, the Pacific Fishery Management Council (PFMC) adopted a set of ocean salmon seasons that provides both recreational and commercial opportunities during the 2011 fishing season. PFMC (2011) reports that "*Greatly improved abundance of Sacramento River fall-run Chinook salmon will fuel the first substantial ocean salmon fisheries off California and Oregon since 2007. Fisheries south of Cape Falcon are supported by Sacramento River fall Chinook. In 2008 and 2009, poor Sacramento returns led to the largest ocean salmon fishery closure on record. The abundance forecast of Sacramento River fall Chinook in 2011 is 730,000, far above the number needed for optimum spawning this fall (122,000-180,000 fish).*"

INLAND SPORT HARVEST

Historically in California, almost half of the river sport fishing effort has occurred in the Sacramento-San Joaquin River system, particularly upstream from the city of Sacramento (Emmett et al. 1991). In-river recreational fisheries historically have taken spring-run Chinook salmon throughout the species' range. During the summer, adult spring-run Chinook salmon are targeted by anglers when the fish congregate and hold in large pools. Poaching also occurs at fish ladders, and other areas where adults congregate. However, the significance of poaching on the adult population is unknown (NMFS 2009a). Specific regulations for the protection of spring-run Chinook salmon in Mill, Deer, Butte, and Big Chico creeks and the lower Yuba River have been added to the CDFW regulations.

DISEASE AND PREDATION

Salmonids are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment (NMFS 1996, 1996a, 1998a), and infectious disease is one of many factors that influence adult and juvenile salmonid survival. Specific diseases such as bacterial kidney disease, Ceratomyxosis shasta, columnaris, furunculosis, infectious hematopoietic necrosis, redmouth and black spot disease, whirling disease, and erythrocytic inclusion body syndrome are known, among others, to affect Chinook salmon and steelhead (NMFS 1996; 1996a; 1998a). Little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases; however, studies have shown that wild fish tend to be less susceptible to pathogens than are hatchery-reared fish (NMFS 2009a). Nevertheless, wild salmonids may contract diseases that are spread through the water column (i.e., waterborne pathogens) as well as through interbreeding with infected hatchery fish. The stress of being released into the wild from a controlled hatchery environment frequently causes latent infections to convert into a more pathological state, and increases the potential of transmission from hatchery reared fish to wild stocks within the same waters.

As described in NMFS (2005a), accelerated predation is also a significant factor affecting critical habitat for spring-run Chinook salmon. Although predation is a natural component of spring-run Chinook salmon life ecology, the rate of predation likely has greatly increased through the introduction of non-native predatory species such as striped bass (*Marone saxatilis*) and largemouth bass (*Micrapterus salmaides*), and through the alteration of natural flow regimes and the development of structures that attract predators, including dams, bank revetment, bridges, diversions, piers, and wharfs (Stevens 1961; Vogel et al. 1988 as cited in NMFS 2009; Garcia 1989 as cited in Reclamation 2008; Decato 1978 as cited in Reclamation 2008). The USFWS found that more predatory fish were found at rock revetment bank protection sites between Chico Landing and Red Bluff than at sites with naturally eroding banks (Michny and Hampton 1984). On the mainstem Sacramento River, high rates of predation are known to occur at RBDD, ACID, GCID, and at south Delta water diversion structures (CDFG 1998). From October 1976 to November 1993, CDFW conducted ten mark/recapture experiments at the SWP's Clifton Court Forebay to estimate prescreen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 to 99%. Predation from striped bass is thought to be the primary cause of the loss (CDFG 1998; Gingras 1997).

Predation on juvenile salmonids has increased as a result of water development activities, which have created ideal habitats for predators and non-native invasive species. As juvenile salmonids pass the Sacramento River system dams, fish are subject to conditions that can disorient them, making them highly susceptible to predation by fish or birds. Striped bass and Sacramento pikeminnow (*Ptychocheilus grandis*), a species native to the Sacramento River Basin that co-evolved with anadromous salmonids, congregate below dams and prey on juvenile salmon in the tail waters. Tucker et al. (1998) reported that: (1) striped bass exhibit a strong preference for juvenile salmonids; (2) during the summer months, juvenile salmonids increased to 66% of the total weight of Sacramento pikeminnow stomach contents; and (3) the percent frequency of occurrence for juvenile salmonids nearly equaled other fish species in the stomach contents of the predatory fish. Additionally, Tucker et al. (2003) showed the temporal distribution for these two predatory species in the RBDD area were directly related to RBDD operations (i.e., predators congregated when the dam gates were in, and dispersed when the dam gates were removed).

Other locations in the Central Valley where predation is of concern include flood bypasses, post-release sites for salmonids salvaged at the CVP and SWP Fish Facilities, and the Suisun Marsh Salinity Control Gates (SMSCG). The dominant predator species at the SMSCG was striped bass, and the remains of juvenile Chinook salmon were identified in their stomach contents (Edwards et al. 1996; Tillman et al. 1996; NMFS 1997a). Striped bass and pikeminnow predation on salmon at salvage release sites in the Delta and lower Sacramento River has been documented (Orsi 1967; Pickard et al. 1982). However, accurate predation rates at these sites are difficult to determine. From October

1976 to November 1993, CDFW conducted 10 mark/recapture studies at the SWP's Clifton Court Forebay to estimate pre-screen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 to 99%, and predation by striped bass is thought to be the primary cause of the loss (Gingras 1997). More recent studies by DWR (2008) have verified this level of predation also exists for steelhead smolts within Clifton Court Forebay, indicating that these predators were efficient at removing salmonids over a wide range of body sizes.

Avian predation on fish contributes to the loss of migrating juvenile salmonids (NMFS 2009a). Fish-eating birds (e.g., great blue herons, black-crowned night herons, gulls, osprey) in the Central Valley have high metabolic rates and require large quantities of food relative to their body size. Mammals can also be an important source of predation on salmonids within the California Central Valley. These animals, especially river otters, are capable of removing large numbers of salmon and trout from the aquatic habitat (Dolloff 1993 as cited in NMFS 2009a). Mammals have the potential to consume large numbers of salmonids, but generally scavenge post-spawned salmon. In the marine environment, Southern Resident killer whales target Chinook salmon as their preferred prey (96% of prey consumed during spring, summer and fall, from long-term study of resident killer whale diet; Ford and Ellis 2006).

ENVIRONMENTAL VARIATION

The scientific basis for understanding the processes and sources of climate variability has grown significantly in recent years, and our ability to forecast human and natural contributions to climate change has improved dramatically. With consensus on the reality of climate change now established (Oreskes 2004; IPCC 2007), the scientific, political, and public priorities are evolving toward determining its ecosystem impacts, and developing strategies for adapting to those impacts. Global climate change is playing an increasingly important role in scientific and policy debates related to effective water management. The most considerable impacts of climate change on water resources in the United States are believed to occur in the mid-latitudes of the West, where the runoff cycle is largely determined by snow accumulation and subsequent melt patterns. Evidence is continuing to accumulate to indicate global climate change will have a marked effect on water resources in California. Numerous peer-reviewed scientific articles on climate and water issues in California have been published to date, with many more in preparation, addressing a range of considerations from proposed improvements in the downscaling of general circulation models to understanding how reservoir operations might be adapted to new conditions (Kiparsky and Gleick 2003).

NMFS (2009) states that the potential effects of long-term climate change may adversely affect spring-run Chinook salmon and steelhead, and the recovery of both species. Current climate change information suggests that the Central Valley climate will become warmer, a challenging prospect for Chinook salmon and steelhead – both of which are coldwater fish at the southern end of their distribution. According to NMFS (2009a), early marine survival for juvenile salmon is a critical phase in their survival and development into adults. The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and local scale, provides an indication of how climate-related factors influence salmon survival in the ocean. Consistent with the approach taken in recent NMFS BOs (NMFS 2011; NMFS 2010; NMFS 2010a; NMFS 2010b), the discussion below describes the potential climate-related threats anticipated to affect the status of listed species, including inter-annual climatic variations (e.g. El Niño and La Niña), the Wells Ocean Productivity Index, and longer term cycles in ocean conditions pertinent to salmonid survival (e.g., Pacific Decadal Oscillation).

NATURAL ENVIRONMENTAL CYCLES

Natural climate variability in freshwater and marine environments has the potential to substantially affect salmonid abundance, particularly during early lifestages (NMFS 2008). Sources of variability include inter-annual climatic variations (e.g., El Niño and La Niña), longer-term cycles in ocean conditions (e.g., Pacific Decadal Oscillation, Mantua et al. 1997), and ongoing global climate change. Climate variability can affect ocean productivity in the marine environment, as well as water storage (e.g., snow pack) and in-stream flow in the freshwater environment. Early lifestage growth and survival of salmon can be negatively affected when climate variability results in conditions that hinder ocean productivity (e.g., Scheuerell and Williams 2005) and water storage (e.g., Independent Scientific Advisory Board 2007) in marine and freshwater systems, respectively.

Fisheries scientists have shown that ocean climate varies strongly at decadal scales (e.g., Beamish 1993; Beamish and Bouillon 1993; Graham 1994; Miller et al. 1994; Hare and Francis 1995; Mantua et al. 1997; Mueter et al. 2002). In particular, the identification of the Pacific Decadal Oscillation (PDO) (Mantua et al. 1997) has led to the belief that decadal-scale variation may be cyclical, and thus predictable (Lindley et al. 2007). Evidence also suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hare et al. 1999 as cited in NMFS 2009a; Mantua and Hare 2002). In addition, large-scale climatic regime shifts, such as the El Niño condition, appear to change productivity levels over large expanses of the Pacific Ocean. A further confounding effect is the fluctuation between drought and wet conditions in the basins of the American west. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years, which reduced inflows to watersheds up and down the west coast.

"El Niño" is an environmental condition often cited as a cause for the decline of West Coast salmonids (NMFS 1996). El Niño is an unusual warming of the Pacific Ocean off South America and is caused by atmospheric changes in the tropical Pacific Ocean (El Niño Southern Oscillation [ENSO]) resulting in reductions or reversals of the normal trade wind circulation patterns. El Niño ocean conditions are characterized by anomalous warm sea surface temperatures and changes to coastal currents and upwelling patterns. Principal ecosystem alterations include decreased primary and secondary productivity in affected regions and changes in prey and predator species distributions. Cold-water species are displaced towards higher latitudes or move into deeper, cooler water, and their habitat niches are occupied by species tolerant of warmer water that move upwards from the lower latitudes with the warm water tongue.

A key factor affecting many West Coast stocks has been a general 30-year decline in ocean productivity. The mechanism whereby stocks are affected is not well understood, partially because the pattern of response to these changing ocean conditions has differed among stocks, presumably due to differences in their ocean timing and distribution. It is presumed that survival of Chinook salmon in the ocean is driven largely by events occurring between ocean entry and recruitment to a sub-adult lifestage. The freshwater life history traits and habitat requirements of juvenile winter-run and fall-run Chinook salmon are similar. Therefore, the unusual and poor ocean conditions that caused the drastic decline in returning fall-run Chinook salmon populations coast-wide in 2007 (Varanasi and Bartoo 2008) are suspected to have also caused the observed decrease in the winter-run Chinook salmon spawning population in 2007 (Oppenheim 2008 as cited in NMFS 2009a). Lindley et al. (2009) reviewed the possible causes for the decline in Sacramento River fall-run Chinook salmon in 2007 and 2008 for which reliable data were available. They concluded that a broad body of evidence suggested that anomalous conditions in the coastal ocean in 2005 and 2006 resulted in unusually poor survival of the 2004 and 2005 broods of fall-run Chinook salmon. However, Lindley et al. (2009) recognize that the rapid and likely temporary deterioration in ocean conditions acted on top of a long-term, steady degradation of the freshwater and estuarine environment.

As suggested by Rudnick and Davis (2003) and Hsieh et al. (2005), apparent regime shifts need not be cyclical or predictable, but rather may be the expression of a stochastic process. If this interpretation is correct, then we should expect future ocean climate conditions to be different than those observed over the past few decades (Lindley et al. 2007).

Lindley et al. (2007) further state that Central Valley salmonid ESUs and DPSs are capable of surviving the kinds of climate extremes observed over the past few thousand years if they have functional habitats, because these lineages are on order of a thousand years old or older. There is growing concern, however, that the future climate will be unlike that seen before, due to global warming in response to anthropogenic greenhouse gas emissions (Lindley et al. 2007).

OCEAN PRODUCTIVITY

The time when juvenile salmonids enter the marine environment marks a critical point in their life history. Studies have shown the greatest rates of growth and energy accumulation for Chinook salmon occur during the first 1 to 3 months after they enter the ocean (Francis and Mantua 2003 as cited in NMFS 2009a; MacFarlane et al. 2008 as cited in NMFS 2009a). Emigration periods and ocean entry can vary substantially among, and even within, runs in the Central Valley. Winter-run Chinook salmon typically rear in freshwater for 5 to 9 months and exhibit a peak emigration period in March and April. Spring-run Chinook salmon emigration is more variable and can occur in December or January (soon after emergence as fry), or from October through March (after rearing for a year or more in freshwater; Reclamation 2008). In contrast to Chinook salmon, steelhead tend to rear in freshwater environments longer (anywhere from 1 to 3 years) and their period of ocean entry can span many months. Juvenile steelhead presence at Chipps Island has been documented between at least October and July (Reclamation 2008). While still acknowledging this variability in emigration patterns, a general statement can be made that Chinook salmon typically rear in freshwater environments for less than a year and enter the marine environment as sub-yearlings in late spring to early summer (NMFS 2009a). Similarly, although steelhead life histories are more elastic, they typically enter the ocean in approximately the same time frame. The general timing pattern of ocean entry is commonly attributed to evolutionary adaptations that allow salmonids to take advantage of highly productive ocean conditions that typically occur off the California coast beginning in spring and extending into the fall (MacFarlane et al. 2008 as cited in NMFS 2009a). Therefore, the conditions that juvenile salmonids encounter when they enter the ocean can play an important role in their early marine survival and eventual development into adults.

Variations in salmon marine survival correspond with periods of cold and warm ocean conditions, with cold regimes being generally favorable for salmon survival and warm regimes unfavorable (Behrenfeld et al. 2006; Wells et al. 2006). Peterson et al. (2006) provide evidence that growth and survival rates of salmon in the California Current System (CCS) off the Pacific Northwest can be linked to fluctuations in ocean conditions. The CCS extends up to 1000 km offshore from Oregon to Baja California and encompasses a southward meandering surface current, a pole-ward undercurrent and surface countercurrents that exhibit high biological productivity, diverse regional characteristics, and intricate eddy motions that have mystified oceanographers for decades.

An evaluation of conditions in the CCS since the late 1970s reveals that a generally warm, unproductive regime persisted until the late 1990s. This regime was followed by a period of high variability that began with colder, more productive conditions lasting from 1999 to 2002. In general, salmon populations increased substantially during this period. However, the brief cold cycle was immediately succeeded by a 4-year period of predominantly warm ocean conditions beginning in late 2002, which appeared to negatively impact salmon populations in the CCS (Peterson et al. 2006). These regime shifts follow a more or less linear pattern beginning with the amount and timing of nutrients provided by upwelling and passing "up" the food chain from plankton to forage fish and eventually, salmon. There are also indications that these same regime shifts affect the migration patterns of larger animals that prey on salmon (e.g., Pacific hake, sea birds) resulting in a "top-down" effect as well (Peterson et al. 2006).

Peterson et al. (2006) evaluated three sets of ecosystem indicators to identify ecological properties associated with warm and cold ocean conditions and determine how those conditions can affect salmon survival. The three sets of ecosystem indicators include: (1) large-scale oceanic and atmospheric conditions [specifically, the PDO and the Multivariate ENSO Index]; (2) local observations of physical and biological ocean conditions off northern Oregon (e.g., upwelling, water temperature, plankton species compositions, etc.); and (3) biological sampling of juvenile salmon, plankton, forage fish, and Pacific hake (which prey on salmon). When used collectively, this information can provide a general assessment of ocean conditions in the northern California Current that pertain to multi-year warm or cold phases. It can also be used to develop a qualitative evaluation for a particular year of the effect these ocean conditions have on juvenile salmon when they enter the marine environment and the potential impact to returning adults in subsequent years (NMFS 2009a).

The generally warmer ocean conditions in the California Current that began to prevail in late 2002 have resulted in coastal ocean temperatures remaining 1°C to 2°C above normal through 2005. A review of the previously mentioned indicators for 2005 revealed that almost all ecosystem indices were characteristic of poor ocean conditions and reduced salmon survival (NMFS 2009a). For instance, in addition to the high sea surface temperatures, the spring transition, which marks the beginning of the upwelling season and typically occurs between March and June, was very late, postponing upwelling until mid-July. In addition, the plankton species present during that time were the smaller organisms with lower lipid contents associated with warmer water, as opposed to the larger, lipid-rich organisms believed to be essential for salmon growth and survival throughout the winter. The number of juvenile salmon collected during trawl surveys was also lower than any other year previously sampled since 1998 (Peterson et al. 2006). Furthermore, although conditions in 2006 appeared to have improved somewhat over those observed in 2005 (e.g., sea surface temperature was cooler, the spring transition occurred earlier, and coastal upwelling was more pronounced), not all parameters were necessarily “good.” In fact, many of the indicators were either “intermediate” (e.g., PDO, juvenile Chinook salmon presence in trawl surveys) or “poor” (e.g., copepod biodiversity, Peterson et al. 2006).

Peterson et al. (2006) shows the transition to colder ocean conditions, which began in 2007 and persisted through 2008. For juvenile salmon that entered the ocean in 2008, ocean indicators suggested a highly favorable marine environment (NMFS 2009a). After remaining neutral through much of 2007, PDO values became negative (indicating a cold California Current) in late 2007 and remained negative through at least August 2008, when sea surface temperatures also remained cold. Because coastal upwelling was initiated early and the larger, energy-rich, coldwater plankton species were present in large numbers during 2007 and 2008, ocean conditions in the broader California Current appear to have been favorable for salmon survival in 2007 and to a greater extent in 2008. These ecosystem indicators can be used to provide an understanding of ocean conditions, and their relative impact on marine survival of juvenile salmon, throughout the broader, northern portion of the California Current. However, they may not provide an accurate assessment of the conditions observed on a more local scale off the California coast.

Wells et al. (2008) developed a multivariate environmental index that can be used to assess ocean productivity on a finer scale for the central California region. This index (also referred to as the Wells Ocean Productivity Index) has also tracked the Northern Oscillation Index, which can be used to understand general ocean conditions in the North Pacific Ocean. The divergence of these two indices in 2005 and 2006 provided evidence that ocean conditions were worse off the California coast than they were in the broader

North Pacific region. The Wells et al. (2008) index incorporates 13 oceanographic variables and indices and has correlated well with the productivity of zooplankton, juvenile shortbelly rockfish, and common murre production along the California coast (MacFarlane et al. 2008 as cited in NMFS 2009a). In addition to its use as an indicator of general ocean productivity, the index may also relate to salmon dynamics due to their heavy reliance on krill and rockfish as prey items during early and later lifestages. For instance, not only did the extremely low index values in 2005 and 2006 correlate well with the extremely low productivity of salmon off the central California coast in those years, but the index also appears to have correlated well with maturation and mortality rates of adult salmon from 1990-2006 in that region (Wells and Mohr 2008 as cited in NMFS 2009a).

Available information suggests ocean conditions in 2007 and 2008 improved substantially over those observed in 2005 and 2006. The spring transition, which marks the beginning of the upwelling season and typically occurs between March and June, was earlier in 2007 and 2008, relative to 2005 and 2006. An early spring transition is often indicative of greater productivity throughout the spring and summer seasons (Wells and Mohr 2008, Peterson et al. 2006). Coastal upwelling, the process by which cool, nutrient rich waters are brought to the surface (perhaps the most important parameter with respect to plankton productivity), was also above average in 2007 and 2008. Moreover, coastal sea surface temperature and sea level height (representative of the strength of the California current and southern transport) values were also characteristic of improved ocean productivity (Wells and Mohr 2008). Thus, contrary to the poor ocean conditions observed in the spring of 2005 and 2006, the Wells et al. (2008) index parameters indicate spring ocean conditions have been generally favorable for salmon survival off California in 2007 and 2008.

In contrast to the relatively “good” ocean conditions that occurred in the spring, the Wells et al. (2008) index values for the summer of 2007 and 2008 were poor in general, and similar to those observed in 2005 and 2006. Summer sea surface temperature followed a similar pattern in both 2007 and 2008, starting out cool in June, and then rising to well above average in July before dropping back down to average in August (Wells and Mohr 2008). The strong upwelling values observed in the spring of 2007 and 2008 were not maintained throughout the summer, and instead dropped to either at or below those observed in 2005 and 2006. Finally, sea level height and spring curl values (a mathematical representation of the vertical component of wind shear which represents the rotation of the vector field), which are negatively correlated with ocean productivity, were both poor (Wells and Mohr 2008). Therefore, during the spring of 2007 and 2008, ocean conditions off California were indicative of a productive marine environment favorable for ocean salmon survival (and much improved over 2005 and 2006). However, those conditions did not persist throughout the year, as Wells et al. (2008) index values observed in the summer of 2007 and 2008 were similar to those experienced in the summer of 2005 and 2006, two years marked by extremely low productivity of salmon off the central California coast.

Changes in the state of the California Current since spring 2009 reflected a transition from cool La Nina conditions into and through a short-lived relatively weak El Nino event (Bjorkstedt et al. 2010). Weaker than normal upwelling and several extended relaxation events contributed to warming over much of the California Current during summer 2009, especially in the north. Moderation of La Niña conditions in the California Current coincided with the development of El Niño conditions in the equatorial Pacific, yet manifested well in advance of any evidence for direct effects of El Niño on the California Current. Responses to El Niño in fall 2009 and winter 2009–2010 appear to have varied substantially with latitude - conditions off southern California returned to near climatological values with the decline of La Niña, and did not indicate any subsequent response to El Niño, yet the northern California Current warmed substantially following the decline of La Niña and was strongly affected by intense downwelling during winter 2009–2010. The 2009–2010 El Niño diminished rapidly in early 2010, and upwelling off central and southern California resumed unusually early and strongly for a spring following an El Niño, but recovery from El Niño in early 2010 appears to be less robust in the northern California Current. Thus, despite dynamic changes in the overall state of the California Current, 2009–2010 continued the recent pattern of strong regional variability across the California Current (Bjorkstedt et al. 2010).

Responses to this climate sequence exhibited some consistent patterns across the California Current, but regional differences noted in recent State of the California Current reports appear to have persisted along the west coast of North America (Goericke et al. 2007; McClatchie et al. 2009). The transition from La Nina conditions appears to have unfolded well in advance of the arrival of direct effects of El Nino in the California Current in late 2009. Cool conditions related to the 2007–2008 La Nina abated in summer 2009, and, in general terms, hydrographic and ecological conditions from southern California north approached climatological values during summer 2009 (Bjorkstedt et al. 2010).

Warmer than usual conditions had already developed off Baja California in 2008 and persisted into the current year, but showed similar directional responses to climate variability as did regions to the north (Bjorkstedt et al. 2010). Overall, changes in the state of the California Current during 2009 coincided with the decay of La Nina conditions in the tropical Pacific Ocean. In the context of the general pattern of transition from La Nina to El Nino, differences between the northern and southern regions of the California Current are readily apparent. Off southern California, the general trend was for mean hydrographic, chemical, and biological properties of the system to return to long-term average conditions during summer 2009. In contrast, the northern California Current experienced anomalous warming of coastal waters and associated ecosystem responses, presumably as a consequence of anomalously weak and intermittent upwelling during 2009. Likewise, regional differences and similarities are apparent from late fall 2009 through spring 2010, the period during which El Nino conditions propagated into the California Current and subsequently diminished. Off southern California, the arrival of El Nino was clearly indicated by anomalously high sea level, but responses to El Nino were limited to changes in isopyncnal depth—presumably related to the passage of poleward-propagating Kelvin waves and their lingering consequences (Bjorkstedt et al. 2010).

Coastal waters off Oregon and northern California were affected by unusually strong downwelling during winter 2009–2010. In neither case, however, was there any evidence for intrusion of unusual water masses such as had been observed during the strong 1997–1998 El Nino. Relatively strong positive anomalies in temperature and salinity off southern Baja California suggest that the 2009–2010 El Nino influenced the southern extent of the California Current, but these changes appear to have been a consequence of local circulation patterns rather than anomalous poleward flows (Bjorkstedt et al. 2010).

Copepod assemblages observed at mid-shelf stations off northern California and Oregon continued to show marked seasonal variation, with high abundances developing over the summer and into the fall and subsequently declining over the winter (Bjorkstedt et al. 2010). Total abundance of copepods over the shelf appears to have been lower or later in developing in summer 2009 than in 2008 in sampled areas of the northern California Current. Patterns in assemblage structure, as indicated by the abundance of species particular biogeographic affinities (e.g., southern (warm) v. northern (cold), neritic v. oceanic; Hooff and Peterson 2006), show a substantial degree of coherence since 2008, particularly at stations north of Cape Mendocino. Compared to winter 2009, the composition of copepod assemblages off Oregon and northern California shifted strongly towards being dominated by southern and oceanic species by winter 2010. Southern taxa were abundant off Bodega Bay in late 2008, coincident with warm temperatures, but largely disappeared from mid-shelf waters in early 2009, possibly as a consequence of intense transport. Although warm water and reduced flows were observed in summer 2009 off Bodega, total copepod abundance did not reach high abundances and southern taxa did not assume a dominant place in the assemblage until winter 2010 (Bjorkstedt et al. 2010).

Catches of juvenile salmonids in pelagic surface trawl surveys were unusually low during September 2009 (Bjorkstedt et al. 2010). The fewest juvenile coho salmon (*Oncorhynchus kisutch*; 2 compared to maximum catch of 158 in 1999) and sub-yearling Chinook salmon (*O. tschawytschwa*; 2 versus 465 in 2001) were caught since the beginning of the time series in 1998. Overall spring 2009 appeared to be relatively good for salmon marine survival but oceanographic conditions appear to have deteriorated for salmon by late summer 2009 (Bjorkstedt et al. 2010).

In 2008 and 2009, poor Sacramento returns, primarily supported by Sacramento River fall-run Chinook salmon, led to the largest fishery closure on record. In 2009, adult spawning escapement for Sacramento River fall Chinook failed to meet the escapement goal (122,000-180,000 adults) for the third year in a row, leading to the formal declaration of an overfishing concern (although fishing is not considered one of the major causes of the stock's decline). The forecast for the index of ocean abundance in 2010 was 245,500 adults, which provided adequate numbers for limited fisheries (PFMC 2011).

Ecosystem observations offer further suggestion of regional variation in responses to El Nino, but it must be noted that such comparisons are limited by disparity in available data sets (Bjorkstedt et al. 2010). Off southern California, estimates of nutrient concentrations, chlorophyll a standing stock, primary productivity, and zooplankton displacement volumes returned to “normal” levels, and did not show evidence for any decline associated with El Nino. In contrast, anomalies in chlorophyll a concentration shifted from positive to negative off Baja California, especially north of Point Eugenia, despite the lack of concomitantly strong changes in hydrographic conditions. Responses at higher trophic levels are much more difficult to connect to simple indices of climate variability, but provide insight to the potential magnitude of ecosystem responses to conditions leading into spring 2009 and the consequences of the 2009–2010 El Nino relative to previous El Ninos. Positive shifts in indices of abundance for the juvenile groundfish assemblage off central California and breeding success of Cassin’s Auklet in 2009 are consistent with the persistence of cool conditions into spring 2009. Interestingly, the pelagic juvenile groundfish assemblage did not appear to collapse in 2010, suggesting that El Nino conditions did not substantially diminish productivity available to these taxa during critical lifestages during winter and early spring. In contrast, juvenile salmonids at sea in the northern region of the California Current appear to have fared poorly during the warmer than usual conditions of summer and fall 2009. Changes in the copepod assemblage off Oregon were consistent with warmer conditions that do not favor salmon production (Peterson and Schwing 2003; Peterson et al. 2010).

In summary, the significant changes in the state of the California Current during 2009 and early 2010 appear to have been more closely associated with diminishment of La Nina conditions than direct effects of El Nino (Bjorkstedt et al. 2010). The signature of the 2009–2010 El Nino throughout much of the California Current was substantially weaker than that of the strong 1997–1998 El Nino when influxes of more tropical waters were observed throughout the California Current. While the 2009–2010 El Nino is perhaps most comparable to the mild 2002–2003 El Nino, direct comparisons between the two events are confounded by the interaction of the 2002–2003 El Nino with a coincident intrusion of subarctic water that affected much of the California Current (Venrick et al. 2003). The more dramatic changes observed during 2009–2010 in the northern California Current might reflect responses to atmospheric forcing favoring coastal warming absent countervailing subarctic influences. Because a transition to moderate La Nina conditions was forecast for summer 2010, the past year might represent a temporary interruption of an otherwise cool period in the California Current (Bjorkstedt et al. 2010).

NMFS (2009a) suggests that early marine survival for juvenile salmon is a critical phase in their survival and development into adults. The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and local scale, provides an indication of the role they play in salmon survival in the ocean. Moreover, when discussing the potential extinctions of salmon populations, Francis and Mantua (2003) state that climate patterns would not likely be the sole cause but could certainly increase the risk of extinction when combined with other factors, especially in ecosystems under stress from humans. Thus, the efforts to try and gain a greater understanding of the role ocean conditions play in salmon productivity will continue to provide valuable information that can be incorporated into the management of these species and should continue to be pursued. However, the highly variable nature of these environmental factors makes it very difficult, if not impossible, to accurately predict what they will be like in the future. Because the potential for poor ocean conditions exists in any given year, and because there is no way for salmon managers to control these factors, any deleterious effects endured by salmonids in the freshwater environment can only exacerbate the problem of an inhospitable marine environment (NMFS 2009a).

GLOBAL CLIMATE CHANGE

Warming over this century is projected to be considerably greater than over the last century (Thomas et al. 2009). Since 1900, the global average temperature has risen by about 1.5°F. By about 2100, it is projected to rise between 2°F and 10.5°F, but could increase up to 11.5°F (Thomas et al. 2009; California Climate Change Center 2006). In the United States, the average temperature has risen by a comparable amount and is very likely to rise more than the global average over this century, with some variation according to location. Regarding climate change impacts already being observed, the

Sierra Nevada Alliance (2008) reports that seven of the largest Sierra glaciers have retreated by 30 to 70% in the past 100 years. Changes observed over the past several decades also have shown that the earth is warming, and scientific evidence suggests that increasing greenhouse gas emissions are changing the earth's climate (Moser et al. 2009). Accumulating greenhouse gas concentrations in the earth's atmosphere have been linked to global warming, and projected future trends of increasing atmospheric greenhouse gas concentrations suggest global warming will continue (National Research Council 2001). Several factors will determine future temperature increases. Increases at the lower end of this range are more likely if global heat-trapping gas emissions are substantially reduced. If emissions continue to rise at or near current rates, temperature increases are more likely to be near the upper end of the range (NMFS 2009).

Global climate change has the potential to impact numerous environmental resources in California through potential, though uncertain, impacts related to future air temperatures and precipitation patterns, and the resulting implications to stream runoff rate and timing, water temperatures, reservoir operations, and sea levels. Although current models are broadly consistent in predicting increases in probable global air temperatures and increasing levels of greenhouse gasses resulting from human activities, there are considerable uncertainties about precipitation estimates. For example, many regional modeling analyses conducted for the western United States indicate that overall precipitation will increase, but uncertainties remain due to differences among larger-scale General Circulation Models (GCMs) (Kiparsky and Gleick 2003). Some researchers believe that climate warming might push the storm track on the West Coast further north, which would result in drier conditions in California. At the same time, relatively newer GCMs, including those used in the National Water Assessment, predict increases in California precipitation (DWR 2005). Similarly, two popular climate models, including HadCM2 developed by the U.K. Hadley Center and PCM developed by the U.S. National Center for Atmospheric Research, also predict very different future scenarios. The HadCM2 predicts wetter conditions while the PCM predicts drier conditions (Brekke et al. 2004).

While much variation exists in projections related to future precipitation patterns, all available climate models predict a warming trend resulting from the influence of rising levels of greenhouse gasses in the atmosphere (Barnett et al. 2005). The potential effects of a warmer climate on the seasonality of runoff from snowmelt in the Central Valley have been well-studied and results suggest that melt runoff will likely shift from spring and summer to earlier periods in the water year (Vanrheenen et al. 2001). Presently, snow accumulation in the Sierra Nevada acts as a natural reservoir for California by delaying runoff from winter months when precipitation is high (Kiparsky and Gleick 2003). However, compared to present water resources development, Null et al. (2010) report that watersheds in the Northern Sierra Nevada are most vulnerable to decreased mean annual flow, southern-central watersheds are most susceptible to runoff timing changes, and the central portion of the range is most affected by longer periods with low flow conditions. Despite the uncertainties about future changes in precipitation rates, it is generally believed that higher temperatures will lead to changes in snowfall and snowmelt dynamics. Higher atmospheric temperatures will likely increase the ratio of rain to snow, shorten and delay the onset of the snowfall season, and accelerate the rate of spring snowmelt, which would lead to more rapid and earlier seasonal runoff relative to current conditions (Kiparsky and Gleick 2003). Studies suggest that the spring stream flow maximum could occur about one month earlier by 2050 (Barnett et al. 2005).

If air temperatures in California rise significantly, it will become increasingly difficult to maintain appropriate water temperatures in order to manage coldwater fisheries, including salmonids. A reduction in snowmelt and increased evaporation could lead to decreases in reservoir levels and, perhaps more importantly, coldwater pool reserves (California Energy Commission 2003). As a result, increasing air temperatures, particularly during the summer, lead to rising water temperatures in rivers and streams, which increase stress on coldwater fish. Projected temperatures for the 2020s and 2040s under a higher emissions scenario suggest that the habitat for these fish is likely to decrease dramatically (Mote et al. 2008; Salathé 2005; Keleher and Rahel 1996; McCullough et al. 2001). Reduced summer flows and warmer water temperatures will create less favorable instream habitat conditions for coldwater fish species.

In the Central Valley, by 2100 mean summer temperatures may increase by 2 to 8°C, precipitation will likely shift to more rain and less snow, with significant declines in total precipitation possible, and hydrographs will likely change, especially in the southern

Sierra Nevada mountains (NMFS 2009). Thus, climate change poses an additional risk to the survival of salmonids in the Central Valley. As with their ocean phase, Chinook salmon and steelhead will be more thermally stressed by stream warming at the southern ends of their ranges (e.g., Central Valley Domain). For example, warming at the lower end of the predicted range (about 2°C) may allow spring-run Chinook salmon to persist in some streams, while making some currently utilized habitat inhospitable (Lindley et al. 2007). At the upper end of the range of predicted warming, very little spring-run Chinook salmon habitat is expected to remain suitable (Lindley et al. 2007).

Under the expected warming of around 5°C, substantial amounts of habitat would be lost, with significant amounts of habitat remaining primarily in the Feather and Yuba rivers, and remnants of habitat in the upper Sacramento, McCloud, and Pit rivers, Battle and Mill creeks, and the Stanislaus River (Lindley et al. 2007). Under the less likely but still possible scenario of an 8°C warming, spring-run Chinook salmon habitat would be found only in the upper-most reaches of the north fork Feather River, Battle Creek, and Mill Creek. This simple analysis suggests that Central Valley salmonids are vulnerable to warming, but more research is needed to evaluate the details of how warming would influence individual populations and subbasins.

As summarized by Lindley et al. (2007), climate change may pose new threats to Central Valley salmonids by reducing the quantity and quality of freshwater habitat. Under the worst case scenario, spring-run Chinook salmon may be driven extinct by warming in this century, while the best-case scenario may allow them to persist in some streams, although prediction of the future status of Central Valley salmonids associated with long-term climate change is fraught with uncertainty.

By contrast to the conditions for other Central Valley floor rivers, climate change may not be likely to have such impacts on salmonids in the lower Yuba River downstream of Englebright Reservoir (YCWA 2010a). Presently, the lower Yuba River is one of the few Central Valley tributaries that consistently has suitable water temperatures for salmonids throughout the year. Lower Yuba River water temperatures generally remain below 58°F year-round at the Smartsville Gage (downstream of Englebright Dam), and below 60°F year-round at Daguerre Point Dam (YCWA et al. 2007). At Marysville, water temperatures generally remain below 60°F from October through May, and below 65°F from June through September (YCWA et al. 2007).

According to YCWA (2010), because of specific physical and hydrologic factors, the lower Yuba River is expected to continue to provide the most suitable water temperature conditions for anadromous salmonids of all Central Valley floor rivers, even if there are long-term climate changes. This is because New Bullards Bar Reservoir is a deep, steep-sloped reservoir with ample coldwater pool reserves. Throughout the period of operations of New Bullards Bar Reservoir (1969 through present), which encompasses the most extreme critically dry year on record (1977), the coldwater pool in New Bullards Bar Reservoir never was depleted. Since 1993, coldwater pool availability in New Bullards Bar Reservoir has been sufficient to accommodate year-round utilization of the reservoir's lower level outlets to provide cold water to the lower Yuba River. Even if climate conditions change, New Bullards Bar Reservoir still will have a very substantial coldwater pool each year that will continue to be available to provide sustained, relatively cold flows of water into the lower Yuba River during the late spring, summer and fall of each year (YCWA 2010).

OCEAN ACIDIFICATION

Ocean acidification has been called a "sister" or co-equal problem to climate change because it is caused by the same human-caused production of large amounts of CO_2. Its impacts are additional to, and may exacerbate, the effects of climate change (Alaska Marine Conservation Council 2011).

Seawater pH is a critical variable in marine systems. Today's surface ocean water is slightly alkaline, with a pH ranging from 7.5 to 8.5 and it is saturated with calcium carbonate, a very important organic molecule for organisms like corals, mollusks and crustaceans that make shells. As CO_2 reacts with the seawater, it lowers the pH and releases hydrogen ions. These ions bind strongly with carbonate, preventing it from forming the important calcium carbonate molecules. If the pH of the global oceans drops 0.4 by the end of the century as predicted, the levels of calcium carbonate available for use by marine organisms will decrease by 50% (Alaska Marine Conservation Council 2011).

Ocean acidification is likely to alter the biodiversity of the world's marine ecosystems and may affect the total productivity of the oceans. Previously it was thought that these changes would take centuries, but new findings indicate that an increasingly acidic environment could cause problems in high-latitude marine ecosystems within just a few decades (Alaska Marine Conservation Council 2011).

Currently, the oceans' surface water layers have sufficient amounts of calcium carbonate for organisms to use (known as saturated conditions). This calcium carbonate rich layer is deeper in warmer regions and closer to the surface in colder regions. Because calcium carbonate is less stable in colder waters, marine life in the polar oceans will be affected by calcium carbonate loss first. A study published in Nature by 27 U.S. and international scientists stated, "*Some polar and sub-polar waters will become under-saturated [at twice the pre-industrial level of* $CO_{2,}$ *560 ppm], probably within the next 50 years*" (Orr et al. 2005). Under-saturated refers to conditions in which the seawater has some calcium carbonate remaining, but it does not have enough available for the organisms to build strong shells (Alaska Marine Conservation Council 2011).

Research has shown that lowered ocean pH will affect the processes by which animals such as corals, mollusks and crustaceans make their support structures. Because these organisms depend on calcium carbonate, increasing acidity threatens their survival. At higher levels of acidity (lower pH levels), any organism that forms a shell through calcification — from clams to pteropods — could be adversely affected. These species use the naturally occurring carbonate minerals calcite and aragonite for the calcification process.

Pteropods are small planktonic mollusks that are at the bottom of the food chain and because of their dependence on calcium carbonate, they will be one of the first casualties of increasing acidity in Alaska's marine waters. In recent experiments exposing live pteropods to the conditions predicted by "business-as-usual" carbon emission scenarios – the pteropod shells showed evidence of dissolution and damage within only 48 hours. Pteropods are a key food source for salmon and other species (Alaska Marine Conservation Council 2011). Increased research into ocean acidification caused by the saturation of water with carbon dioxide suggests that a 10% decline in pteropod production can lead to a 20% reduction in the body weight of mature salmon (Climate Solutions 2011). A decrease in these mineral levels to food web base species like pteropods, also known as sea butterflies, which make up 45% of the diet for juvenile pink salmon, can cause cascading waves of disruption up the food chain (Climate Solutions 2011).

NON-NATIVE INVASIVE SPECIES

Non-native invasive species are of concern throughout the ESU and DPSs and can result in numerous deleterious effects to native species. For example, introduction of non-native invasive species can alter the natural food webs that existed prior to their introduction, as illustrated by the Asiatic freshwater clams *Corbicula fluminea* and *Potamocorbula amurensis* in the Delta. Cohen and Moyle (2004) report that the arrival of these two clam species disrupted the normal benthic community structure, and depressed phytoplankton levels in the Delta due to the highly efficient filter feeding of the introduced clams. Declines in phytoplankton levels have consequently resulted in reduced populations of zooplankton that feed upon them, thereby reducing the forage base available to salmonids transiting through the Delta and the San Francisco estuary on their ocean migrations. The lack of forage base can adversely affect the health and physiological condition of salmonids as they migrate to the Pacific Ocean.

Attempts to control non-native invasive plant species also can adversely affect the health and habitat suitability of salmonids within affected water systems, through either direct exposure to toxic chemicals or reductions in DO levels associated with the decomposition of vegetative matter in the water. As an example, control programs for the invasive water hyacinth and *Egeria densa* plants in the Delta must balance the toxicity of the herbicides applied to control the plants against the probability of exposure to listed salmonids during herbicide application period.

4.2.6.2 Lower Yuba River

The phenotypic lower Yuba River spring-run Chinook salmon population is exposed and subject to the myriad of limiting factors, threats and stressors described above for the Central Valley ESU. Lower Yuba River phenotypic spring-run Chinook salmon generally spend a few months (with some individuals remaining up to several months, or a year) in the lower Yuba River prior to migrating downstream through the lower Feather River, the lower Sacramento River, the Delta, and San Francisco Bay to the Pacific Ocean, where they spend from two to four years growing and maturing. Following their ocean residency, these fish then undertake an upstream migration through this same system, and are again exposed to the associated limiting factors, threats and stressors, prior to spending a few additional months in the lower Yuba River holding and subsequently spawning.

Three separate efforts have been undertaken over the past few years to identify, characterize and prioritize limiting factors (i.e., “stressors”) for anadromous salmonids (including spring-run Chinook salmon) in the lower Yuba River. The Lower Yuba River Fisheries Technical Working Group, a multi-party stakeholder group including the Corps and YCWA, established a process to rank stressors as part of the “*Draft Implementation Plan for Lower Yuba River Anadromous Fish Habitat Restoration*” (CALFED and YCWA 2005). The Yuba Accord Technical Team built upon these efforts and utilized a stressor analysis in the development of the Yuba Accord minimum flow requirements (i.e., “flow schedules”) (YCWA et al. 2007).

Most recently, NMFS (2009) conducted a comprehensive assessment of stressors affecting spring-run Chinook salmon both within the lower Yuba River, and affecting lower Yuba River populations as they migrate downstream (as juveniles) and upstream (as adults) through the lower Feather River, the lower Sacramento River, and the Bay-Delta system.

As stated by NMFS (2009), stressor matrices, which structured hierarchically related tiers in order to prioritize stressors, were developed. After all of the variables in the matrix were identified and weighted, stressors within the matrices were sorted in descending order (from the highest to the lowest biological impact). Although the resultant sorted matrices provide a pseudo-quantitative means of comparatively ranking individual stressors, to avoid attributing unwarranted specificity to the prioritized stressor list, it was distributed into four separate quartiles (“Very High”, “High”, “Medium”, and “Low”).

The ranking and quartile characterization of stressors were organized such that stressors affecting the individual lifestages also could be ascertained.

According to NMFS (2009a), for the lower Yuba River population of spring-run Chinook salmon, the number of stressors according to the categories of “Very High”, “High”, “Medium”, and “Low” that occur in the lower Yuba River or occur out of basin are presented below by lifestage (**Table 4-3**).

Table 4-3. The number of stressors according to the categories of “Very High”, “High”, “Medium”, and “Low” that occur in the lower Yuba River, or occur out-of-basin, by lifestage for the lower Yuba River population of spring-run Chinook salmon (Source: NMFS 2009a).

Lifestage	Location	Stressor Categories			
		Very High	High	Medium	Low
Adult Immigration and Holding					
	Lower Yuba River	2	1	3	1
	Out of Basin	1	5	8	6
Spawning					
	Lower Yuba River	3	2	0	2
	Out of Basin	N/A*	N/A	N/A	N/A
Embryo Incubation					
	Lower Yuba River	1	0	4	0
	Out of Basin	N/A	N/A	N/A	N/A
Juvenile Rearing and Outmigration					
	Lower Yuba River	5	1	1	5
	Out of Basin	12	16	6	9
* Not Applicable. These lifestages for this population only occur in the lower Yuba River.					

As shown by the numbers in Table 4-3, of the total number of 94 stressors affecting all identified lifestages of the lower Yuba River populations of spring-run Chinook salmon, 31 are within the lower Yuba River and 63 are out-of-basin. Because spawning and incubation occurs only in the lower Yuba River, all of the stressors associated with these lifestages occur in the lower Yuba River. Therefore, for the adult immigration and holding, and the juvenile rearing and outmigration lifestages combined, a total of 49 “Very High” and “High” stressors were identified, with 15 of those occurring in the lower Yuba River and 34 occurring out-of-basin.

The NMFS (2009) Draft Recovery Plan states that "*The lower Yuba River, below Englebright Dam, is characterized as having a high potential to support a viable independent population of spring-run Chinook salmon, primarily because: (1) flow and water temperature conditions are generally suitable to support all lifestage requirements; (2) the river does not have a hatchery on it; (3) spawning habitat availability is believed not to be limiting; and (4) high habitat restoration potential*".

The NMFS (2009) Draft Recovery Plan further states that "*For currently occupied habitats below Englebright Dam, it is unlikely that habitats can be restored to pre-dam conditions, but many of the processes and conditions that are necessary to support a viable independent population of spring-run Chinook salmon can be improved with provision of appropriate instream flow regimes, water temperatures, and habitat availability. Continued implementation of the Yuba Accord is expected to address these factors and considerably improve conditions in the lower Yuba River*."

PASSAGE IMPEDIMENTS/BARRIERS

Englebright Dam was not designed for fish passage and presents an impassable barrier to the upstream migration of anadromous salmonids, and marks the upstream extent of currently accessible spring-run Chinook salmon habitat in the lower Yuba River, whereas Daguerre Point Dam presents an impediment to upstream migration.

Englebright Dam, built in 1941 to retain hydraulic mining debris from the Yuba River watershed, blocks upstream migration of fish in the lower Yuba River and, in particular, blocks the migration of steelhead and spring-run Chinook salmon to their historic spawning grounds (NMFS 2002).

Daguerre Point Dam has been reported to be an impediment to upstream migration of adult salmon and steelhead under certain conditions. Factors contributing to impeded adult spring-run Chinook salmon upstream passage have been suggested to include inadequate attraction flows to the ladders, proximity and orientation of the ladder entrances to the spillway, periodic obstruction of the ladders by sediment and woody debris, and other fish ladder physical design issues.

Sheet flow across the dam's spillway, particularly during high-flow periods, may obscure ladder entrances and, thus, makes it difficult for immigrating adult salmonids to find the entrances (NMFS 2007a). For example, fall-run Chinook salmon have been observed attempting to leap over the dam, demonstrating that these fish may have difficulty in finding the fish ladder entrances (Corps 2000). This phenomenon may particularly affect spring-run Chinook salmon, because peak spring-run adult Chinook salmon upstream migration occurs primarily during the relatively high-flow periods of spring through early summer. Since 2001, wooden flashboards have been periodically affixed to the crest of the dam during low flow periods to aid in directing the flows towards the fish ladder entrances. Fish passage monitoring data from 2006 indicates that the installation of the flashboards resulted in an immediate and dramatic increase in the passage of salmon up the ladders, and is thought to have improved the ability of salmon to locate and enter the ladders (NMFS 2007a).

Both the north and south fish ladders at Daguerre Point Dam, particularly the north ladder, historically tended to clog with woody debris and sediment, which had the potential to block passage or substantially reduce attraction flows at the ladder entrances. Additionally: (1) the north and south ladders' exits are close to the spillway, potentially resulting in adult fish exiting the ladder being immediately swept by flow back over the dam; (2) sediment accumulates at the upstream exits of the fish ladders, reducing the unimpeded passage from the ladders to the main channel, and may cause potential "fall-back" into the ladders; and (3) fish could jump out of the upper bays of the fishway, resulting in direct mortality. Many of the past issues associated with woody debris accumulation have either been eliminated or minimized since locking metal grates were installed over the unscreened bays on the north and south fish ladders during 2011.

The RMT (2013) examined passage of adult Chinook upstream of Daguerre Point Dam and corresponding flow data during eight years of available data. Chinook salmon passage was observed over a variety of flow conditions, including ascending or descending flows, as well as during extended periods of stable flows. Flow thresholds prohibiting passage of Chinook salmon through the ladders at Daguerre Point Dam were not apparent in the data (RMT 2013).

Phenotypic spring-run Chinook salmon (those entering the lower Yuba River during spring months) may remain in the lower Yuba River in areas downstream (and proximate) to Daguerre Point Dam for extended periods of time during the spring and summer. It is uncertain whether, or to what extent, the duration of residency in the large pool located downstream of Daguerre Point Dam is associated with upstream passage impediment and delay, or volitional habitat utilization prior to spawning in upstream areas. However, RMT (2013) reported that temporal migrations of adult phenotypic spring-run Chinook salmon to areas upstream of Daguerre Point Dam occurred over an extended period of time. The tagged spring-run Chinook salmon in the lower Yuba River actually migrated upstream of Daguerre Point Dam from May through September, and utilized a broad expanse of the lower Yuba River during the phenotypic summer holding period, including areas as far downstream as Simpson Lane Bridge (i.e., ~RM 1.8), and as far upstream as the area just below Englebright Dam. A longitudinal analysis of acoustic tag detection data indicated that distributions were non-random, and that the tagged spring-run Chinook salmon were selecting locations for holding (RMT 2013).

NMFS (2007) suggested that delays resulting from adult spring-run Chinook salmon adult passage impediments could weaken fish by requiring additional use of fat stores prior to spawning, and potentially could result in reduced spawning success (i.e., production) from reduced resistance to disease, increased pre-spawning mortality, and reduced egg viability. However, these statements suggesting biological effects associated with fish passage issues at Daguerre Point Dam are not supported by studies or referenced literature. For example, the RMT (2010b) included evaluation of water temperatures at Daguerre Point Dam during the spring-run Chinook salmon adult upstream immigration and holding lifestage, which addressed considerations regarding both water temperature effects to pre-spawning adults and egg viability. They concluded that during this lifestage, characterized as extending from April through August, water temperatures [modeled] at Daguerre Point Dam are suitable and remain below the reported optimum water temperature index value of 60°F at least 97% of the time over all water year types during these months. Thus, it is unlikely that this represents a significant source of mortality to spring-run Chinook salmon. Moreover, actual data monitored since the Yuba Accord has been implemented (October 2006 to June 2013) demonstrates that water temperatures at Daguerre Point Dam actually remained at about or below 60°F during the adult immigration and holding period each of the six years (RMT 2013).

As reported by NMFS (2007), Daguerre Point Dam may adversely affect outmigration success of juvenile salmon and steelhead. During downstream migration, juvenile Chinook salmon and steelhead may be disoriented or injured as they plunge over the spillway, increasing their exposure and vulnerability to predators in the large pool at the base of the dam (NMFS 2007).

HARVEST/ANGLING IMPACTS

Fishing for Chinook salmon on the lower Yuba River is regulated by CDFW. Although harvest/angler impacts were previously listed as a stressor, the magnitude of this potential stressor has been reduced associated with changes in fishing regulations over time. Angling regulations on the lower Yuba River are intended to protect sensitive species, in particular spring-run Chinook salmon (and wild steelhead). CDFW angling regulations 2013-2014 (CDFW 2013a) state that the lower Yuba River from its confluence with the lower Feather River up to Englebright Dam is closed year-round to salmon fishing, and no take or possession of salmon is allowed.

Fishing for hatchery trout or hatchery steelhead is allowed on the lower Yuba River from its confluence with the lower Feather River up to the Highway 20 Bridge year-round. The lower Yuba River, between the Highway 20 Bridge and Englebright Dam, is closed to fishing from September through November to protect spring-run Chinook salmon spawning activity and egg incubation.

Although these regulations are intended to specifically protect spring-run Chinook salmon, anglers can potentially harass, harm and kill listed species (spring-run Chinook salmon and wild steelhead) through incidental actions while targeting non-listed species. Examples of potential angler impacts may include, but are not necessarily limited to, angler harvest, physical disturbance of salmonid redds, hooking and catch-and-release stress or mortality, including that which results from incidental hooking (CALFED and YCWA 2005).

POACHING

Whether poaching represents a stressor, or the extent to which spring-run Chinook salmon are targeted for poaching in the lower Yuba River is unknown.

Poaching of adult Chinook salmon at the fish ladders and at the base of Daguerre Point Dam has been previously reported in several documents. Poaching has been previously reported as a “chronic problem” (Falxa 1994 as cited in CALFED and YCWA 2005). The spring-run Chinook salmon status report (CDFG 1998) stated that poaching was an “ongoing problem” at Daguerre Point Dam. Poaching of salmon has been reported as a “long-standing problem” on the Yuba River, particularly at Daguerre Point Dam (John Nelson, CDFG, pers. comm., November 2000, as cited in NMFS 2005a). The Corps (2001) and NMFS (2009) both refer to poaching of adult salmon at the Daguerre Point Dam.

Although these previous reports refer in some fashion to poaching within the fish ladders and immediately downstream of Daguerre Point Dam as issues, the only actual account of documented poaching was provided by Nelson (2009). In his declaration, Nelson (2009) stated that during his tenure at CDFW (which extended until 2006) he personally observed people fishing illegally in the ladders, and further observed gear around the ladders used for poaching. It is not clear regarding the time period to which he was referring, although it may have been referring to the period prior to 2000 (see reference in previous paragraph).

The VAKI Riverwatcher infrared and videographic sampling system began operations in 2003. CDFW monitored these operations at Daguerre Point Dam seasonally from 2003 through 2005. Since 2006 (with implementation of the Yuba Accord Pilot Programs (2006 – 2007) and the Yuba Accord in 2008), PSMFC staff have monitored the system at Daguerre Point Dam on a nearly daily basis, year-round, through the present. Over this 8-year period, neither CDFW nor PSMFC staff have reported poaching in the ladders, or immediately downstream of Daguerre Point Dam. Thus, although poaching has been reported as a stressor, it is unclear whether, or to what extent, it impacts the spring-run Chinook salmon population in the lower Yuba River. According to Sprague (2011), the amount of poaching from the fish ladders has not been quantified, and there does not appear to be data on the amount of poaching, so the extent of the problem is not well understood.

Moreover, it is unclear whether these previous reports of poaching were directed toward spring-run or fall-run Chinook salmon. While data are not available as to the fish species targeted, poachers likely target the fish that are readily available. The greatest numbers of poached fish probably would be fall-run Chinook salmon because they congregate below the dam in large numbers under the low-flow, clear-water conditions of October and November (Corps 2001). According to NMFS (2002), fall-run Chinook salmon are most likely to be subject to poaching because they are the largest salmonid population in the lower Yuba River. Nevertheless, spring-run Chinook salmon also may be affected because they may be present in the lower Yuba River during the periods of the highest recreational use (NMFS 2002).

As early as 2001, the Corps (2001) suggested that although poaching is likely very limited, fencing or screening of the ladder could further reduce or eliminate any poaching. Nelson (2009) suggested that one measure that could reduce poaching would be to place grates over the top of the ladders to restrict poacher access. He further suggested that grates had been installed on other fish ladders to prevent poaching, such as on the Woodbridge Irrigation District Dam fish ladders located on the Mokelumne River near Woodbridge, California. However, Sprague (2011) stated that grates are not recommended, due to the multiple sharp edges and the potential for resultant fish injury. He further suggested that solid covers could be used, but consideration should be given to the potential for how to avoid pressurizing the fish ladders during high flow events. As a temporary solution addressing the potential for fish to jump out of the ladder (and potential poaching within the fish ladders), in 2011 the Corps installed plywood boards over the upper bays at the south ladder at Daguerre Point Dam. As previously discussed, the July 25, 2011 Interim Remedy Order issued by the Court ordered the Corps to install locking metal grates over all but the lower eight bays of the fish ladders at Daguerre Point Dam by September 14, 2011. In response to the Interim Remedy Order issued by the Court on July 25, 2011, during the summer of 2011 the Corps proceeded with installation of locking metal grates on all 33 unscreened bays. Due to concerns expressed by both NMFS and CDFW, the Court then reconsidered the requirement to put grates over the bays on the lowermost section of the south fish ladder at Daguerre Point Dam. Consequently, grates were not installed over the lower eight bays of the south fish ladder at Daguerre Point Dam.

PHYSICAL HABITAT ALTERATION (INCLUDING WATERWAY 13)

According to NMFS (2009), the stressor associated with physical habitat alteration specifically addressed the issue of return flows and attraction of anadromous salmonids into the Yuba Goldfields through Waterway 13. Various efforts have been undertaken to prevent anadromous salmonids from entering the Goldfields via Waterway 13. In May 2005, heavy rains and subsequent flooding breached the structure at the east (upstream facing) end. Subsequently, funded by USFWS, the earthen “plug” was replaced with a "leaky-dike" barrier intended to serve as an exclusion device for upstream migrating adult salmonids (AFRP 2010). The Corps does not have any operations or maintenance responsibilities for the earthen “plug” and Waterway 13, nor has it issued any permits or licenses for it. Nonetheless, until a more permanent solution is implemented, ongoing issues associated with attraction of upstream migrating adult salmonids into Waterway 13 are considered to remain a stressor to spring-run Chinook salmon. For additional information on Waterway 13, see Chapter 5 – Environmental Baseline.

In addition to Waterway 13 issues, physical habitat alternation stressors include Lake Wildwood operations and resultant Deer Creek flow fluctuations (according to the SWRCB’s Revised Decision 1644, Lake Wildwood is operated by the Lake Wildwood Association — a gated community in Penn Valley, California). This stressor refers to the potential for stranding or isolation events to occur in Deer Creek, near its confluence with the lower Yuba River. Observational evidence suggests that, in the past, adult Chinook salmon entered Deer Creek during relatively high flow periods, presumably for holding or spawning purposes, only to subsequently become stranded in the creek when flows receded due to changes in Lake Wildwood operations. Stranding may delay or prevent adult Chinook salmon from spawning, or cause decreased spawning success due to increased energy expenditure or stress due to delayed spawning (CALFED and YCWA 2005).

The Sierra Streams Institute (SSI) is in the process of implementing the Deer Creek Spawning Bed Enhancement Project, which is located on a tributary to the lower Yuba River. From September 4-7, 2012, 250 tons of spawning gravel (~180 cubic yards) was placed in the creek. Chinook salmon redd surveys were conducted after the initial placement to document the number and characteristics of salmon redds created in Deer Creek during the 2012 spawning season. On November 27, 2012, more than 51 salmon redds were observed in Deer Creek, compared to 15 redds in 2011, and 9 redds in 2003 (SSI 2013). Approximately 75% of spawning activity during 2012 occurred in the newly created spawning areas, with the remaining spawning activity occurring in locations where spawning was observed in 2011. Gravel transport also was monitored to understand the effects of higher stream flows on gravel movement, and to evaluate transport of spawning gravels in Deer Creek. Tracer gravel surveys were conducted during February, March, and April 2013. Based on these and other visual observations of substrate deposition in Deer Creek, SSI (2013) report that it is likely that some of the placed gravels remain in Deer Creek providing spawning habitat, and that some of the gravels were mobilized downstream into the Yuba River to provide habitat for anadromous salmonids. To supplement existing available spawning habitat, SSI planned to place an additional 250 tons of spawning gravel in Deer Creek from September 3-13, 2013.

Physical habitat alteration stressors also address habitat complexity and diversity. The concepts of habitat complexity and diversity pertinent to the lower Yuba River were described by CALFED and YCWA (2005), as discussed below.

Habitat complexity and diversity refer to the quality of instream physical habitat including, but not necessarily limited to, the following physical habitat characteristics:

- ☐ Escape cover
- ☐ Feeding cover
- ☐ Allochthonous material contribution
- ☐ Alternating point-bar sequences
- ☐ Pool-to-riffle ratios
- ☐ Sinuosity
- ☐ Instream object cover
- ☐ Overhanging riparian vegetation

The physical structure of rivers plays a significant role in determining the suitability of aquatic habitats for juvenile salmonids, as well as for other organisms upon which salmonids depend for food. These structural elements are created through complex interactions among natural geomorphic features, the power of flowing water, sediment delivery and movement, and riparian vegetation, which provides bank stability and inputs of large woody debris (Spence et al. 1996). The geomorphic conditions caused by hydraulic and dredge mining since the mid-1800s, and the construction of Englebright Dam, which affects the transport of nutrients, fine and course sediments and, to a lesser degree, woody material from upstream sources to the lower river, continue to limit habitat complexity and diversity in the lower Yuba River.

LWM creates both micro- and macro-habitat heterogeneity by forming pools, back eddies and side channels and by creating channel sinuosity and hydraulic complexity. This habitat complexity provides juvenile salmonids numerous refugia from predators and water velocity, and provides efficient locations from which to feed. LWM also functions to retain coarse sediments and organic matter in addition to providing substrate for numerous aquatic invertebrates (Spence et al. 1996).

In the lower Yuba River, mature riparian vegetation is scattered intermittently, leaving much of the banks devoid of LWM and unshaded – affecting components that are essential to the health and survival of the freshwater lifestages of salmonids (NMFS 2002). Although the ability of the lower Yuba River to support riparian vegetation has been substantially reduced by the historic impacts from mining activities, the dynamic nature of the river channel results in periodic creation of high-value shaded riverine aquatic (SRA) cover for fish and wildlife (Beak 1989).

Other important components of habitat structure at the micro-scale include large boulders, coarse substrate, undercut banks and overhanging vegetation. These habitat elements offer juvenile salmonids concealment from predators, shelter from fast current, feeding stations and nutrient inputs. At the macro-scale, streams and rivers with high channel sinuosity, multiple channels and sloughs, beaver impoundments or backwaters typically provide high-quality rearing and refugia habitats (Spence et al. 1996). The lower Yuba River can be generally characterized as lacking an abundance of such features.

LOSS OF RIPARIAN HABITAT AND INSTREAM COVER

RIPARIAN VEGETATION

As stated in CALFED and YCWA (2005), riparian vegetation, an important habitat component for anadromous fish, is known to provide: (1) bank stabilization and sediment load reduction; (2) shade that results in lower instream water temperatures; (3) overhead cover; (4) streamside habitat for aquatic and terrestrial insects, which are important food sources for rearing juvenile fishes; (5) a source of instream cover in the form of woody material; and (6) allochthonous nutrient input.

SRA cover generally occurs in the lower Yuba River as scattered, short strips of low-growing woody species (e.g., *Salix sp.*) adjacent to the shoreline. Beak (1989) reported that the most extensive and continuous segments of SRA cover occur along bars where [then] recent channel migrations or avulsions had cut new channels through relatively large, dense stands of riparian vegetation. SRA cover consists of instream object cover and overhanging cover. Instream object cover provides structure, which promotes hydraulic complexity, diversity and microhabitats for juvenile salmonids, as well as escape cover from predators. The extent and quality of suitable rearing habitat and cover, including SRA, generally has a strong effect on juvenile salmonid production in rivers (Healey 1991 as cited in CALFED and YCWA 2005).

Since completion of New Bullards Bar Reservoir, the riparian community (in the lower Yuba River) has expanded under summer and fall streamflow conditions that have generally been higher than those that previously occurred (SWRCB 2003). However, the riparian habitat is not pristine. NMFS (2005b) reports …"*The deposition of hydraulic mining debris, subsequent dredge mining, and loss/confinement of the active river corridor and floodplain of the lower Yuba River which started in the mid-1800's and continues to a lesser extent today, has eliminated much of the riparian vegetation along the lower Yuba River. In addition, the large quantities of cobble and gravel that remained generally provided poor conditions for re-establishment and growth of riparian* *vegetation. Construction of Englebright Dam also inhibited regeneration of riparian vegetation by preventing the transport of any new fine sediment, woody debris, and nutrients from upstream sources to the lower river. Subsequently, mature riparian vegetation is sparse and intermittent along the lower Yuba River, leaving much of the bank areas unshaded and lacking in large woody debris. This loss of riparian cover has greatly diminished the value of the habitat in this area.*"

Where hydrologic conditions are supportive, riparian and wetland vegetative communities are found adjacent to the lower Yuba River and on the river sides of retaining levees. These communities are dynamic and have changed over the years as the river meanders. The plant communities along the river are a combination of remnant Central Valley riparian forests, foothill oak/pine woodlands, agricultural grasslands, and orchards (Beak 1989).

According to CALFED and YCWA (2005), the lower Yuba River, especially in the vicinity of Daguerre Point Dam and the Yuba Goldfields, is largely devoid of sufficient riparian vegetation to derive the benefits (to anadromous salmonids) discussed above (**Figure 4-4**).

In 2012, YCWA conducted a riparian habitat study in the Yuba River from Englebright Dam to the confluence with the Feather River (see Technical Memorandum 6-2 in YCWA 2013). Field efforts included descriptive observations of woody and riparian vegetation, cottonwood inventory and coring, and a large woody material (LWM) survey. The study was performed by establishing eight LWM study sites and seven riparian habitat study sites. One LWM study site was established within each of eight distinct reaches (i.e., Marysville, Hallwood, Daguerre Point Dam, Dry Creek, Parks Bar, Timbuctoo Bend, Narrows, and Englebright Dam). Riparian habitat sites were established in the same locations as the LWM study sites, with the exception of the Marysville study site. Riparian information regarding the Marysville Reach was developed, but no analysis was performed because of backwater effects of the Feather River.

The RMT contracted Watershed Sciences Inc. to use existing LiDAR to produce a map of riparian vegetation stands by type. The resulting data was subject to a field validation

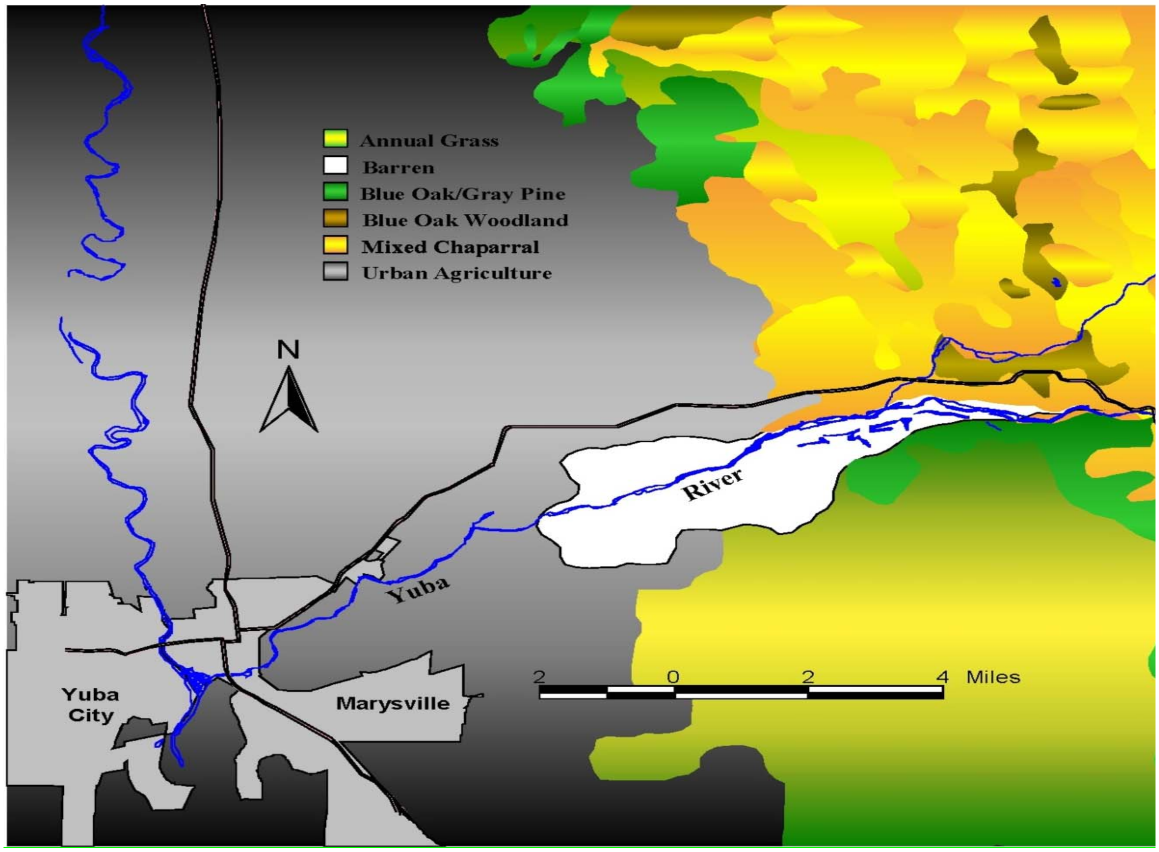

Figure 4-4. Vegetation communities in the lower Yuba River vicinity (Source: CALFED and YCWA 2005).

and briefly summarized in WSI (2010) and the data were also utilized in YCWA's Riparian Study Technical Memorandum 6-2 (YCWA 2013).

Based on field observations, YCWA (2013) reported that all reaches supported woody species in various lifestages - mature trees, recruits, and seedlings were observed within all reaches. Where individuals or groups of trees were less vigorous, beaver (*Castor canadensis*) activity was the main cause, although some trees in the Marysville Reach appeared to be damaged by human camping.

The structure and composition of riparian vegetation was largely associated with four landforms. Cobble-dominated banks primarily supported bands of willow shrubs with scattered hardwood trees. Areas with saturated soils or sands supported the most complex riparian areas and tended to be associated with backwater ponds. Scarps and levees supported lines of mature cottonwood and other hardwood species, typically with a simple understory of Himalayan blackberry or blue elderberry shrubs. Bedrock dominated reaches had limited riparian complexity and supported mostly willow shrubs and cottonwoods (YCWA 2013).

Based on analysis of the mapping data, RMT (2013) reported that the majority of the woody species present in the river valley include, in order of most to least number of individuals: various willow species (*Salix* sp. and *Cephalanthus occidentalis*); Fremont cottonwood (*Populus fremontii*) (i.e., cottonwoods); blue elderberry (*Sambucus nigra* ssp. *caerulea*); black walnut (*Juglans hindsii*); Western sycamore (*Platanus racemosa*); Oregon ash (*Fraxinus latifolia*); white alder (*Alnus rhombifolia*); tree of heaven (*Ailanthus altissima*); and grey pine (*Pinus sabiniana*). Willow species could not be differentiated by species using remote sensing information. Willow on the lower Yuba River are dominated by dusky sandbar willow (*Salix melanopsis*) and narrow leaf willow (*Salix exigua*), and relative dominance of the two species shifts respectively in the downstream direction (WSI 2010). Other species occurring are arundo willow (*Salix lasiolepsis*), Goodings willow (*Salix goodingii*) and red willow (*Salix laevigata*). Goodings and red willow comprise 6.4% of the willow according to a limited field validation survey (WSI 2010).

Cottonwoods are one of the most abundant woody species in the study area, and the most likely source of locally-derived large instream woody material due to rapid growth rates and size of individual stems commonly exceeding 2 feet in diameter and 50 feet in length. Cottonwoods exist in all life stages including as mature trees, recruits, or saplings, and as seedlings. Cottonwoods are more abundant in downstream areas of the study area relative to upstream. Cottonwoods are distributed laterally across the valley floor. Of the estimated 18,540 cottonwood individuals/stands, 12% are within the bankfull channel (flows of 5,000 cfs or less), and 39% are within the floodway inundation zone (flows between 5,000 and 21,100 cfs). However, recruitment patterns of cottonwood have not been analyzed with respect to time or with any more detail regarding channel location (YCWA 2013).

A total of 97 cottonwood trees were cored to estimate age. Age estimates ranged from 11 to 87 years. The cottonwood tree age analysis resulted in age estimates that place the year of establishment for trees in a range of years from ±7 to 16 years, which is too wide to allow for linking the establishment of trees to any year's specific conditions (YCWA 2013).

YCWA conducted a historical aerial photograph analysis to describe changes over time to total vegetation delineated within the valley walls, riparian vegetation delineated within 50 feet of the active river channel,[2] and channel alignment (see Technical Memorandum 6-2 in YCWA 2013). To determine the cumulative change over time[3] in total vegetative cover and riparian vegetation cover for the Marysville, Timbuctoo Bend, Narrows, and Englebright Dam study sites, YCWA compared the aerial photographs from 1937 and 2010.

Cumulative changes in vegetative cover in the Englebright Dam and Narrows study sites decreased. For the remaining study sites, including Marysville, Hallwood, Daguerre Point Dam, Dry Creek, Parks Bar, and Timbuctoo Bend study sites, the cumulative change in vegetative cover increased. The least amount of vegetation change over time was observed in the Englebright Dam, Narrows and Marysville sites. The Dry Creek, Daguerre Point Dam and Hallwood sites had the greatest vegetated area, and YCWA identified those sites as the most dynamic (i.e., both decreased in vegetative cover through 1970 and then increased through 2010).

Cumulative changes in riparian vegetation cover in the Englebright Dam and Narrows study sites decreased with very little detectable change for the Narrows study site. For the remaining study sites, the cumulative change in riparian vegetation cover increased. The observed changes for the Englebright Dam, Narrows and Marysville study sites were very small. For the Dry Creek and Parks Bar study sites, the greatest changes were observed, with dramatic increases in riparian vegetation cover. The magnitude of change of riparian vegetation between photoset years (in a stepwise comparison) was greater than that seen in the cumulative riparian vegetation cover change.

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[2] Total vegetation is inclusive of riparian vegetation.

[3] Cumulative change describes the changes to observable area for either total vegetation or riparian vegetation from the earliest photo date to the most recent photo date.

INSTREAM WOODY MATERIAL

Instream woody material provides escape cover and relief from high current velocities for juvenile salmonids and other fishes. LWM also contributes to the contribution of invertebrate food sources, and micro-habitat complexity for juvenile salmonids (NMFS 2007). Snorkeling observations in the lower Yuba River have indicated that juvenile Chinook salmon had a strong preference for near-shore habitats with instream woody material (JSA 1992).

There is currently a lack of consensus regarding the amount of instream woody material occuring in the lower Yuba River (Corps 2012d). It has been suggested (CALFED and YCWA 2005) that the presence of Englebright Dam has resulted in decreased recruitment of LWM to the lower Yuba River, although no surveys or studies were cited to support these statements. Some woody material may not reach the lower Yuba River due to collecting on the shoreline and sinking in Englebright Reservoir (Corps 2012d). However, Englebright Dam does not functionally block woody material from reaching the lower Yuba River because there is no woody material removal program implemented for Englebright Reservoir, and accumulated woody material therefore spills over the dam during uncontrolled flood events (R. Olsen, Corps, pers. comm. 2011, as cited in Corps 2012d).

About 8.7 miles of the lower Yuba River downstream of Englebright Dam, distributed among study sites per reach, were surveyed and evaluated for pieces of wood (YCWA 2013). The number of pieces of wood was relatively similar above and below Daguerre Point Dam (i.e., about 5,100 and 5,750 pieces, respectively). Woody material was generally found in bands of willow (*Salix* sp.) shrubs near the wetted edge, dispersed across open cobble bars, and stranded above normal high-flow indicators. Most of the woody material was diffuse and located on floodplains and high floodplains, with only about a quarter of the material in heavy concentrations (YCWA 2013).

Most (77-96%) pieces of wood found in each reach were smaller than 25 feet in length and smaller than 24 inches in diameter, which is the definition of large woody material (LWM). These pieces would be typically floated by flood flows and trapped within willows and alders above the 21,100 cfs line, which is defined as the flow delineating the floodway boundary (YCWA 2013).

Instream woody material was not evenly distributed throughout the reaches. For the smaller size classes (i.e., shorter than 50 feet, less than 24 inches in diameter), the greatest abundance of pieces was found in the Hallwood or Daguerre Point Dam reaches, with lower abundances above and below these reaches (YCWA 2013).

The largest size classes of LWM (i.e., longer than 50 feet and greater than 24 inches in diameter) were rare or uncommon (i.e., fewer than 20 pieces total) with no discernible distribution. Pieces of this larger size class were counted as "key pieces", as were any pieces exceeding 25 inches in diameter and 25 feet in length and showing any morphological influence (e.g., trapping sediment or altering flow patterns). A total of 15 key pieces of LWM were found in all study sites, including six in the Marysville study site. Few of the key pieces were found in the active channel or exhibiting channel forming processes (YCWA 2013).

LOSS OF NATURAL RIVER MORPHOLOGY AND FUNCTION

According to NMFS (2009), "Loss of Natural River Morphology and Function" is the result of river channelization and confinement, which leads to a decrease in riverine habitat complexity, and thus, a decrease in the quantity and quality of juvenile rearing habitat. Additionally, this primary stressor category includes the effect that dams have on the aquatic invertebrate species composition and distribution, which may have an effect on the quality and quantity of food resources available to juvenile salmonids.

According to NMFS (2009), attenuated peak flows and controlled flow regimes have altered the lower Yuba River's geomorphology and have affected the natural meandering of the river downstream of Englebright Dam.

As reported by RMT (2013), preliminary evaluation of available data collected to date related to Yuba River fluvial geomorphology indicates that the Yuba River downstream of Englebright Dam has complex river morphological characteristics. Evaluation of the morphological units in the Yuba River as part of the spatial structure analyses indicates that, in general, the sequence and organization of morphological units is non-random, indicating that the channel has been self-sustaining of sufficient duration to establish an ordered spatial structure (RMT 2013).

The Yuba River downstream of Englebright Dam exhibits lateral variability in its form-process associations (RMT 2013). In the Yuba River, morphological unit organization highlights the complexity of the channel geomorphology, as well as the complex and diverse suite of morphological units. The complexity in the landforms creates diversity in the flow hydraulics which, in turn, contributes to a diversity of habitat types available for all riverine lifestages of anadromous salmonids in the Yuba River downstream of Englebright Dam (RMT 2013).

In the lower Yuba River, anadromous salmonids spawn in mean substrate sizes ranging from about 50 to 150 mm, and most of the lower Yuba River from Englebright Dam to the confluence with the Feather River is characterized by average substrate particle sizes within this size range (RMT 2013). The exceptions are sand/silt areas near the confluence with the Feather River, and the boulder/bedrock regions in the upper sections of Timbuctoo Bend and most of the Englebright Dam Reach. However, gravel augmentation funded by the Corps in the Englebright Dam Reach over the past several years has spurred spawning activity and Chinook salmon redd construction in this reach. The net result is an increase in the spatial distribution of spawning habitat availability in the river, particularly for early spawning (presumably spring-run) Chinook salmon (RMT 2013).

LOSS OF FLOODPLAIN HABITAT

NMFS (2009) listed the loss of floodplain habitat in the lower Yuba River as one of the key stressors affecting anadromous salmonids (including spring-run Chinook salmon). NMFS (2009) stated …"*Historically, the Yuba River was connected to vast floodplains and included a complex network of channels, backwaters and woody material. The legacy of hydraulic and dredger mining is still evident on the lower Yuba River where, for much of the river, dredger piles confine the river to an unnaturally narrow channel. The consequences of this unusual and artificial geomorphic condition include reduced floodplain and riparian habitat and resultant limitations in fish habitat, particularly for rearing juvenile salmonids.*"

NMFS (2009) further stated that in the lower Yuba River, controlled flows and decreases in peak flows has reduced the frequency of floodplain inundation resulting in a separation of the river channel from its natural floodplain. Within the Yuba Goldfields area (RM 8–14), confinement of the river by massive deposits of cobble and gravel derived from hydraulic and dredge mining activities resulted in a relatively simple river corridor dominated by a single main channel and large cobble-dominated bars, with little riparian and floodplain habitat (DWR and PG&E 2010).

Loss of off-channel habitats such as floodplains, riparian, and wetland habitats has substantially reduced the productive capacity of the Central Valley for many native fish and wildlife species, and evidence is growing that such habitats were once of major importance for the growth and survival of juvenile salmon (Moyle 2002). Recent observations on the lower Yuba River indicate that remnant side channels and associated riparian vegetation play a similar role by providing flood refugia, protection from predators, and abundant food for young salmonids and other native fishes. These habitats also promote extended rearing and expression of the stream-type rearing characteristic of spring-run Chinook salmon (DWR and PG&E 2010).

As reported by RMT (2013), despite some flow regulation, the channel and floodplain in the lower Yuba River are highly connected, with floods spilling out onto the floodplain more frequently than commonly occurs for unregulated semiarid rivers. Some locations exhibit overbank flow well below 5,000 cfs, while others require somewhat more than that. In any given year, there is an 82% chance the river will spill out of its bankfull channel and a 40% chance that the floodway will be fully inundated. These results demonstrate that floodplain inundation occurs with a relatively high frequency in the lower Yuba River compared to other Central Valley streams which, in turn, contributes to a diversity in habitats available for anadromous salmonids (RMT 2013).

RMT (2013) conducted a flood-frequency analysis of the annual peak discharges recorded at the USGS stream gage near Marysville (#11421000) that showed average annual return periods of 1.25 years and 2.5 years for the bankfull and flood discharges, respectively. Bankfull flows for similar rivers are generally assumed to occur with return periods of 1.5-2 years. The fact that the lower Yuba River is less than this implies that the channel is naturally undersized relative to generalized expectations and flows spill into the floodplain at a more frequent rate (RMT 2013).

ENTRAINMENT

According to NMFS (2009), entrainment of juvenile salmonids remains a stressor in the lower Yuba River. Entrainment represents a suite of potential negative impacts to juvenile fish that may occur while, or after, the fish encounter a diversion facility in operation. For instance, entrainment impacts may include the non-volitional recruitment of juveniles past a diversion facility and/or screening structure, or impingement upon diversion screens and physical damage to fish caused by diversion activities. It has been suggested that as juvenile salmonids pass Daguerre Point Dam, physical injury may occur as they pass over the dam or through its fish ladders (SWRI 2002).

Water diversions in the lower Yuba River generally begin in the early spring and extend through the fall. As a result, potential threats to juvenile salmonids occur at the Hallwood-Cordua and South Yuba/Brophy diversions (NMFS 2009). The relatively recent fish screen constructed at the Hallwood-Cordua diversion is considered a notable improvement over the previous design, and is believed to reduce the amount of fry and juvenile entrainment at the diversion. The new diversion fish screen is believed to reduce loss rates of emigrating fall-run Chinook salmon at this location. However, predation losses of emigrating fry and juvenile fall-run Chinook salmon may remain a limiting factor at this location. In addition, the configuration of the current return pipe and flows though the pipe may also be a limiting factor (CALFED and YCWA 2005).

As previously described, the South Yuba/Brophy system diverts water through an excavated channel from the south bank of the lower Yuba River in the vicinity of Daguerre Point Dam. The water is then subsequently diverted through a porous rock dike that is intended to exclude fish. The current design of this rock structure does not meet current NMFS or CDFW juvenile fish screen criteria (SWRI 2002), and additional issues regarding predation in the diversion channel and the rate of water bypassing the rock gabion and returning to the lower Yuba River through the diversion channel have been raised as potential stressors.

PREDATION

Predation can occur in three forms: (1) natural; (2) predation resulting from a relative increase in predator habitat and opportunity near major structures and diversions; and (3) predation resulting from minimal escape cover and habitat complexity for prey species (CALFED and YCWA 2005). For the purpose of stressor identification in this BA, predation includes the predation associated with increases in predator habitat and predation opportunities for piscivorous species created by major structures and diversions, and predation resulting from limited amounts of prey escape cover in the lower Yuba River.

The extent of predation on juvenile Chinook salmon in the lower Yuba River is not well documented (NMFS 2009). Although predation is a natural component of salmonid ecology, the rate of predation of salmonids in the lower Yuba River has potentially increased through the introduction of non-native predatory species such as striped bass *(Morone saxatilis),* largemouth bass *(Micropterus salmoides)* and American shad *(Alosa sapidissima)* and through the alteration of natural flow regimes and the development of structures that attract predators (NMFS 2009).

Predatory fish are known to congregate around structures in the water including dams, diversions and bridges, where their foraging efficiency is improved by shadows, turbulence and boundary edges (CDFG 1998). Thus, juvenile salmonids can also be adversely affected by Daguerre Point Dam on their downstream migration. Daguerre Point Dam creates a large plunge pool at its base, which provides ambush habitat for predatory fish in an area where emigrating juvenile salmonids may be disoriented after plunging over the face of the dam into the deep pool below (NMFS 2002). The introduced predatory striped bass and American shad have been observed in this pool (CALFED and YCWA 2005). In addition to introduced predatory species, several native fish species also prey on juvenile salmonids in the lower Yuba River, including Sacramento pikeminnow, hardhead and large juvenile and adult rainbow trout/steelhead (CALFED and YCWA 2005). It has been suggested that the rate of predation of juvenile salmonids passing over dams in general, and Daguerre Point Dam in particular, may be unnaturally high (NMFS 2007), although specific studies addressing this suggestion have not been conducted.

In addition to the suggestion of increased rates of predation resulting from disorientation of juveniles passing over Daguerre Point Dam into the downstream plunge pool, it also has been suggested that unnaturally high predation rates may also occur in the diversion channel associated with the South Yuba/Brophy diversion (NMFS 2007). Other structure-related predation issues include the potential for increased rates of predation of juvenile salmonids: (1) in the entryway of the Hallwood-Cordua diversion canal upstream of the fish screen; and (2) at the point of return of fish from the bypass pipe of the Hallwood-Cordua diversion canal into the lower Yuba River.

HATCHERY EFFECTS

Although no fish hatcheries are located on the lower Yuba River, and the river continues to support a persistent population of spring-run Chinook salmon that spawn downstream of Englebright Dam, the genetic integrity of the fish expressing the phenotypic characteristics of spring-run Chinook salmon is presently uncertain. CDFG (1998) suggested that spring-run Chinook salmon populations may be hybridized to some degree with fall-run Chinook salmon due to lack of spatial separation of spawning habitat. Also, the observation of adipose fin clips on adult Chinook salmon passing upstream through the VAKI system at Daguerre Point Dam during the spring demonstrates that hatchery straying into the lower Yuba River has and continues to occur, most likely from the FRFH (NMFS 2009; RMT 2013).

FEATHER RIVER FISH HATCHERY GENETIC CONSIDERATIONS

Spring-run Chinook salmon from the FRFH were planted in the lower Yuba River during 1980 (CDFG 1991). In addition, it is possible that some hatchery-reared juvenile Chinook salmon from the FRFH may move into the lower Yuba River in search of rearing habitat. Some competition for resources with naturally spawned spring-run Chinook salmon could occur as a result (YCWA et al. 2007). The remainder of this discussion pertains to hatchery effects associated with the straying of adult Chinook salmon into the lower Yuba River.

The FRFH is the only hatchery in the Central Valley that currently produces spring-run Chinook salmon. The FRFH was constructed in 1967 to compensate for anadromous salmonid spawning habitat lost with construction of the Oroville Dam. The FRFH has a goal of releasing 2,000,000 spring-run Chinook salmon smolts annually (DWR 2004c).

From 1962 to 1966, spring-run Chinook salmon were trapped and trucked above Oroville Dam. Beginning in 1967, spring-run Chinook salmon were collected for artificial propagation at FRFH as the construction of Oroville Dam was completed. The program is funded by the DWR and managed by CDFW (NMFS 2004).

The program was founded with local native stock collected at the FRFH. Early attempts to over-summer spring-run at the hatchery resulted in high mortality and the decision to allow the run to hold in the river until September 1. Prior to 2004, FRFH hatchery staff differentiated spring-run Chinook salmon from fall-run Chinook salmon by opening the ladder to the hatchery on September 1 (NMFS 2009). Those fish ascending the ladder from September 1 through September 15 were assumed to be spring-run Chinook salmon while those ascending the ladder after September 15 were assumed to be fall-run (Kastner 2003 as cited in NMFS 2009). This practice led to considerable hybridization between spring- and fall-run Chinook salmon (DWR 2004c). Since 2004, the FRFH fish ladder remains open during the spring months, closing on June 30, and those fish ascending the ladder are marked with an external floy tag and returned to the river. This practice allows FRFH staff to identify those previously marked fish as spring-run when they re-enter the ladder in September. Only floy-tagged fish are spawned with floy-tagged fish in the month of September. No other fish are spawned during this time, as part of an effort to prevent hybridization with fall-run, and to introduce a temporal separation between stocks in the hatchery. During the FRFH spring-run spawning season, all heads from adipose fin-clipped fish are taken and sent to CDFW's laboratory in Santa Rosa for tag extraction and decoding. The tag information will be used to test the hypothesis that early spring-run spawners will produce progeny that maintain that run fidelity.

Regardless of recent improved FRFH practices, previous practices appear to have resulted in hybridization between "spring-run" and "fall-run" Chinook salmon. The following discussion was taken from Garza et al. (2008).

Evaluation of the FRFH “spring-run” stock found that it is genetically most similar to the FRFH fall-run stock, as indicated both by clustering on the phylogeographic trees and by comparison of the [standardized variance in allele frequencies between the sample years] (F_{ST}) values, and is nested within the fall-run group of populations in all analyses (Garza et al. 2008). F_{ST} values between the FRFH “spring-run” and naturally-spawned spring-run are in the low end of the range of values for fall-run populations to spring-run populations, but not the lowest. In addition, they are the essentially the same as those of FRFH fall-run to spring-run populations. This demonstrates convincingly that the FRFH “spring-run” stock is dominated by fall-run ancestry. However, Garza et al. (2008) also found very slight, but significant, differentiation between the two FRFH stocks, which is concordant with the results of Hedgecock et al. (unpublished study as cited in Garza et al. 2008) on these stocks. In addition, Garza et al. (2008) found a strong signal of linkage (gametic phase) disequilbrium, absent in all other population samples, in the FRFH “spring-run” stock. Garza et al. (2008) interpreted this as evidence that the FRFH "spring" run retains remnants of the phenotype and ancestry of the Feather River spring-run Chinook salmon that existed prior to the dam and hatchery (as opposed to representing a hatchery selection-created and maintained phenotypic variant), but that has been heavily introgressed by fall-run Chinook salmon through some combination of hatchery practices and natural hybridization, induced by habitat concentration due to lack of access to spring-run Chinook salmon habitat above the dam. This suggests that it may be possible to preserve some additional component of the ancestral Central Valley spring-run Chinook salmon genomic variation through careful management of this stock that can contribute to the recovery of the ESA-listed Central Valley spring-run Chinook salmon ESU, although it will not be possible to reconstitute a “pure” spring-run stock from these fish.

The FRFH spring-run Chinook salmon population is part of the Central Valley spring-run Chinook salmon ESU (70 FR 37160). At the time of issuance of the final rule regarding the listing status of the Central Valley ESU of spring-run Chinook salmon, NMFS (70 FR 37160) recognized that naturally spawning spring-run Chinook in the Feather River are genetically similar to the FRFH spring-run Chinook stock, and that the hatchery stock shows evidence of introgression with Central Valley fall-run Chinook salmon. NMFS also stated that FRFH stock should be included in the ESU because the FRFH spring-run Chinook salmon stock may play an important role in the recovery of spring-run Chinook salmon in the Feather River Basin, as efforts progress to restore natural spring-run populations in the Feather and Yuba Rivers (70 FR 37160).

Although the FRFH spring-run Chinook salmon population is part of the Central Valley spring-run Chinook salmon ESU, concern has been expressed that straying of FRFH fish into the lower Yuba River may represent an adverse impact due to the potential influence of previous hatchery management practices on the genetic integrity of FRFH spring-run Chinook salmon.

STRAYING INTO THE LOWER YUBA RIVER

The RMT (2013) reported that substantially higher amounts of straying of adipose fin-clipped Chinook salmon into the lower Yuba River occur than that which was previously believed. Although no quantitative analyses or data were presented, NMFS (2007) stated that some hatchery fish stray into the lower Yuba River and that these fish likely come from the FRFH.

Some information indicating the extent to which adipose-clipped Chinook salmon originating from the FRFH return to the lower Yuba River is available from coded wire tag analysis. During the October through December 2010 carcass survey period in the lower Yuba River, the RMT collected heads from fresh Chinook salmon carcasses with adipose fin clips, and sent the heads to the CDFW coded wire tag (CWT) interpretive center. In April of 2011, the results of the interpretation of the CWTs became available. Of the 333 Chinook salmon heads sent to the CDFW interpretive center, 11 did not contain a CWT, 8 were fall-run Chinook salmon from the Coleman National Fish Hatchery, 2 were from the RST captured and tagged juveniles in the lower Yuba River, 1 was a naturally-spawned fall-run Chinook salmon from the Feather River, 1 was a fall-run Chinook salmon from the Mokelumne River Hatchery, and 310 were Chinook salmon from the FRFH (234 spring-run and 76 fall-run Chinook salmon). Thus, for all CWT hatchery-origin fish returning to the Yuba River from out-of-basin sources, 97% were from the FRFH. However, this information does not indicate the percentage of hatchery contribution from the FRFH to the phenotypic spring-run Chinook salmon run in the lower Yuba River, because, among other reasons, all of these heads were collected during the fall and represent a mixture of phenotypic spring- and fall-run Chinook salmon spawning in the lower Yuba River (RMT 2013).

Additional information that can be used to assess the amount of straying of FRFH Chinook salmon into the lower Yuba River is provided from VAKI Riverwatcher data collected from 2004 through 2011 (RMT 2013). The estimated numbers of adipose fin-clipped spring-run Chinook salmon that passed upstream of Daguerre Point Dam from 2004 through 2011 that were derived from the VAKI Riverwatcher data are an indicator of the minimum number of Chinook salmon of hatchery origin (most likely of FRFH origin) that strayed into the lower Yuba River. The following discussion of adipose fin-clipped spring-run Chinook salmon is from RMT (2013). Discussion of the procedure utilized by the RMT (2013) to first differentiate phenotypic spring-run from phenotypic fall-run Chinook salmon is provided in Section 4.2.7.2, below.

Because the VAKI Riverwatcher systems located at both the north and south ladder of Daguerre Point Dam can record both silhouettes and electronic images of each fish passage event, the systems were able to differentiate Chinook salmon with adipose fins clipped or absent from Chinook salmon with their adipose fins intact. Thus, annual series of daily counts of Chinook salmon with adipose fins clipped (i.e., ad-clipped fish) and with adipose fins intact (i.e., not ad-clipped fish) that passed upstream of Daguerre Point Dam from March 1, 2004 through February 29, 2012 were obtained. The estimated numbers of spring-run Chinook salmon of hatchery (i.e., ad-clipped fish) and potentially non-hatchery origin (i.e., not ad-clipped fish) passing upstream of Daguerre Point Dam for the last eight years of available VAKI Riverwatcher data are presented in **Table 4-4**.

RELATIONSHIPS BETWEEN SPRING-RUN CHINOOK SALMON STRAYING INTO THE LOWER YUBA RIVER AND ATTRACTION FLOWS AND WATER TEMPERATURES

As reported by RMT (2013), to evaluate the influence of “attraction” flows and water temperatures on the straying of adipose fin-clipped adult phenotypic spring-run Chinook salmon into the lower Yuba River, variables related to flows and water temperatures in the lower Yuba River and the lower Feather River were developed and statistically related to the weekly proportions of adipose fin-clipped phenotypic spring-run Chinook

Table 4-4. Estimated numbers of Chinook salmon, ad-clipped and not ad-clipped phenotypic spring-run Chinook salmon that passed upstream of Daguerre Point Dam annually from 2004 through 2011 (Source: RMT 2013).

Year	Demarcation Date	Chinook Salmon Passage Upstream of Daguerre Point Dam				
		All Chinook Salmon	Spring-run Chinook Salmon			
			Total	Ad-Clipped	Not Ad-Clipped	% Ad-Clipped
2004	8/1/04	5,927	738	72	666	10
2005	8/24/05	11,374	3,592	676	2,916	19
2006	9/6/06	5,203	1,326	81	1,245	6
2007	9/4/07	1,394	372	38	334	10
2008	8/10/08	2,533	521	15	506	3
2009	7/9/09	5,378	723	213	510	29
2010	7/6/10	6,469	2,886	1,774	1,112	61
2011	9/7/11	7,785	1,159	323	836	28

salmon (relative to all spring-run Chinook salmon) passing upstream of Daguerre Point Dam during each of the 8 years when annual VAKI Riverwatcher counts at Daguerre Point Dam are available. Details of this analytical evaluation are provided in RMT (2013).

Results of the RMT (2013) analysis suggest that there is a moderately strong (R^2=0.72) and highly significant ($P < 0.000001$) relationship between the percentage of adipose fin-clipped spring-run Chinook salmon contribution to the weekly spring-run Chinook salmon total counts at Daguerre Point Dam and the attraction flow and water temperature indices four weeks prior. The attraction flow index explained 20.4% of the data variability, the attraction water temperature index explained 27.5% of the variability, and the interaction term explained 24.4% of the variability in the proportion of adipose fin-clipped phenotypic spring-run Chinook salmon passing Daguerre Point Dam weekly (RMT 2013). **Figure 4-5** displays the 3-D response surface produced by the fitted logistic model.

The analysis described above showed that an estimated 72% of the variation in the proportion of adipose fin-clipped phenotypic spring-run Chinook salmon passing upstream of Daguerre Point Dam can be accounted for by the ratio of lower Yuba River flow relative to lower Feather River flow, and the ratio of lower Yuba River water temperature relative to lower Feather River water temperature, four weeks prior to the

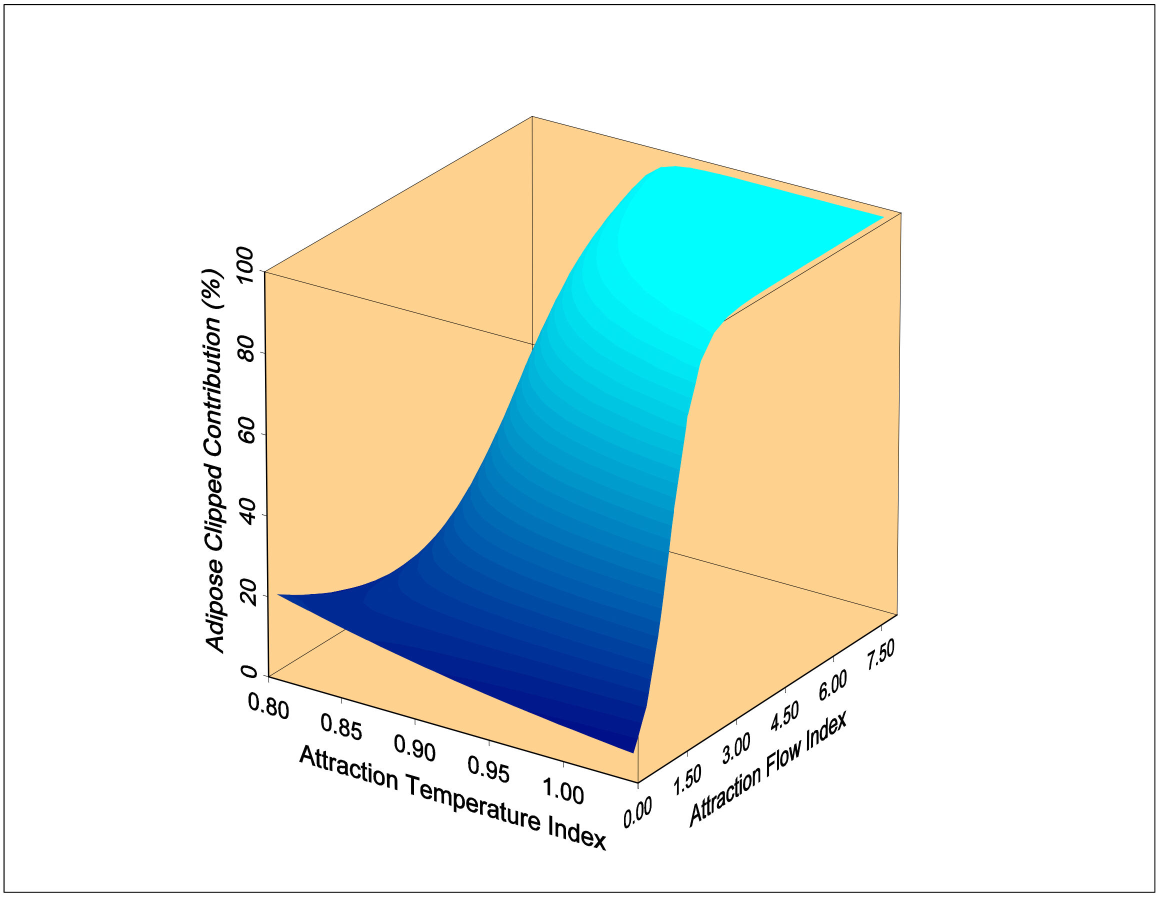

Figure 4-5. Relationship of the weekly percentage of adipose fin-clipped contribution to the weekly phenotypic spring-run Chinook salmon count at Daguerre Point Dam as function of the weekly attraction flow and water temperature indices calculated four weeks prior to the week of passage at Daguerre Point Dam (Source: RMT 2013).

time of passage at Daguerre Point Dam. In other words, the higher the Yuba River flows relative to Feather River flows, combined with the lower the Yuba River water temperatures relative to Feather River water temperatures, the higher the percentage of fin-clipped Chinook salmon passing upstream of Daguerre Point Dam four weeks later (RMT 2013).

As described in RMT (2013), the acoustically-tagged phenotypic spring-run Chinook salmon spent variable and extended periods of time holding below Daguerre Point Dam after being tagged and prior to passing upstream of Daguerre Point Dam, with a range of 0 to 116 days. Based on all 67 acoustically-tagged spring-run Chinook salmon that passed upstream of Daguerre Point Dam, the average holding time before passing upstream of Daguerre Point Dam was about 50 days. For the phenotypic acoustically-tagged spring-run Chinook salmon that passed upstream of Daguerre Point Dam by the annual spring-run Chinook salmon demarcation date for each year, the average holding periods before passing upstream of Daguerre Point Dam were approximately 51, 41, and 57 days during 2009, 2010 and 2011, respectively. Therefore, it would be expected that attraction of adipose fin-clipped fish to the lower Yuba River associated with flows and water temperatures in the lower Yuba River relative to the lower Feather River would occur at least several weeks prior to passage of phenotypic spring-run Chinook salmon upstream of Daguerre Point Dam (RMT 2013).

While the variation in the proportion of adipose fin-clipped phenotypic spring-run Chinook salmon passing Daguerre Point Dam was best explained with ratios of flows and water temperatures in the lower Yuba and Feather rivers four weeks prior to passage at Daguerre Point Dam, the acoustically-tagged individuals exhibited a somewhat longer duration of holding on average. However, due to the relatively small sample size of acoustically-tagged spring-run Chinook salmon passing upstream of Daguerre Point Dam (N=67), the short duration of the study, and based on the highly variable holding duration (i.e., 0-116 days), the average holding time calculated for the acoustically-tagged spring-run Chinook salmon is considered to be a general approximation of holding duration downstream of Daguerre Point Dam (RMT 2013). Therefore, consideration of holding duration downstream of Daguerre Point Dam supports the observation that the ratios of flows and water temperatures in the lower Yuba River relative to the lower Feather River four weeks prior to passage of spring-run Chinook salmon at Daguerre Point Dam may be influencing the attraction of adipose fin-clipped spring-run Chinook salmon of FRFH-origin into the lower Yuba River (RMT 2013).

LOWER YUBA RIVER GENETIC CONSIDERATIONS

Spring-run Chinook salmon historically acquired and maintained genetic integrity through reproductive (spatial-temporal) isolation from other Central Valley Chinook salmon runs. However, construction of dams has prevented access to headwater areas and much of this historical reproductive isolation has been compromised, resulting in intermixed life history traits in many remaining habitats (YCWA 2010).

Between 1900 and 1941, debris dams constructed on the lower Yuba River by the California Debris Commission to retain hydraulic mining debris, now owned and operated by the Corps, completely or partially blocked the migration of Chinook salmon and steelhead to historic spawning and rearing habitats (CDFG 1991a; Wooster and Wickwire 1970; Yoshiyama et al. 1996). Englebright Dam (constructed in 1941) completely blocks spawning runs of Chinook salmon and steelhead, and is the upstream limit of fish migration. Fry (1961) reported that a small spring-run Chinook salmon population historically occurred in the lower Yuba River, but the run virtually disappeared by 1959.

Since the completion of New Bullards Bar Reservoir in 1970 by YCWA, higher, colder flows in the lower Yuba River have improved conditions for over-summering and spawning of spring-run Chinook salmon in the lower Yuba River (YCWA et al. 2007). As of 1991, a remnant spring-run Chinook salmon population reportedly persisted in the lower Yuba River downstream of Englebright Dam maintained by fish produced in the lower Yuba River, fish straying from the Feather River, or fish previously and infrequently stocked from the FRFH (CDFG 1991). In the 1990s, relatively small numbers of Chinook salmon that exhibit spring-run phenotypic characteristics were reported to have been observed in the lower Yuba River (CDFG 1998). Although precise escapement estimates are not available, the USFWS testified at the 1992 SWRCB lower Yuba River hearing that "*…a population of about 1,000 adult spring-run Chinook salmon now exists in the lower Yuba River*" (San Francisco Bay RWQCB 2006).

If spring-run Chinook salmon were extirpated from the lower Yuba River in 1959 (Fry 1961) and, as reported by CDFG (1991), a population of spring-run Chinook salmon became reestablished since the 1970s due to improved habitat conditions and fish straying from the Feather River or stocked and straying from the FRFH, then it is likely that spring-run Chinook salmon on the lower Yuba river do not represent a "pure" ancestral genome.

There also is concern that the existing spring-run Chinook salmon population has interbred with fall-run Chinook salmon and, as a result, it is a hybrid species and not a true spring-run species (Corps 2001). In addition to the effects of hatchery straying, an additional issue regarding the genetic integrity of phenotypic spring-run Chinook salmon in the lower Yuba River pertains to the loss or reduction of reproductive isolation.

Spring-run Chinook salmon acquired and maintained genetic integrity through spatial-temporal isolation from other Central Valley Chinook salmon runs. Historically, spring-run Chinook salmon were temporally isolated from winter-run, and largely isolated in both time and space from the fall-run. Much of this historical spatial-temporal integrity has broken down, resulting in intermixed life history traits in many remaining habitats. Consequently, the present self-sustaining, persistent populations of spring-run Chinook salmon in the upper Sacramento, lower Yuba, and lower Feather rivers may be hybridized to some degree with fall-run Chinook salmon (YCWA et. al 2007).

Englebright Dam is a complete migration barrier to anadromous fish, precluding migration of Chinook salmon to historical holding and spawning areas upstream of the dam. Consequently, both fall-run and spring-run Chinook salmon are restricted to areas below the dam. Because the spawn timing overlaps between the two runs and they potentially interbreed, genetic swamping of the relatively smaller numbers of spring-run Chinook salmon by more abundant fall-run fish could occur (DWR and PG&E 2010).

The presence of Englebright Dam has necessitated that spring-run Chinook salmon spawn in areas that were believed to formerly represent fall-run Chinook salmon spawning areas. Although the lower Yuba River continues to support a persistent population of spring-run Chinook salmon that now are restricted to spawning downstream of Englebright Dam, the genetic integrity of the fish expressing the phenotypic characteristics of spring-run Chinook salmon is presently uncertain. For example, CDFG (1998) suggests that spring-run populations may be hybridized to some degree with fall-run populations due to lack of spatial separation of spawning habitat for the two runs of Chinook salmon in the lower Yuba River.

In the report titled *Salmonid Hatchery Inventory and Effects Evaluation* (NMFS 2004), through an analysis of Yuba River Chinook salmon tissues, NMFS genetically linked the spring-run and fall-run populations, which exhibit a merged run timing similar to that found in the Feather River.

In conclusion, available information indicates that: (1) the phenotypic spring-run Chinook salmon in the lower Yuba River actually represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, and hybridization with

Feather River stocks including the FRFH spring-run Chinook salmon stock, which itself represents a hybridization between Feather River fall- and spring-run Chinook salmon populations; and (2) straying from FRFH origin "spring-run" Chinook salmon into the lower Yuba River occurs, and that this rate of straying is associated with the relative proportion of lower Yuba River flows and water temperatures to lower Feather River flows and water temperatures ("attraction flows and water temperatures"); and (3) the FRFH spring-run Chinook salmon is included in the ESU, in part because of the important role this stock may play in the recovery of spring-run Chinook salmon in the Feather River Basin, including the Yuba River (70 FR 37160). Although straying of FRFH "spring-run" Chinook salmon into the lower Yuba River has oftentimes been suggested to represent an adverse impact on lower Yuba River spring-run Chinook salmon stocks, it is questionable whether the phenotypic spring-run Chinook salmon in the lower Yuba River represents an independent population. The RMT (2013) recently reported that data obtained through the course of implementing the RMT's M&E Program demonstrate that phenotypically "spring-running" Chinook salmon in the lower Yuba River do not represent an independent population – rather, they represent an introgressive hybridization of the larger Feather-Yuba river regional population.

JUVENILE STRANDING AND REDD DEWATERING

In the California State Water Resources Control Board's (SWRCB) 2001 Decision (D)-1644, the SWRCB directed YCWA to submit a plan that described the scope and duration of future flow fluctuation studies to verify that Chinook salmon and steelhead redds are being adequately protected from dewatering with implementation of D-1644 criteria (YCWA 1992). The monitoring and evaluation plan contained the following objectives (JSA 2003):

- ☐ Determine the potential magnitude of redd dewatering in relation to the timing and magnitude of flow fluctuations and reductions
- ☐ Determine the potential magnitude of fry stranding in relation to the timing, magnitude, and rate of flow fluctuations and reductions
- ☐ Evaluate the effectiveness of the D-1644 flow fluctuation and reduction criteria in protecting redds and fry

- ☐ Recommend additional measures to protect redds and fry from flow fluctuations and reductions if warranted

The studies combined habitat mapping, field surveys, and information on the timing and distribution of fry rearing in the Yuba River to evaluate the effectiveness of D-1644 flow fluctuation and reduction criteria in protecting Chinook salmon and steelhead fry. Two studies were conducted and summarized in the 2007 and 2008 *Lower Yuba River Redd Dewatering and Fry Stranding Annual Report* (JSA 2008) to the SWRCB, and results from an additional study were reported in a progress report in 2010 (ICF Jones & Stokes 2010). A preliminary draft report providing the results of all survey activities conducted during 2007 through 2011 was produced in 2012 (ICF Jones & Stokes 2012), although additional evaluation and reporting of the data is ongoing.

The first *Lower Yuba River Redd Dewatering and Fry Stranding Study* was conducted in April 2007 to evaluate bar and off-channel stranding of juvenile salmonids associated with a flow reduction of 1,300-900 cfs at Smartsville at a ramping rate of 100 cfs per hour. Bar stranding was again evaluated in June with a temporary flow reduction of 1,600-1,300 cfs at a rate of 100 cfs per hour. Snorkel surveys were conducted between Rose Bar, located ~2.5 miles downstream of Englebright Dam, and the Highway 20 Bridge, located ~5.7 miles downstream of Englebright Dam.

During the April 5, 2007 drawdown, field crews observed eight stranded salmon fry in the interstitial spaces of substrates on bar slopes (perpendicular to shoreline) ranging from 0.5 to 5.5% in slope. No stranded fish were observed during surveys conducted on June 18, 2007. The presence of both juvenile Chinook salmon and *O. mykiss* were confirmed in shallow, near-shore areas adjacent to the study sites, suggesting that the risk of bar stranding is greatly reduced by June. Following the April 5, 2007 flow reductions, juvenile salmon were found in 16 of the 24 disconnected off-channel sites (ICF Jones & Stokes 2012). Most of the fish that had become isolated in off-channel sites were 30-50 mm fry. Out of the 16 sites where isolation of fry was observed, 70% of the fish were found in the four largest sites, which accounted for nearly 60% of the total wetted area that had become disconnected from the main river. According to ICF Jones & Stokes (2012), these four sites were unique in that they were all associated with man-made features within or adjacent to the main river channel (e.g., diversion channels, ponds and bridge piers).

An updated *Lower Yuba River Redd Dewatering and Fry Stranding Study* was subsequently conducted from May 29, 2008 through June 4, 2008 with a scheduled flow reduction on June 1, 2008. A total of seven stranded trout fry ranging between 30-35 mm were observed in the interstitial spaces of substrates on bar slopes ranging from 2.0 to 5.7% in slope.

Juvenile salmon were found isolated in seven of the 12 off-channel sites that had become disconnected from the main river by the June 1, 2008 event. One site accounted for only about 7% of the total wetted area that had been disconnected from the main river, but nearly 80% of the total number of juvenile salmon that had been isolated by the June 1, 2008 event. A total of 13 steelhead fry were found isolated in 2 of the 12 off-channel sites that had become disconnected from the main river by the June 1, 2008 event. Nearly all of these fish were 30-50 mm fry that had been isolated in a single backwater pool adjacent to the main river in the Timbuctoo Reach (ICF Jones & Stokes 2012).

JSA (2008) suggested that the preliminary findings indicated that juvenile *O. mykiss* fry may be less vulnerable to off-channel stranding than juvenile Chinook salmon because of their more restricted distribution and inability to access off-channel areas under late spring flow conditions. Long-term monitoring of several isolated off-channel sites confirmed that some sites can support juvenile salmonids for long periods and even produce favorable summer rearing conditions.

A 2010 study was conducted from June 21, 2010 through July 1, 2010, with a scheduled flow reduction between June 28 and June 30 from approximately 4,000 cfs to 3,200 cfs as measured at the Smartsville Gage. As reported by ICF Jones & Stokes (2010), fish stranding surveys were conducted on June 21, 22, and 23 to identify potential stranding areas and document habitat conditions and fish presence before the flow reduction, and were repeated on June 29, June 30, and July 1 to document the incidence of fish stranding and habitat conditions after the flow reduction.

After the June flow reduction, a total of six juvenile salmon and 46 juvenile trout was observed in seven of the 26 off-channel sites that had become fully or nearly disconnected (≤0.1 foot deep) from the main river. Most of the stranded fish were juvenile trout 30-70 mm in length that had become isolated in five off-channel sites above Daguerre Point Dam. Below Daguerre Point Dam, observations of stranded fish were limited to six juvenile salmon and two juvenile trout at two study sites (ICF Jones & Stokes 2010).

Hydrologic and operating conditions in January and February 2011 provided the first opportunity to evaluate the effect of a winter flow reduction on the incidence of bar stranding. A series of three successive flow reductions were evaluated. Following a 3-week period of relatively stable flows, Englebright Dam releases were reduced from 3,000-2,600 cfs on January 31, 2,600-2,200 cfs on February 7, and 2,200-2,000 cfs on February 11.

The first event was a 400-cfs flow reduction (3,000–2,600 cfs) conducted from 8:00 AM to 10:00 AM at a target rate of 200 cfs per hour on January 31, 2011. This event resulted in a 2.1–2.5 inch drop in water surface elevation and a rate of change of 0.6–0.8 inch per hour at the three study sites. Field crews searched a total of 764 square feet of dewatered shoreline and found a total of 20 stranded salmon fry (30-40 mm long) and six stranded steelhead (50-90 mm long) (ICF Jones & Stokes 2012).

During the second event on February 7, 2011, flows were again reduced by 400 cfs (2,600–2,200 cfs) from 8:00 AM to 10:00 AM, but at a target rate of 100 cfs per hour. This event resulted in a 1.8–2.1 inch drop in water surface elevation and a rate of change of 0.4–0.5 inch per hour at the three study sites. Field crews searched a total of 560 square feet of dewatered shoreline and found a total of 10 stranded salmon fry (30-40 mm long) and no steelhead (ICF Jones & Stokes 2012).

During the third event on February 11, 2011, flows were reduced by 200 cfs (2,200–2,000 cfs) from 2:00 AM to 4:00 AM at a target rate of 100 cfs per hour. This event resulted in a 0.8–1.3 inch drop in water surface elevation and a rate of change of 0.4–0.7 inch per hour at the three study sites. Field crews searched a total of 248 square feet of dewatered shoreline and found a total of four stranded salmon fry (30-40 mm long) and no steelhead (ICF Jones & Stokes 2012).

4.2.7 Viability of Central Valley Spring-run Chinook Salmon

The "Viable Salmonid Population" (VSP) concept was developed by McElhany et al. (2000) to facilitate establishment of Evolutionarily Significant Unit (ESU)-level delisting goals and to assist in recovery planning by identifying key parameters related to population viability. Four key parameters were identified by McElhany et al. (2000) as the key to evaluating population viability status: (1) abundance; (2) productivity; (3) diversity; and (4) spatial structure. McElhany et al. (2000) interchangeably use the term population growth rate (i.e., productivity over the entire life cycle) and productivity. Good et al. (2007) used the term productivity when describing this VSP parameter, which also is the term used for this parameter in this BA. The following discussion regarding the four population viability population parameters was taken directly from NMFS (2009).

Abundance is an important determinant of risk, both by itself and in relationship to other factors (McElhany et al. 2000). Small populations are at a greater risk for extinction than larger populations because risks that affect the population dynamics operate differently on small populations than in large populations. A variety of risks are associated with the dynamics of small populations, including directional effects (i.e., density dependence - compensatory and depensatory), and random effects (i.e., demographic stochasticity, environmental stochasticity, and catastrophic events).

The parameter of productivity and factors that affect productivity provide information on how well a population is "performing" in the habitats it occupies during the life cycle (McElhany et al. 2000). Productivity and related attributes are indicators of a population's performance in response to its environment and environmental change and variability. Intrinsic productivity (the maximum production expected for a population sufficiently small relative to its resource supply not to experience density dependence), the intensity of density dependence, and stage-specific productivity (productivity realized over a particular part of the life cycle) are useful in assessing productivity of a population.

Diversity refers to the distribution of traits within and among populations, and these traits range in scale from DNA sequence variation at single genes to complex life-history traits

(McElhany et al. 2000). Traits can be completely genetic or vary due to a combination of genetics and environmental factors. Diversity in traits is an important parameter because: (1) diversity allows a species to use a wide array of environments; (2) diversity protects a species against short-term spatial and temporal changes in its environment; and (3) genetic diversity provides the raw material for surviving long-term environmental changes (McElhany et al. 2000). Some of the varying traits include run timing, spawning timing, age structure, outmigration timing, etc. Straying and gene flow strongly influence patterns of diversity within and among populations (McElhany et al. 2000).

Spatial structure reflects how abundance is distributed among available or potentially available habitats, and how it can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change. A population's spatial structure encompasses the geographic distribution of that population, as well as the processes that generate or affect that distribution (McElhany et al. 2000). A population's spatial structure depends fundamentally on habitat quality, spatial configuration, and dynamics as well as the dispersal characteristics of individuals in the population. Potentially suitable but unused habitat is an indication of the potential for population growth.

4.2.7.1 ESU

To determine the current viability of the spring-run Chinook salmon ESU, NMFS (2009a) used the historical population structure of spring-run Chinook salmon presented in Lindley et al. (2007) and the concept of VSP for evaluating populations described by McElhany et al. (2000). Lindley et al. (2004) identified 26 historical populations within the spring-run ESU; 19 were independent populations, and 7 were dependent populations. Of the 19 independent populations of spring-run that occurred historically, only three remain, in Deer, Mill, and Butte creeks. Extant dependent populations occur in Battle, Antelope, Big Chico, Clear, Beegum, and Thomes creeks, as well as in the Yuba River, the Feather River below Oroville Dam, and in the mainstem Sacramento River below Keswick Dam (NMFS 2009a).

Lindley et al. (2007) provide criteria to assess the level of risk of extinction of Pacific salmonids based on population size, recent population decline, occurrences of catastrophes within the last 10 years that could cause sudden shifts from a low risk state to a higher one, and the impacts of hatchery influence. Although these criteria were developed for application to specific populations, insight to the viability of the spring-run Chinook salmon ESU can be obtained by examining population trends within the context of these criteria.

VIABLE SALMONID POPULATION (VSP) PARAMETERS AND APPLICATION

ABUNDANCE

According to NMFS (2009a), spring-run Chinook salmon in the Central Valley declined drastically in the mid- to late 1980s before stabilizing at very low levels in the early to mid-1990s. Since the late 1990s, there does not appear to be a trend in basin-wide abundance (NMFS 2009a). Since NMFS presented these data, additional abundance estimates are available for the spring-run Chinook salmon ESU.

Central Valley-wide spring-run Chinook salmon abundance estimates are available through GrandTab (CDFW 2013). Since 1983, in-river estimates for the lower Feather River have not been included in the system-wide estimates, although FRFH estimates are provided separately. Additionally, spring-run Chinook salmon are not estimated in GrandTab for the lower Yuba River, and all lower Yuba River Chinook salmon escapement estimates are reported as fall-run Chinook salmon. For the Sacramento River system (not including the FRFH or the lower Yuba River) since 1983, spring-run Chinook salmon run size estimates have ranged from a high of 24,903 in 1998 to a low of 1,404 in 1993. For the past five years (2008 - 2012), the abundance of in-river spawning Central Valley spring-run Chinook salmon has steadily declined from a high of 11,927 in 2008 to a low of 2,962 in 2010, before increasing to 5,439 in 2011 and 18,511 in 2012.

The spring-run Chinook salmon run size estimate for the Sacramento River system (not including the FRFH or the lower Yuba River) over the past three consecutive years for which data are available averaged 8,971 fish (i.e., 2,962 fish in 2010, 5,439 fish in 2011, and 18,511 fish in 2012).

PRODUCTIVITY

The spring-run Chinook salmon run size estimate for the Sacramento River system (not including the FRFH or the lower Yuba River) over the past three consecutive years totaled 26,912 fish, thereby exceeding both the minimum total escapement value of 2,500 (Lindley et al. 2007), as well as the mean value of 833 fish per year identified by NMFS (2011a).

From 1983 through 2012, the annual contribution of spring-run Chinook salmon from the FRFH to the total annual run size in the Sacramento River system has ranged from a high of 76.9% (4,672 fish) in 1993 to a low of 5.6% (1,433 fish) in 1986. As an indicator of the FRFH influence on spring-run Chinook salmon in the Sacramento River system, the average annual percent contribution of FRFH spring-run Chinook salmon relative to the total annual run in the Sacramento River system was 31.2% over the entire 30-year period (1983-2012), and was 20.7% over the last 10 years (2003-2012). The percent contribution of FRFH to the total population of Central Valley spring-run Chinook salmon does not represent straying *per se*. The guidelines presented in Figure 1 in Lindley et al. (2007) present extinction risk levels corresponding to different amount, duration and source of hatchery strays, taking into consideration whether hatchery strays are from within the ESU, the diversity group, and from a "best management practices" hatchery. These criteria indicate a high extinction risk if hatchery straying represents more than 20% hatchery contribution for one generation or more than 10% for four generations from a hatchery within a given diversity group, or more than 50% hatchery contribution for one generation or more than 15% for four generations from a best management practices hatchery within a given diversity group. Although not technically representing straying, the average contribution of spring-run Chinook salmon from the FRFH to the total annual run size in the Sacramento River system has been 26.4% over the most recent generation, 21.6% over the two most recent generations, 19.8% over the three most recent generations, and 19.9% over the four most recent generations assuming a three-year life cycle. According to NMFS (2011a), recent anomalous conditions in the coastal ocean, along with consecutive dry years affecting inland freshwater conditions, have contributed to statewide escapement declines.

SPATIAL STRUCTURE

Lindley et al. (2007) indicated that of the 19 independent populations of spring-run that occurred historically, only three (Butte, Mill, and Deer creeks) remain, and their current distribution makes the spring-run ESU vulnerable to catastrophic disturbance (e.g., disease outbreaks, toxic spills, or volcanic eruptions). Butte, Mill, and Deer Creeks all occur in the same biogeographic region (diversity group), whereas historically, independent spring-run populations were distributed throughout the Central Valley among at least three diversity groups (i.e., the Basalt and Porous Lava Diversity Group, the Northern Sierra Nevada Diversity Group, and the Southern Sierra Nevada Diversity Group). In addition, dependent spring-run populations historically persisted in the Northwestern California Diversity Group (Lindley et al. 2004). Currently, there are dependent populations of spring-run Chinook salmon in the Big Chico, Antelope, Clear, Thomes, Battle, and Beegum creeks, and in the Sacramento, Feather, and Yuba rivers (Lindley et al. 2007).

Spring-run Chinook salmon have been reported more frequently in several upper Central Valley creeks, but the sustainability of these runs is still unknown (NMFS 2004). In 2004, NMFS reported that Butte Creek spring-run cohorts had recently utilized all available habitat in the creek, so the population cannot expand further. It is unknown if individuals have opportunistically migrated to other systems. The spatial structure of the Central Valley spring-run Chinook salmon ESU has been reduced with the extirpation of all San Joaquin River Basin spring-run populations (NMFS 2004).

DIVERSITY

As discussed in NMFS (2009a), diversity, both genetic and behavioral, provides a species the opportunity to track environmental changes. As a species' abundance decreases, and spatial structure of the ESU is reduced, a species has less flexibility to track changes in the environment. Spring-run Chinook salmon reserve some genetic and behavioral variation in that in any given year, at least two cohorts are in the marine environment and, therefore, are not exposed to the same environmental stressors as their freshwater cohorts (NMFS 2009a).

Genetic analysis of natural and hatchery spring-run Chinook salmon stocks in the Central Valley reveal that the southern Cascades spring-run population complex has retained its genetic integrity (NMFS 2004). However, although spring-run produced at the FRFH are part of the spring-run Chinook salmon ESU (70 FR 37160, June 28, 2005), they compromise the genetic diversity of naturally-spawned spring-run Chinook salmon (NMFS 2009a). The spring-run hatchery stock introgressed with the fall-run hatchery stock, and both are genetically linked with the natural populations in the Feather River (NMFS 2004). The FRFH program has affected the diversity of the Central Valley spring-run Chinook salmon and, together with the loss of the San Joaquin River Basin spring-run populations, the diversity of the Central Valley spring-run Chinook salmon ESU has been reduced (NMFS 2004).

SUMMARY OF THE VIABILITY OF THE CENTRAL VALLEY SPRING-RUN CHINOOK SALMON ESU

According to NMFS (2005a), threats from hatchery production, climatic variation, predation, and water diversions persist. Because the Central Valley spring-run Chinook salmon ESU is confined to relatively few remaining streams and continues to display broad fluctuations in abundance, high quality critical habitat containing spawning sites with adequate water and substrate conditions, or rearing sites with adequate floodplain connectivity, cover, and water conditions (i.e., key primary constituent elements of critical habitat that contribute to its conservation value) is considered to be limited and the population is at a moderate risk of extinction.

According to NMFS (2009a), spring-run Chinook salmon fail the representation and redundancy rule for ESU viability, because the current distribution of independent populations has been severely constricted to only one of their former geographic diversity groups. NMFS (2009a) concluded that the Central Valley spring-run Chinook salmon ESU is at moderate risk of extinction in 100 years.

In 2011, NMFS completed a 5-year status review of the Central Valley spring-run Chinook salmon ESU. According to NMFS (2011b), new information for the Central Valley spring-run Chinook salmon ESU suggests an increase in extinction risk. With a few exceptions, Central Valley spring-run Chinook salmon escapements has declined over the past 10 years, in particular since 2006 (NMFS 2011b). Overall, the recent declines have been significant but not severe enough to qualify as a catastrophe under the criteria of Lindley et al. (2007). On the positive side, spring-run Chinook salmon appear to be repopulating Battle Creek, home to a historical independent population in the Basalt and Porous Lava diversity group that was extirpated for many decades. Similarly, the spring-run Chinook salmon population in Clear Creek has been increasing, although Lindley et al. (2004) classified this population as a dependent population, and thus it is not expected to exceed the low-risk population size threshold of 2,500 fish (i.e., annual spawning run size of about 833 fish).

The status of the Central Valley spring-run Chinook salmon ESU has probably deteriorated on balance since the 2005 status review and Lindley et al.'s (2007) assessment, with two of the three extant independent populations of spring-run Chinook salmon slipping from low or moderate extinction risk to high extinction risk (NMFS 2011b). Butte Creek remains at low risk, although it is on the verge of moving towards high risk (NMFS 2011b). By contrast, spring-run Chinook salmon in Battle and Clear creeks have increased in abundance over the last decade, reaching levels of abundance that place these populations at moderate extinction risk (NMFS 2011b).

In summary, NMFS (2011b) states that the status of the Central Valley spring-run Chinook salmon ESU has probably deteriorated since the 2005 status review. From 2007-2009, the Central Valley experienced drought conditions and low river and stream discharges, which are generally associated with lower survival of Chinook salmon (NMFS 2011b). There is a possibility that with the recent cessation of the drought and a return to more typical patterns of upwelling and sea-surface temperatures that declining trends in abundance may reverse in the near future (NMFS 2011b). According to NMFS (2011b), improvements in the status of two spring-run Chinook salmon populations in the Central Valley are not sufficient to warrant a downgrading of the ESU extinction risk, and the degradation in status of three formerly low- or moderate-risk independent populations is cause for concern. New information available since Good et al. (2005) indicates an increased extinction risk (NMFS 2011b).

4.2.7.2 Lower Yuba River

As previously discussed, the VSP concept was developed by McElhany et al. (2000) in order to facilitate establishment of ESU-level delisting goals and to assist in recovery planning by identifying key parameters related to population viability. The four parameters established by McElhany et al. (2000) included abundance, productivity, spatial structure and genetic and life-history diversity, although McElhany et al. (2000) did not provide quantitative criteria that would allow assessment of whether particular populations or ESUs/DPSs are viable.

Lindley et al. (2007) characterized the spring-run Chinook salmon population in the lower Yuba River as data deficient, and therefore did not characterize its viability. In 2007, there was limited information on the current population size of spring-run Chinook salmon in the lower Yuba River, although NMFS (2009) stated that ongoing monitoring is providing additional information.

ABUNDANCE AND PRODUCTIVITY

RUN DIFFERENTIATION (SPRING-RUN VS. FALL-RUN CHINOOK SALMON)

Prior to application of VSP performance indicators or the extinction risk criteria, it is necessary to differentiate between annually returning spring-run and fall-run Chinook salmon in the lower Yuba River.

However, as reported by RMT (2013), there is no discernible genetic differentiation available to determine spring-run Chinook salmon, only phenotypic differentiation. The phenotypic expression is often obscure, requiring application of advanced statistical techniques to VAKI Riverwatcher and other datasets in order to identify the phenotypic differences in run timing. The following discussion of differentiating phenotypic spring-run from phenotypic fall-run Chinook salmon in the lower Yuba River is generally taken from RMT (2013).

Infrared-imaging technology has been used to monitor fish passage at Daguerre Point Dam in the lower Yuba River since 2003 using VAKI Riverwatcher systems to document specific observations used to address VSP parameters of adult abundance and diversity. The VAKI Riverwatcher infrared systems produced by VAKI Aquaculture Systems Ltd., of Iceland, provided a tool for monitoring fish passage year-round. The VAKI Riverwatcher system records both silhouettes and electronic images of each fish passage event in both of the Daguerre Point Dam fish ladders. By capturing silhouettes and images, fish passage can be accurately monitored even under turbid conditions.

The VAKI Riverwatcher systems located at both the north and south ladder of Daguerre Point Dam were able to record and identify the timing and magnitude of passage for Chinook salmon at Daguerre Point Dam during most temporal periods of a given year.

Prior to applying any analysis of temporal modalities to the 8 annual time series of Chinook salmon daily VAKI counts, the annual daily count series at each ladder were adjusted to account for days when the VAKI Riverwatcher systems were not fully operational. The procedure used to obtain complete annual daily count series of Chinook salmon migrating upstream of Daguerre Point Dam is provided in RMT (2013).

The daily time series of Chinook salmon moving upstream of Daguerre Point Dam resulting from the previous step were further analyzed and temporal modalities were explored to differentiate spring-run from fall-run Chinook salmon each year. For a full description of the run differentiation process, see RMT (2013).

Figure 4-6 and **Figure 4-7** display the daily number of Chinook salmon that passed upstream of Daguerre Point Dam during the 2004 to the 2011 biological years (March 1 through February 28) and the fitted generalized logistic functions describing the distributions of spring-run and fall-run Chinook salmon resulting from the application of the annually variable temporal demarcation procedure. Finally, **Table 4-5** summarizes the total number of spring-run and fall-run Chinook salmon estimated to have passed upstream of Daguerre Point Dam annually, and the estimated annual percentage of spring-run Chinook salmon relative to all Chinook salmon each year.

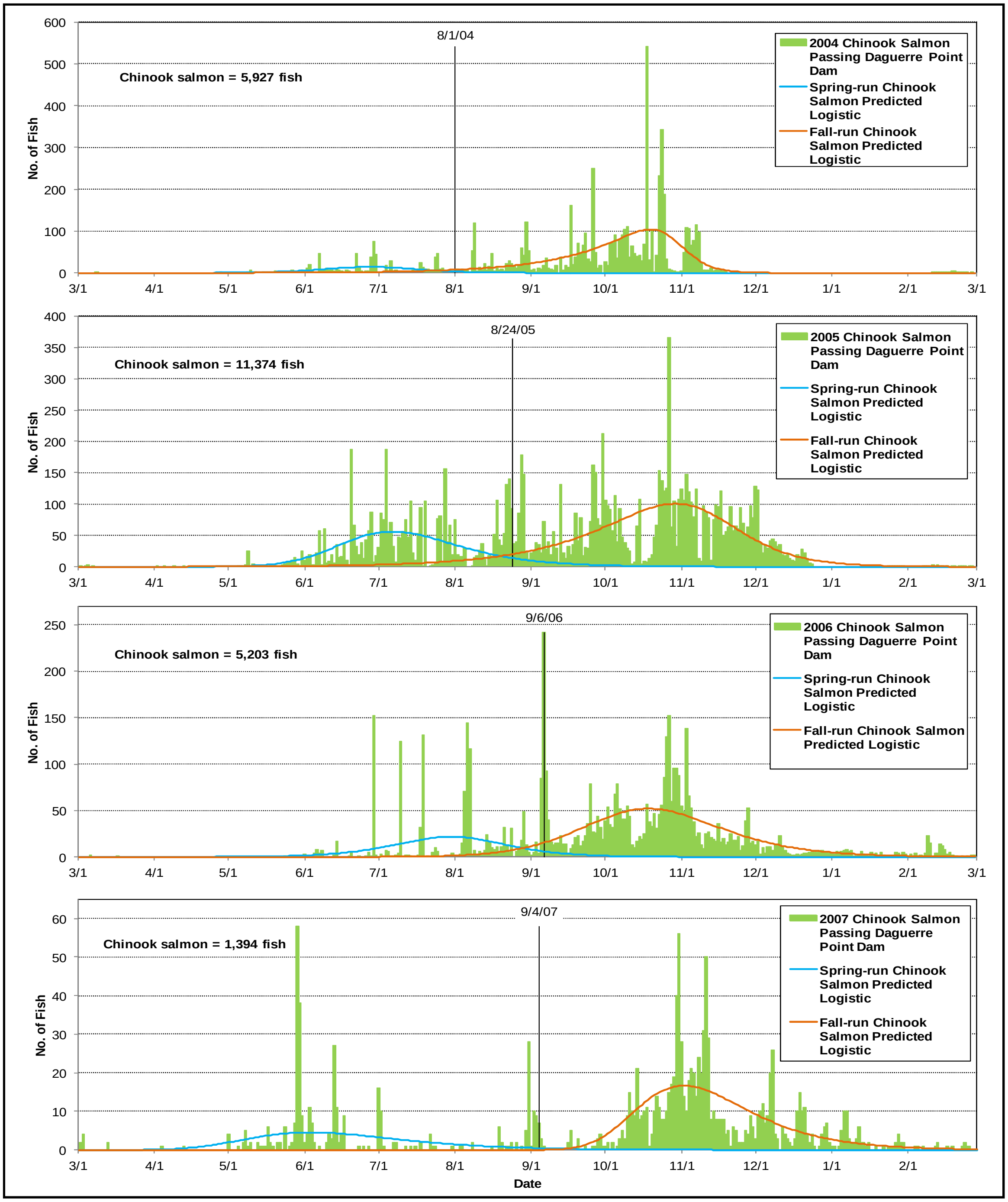

Figure 4-6. Daily number of Chinook salmon passing upstream of Daguerre Point Dam during the 2004 to 2007 biological years. Bars indicate the VAKI Riverwatcher daily counts and lines indicate the predicted daily distributions of spring-run (blue line) and fall-run (orange line) Chinook salmon based on the fitting of two generalized logistic functions to the data. The demarcation date differentiating the two runs of Chinook salmon is indicated for each year (Source: RMT 2013).

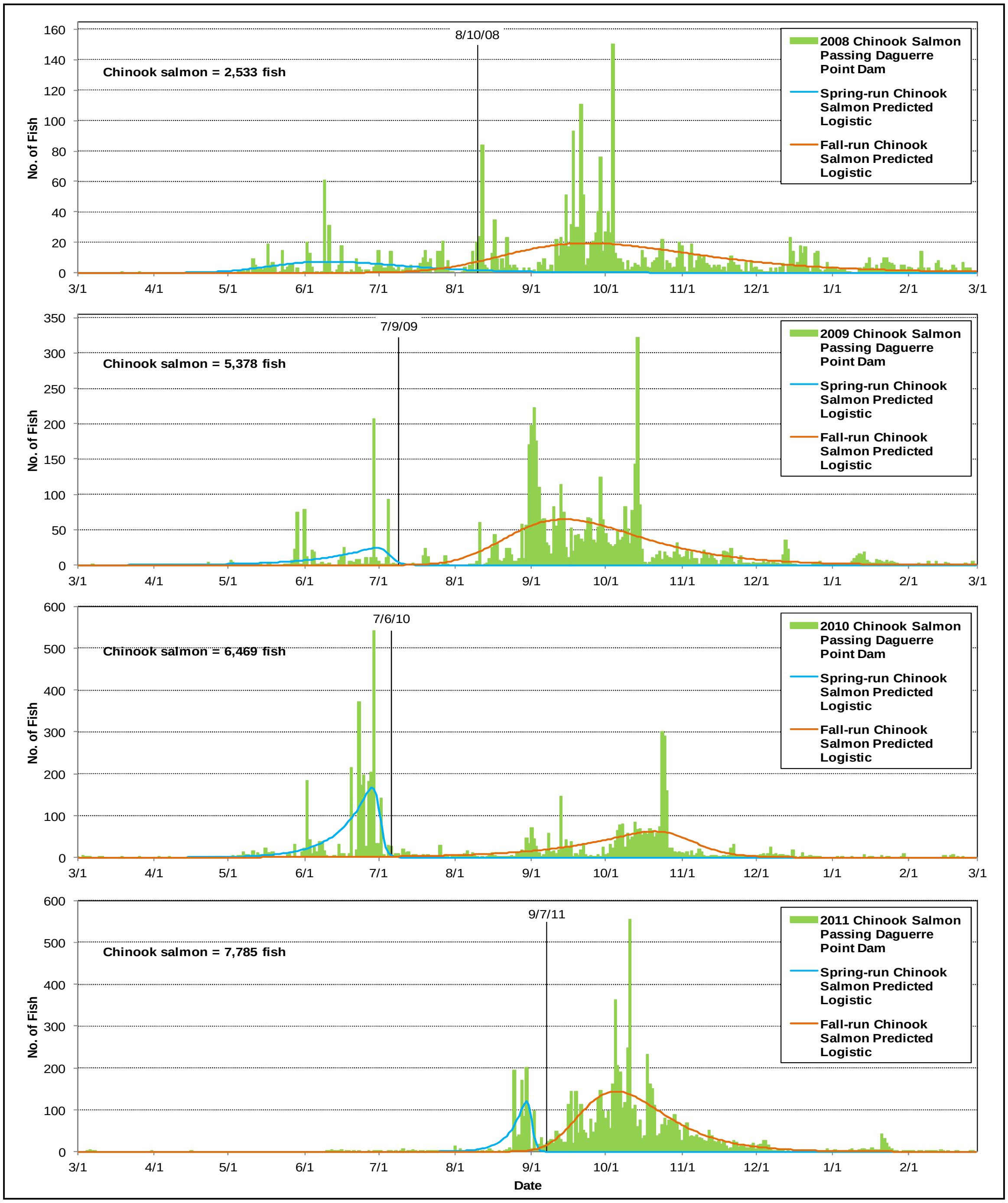

Figure 4-7. Daily number of Chinook salmon passing upstream of Daguerre Point Dam during the 2008 to 2011 biological years. Bars indicate the VAKI Riverwatcher daily counts and lines indicate the predicted daily distributions of spring-run (blue line) and fall-run (orange line) Chinook salmon based on the fitting of two generalized logistic functions to the data. The demarcation date differentiating the two runs of Chinook salmon is indicated for each year. (Source: RMT 2013)

Table 4-5. Annual number of spring-run and fall-run Chinook salmon estimated to have passed upstream of Daguerre Point Dam, and the estimated annual percentage of spring-run Chinook salmon relative to all Chinook salmon each year. (Source: RMT 2013)

Run	Biological Year							
	2004	2005	2006	2007	2008	2009	2010	2011
Spring-run Chinook Salmon	738	3,592	1,326	372	521	723	2,886	1,159
	12.5%	31.6%	25.5%	26.7%	20.6%	13.4%	44.6%	14.9%
Fall-run Chinook Salmon	5,189	7,782	3,877	1,022	2,012	4,655	3,583	6,626
	87.5%	68.4%	74.5%	73.3%	79.4%	86.6%	55.4%	85.1%

ANNUAL ABUNDANCE OF SPRING-RUN CHINOOK SALMON

For the period (2004-2011) during which VAKI Riverwatcher data are available, the annual number of spring-run Chinook salmon estimated to have passed upstream of Daguerre Point Dam ranged from 372 in 2007 to 3,592 in 2005, with an average of 1,415 (RMT 2013). The abundance of spring-run Chinook salmon during the past two years has been substantially higher than the three years prior (RMT 2013).

As previously described by NMFS (2011a), populations with a low risk of extinction (less than 5% chance of extinction in 100 years) are those with a minimum total escapement of 2,500 spawners in 3 consecutive years (mean of 833 fish per year). For the last three consecutive years, an estimated total of 4,768 spring-run Chinook salmon have passed upstream of Daguerre Point Dam, with an average of 1,589 fish per year (RMT 2013). However, as further discussed below, the annual abundances of phenotypic spring-run Chinook salmon in the lower Yuba River are strongly influenced by hatchery fish (RMT 2013).

TRENDS IN THE ANNUAL ABUNDANCE OF SPRING-RUN CHINOOK SALMON

The statistical approach recommended by Lindley et al. (2007) was followed by RMT (2013) to examine whether the abundance of lower Yuba River spring-run Chinook salmon exhibited a statistically significant linear trend over time during the eight most recent years for which VAKI Riverwatcher data are available. The natural logarithms of the abundance estimates of lower Yuba River spring-run Chinook salmon for the eight most recent years (2004-2011) were linearly regressed against time (year) using a simple least-squares approach (RMT 2013). The estimated slope of the resulting line is a measure of the average rate of change of the abundance in the population over time.

Figure 4-8 displays the antilogarithmic transformation of the estimated annual number of spring-run Chinook salmon passing upstream of Daguerre Point Dam from 2004-2011 (RMT 2013). Figure 4-8 demonstrates that the abundance of spring-run Chinook salmon in the lower Yuba River has exhibited a very slight increase over the eight years examined. However, the coefficient of determination is very weak ($r^2 = 0.0005$) and the slope is not statistically significantly different from zero ($P = 0.96$), indicating that the positive trend is not significant (RMT 2013). The relationship indicates that the phenotypic spring-run Chinook salmon annual abundance over this time period is stable, and is not exhibiting a significant declining trend (RMT 2013). These abundance and trend considerations would correspond to low extinction risk according to NMFS criteria (Lindley et al. 2007). However, the RMT (2013) questions the applicability of any of these criteria addressing extinction risk, because they presumably apply to independent populations and, as previously discussed, lower Yuba River anadromous salmonids

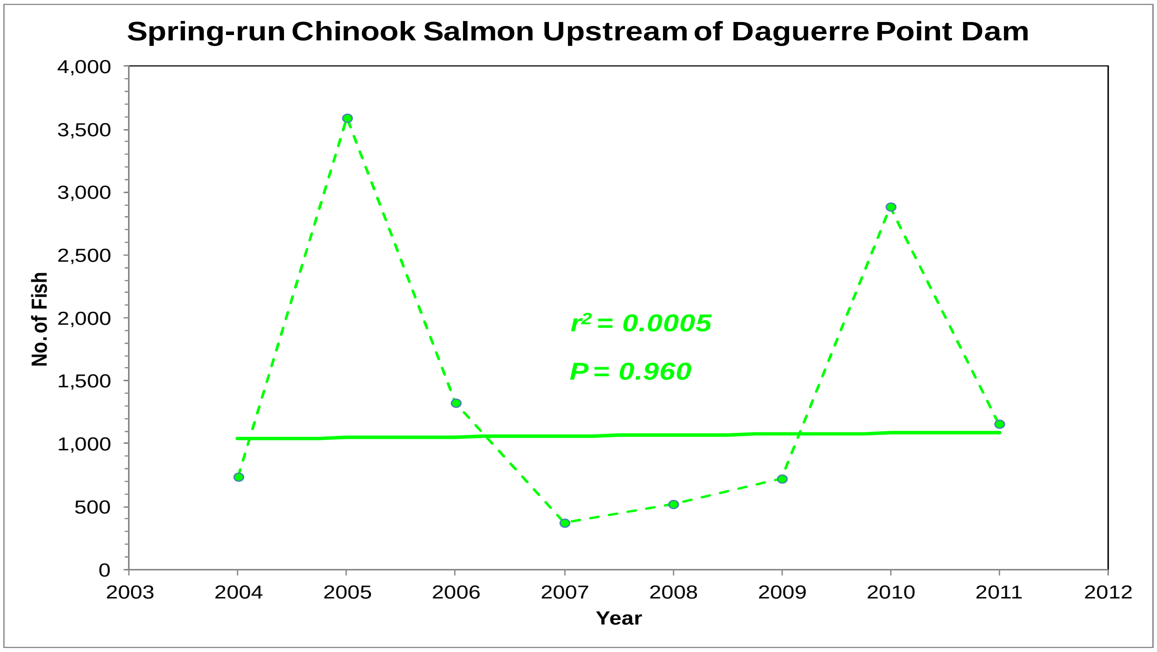

Figure 4-8. Temporal trend and estimated annual number of phenotypic adult spring-run Chinook salmon passing upstream of Daguerre Point Dam from 2004 through 2011. (Source: RMT 2013)

represent introgressive hybridization of larger Feather-Yuba river populations, with substantial contributions of hatchery-origin fish to the annual runs. As previously mentioned, the annual abundances of phenotypic spring-run Chinook salmon in the lower Yuba River are strongly influenced by hatchery fish, as discussed below.

ANNUAL ABUNDANCE OF ADIPOSE FIN-CLIPPED AND NON ADIPOSE FIN-CLIPPED SPRING-RUN CHINOOK SALMON

Because the VAKI Riverwatcher systems located at both the north and south ladder of Daguerre Point Dam can record both silhouettes and electronic images of each fish passage event, the systems were able to differentiate Chinook salmon with adipose fins clipped or absent from Chinook salmon with their adipose fins intact. Thus, annual series of daily counts of Chinook salmon with adipose fins clipped (i.e., ad-clipped fish) and with adipose fins intact (i.e., not ad-clipped fish) that passed upstream of Daguerre Point Dam from March 1, 2004 through February 29, 2012 were obtained by RMT (2013).

The estimated numbers of spring-run Chinook salmon of hatchery (i.e., ad-clipped fish) and potentially non-hatchery origin (i.e., not ad-clipped fish) passing upstream of Daguerre Point Dam for the last eight years of available VAKI Riverwatcher data are presented in **Table 4-6**. Examination of Table 4-6 demonstrates a sharp increase in the annual percent contribution of ad-clipped phenotypic spring-run Chinook salmon to the total estimated annual run beginning in 2009 and extending through 2011 (RMT 2013). This may be due, in part, to the fact that FRFH-origin spring-run Chinook salmon were fractionally marked prior to 2005 and 100% marked thereafter. These fish would have returned as age-3 fish during 2008. Also, fractional marking of fall-run hatchery fish at the FRFH started during 2006, and these fish may return, to some extent, as phenotypic spring-run Chinook salmon. Age 3 fish would have returned during 2009. The first full year (age 3 and age 4) of recovery data from the CFM program occurred during 2010. Evaluation of the lower Yuba River carcass survey data indicated that hatchery-origin Chinook salmon comprised an estimated 71% of the total 2010 Chinook salmon run (Kormos et al. 2012, as cited in RMT 2013), although it was not possible to differentiate between phenotypic spring- and fall-run Chinook salmon in the lower Yuba River carcass surveys (RMT 2013).

Table 4-6. Estimated numbers of Chinook salmon, ad-clipped and non ad-clipped phenotypic spring-run Chinook salmon that passed upstream of Daguerre Point Dam annually from 2004 through 2011. (Source: RMT 2013)

Year	Demarcation Date	Chinook Salmon Passage Upstream of Daguerre Point Dam				
		All Chinook Salmon	Spring-run Chinook Salmon			
			Total	Ad-Clipped	Not Ad-Clipped	% Ad-Clipped
2004	8/1/04	5,927	738	72	666	10
2005	8/24/05	11,374	3,592	676	2,916	19
2006	9/6/06	5,203	1,326	81	1,245	6
2007	9/4/07	1,394	372	38	334	10
2008	8/10/08	2,533	521	15	506	3
2009	7/9/09	5,378	723	213	510	29
2010	7/6/10	6,469	2,886	1,774	1,112	61
2011	9/7/11	7,785	1,159	323	836	28

The average contribution of adipose fin-clipped phenotypic spring-run Chinook salmon to the total annual run size in the lower Yuba River, as inferred by the percentage of adipose fin-clipped fish passing upstream of Daguerre Point Dam during the annual defined phenotypic period, has been 20.8% over the eight years of available data and, assuming a 3-year generation, the four most recent 3-year running averages of adipose fin-clipped phenotypic spring-run Chinook salmon to the total annual run size have been 39.6%, 31.3%, 14.2%, and 6.4%, respectively. The average contribution of adipose fin-clipped phenotypic spring-run Chinook salmon to the total annual run sizes of these four generations is 22.9%. The RMT (2013) recognized that there are limitations to simply using percent adipose fin-clipped spring-run Chinook salmon passing through the VAKI Riverwatcher systems as an estimate of total hatchery influence, and that resulting estimates should be considered as minimum estimates. It is important to note that the adipose fin-clipped phenotypic spring-run Chinook salmon abundance represents a minimum indicator of hatchery-origin individuals due to fractional marking of spring-run hatchery fish prior to 2005, and constant fractional marking (CFM) of fall-run hatchery fish at the FRFH since 2006 which may return as phenotypic spring-run Chinook salmon.

It also is recognized that the hatchery influence criterion presumably is applicable to an independent, genetically distinct population. However, as previously discussed, the phenotypic spring-run Chinook salmon in the lower Yuba River actually represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, and hybridization with Feather River stocks including the FRFH spring-run Chinook salmon stock, which itself represents a hybridization between Feather River fall- and spring-run Chinook salmon populations.

APPLICABILITY OF ADDITIONAL VSP PARAMETERS AND EXTINCTION RISK CRITERIA

The M&E Program Framework developed by the RMT (2010) utilized VSP performance indicators that were identified based on the precept that the lower Yuba River anadromous salmonid populations represented independent populations. However, the RMT has identified a substantial amount of reproductive interaction between lower Yuba River and lower Feather River anadromous salmonid stocks. As described in RMT (2013), phenotypic spring-run Chinook salmon in the lower Yuba River likely represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, hybridization with Feather River fall- and spring-run Chinook salmon stocks, and hybridization with the FRFH spring-run Chinook salmon stock, which itself represents hybridization between Feather River fall- and spring-run Chinook salmon populations. Additionally, it is likely that anadromous *O. mykiss* stocks are similarly hybridized, with fluid intermixing of lower Feather River and lower Yuba River fish.

The recognition of the extent of hybridization and lack of reproductive isolation of lower Yuba River and lower Feather River anadromous salmonid stocks logically constrains the manner in which the VSP concept can be applied to the lower Yuba River, because many of the VSP metrics are designed to evaluate the viability of discrete, independent populations. Even the simplified approach suggested by Lindley et al. (2007) to evaluate 'extinction risk' is of limited applicability in the evaluation of highly introgressed populations whose evaluation metrics are directly influenced by other stocks, and out-of-basin factors.

Lindley et al. (2007) provide criteria to assess the level of risk of extinction of Pacific salmonids based on population size, recent population decline, occurrences of catastrophes within the last 10 years that could cause sudden shifts from a low risk state to a higher one, and the impacts of hatchery influence. Populations with a low risk of extinction (less than 5% chance of extinction in 100 years) are those with a minimum total escapement of 2,500 spawners in 3 consecutive years (mean of 833 fish per year), no apparent decline in escapement, no catastrophic declines within the last 10 years, and a low hatchery influence (NMFS 2011a). The overall estimated risk of extinction for the population is determined by the highest risk score for any category Lindley et al. (2007). While more detailed population viability assessment (PVA) models could be constructed to assess Chinook salmon populations, Lindley et al. (2007) suggest any PVA results should be compared with the results of applying their simpler criteria to estimate status (NMFS 2011a).

Only some of the VSP performance indicators identified in the RMT (2010) M&E Program framework and some of the extinction risk criteria provided by Lindley et al. (2007) are appropriate for application specifically to lower Yuba River anadromous salmonids. VSP performance indicators regarding spatial structure are applicable to the habitat conditions in the lower Yuba River. Similarly, the catastrophe occurrence extinction risk criterion also is applicable to the lower Yuba River. The extinction risk criteria including abundance, and trends in abundance are of limited applicability and serve as illustrative comparative measures in consideration of the non-independent salmonid populations in the lower Yuba River. The hatchery risk extinction criterion does not appear to be applicable to the non-independent lower Yuba River salmonid populations. Considerations regarding each of these applicabilities are discussed below.

SPATIAL STRUCTURE

According to McElhany et al. (2000), spatial structure reflects how abundance is distributed among available or potentially available habitats, and how it can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change. A population's spatial structure depends fundamentally on habitat quality, spatial configuration, and dynamics, as well as on the dispersal characteristics of individuals in the population.

Performance indicators and analytics addressing spatial structure include spatial organization of morphological units (e.g., lateral variability/diversity, adjacency, randomness, and abundance), persistence of morphological units through time, and the quality, number, size and distribution of morphological units available for spawning Chinook salmon. Additional considerations include floodplain connectivity, entrenchment, channel sinuosity, substrate size, changes in topographic depth, scour and fill processes, bankfull and flood flow recurrence interval, and maintenance of watershed processes to maintain suitable habitat for anadromous salmonid lifestages.

As stated in the M&E Plan (RMT 2010a), the spatial structure evaluation includes examination of maintenance of watershed processes and regulatory management practices to create and maintain suitable habitat for all freshwater lifestages of spring-run and fall-run Chinook salmon, and steelhead. As discussed in RMT (2013), one of the performance indicators preliminarily evaluated by Wyrick and Pasternack (2012) is whether the sequence of morphological units in the lower Yuba River is non-random. Highly disturbed systems often degrade into homogeneity or randomness.

Of the 12 major near-bankfull morphological units, the most uniformly distributed (i.e., randomly located) units are slackwater, slow glide, and lateral bar. As an example of non-uniform distribution, pool units were predominantly found in the upstream reaches (i.e., Englebright and Timbuctoo Bend) and the downstream reach (i.e., Marysville), but were less abundant in the middle, wider reaches (i.e., Daguerre Point Dam and Dry Creek). Consequently, evaluation of the morphological units in the lower Yuba River as part of the spatial structure analyses indicates that, in general, the sequence of morphological units is non-random, indicating that the channel has been self-sustaining of sufficient duration to establish an ordered spatial structure (refer to RMT 2013 for additional discussion).

Another new method for analyzing the morphological unit organization that Wyrick and Pasternack (2012) developed is an adjacency probability analysis, which evaluates the frequency at which each morphological unit is adjacent to every other unit, and compares that against random adjacency expectations. Results of this analysis indicate that the in-channel units near the thalweg typically exhibit low adjacency probabilities to the bar units, although they do exhibit higher-than-random probabilities to other in-channel units.

Wide, diverse rivers should also exhibit lateral variability in its form-process associations. In the lower Yuba River, morphological unit organization highlights the complexity of the channel geomorphology, as well as the complex and diverse suite of potential habitat at any given location in the Yuba River. The above summary (described in more detail in RMT 2013) illustrates that spatial structure of morphological units in the lower Yuba River is complex, diverse, and persistent.

CATASTROPHE OCCURRENCE

According to Lindley et al. (2007), the catastrophe criteria trace back to Mace and Lande (1991), and the underlying theory is further developed by Lande (1993). The following discussion was taken from Lindley et al. (2007). The overall goal of the catastrophe criteria is to capture a sudden shift from a low risk state to a higher one. Catastrophes are defined as instantaneous declines in population size due to events that occur randomly in time, in contrast to regular environmental variation, which occurs constantly and can have both positive and negative effects on the population. Lindley et al. (2007) view catastrophes as singular events with an identifiable cause and only negative immediate consequences, as opposed to normal environmental variation which can produce very good as well as very bad conditions. Some examples of catastrophes include disease outbreaks, toxic spills, or volcanic eruptions. A high risk situation is created by a 90% decline in population size over one generation. A moderate risk event is one that is smaller but biologically significant, such as a year-class failure.

EXTINCTION RISK CRITERIA AND APPLICATION

Lindley et al. (2007) characterized the spring-run Chinook salmon population in the lower Yuba River as data deficient, and therefore did not characterize its viability. In 2007, there was limited information on the current population size of spring-run Chinook salmon in the lower Yuba River. NMFS' 5 Year Status Review for the Central Valley Spring-run Chinook Salmon ESU (NMFS 2011) reported that the annual spawning run size of spring-run Chinook salmon in the lower Yuba River generally ranges from a few hundred to a few thousand fish with the annual trend closely following the annual abundance trend of the Feather River Hatchery spring-run Chinook salmon population. NMFS (2011a) concluded that the Yuba River spring-run Chinook salmon population satisfies the moderate extinction risk criteria for abundance, but likely falls into the high risk category for hatchery influence.

Criteria to assess extinction risk of Pacific salmonids are based on population size, recent population decline, occurrences of catastrophes within the last 10 years, and the impacts of hatchery influence (Lindley et al. 2007). As previously discussed, for the last three consecutive years, an estimated total of 4,768 phenotypic spring-run Chinook salmon have passed upstream of Daguerre Point Dam, with an average of 1,589 fish per year. Catastrophes have not occurred in the Yuba River Basin, nor have catastrophic declines been observed within the phenotypic spring-run Chinook salmon abundance estimates within the last ten years. The abundance of phenotypic spring-run Chinook salmon in the lower Yuba River has exhibited a very slight increase over the eight years examined, although the positive trend is not statistically significant. These abundance and trend considerations would correspond to low extinction risk according to NMFS criteria (Lindley et al. 2007). However, RMT (2013) questions the applicability of any of these criteria addressing extinction risk, because they presumably apply to independent populations and, as previously discussed, lower Yuba River anadromous salmonids represent introgressive hybridization of larger Feather-Yuba river populations, with substantial contributions of hatchery-origin fish to the annual runs. For additional discussion, see RMT (2013).

The average contribution of adipose fin-clipped phenotypic spring-run Chinook salmon to the total annual run size in the lower Yuba River, as inferred by the percentage of adipose fin-clipped fish passing upstream of Daguerre Point Dam during the annual defined phenotypic period, has been 20.8% over the eight years of available data and, assuming a 3-year generation, the four most recent 3-year running averages of adipose fin-clipped phenotypic spring-run Chinook salmon to the total annual run size have been 39.6%, 31.3%, 14.2%, and 6.4%, respectively. The average contribution of adipose fin-clipped phenotypic spring-run Chinook salmon to the total annual run sizes of these four generations is 22.9%. RMT (2013) recognized that there are limitations to simply using percent adipose fin-clipped spring-run Chinook salmon passing through the VAKI Riverwatcher systems as an estimate of total hatchery influence, and that resulting estimates should be considered as minimum estimates. As previously discussed, it is important to note that the adipose fin-clipped phenotypic spring-run Chinook salmon abundance represents a minimum indicator of hatchery-origin individuals due to fractional marking of spring-run hatchery fish prior to 2006, and constant fractional marking (CFM) of fall-run hatchery fish at the FRFH which may return as phenotypic spring-run Chinook salmon.

It also is recognized that the hatchery influence criterion presumably is applicable to an independent, genetically distinct population (RMT 2013). However, as previously discussed, the phenotypic spring-run Chinook salmon in the lower Yuba River actually represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, and hybridization with Feather River stocks including the FRFH spring-run Chinook salmon stock, which itself represents a hybridization between Feather River fall- and spring-run Chinook salmon populations.

Although straying of FRFH-origin Chinook salmon into the lower Yuba River occurs, available information indicates that: (1) the FRFH spring-run Chinook salmon is included in the ESU, in part because of the important role this stock may play in the recovery of spring-run Chinook salmon in the Feather River Basin, including the Yuba River (70 FR 37160); (2) the spring-run Chinook program at FRFH is an Integrated Recovery Program which seeks to aid in the recovery and conservation of Central Valley spring-run Chinook salmon (DWR 2009a); and (3) fish produced at FRFH are intended to spawn in the wild or be genetically integrated with the targeted natural population as FRFH broodstock (DWR 2009a).

4.2.8 Public Review Draft Recovery Plan Considerations

According to NMFS (2005) *Recommendations for the Contents of Biological Assessments and Biological Evaluations* pertaining to status of the species in the action area, a BA should:

- ☐ Identify any recovery plan implementation that is occurring in the action area, especially priority one action items from recovery plans.

The NMFS Draft Recovery Plan establishes three population levels to help guide recovery efforts for existing populations, referred to as Core 1, 2, and 3 populations. The NMFS Draft Recovery Plan (pg. 65) identifies lower Yuba River spring-run Chinook salmon [and steelhead] populations as Core 1 populations. Core 1 populations form the foundation of the recovery strategy, and Core 1 populations should be the first focus of an overall recovery effort (NMFS 2009).

To meet recovery objectives for the diversity groups, the conceptual recovery scenarios for the spring-run Chinook salmon ESU (pg. 99) [and the steelhead DPS (pg. 123)] include: (1) securing extant populations by implementing key habitat restoration actions, particularly in the near term; and (2) establishment of additional viable independent populations.

The NMFS Draft Recovery Plan states, that in order to secure a viable independent population of spring-run Chinook salmon (pg. 116), [and to secure the extant population and promote a viable population of steelhead (pg. 140)], in the lower Yuba River, several key near-term and long-term habitat restoration actions were identified, including the following:

- ☐ Continued implementation of the Yuba Accord flow schedules to provide suitable habitat (flow and water temperature) conditions for all lifestages
- ☐ Improvements to adult salmonid upstream passage at Daguerre Point Dam
- ☐ Improvements to juvenile salmonid downstream passage at Daguerre Point Dam
- ☐ Implementation of a spawning gravel augmentation program in the uppermost reach (i.e., Englebright Dam to the Narrows) of the lower Yuba River
- ☐ Improvements to riparian habitats for juvenile salmonid rearing
- ☐ Creation and restoration of side-channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas
- ☐ Implementation of projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing

The NMFS Draft Recovery Plan includes Priority 1, Priority 2 and Priority 3 recovery actions. The NMFS Draft Recovery Plan Appendix C (pgs. 2, 3) states *"According to NMFS' 1990 Endangered and Threatened Species Listing and Recovery Priority*

Guidelines (55 FR 24296), recovery actions identified in a Recovery Plan are to be assigned priorities of 1 to 3, as follows:

> *Priority 1 – An action that must be taken to prevent extinction or to identify those actions necessary to prevent extinction*
>
> *Priority 2 – An action that must be taken to prevent a significant decline in population numbers, habitat quality, or other significant negative impacts short of extinction*
>
> *Priority 3 – All other actions necessary to provide for full recovery of the species."*

The NMFS Draft Recovery Plan (pg. 161) identifies the following proposed action as a Priority 1 recovery action for the Yuba River:

Recovery Action 1.9.6.1. Develop and implement a phased approach to salmon reintroduction planning to recolonize historic habitats above Englebright Dam. Implement actions to: (1) enhance habitat conditions including providing flows and suitable water temperatures for successful upstream and downstream passage, holding, spawning and rearing; and (2) improve access within the area above Englebright Dam, including increasing minimum flows, providing passage at Our House, New Bullards Bar, and Log Cabin dams, and assessing feasibility of passage improvement at natural barriers. The phased approach should include:

- ☐ Conduct feasibility studies
- ☐ Conduct habitat evaluations
- ☐ Conduct 3-5 year pilot testing program
- ☐ Implement long-term fish passage program

The spring-run Chinook salmon conceptual recovery scenario also includes reintroduction of spring-run Chinook salmon to the candidate areas of the North Fork, Middle Fork and South Fork Yuba rivers. Reintroduction of anadromous salmonids above Englebright Dam has been the subject of recent and current investigations. Evaluation of habitat suitability for anadromous salmonids upstream of Englebright Dam was recently undertaken (DWR 2007), but those evaluations have yet to be finalized as part of the Upper Yuba River Watershed Studies Program. Currently, NMFS is evaluating the feasibility of providing passage for anadromous salmonids at Englebright Dam. Hence, the conceptual recovery scenario does not further discuss specific restoration actions associated with reintroduction.

The NMFS Draft Recovery Plan (pg. 161) identifies the following proposed action as a Priority 1 recovery action for the Yuba River:

Recovery Action 1.9.6.2. Improve spawning habitat in the lower river by gravel restoration program below Englebright Dam and improve rearing habitat by increasing floodplain habitat availability.

Also, a gravel restoration program below Englebright Dam is discussed as a Priority 2 action on pg. 73, and lower Yuba River floodplain habitat availability considerations are discussed as Priority 2 actions on pgs. 73, 74, 76, and 92 of Appendix C in NMFS (2009).

Proposed recovery action 1.9.6.2 actually includes two separate proposed actions: (1) improve spawning habitat in the lower river by gravel restoration program below Englebright Dam; and (2) improve rearing habitat by increasing floodplain habitat availability. Each of these is discussed separately, below.

(1) Improve spawning habitat in the lower river by gravel restoration program below Englebright Dam. The Corps completed the injection of 500 tons of gravel approximately 200 yards downstream of Englebright on November 30, 2007 (Grothe 2011). The Corps completed additional injections of 5,000 tons of gravel on January 13, 2011, August 21, 2012 and August 14, 2013.

(2) Improve rearing habitat by increasing floodplain habitat availability. Since the NMFS Draft Recovery Plan was noticed in the Federal Register on October 6, 2009, substantial efforts have been undertaken to identify, develop and consider the relative merits of habitat restoration actions in the lower Yuba River. The need for restoration actions, identification of the specific actions themselves, and the relative merits of the actions to expand habitat and accomplish the goals of the Oroville FERC Relicensing Habitat Expansion Agreement (HEA) were presented in a report submitted to the HEA Steering Committee during early November

> 2009 (YCWA et al. 2009). This report represents a comprehensive consideration of such restoration actions developed for the lower Yuba River. The YCWA et al. (2009) report identified several factors that continue to limit juvenile spring-run Chinook salmon [and steelhead] rearing habitat suitability in the lower Yuba River, including: (1) sparse and restricted amounts of riparian vegetation and associated instream object and overhanging object cover; (2) limited aquatic habitat complexity and diversity; and (3) altered natural river function and morphology in the lower Yuba River. Shaded Riverine Aquatic (SRA) habitat generally occurs in the lower Yuba River as scattered, short strips, with the most extensive and continuous segments of SRA habitat occurring along bars where recent channel migrations or avulsions have cut new channels through stands of riparian vegetation.

Regarding juvenile salmonid rearing habitat, the NMFS Draft Recovery Plan states that, in order to secure a viable independent population of spring-run Chinook salmon (pg. 116), [and to secure the extant population and promote a viable population of steelhead (pg.140)] in the lower Yuba River, the following key near-term and long-term habitat restoration actions should be implemented: (1) the creation and restoration of side channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas; (2) improvements to riparian habitats for juvenile salmonid rearing; and (3) implementation of projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing. Of the proposed actions regarding juvenile rearing, the actions that would be most beneficial and cost-effective for juvenile rearing habitat, and the actions that would yield the most immediate benefits, are the creation of new side-channel habitats associated with existing stands of riparian vegetation that are not presently hydraulically connected to the river channel (YCWA 2010). Specifically, new side-channel habitats would: (1) increase and maintain existing riparian vegetation; (2) provide instream object and overhanging object cover; (3) provide new SRA, and associated allochthonous food sources for rearing juveniles; (4) increase aquatic habitat complexity and diversity; (5) provide habitats more consistent with those previously available in the upper watershed; and (6) provide predator escape cover, and overall increased survival of juvenile spring-run Chinook salmon and steelhead.

The NMFS Draft Recovery Plan (pg. 83) states "*The* [Draft Plan's recovery] *scenarios represent some of the many possible combinations of populations, restoration actions, risk minimization and threat abatement. Different scenarios may fulfill the biological requirements for recovery*". The NMFS Draft Recovery Plan (pg. 83) further states "*As this Recovery Plan is implemented over time, additional information will become available to help determine whether the threats have been abated, to further develop understanding of the linkages between threats and Chinook salmon and steelhead population responses, and to evaluate the viability of Chinook salmon and steelhead in the Central Valley Domain … Such information is expected to lead to adjustments in recovery expectations and restoration actions and, thus, recovery scenarios*."

The NMFS Draft Recovery Plan (pg. 208) states that it may not be necessary to reintroduce fish to all of the listed river and creek systems to meet the recovery criteria for Central Valley spring-run Chinook salmon [and steelhead]. "*It may not be necessary to re-establish populations to all of these rivers. The highest priority areas are the Little Sacramento River, the McCloud River, the North Fork American River, and the San Joaquin River.*"

4.3 Central Valley Steelhead DPS

4.3.1 ESA Listing Status

On March 19, 1998 (63 FR 13347) NMFS listed the California Central Valley steelhead ESU as "threatened", concluding that the risks to Central Valley steelhead had diminished since the completion of the 1996 status review based on a review of existing and recently implemented state conservation efforts and federal management programs (e.g., CVPIA, AFRP, CALFED) that address key factors for the decline of this species. The California Central Valley steelhead ESU included all naturally spawned populations of steelhead in the Sacramento and San Joaquin rivers and their tributaries, but excluded steelhead from the tributaries of San Francisco and San Pablo bays (NMFS 2004b).

On June 14, 2004, NMFS proposed listing determinations for 27 ESUs of West Coast salmon and *O. mykiss*, including the California Central Valley steelhead ESU. In the proposed rule, NMFS concluded that steelhead were not in danger of extinction, but were likely to become endangered within the foreseeable future throughout all or a significant portion of their range and, thus, proposed that steelhead remain listed as threatened under the ESA. Steelhead from the Coleman National Fish Hatchery and the FRFH, as well as resident populations of *O. mykiss* (rainbow trout) below impassible barriers that co-occur with anadromous populations, were included in the California Central Valley steelhead ESU and, therefore, also were included in the proposed listing.

During the 2004 comment period on the proposed listings, the USFWS provided comments that the USFWS does not use NMFS' ESU policy in any USFWS ESA listing decisions. As a result of the comments received, NMFS re-opened the comment period to receive comments on a proposed alternative approach to delineating ''species'' of West Coast *O. mykiss* (70 FR 67130). NMFS proposed to depart from past practice of applying the ESU Policy to *O. mykiss* stocks, and instead proposed to apply the DPS Policy in determining ''species'' of *O. mykiss* for listing consideration. NMFS noted that within a discrete group of *O. mykiss* populations, the resident and anadromous life forms of *O. mykiss* remain ''markedly separated'' as a consequence of physical, physiological, ecological, and behavioral factors, and may therefore warrant delineation as separate DPSs (71 FR 834).

NMFS issued a policy for delineating distinct population segments of Pacific salmon in 1991 (56 FR 58612; November 20, 1991). Under this policy, a group of Pacific salmon populations is considered an ''Evolutionarily Significant Unit'' if it is substantially reproductively isolated from other conspecific populations, and it represents an important component in the evolutionary legacy of the biological species. Further, an ESU is considered to be a ''Distinct Population Segment'' (and thus a ''species'') under the ESA. In 1996, NMFS and USFWS adopted a joint policy for recognizing DPSs under the ESA (DPS Policy; 61 FR 4722; February 7, 1996). The DPS Policy adopted criteria similar to, but somewhat different from, those in the ESU Policy for determining when a group of vertebrates constitutes a DPS – The group must be discrete from other populations, and it must be significant to its taxon. A group of organisms is discrete if it is ''*markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, and behavioral factors*.'' Significance is measured with respect to the taxon (species or subspecies) as opposed to the full species (71 FR 834). Although the ESU Policy did not by its terms apply to steelhead, the DPS Policy stated that NMFS will continue to implement the ESU Policy with respect to ‘‘Pacific salmonids’’ (which included *O. mykiss*). In a previous instance of shared jurisdiction over a species (Atlantic salmon), NMFS and USFWS used the DPS Policy in their determination to list the Gulf of Maine DPS of Atlantic salmon as endangered (65 FR 69459; November 17, 2000).

Given NMFS and USFWS shared jurisdiction over *O. mykiss,* and consistent with joint NMFS and USFWS approaches for Atlantic salmon, it was concluded that application of the joint DPS policy to was logical, reasonable, and appropriate for identifying DPSs of *O. mykiss (*71 FR 834). Moreover, NMFS determined that use of the ESU policy — originally intended for Pacific salmon — should not continue to be extended to *O. mykiss,* a type of salmonid with characteristics not typically exhibited by Pacific salmon (71 FR 834).

On January 5, 2006 NMFS issued a final decision that defined Central Valley steelhead as a DPS rather than an ESU, and retained the status of Central Valley steelhead as threatened (71 FR 834). The DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and manmade impassable barriers in the Sacramento and San Joaquin Rivers and their tributaries, excluding steelhead from San Francisco and San Pablo Bays and their tributaries (63 FR 13347). Steelhead in two artificial propagation programs — the Coleman National Fish Hatchery, and FRFH steelhead hatchery programs are considered to be part of the DPS. NMFS determined that these artificially propagated stocks are no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the DPS (71 FR 834).

As previously discussed, the ESA requires that NMFS review the status of listed species under its authority at least every five years and determine whether any species should be removed from the list or have its listing status changed. In August 2011, NMFS completed a 5-year status review of the Central Valley steelhead DPS. Based upon a review of available information, NMFS (2011c) recommended that the Central Valley steelhead DPS remain classified as a threatened species. However, NMFS (2011c) also indicated that the biological status of the DPS has declined since the previous status review in 2005 and, therefore, NMFS recommend that the DPS's status is reassessed in 2 to 3 years if it does not respond positively to improvements in environmental conditions and management actions. In the interim period, NMFS also recommended that the status of the DPS should be monitored and the most recent genetic information for the DPS, including information for the four steelhead hatchery stocks, should be reviewed to re-assess the DPS membership status of the Nimbus and Mokelumne River hatcheries. New information resulting from the genetics review should be incorporated into any updated status review for the DPS (NMFS 2011c).

4.3.2 Critical Habitat Designation

On February 16, 2000 (65 FR 7764), NMFS published a final rule designating critical habitat for Central Valley steelhead. This critical habitat includes all river reaches accessible to listed steelhead in the Sacramento and San Joaquin rivers and their tributaries in California, including the lower Yuba River upstream to Englebright Dam. NMFS proposed new Critical Habitat for spring-run Chinook salmon and Central Valley steelhead on December 10, 2004 (69 FR 71880) and published a final rule designating critical habitat for these species on September 2, 2005. This critical habitat includes the lower Yuba River (70 FR 52488) from the confluence with the lower Feather River upstream to Englebright Dam.

4.3.2.1 Primary Constituent Elements

The critical habitat designation (70 FR 52488) lists PCEs, which are physical or biological elements essential for the conservation of the listed species. The PCEs include sites essential to support one or more lifestages of the DPS (sites for spawning, rearing, migration, and foraging). The specific PCEs include:

- ☐ Freshwater spawning sites
- ☐ Freshwater rearing sites
- ☐ Freshwater migration corridors

- ☐ Estuarine areas
- ☐ Nearshore marine areas
- ☐ Offshore marine areas

The most recent discussion of PCEs in the Central Valley is in the CVP/SWP OCAP Biological Opinion (NMFS 2009a). The following summary descriptions of the current conditions of the PCEs for the Central Valley steelhead DPS were taken from NMFS (2009a).

FRESHWATER SPAWNING HABITAT

According to NMFS (2009), steelhead in the Sacramento River spawn primarily between Keswick Dam and Red Bluff Diversion Dam during the winter and spring. The highest density spawning area is likely in the upstream portion of this area in the vicinity of the city of Redding, although detailed surveys of steelhead spawning in the mainstem Sacramento River are not available. Most Sacramento River steelhead probably spawn in the tributary streams. Steelhead spawn in Clear Creek mostly within a couple miles of Whiskeytown Dam but spawning extends for about 10 miles downstream of the dam (M. Brown, pers. comm. as cited in Reclamation 2008). Steelhead spawn in the Feather River from the fish barrier dam downstream to Gridley with nearly 50% of all spawning occurring the first mile of the low flow channel (DWR 2003). Steelhead spawn in the American River from Nimbus Dam (RM 23) downstream to the lowest riffle in the river at Paradise Beach (RM 5). Most spawning is concentrated in the upper seven miles of the river (Hannon and Deason 2008). Steelhead (and/or rainbow trout) spawn in the Stanislaus River from Goodwin Dam downstream to approximately the city of Oakdale. Steelhead spawning surveys have not been conducted in the Stanislaus River so detailed spawning distribution is unknown but based on observations of trout fry, most spawning occurs upstream of Orange Blossom Bridge.

FRESHWATER REARING HABITAT

Juvenile steelhead reside in freshwater for a year or more, so they are more dependent on freshwater rearing habitat than are the ocean type Chinook salmon in the Central Valley. Steelhead rearing occurs primarily in the upstream reaches of the rivers where channel gradients tend to be higher and, during the warm weather months, where temperatures are maintained at more suitable levels by cool water dam releases. The Sacramento River contains a long reach of suitable water temperatures even during the heat of the summer. Steelhead rearing in the Sacramento River occurs mostly between Keswick Dam (RM 302) and Butte City (RM 169) with the highest densities likely to be upstream of Red Bluff Diversion Dam. Steelhead rearing in Clear Creek is concentrated in the upper river higher gradient areas but probably occurs down to the mouth. Steelhead rearing in the Feather River is concentrated in the low flow channel where temperatures are most suitable (DWR 2004c). Steelhead rearing in the American River occurs down to Paradise Beach, with concentrations during the summer on most major riffle areas and highest densities near the higher density spawning areas. Steelhead rearing in the Stanislaus River occurs upstream of Orange Blossom Bridge, where gradients are highest. The highest rearing densities are upstream of Knights Ferry (Kennedy and Cannon 2002).

FRESHWATER MIGRATION CORRIDORS

Steelhead migrate during the winter and spring of the year, as juveniles, from the rearing areas described above downstream through the rivers and the Delta to the ocean. The habitat conditions they encounter during migration from the upstream reaches of the rivers downstream to the Delta generally become less suitable as fish move away from their natal streams until they reach the ocean. The generally non-turbulent flows and sand substrates found in the lower river reaches are not preferred types of habitat, so steelhead do not likely reside for extended periods in these areas except when food supplies, such as smaller young fish, are abundant and temperatures are suitable. Predatory fishes such as striped bass tend to be more abundant in the lower rivers and the Delta. Emigration conditions for juvenile steelhead in the Stanislaus River down through the San Joaquin River and the south Delta tend to be less suitable than conditions for steelhead emigrating from the Sacramento River and its tributaries.

Adult steelhead migrate upstream from the ocean to their spawning grounds near the terminal dams primarily during the fall and winter months. Flows are generally lower during the upstream migrations than during the outmigration period. Areas where their upstream progress can be affected are the Delta Cross Channel Gates, RBDD, and Anderson Cottonwood Irrigation District Diversion Dam.

ESTUARINE HABITAT AREAS

Steelhead use the San Francisco estuary as a rearing area and migration corridor between their upstream rearing habitat and the ocean. The San Francisco Bay estuarine system includes the waters of San Francisco Bay, San Pablo Bay, Grizzley Bay, Suisuin Bay, Honker Bay, and can extend as far upstream as Sherman Island during dry periods. At times steelhead likely remain for extended periods in areas of suitable habitat quality where food such as young herring, salmon and other fish and invertebrates is available.

NEARSHORE COASTAL MARINE AND OFFSHORE MARINE AREAS

The most recent discussion of PCEs for the Central Valley steelhead DPS (NMFS 2009a) did not include the PCEs of nearshore coastal marine and offshore marine areas. Although relatively little is known about steelhead utilization of nearshore coastal marine and offshore marine areas, it is reasonable to assume that the discussion of these PCEs previously provided for spring-run Chinook salmon in Section 4.1 of this BA generally is applicable to steelhead.

4.3.3 Historical Distribution and Abundance

According to NMFS (2009), steelhead historically occurred naturally throughout the Sacramento and San Joaquin River basins, although stocks have been extirpated from large areas in both basins. The California Advisory Committee on Salmon and Steelhead (CDFG 1988) reported a reduction in Central Valley steelhead habitat from 6,000 miles historically to 300 miles.

NMFS (2009) reported that prior to dam construction, water development and watershed perturbations, Central Valley steelhead were distributed throughout the Sacramento and San Joaquin rivers (Busby et al. 1996; McEwan 2001). Steelhead were found from the upper Sacramento and Pit rivers (now inaccessible due to Shasta and Keswick dams) south to the Kings and possibly the Kern River systems, and in both east- and west-side Sacramento River tributaries (Yoshiyama et al. 1996). Lindley et al. (2006) estimated that historically there were at least 81 independent Central Valley steelhead populations distributed primarily throughout the eastern tributaries of the Sacramento and San Joaquin rivers. Presently, impassable dams block access to 80% of historically available habitat, and block access to all historical spawning habitat for about 38% of historical populations (Lindley et al. 2006). Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope Creek, Deer Creek, and Mill Creek, and the Yuba River. Populations may exist in Big Chico and Butte creeks, and a few wild steelhead are produced in the American and Feather rivers (McEwan 2001).

Until recently, steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001).

It is possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999, as cited in NMFS 2009). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, throughout accessible streams and rivers in the Central Valley (Good et al. 2005). Naturally spawning populations of steelhead also occur in the Feather, Yuba, American, and Mokelumne rivers, but these populations have had substantial hatchery influence and their ancestries are not clear (Busby et al. 1996). Steelhead runs in the Feather and American rivers are sustained largely by the FRFH and Nimbus Hatchery (McEwan and Jackson 1996). Steelhead also currently occur in the Stanislaus, Calaveras, Merced, and Tuolumne rivers (NMFS 2009).

Historic Central Valley steelhead run sizes are difficult to estimate because of the lack of data, but McEwan (2001) suggested that steelhead run sizes may have approached one to two million adults annually. McEwan and Jackson (1996) suggested that by the early 1960s, the steelhead run size had declined to about 40,000. Over the last 30 years the steelhead populations in the upper Sacramento River have declined substantially (NMFS

2009). In 1996, NMFS estimated the Central Valley total run size based on dam counts, hatchery returns, and past spawning surveys was probably fewer than 10,000 fish. Both natural and hatchery runs have declined since the 1960s. Counts at RBDD averaged 1,400 fish from 1991 to 1996, compared to counts in excess of 10,000 fish in the late 1960s (McEwan and Jackson 1996). American River redd surveys and associated monitoring from 2002 through 2007 indicate that only a few hundred steelhead spawn in the river and a portion of those spawners originated from Nimbus Hatchery (Hannon and Deason 2008).

Specific information regarding steelhead spawning within the mainstem Sacramento River is limited due to lack of monitoring (NMFS 2004). Currently, the number of steelhead spawning in the Sacramento River is unknown because redds cannot be distinguished from a large resident rainbow trout population that has developed as a result of managing the upper Sacramento River for coldwater species.

The lack of sustained monitoring programs for steelhead throughout most of the Central Valley persists to the present time. There is a paucity of reliable data to estimate run sizes of steelhead in the Central Valley, particularly wild stocks. However, some steelhead escapement monitoring surveys have been initiated in upper Sacramento River tributaries (e.g., Beegum, Deer, and Antelope Creeks) using snorkel methods similar to spring-run Chinook escapement surveys (NMFS 2009a).

There is a general lack of steelhead population monitoring in most of the Central Valley (NMFS 2009a). Lindley et al. (2007) stated that there are almost no data with which to assess the status of any of the Central Valley steelhead populations. They further stated that Central Valley steelhead populations are classified as data deficient, with the exceptions restricted to streams with long-running hatchery programs including Battle Creek and the Feather, American and Mokelumne rivers.

According to NMFS (2007a), in the *Updated Status Review of West Coast Salmon and Steelhead* (Good et al. 2005), the Biological Review Team made the following conclusion based on steelhead Chipps Island trawl data:

"If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1% of eggs survive to reach

Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley."

In the Yuba River, definitive historic population estimates do not exist for steelhead, but it is likely that the river supported large steelhead runs in the 1800s (USFWS 1995). McEwan and Jackson (1996) reported that the Yuba River historically supported the largest, naturally reproducing, persistent population of steelhead in the Central Valley.

Prior to construction of Englebright Dam in 1941, CDFW fisheries biologists stated that they observed large numbers of steelhead spawning in the uppermost reaches of the Yuba River and its tributaries (CDFG 1998; Yoshiyama et al. 1996). After construction of Englebright Dam in 1941, CDFW estimated that only approximately 200 steelhead spawned in the lower Yuba River annually before New Bullards Bar Reservoir was completed in 1969. From 1970 to 1979, CDFW annually stocked 27,270–217,378 fingerlings, yearlings, and sub-catchables from Coleman National Fish Hatchery into the lower Yuba River (CDFG 1991a). CDFW stopped stocking steelhead into the lower Yuba River in 1979. Based on angling data, CDFW estimated a run size of 2,000 steelhead in the lower Yuba River in 1975 (CDFG 1991a). McEwan and Jackson (1996) reported that, as of 1996, the status of the lower Yuba River steelhead population was unknown, but it appeared to be stable and able to support a significant sport fishery. CDFW currently manages the river to protect natural steelhead through strict "catch-and-release" fishing regulations.

4.3.4 General Life History and Habitat Requirements

Steelhead exhibits perhaps the most complex suite of life-history traits of any species of Pacific salmonid. Members of this species can be anadromous or freshwater residents and, under some circumstances, members of one form can apparently yield offspring of another form (YCWA 2010).

“Steelhead” is the name commonly applied to the anadromous form of the biological species *O. mykiss*. The physical appearance of *O. mykiss* adults and the presence of seasonal runs and year-round residents indicate that both anadromous (steelhead) and resident rainbow trout exist in the lower Yuba River downstream of Englebright Dam, although no definitive visual characteristics have been identified to distinguish young steelhead from resident trout (SWRI et al. 2000). Zimmerman et al. (2009) analyzed otolith strontium:calcium (Sr:Ca) ratios in 964 otolith samples comprised of young-of-year, age-1, age-2, age-3, and age-4+ fish to determine maternal origin and migratory history (anadromous vs. non-anadromous) of *O. mykiss* collected in Central Valley rivers between 2001 and 2007, including the lower Yuba River. The proportion of steelhead progeny in the lower Yuba River (about 13%) was intermediate to the other rivers examined (Sacramento, Deer Creek, Calaveras, Stanislaus, Tuolumne, and Merced), which ranged from about 4% in the Merced River to 74% in Deer Creek (Zimmerman et al. 2009). Results from Mitchell (2010) indicate *O. mykiss* in the lower Yuba River are exhibiting a predominately residential life history pattern. He found that 14% of scale samples gathered from 71 *O. mykiss* moving upstream and trapped in the fish ladder at Daguerre Point Dam from November 1, 2000, through March 28, 2001, exhibited an anadromous life history. Thus, it is recognized that both anadromous and resident life history strategies of *O. mykiss* have been and continue to be present in the lower Yuba River**.**

The RMT (2013) developed representative temporal distributions for specific steelhead lifestages in the lower Yuba River through review of previously conducted studies, as well as recent and currently ongoing data collection activities of the M&E Program. As with spring-run Chinook salmon, the resultant lifestage periodicities are intended to encompass the majority of activity for a particular lifestage, and are not intended to be inclusive of every individual in the population. The lifestage-specific periodicities for steelhead in the lower Yuba River are summarized in **Table 4-7**, and are discussed below.

4.3.4.1 Adult Immigration and Holding

Adult migration from the ocean to spawning grounds occurs during much of the year, with peak migration occurring in the fall or early winter. Central Valley steelhead are known to use the Sacramento River as a migration corridor to spawning areas in upstream tributaries. Historically, steelhead likely did not utilize the mainstem Sacramento River downstream from the present location of Shasta Dam, except as a migration corridor to and from headwater streams (NMFS 2009).

Table 4-7. Lifestage-specific periodicities for steelhead in the lower Yuba River (Source: RMT 2013).

Lifestage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Steelhead												
Adult Immigration & Holding	■■	■■	■■	□□	□□	□□	□□	■■	■■	■■	■■	■■
Spawning	■■	■■	■■	■■	□□	□□	□□	□□	□□	□□	□□	□□
Embryo Incubation	■■	■■	■■	■■	■■	□□	□□	□□	□□	□□	□□	□□
Fry Rearing	□□	□□	□□	■■	■■	■■	■■	□□	□□	□□	□□	□□
Juvenile Rearing	■■	■■	■■	■■	■■	■■	■■	■■	■■	■■	■■	■■
Juvenile Downstream Movement	□□	□□	□□	■■	■■	■■	■■	■■	■■	□□	□□	□□
Smolt (Yearling+) Emigration	■■	■■	■■	■□	□□	□□	□□	□□	□□	■■	■■	■■

Migration through the Sacramento River mainstem begins in July, peaks at the end of September, and continues through February or March (Bailey 1954; Hallock et al. 1961 both as cited in McEwan and Jackson 1996). Counts made at RBDD from 1969 through 1982 (Hallock 1989 as cited in McEwan and Jackson 1996) and on the Feather River (Painter et al. 1977) follow the above pattern, although some fish were counted as late as April and May. Weekly counts at Clough Dam on Mill Creek during a 10-year period from 1953 to 1963 showed a similar migration pattern as well, with a peak in migration during mid-November and another peak during February (NMFS 2009a). This second peak is not reflected in counts made in the Sacramento River mainstem (Bailey 1954; Hallock et al. 1961; both as cited in McEwan and Jackson 1996) or at RBDD (Hallock 1989 as cited in McEwan and Jackson 1996).

According to NMFS (2009a), Central Valley steelhead are mostly ‘winter steelhead’ and may contain some ‘summer steelhead’ (the naming convention refers to the seasonal period of adult upstream migration). Winter steelhead mature in the ocean and arrive on the spawning grounds nearly ready to spawn, whereas summer steelhead enter freshwater with immature gonads and typically spend several months in freshwater before spawning. The reported minimum depth for successful passage is about 7 inches (Reiser and Bjornn 1979 as cited in McEwan and Jackson 1996). Excessive water velocity (>10 to 13 ft/s) and obstacles may prevent access to upstream spawning grounds (NMFS 2009a).

The optimal temperature range during adult upstream migration is unknown for Central Valley steelhead stocks (NMFS 2009a). Prolonged exposure to water temperatures above 73°F is reported to be lethal to adult steelhead (Moyle 2002). Based on northern stocks, the optimal temperature range for migrating adult steelhead is 46 to 52°F (Bovee 1978; Reiser and Bjornn 1979; Bell 1986; all as cited in McEwan and Jackson 1996).

The immigration of adult steelhead in the lower Yuba River has been reported to occur from August through March, with peak immigration from October through February (CALFED and YCWA 2005; McEwan and Jackson 1996). CDFG (1984a) reported that during the drought years of 1976-1977, two steelhead immigration peaks were observed – one in October and one in February. CDFG (1991a) reported that steelhead enter the lower Yuba River as early as August, migration peaks in October through February, and may extend through March. In addition, they report that a run of “half-pounder” steelhead occurred from late-June through the winter months.

The RMT (2010b) examined preliminary data and identified variable annual timing of *O. mykiss* ascending the fish ladders at Daguerre Point Dam since the VAKI Riverwatcher infrared and videographic sampling system began operations in 2003. For example, Massa et al. (2010) state that peak passage of steelhead at Daguerre Point Dam occurred from April through June during 2007. They also suggest that the apparent disparity between the preliminary data and other reports of steelhead adult immigration periodicity may be explained by the previously reported (Zimmerman et al. 2009; Mitchell 2010) relatively high proportion of resident (vs. anadromous) *O. mykiss* occurring in the lower Yuba River, because the VAKI Riverwatcher system did document larger (>40.6 cm) *O. mykiss* ascending the fish ladders at Daguerre Point Dam during the winter months (December through February). The observed timing of larger *O. mykiss* ascending the fish ladders at Daguerre Point Dam more closely corresponds with previously reported adult steelhead immigration periodicities. The RMT (2010b; 2013) identified the period extending from August through March as encompassing the majority of the upstream migration and holding of adult steelhead in the lower Yuba River.

4.3.4.2 Adult Spawning

Central Valley adult steelhead generally begin spawning in late December and spawning extends through March, but also can range from November through April (CDFG 1986). Steelhead adults typically spawn from December through April with peaks from January through March in small streams and tributaries where cool, well oxygenated water is available year-round (Hallock et al. 1961; McEwan 2001). Based on all available information collected to date, the RMT (2013) recently identified the steelhead spawning period as extending from January through April.

Central Valley steelhead spawn downstream of dams on every major tributary within the Sacramento and San Joaquin River systems. Due to water development projects, most spawning is now confined to lower stream reaches below dams. In a few streams, such as Mill and Deer Creeks, steelhead still have access to historical spawning areas (NMFS 2009a).

The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them (NMFS 2009). Spawning occurs mainly in gravel substrates (particle size range of about 0.2−4.0 inches). Sand-gravel and gravel-cobble substrates are also used, but these must be highly permeable and contain less than 5% sand and silt for the water to be able to provide sufficient oxygen to the incubating eggs. Adults tend to spawn in shallow areas (6−24 inches deep) with moderate water velocities (about 1 to 3.6 ft/s) (Bovee 1978 as cited in McEwan and Jackson 1996; Hannon and Deason 2007 as cited in Reclamation 2008). The optimal temperature range for spawning has been reported to range from 39 to 52°F (Bovee 1978; Reiser and Bjornn 1979; Bell 1986 all as cited in McEwan and Jackson 1996). Egg mortality begins to occur at 56°F (McEwan and Jackson 1996).

Unlike Chinook salmon, Central Valley steelhead may not die after spawning (McEwan and Jackson 1996). Some may return to the ocean and repeat the spawning cycle for two or three years. The percentage of adults surviving spawning is generally thought to be low for Central Valley steelhead, but varies annually and between stocks. Acoustic tagging of Central Valley steelhead kelts from the Coleman Hatchery indicates survival rates can be high, especially for Central Valley steelhead reconditioned by holding and feeding at the hatchery prior to release. Some return immediately to the ocean and some remain and rear in the Sacramento River (NMFS 2009a).

Steelhead spawning has been reported to generally extend from January through April in the lower Yuba River (CALFED and YCWA 2005; CDFG 1991a; YCWA et al. 2007). The RMT conducted a pilot redd survey from September 2008 through April 2009 (RMT 2010a). Surveys were not conducted during March, which is a known time for steelhead spawning in other Central Valley rivers, due to high flows and turbidity. An extensive area redd survey was conducted by surveyors kayaking from the downstream end of the Narrows pool to the Simpson Lane Bridge. During the extensive area redd survey, redds that were categorized as steelhead based on redd size criteria were reportedly observed from October through April. However, some of those redds categorized as steelhead, particularly during October, may actually have been small Chinook salmon redds because the size criteria used to identify steelhead redds was found to be 53% accurate for identifying steelhead redds in the Feather River (USFWS 2008a).

Campos and Massa (2010b and 2011) synthesized results of near-census redd surveys conducted on the lower Yuba River during the 2009 and 2010 survey periods. During both annual survey efforts, a substantial proportion of the weekly strata in the January through April time periods were not sampled due to elevated flows and associated turbidity levels. Nonetheless, RMT (2013) demonstrated that based upon cumulative temporal distribution curves, the steelhead spawning period in the lower Yuba River is generally characterized to extend from January through April.

Steelhead spawning has been reported to primarily occur in the lower Yuba River upstream of Daguerre Point Dam (SWRI et al. 2000; YCWA et al. 2007). Kozlowski (2004) states that field observations during winter and spring 2000 (YCWA unpublished data) indicated that the majority of steelhead spawning in the lower Yuba River occurred from Long Bar upstream to the Narrows, with the highest concentration of redds observed upstream of the Highway 20 Bridge. USFWS (2007) data were collected on *O. mykiss* redds in the lower Yuba River during 2002, 2003, and 2004, with approximately 98% of the redds located upstream of Daguerre Point Dam. During the pilot redd survey conducted from the fall of 2008 through spring of 2009, the RMT (2010) report that most (65%) of the steelhead redds were observed upstream of Daguerre Point Dam. Female steelhead construct redds within a range of depths and velocities in suitable gravels, oftentimes in pool tailouts and heads of riffles. In the lower Yuba River, steelhead have also been observed to spawn in side channel areas (YCWA unpublished data).

4.3.4.3 Embryo Incubation

California Central Valley adult steelhead eggs incubate within the gravel and hatch from approximately 19 to 80 days at water temperatures ranging from 60°F to 40°F, respectively (NMFS 2009). After hatching, the young fish (alevins) remain in the gravel for an extra two to six weeks before emerging from the gravel and taking up residence in the shallow margins of the stream.

Steelhead embryo incubation generally occurs from December through June in the Central Valley. The RMT (2013) identified the period of January through May as encompassing the majority of the steelhead embryo incubation period in the lower Yuba River. Following deposition of fertilized eggs in the redd, they are covered with loose gravel. Central Valley steelhead eggs can reportedly survive at water temperature ranges of 35.6°F to 59°F (Myrick and Cech 2001). Steelhead eggs reportedly have the highest survival rates at water temperature ranges of 44.6°F to 50.0°F (Myrick and Cech 2001). Studies conducted at or near 54.0°F report high survival and normal development of steelhead incubating embryos, a relatively low mortality of incubating steelhead embryos is reported to occur at 57.2°F, and a sharp decrease in survival has been reported for *O. mykiss* embryos incubated above 57.2°F (RMT 2010b).

Steelhead eggs hatch in three to four weeks at 50°F to 59°F, and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954). Steelhead embryo development requires a constant supply of well oxygenated water. This implies a loose gravel substrate allowing high permeability, with little silt or sand deposition during the development time period. Merz et al. (2004) showed that spawning substrate quality influenced a number of physical parameters affecting egg survival including temperature, dissolved oxygen, and substrate permeability.

The entire egg incubation lifestage encompasses the time when adult steelhead spawn through the time when emergent fry exit the gravel (CALFED and YCWA 2005). In the lower Yuba River, steelhead embryo incubation generally occurs from January through May (CALFED and YCWA 2005; SWRI 2002).

4.3.4.4 Juvenile Rearing and Outmigration

As reported in NMFS (2009a), juvenile Central Valley steelhead may migrate to the ocean after spending one to three years in freshwater (McEwan and Jackson 1996). Upon emergence from the gravel, the fry move to shallow protected areas associated with the stream margin (Royal 1972; Barnhart 1986; both as cited in McEwan and Jackson 1996). Steelhead fry tend to inhabit areas with cobble-rubble substrate, a depth less than 14 inches, and temperature ranging from 45 to 60°F (Bovee 1978 as cited in McEwan and Jackson 1996). Myrick (1998, as cited in Reclamation 2008) found steelhead from the Feather and Mokelumne rivers preferred temperatures between 62.5°F and 68°F.

In general, it has been reported that after emergence steelhead fry move to shallow-water, low velocity habitats, such as stream margins and low gradient riffles, and will forage in open areas lacking instream cover (Hartman 1965; Everest et al. 1986; Fontaine 1988). As fry increase in size and their swimming abilities improve in late summer and fall, juvenile steelhead have been reported to increasingly use areas with cover and show a preference for higher velocity, deeper mid-channel areas near the thalweg (Hartman 1965; Everest and Chapman 1972; Fontaine 1988).

Juvenile steelhead have been reported to occupy a wide range of habitats, preferring deep pools as well as higher velocity rapid and cascade habitats (Bisson et al. 1982; 1988). During the winter period of inactivity, steelhead prefer low velocity pool habitats with large rocky substrate or woody debris for cover (Hartman 1965; Swales et al. 1986; Raleigh et al. 1984; Fontaine 1988). During periods of low temperatures and high flows associated with the winter months, juvenile steelhead seek refuge in interstitial spaces in cobble and boulder substrates (Bustard and Narver 1975; Everest et al. 1986).

Older juveniles use riffles and larger juveniles may also use pools and deeper runs (Barnhart 1986 as cited in McEwan and Jackson 1996). However, specific depths and habitats used by juvenile rainbow trout can be affected by predation risk (Brown and Brasher 1995). Central Valley steelhead can show mortality at constant temperatures of 77°F although they can tolerate 85°F for short periods (Myrick and Cech 2001). Juvenile steelhead in northern California rivers reportedly exhibited increased physiological stress, increased agonistic activity, and a decrease in forage activity after ambient stream temperatures exceeded 71.6°F (Nielsen et al. 1994). Hatchery reared steelhead in thermal gradients selected temperatures of 64-66°F while wild caught steelhead selected temperatures around 63°F (Myrick and Cech 2001). An upper water temperature limit of 65°F is preferred for growth and development of Sacramento River and American River juvenile steelhead (NMFS 2002a).

In the lower Yuba River, juvenile steelhead exhibit variable durations of rearing. The RMT (2010b) distinguished fry, juvenile, and yearling+ lifestages through evaluation of bi-weekly length-frequency distributions of *O. mykiss* captured in rotary screw traps in the lower Yuba River, and other studies that report length-frequency estimates (Mitchell 2010; CDFG 1984a). Some juvenile *O. mykiss* may rear in the lower Yuba River for short periods (up to a few months) and others may spend from one to three years rearing in the river.

Some age-0 *O. mykiss* disperse downstream soon after emerging and continue throughout the year (Kozlowski 2004). Thus, the steelhead fry (individuals less than about 45 mm) lifestage generally extends from the time of initial emergence (based upon accumulated thermal units from the time of egg deposition through hatching and alevin incubation) until three months following the end of the spawning period. YCWA (2010) identified the fry rearing lifestage as generally extending from mid-March through July, and identified the juvenile rearing lifestage as extending year-round. Based on all information collected to date, the RMT (2013) identified the steelhead fry rearing period as extending from April through July.

Juvenile steelhead have been reported to rear in the lower Yuba River for up to 1 year or more (SWRI 2002). CDFG (1991a) reported that juvenile steelhead rear throughout the year in the lower Yuba River, and may spend from 1 to 3 years rearing in the river. Scale analysis conducted by Mitchell (2010) indicates the presence of at least four age categories for *O. mykiss* in the lower Yuba River that spent 1, 2, or 3 years in freshwater and 1 year at sea before returning to the lower Yuba River to spawn.

Based on the combined results from electrofishing and snorkeling surveys conducted during the late 1980s, CDFG (1991a) reported that juvenile steelhead were observed in all river reaches downstream of the Englebright Dam and, in addition to Chinook salmon, were the only fish species observed in the Narrows Reach. They also indicated that most juvenile steelhead rearing occurred above Daguerre Point Dam. SWRI et al. (2000) summarized data collection in the lower Yuba River obtained from 1992 through 2000. Since 1992, Jones and Stokes Associates (JSA) biologists conducted fish population surveys in the lower Yuba River using snorkel surveys to determine annual and seasonal patterns of abundance and distribution of juvenile *O. mykiss* (and Chinook salmon) during the spring and summer rearing periods. The primary rearing habitat for juvenile *O. mykiss* is upstream of Daguerre Point Dam. In 1993 and 1994, snorkeling surveys indicated that the population densities and overall abundance of juvenile *O. mykiss* (age 0 and 1+) were substantially higher upstream of Daguerre Point Dam, with decreasing abundance downstream of Daguerre Point Dam.

Similarly, Kozlowski (2004) found higher abundances of juvenile *O. mykiss* above Daguerre Point Dam, relative to downstream of Daguerre Point Dam. Kozlowski (2004) observed age-0 *O. mykiss* throughout the entire study area, with highest densities in upstream habitats and declining densities with increasing distance from the Narrows. Approximately 82% of juvenile *O. mykiss* were observed upstream of Daguerre Point Dam. Kozlowski (2004) suggested that the distribution of age-0 *O. mykiss* appeared to be related to the distribution of spawning adults. SWRI et al. (2000) suggested that higher abundances of juvenile *O. mykiss* above Daguerre Point Dam may have been due to larger numbers of spawners, greater amounts of more complex, high quality cover, and lower densities of predators such as striped bass and American shad, which reportedly were restricted to areas below Daguerre Point Dam.

In the lower Yuba River, Kozlowski (2004) reports that juvenile *O. mykiss* were observed in greater numbers in pool habitats than in run habitats. He suggests that results of his study indicated a relatively higher degree of habitat complexity, suitable for various lifestages, in the reaches just below the Narrows compared to farther downstream. The Narrows reach includes greater occurrence of pool-type microhabitat suitable for juvenile *O. mykiss* rearing, as well as small boulders and cobbles preferred by the age-0 emerging lifestage (Kozlowski 2004).

Juvenile *O. mykiss* apparently demonstrate a proclivity for near-bank areas, rather than open-channel habitats, in the lower Yuba River. USFWS (2008a) reports 258 observations of juvenile *O. mykiss* and 244 observations of juvenile Chinook salmon, all but 8 of them made near the river banks in the lower Yuba River.

A broad range of *O. mykiss* size classes have been observed in the lower Yuba River during spring and summer snorkeling, electrofishing, and angling surveys (SWRI et al. 2000). Juvenile *O. mykiss* ranging in size from 40-150 mm were commonly observed upstream of Daguerre Point Dam. Numerous larger juveniles and resident trout up to 18 inches long were also commonly observed in the mainstem upstream and downstream of Daguerre Point Dam (SWRI et al. 2000). Age 0 (young-of-the-year) *O. mykiss* were clearly shown by the distinct mode in lengths of fish caught by electrofishing (40-100 mm fork length). A preliminary examination of scales indicated that most yearling (age 1+) and older *O. mykiss* were represented by fish greater than 110 mm long, including most if not all of the fish caught by hook and line. The sizes of age 0 and 1+ *O. mykiss* indicated substantial annual growth of *O. mykiss* in the lower Yuba River. Seasonal growth of age 0 *O. mykiss* was evident from repeated sampling in 1992 and 1999, but actual growth rates could not be estimated because of continued recruitment of fry (newly emerged juveniles) or insufficient sample sizes (SWRI et al. 2000).

Mitchell (2010) reports that analysis of scale growth patterns of juvenile *O. mykiss* in the lower Yuba River indicates a period of accelerated growth during the spring peaking during the summer months, followed by decelerated growth during the fall and winter. Following the second winter, juvenile *O. mykiss* in the lower Yuba River exhibit reduced annual growth in length with continued growth in mass until reaching reproductive age. Additionally, more rapid juvenile and adult *O. mykiss* growth occurred in the lower Yuba River compared to the lower Sacramento River and Klamath River *O. mykiss*, with comparable growth rates to *O. mykiss* in the upper Sacramento River (Mitchell 2010).

CDFG (1991a) reports that juvenile steelhead in the lower Yuba River rear throughout the year, and may spend from one to three years in the river before emigrating primarily from March to June. Salvage data at the Hallwood-Cordua fish screen suggest that most juvenile fish initiated their downstream movements immediately preceding and following a new moon, indicating the presence of lunar periodicity in the timing or outmigration patterns in the lower Yuba River (Kozlowski 2004).

Based on all information collected to date, the RMT (2013) identified the steelhead juvenile rearing period as extending year-round, and the steelhead juvenile downstream movement period as extending from April through September.

In the lower Yuba River, some young-of-year (YOY) *O. mykiss* are captured in rotary screw traps (RSTs) located downstream of Daguerre Point Dam during late-spring and summer, indicating movement downstream. However, at least some of this downstream movement may be associated with the pattern of flows in the river. Water transfer monitoring in 2001, 2002, and 2004 (YCWA and SWRCB 2001; YCWA 2003; YCWA 2005), generally from about mid-June through September, indicated that the character of the initiation of the water transfers could potentially affect juvenile *O. mykiss* downstream movement. Based upon the substantial differences in juvenile *O. mykiss* downstream movements (RST catch data) noted between the 2001 study, and the 2002 and 2004 studies, it was apparent that the increases in juvenile *O. mykiss* downstream movement associated with the initiation of the 2001 water transfers were avoided due to a more gradual ramping-up of flows that occurred in 2002 and 2004 (YCWA et al. 2007).

Numerous studies have been conducted regarding temperature preference, mortality, and water temperature growth-related relationships for *O. mykiss*. As previously described, some steelhead may rear in freshwater for up to three years before emigrating as yearling+ smolts, whereas other individuals move downstream shortly after emergence as post-emergent fry, or rear in the river for several months and move downstream as juveniles without exhibiting the ontogenetic characteristics of smolts. Presumably, these individuals continue to rear and grow in downstream areas (e.g., lower Feather River, Sacramento River, and Upper Delta) and undergo the smoltification process prior to entry into saline environments. Thus, fry and juvenile rearing occur concurrently with post-emergent fry and juvenile downstream movement.

4.3.4.5 Smolt Emigration

Most juvenile steelhead spend one to three years in fresh water before emigrating to the ocean as smolts (Shapovalov and Taft 1954). During their downstream migration, juvenile steelhead undergo a process referred to as smoltification, which is a physiologic transformation and osmoregulatory pre-adaptation to residence in saline environs. Physiologic expressions of smoltification include increased gill ATPase and thyroxin levels, and more slender body form which is silvery in appearance. The primary period of steelhead smolt outmigration from rivers and creeks to the ocean generally occurs from January to June (NMFS 2009).

In the Sacramento River, juvenile steelhead migrate to the ocean in spring and early summer at 1 to 3 years of age with peak migration through the Delta in March and April (Reynolds et al. 1993 as cited in NMFS 2009). Hallock et al. (1961) found that juvenile steelhead in the Sacramento River Basin migrate downstream during most months of the year, but the peak emigration period occurred in the spring, with a much smaller peak in the fall (NMFS 2009).

According to NMFS (2009a), steelhead are present at Chipps Island between at least October and July, according to catch data from the USFWS Chipps Island Trawl. It appears that adipose fin-clipped steelhead have a different emigration pattern than unclipped steelhead. Adipose fin-clipped steelhead showed distinct peaks in catch between January and March corresponding with time of release, whereas unclipped steelhead were more evenly distributed over a period of six months or more. These differences are likely an artifact of the method and timing of hatchery releases (NMFS 2009a).

Steelhead successfully smolt at water temperatures in the 43.7°F to 52.3°F range (Myrick and Cech 2001). The optimum water temperature range for successful smoltification in young steelhead has been reported as 44.0°F to 52.3°F (Rich 1987 as cited in NMFS 2009). Wagner (1974) reported smolting ceased rather abruptly when water temperatures increased to 57°F-64°F. NMFS (2009a) reported that water temperatures under 57°F are considered best for smolting.

In the lower Yuba River, the steelhead smolt emigration period has been reported to extend from October through May (CALFED and YCWA 2005; SWRI 2002; YCWA et al. 2007). The RMT's (2010b; 2013) review of all available data indicate that yearling+ steelhead smolt emigration may extend from October through mid-April.

For the purposes of impact assessment, the RMT (2010b) developed separate water temperature index values for the yearling+ smolt emigration lifestages distinct from values for juvenile steelhead rearing and/or outmigration as juveniles from the lower Yuba River. They assumed that juvenile steelhead that exhibit extended rearing in the lower Yuba River undergo the smoltification process and volitionally emigrate from the river as yearling+ individuals.

4.3.4.6 Lifestage-Specific Water Temperature Suitabilities

Since the RMT prepared its November 2010 water temperature objectives memorandum, additional water temperature monitoring and life history investigations of anadromous salmonids in the lower Yuba River have been conducted by the RMT. Through review of previously conducted studies, as well as recent and currently ongoing data collection activities of the M&E Program, the RMT (2013) developed the following representative steelhead lifestage-specific periodicities and primary locations for water temperature suitability evaluations. The locations used for water temperature evaluations correspond to Smartsville, Daguerre Point Dam, and Marysville.

- ☐ Adult Immigration and Holding (August through March) – Smartsville, Daguerre Point Dam, and Marysville
- ☐ Spawning (January through April) – Smartsville and Daguerre Point Dam
- ☐ Embryo Incubation (January through May) – Smartsville and Daguerre Point Dam
- ☐ Juvenile Rearing and Downstream Movement (Year-round) – Daguerre Point Dam and Marysville

- ☐ Smolt (Yearling+) emigration (October through mid-April) – Daguerre Point Dam and Marysville

Steelhead lifestage-specific WTI values are provided in **Table 4-8**. The lifestages and periodicities presented in Table 4-8 differ from those presented in Table 4-7 due to specific lifestages that have the same or distinct upper tolerable WTI values.

Table 4-8. Steelhead lifestage-specific upper tolerance WTI values.

Lifestage	Upper Tolerance WTI	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration	68°F	▨▨	▨▨	▨▨					▨▨	▨▨	▨▨	▨▨	▨▨
Adult Holding	65°F	▨▨	▨▨	▨▨					▨▨	▨▨	▨▨	▨▨	▨▨
Spawning	57°F	▨▨	▨▨	▨▨	▨▨								
Embryo Incubation	57°F	▨▨	▨▨	▨▨	▨▨	▨▨							
Juvenile Rearing and Downstream Movement	68°F	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨	▨▨
Smolt (Yearling+) Emigration	55°F	▨▨	▨▨	▨▨	▨						▨▨	▨▨	▨▨

Recent water temperature monitoring data in the lower Yuba River are available for the period extending from 2006 into June 2013, during which time operations have complied with the Yuba Accord. **Figure 4-9** displays daily water temperature monitoring results from October 2006 through June 2013 at Smartsville, Daguerre Point Dam, and Marysville water temperature gages, with steelhead lifestage-specific upper tolerance WTI values. Water temperatures at all three gages are always below the upper tolerance WTI values for juvenile rearing and downstream movement, and adult immigration and holding. The upper tolerance spawning and embryo incubation WTI value is never exceeded at Smartsville, and is generally not exceeded at Daguerre Point Dam with the exception of the end of May of some years. The smolt (yearling+) emigration upper tolerance WTI value generally is not exceeded at the Smartsville Gage, and is not exceeded at the Daguerre Point Dam and Marysville gages after mid-November.

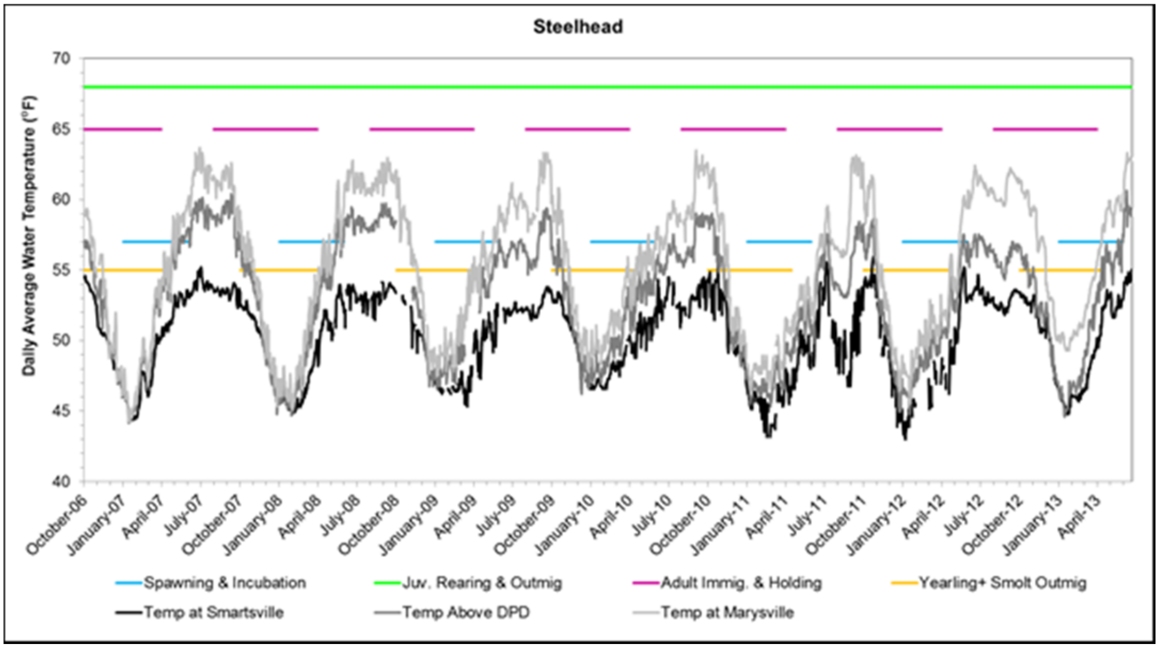

Figure 4-9. Lower Yuba River monitored water temperatures and steelhead upper tolerance WTI values.

4.3.5 Limiting Factors, Threats and Stressors

As stated by NMFS (2005b), the factors affecting the survival and recovery of Central Valley steelhead and their habitat are similar to those affecting spring-run Chinook salmon and are primarily associated with habitat loss (McEwan 2001). McEwan and Jackson (1996) attribute this habitat loss and other impacts to steelhead habitat primarily to water development resulting in inadequate flows, flow fluctuations, blockages, and entrainment into diversions. Other effects on critical habitat related to land use practices and urbanization have also contributed to steelhead declines (Busby et al. 1996). Although many of the factors affecting spring-run Chinook salmon habitat are common to steelhead, some stressors, especially summer water temperatures, cause greater effects to steelhead because juvenile steelhead rear in freshwater for more than one year. Because most suitable habitat has been lost to dam construction, juvenile steelhead rearing is generally confined to lower elevation stream reaches, where water temperatures during late summer and early fall can be sub-optimal (NMFS 2005b).

Many of the improvements to critical habitat that have benefited spring-run Chinook salmon, including water management through the CVPIA Section 3406(b)(2) water supply and the CALFED Environmental Water Account, improved screening conditions at water diversions, and changes in inland fishing regulations (there is no ocean steelhead fishery) also benefit Central Valley steelhead (NMFS 2005b). However, many dams and reservoirs in the Central Valley do not have water storage capacity or release mechanisms necessary to maintain suitable water temperatures for steelhead rearing through the critical summer and fall periods, especially during critically dry years (McEwan 2001).

4.3.5.1 DPS

According to the NMFS Draft Recovery Plan (NMFS 2009), threats to Central Valley steelhead are similar to those for spring-run Chinook salmon and fall into three broad categories: (1) loss of historical spawning habitat; (2) degradation of remaining habitat; and (3) threats to the genetic integrity of the wild spawning populations from hatchery steelhead production programs in the Central Valley. Also, as for spring-run Chinook salmon, the potential effects of long-term climate change also may adversely affect steelhead and their recovery.

In 1998, NMFS concluded that the risks to Central Valley steelhead had diminished, based on a review of existing and recently implemented state conservation efforts and federal management programs (e.g., CVPIA, AFRP, CALFED) that address key factors for the decline of this species (NMFS 2009). NMFS stated that Central Valley steelhead were benefiting from two major conservation initiatives, being simultaneously implemented: (1) the CVPIA, which was passed by Congress in 1992; and (2) the CALFED Program, a joint state/federal effort implemented in 1995. The following discussion of these two programs was taken directly from NMFS (2009).

The CVPIA is specifically intended to remedy habitat and other problems associated with the construction and operation of the CVP. The CVPIA has two key features related to steelhead. First, it directs the Secretary of the Interior to develop and implement a program that makes all reasonable efforts to double natural production of anadromous fish in Central Valley streams (Section 3406(b)(1)) by the year 2002. The AFRP was initially drafted in 1995 and subsequently revised in 1997. Funding has been appropriated since 1995 to implement restoration projects identified in the AFRP planning process. Second, the CVPIA dedicates up to 800,000 acre-feet of water annually for fish, wildlife, and habitat restoration purposes (Section 3406(b)(2)) and provides for the acquisition of additional water to supplement the 800,000 acre-feet (Section 3406(b)(3)). USFWS, in consultation with other federal and state agencies, has directed the use of this dedicated water yield since 1993.

The CALFED Program, which began in June 1995, was charged with the responsibility of developing a long-term Bay-Delta solution. A major element of the CALFED Program is the Ecosystem Restoration Program (ERP), which was intended to provide the foundation for long-term ecosystem and water quality restoration and protection throughout the region. Among the non-flow factors causing decline that have been targeted by the program are unscreened diversions, waste discharges and water pollution, impacts due to poaching, land derived salts, exotic species, fish barriers, channel alterations, loss of riparian wetlands, and other causes of estuarine habitat degradation. The level of risk faced by the Central Valley steelhead DPS may have diminished since the 1996 listing proposal as a result of habitat restoration and other measures that have recently been implemented through the CALFED and CVPIA programs. Although most restoration measures designed to recover Chinook salmon stocks can benefit steelhead, focusing restoration solely on Chinook salmon may lead to inadequate measures to restore steelhead because of their different life histories and resource requirements, particularly for rearing juveniles (McEwan 2001). Additional actions that benefit Central Valley steelhead include efforts to enhance fisheries monitoring, such as the Central Valley Steelhead Monitoring Plan, and conservation actions to address artificial propagation.

In spite of the benefits derived from implementation of these two programs, NMFS (2009) identified several major stressors presently applicable to the entire Central Valley steelhead DPS. Many of the most important stressors specific to the steelhead DPS correspond to the stressors described for the spring-run Chinook salmon ESU. As previously stated, the 2009 NMFS OCAP BO (2009a) identified factors leading to the current status of the spring-run Chinook salmon ESU, which also are applicable to the steelhead DPS, including habitat blockage, water development and diversion dams, water conveyance and flood control, land use activities, water quality, hatchery operations and practices, over-utilization (e.g., ocean commercial and sport harvest, inland sport harvest), disease and predation, environmental variation (e.g., natural environmental cycles, ocean productivity, climate change), and non-native invasive species. The previous discussions in this BA addressing limiting factors and threats for the spring-run Chinook salmon ESU and their specific geographic influences, including the Sacramento River and the Delta, are not repeated in this section of this BA. Stressors that are unique to the steelhead DPS, or substantially differ in the severity from the stressor for the previously described spring-run Chinook salmon ESU, are described below.

Threats and stressors for the Central Valley steelhead DPS identified in Appendix B (Threats Assessment) of the NMFS Draft Recovery Plan (NMFS 2009) include: (1) destruction, modification, or curtailment of habitat or range; (2) overutilization for commercial, recreational, scientific or education purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms, including federal and non-federal efforts; (5) other natural and man-made factors affecting its continued existence; and (6) non-lifestage specific threats and stressors including artificial propagation programs, small population size, genetic integrity and long-term climate change. The following summarization of threats and stressors for the Central Valley steelhead DPS is taken directly from Appendix B (Threats Assessment) of the NMFS Draft Recovery Plan (NMFS 2009).

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

The spawning habitat for Central Valley steelhead has been greatly reduced from its historical range (NMFS 2009). The vast majority of historical spawning habitat for Central Valley steelhead has been eliminated by fish passage impediments associated with water storage, withdrawal, conveyance, and diversions for agriculture, flood control, and domestic and hydropower purposes (NMFS 2009). Modification of natural flow regimes has resulted in increased water temperatures, changes in fish community structures, depleted flow necessary for migration, spawning, rearing, and flushing of sediments from spawning gravels. These changes in flow regimes may be driving a shift in the frequencies of various life history strategies, especially a decline in the proportion of the population migrating to the ocean. Land use activities, such as those associated with agriculture and urban development, have altered steelhead habitat quantity and quality. Although many historically harmful practices have been halted, much of the historical damage to habitats limiting steelhead remains to be addressed, and the necessary restoration activities will likely require decades.

Overutilization for Commercial, Recreational, Scientific or Educational Purposes (Inland Sport Harvest)

Steelhead have been, and continue to be, an important recreational fishery throughout their range. Although there are no commercial fisheries for steelhead in the ocean, inland steelhead fisheries include tribal and recreational fisheries. In the Central Valley, recreational fishing for steelhead is popular, yet harvest is restricted to only the visibly marked hatchery-origin fish, which reduces the likelihood of retaining naturally spawned wild fish. The permits NMFS issues for scientific or educational purposes stipulate specific conditions to minimize take of steelhead individuals during permitted activities. There are currently 11 active permits in the Central Valley that may affect steelhead. These permitted studies provide information about Central Valley steelhead that is useful to the management and conservation of the DPS. [Additional information regarding inland sport harvest of steelhead in the Central Valley contained in Reclamation (2008) is provided below.]

Inland Sport Harvest

Historically in California, almost half of the river sport fishing effort has occurred in the Sacramento-San Joaquin River system, particularly upstream from the city of Sacramento (Emmett et al. 1991). There is little information on steelhead harvest rates in California. Hallock et al. (1961) estimated that harvest rates for Sacramento River steelhead from the 1953/1954 through 1958/1959 seasons ranged from 25.1 to 45.6% assuming a 20% non-return rate of tags. The average annual harvest rate of adult steelhead above RBDD for the 3-year period from 1991/1992 through 1993/1994 was 16% (McEwan and Jackson 1996). Since 1998, all hatchery steelhead have been marked with an adipose fin clip allowing anglers to distinguish hatchery and wild steelhead. Current regulations restrict anglers from keeping unmarked steelhead in Central Valley streams. Overall, this regulation has greatly increased protection of naturally produced adult steelhead (Reclamation 2008). However, the total number of steelhead contacted might be a significant fraction of basin-wide escapement, and even low catch-and-release mortality may pose a problem for wild populations (Good et al. 2005).

DISEASE OR PREDATION

Steelhead are exposed to bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment. Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases for steelhead. Naturally spawned fish tend to be less susceptible to pathogens than hatchery-reared fish. Introduction of non-native species and modification of habitat have resulted in increased predatory populations and salmonid predation in river systems. In general, predation rates on steelhead are considered to be an insignificant contribution to the large declines observed in West Coast steelhead populations. In some local populations, however, predation may significantly influence salmonid abundance when other prey species are not present and habitat conditions lead to the concentration of adults and/or juveniles.

INADEQUACY OF EXISTING REGULATORY MECHANISMS (FEDERAL EFFORTS, NON-FEDERAL EFFORTS)

FEDERAL EFFORTS

There have been several federal actions attempting to reduce threats to the Central Valley steelhead DPS. The BOs for the CVP and SWP and other federal projects involving irrigation and water diversion and fish passage, for example, have improved or minimized adverse impacts to steelhead in the Central Valley. There have also been several habitat restoration efforts implemented under CVPIA and CALFED programs that have led to several projects involving fish passage improvements, fish screens, floodplain management, habitat restoration, watershed planning, and other projects that have contributed to improvement of steelhead habitat. However, despite federal actions to reduce threats to the Central Valley steelhead DPS, the existing protective efforts are inadequate to ensure the DPS is no longer in danger of extinction. There remain high risks to the abundance, productivity, and spatial structure of the steelhead DPS.

NON-FEDERAL EFFORTS

Measures to protect steelhead throughout the State of California have been in place since 1998. The State's Natural Communities Conservation Planning (NCCP) program involves long-term planning with several stakeholders. A wide range of measures have been implemented, including 100% marking of all hatchery steelhead, zero bag limits for unmarked steelhead, gear restrictions, closures, and size limits designed to protect smolts. NMFS and CDFW are working to improve inland fishing regulations to better protect both anadromous and resident forms of *O. mykiss* populations. A proposal to develop a comprehensive status and trends monitoring plan for Central Valley steelhead was submitted for funding consideration to the CALFED ERP in 2005. The proposal, drafted by CDFW and the interagency Central Valley Steelhead Project Work Team, was selected by the ERP Implementing Agency Managers, and is to receive funding as a directed action. Long-term funding for implementation of the monitoring plan, once it is developed, still needs to be secured. There are many sub-watershed groups, landowners, environmental groups, and non-profit organizations that are conducting habitat restoration and planning efforts that may contribute to the conservation of steelhead. However, despite federal and non-federal efforts to promote the conservation of the Central Valley steelhead DPS, few efforts address conservation needs at scales sufficient to protect the entire steelhead DPS. The lack of status and trend monitoring and research is one of the critical limiting factors to this DPS.

OTHER NATURAL AND MAN-MADE FACTORS AFFECTING THE CONTINUED EXISTENCE OF THE DPS

NMFS and the Biological Review Team (BRT) are concerned that the proportion of naturally produced fish is declining. Two artificial propagation programs for steelhead in the Central Valley – Coleman National Fish Hatchery and FRFH – may decrease risk to the DPS to some degree by contributing increased abundance to the DPS. Potential threats to natural steelhead posed by hatchery programs include: (1) mortality of natural steelhead in fisheries targeting hatchery-origin steelhead; (2) competition for prey and habitat; (3) predation by hatchery-origin fish on younger natural fish; (4) genetic introgression by hatchery-origin fish that spawn naturally and interbreed with local natural populations; and (5) disease transmission.

Changes in climatic events and global climate, such as El Niño ocean conditions and prolonged drought conditions, can threaten the survival of steelhead populations already reduced to low abundance levels as the result of the loss and degradation of freshwater and estuarine habitats. Floods and persistent drought conditions have reduced already limited spawning, rearing, and migration habitats. Unscreened water diversions and CVP and SWP pumping plants entrain outmigrating juvenile steelhead and fry, leading to fish mortality.

NON-LIFESTAGE SPECIFIC THREATS AND STRESSORS FOR THE DPS (ARTIFICIAL PROPAGATION PROGRAMS, SMALL POPULATION SIZE, GENETIC INTEGRITY AND LONG-TERM CLIMATE CHANGE)

Potential threats to the Central Valley steelhead population that are not specific to a particular lifestage include the potential negative impacts of the current artificial propagation program utilizing several hatcheries in the Sacramento-San Joaquin drainage, the small wild population size, the genetic integrity of the population due to both hatchery influence and small population size, and the potential effects of long-term climate change. Each of these potential threats is discussed in the following sections.

ARTIFICIAL PROPAGATION PROGRAM

Recent research has indicated that approximately 63 to 92% of steelhead smolt production is of hatchery-origin (NMFS 2003). These data suggest that the relative proportion of wild to hatchery smolt production is decreasing (NMFS 2003). All California hatchery steelhead programs began 100% adipose fin-clipping in 1998 to differentiate between hatchery steelhead from natural steelhead.

Propagation of steelhead at the Coleman National Fish Hatchery has been occurring for over 50 years. Hatchery-origin and natural-origin steelhead have been managed as a single stock; mixing of hatchery and natural origin population components occurred through spawning at the hatchery and intermingling with natural spawners in Battle Creek. Niemela et al. (2008) used genetic pedigree analysis to evaluate relative reproductive success and fitness among hatchery-origin and natural origin population components based on multilocus DNA microsatellite genotypes. Preliminary results suggest that hatchery origin spawners experienced low relative reproductive success, producing significantly fewer adult offspring in comparison to natural origin spawners.

Additionally, repeat spawning was more prevalent in the natural origin component of the population.

POPULATION SIZE

In the technical memorandum titled *Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead* (Good et al. 2005), NMFS estimated the abundance of natural spawners for the steelhead DPS (then classified as an ESU), which was reported as the geometric mean (and range) of the most recent data available at that time, consistent with previous coast-wide status reviews of the species (Weitkamp et al. 1995; Busby et al. 1996; Gustafson et al. 1997; Johnson et al. 1997; Myers et al. 1998). Geometric means were calculated to represent the abundance of natural spawners for each population or quasi-population. Geometric means were calculated for the most recent 5 years of steelhead data, to correspond with modal age at maturity (Good et al. 2005). Where possible, the BRTs obtained population or ESU-level estimates of the fraction of hatchery-origin spawners or calculated estimates from information using scale analyses, fin clips, etc. (Good et al. 2005).

The Central Valley steelhead DPS mean annual escapement of natural spawners was estimated at 1,952 based on a 5-year period ending in 1993 (Good et al. 2005). During that time period a minimum escapement of 1,425 and a maximum escapement of 12,320 were observed (Good et al. 2005). A long-term trend analysis indicated that the population was declining (Good et al. 2005). In the *Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead* (Good et al. 2005), NMFS suggests that there has been no significant status change since the 1993 data and the Central Valley steelhead population continues to decline (Good et al. 2005). Good et al. (2005) also suggested that hatchery production is large relative to natural production. As an example, the steelhead run in the lower Feather River has been increasing over the past several years; however, over 99% of the run is of direct hatchery-origin (DWR 2002).

GENETIC INTEGRITY

There is still significant local genetic structure to Central Valley steelhead populations, although fish from the San Joaquin and Sacramento basins cannot be distinguished genetically (Nielsen et al. 2003). Hatchery effects appear to be localized – for example, Feather River and FRFH steelhead are closely related as are American River and Nimbus Hatchery fish (DWR 2002). Leary et al. (1995) report that hatchery straying has increased gene flow among steelhead populations in the Central Valley and that a smaller amount of genetic divergence is observed among Central Valley populations compared to wild British Columbia populations largely uninfluenced by hatcheries. Natural annual production of steelhead smolts in the Central Valley is estimated at 181,000 and hatchery production is 1,340,000 for a ratio of 0.148 (Good et al. 2005). Current monitoring by hydroacoustic tracking has revealed that Mokelumne River/Hatchery steelhead (FRFH source stock) are straying into the American River (J. Smith, EBMUD, pers. comm. as cited in NMFS 2009).

There has also been significant transfer of genetic material among hatcheries within the Central Valley as well as some transfer from systems outside the Central Valley. There have also been transfers of steelhead from the FRFH to the Mokelumne Hatchery. For example, eyed eggs from the Nimbus Hatchery were transferred to the FRFH several times in the late 1960s and early 1970s (DWR 2002). Also, Nimbus Hatchery steelhead eggs have often been transferred to the Mokelumne Hatchery. Additionally, an Eel River strain of steelhead was used as the founding broodstock for the Nimbus Hatchery (CDFG 1991a). In the late 1970s, a strain of steelhead was brought in from Washington State for the FRFH (DWR 2002).

LONG-TERM CLIMATE CHANGE

Because steelhead normally spend a longer time in freshwater as juveniles than other anadromous salmonids, any negative effects of climate change may be more profound on steelhead populations.

HATCHERY OPERATIONS AND PRACTICES

In addition to the immediately previous discussion taken from Appendix B (Threats Assessment) of the NMFS Draft Recovery Plan (NMFS 2009), an additional discussion regarding the impacts of hatcheries on the Central Valley steelhead DPS is provided below.

Hatcheries have come under scrutiny for their potential effects on wild salmonid populations (Bisson et al. 2002; Araki et al. 2007). The concern with hatchery operations is two-fold. First, they may result in unintentional, but maladaptive genetic changes in wild steelhead stocks (McEwan and Jackson 1996). CDFW believes its hatcheries take eggs and sperm from enough individuals to avoid loss of genetic diversity through inbreeding depression and genetic drift. However, artificial selection for traits that improve hatchery success (e.g., fast growth, tolerance of crowding) are not avoidable and may reduce genetic diversity and population fitness (Araki et al. 2007). Past and present hatchery practices represent the major threat to the genetic integrity of Central Valley steelhead (NMFS 2009). Overlap of spawning hatchery and natural fish within the steelhead DPS exists, resulting in genetic introgression. Also, a substantial problem with straying of hatchery fish exists within this DPS (Hallock 1989). Habitat fragmentation and population declines resulting in small, isolated populations also pose genetic risk from inbreeding, loss of rare alleles, and genetic drift (NMFS 2009).

The second concern with hatchery operations revolves around the potential for undesirable competitive interactions between hatchery and wild stocks. Intraspecific competition between wild and artificially produced stocks can result in wild fish declines (McMichael et al. 1997; 1999). Although wild fish are presumably more adept at foraging for natural foods than hatchery-reared fish, this advantage can be negated by density-dependent effects resulting from large numbers of hatchery fish released at a specific locale, as well as the larger size and more aggressive behavior of the hatchery fish (Reclamation 2008).

Currently, four hatcheries in the Central Valley produce steelhead to supplement the Central Valley wild steelhead population. These four Central Valley steelhead hatcheries (Mokelumne River, FRFH, Coleman, and Nimbus hatcheries) collectively produce approximately 1.5 million steelhead yearlings annually when all four hatcheries reach production goals (CMARP 1998). The hatchery steelhead programs originated as mitigation for the habitat lost by construction of dams. Steelhead are released at downstream locations in January and February at about four fish per pound, generally corresponding to the initiation of the peak of outmigration (Reclamation 2008). In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels (USDOI 1999, as cited in NMFS 2009a).

According to Reclamation (2008), the hatchery runs in the American and Mokelumne rivers are probably highly introgressed mixtures of many exotic stocks introduced in the early days of the hatcheries (McEwan and Jackson 1996; NMFS 1998b). Beginning in 1962, steelhead eggs were imported into Nimbus Hatchery from the Eel, Mad, upper Sacramento, and Russian rivers and from the Washougal and Siletz Rivers in Washington and Oregon, respectively (McEwan and Nelson 1991, as cited in McEwan and Jackson 1996). Egg importation has also occurred at other Central Valley hatcheries (McEwan and Jackson 1996).

Reclamation (2008) further states that stock introductions began at the FRFH in 1967, when steelhead eggs were imported from Nimbus Hatchery to be raised as broodstock. In 1971, the first release of Nimbus origin fish occurred. From 1975 to 1982, steelhead eggs or juveniles were imported from the American, Mad, and Klamath rivers and the Washougal River in Washington. The last year that Nimbus-origin fish were released into the Feather River was 1988. Based on preliminary genetic assessments of Central Valley steelhead, NMFS (1998b) concluded the FRFH steelhead were part of the Central Valley DPS despite an egg importation history similar to the Nimbus Hatchery stock, which NMFS did not consider part of the Central Valley DPS.

The increase in Central Valley hatchery production has reversed the composition of the steelhead population, from 88% naturally-produced fish in the 1950s (McEwan 2001) to an estimated 23 to 37% naturally-produced fish (Nobriga and Cadrett 2003). The increase in hatchery steelhead production proportionate to the wild population has reduced the viability of the wild steelhead populations, increased the use of out-of-basin stocks for hatchery production, and increased straying (NMFS and CDFG 2001). Thus, the ability of natural populations to successfully reproduce and continue their genetic integrity likely has been diminished (Reclamation 2008).

In addition, harvest impacts associated with hatchery-wild population interactions have been identified as a stressor to wild Central Valley steelhead stocks (NMFS 2009). The relatively low number of spawners needed to sustain a hatchery population can result in high harvest-to-escapements ratios in waters where fishing regulations are set according to hatchery population. This can lead to over-exploitation and reduction in the size of wild populations existing in the same system as hatchery populations due to incidental bycatch (McEwan 2001). According to CDFW creel census surveys, the majority (93%) of steelhead catches occur on the American and Feather rivers, sites of steelhead hatcheries (CDFG 2001d, as cited in NMFS 2009). Creel census surveys conducted during 2000 indicated that 1,800 steelhead were retained, and 14,300 were caught and released. The total number of steelhead contacted might be a significant fraction of basin-wide escapement, so even low catch-and-release mortality may pose a problem for wild populations. Additionally, NMFS (2005b) asserted that steelhead fisheries on some tributaries and the mainstem Sacramento River may affect some steelhead juveniles.

4.3.5.2 Lower Yuba River

The lower Yuba River steelhead population is exposed and subject to the myriad of limiting factors, threats and stressors described above for the DPS. Concurrently with the effort conducted for spring-run Chinook salmon, NMFS (2009) recently conducted a comprehensive assessment of stressors affecting both steelhead within the lower Yuba River, and lower Yuba River steelhead populations as they migrate downstream (as juveniles) and upstream (as adults) through the lower Feather River, the lower Sacramento River, and the Bay-Delta system. For the lower Yuba River population of steelhead, the number of stressors according to the categories of “Very High”, “High”, “Medium”, and “Low” that occur in the lower Yuba River or occur out of basin are presented below by lifestage (**Table 4-9**).

As shown by the numbers in Table 4-9, of the total number of 94 stressors affecting all identified lifestages of lower Yuba River populations or steelhead, 31 are within the lower Yuba River and 63 are out-of-basin. Because spawning and incubation occurs only in the lower Yuba River, all of the stressors associated with these lifestages occur in the lower Yuba River. For the adult immigration and holding, and the juvenile rearing and outmigration lifestages combined, a total of 49 “Very High” and “High” stressors were identified, with 15 of those occurring in the lower Yuba River and 34 occurring out-of-basin.

Table 4-9. The number of stressors according to the categories of "Very High", "High", "Medium", and "Low" that occur in the lower Yuba River, or occur out-of-basin, by lifestage for the lower Yuba River population of steelhead (Source: NMFS 2009).

Lifestage	Location	Stressor Categories			
		Very High	High	Medium	Low
Adult Immigration and Holding					
	Lower Yuba River	2	1	3	1
	Out of Basin	1	5	10	4
Spawning					
	Lower Yuba River	3	2	0	2
	Out of Basin	N/A*	N/A	N/A	N/A
Embryo Incubation					
	Lower Yuba River	1	0	4	0
	Out of Basin	N/A	N/A	N/A	N/A
Juvenile Rearing and Outmigration					
	Lower Yuba River	5	1	1	5
	Out of Basin	12	16	6	9
* N/A – Not Applicable.					

The NMFS (2009) Draft Recovery Plan states that "*The lower Yuba River, below Englebright Dam, is characterized as having a high potential to support a viable population of steelhead, primarily because: (1) the river supports a persistent population of steelhead and historically supported the largest, naturally reproducing population of steelhead in the Central Valley (McEwan and Jackson 1996); (2) flow and water temperature conditions are generally suitable to support all life stage requirements; (3) the river does not have a hatchery on it; (4) spawning habitat availability does not appear to be limited; and (5) high habitat restoration potential*".

Similar to the statement for spring-run Chinook salmon, the NMFS (2009) Draft Recovery Plan further states that "*For currently occupied habitats below Englebright Dam, it is unlikely that habitats can be restored to pre-dam conditions, but many of the processes and conditions that are necessary to support a population of steelhead can be improved with improvements to instream flow regimes, water temperatures, and habitat availability. Continued implementation of the Yuba Accord is expected to address these factors and considerably improve conditions in the lower Yuba River*."

Many of the most important stressors specific to steelhead in the lower Yuba River correspond to the stressors described for spring-run Chinook salmon in the lower Yuba River, which included passage impediments and barriers, harvest and angling impacts, poaching, physical habitat alteration, loss of riparian habitat and instream cover (e.g., riparian vegetation, instream woody material), loss of natural river morphology and function, loss of floodplain habitat, entrainment, predation, and hatchery effects.

The previous discussions in this BA addressing limiting factors and threats for the spring-run Chinook salmon population in the lower Yuba River that are pertinent to the steelhead population in the lower Yuba River are not repeated in this section of the BA. Stressors that are unique to steelhead in the lower Yuba River, and stressors that substantially differ in severity for steelhead, are described below.

HARVEST/ANGLING IMPACTS

Fishing for steelhead on the lower Yuba River is regulated by CDFW. Angling regulations on the lower Yuba River are intended to protect sensitive species, including wild steelhead. CDFW angling regulations (2013/2014) permit fishing for steelhead from the mouth of the Yuba River to the Highway 20 Bridge with only artificial lures with barbless hooks all year-round. The regulations include a daily bag limit of two hatchery trout or hatchery steelhead (identified by an adipose fin clip), and a possession limit of four hatchery trout or hatchery steelhead. From the Highway 20 Bridge to Englebright Dam, fishing for steelhead is permitted from December 1 through August 31 only, with only artificial lures with barbless hooks. For this time period, the regulations include a daily bag limit of two hatchery trout or hatchery steelhead (identified by an adipose fin clip), and a possession limit of four hatchery trout or hatchery steelhead.

POACHING

By contrast to the previous discussion regarding the potential for poaching to be a stressor to spring-run Chinook salmon, no references have been reported regarding the potential poaching of steelhead at the fish ladders, or at the base of Daguerre Point Dam. In addition, no reference has been located regarding the occurrence of steelhead jumping out of the fish ladders at Daguerre Point Dam.

HATCHERY EFFECTS

The previous discussion in this BA addressing limiting factors, threats and stressors resulting from straying and other hatchery effects on the steelhead DPS that are pertinent to steelhead in the lower Yuba River are not repeated in this section of the BA. Hatchery-related stressors that are unique to steelhead in the lower Yuba River, or substantially differ in severity for Yuba River steelhead, are described below.

Although it has been oft-repeated that hatcheries historically have not been located on the Yuba River, that does not appear to be the case. According to a document titled "*A History of California's Fish Hatcheries 1870–1960*" (Leitritz 1970), an experimental fish hatchery station (i.e., the Yuba River Hatchery) was established in 1928 by the California Department of Natural Resources, Division of Fish and Game. The site was on Fiddle Creek, a tributary of the North Fork Yuba River about 34 miles north of Nevada City, near Camptonville. Fish rearing began at the station in 1929. Over the years, improvements were made to the hatchery. No reference could be found regarding salmon, but the hatchery was reported to hatch and rear trout, including steelhead (CDNR 1931). The hatchery continued operations until storms during November 1950 caused such extensive damage that repairs could not be made and it was permanently closed (Leitritz 1970).

Since that time, no fish hatcheries have been located on the lower Yuba River, and the river continues to support a persistent population of steelhead. According to the NMFS Draft Recovery Plan (NMFS 2009), the major threat to the genetic integrity of Central Valley steelhead results from past and present hatchery practices. These practices include the planting of non-natal fish, overlap of spawning hatchery and natural fish, and straying of hatchery fish.

GENETIC CONSIDERATIONS

From 1970 to 1979, CDFW annually stocked 27,270–217,378 fingerlings, yearlings, and sub-catchable steelhead from Coleman National Fish Hatchery into the lower Yuba River (CDFG 1991a). CDFW stopped stocking steelhead into the lower Yuba River in 1979. In addition, it is possible that some hatchery-reared juvenile steelhead from the FRFH may move into the lower Yuba River in search of rearing habitat. Some competition for resources with naturally spawned steelhead could occur as a result.

Previous genetic work on population structure of steelhead in California has relied primarily on analyses of mitochondrial DNA (e.g. Berg and Gall 1988; Nielsen et al. 1997), which is a single gene that is often not reflective of population history or true relationships (Chan and Levin 2005). However, microsatellites, also known as simple sequence repeat loci, have been used in numerous studies of salmonids and have proven to be a valuable tool for elucidating population genetic structure. Work on *O. mykiss* in California using microsatellite loci has demonstrated that genetic structure can be identified with such data, both at larger scales (Aguilar and Garza 2006) and at relatively fine ones (Deiner et al. 2007; Pearse et al. 2007). The following discussion was taken from Garza and Pearse (2008).

Garza and Pearse (2008) studied populations of *O. mykiss* in the Central Valley using molecular genetic techniques to provide insight into population structure in the region. Data were collected from 18 nuclear microsatellite loci and variation analyzed to trace ancestry and evaluate genetic distinction among populations. The goals of the study were to use population genetic analyses of the data to assess origins and ancestry of *O. mykiss* populations above and below dams in Central Valley tributary rivers, to better understand the relationship of these populations to others in California, and to provide information on genetic diversity and population structure of these populations. Genotypes were collected from over 1,600 individual fish from 17 population samples and five hatchery rainbow trout strains. Fish populations from rivers and creeks that flow to both the Sacramento and San Joaquin Rivers were evaluated, including the McCloud River, Battle Creek, Deer Creek, Butte Creek, Feather River, Yuba River, American River, Calaveras River, Stanislaus River and Tuolumne River sub-basins. Analyses included fish collected both above and below barriers to anadromy in some of the study basins (Garza and Pearse 2008).

Phylogeographic trees were used to visually and quantitatively evaluate genetic relationships of Central Valley *O. mykiss* populations both with each other and with other California populations. Genetic diversity was relatively similar throughout the Central

Valley. Above-barrier populations clustered with one another and below-barrier populations are most closely related to populations in far northern California, specifically the genetic groups that include the Eel and Klamath Rivers. Since Eel River origin broodstock were used for many years at Nimbus Hatchery on the American River, it is likely that Eel River genes persist there and have also spread to other basins by migration, and that this is responsible for the clustering of the below-barrier populations with northern California ones. This suggests that the below-barrier populations in this region appear to have been widely introgressed with hatchery fish from out-of-basin broodstock sources. In phylogeographic analyses, above-barrier populations are more similar to San Francisco Bay *O. mykiss* populations than the below-barrier populations in the Central Valley. Because this relationship is expected for steelhead, given their extraordinary historic dependence on short distance migration events (Pearse and Garza 2007), they may represent relatively non-introgressed historic population genetic structure for the region. Other possible explanations for this pattern that rely on complicated, widespread patterns of introgression with hatchery fish are not entirely ruled out, but are highly improbable given that the above-barrier populations also group with moderate consistency into geographically-consistent clusters (e.g. Yuba-Upper and Feather-Upper) in all analyses and also because of the low apparent reproductive success of hatchery trout in streams throughout California (Garza and Pearse 2008).

The analyses also identified possible heterogeneity between samples from different tributaries of the upper Yuba and Feather Rivers, although linkage disequilibrium was lower in these populations. Linkage disequilibrium can be caused by physical linkage of loci, sampling of related individuals/family structure, and by the sampling of more than one genetically distinct group within a population sample (Garza and Pearse 2008).

In general, although structure was found, all naturally-spawned *O. mykiss* populations within the Central Valley Basin were closely related, regardless of whether they were sampled above or below a known barrier to anadromy (Garza and Pearse 2008). This is due to some combination of pre-impoundment historic shared ancestry, downstream migration and, possibly, limited anthropogenic upstream migration. However, lower genetic diversity in above-barrier populations indicates a lack of substantial genetic input upstream and highlights lower effective population sizes for above-barrier populations.

The consistent clustering of the above-barrier populations with one another, and their position in the California-wide trees, indicate that they are likely to most accurately represent the ancestral population genetic structure of steelhead in the Central Valley (Garza and Pearse 2008).

STRAYING INTO THE LOWER YUBA RIVER

The observation of adipose fin clips on adult steelhead passing upstream through the VAKI Riverwatcher system at Daguerre Point Dam demonstrates that hatchery straying into the lower Yuba River has, and continues, to occur. Although no information is presently available regarding the origin of adipose-clipped steelhead observed at the VAKI Riverwatcher system at Daguerre Point Dam, it is reasonable to surmise that they most likely originate from the FRFH. The remainder of this discussion pertains to hatchery effects associated with the straying of adult steelhead into the lower Yuba River.

If hatchery-origin steelhead stray into the lower Yuba River and interbreed with naturally-spawning Yuba River steelhead, then such interbreeding has been suggested to represent a threat to the genetic diversity and integrity of the naturally-spawning steelhead population in the lower Yuba River. No previously conducted quantitative analyses or data addressing the extent of hatchery-origin steelhead straying into the lower Yuba River is available for presentation in this BA. However, some information is presently available to assess the amount of straying of hatchery-origin (adipose fin-clipped) steelhead into the lower Yuba River from VAKI Riverwatcher data.

In the lower Yuba River, attempts were made to differentiate adult steelhead from other *O. mykiss* (i.e., juvenile steelhead and resident rainbow trout) recorded passing Daguerre Point Dam utilizing daily VAKI Riverwatcher data. However, only two years of data (2010/2011 and 2011/2012) are available identifying adipose fin-clipped *O. mykiss* passing through the VAKI Riverwatcher system, during which extensive inoperable periods did not occur during the adult steelhead upstream migration period. Data reduction, limitations and applications are described in Section 4.2.6 (Viability) of this BA, below.

Analysis of the VAKI Riverwatcher data indicates that the percent contribution of hatchery-origin adult upstream migrating fish (represented by the percentage of adipose fin-clipped adult steelhead relative to the total number of adult upstream migrating steelhead, because 100% of FRFH-origin steelhead have been marked since 1996) was approximately 43% for the 2010/2011 biological year, and about 63% for the 2011/2012 biological year (RMT 2013).

4.3.6 Viability of the Central Valley Steelhead DPS

The VSP concept (McElhany et al. 2000) previously described in Section 4.1.6 of this BA for the spring-run Chinook salmon ESU also is used to address and describe the viability of the Central Valley Steelhead DPS.

4.3.6.1 DPS

As described by NMFS (2009), there are few data with which to assess the status of Central Valley steelhead populations. Lindley et al. (2007) stated that, with the few exceptions of streams with long-running hatchery programs such as Battle Creek and the Feather, American and Mokelumne rivers, Central Valley steelhead populations are classified as data deficient. In all cases, hatchery-origin fish likely comprise the majority of the natural spawning run, placing the natural populations at high risk of extinction (Lindley et al. 2007). As of 2009, NMFS (2009) reinforced the conclusion that the Central Valley steelhead DPS is data deficient, with the exception of these hatchery programs.

From 1967-1993, steelhead run-size estimates were generated from fish counts in the fish ladder at RBDD (CDFG 2010a). From these counts, estimates of the natural spawner escapement upstream of RBDD were generated. Because RBDD impacted winter-run Chinook salmon by delaying their upstream migration, dam operations were changed in 1993 so that dam gates were raised earlier in the season, which eliminated the need for fish to navigate fish ladders, but also eliminated the ability to generate accurate run-size estimates for the upper Sacramento River Basin (CDFG 2010a).

Presently, little information is available regarding the abundance of steelhead in the Central Valley (CDFG 2010a). Currently there is virtually no coordinated, comprehensive, or consistent monitoring of steelhead in the Central Valley. In 2004, the

Interagency Ecological Program Steelhead Project Work Team developed a proposal to develop a comprehensive monitoring plan for Central Valley steelhead. In 2007, development of this steelhead monitoring plan was funded by the CALFED Ecosystem Restoration Program. In 2010, a document titled "A Comprehensive Monitoring Plan for Steelhead in the California Central Valley" was completed by CDFG (2010a), which recommended steelhead monitoring activities in the Central Valley. The objectives of the plan include: (1) estimate steelhead population abundance with levels of precision; (2) examine trends in steelhead abundance; and (3) identify the spatial distribution of steelhead in the Central Valley to assess their current range and observe changes in their range that may occur over time. However, for the most part, recommendations in the plan remain to be implemented.

According to NMFS (2009), data are lacking to suggest that the Central Valley steelhead DPS is at low risk of extinction, or that there are viable populations of steelhead anywhere in the DPS. Conversely, there is evidence to suggest that the Central Valley steelhead DPS is at moderate or high risk of extinction (McEwan 2001; Good et al. 2005). Most of the historical habitat once available to steelhead has been lost (Yoshiyama et al. 1996; McEwan 2001; Lindley et al. 2006). Furthermore, the observation that anadromous *O. mykiss* are becoming rare in areas where they were probably once abundant indicates that an important component of life history diversity is being suppressed or lost (NMFS 2009). Habitat fragmentation, degradation, and loss are likely having a strong negative impact on many resident as well as anadromous *O. mykiss* populations (Hopelain 2003 as cited in NMFS 2009).

VIABLE SALMONID POPULATION (VSP) PARAMETERS AND APPLICATION

ABUNDANCE AND PRODUCTIVITY

According to NMFS (2009a) and CDFG (2010a), there is still a paucity of steelhead monitoring in the Central Valley. Therefore, data are lacking regarding abundance estimates for the steelhead DPS, or for specific steelhead populations in the Central Valley (NMFS 2009a). Recognizing these data limitations, NMFS (2009a) suggested that natural steelhead escapement in the upper Sacramento River declined substantially from 1967 through 1993, and that the little data that do exist indicate that the steelhead population continues to decline. Also, according to Lindley et al. (2007), even if there were adequate data on the distribution and abundance of steelhead in the Central Valley, their approaches for assessing steelhead population and DPS viability might be problematical because the effect of resident *O. mykiss* on the viability of steelhead populations and the DPS is unknown.

SPATIAL STRUCTURE

For the Central Valley steelhead DPS, Lindley et al. (2006) identified historical independent populations based on a model that identifies discrete habitat and interconnected habitat patches isolated from one another by downstream regions of thermally unsuitable habitat. They hypothesized that historically 81 independent populations of steelhead were dispersed throughout the Central Valley domain.

About 80% of the habitat that was historically available to steelhead is now behind impassable dams, and 38% of the populations have lost all of their habitats (NMFS 2009a). Although much of the habitat has been blocked, or degraded, by impassable dams, small populations of steelhead are still found throughout habitat available in the Sacramento River and many of the tributaries, and some of the tributaries to the San Joaquin River. The current distribution of steelhead is less well understood, but the DPS is composed of at least four diversity groups and at least 26 populations (NMFS 2009).

Remnant steelhead populations are presently distributed through the mainstem of the Sacramento and San Joaquin rivers, as well as many of the major tributaries of these rivers (NMFS 2009). Steelhead presence in highly variable “flashy” streams and creeks in the Central Valley depend primarily on flow and water temperature, which can change drastically from year to year (McEwan and Jackson 1996). As stated in NMFS (2009), spawner surveys of small Sacramento River tributaries (Mill, Deer, Antelope, Clear, and Beegum creeks) and incidental captures of juvenile steelhead during Chinook salmon monitoring (Calaveras, Cosumnes, Stanislaus, Tuolumne, and Merced rivers) confirmed that steelhead are widespread, if not abundant, throughout accessible streams and rivers (Good et al. 2005).

DIVERSITY

Steelhead naturally experience the most diverse life history strategies of the listed Central Valley anadromous salmonid species (NMFS 2009a). However, steelhead has less flexibility to track changes in the environment as the species' abundance decreases and spatial structure of the DPS is reduced (NMFS 2009a).

The posited historical existence of 81 independent steelhead populations is likely to be an underestimate because large watersheds that span a variety of hydrological and environmental conditions, such as the Pit River, probably contained multiple populations (Lindley et al. 2006). Regardless, the distribution of many discrete populations across a wide variety of environmental conditions implies that the Central Valley steelhead DPS contained biologically significant amounts of spatially structured genetic diversity (Lindley et al. 2006). However, it appears that much of the historical diversity within Central Valley *O. mykiss* has been lost or is threatened by dams, which have heavily altered the distribution and population structure of steelhead in the Central Valley (Lindley et al. 2006).

Although historically two different runs of steelhead (summer-run and winter-run) occurred in the Central Valley (McEwan and Jackson 1996), the summer run has been largely extirpated due to a lack of suitable holding and staging habitat, such as coldwater pools in the headwaters of Central Valley streams, presently located above impassible dams (Lindley et al. 2006).

Throughout the Central Valley (and in particular the Merced River, Tuolumne River, and upper Sacramento River) it is difficult to discriminate between adult anadromous and resident forms of *O. mykiss*, as well as their progeny (McEwan 2001), further complicating resource management agencies' understanding of steelhead distribution in the Central Valley (CDFG 2008).

The genetic diversity of steelhead also is compromised by hatchery-origin fish. According to Reclamation (2008), estimates of straying rates only exist for Chinook salmon produced at the FRFH. However, general principles and the potential effects of straying are also applicable for steelhead. Based on available genetic data, the effects of hatcheries that rear steelhead appear to be restricted to the populations on hatchery streams (DWR 2004c). These findings suggest that, although ongoing operations may impact the genetic composition of the naturally spawning steelhead population in these rivers, hatchery effects appear to be localized, although it should be noted that genetic data for steelhead are limited (DWR 2004c).

SUMMARY OF THE VIABILITY OF THE CENTRAL VALLEY STEELHEAD DPS

Although data are lacking to quantitatively evaluate extinction risk for the Central Valley steelhead DPS, NMFS (2009) states that there is evidence to suggest that the Central Valley steelhead DPS is at moderate or high risk of extinction. Steelhead have been extirpated from most of their historical range throughout the Central Valley domain, and most of the historical habitat once available to steelhead is largely inaccessible. Anadromous forms of *O. mykiss* are becoming less abundant or rare in areas where they were probably once abundant, and habitat fragmentation, degradation, and loss are likely having a strong negative impact on many resident as well as anadromous *O. mykiss* populations. In addition, widespread hatchery steelhead production within this DPS also raises concerns about the potential ecological interactions between introduced stocks and native stocks (Corps 2007).

As previously discussed, NMFS completed a 5-year status review of the Central Valley steelhead DPS during August 2011. Good et al. (2005) previously found that Central Valley steelhead were in danger of extinction, with a minority of the NMFS BRT viewing the DPS as likely to become endangered. The NMFS BRT's primary concerns for the DPS included the low abundance of naturally-produced anadromous fish at the DPS level, the lack of population-level abundance data, and the lack of information to suggest that the monotonic decline in steelhead abundance evident from 1967-1993 dam counts has stopped (NMFS 2011c).

Steelhead population trend data remain extremely limited (Williams et al. 2011). The Chipps Island midwater trawl dataset of USFWS provides information on the trend in abundance for the Central Valley steelhead DPS as a whole. Updated through 2010, the trawl data indicate that the decline in natural production of steelhead has continued unabated since the 2005 status review (NMFS 2011c). Catch-per-unit-effort has fluctuated but remained level over the past decade, but the proportion of the catch that is ad-clipped (100% of hatchery steelhead production have been ad-clipped starting in 1998) has risen steadily, exceeding 90% in recent years and reaching 95% in 2010 (NMFS 2011c). Because hatchery releases have been fairly constant, this implies that natural production of juvenile steelhead has been declining (NMFS 2011c).

According to NMFS (2011c), steelhead returns to the FRFH have decreased substantially in the last several years with only 679, 312 and 86 fish returning in 2008, 2009 and 2010, respectively. Because almost all of the returning fish are of hatchery origin and stocking levels have remained fairly constant over the years, data suggest that adverse freshwater and/or ocean survival conditions have caused or at least contribute to these declining hatchery returns (NMFS 2011c). The Central Valley experienced three consecutive years of drought (2007-2009), which NMFS (2011c) states would likely have impacted parr and smolt growth and survival. Additionally, poor ocean conditions have occurred in at least 2005 and 2006, which have affected Chinook populations in the Central Valley and also may have affected steelhead populations (NMFS 2011c). Preliminary return data for 2011 from CDFW suggest a strong rebound in return numbers during 2011, with 712 adults returning to the FRFH through April 5th (NMFS 2011c). Based on steelhead returns to Central Valley hatcheries and the redd counts on Clear Creek, the American River, and the Mokelumne River, it appears that naturally-produced steelhead may not have been impacted by poor freshwater and marine rearing conditions as much as hatchery-origin fish during the last several years (NMFS 2011c). However, NMFS (2011c) suggests that this observation may reflect greater fitness of naturally-produced steelhead relative to hatchery fish, and merits further study.

The steelhead DPS includes two hatchery populations — the FRFH and Coleman National Fish Hatchery. Two additional hatchery populations (i.e., Nimbus and Mokelumne River hatcheries) also are present in the Central Valley, but they were founded from out-of-DPS broodstock and are not considered part of the DPS (NMFS 2011c). Recent genetic information suggests that below dam populations of *O. mykiss* are similar genetically throughout the Central Valley and that genetic diversity and population structure may have been lost over time. Garza and Pearse (2008) analyzed the genetic relationships among Central Valley *O. mykiss* populations and found that all below-barrier populations were generally closely related, and that there was a high level of genetic similarity to Eel River and Klamath River steelhead in all below-barrier population samples. These findings raises an issue about whether or not the steelhead stocks propagated at the Nimbus and Mokelumne River hatcheries should be excluded from the Central Valley steelhead DPS. These two stocks were excluded from the DPS in 2006 because they originated from the Eel River which is not from within the DPS. Because the Eel River strain appears to be widely introgressed in many Central Valley steelhead populations, NMFS (2011c) states that it may be appropriate to re-evaluate whether or not these stocks should be in the DPS based upon the new genetic information.

Using data through 2005, Lindley et al. (2007) found the data were insufficient to determine the status of any of the naturally-spawning populations of Central Valley steelhead, except for those spawning in rivers adjacent to hatcheries. These hatchery influenced populations were likely to be at high risk of extinction due to extensive spawning of hatchery-origin fish in natural areas (NMFS 2011c).

Overall, the status of the Central Valley steelhead DPS appears to have worsened since the 2005 status review when the DPS was considered to be in danger of extinction (Good et al. 2005). Analysis of catch data from the Chipps Island monitoring program suggests that natural steelhead production has continued to decline and that hatchery origin fish represent an increasing proportion of the juvenile production in the Central Valley. Data from the Delta fish salvage facilities also suggests a general decline in the natural production of steelhead (NMFS 2011c). Data on Coleman and FRFH hatchery populations suggest they have declined in the last several years perhaps in response to poor freshwater and ocean habitat conditions. Limited information suggest some individual steelhead populations in the Central Valley are declining in abundance, but more complete data for the Battle Creek population indicate the declines there have been relatively moderate since 2005 and that the population in Clear Creek is increasing (NMFS 2011c).

One continuing area of strength for the Central Valley steelhead DPS is its widespread spatial distribution throughout most watersheds in the Central Valley. All of the factors originally identified as being responsible for the decline of this DPS are still present, although in some cases they have been reduced by regulatory actions (e.g., NMFS CVP/SWP OCAP Biological Opinion in 2009, actions required by CVPIA). Good et al. (2005) described the threats to Central Valley salmon and steelhead as falling into three broad categories, including: (1) loss of historical spawning habitat; (2) degradation of remaining habitat; and (3) genetic threats from the stocking programs. Cummins et al. (2008) attributed the much reduced biological status of anadromous salmonid stocks in the Central Valley, including steelhead, to the construction and operation of the CVP and SWP. Important conservation efforts have been implemented including the 2009 CVP/SWP biological opinion, CVPIA restoration efforts, and continued efforts to implement the Battle Creek Restoration Project that will eventually open up 42 miles of high quality habitat to steelhead (NMFS 2011c). Although these efforts have provided benefits to steelhead and its habitat in the Central Valley, threats from lost habitat and degraded habitat continue to be important factors affecting the status of this DPS. Impacts to steelhead from harvest, research activities, disease and predation were considered relatively minor factors in previous reviews, and there is little or no evidence indicating impacts from these factors have changed (NMFS 2011c). In contrast, threats from other factors such as hatcheries, drought, poor ocean survival conditions, and climate change have not been addressed and/or they have increased since the 2005 status review and some are likely responsible for the recent declining abundance of the DPS (NMFS 2011c).

In summary, the most recent biological information suggests that the extinction risk of this DPS has increased since the last status review and that several of the listing factors have contributed to the decline, including recent years of drought and poor ocean conditions (NMFS 2011c). According to NMFS (2011c), there continue to be ongoing threats to the genetic integrity of naturally-spawning steelhead from Central Valley steelhead hatchery programs, but it is unclear if or how this factor has influenced the overall viability of the DPS. The best available information on the biological status of the DPS and continuing and new threats to the DPS indicate that its ESA status as a threatened species is appropriate (NMFS 2011c).

4.3.6.2 Lower Yuba River

As with all naturally-spawning populations of steelhead in the Central Valley, Lindley et al. (2007) characterized the steelhead population in the lower Yuba River as data deficient, and therefore did not characterize its viability. Data limitations, particularly regarding abundance and productivity, continue to render problematic quantitative estimation procedures to assess the viability of the steelhead population in the lower Yuba River. Continued monitoring of adult steelhead in the lower Yuba River is providing additional information that is needed to assess extinction risk based on Lindley et al. (2007) criteria regarding population size, recent population decline, occurrences of catastrophes within the last 10 years that could cause sudden shifts from a low risk state to a higher one, and the impacts of hatchery influence. The VSP parameters of abundance, productivity, spatial structure and diversity for the steelhead population in the lower Yuba River are discussed below.

ABUNDANCE AND PRODUCTIVITY

VAKI RIVERWATCHER DATA

Ongoing monitoring of the adult steelhead population in the lower Yuba River has been conducted since 2003 with VAKI Riverwatcher systems at Daguerre Point Dam. By contrast to Chinook salmon, escapement surveys involving carcass mark-recovery experiments are not performed on steelhead/*O. mykiss*.

In the lower Yuba River, silhouettes and corresponding photographs were examined for species identification and categorization using methodology similar to that which is described for spring-run Chinook salmon. However, the accurate identification of *O. mykiss* in the VAKI Riverwatcher is more difficult than it is for Chinook salmon.

By contrast to the identification of Chinook salmon which may be conducted with a single attribute, the identification of steelhead becomes more problematic with the absence of a defining silhouette or a clear digital photograph. Additionally, the silhouettes of steelhead cannot reliably be differentiated from resident rainbow trout, and photo documentation of an individual is problematic because adult steelhead typically immigrate during periods of high flow and associated high turbidity and low visibility.

The VAKI Riverwatcher systems cannot differentiate an individual as a resident form of the species (i.e., rainbow trout) or as anadromous (i.e., steelhead). Additionally, the VAKI Riverwatcher systems cannot directly distinguish between an adult or juvenile *O. mykiss* (RMT 2013).

DIFFERENTIATION OF ADULT STEELHEAD VAKI RIVERWATCHER COUNTS

The silhouettes and/or electronic images of each fish passage event that was identified as an *O. mykiss* fish passage event allow the VAKI Riverwatcher systems to calculate an approximate length (in centimeters) for the observed fish.

As reported by the RMT (2013), as an initial step in the differentiation of adult steelhead passing upstream of Daguerre Point Dam, the length distribution of all fish identified as *O. mykiss* passing through both the north and south ladders at Daguerre Point Dam over the entire data availability period (January 1, 2004 through February 29, 2012) was plotted and visually examined (**Figure 4-10)**. This figure indicates the possible presence of at least six length groups. These groups represent the potential combination of juvenile and adult anadromous *O. mykiss* (steelhead), as well as juvenile and adult resident *O. mykiss* (rainbow trout). However, this length-frequency distribution does not provide information necessary to differentiate between steelhead and rainbow trout.

Beginning March 1, 2009, VAKI Riverwatcher fish identified as *O. mykiss* also were classified as fish with or without clipped adipose fins, based on the inspection of the fish silhouette and photogrammetric representation (digital photographs and/or video imagery). The analysis of the length-frequency distribution of all adipose fin-clipped *O. mykiss* provides a means of differentiating adult steelhead passing upstream of Daguerre Point Dam from all other *O. mykiss*, because all adipose fin-clipped *O. mykiss* are steelhead that were released by a Central Valley hatchery.

The lengths of all fish passing upstream at Daguerre Point Dam that were identified as *O. mykiss* with clipped adipose fins (i.e., all hatchery steelhead) between March 1, 2009 through February 29, 2012 are presented in **Figure 4-11**. Visual examination of the observed length distribution in Figure 4-11 indicates the possible presence of up to five groups of fish. Two of the length categories demarcating the first two possible groups of fish occur at 20 cm (7.9 inches) and 29 cm (11.4 inches).

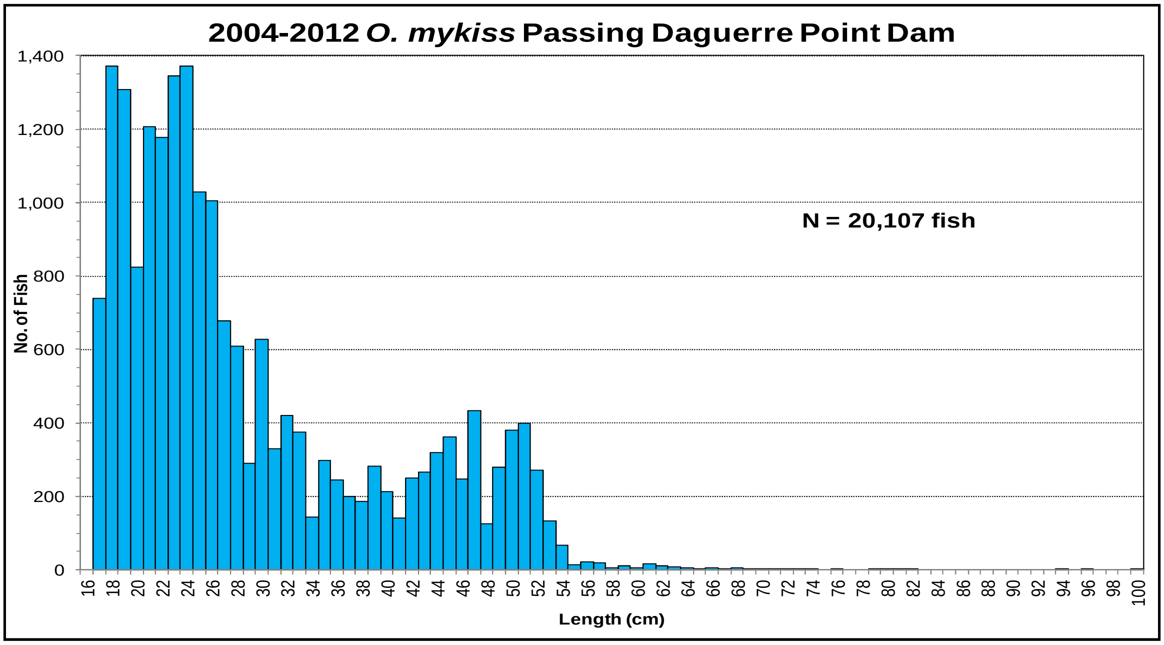

Figure 4-10. Length distribution of all fish identified by the VAKI Riverwatcher systems as *O. mykiss* passing upstream through the north and south ladders of Daguerre Point Dam from January 1, 2004 through February 29, 2012 (Source: RMT 2013).

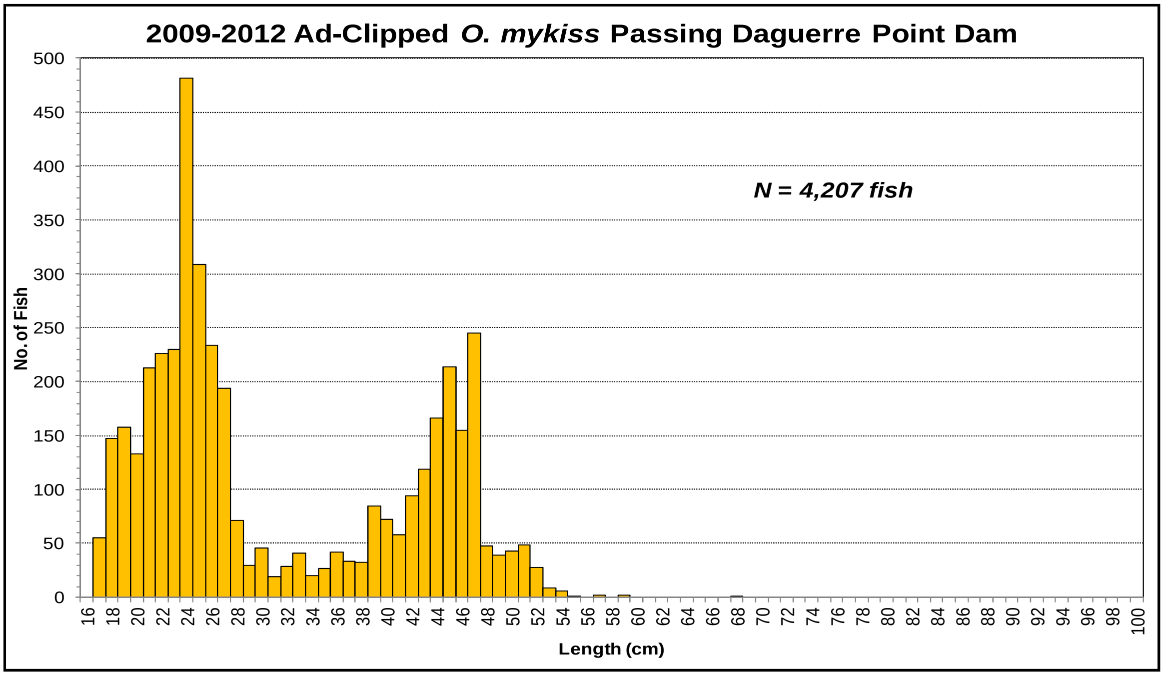

Figure 4-11. Length distribution of all fish identified by the VAKI Riverwatcher systems as adipose clipped *O. mykiss* passing upstream through the north and south ladders of Daguerre Point Dam from March 1, 2009 through February 29, 2012 (Source: RMT 2013).

According to CDFG and USFWS (2010), the normal FRFH release schedule includes the release of steelhead yearlings, from January to February, released in the Feather River near Gridley at four fish per pound. Although not readily available from CDFW, other sources indicate that steelhead smolts averaging 4 to 5 fish per pound range in length from approximately 8-9 inches (20-23 cm) (IDFG 1992). The presence of small, adipose fin-clipped steelhead in the lower Yuba River as displayed in Figure 4-11 may be related to releases of yearling FRFH-produced steelhead on the Feather River.

Since 2007, the FRFH has been releasing only steelhead yearlings at various sites along the Feather River, as well as in the Sacramento River at Sutter Slough, and in Butte Creek (**Table 4-10**). To determine whether fish planted in the lower Feather River may have been detected in the lower Yuba River, an examination of the VAKI Riverwatcher data was conducted for adipose fin-clipped steelhead consistent with the observed potential length-mode demarcation length of 29 cm (11.4 in) (RMT 2013).

Table 4-10. Recent releases of hatchery steelhead by the Feather River Fish Hatchery (Source: Regional Mark Information System (RMIS) of the Regional Mark Processing Center; RMT 2013).

Release Dates		Brood Year	Numbers Released		Release Stage[2]	Study Type[3]	Release Location	Agency	
Start	End		Tagged[1] Adclipped	Untagged Adclipped				Reporting	Release
01/08/07	02/05/07	2006	0	10,036	Y	E	Feather River Thermalito Bypass	CDFG	CDWR
02/05/07	02/21/07	2006	0	488,043	Y	E	Feather River	CDFG	CDWR
05/29/07	05/29/07	2006	0	1,643	Y	E	Feather River	CDFG	CDWR
05/30/08	05/30/08	2007	0	1,109	Y	E	Feather River	CDFG	CDWR
02/01/08	02/14/08	2007	0	307,986	Y	P	Feather River Boyds Pump Ramp	CDFG	CDWR
02/03/09	02/03/09	2008	0	2,750	Y	P	Feather River at Live Oak	CDFG	CDFG
02/03/09	02/17/09	2008	0	398,148	Y	P	Feather River Boyds Pump Ramp	CDFG	CDFG
02/01/10	02/11/10	2009	0	272,798	Y	P	Feather River Boyds Pump Ramp	CDFG	CDFG
02/02/11	02/15/11	2010	0	49,800	Y	P	Feather River Boyds Pump Ramp	CDFG	CDFG

[1] Tagged releases refer to releases with coded wire tags

[2] Release stage Y indicates yearling releases.

[3] Study type E stands for experimental releases, and study type P indicates a production releases.

From February 1, 2010 to February 2, 2011 (i.e., the starting date for the last reported release of adipose fin-clipped juvenile steelhead from the FRFH), 104 adipose fin-clipped juvenile steelhead with lengths less than or equal to 29 cm (11.4 in) were recorded passing upstream of Daguerre Point Dam. Most of these individuals were observed in the VAKI Riverwatcher system during February through April of 2010. Additionally, from February 2, 2011 through January 31, 2012, a total of 1,702 adipose fin-clipped steelhead with lengths less than or equal to 29 cm (11.4 in) were recorded passing upstream of Daguerre Point Dam. While these individuals were observed in the VAKI Riverwatcher system throughout calendar year 2011, they were most frequently observed during April and May of 2011. In other words, most of the observed adipose fin-clipped juvenile steelhead less than or equal to 29 cm (11.4 in) passing upstream of Daguerre Point Dam occurred within a few months after plantings of juvenile steelhead in the Feather River from the FRFH. Additionally, between February 2011 and January 2012, approximately 676 adipose fin-clipped steelhead with lengths less than or equal to 29 cm were recorded passing downstream of Daguerre Point Dam, with the majority of these individuals passing downstream during April through June. Therefore, approximately one-third of the presumed FRFH steelhead that migrated upstream of Daguerre Point Dam during 2011 apparently turned around and migrated back downstream of Daguerre Point Dam shortly after passing upstream of Daguerre Point Dam (RMT 2013).

If the observation of adipose fin-clipped juvenile steelhead passing upstream at Daguerre Point Dam is associated with the release of yearling steelhead from the FRFH into the lower Feather River, then it logically follows that the planted FRFH yearling steelhead would have had to swim 6 miles upstream from the planting location at Boyds Pump Ramp to the mouth of the lower Yuba River, and then an additional nearly 12 miles upstream to reach Daguerre Point Dam. Although this phenomenon may seem somewhat illogical, it has been reported elsewhere (Steiner Environmental Consulting 1987, as cited in RMT 2013) and is an explanation for the observation of adipose fin-clipped juvenile steelhead passing upstream at Daguerre Point Dam, because no marked juvenile steelhead have been reported to be released over this time frame into the lower Yuba River.

The length-frequency distribution of all adipose fin-clipped steelhead observed at Daguerre Point Dam from March 1, 2009 through February 29, 2012 was used to differentiate between "juvenile" and "adult" steelhead. The second step in the separation of "juvenile" and "adult" steelhead was to fit modeled length-frequency distributions to the observed data to determine a threshold length to separate both fish groups. A detailed description of the analytical processes is provided in RMT (2013).

Unlike the methodology employed for Chinook salmon, the daily counts of adult steelhead passing upstream of Daguerre Point Dam were not corrected for days when the VAKI Riverwatcher systems were not fully operational. The RMT determined it would be inappropriate to attempt to correct the adult steelhead counts due to: (1) the relatively low numbers of adult steelhead recorded during most of the steelhead biological years; and (2) the frequently extended durations when the VAKI Riverwatcher systems were not fully operational during the steelhead immigration season. Instead, the daily counts of adult steelhead passing upstream at Daguerre Point Dam were used to represent the abundance of steelhead, with the understanding that the resultant estimates are minimum numbers, and most of the survey years considerably underestimate the potential number of steelhead because the annual estimates do not include periods of VAKI Riverwatcher system non-operation, and do not consider the fact that not all steelhead migrate past Daguerre Point Dam, due to some spawning occurring downstream Daguerre Point Dam.

ASSESSMENT OF AVAILABLE VAKI RIVERWATCHER DATA

For assessment purposes, a "steelhead biological year" was identified as extending from August 1 through July 31 each year, because: (1) preliminary review of the VAKI Riverwatcher data indicated a general paucity of upstream migrant *O. mykiss* during early summer; (2) the immigration of adult steelhead in the lower Yuba River has been reported to occur beginning during August (CALFED and YCWA 2005; McEwan and Jackson 1996); and (3) the RMT (2010b) identified the steelhead upstream migration period as beginning during August in the lower Yuba River (RMT 2013).

ANNUAL TIME SERIES OF STEELHEAD PASSING UPSTREAM OF DAGUERRE POINT DAM

Figures 4-12 through 4-16 illustrate the daily counts of adult steelhead passing upstream at Daguerre Point Dam through both the North and South ladders combined, and the percentage of the daily number of hours when the VAKI Riverwatcher systems were operational at both ladders, during the eight steelhead biological years.

Examination of Figures 4-12 through 4-16 demonstrates that although the VAKI Riverwatcher systems have been in place since June of 2003, reliable estimates of the number of adult steelhead passing upstream at Daguerre Point Dam are essentially restricted to the last two years of available data (2010/2011 and 2011/2012).

Due to system failures, including equipment malfunctions and operationally detrimental environmental conditions (heavy overcast and foggy conditions resulting in lack of photovoltaic charging of the system), the VAKI Riverwatcher systems were partially operational or completely non-operational during several months each year of sampling. Additionally, high flows and turbidities reduced the ability of the system to identify, or prevented the system from identifying, adult steelhead oftentimes when the systems were operational. Although improvements to the system have been made over time, it was not until the most recent system improvements were implemented during the 2010/2011 sampling season that the system began demonstrating sustained reliability in the documentation of steelhead passing upstream of Daguerre Point Dam, over a range of environmental conditions.

Since June 2003, numerous improvements have been implemented to improve the reliability of the VAKI Riverwatcher systems, and particularly their ability to document passage during the steelhead upstream migration season. A chronology of the VAKI Riverwatcher system improvements that have occurred over time are described in RMT (2013).

This suite of improvements to the VAKI Riverwatcher systems at Daguerre Point Dam have resulted in much more reliable estimates of steelhead passing the dam. Correspondingly, the largest number of steelhead recorded immigrating past Daguerre Point Dam occurred during the 2010/2011 sampling season. As a result, it is not reasonable to consider data gathered prior to 2010/2011 to be reliable estimates of the annual number of adult steelhead passing upstream of Daguerre Point Dam (RMT 2013).

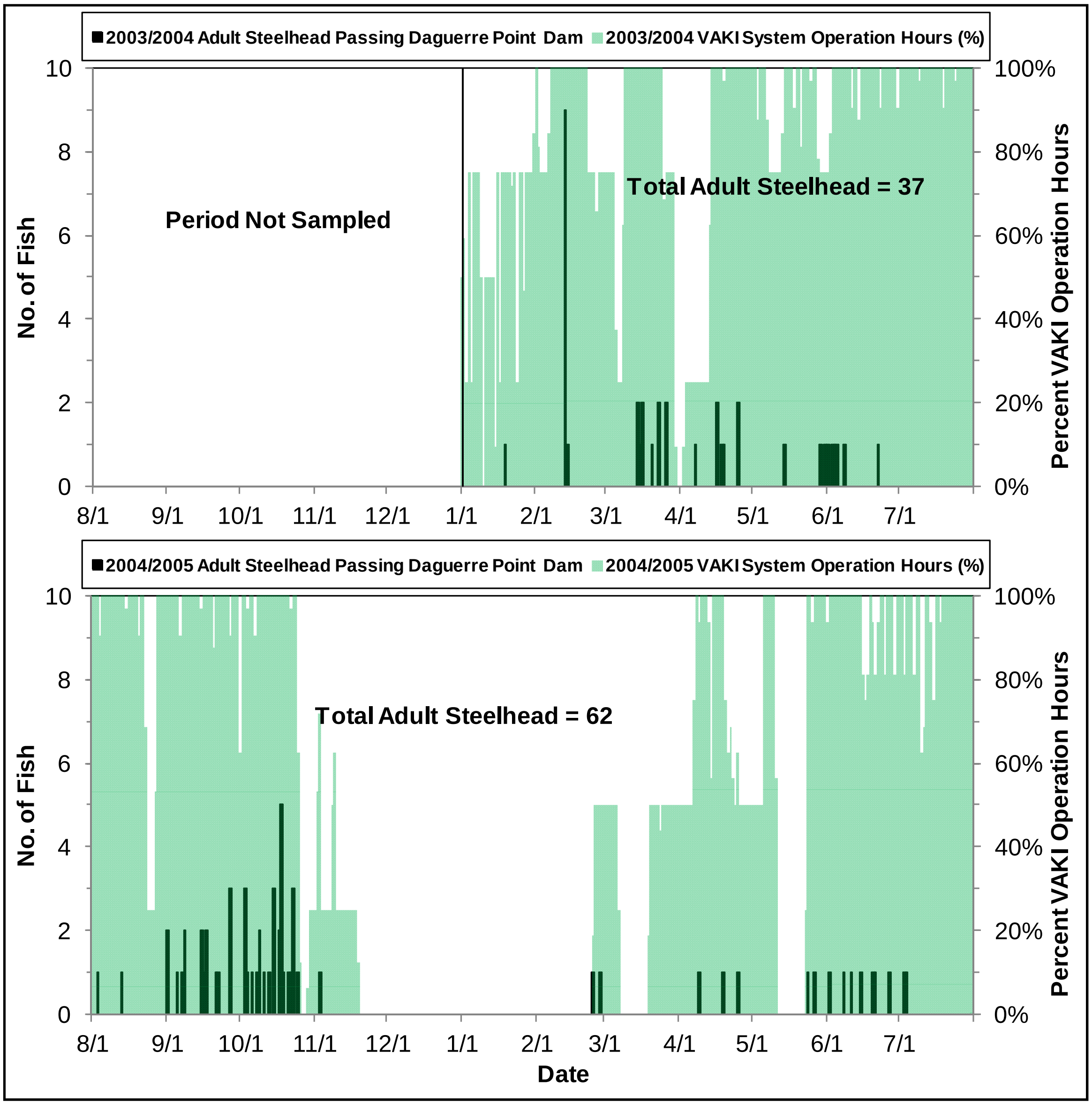

Figure 4-12. Daily counts of adult steelhead passing upstream of Daguerre Point Dam (dark green bars), and daily number of hours when the VAKI Riverwatcher systems were operational (light green bars), during the 2003/2004 and 2004/2005 steelhead biological years (August 1 through July 31) (Source: RMT 2013).

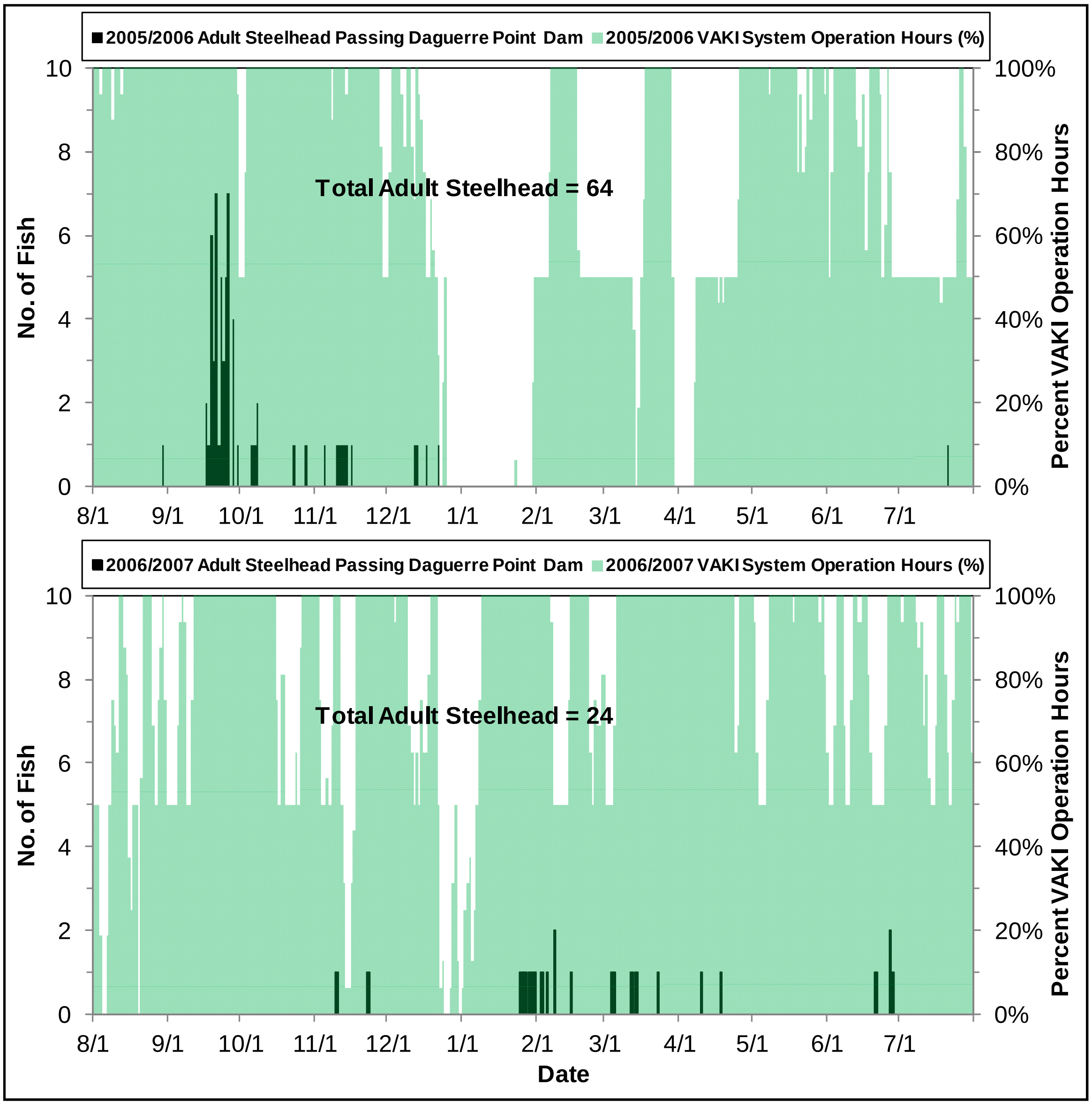

Figure 4-13. Daily counts of adult steelhead passing upstream Daguerre Point Dam (dark green bars), and daily number of hours when the VAKI Riverwatcher systems were operational (light green bars), during the 2005/2006 and 2006/2007 steelhead biological years (August 1 through July 31) (Source: RMT 2013).

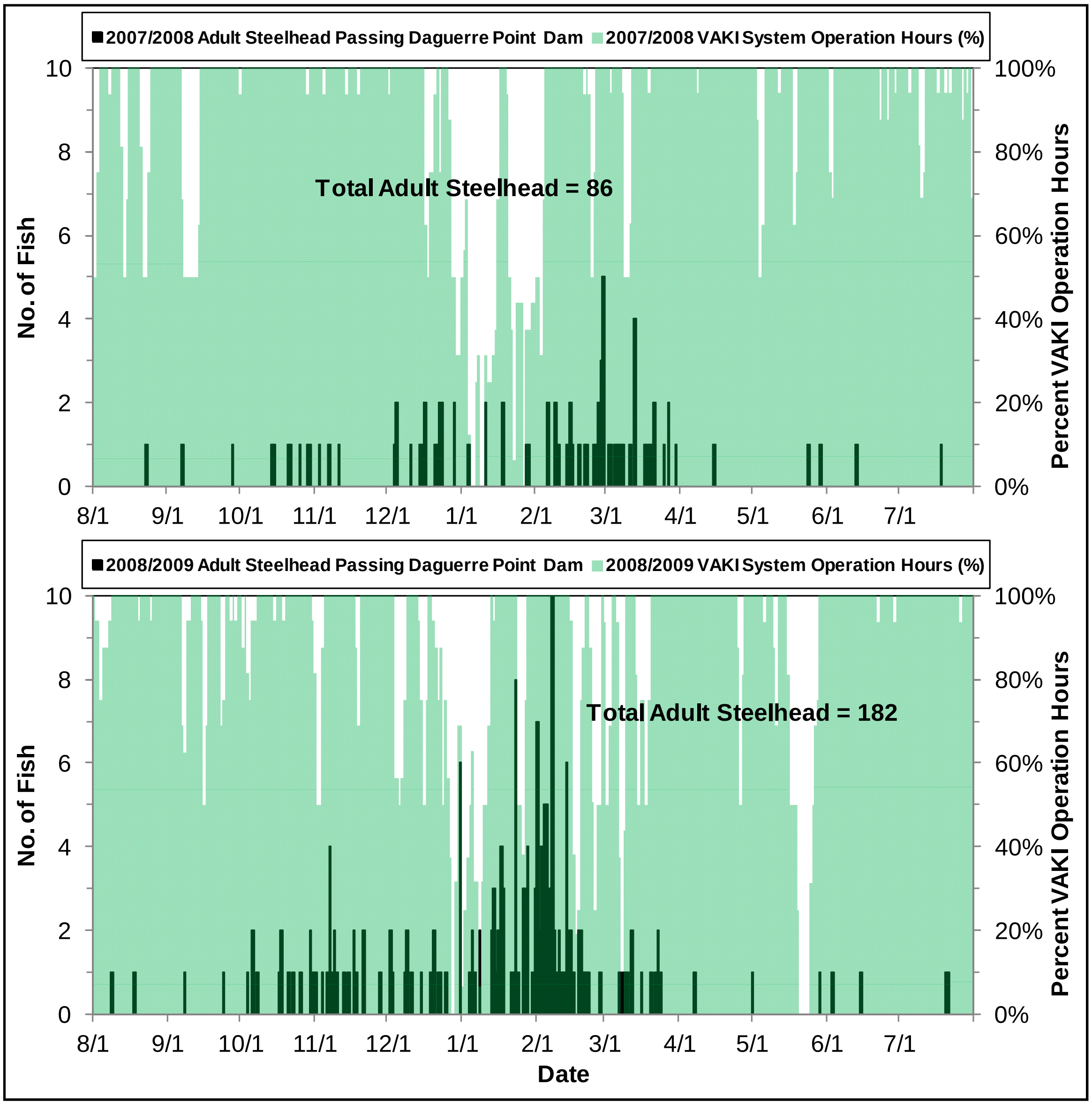

Figure 4-14. Daily counts of adult steelhead passing upstream of Daguerre Point Dam (dark green bars), and daily number of hours when the VAKI Riverwatcher systems were operational (light green bars), during the 2007/2008 and 2008/2009 steelhead biological years (August 1 through July 31) (Source: RMT 2013).

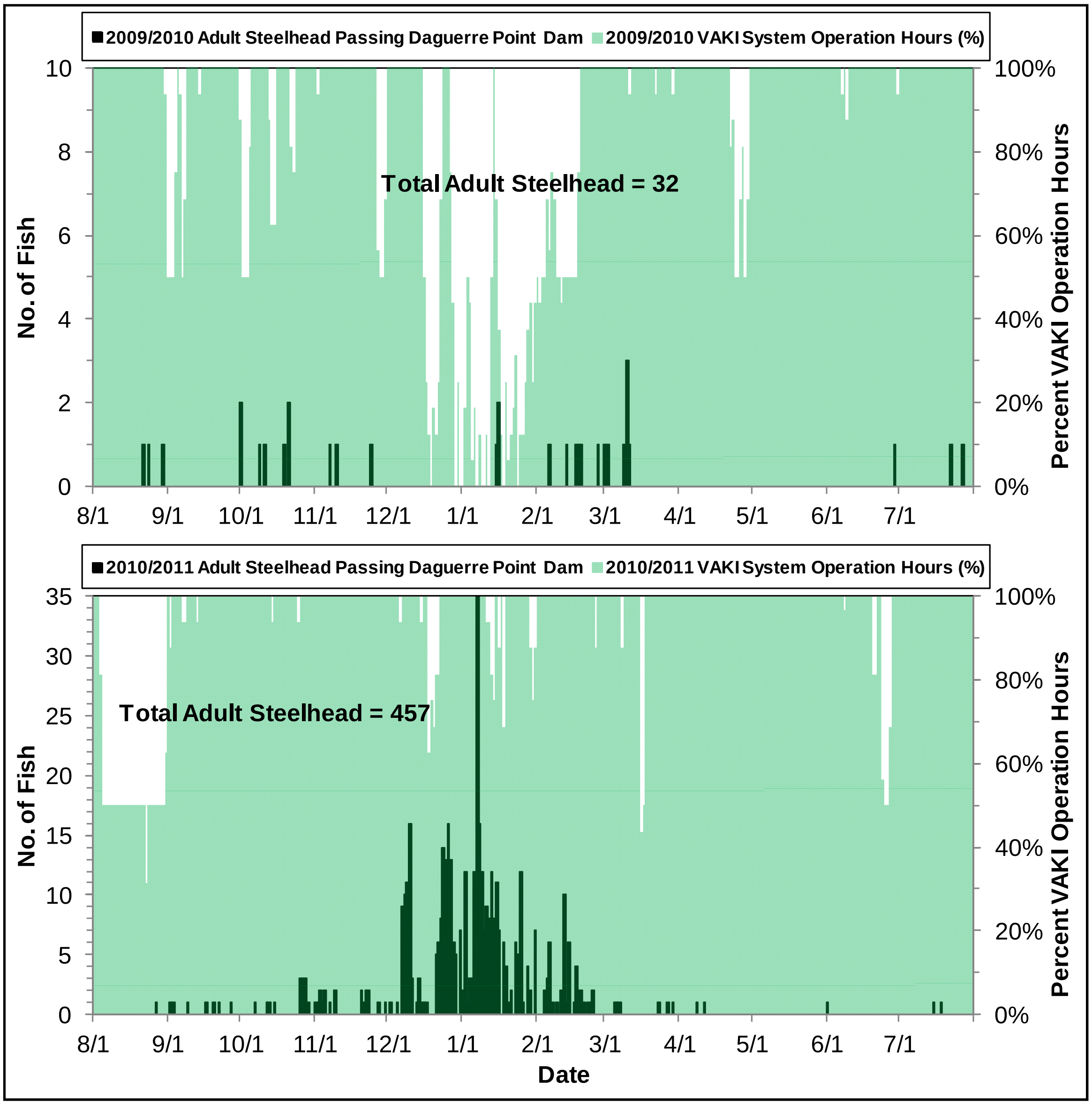

Figure 4-15. Daily counts of adult steelhead passing upstream of Daguerre Point Dam (dark green bars), and daily number of hours when the VAKI Riverwatcher systems were operational (light green bars), during the 2009/2010 and 2010/2011 steelhead biological years (August 1 through July 31) (Source: RMT 2013).

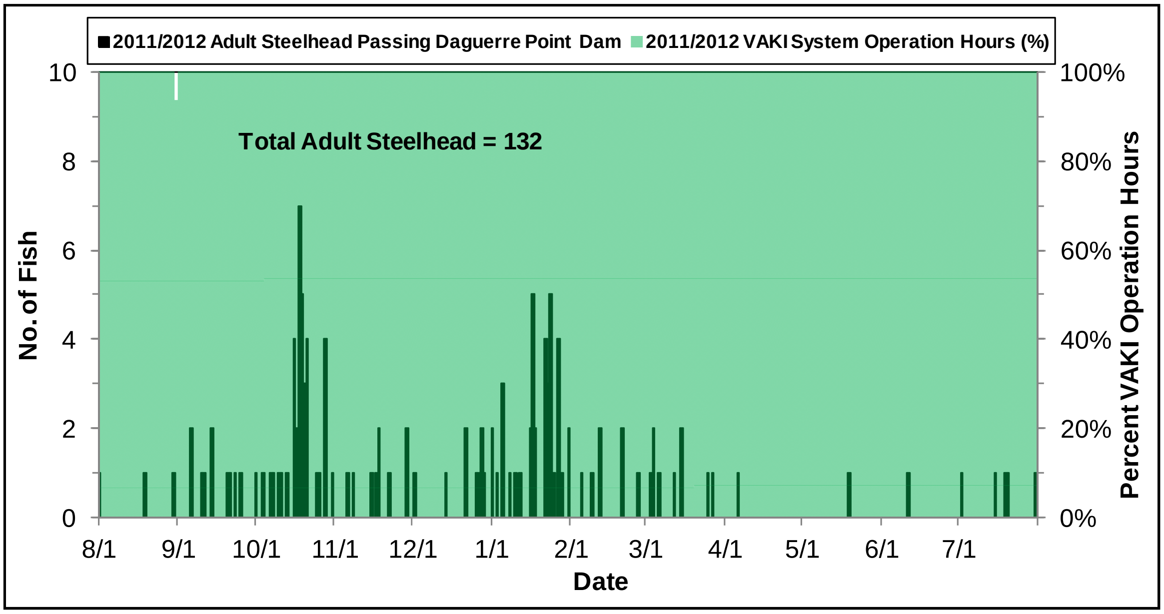

Figure 4-16. Daily counts of adult steelhead passing upstream of Daguerre Point Dam (dark green bars), and daily number of hours when the VAKI Riverwatcher systems were operational (light green bars), during the 2011/2012 steelhead biological year (August 1 through July 31) (Source: RMT 2013).

As stated approximately six years ago by Lindley et al. (2006), there are almost no data with which to assess the status of any of the Central Valley steelhead populations, with the exceptions of the hatchery programs on Battle Creek and the Feather, American and Mokelumne rivers. Therefore, they classified Central Valley steelhead populations as data deficient. As of 2010, CDFG (2010a) stated that steelhead monitoring programs in the Central Valley lack statistical power, are not standardized and in many cases lack dedicated funding.

The relatively short time period encompassed by the reporting of reliable abundance estimates, and in consideration that steelhead may have returned to the lower Yuba River but remained and spawned in the river downstream of Daguerre Point Dam, currently render problematic the determination of abundance or trends in the productivity of the steelhead over recent years (RMT 2013). Continued implementation of the improved VAKI Riverwatcher systems at Daguerre Point Dam is likely to obtain some of the data necessary to allow abundance estimation and productivity evaluation of steelhead in the lower Yuba River. However, presently the lack of multi-year abundance data precludes the provision of quantitative values associated with extinction risk assessment, addressing abundance and productivity (RMT 2013).

SPATIAL STRUCTURE

Spatial structure and considerations regarding anadromous salmonid viability was presented for spring-run Chinook salmon previously in this BA. The spatial structure considerations, as one of the four VSP parameters, for steelhead are analogous to those for spring-run Chinook salmon previously presented. Namely, spatial structure of morphological units in the lower Yuba River is complex, diverse, and persistent.

DIVERSITY

Phenotypic Considerations

O. mykiss in the lower Yuba River exhibit a high amount of diversity in phenotypic expression and life history strategy. As demonstrated in Figures 4-12 through 4-16, *O. mykiss* categorized as adult steelhead exhibit a broad temporal distribution in passing upstream of Daguerre Point Dam. *O. mykiss* (including steelhead) exhibit highly diverse spatial and temporal distributions in patterns of spawning, and juvenile outmigration (RMT 2013). Moreover, *O. mykiss* in the lower Yuba River exhibit polyphenism, or the occurrence of several phenotypes in a population which may not be due to different genetic types, including expressions of anadromy or residency. A thorough discussion of anadromy vs. residency of *O. mykiss* in the lower Yuba River is provided in RMT (2013). A polymorphic *O. mykiss* population structure may be necessary for the long-term persistence in highly variable environments such as the Central Valley (McEwan 2001). Resident fish may reduce extinction risk through the production of anadromous individuals that can enhance weak steelhead populations (Lindley et al. 2007). Such considerations may be applicable to the *O. mykiss* populations in the lower Yuba River.

Genetic Considerations

Although no fish hatcheries have been located on the Yuba River since 1950, and the lower Yuba River continues to support a persistent population of steelhead, the genetic integrity of these fish is presently uncertain. According to the NMFS Draft Recovery

Plan (NMFS 2009a), the major threat to the genetic integrity of Central Valley steelhead results from past and present hatchery practices. These practices include the planting of non-natal fish, overlap of spawning hatchery and natural fish, and straying of hatchery fish.

The observation of adipose fin clips on adult steelhead passing upstream through the VAKI Riverwatcher system at Daguerre Point Dam demonstrates that hatchery straying into the lower Yuba River occurs. Although no information is presently available regarding the origin of adipose-clipped steelhead observed at the VAKI Riverwatcher system at Daguerre Point Dam, it is reasonable to surmise that they most likely originate from the FRFH.

As previously stated, analysis of the VAKI Riverwatcher data indicates that the percent contribution of hatchery-origin adult upstream migrating fish (represented by the percentage of adipose fin-clipped adult steelhead relative to the total number of adult upstream migrating steelhead, because 100% of FRFH-origin steelhead have been marked since 1996) was approximately 43% for the 2010/2011 biological year, and about 63% for the 2011/2012 biological year (RMT 2013). If hatchery-origin steelhead stray into the lower Yuba River and interbreed with naturally-spawning Yuba River steelhead, then such interbreeding has been suggested to represent a threat to the genetic diversity and integrity of the naturally-spawning steelhead population in the lower Yuba River. Nonetheless, the question remains regarding the implication of straying of hatchery-origin adult steelhead into the lower Yuba River, given past management practices. From 1970 to 1979, CDFW annually stocked 27,270–217,378 fingerlings, yearlings, and sub-catchable steelhead from Coleman National Fish Hatchery into the lower Yuba River (CDFG 1991a). CDFW stopped stocking steelhead into the lower Yuba River in 1979. In addition, as previously discussed, it is possible that some hatchery-reared juvenile steelhead from the FRFH may move into the lower Yuba River in search of rearing habitat. Some competition for resources with naturally spawned steelhead could occur as a result.

Garza and Pearse (2008) studied populations of *O. mykiss* in the Central Valley using molecular genetic techniques to provide insight into population structure in the region.

Genotypes were collected from over 1,600 individual fish from 17 population samples and five hatchery rainbow trout strains. Evaluated fish populations included those from the McCloud River, Battle Creek, Deer Creek, Butte Creek, Feather River, Yuba River, American River, Calaveras River, Stanislaus River and Tuolumne River sub-basins. Analyses included fish collected both above and below barriers to anadromy in some of the study basins (Garza and Pearse 2008).

Phylogeographic trees were used to visually and quantitatively evaluate genetic relationships of Central Valley *O. mykiss* populations both with each other and with other California populations. Genetic diversity was relatively similar throughout the Central Valley. Above-barrier populations clustered with one another and below-barrier populations are most closely related to populations in far northern California, specifically the genetic groups that include the Eel and Klamath Rivers. Since Eel River origin broodstock were used for many years at Nimbus Hatchery on the American River, it is likely that Eel River genes persist there and have also spread to other basins by migration, and that this is responsible for the clustering of the below-barrier populations with northern California ones. This suggests that the below-barrier populations in this region appear to have been widely introgressed with hatchery fish from out-of-basin broodstock sources. In phylogeographic analyses, above-barrier populations are more similar to San Francisco Bay *O. mykiss* populations than the below-barrier populations in the Central Valley. Because this relationship is expected for steelhead, given their extraordinary historic dependence on short distance migration events (Pearse and Garza 2007), they may represent relatively non-introgressed historic population genetic structure for the region. Other possible explanations for this pattern that rely on complicated, widespread patterns of introgression with hatchery fish are not entirely ruled out, but are highly improbable given that the above-barrier populations also group with moderate consistency into geographically-consistent clusters (e.g. Yuba-Upper and Feather-Upper) in all analyses and also because of the low apparent reproductive success of hatchery trout in streams throughout California (Garza and Pearse 2008).

The analyses also identified possible heterogeneity between samples from different tributaries of the upper Yuba and Feather Rivers, although linkage disequilibrium was lower in these populations. Linkage disequilibrium can be caused by physical linkage of loci, sampling of related individuals/family structure, and by the sampling of more than one genetically distinct group within a population sample (Garza and Pearse 2008).

In general, although structure was found, all naturally-spawned *O. mykiss* populations within the Central Valley Basin were closely related, regardless of whether they were sampled above or below a known barrier to anadromy (Garza and Pearse 2008). This is due to some combination of pre-impoundment historic shared ancestry, downstream migration and, possibly, limited anthropogenic upstream migration. However, lower genetic diversity in above-barrier populations indicates a lack of substantial genetic input upstream and highlights lower effective population sizes for above-barrier populations. The consistent clustering of the above-barrier populations with one another, and their position in the California-wide trees, indicate that they are likely to most accurately represent the ancestral population genetic structure of steelhead in the Central Valley (Garza and Pearse 2008).

The above discussions indicating that below-barrier populations of steelhead in the Central Valley, including the lower Yuba River (particularly in consideration of historic plantings and documented straying) likely do not accurately represent the ancestral population genetic structure. In other words, the current steelhead population in the lower Yuba River likely does not represent a "pure" ancestral genome (RMT 2013).

EXTINCTION RISK

As stated approximately six years ago by Lindley et al. (2006), there are almost no data with which to assess the status of any of the Central Valley steelhead populations, with the exceptions of the hatchery programs on Battle Creek and the Feather, American and Mokelumne rivers. Therefore, they classified Central Valley steelhead populations, including the lower Yuba River, as data deficient.

According to NMFS (2009a), data are lacking to suggest that the Central Valley steelhead DPS is at low risk of extinction, or that there are viable populations of steelhead anywhere in the DPS. Lindley et al. (2007) stated that even if there were adequate data on the distribution and abundance of steelhead in the Central Valley, approaches for assessing steelhead population and DPS viability might be problematic because the effect of resident *O. mykiss* on the viability of steelhead populations and the DPS is unknown.

For the lower Yuba River, the data limitations previously discussed preclude multi-year abundance and trend analyses (RMT 2013). However, continued implementation of the improved VAKI Riverwatcher systems at Daguerre Point Dam is likely to obtain some of the data necessary to allow abundance estimation and productivity evaluation of steelhead in the lower Yuba River (RMT 2013). Moreover, the previous discussion regarding the limited applicability of VSP parameters and extinction risk criteria for spring-run Chinook salmon also pertain to steelhead in the lower Yuba River, in consideration of non-independent populations. For additional discussion, see RMT (2013).

4.3.7 Public Review Draft Recovery Plan Considerations

The discussion regarding recovery plan implementation provided for spring-run Chinook salmon in Section 4.2.8 of this BA also directly pertains to steelhead in the Yuba River Basin. Therefore, it is not repeated in this section of this BA.

4.4 Southern DPS of North American Green Sturgeon

The green sturgeon is the most widely distributed member of the sturgeon family Acipenseridae (70 FR 17386). North American green sturgeon are found in rivers from British Columbia south to the Sacramento River, California, and their ocean range is from the Bering Sea to Ensenada, Mexico. In assessing North American green sturgeon status, NMFS determined that two DPSs exist. The northern DPS is made up of known North American green sturgeon spawning (or single stock populations) in the Rogue, Klamath and Eel rivers. In 2005, the southern DPS was believed to contain only a single spawning population in the Sacramento River (70 FR 17386). However, four fertilized green sturgeon eggs collected in 2011 near the Thermalito Afterbay Outlet provide the first documentation of at least some successful spawning in the Feather River (A. Seesholtz, DWR, pers. comm., June 16, 2011).

The Southern DPS of North American green sturgeon (*Acipenser medirostrus*) was listed as a federally threatened species on April 7, 2006 (71 FR 17757) and includes the green sturgeon population spawning in the Sacramento River and utilizing the Sacramento-San

Joaquin River Delta, and San Francisco Estuary. NMFS (2009b) *Draft Environmental Assessment for the Proposed Application of Protective Regulations Under Section 4(D) of the Endangered Species Act for the Threatened Southern Distinct Population Segment of North American Green Sturgeon* indicated that the Southern DPS of North American green sturgeon faces several threats to its survival, including the loss of spawning habitat in the upper Sacramento River, and potentially in the Feather and Yuba rivers, due to migration barriers and instream alterations.

4.4.1 ESA Listing Status

On October 9, 2009, NMFS (74 FR 52300) designated critical habitat for the Southern DPS of North American green sturgeon. This designated critical habitat includes most of the DPS's occupied range, including: (1) coastal marine waters from Monterey Bay to the Washington/Canada border; (2) coastal bays and estuaries in California, Oregon, and Washington; and (3) fresh water rivers in the Central Valley, California. In the Central Valley, critical habitat for green sturgeon includes the Sacramento River, lower Feather River, lower Yuba River, the Sacramento-San Joaquin River Delta, and San Francisco Estuary. NMFS (74 FR 52300) defined specific habitat areas in the Sacramento, Feather, and Yuba rivers in California to include riverine habitat from each river mouth upstream to and including the furthest known site of historic and/or current sighting or capture of North American green sturgeon, as long as the site is still accessible. Critical habitat in the lower Yuba River includes the stream channels to the ordinary high water line extending from the confluence with the mainstem Feather River upstream to Daguerre Point Dam.

Section 4(c)(2) of the ESA requires that NMFS review the status of listed species under its authority at least every five years and determine whether any species should be removed from the list or have its listing status changed. In October 2012, NMFS noticed the initiation of the 5-year status review of the Southern DPS of North American green sturgeon (77 FR 64959).

The purpose of the 5-year review is to ensure the accuracy of the listing classification for the Southern DPS of North American green sturgeon. A 5-year review is based on the best scientific and commercial data available; therefore, NMFS is requesting submission of any such information on the Southern DPS that has become available since the listing determination in 2006. To ensure that the 5-year review is complete and based on the best available scientific and commercial information, NMFS is soliciting new information from the public, governmental agencies, Tribes, the scientific community, industry, environmental entities, and any other interested parties concerning the status of the Southern DPS since the listing determination in 2006 (77 FR 64959).

4.4.2 Critical Habitat Designation

The essential physical and biological habitat features identified for the Southern DPS of North American green sturgeon include food resources (e.g., benthic invertebrates and small fish), substrate types (i.e., appropriate spawning substrates within freshwater rivers), water flow (particularly in freshwater rivers), water quality, water depth, migratory corridors, and sediment quality. The following summary descriptions of the current conditions of the freshwater PCEs for the Central Valley steelhead DPS were taken from the 2009 NMFS OCAP BO (NMFS 2009a) and the 2009 NMFS Draft Biological and Conference Opinion for the Federal Energy Regulatory Commission's (FERC) Relicensing of the California Department of Water Resources Oroville Facilities (FERC Project No. 2100-134) (NMFS 2009d).

4.4.2.1 Primary Constituent Elements

FRESHWATER RIVERINE SYSTEMS

FOOD RESOURCES

Abundant food items for larval, juvenile, sub-adult, and adult lifestages should be present in sufficient amounts to sustain growth (larvae, juveniles, and sub-adults) or support basic metabolism (adults). Although specific data is lacking on food resources for green sturgeon within freshwater riverine systems, nutritional studies on white sturgeon suggest that juvenile green sturgeon most likely feed on macro benthic invertebrates, which can include plecoptera (stoneflies), ephemeroptera (mayflies), trichoptera (caddis flies), chironomid (dipteran fly larvae), oligochaetes (tubifex worms) or decapods (crayfish).

These food resources are important for juvenile foraging, growth, and development during their downstream migration to the Delta and bays. In addition, sub-adult and adult green sturgeon may forage during their downstream post-spawning migration or on non-spawning migrations within freshwater rivers. Sub-adult and adult green sturgeon in freshwater rivers most likely feed on benthic invertebrates similar to those fed on in bays and estuaries, including freshwater shrimp and amphipods. Many of these different invertebrate groups are endemic to and readily available in the Sacramento River from Keswick Dam downstream to the Delta. Heavy hatches of mayflies, caddis flies, and chironomids occur in the upper Sacramento River, indicating that these groups of invertebrates are present in the river system. NMFS anticipates that the aquatic lifestages of these insects (nymphs, larvae) would provide adequate nutritional resources for green sturgeon rearing in the river.

SUBSTRATE TYPE OR SIZE

Suitable freshwater riverine system habitat includes substrates suitable for egg deposition and development (e.g., cobble, gravel, or bedrock sills and shelves with interstices or irregular surfaces to "collect" eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (e.g., substrates with interstices or voids providing refuge from predators and from high flow conditions), and sub-adults and adult lifestages (e.g., substrates for holding and spawning). Stream surveys by USFWS and Reclamation biologists have identified approximately 54 suitable holes and pools between Keswick Dam and the GCID diversion that would support spawning or holding activities for green sturgeon, based on identified physical criteria. Many of these locations are at the confluences of tributaries with the mainstem Sacramento River or at bend pools. Observations of channel type and substrate compositions during these surveys indicate that appropriate substrate is available in the Sacramento River between Keswick Dam and the GCID diversion. Ongoing surveys are anticipated to further identify river reaches in the upper river with suitable substrate characteristics and their utilization by green sturgeon.

WATER FLOW

An adequate flow regime (i.e., magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) is necessary for normal behavior, growth, and survival of all lifestages in the upper Sacramento River. Such a flow regime should include stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development (11-19°C) (Cech et al. 2000; Mayfield and Cech 2004; Van Eenennaam et al. 2005; Allen et al. 2006). Sufficient flow is also needed to reduce the incidence of fungal infestations of the eggs, and to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in and to maintain surfaces for feeding. Successful migration of adult green sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning success is more associated with water flow and water temperature than compared with other variables. Spawning in the Sacramento River is believed to be triggered by increases in water flow to about 14,000 cfs (Brown 2007). Post-spawning downstream migrations are triggered by increased flows, ranging from 6,150-14,725 cfs in the late summer (Vogel 2005) and greater than 3,550 cfs in the winter (Erickson et al. 2002; Benson et al. 2007). The current suitability of these flow requirements is almost entirely dependent on releases from Shasta Dam. High winter flows associated with the natural hydrograph do not occur within the section of the river utilized by green sturgeon with the frequency and duration that occurred during pre-dam conditions.

WATER QUALITY

Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all green sturgeon lifestages, is required for the proper functioning of the freshwater habitat. Suitable water temperatures include: (1) stable water temperatures within spawning reaches (wide fluctuations could increase egg mortality or deformities in developing embryos); (2) water temperatures within 51.8-62.6°F (optimal range = 57.2-60.8°F) in spawning reaches for egg incubation (March-August) (Van Eenennaam et al. 2005); (3) water temperatures below 68°F for larval development (Werner et al. 2007 as cited in

NMFS 2009a); and (4) water temperatures below 75.2°F for juveniles (Mayfield and Cech 2004; Allen et al. 2006). Due to the temperature management of the releases from Keswick Dam for winter-run Chinook salmon in the upper Sacramento River, water temperatures in the river reaches utilized currently by green sturgeon appear to be suitable for proper egg development and larval and juvenile rearing. Suitable salinity levels range from fresh water [<3 parts per thousand (ppt)] for larvae and early juveniles [to about 100 days post hatch (dph)] to brackish water (10 ppt) for juveniles prior to their transition to salt water. Prolonged exposure to higher salinities may result in decreased growth and activity levels and even mortality (Allen and Cech 2007). Salinity levels are suitable for green sturgeon in the Sacramento River and freshwater portions of the Delta for early lifestages. Adequate levels of DO are needed to support oxygen consumption by early lifestages (Allen and Cech 2007). Current DO levels in the mainstem Sacramento River are suitable to support the growth and migration of green sturgeon. Suitable water quality also includes water free of contaminants (i.e., pesticides, organochlorines, elevated levels of heavy metals, etc.) that may disrupt normal development of embryonic, larval, and juvenile lifestages of green sturgeon. Legacy contaminants such as mercury still persist in the watershed and pulses of pesticides have been identified in winter storm discharges throughout the Sacramento River Basin.

WATER DEPTH

Pools of ≥ 5 m depth are critical for adult green sturgeon spawning and for summer holding within the Sacramento River. Summer aggregations of green sturgeon are observed in these pools in the upper Sacramento River upstream of the GCID diversion. The significance and purpose of these aggregations are unknown at the present time, although it is likely that they are the result of an intrinsic behavioral characteristic of green sturgeon. Adult green sturgeon in the Klamath and Rogue rivers also occupy deep holding pools for extended periods of time, presumably for feeding, energy conservation, and/or refuge from high water temperatures (Erickson et al. 2002; Benson et al. 2007). As described above, approximately 54 pools with adequate depth have been identified in the Sacramento River upstream of the GCID diversion.

MIGRATION CORRIDOR

Unobstructed migratory pathways are necessary for passage within riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for passage). Unobstructed migratory pathways are necessary for adult green sturgeon to migrate to and from spawning habitats, and for larval and juvenile green sturgeon to migrate downstream from spawning/rearing habitats within freshwater rivers to rearing habitats within the estuaries. Unobstructed passage throughout the Sacramento River up to Keswick Dam (RM 302) is important, because optimal spawning habitats for green sturgeon are believed to be located upstream of the RBDD (RM 242).

Green sturgeon adults that migrate upstream during April, May, and June are completely blocked by the ACID diversion dam. Therefore, five miles of spawning habitat are inaccessible upstream of the diversion dam. It is unknown if spawning is occurring in this area. Adults that pass upstream of ACID dam before April are forced to wait six months until the stop logs are pulled before returning downstream to the ocean. Upstream blockage at the ACID diversion dam forces sturgeon to spawn in approximately 12% less habitat between Keswick Dam and RBDD. Newly emerged green sturgeon larvae that hatch upstream of the ACID diversion dam are forced to hold for six months upstream of the dam or pass over it and be subjected to higher velocities and turbulent flow below the dam, thus rendering the larvae and juvenile green sturgeon more susceptible to predation.

Closure of the gates at RBDD from May 15 through September 15 previously precluded all access to spawning grounds above the dam during that time period. However, as previously discussed, the RBDD gates were permanently raised in September 2011.

Juvenile green sturgeon first appear in USFWS sampling efforts at RBDD during May, June, and July. Juvenile green sturgeon are likely subjected to the same predation and turbulence stressors caused by RBDD as the juvenile anadromous salmonids, leading to diminished survival through the structure and waters immediately downstream.

SEDIMENT QUALITY

Sediment should be of the appropriate quality and characteristics necessary for normal behavior, growth, and viability of all lifestages. This includes sediments free of contaminants (e.g., elevated levels of heavy metals such as mercury, copper, zinc, cadmium, and chromium), polycyclic aromatic hydrocarbons, and organochlorine pesticides) that can result in negative effects on any lifestages of green sturgeon. Based on studies of white sturgeon, bioaccumulation of contaminants from feeding on benthic species may negatively affect the growth, reproductive development, and reproductive success of green sturgeon. The Sacramento River and its tributaries have a long history of contaminant exposure from abandoned mines, separation of gold ore from mine tailings using mercury, and agricultural practices with pesticides and fertilizers which result in deposition of these materials in the sediment horizons in the river channel. Disturbance of these sediment horizons by natural or anthropogenic actions can liberate the sequestered contaminants into the river. This is a continuing concern throughout the watershed.

ESTUARINE HABITAT AREAS

FOOD RESOURCES

Abundant food items within estuarine habitats and substrates for adult, sub-adult and juvenile lifestages are required for the proper functioning of this PCE for green sturgeon. Prey species for green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fish, including crangonid shrimp, callianassid shrimp, burrowing thalassinidean shrimp, amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for the rearing, foraging, growth, and development of juvenile, sub-adult, and adult green sturgeon within the bays and estuaries. Currently, the estuary provides these food resources, although annual fluctuations in the population levels of these food resources may diminish the contribution of one group to the diet of green sturgeon relative to another food source. The recent spread of the Asian overbite clam has shifted the diet profile of white sturgeon to this invasive species. The overbite clam now makes up a substantial proportion of the white sturgeon’s diet in the estuary. NMFS assumes that green sturgeon have also altered their diet to include this new food source, because of its increased prevalence in the benthic invertebrate community.

WATER FLOW

Within bays and estuaries adjacent to the Sacramento River (i.e., the Sacramento-San Joaquin Delta and the Suisun, San Pablo, and San Francisco bays), sufficient inflow to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds is required. Sufficient flows are needed to attract adult green sturgeon to the Sacramento River from the bay and to initiate the upstream spawning migration into the upper river. Currently, flows provide the necessary attraction to green sturgeon to enter the Sacramento River. Nevertheless, these flows are substantially less than those that historically occurred and stimulated the spawning migration.

WATER QUALITY

Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics, is necessary for normal behavior, growth, and viability of all lifestages. Suitable water temperatures for juvenile green sturgeon should be below 75^{o}F. At temperatures above 75.2°F, juvenile green sturgeon exhibit decreased swimming performance (Mayfield and Cech 2004) and increased cellular stress (Allen et al. 2006). Suitable salinities in the estuary range from brackish water (10 ppt) to salt water (33 ppt). Juveniles transitioning from brackish to salt water can tolerate prolonged exposure to salt water salinities, but may exhibit decreased growth and activity levels (Allen and Cech 2007), whereas sub-adults and adults tolerate a wide range of salinities (Kelly et al. 2007 as cited in Reclamation 2008). Sub-adult and adult green sturgeon occupy a wide range of DO levels, but may need a minimum DO level of at least 6.54 mg O2/l (Kelly et al. 2007 as cited in Reclamation 2008; Moser and Lindley 2007 as cited in Reclamation 2008). Suitable water quality also includes water free of contaminants, as described above. In general, water quality in the Delta and estuary meets these criteria, but local areas of the Delta and downstream bays have been identified as having deficiencies. Water quality in the areas such as the Stockton turning basin and Port of Stockton routinely have depletions of DO and episodes of first flush contaminants from the surrounding industrial and urban watershed. Discharges of agricultural drain water have also been implicated in local elevations of pesticides and other related agricultural compounds within the Delta and the tributaries and sloughs feeding into the Delta.

Discharges from petroleum refineries in Suisun and San Pablo Bay have been identified as sources of selenium to the local aquatic ecosystem (Linville et al. 2002).

WATER DEPTH

A diversity of depths is necessary for shelter, foraging, and migration of juvenile, sub-adult, and adult lifestages. Sub-adult and adult green sturgeon occupy deep (≥ 5 m) holding pools within bays and estuaries as well as within freshwater rivers. These deep holding pools may be important for feeding and energy conservation, and may serve as thermal refugia for sub-adult and adult green sturgeon (Benson et al. 2007). Tagged adults and sub-adults within the San Francisco Bay estuary primarily occupied waters with depths of less than 10 m, either swimming near the surface or foraging along the bottom (Kelly et al. 2007 as cited in Reclamation 2008). In a study of juvenile green sturgeon in the Delta, relatively large numbers of juveniles were captured primarily in shallow waters from 3 to 8 feet deep, indicating juveniles may require shallower depths for rearing and foraging (Radtke 1966). Thus, a diversity of depths is important to support different lifestages and habitat uses for green sturgeon within estuarine areas.

Currently, there is a diversity of water depths found throughout the San Francisco Bay estuary and Delta waterways. Most of the deeper waters, however, are comprised of artificially maintained shipping channels, which do not migrate or fluctuate in response to the hydrology in the estuary in a natural manner. The channels are simplified trapezoidal shapes with little topographical variation along the channel alignment. Shallow waters occur throughout the Delta and San Francisco Bay. Extensive “flats” occur in the lower reaches of the Sacramento and San Joaquin River systems as they leave the Delta region and are even more extensive in Suisun and San Pablo bays. In most of the region, variations in water depth in these shallow water areas occur due to natural processes, with only localized navigation channels being dredged (e.g., the Napa River and Petaluma River channels in San Pablo Bay).

MIGRATION CORRIDOR

Within the waterways comprising the Delta and bays downstream of the Sacramento River, unobstructed passage is needed for juvenile green sturgeon during the rearing phase of their life cycle. Rearing fish need the ability to freely migrate from the river through the estuarine waterways of the Delta and bays and eventually out into the ocean. Passage within the bays and the Delta is also critical for adults and sub-adults for feeding and summer holding, as well as to access the Sacramento River for their upstream spawning migrations and to make their outmigration back into the ocean. Within bays and estuaries outside of the Delta and the areas comprised by Suisun, San Pablo, and San Francisco bays, unobstructed passage is necessary for adult and sub-adult green sturgeon to access feeding areas, holding areas, and thermal refugia, and to ensure passage back out into the ocean. Currently, unobstructed passage has been diminished by human actions in the Delta and bays. The CVP and SWP water projects alter flow patterns in the Delta due to export pumping and create entrainment issues in the Delta at the pumping and fish facilities.

Power generation facilities in Suisun Bay create risks of entrainment and thermal barriers through their cooling water diversions and discharges. Installation of seasonal barriers in the South Delta and operations of the radial gates in the Delta Cross Channel facilities alter migration corridors available to green sturgeon. Actions such as the hydraulic dredging of ship channels and operations of large ocean going vessels create additional sources of risk to green sturgeon within the estuary. Hydraulic dredging can result in the entrainment of fish into the dredger’s hydraulic cutterhead intake. Commercial shipping traffic can result in the loss of fish, particularly adult fish, through ship and propeller strikes.

SEDIMENT QUALITY

Sediment quality (i.e., chemical characteristics) is necessary for normal behavior, growth, and viability of all lifestages. This includes sediments free of contaminants (e.g., elevated levels of selenium, polycyclic aromatic hydrocarbons [PAHs], and organochlorine pesticides) that can cause negative effects on all lifestages of green sturgeon (see description of sediment quality for riverine habitats above).

4.4.3 Historical Distribution and Abundance

Green sturgeon are widely distributed along the Pacific Coast, have been documented offshore from Ensenada, Mexico, to the Bering Sea, and are found in rivers from British Columbia to the Sacramento River (Moyle 2002). As is the case for most sturgeon, the Southern DPS of North American green sturgeon are anadromous; however, they are the most marine-oriented of the sturgeon species (Moyle 2002).

The historical distribution of green sturgeon in the Sacramento-San Joaquin river basins is poorly documented, but Adams et al. (2007) summarizes information that suggests that green sturgeon may have been distributed above the locations of present-day dams on the Sacramento and Feather rivers (Mora et al. 2009). Historical records from the 1930s indicate that green sturgeon were not listed as either “known to occur” or “presumed to occur” in the Yuba or American Rivers (Sumner and Smith 1939; Evermann and Clark 1931).

According to NMFS (2009a), spawning populations of green sturgeon in North America are currently found in only three river systems: the Sacramento and Klamath rivers in California and the Rogue River in southern Oregon. Data from commercial trawl fisheries and tagging studies indicate that the green sturgeon occupy ocean waters down to the 110 meter contour (Erickson and Hightower 2007). During the late summer and early fall, sub-adults and non-spawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett et al. 1991; Moser and Lindley 2007 as cited in Reclamation 2008). Particularly large concentrations of green sturgeon from both the northern and southern populations occur in the Columbia River estuary, Willapa Bay, Grays Harbor and Winchester Bay, with smaller aggregations in Humboldt Bay, Tillamook Bay, Nehalem Bay, and San Francisco and San Pablo bays (Emmett et al 1991; Moyle et al. 1992 as cited in Reclamation 2008; Beamesderfer et al. 2007). Lindley et al. (2008) reported that green sturgeon make seasonal migratory movements along the west coast of North America, overwintering north of Vancouver Island and south of Cape Spencer, Alaska. Individual fish from the Southern DPS of green sturgeon have been detected in these seasonal aggregations. Information regarding the migration and habitat use of green sturgeon has recently emerged. Lindley (2006 as cited in NMFS 2009a) presented preliminary results of large-scale green sturgeon migration studies, and verified past population structure delineations based on genetic work and found frequent large-scale migrations of green sturgeon along the Pacific Coast. This work was further expanded by recent tagging studies of green sturgeon conducted by Erickson and Hightower (2007) and Lindley et al. (2008). To date, the data indicate that green sturgeon are migrating considerable distances up the Pacific Coast into other estuaries, particularly the Columbia River estuary. This information also agrees with the results of previous green sturgeon tagging studies (CDFG 2002), where CDFW tagged a total of 233 green sturgeon in the San Pablo Bay estuary between 1954 and 2001. A total of 17 tagged fish were recovered: 3 in the Sacramento-San Joaquin Estuary, 2 in the Pacific Ocean off of California, and 12 from commercial fisheries off of the Oregon and Washington coasts. Eight of the 12 commercial fisheries recoveries were in the Columbia River estuary (CDFG 2002).

In the lower Feather River, green sturgeon have intermittently been observed (Beamesderfer et al. 2007). NMFS (2008b) states that the presence of adult, and possibly sub-adult, green sturgeon within the lower Feather River has been confirmed by photographs, anglers' descriptions of fish catches (P. Foley, pers. comm. cited in CDFG 2002), incidental sightings (DWR 2005), and occasional catches of green sturgeon reported by fishing guides (Beamesderfer et al. 2004).

In the mid-1970s, green sturgeon were caught each year on the Feather River, with the majority of catches occurring from March to May and a few additional catches occurring in July and August (USFWS 1995). In 1993, seven adult green sturgeon were captured at the Thermalito Afterbay Outlet, ranging in size from 60.9 to more than 73.2 inches (USFWS 1995). In a broad scale survey from 1999 to 2001, green sturgeon were infrequently observed within the area downstream of the Thermalito Afterbay Outlet and none observed upstream (DWR 2003a). In 2006, four green sturgeon were positively identified by DWR biologist near the Thermalito Afterbay Outlet. Eight additional sturgeon were also observed in the same area but could not be positively identified as green sturgeon (DWR 2007a as cited in Reclamation 2008).

Although adult green sturgeon occurrence in the Feather River has been previously documented, larval and juvenile green sturgeon have not been collected despite attempts to collect larval and juvenile sturgeon during early spring through summer using rotary screw traps, artificial substrates, and larval nets deployed at multiple locations (Seesholtz et al. 2003). Moreover, unspecific past reports of green sturgeon spawning (Wang, 1986; USFWS 1995; CDFG 2002) have not been corroborated by observations of young fish or significant numbers of adults in focused sampling efforts (Niggemeyer and Duster 2003; Seesholz et al. 2003; Beamesderfer et al. 2004). Based on these results, in 2006, NMFS concluded that an effective population of spawning green sturgeon did not exist in the lower Feather River (71 FR 17757). However, four fertilized green sturgeon eggs were collected near the Thermalito Afterbay Outlet on June 14, 2011, thus providing the first documentation of at least some successful spawning in the Feather River (A. Seesholtz, DWR, pers. comm., June 16, 2011).

Historical accounts of sturgeon in the Yuba River have been reported by anglers, but these accounts do not specify whether the fish were white or green sturgeon (Beamesderfer et al. 2004). Since the 1970s, numerous surveys of the lower Yuba River downstream of Englebright Dam have been conducted, including annual salmon carcass surveys, snorkel surveys, beach seining, electrofishing, rotary screw trapping, redd surveys, and other monitoring and evaluation activities. Over the many years of these surveys and monitoring of the lower Yuba River, only one confirmed observation of an adult green sturgeon has occurred prior to 2011. The NMFS September 2008 *Draft Biological Report, Proposed Designation of Critical Habitat for the Southern Distinct Population Segment of North American Green Sturgeon* (NMFS 2008a) states that of the three adult or sub-adult sturgeon observed in the Yuba River below Daguerre Point Dam during 2006, only one was confirmed to be a green sturgeon, and that *"Spawning is possible in the river, but has not been confirmed and is less likely to occur in the Yuba River than in the Feather River. No green sturgeon juveniles, larvae, or eggs have been observed in the lower Yuba River to date."*

As part of ongoing sturgeon monitoring efforts in the Feather River Basin under the AFRP, Cramer Fish Sciences conducted roving underwater video surveys in the lower Feather and lower Yuba rivers using a drop-down camera suspended from a motorized boat. On May 24, 25 and 26, 2011, underwater videographic monitoring was conducted in the lower Yuba River downstream of Daguerre Point Dam. Although results are preliminary, a memorandum dated June 7, 2011 Cramer Fish Sciences (2011) stated that they observed what they believed were 4-5 green sturgeon near the center of the channel at the edge of the bubble curtain below Daguerre Point Dam. The sturgeon were observed either on a gravel bar approximately 1.5 m deep, or in a pool approximately 4 m deep immediately adjacent to the gravel bar. Photographs taken by Cramer Fish Sciences (2011) were forwarded to green sturgeon experts. Olaf P. Langness, Sturgeon and Smelt Projects, Washington Department of Fish and Wildlife Region 5, expressed the opinion that the photographs were of green (rather than white) sturgeon. Also, David Woodbury, NMFS Sturgeon Recovery Coordinator, expressed his opinion that the fish in the photographs were green sturgeon.

During 2012, underwater videography also was used in an attempt to document the presence of green sturgeon downstream of Daguerre Point Dam, but no observations of green sturgeon were made.

YCWA (2013) examined the potential occurrence of green sturgeon in the lowermost 24 miles of the Yuba River based on detections of acoustically-tagged green sturgeon in the Yuba River. The examination included coordination with agencies and organizations involved with green sturgeon research in the Central Valley, and collection of available information and data regarding the presence and use of the Yuba River by green sturgeon. YCWA collaborated with DWR's Feather River Program, the California Fish Tracking Consortium (CFTC), and CDFW's Heritage and Wild Trout and Steelhead Management and Recovery Programs to examine whether any of the acoustically-tagged green sturgeon were found in the lower Yuba River. The CFTC is tracking 217 green sturgeon acoustically tagged in the Central Valley, and DWR's Feather River Program has acoustically tagged 2 green sturgeon in the lower Feather River.

None of the 217 green sturgeon acoustically-tagged in the Central Valley were detected in the Yuba River, with the exception of one fish tagged by DWR in the Feather River. This individual fish was detected once on September 6, 2011 in the Yuba River by the CDFW’s lowermost acoustic receiver located at the confluence of the Yuba and Feather rivers. That fish also was detected upstream in the Feather River earlier on the same day and downstream in the Sacramento River on the evening of September 6, 2011. Therefore, the fish apparently only entered the mouth of the lower Yuba River for a very brief period of time before continuing its downstream migration in the Feather and Sacramento rivers.

4.4.4 General Life History and Habitat Requirements

Limited information regarding green sturgeon distribution, movement and behavioral patterns, as well as lifestage-specific habitat utilization preferences, is available for the Sacramento and Feather rivers.

4.4.4.1 Adult Immigration, Holding and Emigration

Green sturgeon in the Sacramento River have been documented and studied more widely than they have in either the Feather or the Yuba rivers. Green sturgeon adults in the Sacramento River are reported to begin their upstream spawning migrations into freshwater during late February, before spawning between March and July, with peak spawning believed to occur between April and June (Adams et al. 2002). NMFS (2009) reports that, based on recent data gathered from acoustically tagged adult green sturgeon, these fish migrate upstream during May as far as the mouth of Cow Creek, near Bend Bridge on the Sacramento River.

For the Sacramento River, NMFS (2009) reports that adult green sturgeon prefer deep holes (≥ 5 m depth) at the mouths of tributary streams, where they spawn and rest on the bottom. After spawning, the adults hold over in the upper Sacramento River between RBDD and the GCID diversion until November (Klimley 2007). Heublein et al. (2006, 2009) reported the presence of adults in the Sacramento River during the spring through the fall into the early winter months, holding in upstream locations before their emigration from the system later in the year. Green sturgeon downstream migration appears to be triggered by increased flows and decreasing water temperatures, and occurs rapidly once initiated (NMFS 2009). Some adult green sturgeon rapidly leave the system following their suspected spawning activity and re-enter the ocean in early summer

(Heublein 2006). NMFS (2009) states that green sturgeon larvae and juveniles are routinely observed in rotary screw traps at RBDD and the GCID diversion, indicating that spawning occurs upstream of both these sites.

Before the studies conducted by UC Davis, there were few empirical observations of green sturgeon movement in the Sacramento River (Heublein et al. 2009). The study by Heublein et al. (2009) is reportedly the first to describe the characteristics of the adult green sturgeon migration in the Sacramento River, and to identify putative regions of spawning habitat, based on the recorded movements of free-swimming adults.

The Sacramento River adjacent to the GCID diversion routinely contains a large aggregation of green sturgeon during summer and fall months, although the GCID aggregation site is atypical of over-summering habitats in other systems, being an area of high water velocity (Heublein et al. 2009). The GCID site is over five meters deep, with structural current refuges and eddy formations. It is possible that green sturgeon occupy lower-velocity subsections of the site, although observations of green sturgeon capture, and manual tracking estimates, indicate that green sturgeon are found in, or in very close proximity to, high velocity areas (Heublein et al. 2009).

4.4.4.2 Adult Spawning

Adult green sturgeon are believed to spawn every two to five years (Beamesderfer et al. 2007). Upon maturation of their gonadal tissue, but prior to ovulation or spermiation, the adult fish enter freshwater and migrate upriver to their spawning grounds (NMFS 2009a). Heublein et al. (2009) observed that green sturgeon enter San Francisco Bay in March and April and migrate rapidly up the Sacramento River to the region between GCID and Cow Creek. The fish lingered at these regions at the apex of their migration for 14 to 51 days, presumably engaged in spawning behavior, before moving back downriver (Heublein et al. 2009).

To investigate adult immigration, spawning or juvenile nursery habits of green sturgeon in the upper Sacramento River, Brown (2007) developed a study to identify green sturgeon spawning locations and dates in the upper Sacramento River. Using a depth finder, study sites were selected at locations upstream of deeper holes in higher velocity water in the Sacramento River (Brown 2007). The study was originally designed in 1997 using the prevalent methodology at the time (e.g., artificial substrate mats) for the capture of eggs and larvae of white sturgeon. Brown (2007) reports that later findings from artificial spawning and larval rearing of green sturgeon (Van Eenennaam et al. 2001) indicate that green sturgeon eggs may be less adhesive than eggs from other acipenserids, possibly reducing the effectiveness of artificial substrate sampling.

Brown (2007) suggested that spawning in the Sacramento River may occur from April to June, and that the potential spawning period may extend from late April through July, as indicated by the rotary screw trap data at the RBDD from 1994 to 2000.

Heublein et al. (2009) stated that, in contrast to the behavior of green sturgeon observed during 2004–2005, the majority of out-migrants detected in 2006 displayed an entirely different movement strategy. Nine of the ten tagged fish detected that year exited the system with no extended hold-over period and with no apparent relation to flow increases, eight leaving before July 4th and the last on August 22nd. Heublein et al. (2009) suggested that the rapid out-migration of green sturgeon in 2006, and the reduced aggregation period at the GCID site could be a result of consistently higher flows and lower temperatures than in previous study years. Alternatively, this could be an unusual behavior, related to unknown cues, that has not been documented in green sturgeon before this study (Heublein et al. 2009).

The apex detections of individual fish indicate reaches and dates when spawning might have occurred during the study conducted by Heublein et al. (2009). They reported that spawning may have occurred between May and July, and that high water velocities and extensive bedrock habitat were found in all of the apex detection reaches. Furthermore, water temperatures did not exceed 62.6°F in these reaches during this study, which would have permitted normal green sturgeon larval development (Van Eenennaam et al. 2005 as cited in Heublein et al. 2009).

The Sacramento River currently hosts the only known spawning population of green sturgeon (Poytress et al. 2010). During 2009, four spawning sites of green sturgeon were confirmed in the upper Sacramento River (Poytress et al. 2010). Three confirmed sites from 2008 surveys were reconfirmed and one of three newly sampled sites in 2009 was confirmed by the presence of green sturgeon eggs on artificial substrate mats.

During 2010, five spawning sites of green sturgeon were confirmed within a 60 river kilometer reach of the upper Sacramento River, California (Poytress et al. 2011). As stated by Poytress et al. (2010), spawning events occurred several river kilometers upstream and downstream of the RBDD before and after the June 15th seasonal dam gate closure. Spawning occurred directly below RBDD within two weeks after the gate closure. The temporal distribution pattern suggested by 2009 sampling results indicates spawning of Sacramento River green sturgeon occurs from early April through late June (Poytress et al. 2010). Sampling conducted during 2010 suggested that spawning of Sacramento River green sturgeon occurs from early April through mid-June (Poytress et al. 2011). During 2010 sampling, depths for eggs collected from all of the sites combined ranged from 2.4 to 10.9 m (7.9 to 35.8 ft) with an average of 6.9 m (22.6 ft). Sacramento River flows and water temperatures at sites located above RBDD during the estimated spawning period ranged from 166 to 459 m3s-1 (5,862 cfs to 16,209 cfs), with an average of 293 m3s-1 (10,347 cfs), and 52.0°F to 57.9°F during the estimated spawning period. Sacramento River flows and temperatures at sites located below RBDD during the estimated spawning period ranged from 268 to 509 m3s-1 (9,464 cfs to 17,975 cfs), with an average of 349 m3s-1 (12,324 cfs), and 52.9°F to 60.1°F during the estimated spawning period (Poytress et al. 2011).

The habitat requirements of green sturgeon are not well known. Eggs are likely broadcast and externally fertilized in relatively fast water and probably in depths greater than three meters (Moyle 2002). Preferred spawning substrate is likely large cobble where eggs settle into cracks, but spawning substrate can range from clean sand to bedrock (Moyle 2002). Spawning is believed to occur over substrates ranging from clean sand to bedrock, with preferences for cobble (Emmett et al. 1991; Moyle et al. 1995). Eggs likely adhere to substrates, or settle into crevices between substrates (Van Eenennaam et al. 2001; Deng et al. 2002). Both embryos and larvae exhibited a strong affinity for benthic structure during laboratory studies (Van Eenennaam et al. 2001; Deng et al. 2002; Kynard et al. 2005), and may seek refuge within crevices, but use flatsurfaced substrates for foraging (Nguyen and Crocker 2007 as cited in NMFS 2009a).

4.4.4.3 Embryo Incubation

Green sturgeon larvae hatch from fertilized eggs after approximately 169 hours of incubation at a water temperature of 59°F (Van Eenennaam et al. 2001; Deng et al. 2002), which is similar to the sympatric white sturgeon development rate (176 hours). Van Eenennaam et al. (2005) indicated that an optimum range of water temperatures for egg development was between 57.2°F and 62.6°F. Water temperatures over 73.4°F resulted in 100% mortality of fertilized eggs before hatching. Water temperatures above 68°F are reportedly lethal to green sturgeon embryos (Cech et al. 2000; Beamesderfer and Webb 2002).

Newly hatched green sturgeon are approximately 12.5 to 14.5 mm long. After approximately 10 days, larvae begin feeding and growing rapidly. Green sturgeon larvae do not exhibit the initial pelagic swim-up behavior characteristic of other Acipenseridae. They are strongly oriented to the bottom and exhibit nocturnal activity patterns. Under laboratory conditions, green sturgeon larvae cling to the bottom during the day, and move into the water column at night (Van Eenennaam et al. 2001). After six days, the larvae exhibit nocturnal swim-up activity (Deng et al. 2002) and nocturnal downstream migrational movements (Kynard et al. 2005). Exogenous feeding starts at approximately 14 days (23 to 25 mm) (Van Eenennaam et al. 2001).

4.4.4.4 Juvenile Rearing

Green sturgeon larvae do not exhibit the initial pelagic swim–up behavior characteristic of other *acipenseridae*. They are strongly oriented to the bottom and exhibit nocturnal activity patterns (NMFS 2009a). After 6 days, the larvae exhibit nocturnal swim-up activity (Deng et al. 2002) and nocturnal downstream migrational movements (Kynard et al. 2005). Juvenile fish continue to exhibit nocturnal behavior beyond the metamorphosis from larvae to juvenile stages (NMFS 2009a). Kynard et al. (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first six months of life. Observations made during nocturnal sampling in the Sacramento River indicate a possible preference of larvae for mid-channel environments or swift water velocity areas (Poytress et al. 2010). When ambient water temperatures reached 8°C (46.4°F), downstream migrational behavior diminished and holding behavior increased (Kynard et al. 2005). This data suggests that 9 to 10 month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds (NMFS 2009a).

Post-migrant larvae are benthic, foraging up- and downstream diurnally with a nocturnal activity peak (NMFS 2009a). Foraging larvae select open habitat, not structure habitat, but continue to use cover during the day (NMFS 2009a).

As reported in Corps (2007a), metamorphosis to the juvenile stage is complete at 45 days, and juveniles continue to grow rapidly, reaching 300 mm in one year. Juveniles spend from one to four years in fresh and estuarine waters and disperse into salt water at lengths of 300 to 750 mm (Corps 2007a).

The primary diet for juvenile green sturgeon reportedly consists of small crustaceans, such as amphipods and opossum shrimp (CDFG 2001). As juvenile green sturgeon develop, they reportedly eat a wider variety of benthic invertebrates, including clams, crabs, and shrimp (CDFG 2001).

Green sturgeon juveniles tested under laboratory conditions had optimal bioenergetic performance (i.e., growth, food conversion, swimming ability) between 59°F and 66.2°F under either full or reduced rations (Mayfield and Cech 2004).

Larvae and juvenile green sturgeon appear to be nocturnal (Cech et al. 2000), which may protect them from downstream displacement (LCFRB 2004). Green sturgeon larvae and juveniles (up to day 84) forage day and night, but activity is reported to peak at night. At day 110 to 118, juvenile green sturgeon move downstream at night, and habitat preference suggests that juveniles prefer deep pools with low light and some rock structure (Kynard et. al. 2005).

Wintering juveniles forage actively at night between dusk and dawn and are inactive during the day, seeking the darkest available habitat (Kynard et al. 2005).

Rearing habitat preferences of green sturgeon larvae and juveniles in the Sacramento River are poorly understood (Stillwater Sciences 2007). However, additional information about habitat use is available for white sturgeon populations, which has been used as a proxy for green sturgeon.

The seemingly random foraging patterns used by young sturgeon are probably a result of their poor ability to use visual cues to locate and capture food. Juveniles of other species of sturgeon have been shown to be non-visual feeders (Sbikin 1974), and it is generally assumed that most sturgeon use other senses than vision when feeding (Buddington and Christofferson 1985). This means that the success sturgeon have with mobile prey could be dependant on the amount of light available for prey to detect their approach (Utter et al. 1985). A non-visual predatory strategy would be an advantage to sturgeon when feeding on large populations of visually oriented prey species in habitats that are often turbid (Miller 1978, as cited in Utter et al. 1985). A dependence on sensory systems other than vision would also be advantageous when foraging at night or in areas too deep for light penetration. A random searching pattern is characteristic of all ages of juvenile sturgeon that were observed in laboratory and hatchery settings (Utter et al. 1985).

Olfactory cues are important for sturgeon when feeding on odorous food types. Sturgeon have large olfactory rosettes with both ciliated and microvillus receptors (Hara 1972, as cited in Utter et al. 1985), and Utter et al. (1985) observed that sturgeon behavior is instantaneously affected by contact with food odors. Sturgeon will often stop after detecting an odor and begin circling the general area in an attempt to contact the food item (Utter et al. 1985).

Tagged adult and subadult green sturgon in the San Francisco Bay estuary primarily occupied waters over shallow depths of less than 10 m, either swimming near the surface or foraging along the bottom (Kelly et al. 2007 as cited in Reclamation 2008). In a study of juvenile green sturgeon in the Delta, relatively large numbers of juveniles were captured primarily in shallow waters from 1–3 m deep, indicating juveniles may require shallower depths for rearing and foraging (Radtke 1966).

4.4.4.5 Juvenile Emigration

Juvenile green sturgeon migrate downstream and feed mainly at night. Juvenile green sturgeon are taken in traps at the RBDD and the GCID diversion in Hamilton City, primarily in the months of May through August. Peak counts occur in the months of June and July (68 FR 4433). Juvenile emigration may reportedly extend through September (Environmental Protection Information Center et al. 2001).

Juvenile green sturgeon have been salvaged at the Harvey O. Banks Pumping Plant and the John E. Skinner Fish Collection Facility in the South Delta, and captured in trawling studies by CDFW during all months of the year (CDFG 2002). The majority of these fish were between 200 and 500 mm long, indicating they were from 2 to 3 years of age based on Klamath River age distribution work by Nakamoto et al. (1995). The lack of a significant proportion of juveniles shorter than approximately 200 mm in Delta captures indicates that juvenile green sturgeon likely hold in the mainstem Sacramento River, as suggested by Kynard et al. (2005).

4.4.4.6 Lifestage-Specific Water Temperature Suitabilities

Since the RMT prepared its November 2010 water temperature objectives memorandum, additional water temperature monitoring in the lower Yuba River has been conducted by the RMT. The RMT (2013) developed the following representative green sturgeon lifestage-specific periodicities and primary locations for water temperature suitability evaluations.

- ☐ Adult Immigration and Holding (mid-February through April) – Daguerre Point Dam and Marysville
- ☐ Spawning and Embryo Incubation (March through July) – Daguerre Point Dam and Marysville
- ☐ Post-Spawning Holding (March through November) – Daguerre Point Dam and Marysville
- ☐ Juvenile Rearing and Outmigration (Year-round) – Daguerre Point Dam and Marysville

Green sturgeon lifestage-specific WTI values are provided in **Table 4-11**.

Table 4-11. Green sturgeon lifestage-specific WTI value ranges and associated periodicities.

Lifestage	Water Temperature Range	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult Immigration and Holding	44°F – 61°F				▨	▨	▨	▨	▨																
Spawning and Embryo Incubation	46°F – 63°F					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨										
Post-Spawning Holding	44°F – 61°F					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		
Juvenile Rearing and Outmigration	52°F – 66°F	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨

Recent water temperature monitoring data in the lower Yuba River are available for the period extending from 2006 into June 2013, during which time operations have complied with the Yuba Accord. **Figure 4-17** displays water temperature monitoring results from October 2006 through June 2013 at Daguerre Point Dam and Marysville water temperature gages, with the upper end of the green sturgeon lifestage-specific water temperature index value ranges. Water temperature monitoring over the past six years demonstrated that water temperatures remain below the upper WTI values for all lifestages of green sturgeon at Daguerre Point Dam, and for most lifestages at the Marysville Gage. The upper end of the WTI value range for post-spawning adult holding (i.e., 61°F) was exceeded at the Marysville Gage during a portion of this lifestage evaluation period, and the upper end of the WTI range for spawning and incubation was exceeded slightly for a very brief period of time during 2007 and 2013.

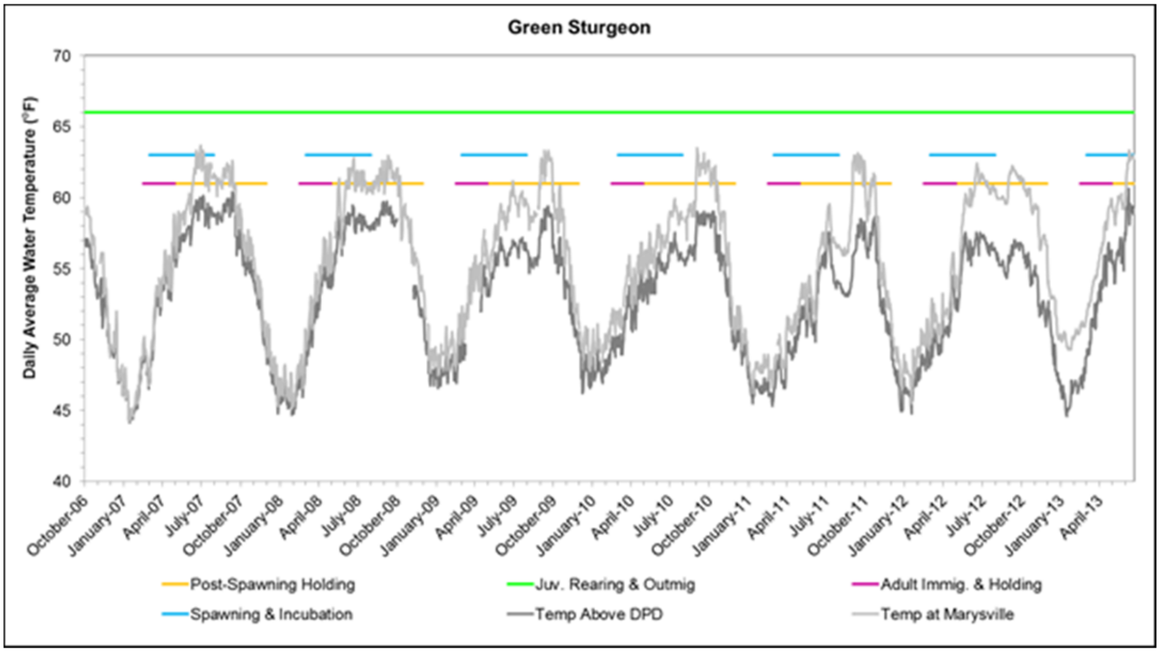

Figure 4-17. Lower Yuba River monitored water temperatures and green sturgeon upper tolerance water temperature index values.

4.4.5 Limiting Factors, Threats and Stressors

4.4.5.1 DPS

Limiting factors and threats to the Southern DPS of North American green sturgeon, both natural and anthropogenic, are presented according to the following five ESA listing factors.

PRESENT OR THREATENED DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE (REDUCTION IN SPAWNING HABITAT, ALTERATION OF HABITAT)

REDUCTION IN SPAWNING HABITAT

Access to historical spawning habitat has been reduced by construction of migration barriers, such as major dams, that block or impede access to the spawning habitat. The principal factor for the decline of green sturgeon reportedly comes from the reduction of green sturgeon spawning habitat to a limited area of the Sacramento River (70 FR 17391). Although existing water storage dams only block access to about 9% of historically available green sturgeon habitat, Mora et al. (2009) suggest that the blocked areas historically contained relatively high amounts of spawning habitat because of their upstream position in the river system. Adams et al. (2007) hypothesized that significant amounts of historically-utilized spawning habitat may be blocked by Shasta Dam and Oroville Dam on the Feather River, reducing the productive capacity and simplifying the spatial structure of the Sacramento River green sturgeon population.

Keswick Dam is an impassible barrier blocking green sturgeon access to what are thought to have been historic spawning grounds upstream (70 FR 17386). Spawning currently appears to be limited to the upper portion of the mainstem Sacramento River downstream of Keswick Dam. In addition, a substantial amount of what may have been historical spawning and rearing habitat in the Feather River upstream of Oroville Dam has also been lost (70 FR 17386).

ALTERATION OF HABITAT

Green sturgeon habitat in the mainstem Sacramento River and the Delta has been greatly modified since the mid-1800s. Based on NMFS (2010d), the following examples illustrate relationships between threats to green sturgeon and specific types of habitat alteration:

- ☐ Hydraulic gold mining resulted in the removal of gravel and the deposition of mercury-laced fine sediment within streams, rivers, and the Bay/Delta estuary.
- ☐ Agricultural practices have converted tidal and seasonal marshlands and continue to release contaminants into Central Valley waterways.
- ☐ Levees have been created extensively along the Sacramento River and the Delta, resulting in the removal of riparian vegetation and the reduction of channel complexity.
- ☐ Historical reclamation of wetlands and islands, channelization and hardening of levees with riprap have reduced and degraded in- and off-channel intertidal and sub-tidal rearing habitat for green sturgeon.
- ☐ The hydrographs of the Sacramento River and its tributaries have been substantially altered from unimpaired conditions, and may no longer favorably correspond with green sturgeon lifestage periodicities.

- ☐ In-river water diversions alter flow and potentially entrain larval/juvenile green sturgeon.
- ☐ Introduced and invasive species have likely modified trophic relationships in both freshwater and estuarine habitats, which may have resulted in increased predation on young green sturgeon, as well as reduced growth and fitness as a result of feeding on non-optimal prey resources.

Flows

NMFS (2005c) and USFWS (1995) found a strong correlation between mean daily freshwater outflow (April to July) and white sturgeon year class strength in the Sacramento-San Joaquin Estuary (these studies primarily involve the more abundant white sturgeon; however, the threats to green sturgeon are thought to be similar), indicating that insufficient flow rates are likely to pose a significant threat to green sturgeon (71 FR 17757). Low flow rates affect adult migration and may cause fish to stop their upstream migration or may delay access to spawning habitats. Also, it was posited that low flow rates could dampen survival by hampering the dispersal of larvae to areas of greater food availability, hampering the dispersal of larvae to all available habitat, delaying the transportation of larvae downstream of water diversions in the Delta, or decreasing nutrient supply to the nursery, thus stifling productivity (NMFS 2005c). Very little information is available on the habitat requirements and utilization patterns for early lifestages of green sturgeon (Mora et al. 2009).

Stranding due to flow reduction also may pose a threat to green sturgeon in the Sacramento River system. Green sturgeon that are attracted by high flows in the Yolo Bypass move onto the floodplain and eventually concentrate behind Fremont Weir, where they are blocked from further upstream migration (DWR 2005). As the Yolo Bypass recedes, these sturgeon become stranded behind the flashboards of the weir and can be subjected to heavy illegal fishing pressure. Sturgeon can also be attracted to small pulse flows and trapped during the descending hydrograph (Harrell and Sommer 2003).

Water Temperatures

The installation of the Shasta Dam temperature control device in 1997 is thought to have reduced the previous problems related to high water temperatures in the upper Sacramento River, although Shasta Dam has a limited storage capacity and cold water reserves could be depleted in long droughts (NMFS 2007). Water temperatures at RBDD have not been higher than 62°F since 1995 (NMFS 2007) and have been within the green sturgeon egg and larvae optimum range for growth and survival of 59 to 66°F (Mayfield and Cech 2004). According to Reclamation (2008), water temperatures in the Feather River appear adequate for spawning and egg incubation, contrary to previous concerns that releases of warmed water from Thermalito Afterbay are one reason neither green nor white sturgeon are found in the river in low-flow years (CDFG 2002; SWRI 2003). In some years, water temperatures downstream of the Thermalito Outlet are inadequate for spawning and egg incubation, which has been suggested as a reason why green sturgeon are not found in the river during low flow years (DWR 2007). However, post-Oroville Dam water temperatures are cooler than historic river temperatures during the summer months when early lifestages are likely to be present in the lower Feather River (DWR 2005a in Reclamation 2008). Prior to the construction of the Oroville Dam, water temperatures in the Feather River at Oroville averaged 65-71°F from June through August for the period of 1958-1968 (DWR 2004c). After Oroville Dam construction, water temperatures in the Feather River at the Thermalito Afterbay averaged 60-65°F from June through August for the period of 1993-2002 (DWR 2004c). It is likely that high water temperatures (greater than 63°F) may deleteriously affect sturgeon egg and larval development, especially for late-spawning fish in drier water years (70 FR 17386).

DELAYED OR BLOCKED MIGRATION

It has been suggested that the primary effect of construction of large water-storage reservoirs in the Sacramento–San Joaquin river basin has been to curtail the distribution of green sturgeon within the DPS (Mora et al. 2009). For example, water storage dams are hypothesized to be a major factor in the decline of green sturgeon in the Sacramento River (Adams et al. 2007). The existence and ongoing effects of these dams may have reduced the amount and altered the spatial distribution of spawning, rearing and holding habitat available and by restriction to the mainstem Sacramento River, resulting in green sturgeon becoming more vulnerable to environmental catastrophes (Mora et al. 2009).

Other potential adult migration barriers to green sturgeon have been reported to include the Sacramento Deep Water Ship Channel locks, Fremont Weir, Sutter Bypass, and the DCC Gates on the Sacramento River, and Shanghai Bench and Sunset Pumps on the Feather River (71 FR 17757).

DWR (2005) reported that the lock connecting the Sacramento River Deep Water Ship Channel with the Sacramento River blocks the migration of all fish from the deep water ship channel back to the Sacramento River. Thus, if green sturgeon enter the Sacramento River Deep Water Ship Channel, they will be unable to continue their migration upstream in the Sacramento River.

Green sturgeon are attracted by high floodwater flows into the Yolo Bypass, but are restricted from entering the Sacramento River by the Fremont Weir (DWR 2005). Sturgeon also may be attracted to small pulse flows into the Yolo Bypass, and isolated during the descending hydrograph (Harrell and Sommer 2003).

Green sturgeon can become entrained in the Sutter Bypass during storm flow events. During April 2011, several sturgeon (green and white) were stranded behind the Tisdale Weir on the Sutter Bypass when storm flows receded. CDFW, in collaboration with UC Davis, organized a fish rescue operation and returned the sturgeon to the Sacramento River.

According to NMFS (2010d), the DCC, located near Walnut Grove, California, was constructed in 1951 to facilitate the transfer of fresh water from the Sacramento River to the federal and state pumps located in the south Delta. Flow from the Sacramento River into the DCC is controlled by two radial arm gates that can be opened or closed depending on water quality, flood protection, and fish protection requirements. When the gates are open, Sacramento River water is diverted into the Mokelumne and San Joaquin rivers. The gates are closed in fall to protect migrating salmonids, then are opened the following spring. Thirty-percent of the tagged adult green sturgeon migrating down the Sacramento River after spawning entered the DCC (Israel et al. 2010). Most of these fish were able to successfully negotiate their way through the Delta and reach the Pacific

Ocean. However, four fish were detected in the south Delta, with only one surviving to reach the Pacific Ocean. Juvenile green sturgeon may also be entrained into the interior delta during the summer when the DCC is open. Further studies are necessary to investigate the threat this alternative route through the Delta poses for these fish (NMFS 2010d).

NMFS (2009d) stated that potential physical barriers to adult green sturgeon migration in the Feather River are located at Shanghai Bench (RM 25) and at the Sutter Extension Water District's Sunset Pumps (RM 39). Although Shanghai Bench was breached during 2011, it is uncertain whether or not it still imposes a migration barrier or impediment to adult green sturgeon. Each of these barriers could impede adult upstream migration during low flows (USFWS 1995a). Impediments to migration may cause fish to stop their natural upstream migration or may delay access to spawning habitats (Moser and Ross 1995). Natural (Shanghai Bench) and man-made (Sunset Pumps) impediments to upstream movements in the Feather River during low flow years might also limit significant spawning activities of green sturgeon above these obstacles to wet, high flow water years when they are most likely to be able to pass these obstacles (Beamesderfer et al. 2004).

IMPAIRED WATER QUALITY

Exposure of green sturgeon to toxics has been identified as a factor that can lower reproductive success, decrease early lifestage survival, and cause abnormal development, even at low concentrations (USFWS 1995). Contamination of the Sacramento River increased substantially in the mid-1970s when application of rice pesticides increased (70 FR 17386). Additionally, water discharges containing metals from Iron Mountain Mine, located adjacent to the Sacramento River, have been identified as a factor affecting survival of sturgeon downstream of Keswick Dam. However, treatment processes and improved drainage management in recent years have reduced the toxicity of runoff from Iron Mountain Mine to acceptable levels. It has been reported that white sturgeon may accumulate PCBs and selenium (White et al. 1989 as cited in Reclamation 2008). While green sturgeon spend more time in the marine environment than white sturgeon and, therefore, may have less exposure, the NMFS BRT for North American green sturgeon concluded that contaminants also pose some risk for green sturgeon. However, this risk has not been quantified or estimated (NMFS 2007).

Additionally, events such as toxic oil or chemical spills in the upper Sacramento River could result in the loss of both spawning adults and their progeny, and lead to year-class failure (BRT 2005).

DREDGING AND SHIP TRAFFIC

Hydraulic suction dredging is conducted in the Sacramento and San Joaquin rivers, navigation channels within the Delta, and Suisun, San Pablo, and San Francisco bays. Juvenile green sturgeon residing within the Delta and the San Francisco Bay Estuary may be entrained during hydraulic suction dredging, which is conducted to maintain adequate depth within navigation areas or to mine sand for commercial use (NMFS 2010d). Additionally, the disposal of dredged material at aquatic sites within the estuary might bury green sturgeon or their prey, and expose green sturgeon to elevated levels of contaminated sediments (NMFS 2010d).

OCEAN ENERGY PROJECTS

According to NMFS (2010d), projects that harness the ocean's energy are currently being considered along the entire west coast. Potential concerns for green sturgeon include, but are not limited to, exposure to electromagnetic field (EMF) emissions, blade strikes, turbine entrainment, and ocean energy facilities functioning as fish aggregation devices. One of the primary concerns involves the exposure of green sturgeon to EMF generated from project cables, turbine structures, and junction boxes, because green sturgeon use electroreceptors for feeding and perhaps migration, and these activities may be affected by EMF.

NMFS (2010d) suggested that the proposed installation and operation of energy-generating turbines at the mouths of several estuaries, including San Francisco Bay, may lead to injury and mortality as a result of potential blade strikes in association with turbine operation. Additionally, wave buoy and tidal turbine arrays may act as artificial reefs (e.g., DuPont 2008) or fish aggregation devices for marine mammals, fish, and invertebrates. If so, related changes to the local marine community, predator-prey interactions (i.e., increased presence of sea lions), or the distribution and abundance of marine species around ocean energy installation sites are also possible, and these sites are within the migratory corridors of green sturgeon (NMFS 2010d).

COMMERCIAL, RECREATIONAL, SCIENTIFIC, OR EDUCATIONAL OVERUTILIZATION

While this factor was not considered the primary factor causing the decline of the Southern DPS of North American green sturgeon, it is believed that past and present commercial and recreational fishing is likely to pose a threat to green sturgeon (71 FR 17757).

Commercial, tribal, and recreational fishing probably had negative impacts on green sturgeon in the past. Current fishing regulations in Washington, Oregon, and California prohibit retention of green sturgeon in all commercial and recreational fisheries, although a small number of tribes still retain green sturgeon captured in some coastal bays and estuaries (NMFS 2010d).

Coastal groundfish trawl fisheries have been substantially reduced since the 1990s due to increasingly restrictive management measures (NMFS 2010d). These include reduced trip limits, increased gear restrictions, and a vessel buyback program, all of which are expected to reduce green sturgeon bycatch. Recent modifications to existing fishing regulations have almost certainly reduced overall green sturgeon take, but the impact of discard mortality and sublethal effects of capture remain unknown (NMFS 2010d).

As a long-lived, late maturing fish with relatively low fecundity and only periodic spawning, the green sturgeon is particularly susceptible to threats from overfishing (Musick 1999 as cited in Reclamation 2008). Green sturgeon are vulnerable to recreational sport fishing with the Bay-Delta estuary and Sacramento River. Green sturgeon are primarily captured incidentally in California by sport fishermen targeting the more desirable white sturgeon, particularly in San Pablo and Suisun bays (Emmett et al. 1991). Since the listing of the Southern DPS of green sturgeon, new federal and state regulations, including the June 2, 2010 NMFS take prohibition (75 FR 30714), mandate that no green sturgeon can be taken or possessed in California (CDFG 2007a). If green sturgeon are caught incidentally and released during fishing for white sturgeon, the event must be reported to CDFW. The level of hooking mortality that results following release of green sturgeon by anglers is unknown. CDFG (2002) indicates that sturgeon are highly vulnerable to the fishery in areas where sturgeon are concentrated, such as the Delta and Suisun and San Pablo Bays in late winter and the upper Sacramento River during spawning migration. In March 2010, CDFW prohibited fishing for either white or green sturgeon within the upper mainstem Sacramento River between Keswick Dam and Butte Bridge (Hwy 162) in an effort to protect adult green sturgeon during their spawning runs (NMFS 2010d).

The demand for sturgeon caviar continues to increase both nationally and globally, and enforcement to protect sturgeon from poaching within the Central Valley is a high priority (CDFG 2002), as indicated by the number of sturgeon poaching operations that have been discovered there in recent years (NMFS 2010d). However, the degree to which poaching of green sturgeon occurs is largely unknown.

Poaching (illegal harvest) of sturgeon is known to occur in the Sacramento River, particularly in areas where sturgeon have been stranded (e.g., Fremont Weir), as well as throughout the Bay-Delta. Catches of sturgeon are thought to occur during all years, especially during wet years. The small population of green sturgeon inhabiting the San Joaquin River experiences heavy fishing pressure, particularly from illegal fishing (USFWS 1995). Areas just downstream of Thermalito Afterbay Outlet, Cox’s Spillway, and several barriers impeding migration on the Feather River may be areas of high adult mortality from increased fishing efforts and poaching.

Poaching pressure is expected to remain high because of the increasing demand for caviar, coupled with the decline of other sturgeon species around the world, primarily the beluga sturgeon (71 FR 17757). Presently, however, poaching rates in the rivers and estuary and the impact of poaching on green sturgeon abundance and population dynamics are unknown.

The amount of green sturgeon take associated with scientific research has recently become a concern. NMFS (2010d) suggested that any project (or suite of projects) that allows green sturgeon to be taken be carefully reviewed and evaluated.

DISEASE AND PREDATION

A number of viral and bacterial infections have been reported for sturgeon in general (Mims et al. 2002), however specific issues related to diseases of green sturgeon have not been studied or reported. Therefore, it is not known if disease has played a role in the decline of the Southern DPS of green sturgeon.

The significance of predation on each lifestage of green sturgeon has not been determined. There has been an increasing prevalence of nonnative species in the Sacramento and San Joaquin rivers and the Delta (CDFG 2002) and this may pose a significant threat (NMFS 2010d). Striped bass, an introduced species, may affect the population viability of Chinook salmon (Lindley et al. 2004), and probably preys on other species, such as sturgeon (Blackwell and Juanes 1998). It is likely that sea lions consume green sturgeon in the San Francisco Bay estuary, but the extent to which this occurs is unknown (NMFS 2010d).

INADEQUACY OF EXISTING REGULATORY MECHANISMS

Inadequacy of existing regulatory mechanisms has contributed significantly to the decline of green sturgeon and to the severity of threats they currently face (NMFS 2010d). During the process of developing the 4(d) rule for the Southern DPS of green sturgeon (70 FR 17386), NMFS noted several Federal, State, and local regulatory programs that have been implemented to help reduce historical risk, including the AFRP of the CVPIA and the CALFED ERP. However, growing conflicts between the protection of other species (e.g., Sacramento River winter-run Chinook salmon and sea lions) may prove problematic for green sturgeon (NMFS 2010d). Although some effort has been made to improve habitat conditions across the range of the Southern DPS of green sturgeon, less progress has been accomplished through regulatory mechanisms to reduce threats posed by water diversions or blocked passage to spawning habitat (NMFS 2010d).

OTHER NATURAL OR MAN-MADE FACTORS AFFECTING THE SPECIES' CONTINUED EXISTENCE (NON-NATIVE INVASIVE SPECIES, ENTRAINMENT)

NON-NATIVE INVASIVE SPECIES

This factor was not considered a primary factor in the decline of the Southern DPS of green sturgeon. However, non-native species are an ongoing problem in the Sacramento and San Joaquin rivers and the Delta (CDFG 2002). One risk for green sturgeon associated with the introduction of non-native species involves the replacement of relatively uncontaminated food items with those that may be contaminated (70 FR 17386). Sturgeon regularly consume overbite and Asian clams, which is of particular concern because of the high bioaccumulation rates of these clams (Doroshov 2006 in BDCP 2010). The significance of this threat to green sturgeon is unclear (NMFS 2007). Green sturgeon also are likely to experience predation by introduced species including striped bass, but the actual impacts of predation have yet to be estimated (70 FR 17392). Introductions of non-native invasive plant species such as water hyacinth and Brazilian waterweed have altered habitat and have affected local assemblages of fish within the Bay-Delta estuary (Nobriga et al. 2005), and may also affect green sturgeon through habitat alteration and potential increased predation rates on juveniles.

ENTRAINMENT

Larval and juvenile green sturgeon entrainment or impingement from screened and unscreened agricultural, municipal, and industrial water diversions along the Sacramento River and within the Delta is still considered an important threat (71 FR 17757). The threat of screened and unscreened agricultural, municipal, and industrial water diversions in the Sacramento River and Delta to green sturgeon is largely unknown because juvenile sturgeon are often not identified and current CDFW and NMFS screen criteria do not address sturgeon. Based on the temporal occurrence of juvenile green sturgeon and the high density of water diversion structures along rearing and migration routes, NMFS (2005) found the potential threat of these diversions to be serious and in need of study.

In 1997, NMFS and CDFW developed screening criteria designed to prevent entrainment and impingement of juvenile salmonids. Similar criteria for larval and juvenile green sturgeon have not been developed and, although discussions regarding their development are occurring, there has been no timeline created for when guidelines will be available (NMFS 2010d).

The largest diversions within the Delta are the SWP and CVP export facilities, located in the southern Delta. Juvenile and sub-adult green sturgeon are recovered year-round at the CVP/SWP facilities, and have higher levels of salvage during the months of July and August compared to the other months of the year. The reason for this distribution is unknown. Based on salvage data, it appears that green sturgeon juveniles are present in the Clifton Court Forebay year round, but in varying numbers. NMFS (2009a) expects that predation on green sturgeon during their stays in the forebay is minimal, given their size and protective scutes, but this has never been verified.

4.4.5.2 Lower Yuba River

Given the extremely infrequent sightings of green sturgeon in the lower Yuba River, and the lack of green sturgeon life history information for the lower Yuba River, the foregoing discussion regarding threats and stressors for the DPS is assumed to be generally applicable to the lower Yuba River.

Moreover, according to NMFS (2008a), the lower Yuba River downstream of Daguerre Point Dam is subject to the same management considerations as the lower Feather River, which include operation of dams and water diversion operations resulting in the alteration of water flow and reduced water quality, in-water construction or alterations (e.g., bridge repairs, gravel augmentation, bank stabilization), and NPDES activities and other activities resulting in non-point source pollution (e.g., agricultural pesticide application, agricultural runoff and outfalls).

4.4.6 Summary of the Current Viability of the Southern DPS of North American Green Sturgeon

Although McElhany et al. (2000) specifically addresses viable populations of salmonids, NMFS (2009a) suggested that the concepts and viability parameters in McElhany et al. (2000) also could be applied to the Southern DPS of green sturgeon. Therefore, NMFS (2009a) applied the concept of VSP and reviewed population size, abundance, spatial distribution and diversity in the 2009 NMFS OCAP BO, and also applied the VSP concepts to green sturgeon in the 2009 Oroville FERC Relicensing NMFS BO (2009d).

4.4.6.1 DPS

ABUNDANCE

Currently, there are no reliable data on population sizes and population trends are lacking. The Oroville FERC Relicensing BO (NMFS 2009d) stated that the only existing information regarding changes in abundance of green sturgeon includes changes in the numbers of green sturgeon salvaged at the federal and state facilities in the South Delta. NMFS (2009d) stated that, before 1986, an average of 732 green sturgeon were taken annually at the John E. Skinner Fish Collection Facility. From 1986 to 2006, the average per year was 47. NMFS (2009d) also stated that for the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889, and from 1986 to 2001 the average was 32. In consideration of increased water exports in recent years, NMFS (2009d) concluded that the abundance of green sturgeon has declined.

According to NMFS (2009a), the current population status of green sturgeon is unknown. Based on captures of green sturgeon during surveys for the sympatric white sturgeon in the San Francisco Bay estuary, NMFS (2009a) suggested that the population is relatively small, ranging from several hundred to a few thousand adults. However, these estimates are very uncertain, and limited by the inherent biases of the sampling methods (NMFS 2009a).

Green sturgeon in the Sacramento River have been documented and studied more widely than those in either the Feather River or the Yuba River. In general, sturgeon year class strength appears to be episodic with overall abundance and dependent on a few successful spawning events. Genetic techniques were used to estimate the number of green sturgeon spawners contributing to juvenile production between 2002 and 2006 in the upper segment of spawning habitat above RBDD. Based upon these techniques, it was estimated that between 10 and 28 individuals contributed to juvenile production (Israel and May 2010). Because populations appear to be not in equilibrium, conclusions regarding equilibrium dynamics are uncertain given the lack of information (NMFS 2010d).

Green sturgeon occasionally range into the Feather River, but numbers are low. NMFS (71 FR 17757) concluded that an effective population of spawning green sturgeon does not exist in the Feather River at the present time.

PRODUCTIVITY

There is insufficient information to evaluate the productivity of green sturgeon (NMFS 2009d). Recruitment data for green sturgeon are essentially nonexistent (NMFS 2009a). Incidental catches of larval green sturgeon in the mainstem Sacramento River and juvenile fish at the CVP and SWP pumping facilities in the South Delta suggest that green sturgeon are successful at spawning, but that annual year class strength may be highly variable (Beamesderfer et al. 2007; Adams et al. 2002). Recent declines in the number of larvae captured in the RSTs near the RBDD may indicate a reduction in spawning success in the past several years, with resulting depressions in the year class strengths for those years. However, green sturgeon are iteroparous and long-lived, so that spawning failure in any one year may be rectified in a succeeding spawning year (NMFS 2009a).

SPATIAL STRUCTURE

Historical green sturgeon spawning habitat may have extended up into the three major branches of the upper Sacramento River above the current location of Shasta Dam - the Little Sacramento River, the Pit River, and the McCloud River (NMFS 2009a; NMFS 2009d). Additional spawning habitat is believed to have once existed above the current location of Oroville Dam on the Feather River (NMFS 2009a). The Southern DPS of green sturgeon population has been relegated to a single spawning area, which is, for the most part, outside of its historical spawning area.

According to NMFS (2009a), the reduction of green sturgeon spawning habitat into one reach on the Sacramento River between Keswick Dam and Hamilton City has increased the vulnerability of this spawning population to catastrophic events. One spill of toxic materials into this reach of river, similar to the Cantara Loop spill of herbicides on the upper Sacramento River, could remove a significant proportion of the adult spawning broodstock from the population, as well as reduce the recruitment of the exposed year class of juvenile fish. Additionally, extended drought conditions could imperil the spawning success for green sturgeon, particularly those that are restricted to the river reaches below RBDD (NMFS 2009a).

DIVERSITY

Diversity, both genetic and behavior, provides a species the opportunity to track and adapt to environmental changes. The reduction of the Southern DPS of green sturgeon population to one extant spawning population has reduced the potential variation of life history expression and genetic diversity within this population (NMFS 2009d). In addition, the closed gate configuration at RBDD from mid-May to September may have altered the genetic diversity of the population by separating the population into upstream and downstream spawning groups based on run timing (NMFS 2009a).

Green sturgeon stocks from the northern and southern DPSs are genetically differentiated (Israel et al. 2004; Israel et al. 2009). Genetic differentiation is moderate and statistically similar between the southern and northern DPSs (NMFS 2010d). However, the genetic diversity of the Southern DPS is not well understood (NMFS 2009d).

SUMMARY OF THE CURRENT VIABILITY OF THE SOUTHERN DPS OF NORTH AMERICAN GREEN STURGEON

The Southern DPS of green sturgeon is at substantial risk of future population declines (Adams et al. 2007). The principal threat to green sturgeon in the Southern DPS is the reduction in available spawning habitat due to the construction of barriers on Central Valley rivers (NMFS 2009d). According to NMFS (2009a), the potential threats faced by the green sturgeon include enhanced vulnerability due to the reduction of spawning habitat into one concentrated area on the Sacramento River, lack of good empirical population data, vulnerability of long-term cold water supply for egg incubation and larval survival, loss of juvenile green sturgeon due to entrainment at the project fish collection facilities in the South Delta and agricultural diversions within the Sacramento River and the Delta, alterations of food resources due to changes in the Sacramento River and Delta habitats, and exposure to various sources of contaminants throughout the basin to juvenile, sub-adult, and adult lifestages. In summary, NMFS (2009d) concluded that the Southern DPS of green sturgeon remains at a moderate to high risk of extinction.

A recent study (Thomas et al. 2013) provided additional analysis regarding population-level impacts due to stranding of green sturgeon. During April 2011, 24 green sturgeon were rescued that had been stranded behind two weirs (Fremont and Tisdale) along the Sacramento River. Those 24 green sturgeon were acoustically tagged and their survival and migration success to their spawning grounds was analyzed. Additionally, population viability modeling and analysis was conducted to show the potential impacts of stranding and the benefits of conducting rescues at the population level. Population viability analyses of rescue predicted a 7% decrease below the population baseline model over 50 years as opposed to 33% without rescue (Thomas et al. 2013).

4.4.6.2 Lower Yuba River

As previously discussed, very few observations of green sturgeon have occurred in the Yuba River historically or in recent years. The few occasions when confirmed observations have occurred were downstream of Daguerre Point Dam and consisted of adult green sturgeon. Green sturgeon acoustic tag detections do not indicate substantive use of the Yuba River (YCWA 2013).

Monitoring and studies of green sturgeon in the Delta, the Sacramento River and its tributaries continue to be undertaken by a variety of agencies implementing numerous different programs. The CFTC continues to monitor acoustically tagged green sturgeon throughout the system, and fixed-station acoustic monitors and roving hydrophonic surveys continue to be conducted on the lower Yuba River by both the RMT and CDFW's Heritage and Wild Trout and the Steelhead Management and Recovery Programs. The AFRP is continuing to fund ongoing sturgeon videographic monitoring efforts in the Feather River Basin, including the lower Yuba River. Additionally, the Sturgeon IEP Project Work Team coordinates green sturgeon research, disseminates information and is overseeing the development of a green sturgeon population model, and the Corps' LTMS for the Placement of Dredged Material in the San Francisco Bay Region Program includes green sturgeon tracking, evaluation of susceptibility to suction dredging and development of entrainment models. Available results from these and other programs may provide additional information regarding green sturgeon in the Central Valley and lower Yuba River. However, despite the contribution resulting from these and other studies conducted to date, knowledge of the population biology and dynamics of green sturgeon remains limited.

Limited information regarding green sturgeon abundance, distribution, movement and behavioral patterns, as well as lifestage-specific habitat utilization preferences, is available for the Sacramento and Feather rivers. According to NMFS (2009a), the current population status of the Southern DPS of North American green sturgeon is unknown. Currently, there are no reliable data on population sizes, and population trends are lacking (NMFS 2009d). There is insufficient information to evaluate the productivity of green sturgeon (NMFS 2009d), and recruitment data for green sturgeon are essentially nonexistent (NMFS 2009a). Essentially no information regarding these topics is available for the lower Yuba River.

Hence, it is not practicable to attempt to apply the VSP concepts developed for salmonids to green sturgeon in the lower Yuba River. Moreover, the lack of information pertaining to abundance, productivity, habitat utilization, life history and behavioral patterns in the lower Yuba River, due to infrequent sightings over the past several decades, does not provide the opportunity for reliable alternative methods of viability assessment of green sturgeon in the lower Yuba River.

4.4.7 Recovery Considerations

In November 2009, NMFS (74 FR 58245) announced its intent to develop a recovery plan for the Southern DPS of North American green sturgeon. NMFS is required by the ESA to develop and implement recovery plans for the conservation and survival of ESA-listed species. As part of the process, NMFS will be coordinating with state, Federal, tribal, and local entities in California, Oregon, Washington, Canada, and Alaska to develop the recovery plan.

Presently, NMFS is in the process of preparing the draft recovery plan, and has prepared an outline of the plan (NMFS 2010d). As stated in the outline, the goal is to set out a plan to conserve and recover green sturgeon by identifying actions that may improve its potential for recovery. These include, but are not limited to, the following:

- ☐ Improve existing research and initiate novel research and monitoring on distribution, status, trends, and lifestage survival of the Southern DPS of green sturgeon at the population level.
- ☐ Establish better inter- and intra-agency coordination regarding scientific research conducted on green sturgeon under ESA sections 7, 10, and 4(d).
- ☐ Evaluate the significance of green sturgeon bycatch in commercial fisheries through the implementation of directed surveys.
- ☐ NMFS Office of Law Enforcement (OLE) should monitor and collaborate with state enforcement agencies along the west coast related to illegal retention of green sturgeon in recreational fisheries.
- ☐ NMFS OLE should collaborate with CDFW wardens to address sturgeon poaching in the Central Valley.
- ☐ Assess the potential for establishing independent spawning populations in areas outside of the mainstem Sacramento River (e.g., Feather, Yuba, Russian rivers, as well as tributaries of San Joaquin River).
- ☐ Address the need to develop a multiple species water flow and temperature management plan for Shasta, Keswick, Oroville and Englebright dams.
- ☐ Address the application of pesticides (Carbaryl and others) and herbicides applied to control burrowing shrimp and non-native plants in estuaries.
- ☐ Identify and prioritize potential contaminants of concern in the Central Valley.
- ☐ Ensure that screens are placed on water diversions on the upper mainstem Sacramento River below Keswick Dam and that they are designed to be protective of larval and juvenile green sturgeon. Research on screening criteria should be initiated as soon as feasible.
- ☐ Continue to support the removal of the Red Bluff Diversion Dam.

- ❑ Monitor hydraulic suction dredges for potential entrainment of juvenile green sturgeon.
- ❑ Determine the impact of non-native species.
- ❑ Determine if electromagnetic fields produced by offshore energy projects alter green sturgeon migration patterns.

The draft recovery plan outline (NMFS 2010d) further states that recovery actions will be refined in the recovery plan and will be specific to several regions, including the Sacramento River, the Delta/Estuary, and coastal marine areas, which include several estuaries/bays. Actions specific to lifestages in each region will be identified to address more localized factors that currently suppress potential for recovery for green sturgeon (NMFS 2010d).

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5.0 Environmental Baseline

The regulations governing ESA consultations (50 CFR §402.02) define "*Environmental Baseline" as follows: "The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process*." The ESA Consultation Handbook explains that the Environmental Baseline should provide an… "*analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area*" (USFWS and NMFS 1998). While the Environmental Baseline includes ongoing effects, it does not include the future effects of the Proposed Action under review. The assessment of "future" effects of the Proposed Action is included in Chapter 7.0 of this BA.

The Environmental Baseline for this BA adopts the NMFS (2005) Recommendations for the Contents of Biological Assessments and Biological Evaluations pertinent to the Environmental Baseline. The Environmental Baseline analysis in this BA therefore:

- ☐ Provides information on past, present and future state, local, private, or tribal activities in the action area – specifically, the positive or negative impacts those activities have had on the species or habitat in the area in terms of abundance, reproduction, distribution, diversity, and habitat quality or function.
- ☐ Includes the impacts of past and present Federal actions.
- ☐ Describes the impacts of the past existence and operation of the action under consultation (for continuing actions).
- ☐ Presents all known and relative effects on the population (e.g., fish stocking, fishing, hunting, other recreation, illegal collecting, private wells, development, grazing, local trust programs).

- ☐ Includes impacts to the listed and proposed species in the action area that are occurring, and that are unrelated to the Proposed Action (e.g., poaching, road kills from off-road vehicle use, trespass).

The purpose of this Environmental Baseline chapter is to use the best available science to summarize the status of the species and critical habitat, and analyze the effects of factors affecting the species and critical habitat within the Action Area of the lower Yuba River. The species' current status is described in relation to the risks presented by the continuing effects of all previous actions and resource commitments that are not subject to further exercise of Federal discretion (WSDOT 2013). For projects that may affect designated critical habitat, the environmental baseline should include a detailed description of the current functional condition of the individual PCEs within the action area. The condition of the environmental baseline will influence the effects analysis in that the effects on the critical habitat in the action area to the proposed action will depend, in part, on existing environmental conditions (WSDOT 2013).

Because previous ESA consultations related to the Corps' activities have intermingled effects of the Proposed Action with potential stressors and impacts of the Environmental Baseline, the analysis provided in this BA attempts to more clearly distinguish between the potential effects to listed fish species that are attributable to the Environmental Baseline, compared to those that are expected to occur as a result of the Proposed Action (see Chapter 7.0). Additionally, because the scope of the Action Area has changed, relative to earlier consultations, some areas that may have previously been associated with Environmental Baseline effects are now described in the Status of the Species (see Chapter 4). Specifically, because the most upstream extent of the Action Area for this BA is located immediatedly downstream of the Narrows II Powerhouse, which corresponds with the gravel augmentation component of the Proposed Action, Englebright Dam is not included in the Action Area and therefore is not included in the Environmental Baseline. As stated in WSDOT (2013), "*The baseline discussion should summarize the actions that have (and continue to) occur* *<u>in the action area</u>* *and describe how these actions have influenced environmental conditions and the status of the species* *<u>in the action area</u>* [emphasis added]."

USFWS and NMFS (1998) explain that the Environmental Baseline should provide an "*analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area*." While the Environmental Baseline includes ongoing effects, it does not include the future effects of the Proposed Action under review.

Distinguishing between the effects of an ongoing action and the environmental baseline can be a complex task for many ongoing water projects. The ESA presents different challenges for civil works projects that have already been constructed and that are now being operated and maintained by the Corps. Many of those projects were planned, designed, and built before the ESA was enacted in 1973, and sometimes the listed species or designated critical habitats were not present in the area until after the Corps' projects were built.

The Corps' responsibilities, as well as its ability to conduct activities at Daguerre Point Dam on the lower Yuba River, are primarily governed by the facilities' respective authorized purposes (see Appendix A regarding Corps' Authorities). Consequently, the Corps' actions that are proposed and evaluated in this BA and that could potentially affect (positively or negatively) listed fish species or critical habitat in the Action Area of the lower Yuba River are limited.

Due to the Corps' limited authority and discretion regarding the operations of facilities associated with this Proposed Action, distinguishing between effects of the Proposed Action and effects of the Environmental Baseline in this BA is not overly complex. Future effects to listed species that are solely attributable to the presence of pre-existing facilities that the Corps does not have authority to change should be included in the Environmental Baseline. USFWS and NMFS (1998) explain in detail how future effects from an existing dam are considered part of the environmental baseline when the USFWS and NMFS consult on later, related actions.

According to USFWS and NMFS (1998)… "*Ongoing effects of an existing dam are already included in the Environmental Baseline and would not be considered an effect of the proposed action under consultation*." This applies to the effects of the physical structure of the dam and the effects of past operations, but not to the future activities over which the action agency has discretion.

With the possible exception of effects of fish ladder performance that are associated with discretionary routine operations and maintenance activities, the Corps does not have the ability to lessen other stressors associated with at Dagurre Point Dam. Therefore, it is appropriate that most of the ongoing effects from the stressors attributable to the presence of Daguerre Point Dam and the non-discretionary operations and maintenance activitities to maintain the dam are associated with the Environmental Baseline that has led to the current status of the species.

5.1 2012 NMFS BO RPA and RPMs

NMFS issued three different BOs (two final and one interim) regarding the Corps' activities at Englebright and Daguerre Point dams between March 2002 and November 2007. All three BOs concluded that the Corps' activities in operating and maintaining the two dams did not jeopardize listed fish species in the lower Yuba River. The third BO, issued on November 21, 2007, ultimately prompted litigation that was adjudicated before another court in the Eastern District. Following that decision, the Corps voluntarily reinitiated formal consultation with NMFS during October 2011 on the Corps' ongoing operation and maintenance of Englebright Dam and Daguerre Point Dam and associated facilities. During January 2012, a Final BA (referred to herein as the 2012 BA) was prepared to, among other things, analyze the effects of that action on listed species and designated critical habitat. NMFS issued its Final BO (2012 BO) and jeopardy opinion on February 29, 2012 regarding the effects of Englebright Dam and Daguerre Point Dam on the Yuba River in Yuba and Nevada Counties, California on threatened Central Valley spring-run Chinook salmon, threatened Central Valley steelhead, the threatened Southern DPS of North American green sturgeon, and their designated critical habitat.

According to the August 12, 2013 Memorandum and Order of the United States District Court, Eastern District of California, in Case No. 2:13-cv-00042-MCE-CKD, unlike its predecessors, the 2012 NMFS BO concluded that the Corps' 2012 Proposed Action adversely affected the concerned fish because it blocked access to suitable habitat above

Englebright Dam for spring-run Chinook salmon and steelhead. The 2012 NMFS BO concluded that continued inaccessiblity to upstream habitat would likely jeopardize the continued existance of those listed species. The 2012 BO included an RPA that modified the Proposed Action to avoid jeopardizing the species and adversely modifying their critical habitat. The RPA was divided into eight categories containing almost 60 specific actions to be implemented by the Corps.

As discussed in Chapter 1, the Corps sent a letter to NMFS on July 3, 2012 acknowledging receipt of the 2012 BO (see Appendix B). Although the Corps conditionally accepted the RPA described in the BO, the Corps expressed serious concerns about various aspects of the BO that needed to be resolved. The Corps determined it could not implement certain actions in the RPA. Also, according to the ESA Consultation Handbook (USFWS and NMFS 1998), when characterizing the environmental baseline, an agency action can be removed from the environmental baseline analysis if "*a Biological Opinion for the proposed action (not an ongoing action) is no longer valid because reinitiation of consultation is required and the action agency has been so informed in writing by the Services, or has requested that the Services reinitiate consultation.*" The Corps formally requested reinitiation of consultation proceedings under Section 7 of the ESA on February 26, 2013. For these reasons, the actions specified in the 2012 BO are not included in the Environmental Baseline for this BA.

5.2 Characterization of the Environmental Baseline

The Environmental Baseline is characterized by the existing physical features and habitat conditions in the Action Area. Because the construction and the continued existence of Daguerre Point Dam have resulted in effects that have contributed to the current status of the species within the Action Area, these effects are considered to be part of the Environmental Baseline. The existing status of listed species in the Action Area associated with the Environmental Baseline is described in Chapter 4.0 of this BA.

5.2.1 Physical Features

5.2.1.1 Daguerre Point Dam

The Rivers and Harbor Act of June 13, 1902 authorized the construction of the Yuba River Debris Control Project, of which Daguerre Point Dam is a part (Corps 2001). Construction of Daguerre Point Dam was funded through a 50/50 cost share between the California Debris Commission and the State of California.

The original purpose of the Daguerre Point Dam was to create a basin for the storage of debris originating from the operation of hydraulic equipment for gold mining in the Yuba River watershed. Since the cessation of hydraulic mining operations, Daguerre Point Dam has retained the debris stored behind the dam and prevented it from being washed into the Feather and Sacramento Rivers to the detriment of associated navigation and flood control facilities. The dam was not intended for, nor does it provide for, the control of floods (Corps 2001).

HISTORY/BACKGROUND

Hydraulic mining in the Yuba River watershed during the mid-1800s contributed large quantities of sediment to the river. About 600 million cubic yards of material exposed by hydraulic mining had entered the Yuba River between 1849 and 1909 (Hagwood 1981). The sediment deposited in the channel raised the channel bed to the point that in 1868 it was higher than the streets in Marysville. Subsequent flooding of Marysville in the late 1800s led to attempts to mitigate the adverse effects of hydraulic mining (Corps 2005).

Efforts to control sediment came together with a project known as the “1898 Project”. This project involved controlling sediment with several small dams and building gravel berms to confine the low-water channel (Ayers 1997 as cited in DWR and Corps 2003a). In 1901, the California Debris Commission approved a plan to construct four barrier dams, build a settling basin, and build training walls. The plan was authorized by the Rivers and Harbor Act of 1902 (Hagwood 1981).

The major features of the "1898 Project" included: (1) storage of the mining debris within the bed of the Yuba River; (2) control of the low water channel within well-defined limits; and (3) the erection of several barriers of modest size across the bed of the river, specifically: (a) Barriers No. 1 and No. 2 to be located about 3 miles east of the mouth of Dry Creek; (b) a barrier to be built just below the mouth of Dry Creek; (c) a barrier to be placed at Daguerre Point; (d) construction of a settling basin about 3 miles by 1½ miles wide on the south side of the river; and (e) the building of gravel berms below the basin to confine the river channel within well-defined limits (Hagwood 1981).

The first attempt to constrain mine tailings and debris in the lower Yuba River was made using a structure referred to as Barrier No. 1, located about 1 mile downstream of the Parks Bar Bridge and 4.5 miles upstream of Daguerre Point (Hunerlack et al. 2004; Sumner and Smith 1939 as cited in Hagwood 1981). Work on Barrier No. 2, located about a half mile above Barrier No. 1, was initiated during September 1903, and work on Barrier No. 1 commenced shortly thereafter (Hagwood 1981). Unusually high water came down the Yuba River in November 1903, and destroyed much of the work completed. Barrier No. 1, re-constructed in 1905, was 14 feet high and constrained 1,690,000 cubic yards of gravel that were transported in the river channel during the winter and spring of 1906 (Gilbert 1917 as cited in Yoshiyama et al. 2001). Of this total, 920,000 cubic yards were constrained upstream of the barrier during the January 1906 flood alone. Barrier No. 1 probably hindered salmon upstream movement until it failed the following year when floods destroyed it during March 1907 (Sumner and Smith 1939 as cited in Hagwood 1981). Many acres of farmlands were repeatedly destroyed by flooding and silting in the Yuba River watershed, and properties in the cities of Marysville were threatened frequently by the rise of the riverbed (Hunerlack et al. 2004). When the flood subsided, the engineers decided to cease construction at the Barrier No. 1 site, and instead proposed to complete a barrier at Daguerre Point (the fourth dam of the original proposal) and the settling basin immediately below. The gravel berms below the Daguerre Point cut also were to be completed. The gravel berms built on the south side of the river were completed by the Yuba Consolidated Gold Fields and the Marysville Gold Dredging Company as part of their gold dredging operations. Finally, the Yuba Consolidated Gold Fields Company also built a rock levee which took the place of Barriers No. 1 and No. 2 (Hagwood 1981). In other words, the "1898 Project" was revised so as to concentrate the Commission's effort at and near Daguerre Point (Hagwood 1981).

The California Debris Commission constructed the original Daguerre Point Dam in 1906 as part of the later Yuba River Debris Control Project (Corps 2001). Daguerre Point Dam was constructed in a cut above and to the north of the original Yuba River channel. The bedrock under Daguerre Point Dam is a portion of the Daguerre Point Terrace, a feature that facilitated the construction of a low dam at a relatively low cost. Over the next few years, the cut through Daguerre Point was completed and a concrete inlet wall, or spillway, was constructed. Gravel berms extending about 12,000 feet on each side of the river below the cut were built. The entrance gates to the settling basin were constructed, most of its enclosing levees were built, and the outlet works were practically completed when this part of the project was found no longer necessary and was abandoned under authority of the River and Harbor Act of June 25, 1910. The settling basin itself was never constructed. The land acquired for the settling basin, together with the intake and outlet works, was then sold (Hagwood 1981).

Daguerre Point Dam was completed in May of 1906, but the river was not diverted over the dam until 1910 (Corps 2007). Daguerre Point Dam rapidly filled to capacity with sediment and debris that moved downstream during flooding in 1911 (Hunerlach et al. 2004). The “1898 Project”, as modified, was completed in 1935 (Hagwood 1981). By that time, three gravel berms existed, having a total length of approximately 85,100 feet which provided two 500-foot channels. The result of the work on the Yuba River in and around Daguerre Point has held back millions of cubic yards of mining debris in the Yuba River which would otherwise have passed into the navigable channels of the Feather and Sacramento Rivers (Hagwood 1981).

After its construction, Daguerre Point Dam was reported to be a partial or complete barrier to salmon and steelhead for many years because of the lack of functional fish ladders (Mitchell 2010). However, although the dam made it difficult for spawning Chinook salmon and steelhead to migrate upstream, salmon reportedly did surmount that dam in occasional years because they were observed in large numbers in the North Yuba River at Bullards Bar during the early 1920s (Yoshiyama et al. 2001). Two fishways, one for low water and the other for high water, were constructed at Daguerre Point Dam prior to the floods of 1927-1928 (Clark 1929; CDFG 1991a), the fish ladders were destroyed, and were not replaced until 1938, leaving a 10-year period when upstream fish passage at

Daguerre Point Dam was blocked (CDFG 1991). That 10-year period coincided with the drought of 1928 through 1934, which raised water temperatures below Daguerre Point Dam much higher than those tolerated by Chinook salmon (Mitchell 1992 as cited in NMFS 2012). These conditions probably caused the extirpation of spring-run Chinook salmon from the lower Yuba River (Mitchell 1992 as cited in NMFS 2012). On the southern end of the dam, a fish ladder was constructed in 1938 and consisted of 8- by 10-foot bays arranged in steps with about 1 foot of difference in elevation between steps. However, it was generally ineffective (Sumner and Smith 1939). Two functional fish ladders were installed in 1951 by the State of California and it was stated that "*With ladders at both ends, the fish have no difficulty negotiating this barrier at any water stage*" (CDFG 1953).

Precipitation regimes in the region are highly variable in timing and quantity, with unpredictable autumn rainfall and occasional winter deluges producing a considerable part of the average annual runoff (USGS gage data 1858-2009). The flood of February 1963, estimated at about 120,000 cfs, washed out a section of Daguerre Point Dam between the mid-stream stations. During the summer of 1964, the Corps met with the USFWS and CDFG to develop criteria for the reconstruction and modification of the existing fishways at Daguerre Point Dam. Repairs were made in 1964 to Daguerre Point Dam and to the southern fish ladder, but before modifications could be made to the northern ladder, the flood of December 1964 washed out a portion of the dam that had not been reconstructed and eroded the underlying rock foundation to an estimated depth of 15 to 25 feet (Corps 2007). The floods of 1964 also washed out nearly all of the sediments and debris that had accumulated behind the dam up to that time. The flood of December 1964, estimated at about 180,000 cfs, also washed out the retaining walls of the Hallwood-Cordua diversion structure, completely destroyed the fish ladder headwork on the north as well as a large part of the original fish ladder, but the portion of the fish ladder completed with the rehabilitation from the 1963 floods of the dam was still intact (Dettmer, Memo For Record, 1964). Temporary repairs of the damage were made in February and March 1965. Extensions to the fish ladders were added, and slide gates, which also permit the passage of fish, were added to both upstream ends of the ladders in 1965 (Corps 2007). "*Permanent repair of Daguerre Point Dam abutment and fish* *facilities was completed in October 1965 at a cost of $447,808 with Federal and required State contributed funds on a matching basis*." (ERDC 2008).

PHYSICAL FACILITIES DESCRIPTION

The current configuration of Daguerre Point Dam is a reinforced, overflow concrete ogee ("s-shaped") spillway with concrete apron and concrete abutments. The ogee spillway section is 575 feet wide and 25 feet tall (NMFS 2007).

There is no reservoir associated with Daguerre Point Dam. The dam is a low-head dam across the Yuba River. In addition to the dam structure, there are two fish ladders, each with a control gate. The two fish ladders utilize the hydraulic head created by the dam due to the influence of the dam preventing additional channel incision above the dam. The purpose of these two fish ladders is to permit salmon and steelhead access upriver to the seasonal spawning areas. There are no recreation facilities located at Daguerre Point Dam.

Daguerre Point Dam is the primary diversion point for water entering the Hallwood-Cordua Canal and the South Canal, which supply the water districts located north and south of the lower Yuba River, respectively. Water levels in the Hallwood-Cordua and South canals are manually controlled year-round using board weirs. Minimum water levels are maintained to ensure there is enough pressure for any user to divert water when needed (R. McDaniel, pers. comm. 2006 in YCWA et. al. 2007). While water elevations in these primary conveyances remain constant, the flow rates through these conveyances may change with changes in agricultural demands. The amounts of groundwater pumping by farmers have no effects on surface water levels in the primary conveyances. Even during seasons when farmers are implementing groundwater conjunctive use measures, water levels are maintained in the primary conveyances for those districts or farmers that are not participating in the conjunctive use programs.

FISH LADDERS AND FISH PASSAGE

Under the Environmental Baseline, there are numerous issues associated with anadromous fish passage at Daguerre Point Dam. NMFS (2007) stated that passage conditions at Daguerre Point Dam are considered to be inadequate for Chinook salmon and steelhead throughout much of the year due to the design of the existing ladders.

When high flow conditions occur during winter and spring, adult spring-run Chinook salmon and steelhead reportedly can experience difficulty in finding the entrances to the ladders because of the relatively low amount of attraction flows exiting the fish ladders, compared to the magnitude of the sheet-flow spilling over the top of Daguerre Point Dam. In addition, the NMFS (2007) stated that the angles of the fish ladder entrance orifices and their proximities to the plunge pool also increase the difficulty for fish to find the entrances to the ladders.

As previously described in this BA, other configuration and design features of the fish ladders and passage facilities that reportedly could either delay or impede anadromous salmonid access to spawning and rearing areas above the dam include: (1) the control gate, acting as a submerged orifice, is only passable at low flows (actual flow data are unavailable) during the summer and fall; (2) the ladders become clogged with debris; (3) insufficient attraction flows during non-overflow operational conditions; (4) unfavorable within-bay hydraulic characteristics, particularly associated with debris collection; (5) unfavorable fish ladder geometric configurations; and (6) sedimentation and unfavorable habitat conditions associated with egress from the fish ladders.

The Corps installed locking metal grates on 33 unscreened bays of the Daguerre Point Dam fish ladders in response to the Interim Remedy Order issued by the Court on July 25, 2011. Because the fish ladder bays are not uniformly sized, each metal grate needed to be custom fabricated by hand (**Figure 5-1**). Due to concerns expressed by both NMFS and CDFW, the Court then reconsidered the requirement to put grates over the bays on the lowermost section of the south fish ladder at Daguerre Point Dam. Consequently, grates were not installed over the lower eight bays of the south fish ladder at Daguerre Point Dam.

NMFS (2007) suggested that the biological consequences to anadromous salmonids of blockage or passage delays include changes in spawning distribution, increased adult prespawning mortality, and decreased egg viability, which may result in the reduction of the abundance and productivity of the listed species.

However, DWR and Corps (2003) stated that there is no direct evidence that holding below the dam when the fish ladders are not fully functional affects the condition of salmon during their migration, except that repeated attempts to pass over the dam probably result in injury from contact with the rough concrete surface of the dam face. Moreover, short-term delays in spawning migration are not inherently problematic, and salmon and steelhead health and/or egg viability may not be adversely affected by short-term delays (DWR and Corps 2003). It has been suggested that water temperatures in the pool below Daguerre Point Dam may be higher than optimum for all salmonids during the warmer parts of the year, especially during low flow conditions in late summer, and that water temperature effects may adversely impact egg viability (DWR and Corps 2003). However, the RMT recently evaluated the potential effects of water temperatures on spring-run Chinook salmon, fall-run Chinook salmon and steelhead, by lifestage, using the mean monthly water temperature modeling conducted for the 2007 Lower Yuba River Accord EIR/EIS and water temperature monitoring data conducted from 2006 - 2012. The RMT (2013) included evaluation of water temperatures at Daguerre Point Dam during the spring-run Chinook salmon adult upstream immigration and holding lifestage, which addressed considerations regarding both water temperature effects to pre-spawning adults and egg viability, characterized as extending from April through August, and concluded that water temperatures were suitable.

Concern has been expressed that if emigrating salmon and steelhead juveniles encounter high water temperatures in the reach below Daguerre Point Dam, they cannot return to the lower-temperature habitat upstream because their passage is blocked by the dam (DWR and Corps 2003). However, this concern was raised prior to implementation of the Yuba Accord minimum flow schedules and associated water temperatures (initiated as Pilot Programs in 2006 and 2007, and now being implemented through the permanent changes made to YCWA's water-right permits in 2008). The RMT (2013) also included an evaluation of water temperatures at Daguerre Point Dam and at the Marysville Gage on the lower Yuba River during the year-round juvenile rearing period for spring-run Chinook salmon and steelhead, and found that water temperatures remained at suitable levels.

Figure 5-1. Installation of metal grates on the Daguerre Point Dam fish ladder bays during August 2011 (Corps 2011).

NMFS (2007) and other documents (NMFS 2002; CALFED and YCWA 2005) suggest that juvenile salmonids may be adversely affected by Daguerre Point Dam on their downstream migrations, because Daguerre Point Dam creates a large plunge pool at its base, which provides ambush habitat for predatory fish in an area where emigrating juvenile salmonids may be disoriented after plunging over the face of the dam into the deep pool below. The introduced predatory striped bass and American shad have been observed in this pool (CALFED and YCWA 2005). It has been suggested that the rates of predation of juvenile salmonids passing over dams in general, and Daguerre Point Dam in particular, may be unnaturally high (NMFS 2007). However, DWR and Corps (2003) stated that there is no substantial evidence of predation on emigrating juvenile salmon by warmwater fish, and that temperature and habitat conditions in the lower Yuba River are not conducive to the establishment of significant populations of such fish, except perhaps in the Marysville area. Daguerre Point Dam may influence predation rates on emigrant juvenile anadromous salmonids, although DWR and Corps (2003) stated that there are no data indicating that such predation is significant, whether predation at the dam is offset by lower predation rates downstream, or even what percentage of juvenile salmonids are taken by predators. Presently, there are limited studies or data regarding predation rates on juvenile anadromous salmonids in the vicinity of Daguerre Point Dam relative to elsewhere in the lower Yuba River.

An additional issue associated with fish passage at Daguerre Point Dam relates to the abundance and distribution of rearing juvenile anadromous salmonids relative to predators. Most juvenile Chinook salmon and steelhead rearing has been reported to occur above Daguerre Point Dam (Beak 1989; CDFG 1991; SWRI et al. 2000). Kozlowski (2004) observed age-0 *O. mykiss* throughout the entire study area, with highest densities in upstream habitats and declining densities with increasing distance downstream from the Narrows. Approximately 82% of juvenile *O. mykiss* were observed upstream of Daguerre Point Dam. Kozlowski (2004) suggested that the distribution of age-0 *O. mykiss* appeared to be related to the distribution of spawning adults. The higher abundance of juvenile salmonids above Daguerre Point Dam may be due to larger numbers of spawners, greater amounts of more complex, high-quality cover, and lower densities of predators such as striped bass and American shad, which reportedly are generally restricted to areas below the dam (YCWA et al. 2007).

The population viability assessments, which addressed population abundance and productivity of the listed species, were previously presented in Chapter 4 of this BA. It is uncertain the extent to which the design, operational and maintenance activities have incrementally contributed to the current status of the species, including their viabilities and extinction risks. However, potential effects on the populations associated with Daguerre Point Dam passage considerations were inherently included in the viability assessments.

Daguerre Point Dam was not designed for green sturgeon and is therefore a complete barrier to upstream passage because green sturgeon are unable to ascend the fish ladders on the dam, or otherwise pass over or around the structure. The scarcity of information on green sturgeon in the lower Yuba River makes it difficult to determine how these fish are utilizing the habitat in the river, or for what purpose green sturgeon are entering the river.

According to NMFS (2007), it is possible that the plunge pool below Daguerre Point Dam or other deep holes downstream of the dam provide suitable habitat for green sturgeon spawning. It is unlikely that any green sturgeon alive today could have been spawned above Daguerre Point Dam, and are attempting to return to their natal spawning habitat above the dam, because the dam has been in place longer than the expected maximum life span (60 to 70 years (Moyle 2002)) of green sturgeon.

At the time that the Daguerre Point Dam fish ladders were reconstructed in 1965, the fish passage facility and ladder design were developed following USFWS and CDFG provided criteria. If the ladders were to be reconstructed today, the Corps anticipates that the design would be considerably different, given the advances in fisheries biology, engineering, and technology that have occurred over the past 48 years, as well as changes in fisheries management objectives resulting from new species listings (e.g., green sturgeon) under the ESA.

In this BA, a distinction is made between effects on listed species attributable to designs of facilities that have been operational since 1965, and effects associated with the Corps authorized activities associated with the fish ladders. The Corps has the authority and discretion to lessen adverse effects associated with O&M of the fish ladders and sediment removal upstream of Daguerre Point Dam, removal of sediment and woody debris from the fish ladders themselves, and minor adjustments to the hydraulic performance of the ladders. Therefore, effects to listed species associated specifically with these activities are characterized as effects of the Proposed Action. All other effects associated with design of the ladders and the facilities are part of the Environmental Baseline.

OPERATIONS AND MAINTENANCE ACTIVITIES

The Corps past operational criteria required that the fish ladders be physically closed when water elevations reached 130 feet, or when flows were slightly less than 10,000 cfs (SWRCB 2003), and to keep them closed until the water receded to an elevation of 127 feet (CALFED and YCWA 2005). However, current operation of the fish ladder gates differs from past operations in that the Corps coordinates with NMFS and CDFW to keep the gates open at all flow levels.

In 2003, the Corps first installed a log boom at the north ladder exit to divert debris away from the ladder. In June 2010, CDFW installed flashboards in the lower bays of the south fish ladder in an effort to improve attraction flows to the south ladder (Grothe 2011). Since completing this work, CDFW reported that the number of fish moving through the south ladder increased compared to numbers recorded prior to installation of the flashboards.

On October 20, 2010, CDFW advised the Corps that staff from the Pacific States Marine Fisheries Commission (PSMFC) had documented as many as a dozen fall-run Chinook salmon that had jumped out of the south fish ladder over the previous 4 to 6 weeks. That same day, Corps staff placed plywood boards over the bay from which the fish reportedly jumped as a temporary measure to prevent any more fish from escaping the ladder. By email dated November 5, 2010, Duane Massa, a project manager for PSMFC, provided additional information to the Corps regarding the incident. According to Mr. Massa, PSMFC maintenance logs indicated that six fall-run Chinook salmon carcasses were observed outside the south fish ladder over a period of four weeks (September 27, 2010 – October 26, 2010) rather than one dozen as initially reported. No further incidences of fish escaping the ladder were reported during 2010 (D. Massa, PSMFC, pers. comm. 2010). More recently, in response to the Interim Remedy Order issued by the Court on July 25, 2011, during the summer of 2011, the Corps proceeded with installation of locking metal grates on 33 unscreened bays. Due to concerns expressed by both NMFS and CDFW, the Court then reconsidered the requirement to put grates over the bays on the lowermost section of the south fish ladder at Daguerre Point Dam (**Figure 5-2 and Figure 5-3**). Consequently, grates were not installed over the lower eight bays of the south fish ladder at Daguerre Point Dam.

The fish ladder upstream exit periodically becomes ineffective due to sediment buildup in the channel, which acts as a barrier that prevents upstream fish migration. As an example of the maintenance activities typically conducted, CDFW observed fall-run Chinook salmon migration problems resulting from a clogged channel at the north fish ladder upstream exit during fall of 1999. The Corps, in co-operation with CDFW, excavated the entire area just upstream from the ogee spillway, as well as two deeper channels running diagonally from each ladder upstream toward the middle of the river channel. The gravel bar that blocked access from the south ladder also was cleared to allow access to the river channel (Corps 2001). During 2009, the Corps dredged the upstream side of Daguerre Point Dam to provide egress from the fish ladders and continued fish passage opportunity.

Gravel buildup can itself block fish passage, as well as further reduce attraction flows in the fish ladders at Daguerre Point Dam. As discussed in the July 8, 2010 Order of the United States District Court, Eastern District of California, in Case No. Civ. S-06-2845 LKK/JFM, the Corps has implemented a plan to ensure that a minimum 30 foot wide by 3 foot deep channel remains open to facilitate fish passage and avoid blocking attraction flows.

Figure 5-2. North fish ladders at Daguerre Point Dam (Corps 2012c).

Figure 5-3. South fish ladders at Daguerre Point Dam (Corps 2012c).

In late August 2010, the Corps removed sediment that had accumulated on the north side of the channel upstream of Daguerre Point Dam (Grothe 2011), and the material that was removed was disposed of above the ordinary high water mark. Again during August 2011, the Corps removed sediment that had accumulated upstream of Daguerre Point Dam and placed that excavated material above the ordinary high water mark. The Corps also inspected the sediment depth upstream from Daguerre Point Dam and cleared sediment and gravel from the channels upstream of the dam and along the upstream face of the dam on August 7, 2012. Because the Yuba River was too deep at that time, the gravel was moved to the downstream gravel bar in late October 2012 (D. Grothe, Corps, pers. comm. 2013).

DAGUERRE POINT DAM FISH PASSAGE IMPROVEMENT STUDIES

In 1994, the Yuba River Technical Working Group and the USFWS identified fish passage issues at Daguerre Point Dam (DWR and Corps 2003). As a result, a preliminary evaluation of measures and alternative concepts to improve fish passage was conducted by the Corps and others.

Initiated by the State Legislature and the California Bay-Delta Program agencies in 1999, the Fish Passage Improvement Program (FPIP), an element of the ERP, is a partnership-building effort to improve and enhance fish passage in Central Valley rivers and streams (DWR 2005a). The program works with other local, State, and Federal agencies and stakeholders to plan and implement projects to remove barriers that impede migration and spawning of anadromous fish. FPIP does not provide for screening diversions.

In 1999, CALFED established the Upper Yuba River Studies Program, a stakeholder-driven collaborative process to discuss fish passage. Also in 1999, the AFRP funded a project to develop fish screen and diversion bypass feasibility alternatives at the Hallwood-Cordura Irrigation District Diversion.

In 1999, USFWS funded a Corps Preliminary Fish Passage Improvement Study of fish passage alternatives at Daguerre Point Dam (Corps 2001). Initiated in 2001, DWR and the Corps undertook the preparation of a joint Draft EIR/EIS to evaluate the Daguerre Point Dam Fish Passage Improvement Project on the Yuba River.

According to CALFED and YCWA (2005), the USFWS Fish Passage Improvement Study identified the following concerns with Daguerre Point Dam's fishways for upstream migration of adult fish:

- The fish ladder control gate entrance, acting as a submerged orifice, is more passable at low flows during summer and fall rather than at high flows during winter and spring
- The fish ladder exit sometimes becomes unusable due to clogging by woody and non-woody debris
- Fish may have difficulty finding the orifice during high flows
- The fish ladders are narrow and have low flow capacities

The passage study also identified the following concerns for emigration of juvenile anadromous fish:

- Emigration may be impeded during low flows
- Pools immediately upstream and downstream harbor piscivorous fish
- Fish may be injured or killed by passing over the dam
- Water diversion operations may trap fish

The Daguerre Point Dam Fish Passage Improvement Project aims to improve upstream and downstream passage for all lifestages of native anadromous fish, while keeping water interests whole and with no increase in downstream flood risks (DWR 2011). Historically, DWR has had a cost sharing agreement with the Corps on any fish passage improvement or studies regarding Daguerre Point Dam. Stakeholders and partner agencies were developing a restoration prioritization plan, and implementing other actions to improve habitat conditions in the lower Yuba, including separate actions implemented through the Lower Yuba River Accord.

Several documents related to the Daguerre Point Dam Fish Passage Improvement Project have been completed. These documents include: (1) a draft of the Daguerre Point Dam Fish Passage Improvement Project Alternative Concepts Evaluation, released in September 2003; (2) a stakeholder review draft of the Analysis of Potential Benefits to

Salmon and Steelhead from Improved Fish Passage at Daguerre Point Dam released in March 2003; and (3) a stakeholder review draft of the Daguerre Point Dam Fish Passage Improvement Project 2002 Water Resources Study for DWR and the Corps, released in June 2003 (DWR 2011).

In 2008, NMFS awarded a contract to evaluate options for fish passage in the Yuba River (DWR 2011). The main goal of that study was to identify and describe potential fish passage facilities for the reintroduction of spring-run Chinook salmon and steelhead in the upper Yuba River watershed. The study included fish passage option considerations at Daguerre Point Dam (NMFS 2010).

DIVERSIONS IN THE VICINITY OF DAGUERRE POINT DAM

As development intensified within the Yuba River Basin during the early 1950s, the lower Yuba River and Daguerre Point Dam took on a new purpose. The people of Yuba and Sutter counties recognized the demand for securing, utilizing, and distributing available water resources for the impending domestic and agricultural development. The function of Daguerre Point Dam subsequently evolved to provide additional benefits for water supply purposes (DWR and Corps 2003b). There are three water diversions associated with Daguerre Point Dam, which utilize the elevated head[1] created by the dam, or the influence of the dam in the prevention of additional river channel incision, to gravity-feed their canals. The three diversions are the Hallwood-Cordua diversion, the South Yuba/Brophy diversion, and the Browns Valley Irrigation District (BVID) diversion (**Figure 5-4**).

Diverters using these facilities divert water under their own water rights, purchase water from YCWA, or do both. YCWA has contractual agreements to deliver water to these irrigation districts, and the three diversions have a combined capacity of 1,085 cfs. As with the Yuba River Development Project, the Corps does not regulate water right diversions or control: (1) whether or not water is diverted from the lower Yuba River

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[1] The “elevated head” at Daguerre Point Dam is created by the hydraulic conditions associated with water being impounded behind (i.e., upstream) of the dam. The Corps has no control over the in-river flows, and has no discretionay control over the “head” for local water users in the vicinity of Daguerre Point Dam.

through the three agricultural diversions near Daguerre Point Dam (i.e., Hallwood-Cordua, South Yuba-Brophy, and BVID); (2)_the quantity and timing of those diversions; or (3) the ultimate use of the water once diverted (Corps 2012b). From the primary conveyances, the irrigation districts use smaller ditches to supply water to their customers according to the following seasonal considerations:

- ☐ Irrigation Season, April 1 through October 15
- ☐ Waterfowl/Straw Management Season, October 15 through January 31
- ☐ Maintenance Season, January 31 through April 1

The Corps is not responsible for continued operations and maintenance of these three facilities. The Proposed Action does not include operation or maintenance of the irrigation diversion facilities located at or in the vicinity of Daguerre Point Dam. Operation and maintenance responsibilities associated with each of the diversion facilities are, and will remain, the responsibility of each of the respective individual non-Federal irrigation districts.

HALLWOOD-CORDUA NORTH CANAL

Hallwood Irrigation Company and Cordua Irrigation District divert water from the Hallwood-Cordua Diversion (also referred to as the "North Canal") under pre-1914 and post-1914 appropriative water rights and contracts with YCWA. The license issued by the Secretary of War to the Hallwood Irrigation Company and the Cordua Irrigation District (formerly the Stall Ditch Company) in 1911 allow Hallwood and Cordua to continue their diversions of water from the Yuba River, which pre-dated the construction of Daguerre Point Dam.

Cordua Irrigation District is located in an area covering approximately 11,400 acres. Cordua Irrigation District's first surface water deliveries from the lower Yuba River began in the late 1890s, with receipt of water deliveries under the YCWA contract beginning in October 1971 (YCWA 2008). Rice is the primary crop, which is irrigated primarily by surface water diverted under a combination of water rights (totaling 60,000 acre-feet per year) and under a contract with YCWA (for 12,000 acre-feet per year), for an annual surface water supply of up to 72,000 acre-feet.

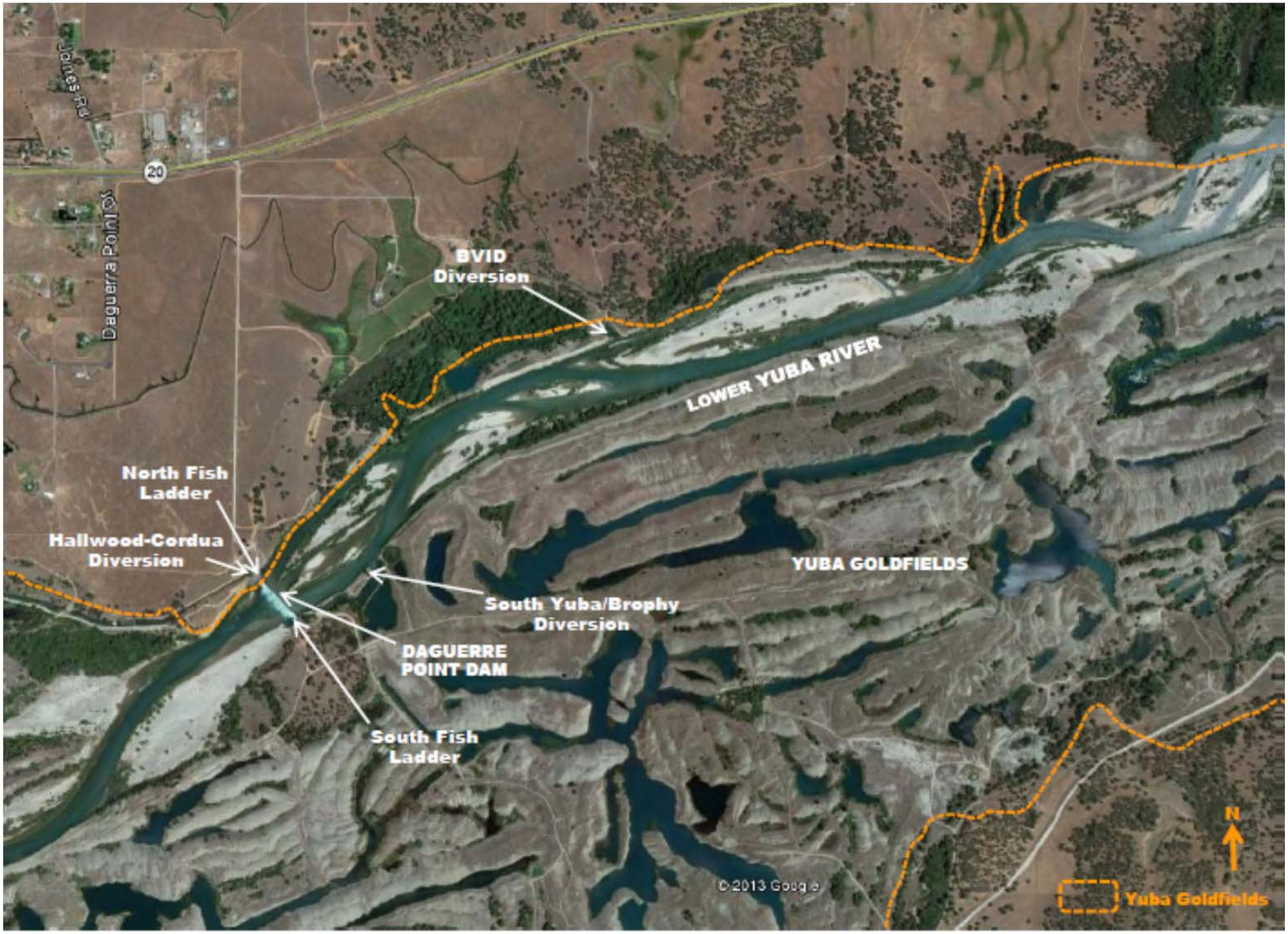

Figure 5-4. Non-Federal water diversion facilities in the vicinity of Daguerre Point Dam on the lower Yuba River.

The Hallwood-Cordua Diversion (**Figure 5-5**), a gravity flow diversion facility located on the north bank of the lower Yuba River at Daguerre Point Dam, has a diversion capacity of 625 cfs (SWRCB 2001). The diversion was originally screened in 1972, and later modified in 1977 (CALFED and YCWA 2005). The Hallwood-Cordua fish screen located in the North Canal utilized a V-shaped perforated plate screen constructed, operated and maintained by CDFW. A bypass system diverted fish captured by the screen into a collection tank, and collected fish were returned to the river either through a pipeline or by truck (SWRCB 2001). CDFW initially operated the fish screen in the North Canal, located approximately one-quarter mile down the canal from the river, for intermittent periods during the Chinook salmon juvenile emigration period of April through June (SWRI et al. 2000).

The original design and operation of the Hallwood-Cordua fish screen resulted in the losses of significant numbers of fish (SWRCB 2001). During some years, the fish screen was not operated at all, which resulted in occasions when reportedly up to a million juvenile salmonids were entrained in the diversion (CALFED and YCWA 2005). When operational, the CDFW screen was reported to be effective in preventing the entrainment and impingement of juvenile salmonids, but salmonid losses reportedly did occur as a result of predation in the intake channel between Daguerre Point Dam and the CDFW fish screen. In addition, predation resulted from the removal of the screen by CDFW during the emigration period of juvenile steelhead (YCWA et al. 2000).

Figure 5-5. Hallwood-Cordua Diversion. Image on the left shows the control gate headworks on the north abutment of Daguerre Point Dam. Image on the right shows the current v-shaped screen (Source: YCWA 2013b).

According to SWRCB (2001), the number of Chinook salmon entrained at a diversion facility is related to the percent of river flow that is diverted. SWRCB (2001) reported that an analysis of the daily North Canal fish screen trap records for 1972 to 1991 by the USFWS showed that the number of juvenile salmonids entering the trap was directly related to the percent of river flow diverted. Fish losses also occurred at the fish trapping facility that returned fish from the diversion canal to the river. The long distance between the diversion channel intake and the fish screen, low bypass flows, and excessive handling of the fish stopped by the screen all contributed to the loss of salmonids at the Hallwood-Cordua fish screen (SWRCB 2001).

In 1999, CDFW began an outmigration study of juvenile salmonids using a rotary screw trap located in the lower Yuba River near Hallwood Boulevard. CDFW reported that significant numbers of juvenile Chinook salmon, including spring-run Chinook salmon, were captured in the traps, and recently emerged steelhead also were present throughout the summer months (SWRCB 2001). Steelhead as small as 24 mm were observed in July, with 27 and 37 mm fish observed during August and September. Based on the size and numbers of juvenile steelhead and Chinook salmon present throughout the year, it was determined that large numbers of fish were vulnerable to entrainment at the Hallwood-Cordua Diversion. In addition, CDFW stated that the 5/32 inch mesh size of the Hallwood-Cordua fish screen was much larger than the 3/32 inch mesh recommended by CDFW and NMFS (SWRCB 2001). The ineffectiveness of the screen in salvaging fry-size fish was evident when comparing catches at the screen with catches in the rotary screw trap during the same period. During periods when catches of fry-size fish were still high in the rotary screw trap, the fish screen was capturing no fish in that size range. In addition, the approach velocities at approximately 25% of the screen area exceeded approach velocities that were, and still are, recommended by NMFS and CDFW. CDFW recommended installation of a fish screen at the Hallwood-Cordua diversion that meets the criteria established by NMFS and CDFW for protection of juvenile Chinook salmon and steelhead (SWRCB 2001).

Consequently, the Hallwood-Cordua fish screen was replaced with a screen that more closely conforms to CDFW and NMFS criteria in 2001. This screen is at the same location, but has appropriate openings and sweeping and approach velocities to facilitate direct return of screened fish back to the river below Daguerre Point Dam. Addionally, the fish screen is operated for the entire diversion season (NMFS 2002). Although this fish screen does not meet all of CDFW and NMFS criteria, the rehabilitation efforts included the installation of the proper-sized screening material and have allowed continuous operation of the screen throughout the irrigation season along with the direct return of screened fish back to the river below the dam (NMFS 2007). The Corps was not involved in the 2001 Hallwood-Cordua fish screen replacement, nor does the Corps operate or maintain the fish screen facility or have discretionary control over it. Therefore, the effects of operation and maintenance of the fish screen facility at the Hallwood-Cordua diversion location at Daguerre Point Dam is not part of the Proposed Action and is therefore included as part of the Environmental Baseline.

SOUTH YUBA/BROPHY DIVERSION CANAL AND FACILITIES

Approximately 1,000 feet upstream of Daguerre Point Dam on the south side of the river, the South Yuba/Brophy Diversion Canal and Facilities divert water through an excavated channel from the Yuba River's south bank. The South Yuba/Brophy diversion facility includes a 450-foot long porous rock weir fitted with a fine-mesh barrier (geotextile cloth) within the weir, intended to protect juvenile fish from becoming entrained into the canal (Corps 2007).

The South Yuba/Brophy Diversion Canal and Facilities was constructed in the mid-1980s. Prior to construction of the diversion headworks, the rate at which water could be diverted was limited by flows in the lower Yuba River and the percolation rate through the dredge spoil gravel mounds (USFWS 1990).

The South Yuba Water District encompasses about 9,800 acres of land, with the primary crops consisting of rice and pasture (YCWA 2008). The South Yuba Water District began receiving surface water jointly with Brophy Water District in 1983.

Brophy Water District serves approximately 17,200 acres of land, with rice being the dominant irrigated crop, distantly followed by pasture and field crops (YCWA 2008).

Since 1985, all water from the lower Yuba River used by the Brophy Water District has been delivered through the South Canal under contract with YCWA.

The South Yuba/Brophy diversion headworks are located above Daguerre Point Dam on the Yuba River, adjacent to the Yuba Goldfields, roughly 9 miles northeast of Marysville, California (Demko and Cramer 2000a). The diversion headworks consist of an intake channel and bypass channel (collectively called the diversion channel), a porous rock gabion, a diversion pond behind the rock gabion and an irrigation canal existing at the diversion pond (**Figure 5-6**). The South Yuba/Brophy Diversion Canal and Facilities (or the South Canal) is a gravity flow diversion with a current diversion capacity of 380 cfs (SWRCB 2001), and it is authorized to divert water at a rate of up to 600 cfs (DWR and Corps 2003).

Water flows from the mainstem of the lower Yuba River into the diversion channel (side channel of the Yuba River) where it percolates through the porous rock gabion and surrounding gravel deposits into the diversion pond (Corps 2001).

Figure 5-6. Diversion headworks area for the South Yuba/Brophy Diversion Canal and Facilities.

The pond has a surface area of about 3 acres. The rock gabion consists of cobble size rock, and is roughly 400 feet long, ranging in width from roughly 30 feet at the base to 10 feet at the top. A fine-meshed, geotextile fabric was placed a few feet inside the river-side of the rock gabion during construction to prevent juvenile salmonids from passing through the rock gabion (Corps 2001).

At the far south end of the pond into which water percolates (approximately 300 feet away from the rock gabion) three 5-feet diameter pipes withdraw water from the pond to the main irrigation canal (Demko and Cramer 2000a).

Gates at the entrance of each pipe allow the flow of water to be controlled manually (Corps 2001). The pipes extend underground approximately 450 feet from the southwest corner of the diversion pond to the head of the main irrigation canal. Water can also enter the main irrigation canal by natural seepage. At times when water demand in the irrigation districts is low, the demand can be met entirely from seepage (around 100 cfs) into the canal (Demko and Cramer 2000a). The diversion channel and the head control structure require regular maintenance to remove accumulated gravel and debris deposited during high flows (USFWS 1990).

Some of the water that enters the diversion channel remains in the channel as it passes the rock gabion and flows back to the lower Yuba River through a lower portion of the diversion channel referred to as the bypass channel. The bypass channel extends roughly 450 feet from the downstream end of the rock gabion to the box culvert, which is located about 270 feet upstream of Daguerre Point Dam.

The diversion system and the percolation water outfall system are directly connected at an eight foot culvert and check structure located in a dredge pond near the river diversion facility (USFWS 1990). During the irrigation season (April-November), headboards are placed in the check structure to increase pond storage and capture percolation flows for conveyance. The headboards are pulled during the non-irrigation season to reduce pond storage and allow percolation water to return to the river via the culvert and outfall. The Corps has no involvement in these activities. As of 1990, USFWS (1990) reported that a seasonal dam located near the culvert protects the culvert structure during high winter flow conditions. When percolation flows exceed the capacity of the culvert, the seasonal dam was designed to blow-out and allow the high flows to bypass the culvert and return to the lower Yuba River via the outfall channel. This seasonal dam and blow-out feature also provided for winter-time flood protection of the various structures and activities occurring in the Goldfields Area (USFWS 1990).

Although the diversion structure addressed CDFW fish screening requirements at the time of construction in 1985, fish screening requirements have changed over time and the diversion structure does not meet current NMFS and CDFW screening criteria. Screening criteria issues associated with the diversion structure include potential non-compliance with: (1) screen space size (i.e., 3/32 inch mesh size); (2) screen porosity; (3) uniformity of approach velocity; (4) sweeping flow; and (5) cleaning frequency. Additional issues associated with the diversion structure include predation in the channel that leads to the diversion and at the face of the rock weir, and overtopping of the weir and subsequent entrainment of juvenile salmonids behind the weir.

The interstitial spaces between the rocks of the levee are larger than the maximum 3/32 inches required by NMFS fish screening criteria (CALFED and YCWA 2005). The fine mesh barrier imbedded within the rock gabion was designed to prevent fry or juvenile salmonids from passing through the gabion. However, it has been suggested that flows, at times, reportedly are not sufficient to sweep fry along the face of the rock gabion and, as a result, fry may become impinged or entrained into the diversion (CALFED and YCWA 2005).

NMFS (2007) also discussed the effects on salmonids of the South Yuba/Brophy Diversion Canal and Facilities, and stated that the fine-meshed, geotextile fabric buried within the rock gabion weir at this diversion "*may meet the opening size criteria (if it is still intact) but there is obviously no sweeping flow along the face of this fabric inside of the weir and therefore any fry which encounter this mesh, instead of being swept along the face of the fabric, would be more likely to become impinged on the fabric and perish*." NMFS (2007) also noted that several studies have suggested that the structure does not exclude juvenile salmonids from being entrained into this diversion.

By agreement with CDFW, at least 10% of the water diverted into the diversion channel is required to bypass the rock gabion and flow back to the river, to allow migrant fish entering the diversion channel to return to the river. However, it has been reported that the 10% bypass flow has not always been met historically (NMFS 2002). In September 2010, YCWA replaced the two 48-inch culverts located at the downstream terminus of the bypass channel with a concrete box culvert and then restored the site. YCWA undertook the project to improve water flow at various river stages, reduce debris loading, and reduce maintenance. Installation of the concrete box culvert also was necessary to efficiently accommodate new flow metering equipment to measure the flow returning to the Yuba River from the diversion channel. YCWA installed a downlooking acoustic Doppler flow meter was installed in the access port in the box culvert, and the flow meter was connected to the data monitoring and communication equipment located in the concrete building at the south abutment of Daguerre Point Dam. These improvements were made to ensure that the 10% return flows occur in the future pursuant to the stipulated settlement and order in the SYRCL v. NMFS case. High flows during the winter and spring of 2010/2011 resulted in the deposition of sediment and debris requiring clearance and maintenance of the box culvert and immediate vicinity, prior to the installation of the flow monitoring equipment.

In addition, predation of juvenile anadromous salmonids in the pool located within the diversion channel in front of the porous rock gabion has been raised as an issue by CDFW and NMFS. Construction of the porous rock gabion has resulted in a relatively wide, deep pool directly in front of the rock gabion characterized by reduced water velocities, which potentially could delay the continued downstream migration of juvenile salmonids (NMFS 2002). The pool also reportedly provides holding and ambush habitat for predatory fish such as Sacramento pikeminnow (NMFS 2002).

The issues of predation, impingement, and entrainment at the South Yuba/Brophy Diversion Canal and Facilities have been the subject of numerous evaluations over the past many years. A brief summary of the various studies and resultant findings is presented in chronological order hereas follows.

Pursuant to the 1984 Agreements between the South Yuba Water District and the Brophy Water District and CDFW, South Yuba/Brophy built Alternative No. 4, which stipulated additional criteria including "*c. A return diversion will provide for returning at least 10%*

of the quantity diverted back into the river." In 1988, CDFG (1988a) conducted a mark-recapture study to: (1) evaluate the effectiveness of the rock gabion; and (2) determine whether bypass flows were at least 10% of the diverted quantity.

The mark-recapture survey was conducted using a fyke net located in the upstream portion of the diversion channel, and two additional fyke nets located near the downstream terminous of the bypass channel. During the first treatment period, which began on May 11, 1988, a total of 4,746 salmon were captured in the upstream fyke net, whereas a total of 2,684 salmon were captured during the second treatment period (CDFG 1988a). The recapture rate at the downstream fyke nets after 72 hours approached zero. According to CDFG (1988a), the results of this mark-recapture study showed that less than 95% of the marked fish made it through the bypass canal, potentially because of the large predator (Sacramento pikeminnow) populations that existed in the diversion channel. CDFG (1988a) suggested that losses of juvenile salmonids at the South Yuba/Brophy diversion were between 40 and 60%. However, Cramer (1992) used the observed capture efficiency estimates to expand the number of marked fish recovered by CDFG (1988a) and found that estimated survival from the mouth of the diversion channel all of the way to the bypass exit was substantially higher than the estimates given by CDFG (1988a) and likely exceeded the 95% survival criterion stipulated by CDFW. During this study, Sacramento pikeminnow were observed feeding on juvenile salmonids as they attempted to migrate out of the diversion channel (CDFG 1988a). Flow measurements were taken by a SWRCB engineer, with assistance from CDFW and USFWS, at the following locations: (1) the inflow to South Yuba/Brophy Diversion Canal and Facilities (downstream of the intake fyke); and (2) the return flow to the lower Yuba River in the bypass canal (just downstream of the upper bypass fyke). Bypass flows exceeded 10% of the diverted flows of water during both treatment periods (CDFG 1988a).

Juvenile salmonids have been collected behind the rock gabion. These fish either passed through the mesh barrier or were washed over the top of the rock gabion during high flows (NMFS 2002). Juvenile sampling surveys have had mixed results in capturing salmon behind the rock gabion fish screen (USFWS 1990). An electrofishing survey of the diversion pond was conducted by CDFW in March 1987. Although juvenile salmonids were found in the pond behind the rock gabion prior to this study, salmonids were not captured when the pond was electrofished (CDFG 1988a). However, Preston (1987 as cited in CDFG 1988a) stated that three juvenile Chinook salmon were captured behind the gabion prior to diversions from the river. In that year, flows in the lower Yuba River reportedly did not exceed 2,000 cfs that could over-top the present height of the gabion, and allow for fish to pass over the gabion (USFWS 1990).

In April 1989, USFWS seined 31 juvenile Chinook salmon ranging in size from 46 to 70 mm fork length in the diversion pond area behind the rock gabion (USFWS 1990; SWRCB 2001). These fish reportedly had become trapped in the pond prior to any diversion. Although this was the only date USFWS seined the diversion pond, USFWS also observed several hundred juvenile salmonids feeding in the same area on May 5, 1989. After diversions began about May 10, 1989, USFWS (1990) did not observe any Chinook salmon in the diversion pond.

The entire back side of the rock gabion fish screen was observed during a scuba dive survey on May 11, 1989 (USFWS 1990). Water depth at the base of the gabion was approximately 20 feet with water visibility about 6 feet. The rock material was consistent in size and placement along the entire screen face. USFWS (1990) did not observe any unusually large sized openings that would allow for unimpeded flow through the gabion. An unknown amount of water was being diverted from the river through the gabion, and this diversion did not create any noticeable head differential between the pool in front of the gabion and the pool behind. The gabion appeared to be fairly fish tight (USFWS 1990). USFWS (1990) concluded that the salmon collected in 1989 behind the gabion most likely were washed into the pond during early March when river flows exceeded 20,000 cfs and over-topped the gabion structure. Although USFWS (1990) did not directly observe the flooding of the gabion, based on the accumulation of woody debris and dead leaves in small shrubs along the top of the gabion, it appeared that about 1 to 2 feet of water flowed over the north end of the structure. Flow measurements at Marysville from 1969 to 1989 indicate that flows that overtop the levee (exceeding 20,000 cfs) have occurred numerous times in eight of those 20 years (SWRCB 2001).

To determine whether juvenile fish were passing through the rock gabion, Demko and Cramer (1992 as cited in Corps 2001) installed a fyke net on the outfall of the diversion pipe that enters the South Yuba/ Brophy irrigation canal. They sampled continuously whenever water was diverted, from the day water diversions began on May 7 through July 22, and captured 17 juvenile Chinook and 2 steelhead fry during the sampling period. However, all Chinook salmon caught in the irrigation canal were substantially larger than those migrating down the river at the same time, and Demko and Cramer (1993) concluded that the large juvenile Chinook could not have passed through the interstitial spaces in the rock gabion at the time they were captured. They deduced, as did the USFWS in the 1988 study (USFWS 1990), that fish were not passing through the porous dyke, but rather that a small number of fish passed into the diversion pond during winter during times of high flows that over-topped the rock gabion (Corps 2001). However, CDFW suggested that the fyke net, constructed of 1/8 inch mesh, used in the study may not have been efficient for small salmonids and SWRCB (2001) suggested that the number of small juvenile steelhead entering the irrigation canal, therefore, may have been significantly underestimated. Regardless of the manner in which fish entered the diversion pond, SWRCB (2001) suggested that fish, including listed species, continued to be lost from the lower Yuba River fishery at the rock gabion.

In August 1993, Demko and Cramer (1993) observed nineteen 20 cm and larger pikeminnow in the diversion channel that were large enough to be predators of juvenile Chinook salmon. However, Cramer (2000 as cited in Corps 2001) reviewed all studies performed at the South Yuba/Brophy diversion, and found that none of the research by USFWS, CDFW or fisheries consultants had indicated that juvenile Chinook became disoriented upon entering the diversion channel, or that abnormally high predation on juvenile Chinook salmon occurred in the diversion channel.

SWRCB (2001) stated that during the 2000 SWRCB hearing, USFWS presented data showing that bypass flows in the return channel were at times less than 10% of the water diverted, and recommended that higher bypass flows be maintained. SWRCB (2001) also stated that because there was no way to prevent water from entering the diversion channel when water was not being diverted into the South Canal for irrigation, losses at the diversion facilities due to predation and other factors occur even when no water is being diverted for beneficial use (SWRCB 2001). USFWS presented evidence to the SWRCB that deposition and accumulation of gravel and debris in the diversion channel as a result of floods or other events can adversely affect flow and migration of juvenile salmon through the diversion facility (SWRCB 2001).

On July 8, 2004, representatives of CDFW and NMFS made a series of water velocity measurements along the face of the permeable rock gabion that separates the lower Yuba River from the headgates for the South Yuba/Brophy diversion. The purpose of the flow measurements was to characterize the flow conditions along the upstream face of the rock gabion. The flow along the upstream face of the rock gabion appeared to be irregular and complex in all three components of the velocity measurements (NAFWB 2004). According to NAFWB (2004), this was probably due to roughness of the gravel/cobble surface, irregularities in the rock gabion profile, differences in the permeability along the length of the rock gabion, and variations in the plugging of the upstream face of the rock gabion. Approach velocities varied from -0.054 feet per second (fps) to 0.686 fps with mean velocity of 0.052 fps. One approach velocity measurement exceeded 0.33 fps. Sweeping velocities varied from -0.167 fps to 1.034 fps with mean velocity of 0.260 fps. Two sweeping velocity measurements exceeded 0.67 fps. The head loss across the rock gabion was approximately 0.9 feet on the day of the measurements (NAFWB 2004).

On August 30, 2011, PSFMC personnel and YCWA representatives conducted a reconnaissance survey to investigate the presence/absence of predatory fish in the South Yuba/Brophy diversion channel. A jet boat was used to navigate through the diversion channel, initially entering from the upstream point of the diversion channel and drifting downstream to the box culvert at the lower end of the diversion channel (Figure 5-6). During the first pass, six fish, preliminarily identified as pikeminnow, ranging from approximately 16 to 20 inches in length were observed at about the mid-way point of the diversion channel. Three additional pikeminnow also approximately 16 to 20 inches in length were observed during a second pass, which was taken in an upstream direction from the box culvert crossing to the upstream point of the diversion channel. The jet boat then drifted down to the lower portion of the diversion channel and then slowly powered upstream. At approximately the mid-point of the diversion channel, pikeminnow were observed darting ahead of the boat and continued to do so until 13 pikeminnow were observed darting ahead of the boat into a relatively deep, fast flowing section at the upstream end of the diversion channel.

During May and June of 2012, field studies were conducted to investigate potential sources of juvenile Chinook salmon and steelhead mortality associated with the South Yuba/Brophy Diversion Canal and Facilities, including: (1) predation due to a concentration of predators in the diversion canal; and (2) entrainment or impingement caused by fish becoming trapped in the permeable rock gabion.

The data suggest that the diversion channel does not support a unique concentration of predators (Bergman et al. 2013). Adult pikeminnow densities were not significantly different between the diversion channel and the mainstem lower Yuba River adjacent to the diversion. Similarly, previous snorkeling surveys conducted in the diversion channel found relatively low abundances of adult Sacramento pikeminnow, with only 12 fish observed in 1988 (CDFG 1988a) and 19 in 1993 (Demko and Cramer 1993).

According to Bergman et al. (2013), approach velocities (perpendicular) and sweeping velocities (parallel) varied along the upstream side of the permeable rock gabion, and ranged from -0.15 to 0.17 meters per second (m/s) and -0.15 to 0.31 m/s, respectively (**Figure 5-7**). Although variable along the face of the rock gabion, approach velocities were relatively low, with only 15 of 147 locations having approach velocities above 0.06 m/s, and 0.17 m/s being the highest velocity observed. Sweeping velocities were lower at the up-river and down-river ends of the rock gabion (-0.14 to 0 m/s) and consistently higher in the middle of the gabion. The observed variability is likely due to the roughness of the gravel/cobble substrate, irregularities in the gabion profile, and differences in the permeability along the rock gabion, as was previously concluded by CDFG (2004, as cited in Bergman et al. 2013).

Bergman et al. (2013) concluded that present operations at the diversion facility provide adequate bypass flows to create positive sweeping velocities along the rock gabion, and measured approach velocities satisfied NMFS approach velocity standards except at a

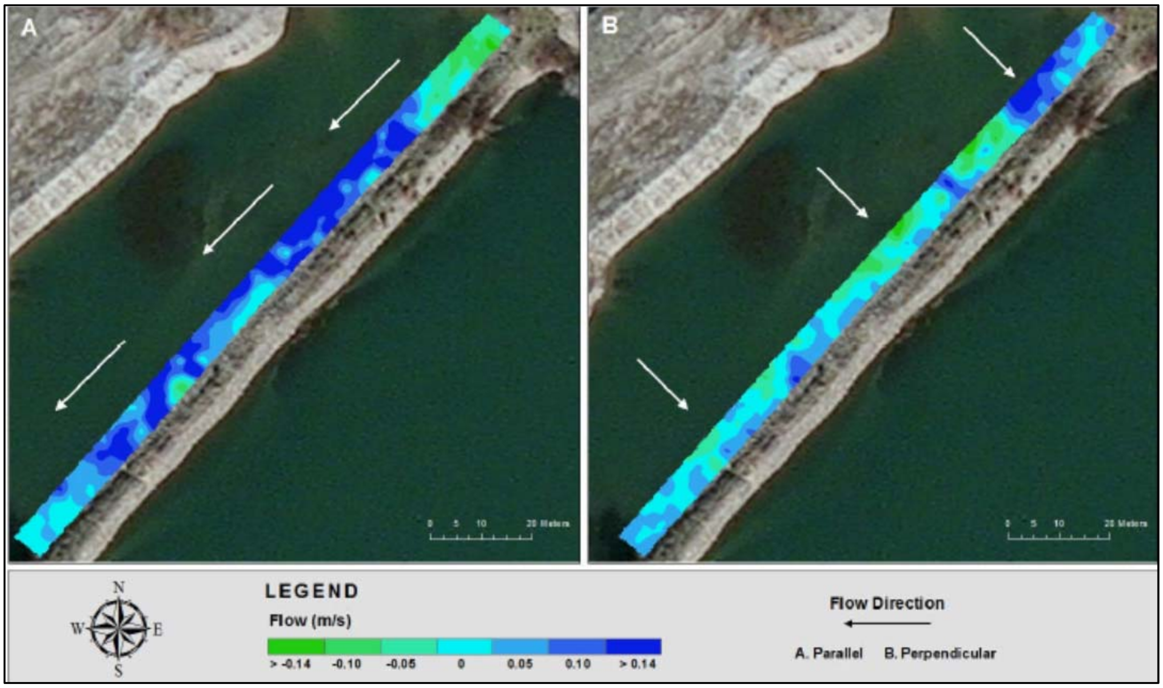

Figure 5-7. Gradient of sweeping velocities (parallel to the rock gabion) and approach velocities (perpendicular to the rock gabion) measured along the permeable face of the gabion on June 28, 2012 (Bergman et al. 2013).

bend at the upstream end of the rock gabion, where an eddy draws water up-river (Bergman et al. 2013). The end of the gabion where an eddy draws water up-river was identified because this anomalous area of higher approach velocities did not meet the NMFS (2011d) criteria of providing "nearly uniform" flow distribution along the face of a screen and, thus, may increase susceptibility of juvenile salmonids to impingement or entrainment. To improve these conditions, Bergman et al. (2013) state that re-grading the upstream entry into the diversion channel by "smoothing out" the pronounced bend could provide more uniform flow distribution along the face of the rock gabion.

Underwater video showed no evidence for impingement or entrainment risk to juvenile salmonids along the permeable rock gabion, and little risk even to larval fish much smaller than the juvenile samonids. The interstitial spaces along the rock gabion and the back side of cobbles were used as temporary cover by juvenile salmonids. Bergman et al. (2013) also observed that juvenile salmonids moved freely along the river bottom between cobbles, without indication of being drawn into the interstices within the rock gabion.

Daily bypass flows measured during 2012 were consistently above 10% of the diverted flow, and bypass flows ranged from 40 to 80 cfs (Bergman et al. 2013). According to Bergman et al. (2013), present operations provide adequate bypass flows to create positive sweeping velocities along the rock gabion.

Wheatland Project

The Wheatland Water District (WWD) is located in Yuba County in the southeastern portion of the South Yuba Basin, with much of the district located between Best Slough and Dry Creek, east of Highway 65 (YCWA 2008). Wheatland's service area contains about 10,400 acres, which are dominated by orchards, pasture, and rice. Historically, agricultural water demands were met with groundwater. The intense groundwater use in this area resulted in declining groundwater levels and deteriorating groundwater quality, forcing the abandonment of several wells. The project was jointly financed by YCWA, WWD and a grant from DWR. Completed in 2010, a canal was built to enable YCWA to provide water from the South Canal to WWD. Providing surface water in-lieu of groundwater pumping is intended to improve local groundwater conditions within the district and the surrounding areas, including the City of Wheatland, which is currently entirely dependent on groundwater (YCWA 2008).

The Yuba Wheatland In-Lieu Groundwater Recharge and Storage Project (Wheatland Project) supplies surface water from the YCWA South Canal to agricultural lands within the WWD and the Brophy Water District in southern Yuba County (YCWA 2012a). This surface water supply is intended to improve the water quality and water supply reliability to farmers who mainly rely on groundwater to grow crops such as fruit, nuts, rice and pasture for cattle. The project also is intended to recharge depleted groundwater aquifers and provide opportunities for conjunctive use of surface and groundwater supplies to enhance the reliability of YCWA's water system (YCWA 2012a).

YCWA diverts water from the lower Yuba River through the South Yuba/Brophy diversion structure located near Daguerre Point Dam and conveyed via the South Canal to the WWD's service area in southern Yuba County. Many of the ongoing effects associated with the existence of the South Yuba/Brophy Diversion Canal and Facilities may appropriately be considered stressors under the Environmental Baseline. Updated demand projections indicate that annual water deliveries to the Wheatland Project in the future are projected to increase up to about 35,000 to 36,000 acre-feet, depending on water year type. Projected future Wheatland Project demands are represented in modeling simulations for future Cumulative Conditions (for additional detail, see Chapter 7 and **Appendix F**).

Through a separate environmental process, YCWA is developing a fisheries improvement project at the South Yuba/Brophy Diversion Canal and Facilities that is investigating and addressing potential NMFS and CDFG fisheries compliance issues. Potential construction-related effects to listed species and their critical habitats in the lower Yuba River associated with YCWA's proposed fisheries improvement project at the South Yuba/Brophy Diversion Canal and Facilities will be evaluated and addressed through a separate ESA consultation process. The Corps is not responsible for the operations or maintenance of the diversion facility or any appurtenant facilities, and the Corps will not be responsible for these activities in the future.

BROWNS VALLEY IRRIGATION DISTRICT DIVERSION

Formed in 1888, BVID is an agricultural water purveyor that delivers water to over 1,300 agricultural water users encompassing about 55,000 acres of land along the Sierra Nevada foothills and the eastern edge of the Sacramento Valley floor (YCWA 2008). In addition to other water sources, BVID has a contract with YCWA authorizing diversions of 9,500 acre-feet per year from the lower Yuba River at BVID's Pumpline Diversion Facility (Pumpline Facility) to supplement BVID's water rights diversions. BVID has received deliveries from YCWA since October 1971 (YCWA 2008). BVID may divert up to 25,687 acre-feet annually.

In 1964, BVID built the Pumpline Facility (**Figure 5-8**) on the north bank of the lower Yuba River about 0.75 mile upstream (i.e., 4,200 feet) of Daguerre Point Dam (SWRI 2003). The Pumpline Facility has a diversion capacity of 80.2 cfs (CALFED and YCWA 2005). In 1990, BVID ceased diversions from the Yuba River at locations other than the Pumpline Facility. For many years, the (Pumpline Facility) was unscreened until a new fish screen was completed in 1999.

Figure 5-8. BVID diversion facility, including the fish screen and diversion forebay (Source: YCWA 2013b).

Inflow to the canal depends on sufficient head at the point of diversion. The presence of Daguerre Point Dam serves to prevent additional down-cutting, or incision, of the Yuba River and therefore contributes to the maintenance of sufficient head at the BVID point of diversion. Diverted water enters an excavated side channel, passes through the fish screen described in the following paragraph and is then pumped up into the canal supplying the BVID service area. The Pumpline Facility diversion uses pumps located on the north bank of the river to divert water through an excavated side channel and up into the canal at rates estimated up to 100 cfs. Water bypassing the fish screen continues through the side channel and reenters the lower Yuba River upstream of Daguerre Point Dam.

In 1999, a new state-of-the-art fish screen was installed at the Pumpline Facility that meets NMFS and CDFW screening criteria (SWRCB 2001; NMFS 2002; CALFED and YCWA 2005). Funding for design and construction of the screen was obtained from DWR, the Reclamation’s CVPIA Anadromous Fish Screen Program, the California Urban Water Agencies Category III Account, PG&E, and YCWA. BVID contributed manpower and equipment to the construction and assumed the obligation to operate and maintain the fish screen (SWRCB 2001). The SWRCB (2001) determined that the new fish screen at the Browns Valley Pumpline Diversion Facility provided adequate protection for juvenile salmonids, and that BVID should continue to operate and maintain the new fish screen in compliance with NMFS and CDFW criteria.

The BVID diversion is not licensed by the Corps, and it has no direct physical link to Corps property. Although there is no apparent nexus with the Corps, BVID's Browns Valley Pumpline Diversion Facility was either included in the project description or discussed under effects of the Proposed Action in the 2000 Corps BA, 2002 NMFS BO, 2007 Corps BA, and 2007 NFMS BO. However, because the BVID diversion is not licensed by the Corps and it has no direct physical link to Corps property, there are no permits, licenses, or easements associated with the Corps' operation and maintenance of Daguerre Point Dam. Therefore, the Browns Valley Pumpline Diversion Facility and associated effects of diversion on the listed species and their habitat ithe lower Yuba River are included in the Environmental Baseline, and not in the Proposed Action.

5.3 Physical Habitat

During the period of hydraulic gold mining in the 1800s, vast quantities of sand, gravel, and cobble entered the Yuba River (Gilbert 1917 as cited in Yoshiyama et al. 2001) and deposited throughout the system. This human impact completely transformed the river. Daguerre Point Dam was constructed at the downstream end of an enormous gravel deposit, and about 16 miles of "gravel berms" were erected to channelize the river by piling gravel on both the north and south banks, as well as down the center of the river in some places to create two channels. These activities were two of the major features of the "1898 Project", which was completed in 1935 (Hagwood 1981). By that time, three gravel berms existed, having a total length of 85,100 feet which provided two 500-foot-wide channels. In 1944, the California Debris Commission issued a permit to the Yuba Consolidated Gold Fields to dredge a 600-foot-wide channel and build gravel berms to take the place of the pair of 500-foot-wide channels completed in 1935 (Hagwood 1981). The effect of the gravel berms was to keep the river from spreading in its floodplain and to turn this stretch of the lower Yuba River into a channel that conveys water downstream to serve agricultural and municipal users (Gustaitis 2009). Downstream of Daguerre Point Dam, the Yuba River has resumed a meandering course through the fluvial tailings.

Down-cutting of the streambed downstream of Daguerre Point Dam has exposed the bedrock of Daguerre Point (Hunerlach et al. 2004).

The Corps has not issued any permits, licenses, or easements to other parties, and does not conduct inspection or maintenance activities associated with the gravel berms (R. Olsen, Corps, pers. comm. 2011). Consequently, the Corps is not responsible for operations and maintenance of the gravel berms along the lower Yuba River. Because the Corps does not have the ability to lessen any effects on listed species habitat availability associated with dynamic fluvial/geomorphologic processes in the floodplain of the lower Yuba River located between the gravel berms, and because the Corps is not proposing any actions pertaining to the gravel berms, any such effects are appropriately considered part of the Environmental Baseline and not the Proposed Action.

5.3.1 Fluvial Geomorphology

Fluvial geomorphologic processes in the lower Yuba River downstream of Englebright Dam continue to represent adjustments to the tremendous influx of hydraulic mining debris, and the construction of Englebright Dam. Since the construction of Englebright Dam, the lower Yuba River continues to incise and landform adjustments continue to occur - as illustrated by Pasternack (2008), who estimated that about 605,000 yds^3 of sediment (primarily gravel and cobble) were exported out of Timbuctoo Bend from 1999 to 2006. The lower Yuba River is adjusting toward its historical geomorphic condition, by going back to the pre-existing state prior to hydraulic gold mining (Pasternack 2010).

The lower Yuba River has been subjected to additional in-channel human activities such as: (1) the formation of the approximately 10,000-acre Yuba Goldfields in the ancestral migration belt; (2) the relocation of the river to the Yuba Goldfield’s northern edge and its isolation from most of the Goldfields by large “gravel berms” of piled-up dredger spoils; (3) mechanized gold mining facilitated by bulldozers beginning in about 1960 in the vicinity of the confluence with Deer Creek, changing the lower Yuba River geomorphology (Pasternack et al. 2010); (4) bulldozer debris constricting the channel significantly and inducing abrupt hydraulic transitioning; and (5) mining operations combined with the 1997 flood which caused angular hillside rocks and "shot rock" debris to be deposited on top of the hydraulic-mining alluvium in the canyon (Pasternack 2010).

All of these activities have influenced physical habitat conditions in the lower Yuba River downstream of Englebright Dam. Physical conditions related to fisheries habitat in the lower Yuba River have been studied over many years. With respect to the spawning lifestage, Fulton (2008) found spawning habitat conditions to be very poor to nonexistent in the Englebright Dam Reach. Spring-run Chinook salmon individuals immigrating into the Yuba River each year attempt to spawn in the Englebright Dam Reach, which historically was characterized by a paucity of suitable spawning gravels. However, gravel augmentation funded by the Corps in the Englebright Dam Reach over the past several years has spurred spawning activity and Chinook salmon redd construction in this reach (see Chapter 2 for additional discussion). The net result is an increase in the spatial distribution of spawning habitat availability in the river, particularly for early spawning (presumably spring-run) Chinook salmon (RMT 2013). Farther downstream, spawning habitat does not appear to be limited by an inadequate supply of gravel in the lower Yuba River due to ample storage of mining sediments in the banks, bars, and dredger-spoil gravel berms (RMT 2013).

According to NMFS (2009), river channelization and confinement has led to a decrease in riverine habitat complexity and a decrease in the quantity and quality of juvenile rearing habitat. Also according to NMFS (2009), attenuated peak flows and controlled flow regimes have altered the lower Yuba River's geomorphology and have affected the natural meandering of the river downstream of Englebright Dam.

As reported by RMT (2013), the Yuba River downstream of Englebright Dam has complex river morphological characteristics. Evaluation of the morphological units in the Yuba River as part of the spatial structure analyses indicates that, in general, the sequence and organization of morphological units is non-random, indicating that the channel has been self-sustaining of sufficient duration to establish an ordered spatial structure (RMT 2013). In addition, the Yuba River downstream of Englebright Dam exhibits: (1) lateral variability in its form-process associations; (2) complex channel geomorphology; and (3) a complex and diverse suite of morphological units. The complexity in the landforms creates diversity in the flow hydraulics which, in turn, contributes to a diversity in habitats available for all riverine lifestages of anadromous salmonids in the Yuba River downstream of Englebright Dam (RMT 2013).

NMFS (2009) further stated that in the lower Yuba River, controlled flows and decreases in peak flows has reduced the frequency of floodplain inundation resulting in a separation of the river channel from its natural floodplain. However, as reported by RMT (2013), despite some flow regulation the channel and floodplain in the lower Yuba River are highly connected, with floods spilling out onto the floodplain more frequently than commonly occurs for unregulated semi-arid rivers. Some locations exhibit overbank flow well below 5,000 cfs, while others require somewhat more than that. In any given year, there is an 82% chance the river will spill out of its bankfull channel and a 40% chance that the floodway will be fully inundated. These results demonstrate that floodplain inundation occurs with a relatively high frequency in the lower Yuba River compared to other Central Valley streams which, in turn, contributes to a diversity in habitats available for anadromous salmonids (RMT 2013).

5.3.2 Waterway 13 and the Yuba Goldfields Fish Barrier Project

Located along the Yuba River near Daguerre Point Dam, the Yuba Goldfields consist of more than 8,000 acres of dredged landscape and represent one of the largest tracts of mining debris in northern California (Hunerlach et al. 2004). Historical records from the Yuba Goldfields indicate that dredging near Daguerre Point Dam took place on a nearly continuous basis from 1904 through 1968. Since 1904, dredging has been the principal form of mining in the Yuba Goldfields. Mining company records indicate that extensive areas were re-dredged as technology improved, allowing deeper digging. The area of the present Yuba River channel upstream of Daguerre Point Dam was dredged primarily during 1916-1934. Water flowing through the gravels creates large tracts of ponds throughout the mined landscape (Hunerlach et al. 2004).

As a result of the high permeability of the Goldfield’s rocky soil, water from the Yuba River freely migrates into and through the Goldfields, forming interconnected ponds and canals throughout the undulating terrain (DWR 1999). This high permeability causes water levels in the ponds and canals to rise and fall according to the stage of the Yuba River. Generally, water from the Yuba River enters the Goldfield area from above Daguerre Point Dam, then migrates down-gradient through the Yuba Goldfields. A portion of this migrating water eventually returns to the Yuba River approximately one mile downstream of Daguerre Point Dam via an outlet canal, referred to as Waterway 13, the origin of which is uncertain. This outlet canal helps to drain water out of the Goldfields to the Yuba River, which prevents high water levels from adversely impacting current mining and aggregate operations (DWR 1999).

During the fall of 1988 and the winter and spring of 1989, adult fall/late fall-run Chinook salmon and American shad were observed in the area of the Yuba Goldfields (USFWS 1990). It was suggested that these fish were attracted into the area via the outfall channel referred to as Waterway 13. In 1989, the Red Bluff Fisheries Assistance Office conducted a fishery investigation in the Yuba Goldfields area near Daguerre Point Dam on the lower Yuba River. Several hundred fall-run Chinook were observed spawning in the open access channel in December 1988. In the 1980s, it was discovered that adult anadromous fish (Chinook salmon, American shad, and steelhead) had migrated into the interconnected ponds and canals of the Yuba Goldfields via the area's outlet canal. USFWS (1990) also observed a pair of spawning late fall-run Chinook salmon during March 1989.

Salmon spawning habitat in the Yuba Goldfields was observed in several interconnecting stream channels between ponds, and numerous fall-run Chinook salmon redds were observed (USFWS 1990). From February through April 1989, USFWS (1990) captured 241 juvenile Chinook salmon in the Yuba Goldfields ponds with beach seines at five sample sites located in ponds downstream of the spawning area. In May 1989, juvenile sampling was terminated when reduced flows through the ponds prevented access to the sampling sites. The juveniles ranged in size from about 30 to 65 mm, with the average fork length about 40 mm (USFWS 1990). It was suggested that these small individuals would have a poor chance of survival because increasing water temperatures during May would likely increase predation rates from the numerous adult squawfish and bass observed in the ponds (USFWS 1990).

SWRCB (2000) reported that on various occasions CDFW staff also observed from a few fish to several hundred adult fall-run Chinook salmon attracted up through the outfall into the Yuba Goldfields in the late 1990s. Attraction of adult fall-run Chinook salmon was of concern because there is a general lack of spawning habitat in the Yuba Goldfields, and water temperatures in the Yuba Goldfields can be unsuitable, especially in the lower ends where water discharges into the lower Yuba River (SWRCB 2000). Additionally, fish habitat within the ponds and canals is not conducive to anadromous fish survival because food supply is limited, predator habitat is extensive, and water quality conditions, especially water temperature, are poor (DWR 1999).

There have been several past attempts at taking actions to preclude anadromous salmonids from entering the Yuba Goldfields (SWRCB 2000). In the early 1980s, a large grate was placed on the outfall of Waterway 13 to preclude fish from entering the Yuba Goldfields. However, no one maintained the grate and it was damaged by debris. Thus, adult salmon and steelhead continued to access the Yuba Goldfields. During the January 1997 floods, flows through the Yuba Goldfields became so high that they washed out the structure (SWRCB 2000). The entry point remained open for several years. Realizing that adult fish were once again entering the Yuba Goldfields, CDFW worked with a local aggregate company to install a temporary aggregate berm to exclude adult fish, which was effective for several years. However, any time there is high water in the Yuba Goldfields, the barrier can be breached and activities to replace that barrier cannot begin until the summer or late spring (SWRCB 2000).

The USFWS provided funding for an investigation through the AFRP, and engineering design and environmental evaluation of an adult fish barrier in Waterway 13 that would meet the resource needs of CDFW, USFWS, and NMFS, as well as the needs of the Goldfields' owners - Western Aggregates and Cal-Sierra Development was conducted (SWRCB 2000). Design objectives for a fish barrier located in the Yuba Goldfields outlet canal included the following: (1) prevent adult anadromous fish from entering the Yuba Goldfields; (2) not increase water elevations within the Yuba Goldfields; (3)

require minimal maintenance; and (4) allow for passage or removal of debris (DWR 1999). The primary project objective was to prevent adult anadromous fish from entering the Yuba Goldfields through the outlet canal. The outlet canal is especially important during periods of high flows, when the outlet canal must be able to pass high flows in order to prevent flooding in nearby low-lying areas. It is also important that flows not be greatly restricted during non-flood conditions. If flows during these periods are restricted, water elevations within the Yuba Goldfields rise, adversely affecting Yuba Goldfields mining operations. Consequently, a project needed to be designed to accommodate high flows exiting the Yuba Goldfields. In addition, this project needed to be low maintenance and allow for the passage or removal of debris (DWR 1999). Outlet canal flows during summer and fall months were estimated to range from five to 50 cfs, whereas canal flows during winter and spring months can exceed 1,000 cfs (DWR 1999).

In 2002, the BLM signed a Finding of No Significant Impact for the Yuba Goldfields Fish Barrier Replacement Project. The BLM approved the replacement of the original structure in the same location as the previous structure. The construction of a temporary rock embankment was completed in September 2003 (**Figure 5-9**). In May 2005, heavy rains and subsequent flooding breached the structure at the east (upstream facing) end. AFRP funding was available to repair the “plug” (i.e., temporary aggregate berm) but, because there was no project proponent to do the necessary work, YCWA facilitated the effort but did not accept any responsibility for construction, operation or maintenance (C. Aikens, YCWA, pers. comm. 2011). A "leaky-dike" barrier (**Figure 5-10**) intended to serve as an exclusion device for upstream migrating adult salmonids was constructed at the outfall of Waterway 13 (AFRP 2010).

Although most of the area encompassing the Yuba Goldfields is located on private land, it has been determined that the rock weir plug on Waterway 13 is located on Corps property. However, the Corps does not have any operations or maintenance responsibilities for the earthen “plug” and Waterway 13, nor has it issued any permits or licenses for it. Thus, operation and maintenance of Waterway 13 is part of the Environmental Baseline, and is not part of the Proposed Action.

Figure 5-9. Yuba Goldfields barrier located at the outfall of Waterway 13 (Source: AFRP 2011).

Figure 5-10. Location of the Waterway 13 "leaky-dike" barrier prior to it washing out during the spring of 2011 due to high flows through the Yuba Goldfields.

During the spring of 2011, high flows (~30,000 cfs) in the lower Yuba River and high flows through the Yuba Goldfields once again caused the “leaky-dike” barrier at the entrance to Waterway 13 to wash out. In response to this recent loss of the “leaky-dike” barrier at Waterway 13, the Corps conducted a real estate investigation and determined that Waterway 13 is located on lands that are under the Corps’ jurisdiction. As a separate action unrelated to this ESA consultation, the Corps will work with local stakeholders and resource agencies to identify potential biological concerns associated with Waterway 13 and will support the development of measures to repair the barrier. If needed in the future, the Corps will collaborate with the stakeholders involved to develop a shared agreement (e.g., a right-of-way or easement) that would provide access to those parties that would conduct future maintenance activities that may become necessary if and when the fish barrier at Waterway 13 washes out again in the future. However, because these activities would occur in the future, and a project has not been proposed at this time, Waterway 13 activities are not part of the Proposed Action.

5.3.3 Riparian Vegetation

Most of the original plant communities along the lower Yuba River have been significantly altered from pristine conditions (Corps 1977 as cited in CDFG 1991). Although little has been written specifically about the ancestral riparian forests of the lower Yuba River, it is believed that the banks of the lower Yuba River and its adjacent natural levees once were covered by riparian forest of considerable width. It has been suggested that most riverine floodplains in the Central Valley supported riparian vegetation to the 100-year floodplain, and it is likely that the Yuba River was no exception (CDFG 1991).

In its *Final Biological and Conference Opinion for the Yuba River Development Project License Amendment (FERC No. 2246)*, NMFS (2005b) reports that “*The deposition of hydraulic mining debris, subsequent dredge mining, and loss/confinement of the active river corridor and floodplain of the lower Yuba River which started in the mid-1800’s and continues to a lesser extent today, has eliminated much of the riparian vegetation along the lower Yuba River. In addition, the large quantities of cobble and gravel that* *remained generally provided poor conditions for re-establishment and growth of riparian vegetation. Construction of Englebright Dam also inhibited regeneration of riparian vegetation by preventing the transport of any new fine sediment, woody debris, and nutrients from upstream sources to the lower river. Subsequently, mature riparian vegetation is sparse and intermittent along the lower Yuba River, leaving much of the bank areas unshaded and lacking in large woody debris.*"

To determine the cumulative change over time in total vegetative cover and riparian vegetation cover in the lower Yuba River, YCWA compared aerial photographs from 1937 and 2010. Over this time period, riparian vegetation cover in the Englebright Dam site decreased over time, and the Narrows study site exhibited little detectable change over time. For the remaining study sites distributed throughout the lower Yuba River, riparian vegetation cover increased over time. Dramatic increases in riparian vegetation cover were observed for the Dry Creek and Parks Bar study sites.

Riparian habitats support the greatest diversity of wildlife species of any habitat in California, including many species of fish within channel edge habitats (CALFED 2000a as cited in RMT 2013). Furthermore, more extensive and continuous riparian forest canopy on the banks of estuaries and rivers can stabilize channels, provide structure for submerged aquatic habitat, contribute shade, overhead canopy, and instream cover for fish, and reduce water temperatures (CALFED 2000a as cited in RMT 2013).

Although fish species do not directly rely on riparian habitat, they are directly and indirectly supported by the habitat services and food sources provided by the highly productive riparian ecosystem. Riparian communities provide habitat and food for species fundamental to the aquatic and terrestrial food web, from insects to top predators. As stated in CALFED and YCWA (2005), riparian vegetation, an important habitat component for anadromous fish, is known to provide: (1) bank stabilization and sediment load reduction; (2) shade that results in lower instream water temperatures; (3) overhead cover; (4) streamside habitat for aquatic and terrestrial insects, which are important food sources for rearing juvenile fishes; (5) a source of instream cover in the form of woody material; and (6) allochthonous nutrient input. Riparian vegetation on floodplains can provide additional benefits to fish when the floodplain is inundated, by providing velocity and predator refugia.

In 2012, YCWA conducted a riparian habitat study in the Yuba River from Englebright Dam to the confluence with the Feather River (YCWA 2013). Field efforts included descriptive observations of woody and riparian vegetation, cottonwood inventory and coring, and a LWM survey. The RMT contracted Watershed Sciences Inc. to use existing LiDAR to produce a map of riparian vegetation stands by type. The resulting data was subject to a field validation and briefly summarized in WSI (2010 as cited in RMT 2013) and the data were also utilized in YCWA (2013).

Based on field observations, YCWA (2013) reported that all reaches supported woody species in various lifestages - mature trees, recruits, and seedlings were observed within all reaches. Where individuals or groups of trees were less vigorous, beaver (*Castor canadensis*) activity was the main cause, although some trees in the Marysville Reach appeared to be damaged by human camping.

The structure and composition of riparian vegetation was largely associated with four landforms. Cobble-dominated banks primarily supported bands of willow shrubs with scattered hardwood trees. Areas with saturated soils or sands supported the most complex riparian areas and tended to be associated with backwater ponds. Scarps and levees supported lines of mature cottonwood and other hardwood species, typically with a simple understory of Himalayan blackberry or blue elderberry shrubs. Bedrock dominated reaches had limited riparian complexity and supported mostly willow shrubs and cottonwoods.

The longitudinal distribution of riparian species in the lower Yuba River downstream of the Englebright Dam shows a trend of limited vegetation in the confined, bedrock areas, with increased vegetation in the less-confined, alluvial areas downstream, which is within expected parameters (Naiman et al. 2005 as cited in YCWA 2013). The increase in hardwood diversity and cover downstream of Daguerre Point Dam may be associated with sediment, as reaches above the Daguerre Point Dam have greater scour, while the downstream reaches have more deposition (YCWA 2012a).

Cottonwoods are one of the most abundant woody species in the Action Area, and the most likely source of locally-derived large instream woody material due to rapid growth rates and size of individual stems commonly exceeding 2 feet in diameter and 50 feet in length. Cottonwoods exist in all life stages including as mature trees, recruits, or saplings, and as seedlings. Cottonwoods are more abundant in downstream areas of the Action Area relative to upstream. Of the estimated 18,540 cottonwood individuals/stands, 12% are within the bankfull channel (flows of 5,000 cfs or less), and 39% are within the floodway inundation zone (flows between 5,000 and 21,100 cfs).

The RMT conducted a LiDAR survey of the lower Yuba River from Highway 20 to the confluence, and digitized the patches of vegetation in recent aerial imagery of Timbuctoo Bend and the Englebright Dam Reach (Pasternack 2012). With respect to having sufficient riparian vegetation to provide ecological functionality, the RMT conducted paired hydrodynamic modeling of the lower Yuba River in which one set of models lacks vegetation and the other represents the actual lower Yuba River vegetation pattern and height as best as possible. As shown at the 2011 Lower Yuba River Symposium and in RMT meeting presentations, vegetation was found to significantly affect the hydraulics of the lower Yuba River and, thus, may be deemed present in a significant quantity relative to that functionality (Pasternack 2012).

YCWA (2013) assessed the riparian communities in the Yuba River downstream of the Englebright Dam as healthy and recovering from historical disturbance. Historical aerial photograph analysis indicates that vegetation cover has increased over time, with short-term decreases associated with stochastic flow events, which are normal for riparian systems, and anthropogenic channel changes. Although the riparian vegetation is healthy (plants have high vigor and are present in all age classes), the vegetation communities tend to be simplistic in structure. Riparian communities are seral, establishing first with simplistic herb and shrub layers, then canopies of hardwood trees, and becoming more complex over time. Indicative of early seral stages, the assessed riparian communities tended to be simplistic in both lateral and horizontal stratification, with limited pockets of diverse and well-stratified riparian forests (YCWA 2013). As an example, bands of willows on the floodplains, with some alder and cottonwood recruits, are early in the seral process and still capturing sediment or developing soils to support more productive systems. However, these areas on the floodplains may not become more complex, as they are likely to be scoured during peak flow events (YCWA 2013). Areas dominated by cottonwood trees with only herbaceous understories (e.g., those found on levees), are likely a sign of interrupted riparian development, and maintenance of the levees may have prevented the natural stages of the riparian community to develop.

5.3.4 Large Woody Material

LWM creates both micro- and macro-habitat heterogeneity by forming pools, back eddies Instream object cover provides structure, which promotes hydraulic complexity, diversity and microhabitats for juvenile salmonids, as well as escape cover from predators. The extent and quality of suitable rearing habitat and cover, including SRA, generally has a strong effect on juvenile salmonid production in rivers (Healey 1991 as cited in CALFED and YCWA 2005). LWM also contributes to the contribution of invertebrate food sources, and micro-habitat complexity for juvenile salmonids (NMFS 2007). Snorkeling observations in the lower Yuba River have indicated that juvenile Chinook salmon had a strong preference for near-shore habitats with LWM (JSA 1992).

LWM mapping was conducted from the fall 2011 through the fall of 2012 as part of YCWA's FERC relicensing efforts. YCWA also conducted field surveys in the spring of 2013 to collect LWM data for pieces found exclusively within bankfull widths. The LWM observed in study sites tended to accumulate in one of three distributions within the active channel: (1) in the bands of willow (*Salix sp.*) shrubs near the wetted edge; (2) dispersed across open cobble bars; and (3) stranded above normal high-flow indicators (YCWA 2012a). Bands of woody vegetation, dominated by willow shrubs, were present along the cobble bars and floodplains at various distances from the wetted channel. The shrubs acted as a capture point for much of the LWM, creating tall piles of small woody debris and LWM against the upstream side of the vegetation and around the base of the shrubs. On open cobbles of bars in the alluvial reaches, YCWA observed LWM and smaller woody debris deposited at high flow lines (**Figure 5-11**); this distribution comprised the smallest number of LWM pieces. A great deal of LWM was observed at flood heights, either far from the wetted channel in depressions, in stands of riparian forests, or in areas with reduced floodplains. Piles accumulated on top of boulders or rip-rap at flood flow levels. The majority of the wood surveyed at flood flow levels was highly degraded (YCWA 2012a). Most pieces of LWM were found to be mobile (not stabilized to resist high flows) and few pieces were observed to have channel forming influences (greater than one square meter) including the capture of other woody debris (**Figure 5-12**).

The majority of the LWM located within bankfull areas appeared to have floated in, with less LWM appearing to have fallen from the bank. The largest pieces of LWM were cottonwoods that fell from erosional banks.

Pasternack (2012) states that because the lower Yuba River floodway is so wide that on the falling limb of a flood, the LWM gets scattered over a vast area, with disproportionate concentrations racked behind flow obstructions, racked throughout vegetation patches, and lining the water's edge demarking peak flood stages. Pasternack (2012) further states that there is ample roughness along the fringe to catch very large pieces of wood, but the lower Yuba River is so wide and deep during flood conditions that LWM cannot produce log jams relative to the scale of the system. Piles of LWM (**Figures 5-13 and 5-14**) also were found to accumulate on top of boulders or rip-rap at flood flow levels (YCWA 2013).

5.3.5 Other Environmental Baseline Considerations

Instream flow requirements are specified for the lower Yuba River at the Smartsville Gage (RM 23.6), located approximately 2,000 feet downstream from Englebright Dam, and at the Marysville Gage (RM 6.2). Downstream of the Smartsville Gage, accretions, local inflow, and runoff contribute, on average, approximately 200 TAF per year to the lower Yuba River (JSA 2008).

Figure 5-11. LWM and smaller woody debris deposited downstream from Englebright Dam at a high flow line in the Timbuctoo Bend study site, looking downstream on the south side of the lower Yuba River (YCWA 2013).

Figure 5-12. Example of mobile LWM downstream from Englebright Dam at a mid-channel bar looking downstream at the Hallwood study site in the lower Yuba River (YCWA 2013).

Figure 5-13. LWM accumulated downstream from Englebright Dam against the lower portion of the gravel berms that line the north side of the lower Yuba River in the Dry Creek study site at flood flow levels (YCWA 2013).

Figure 5-14. LWM and smaller woody debris accumulated downstream from Englebright Dam on rip-rap at flood flow heights in the Parks Bar study site on the lower Yuba River (YCWA 2013).

The hydrology and fluvial geomorphology of the lower Yuba River have been altered through anthropogenic influences. Construction of numerous upstream reservoirs has considerably altered the hydrologic regime of the lower Yuba River. The effects of water storage and subsequent releases for irrigation have been to reduce month-to-month flow variations in the river and have shifted the pattern of peak and minimum flows (DWR and Corps 2003). Upstream dams have reduced the magnitude of more frequently occurring flood flows (i.e. 1.5 to 20 year return period floods) (cbec and McBain & Trush 2010). However, larger magnitude, less frequent floods still occur, and cause the lower Yuba River to respond to geomorphic processes.

The two major tributaries to the lower Yuba River are Deer Creek and Dry Creek. Located about 1.2 miles downstream of Englebright Dam, Deer Creek flows into the lower Yuba River at approximately RM 22.7. A significant falls exists approximately 500 feet upstream of the mouth of Deer Creek, which is likely impassable during drier years, but steelhead have been found above the falls during wetter years with high runoff (CDFG 1991). Deer Creek flows are regulated at Lake Wildwood (CALFED and YCWA 2005).

Located about 10.3 miles downstream of Englebright Dam, Dry Creek flows into the lower Yuba River at RM 13.6, approximately two miles upstream of Daguerre Point Dam (JSA 2008). The flow in Dry Creek is regulated by BVID's operation of Merle Collins Reservoir, located on Dry Creek about 8 miles upstream from its confluence with the Yuba River.

5.3.5.1 Regulatory Requirements

Flow releases through the powerplants at Englebright Dam are subject to provisions of various permits, licenses and contracts, including water rights permits and licenses administered by the SWRCB, PG&E's FERC License for Project No. 1403, YCWA's FERC License for Project No. 2246, YCWA's 1966 Power Purchase Contract with PG&E, a 1965 contract between YCWA and CDFW concerning instream flows, and a 1966 contract between YCWA and DWR under the Davis-Grunsky Act (NMFS 2007).

In 1962 and 1965, YCWA entered into agreements with CDFW to provide the following minimum instream flows for normal water years for preserving and enhancing the fish resources in the lower Yuba River downstream of Daguerre Point Dam:

- ☐ October through December – 400 cfs
- ☐ January through June – 245 cfs
- ☐ July through September – 70 cfs

Minimum flows required by the agreements were subject to reductions in critical dry years. However, in no event were flows to be reduced to less than 70 cfs. YCWA's FERC license also contains these requirements. In most years, YCWA voluntarily exceeded the 1962 and 1965 agreements' minimum flow requirements. However, when these minimum flows were implemented they often produced water temperatures and habitat conditions that were well outside the optimal preferred ranges for salmonids (NMFS 2007).

On February 23, 1988, the SWRCB received a complaint filed by a coalition of fishery groups referred to as the United Groups regarding fishery protection and water rights issues on the lower Yuba River. In 1992 and 2000, the SWRCB held hearings to receive testimony and other evidence regarding fishery issues in the lower Yuba River and other issues raised in the United Groups complaint. The SWRCB held supplemental hearings in 2003.

On July 16, 2003, the SWRCB issued a decision (RD-1644) regarding the protection of fishery resources and other issues relating to diversion and use of water from the lower Yuba River. Among other requirements, RD-1644 specified new minimum flow requirements and flow fluctuation criteria for the lower Yuba River. Although these minimum flow requirements did not provide the level of flow protection recommended by CDFW or NMFS, according to RD-1644 these flows were developed to attempt to enhance habitat for adult attraction and passage, spawning, egg incubation, juvenile rearing, and emigration of Chinook salmon, steelhead, and American shad in the lower Yuba River (NMFS 2007).

Conflicts among fisheries resources, water supply reliability, flood concerns, and surface and groundwater management associated with the lower Yuba River resulted in litigation between environmental and water supply interests regarding RD-1644. The Yuba Accord was developed as an alternative to litigation over the flow requirements specified in RD-1644.

LOWER YUBA RIVER ACCORD

The Yuba Accord includes three separate but interrelated agreements that protect and enhance fisheries resources in the lower Yuba River, increase local supply reliability, and provide Reclamation and DWR with increased operational flexibility for protection of Delta fisheries resources through the Environmental Water Account (EWA) Program, and provision of supplemental dry-year water supplies to State and Federal water contractors (YCWA et al. 2007). These agreements are:

- ☐ *Lower Yuba River Fisheries Agreement* (Fisheries Agreement)
- ☐ *Conjunctive Use Agreements* (Conjunctive Use Agreements)
- ☐ *Long-term Water Purchase Agreement* (Water Purchase Agreement)

The development of the Yuba Accord was a collaborative process, which led to a comprehensive settlement of 20 years of litigation over lower Yuba River instream flow requirements and related issues. Stakeholders that participated in the development of the Yuba Accord include NMFS, CDFW, USFWS, YCWA, SYRCL, Trout Unlimited (TU), FOR, and the Bay Institute.

The Fisheries Agreement is the cornerstone of the Yuba Accord. The Fisheries Agreement contains new instream flow requirements for the lower Yuba River, developed to increase protection of the river's fisheries resources. In addition to the best available science and data, the interests of the participating State, Federal, and local fisheries biologists, fisheries advocates, and policy representatives were considered during development of the Fisheries Agreement. The Fisheries Agreement provides for minimum instream flows during specified periods of the year that are higher than the corresponding flow requirements of RD-1644.

Besides the new minimum instream flows, the Fisheries Agreement also contains provisions for a monitoring and evaluation program to oversee the success of the flow schedules and a funding mechanism to pay for monitoring and study activities.

The Yuba Accord Technical Team tasked with flow schedule development pursued a variety of analytic techniques and tools, and performed numerous evaluations to develop minimum flow requirements, referred to as "flow schedules" for the lower Yuba River. 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 under each of several hydrological conditions.

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

(1) Development of a stressor matrix for key fisheries species in the lower Yuba River

(2) Focusing on key fish species,but also considering general aquatic habitat conditions and health in the lower Yuba River

(3) Defining general fisheries goals (e.g., maintenance, recovery, enhancement, etc.)

(4) Defining specific fisheries-related goals of the new flow regime in terms of flow, temperature, habitat, etc.

(5) Developing a comprehensive understanding of the hydrology and range of variability in hydrology for the Yuba Basin

(6) Developing a comprehensive understanding of the operational constraints (regulatory, contractual, and physical) of the YRDP and lower Yuba River, as well as an understanding of the flexibilities and inflexibilities of those constraints

(7) Developing flow regimes based on specific fisheries-related goals and water availability (as defined by operational constraints and hydrologic conditions)

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

(1) Maximize the occurrence of “optimal” flows and minimize the occurrence of sub-optimal flows, within the bounds of hydrologic constraints

(2) Maximize occurrence of appropriate flows for Chinook salmon and steelhead immigration spawning, rearing, and emigration

(3) Provide month-to-month flow sequencing in consideration of Chinook salmon and steelhead life history periodicities

(4) Provide appropriate water temperatures for Chinook salmon and steelhead immigration and holding, spawning, embryo incubation, rearing and emigration

(5) Promote a dynamic, resilient, and diverse fish assemblage

(6) Minimize potential stressors to fish species and lifestages

(7) 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 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.

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 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 would generally 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 also 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 not included in the stressor prioritization process, were American shad, striped bass, and green sturgeon. At the time of development, green sturgeon were neither listed nor proposed for listing under the Federal ESA. 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 – the ultimate product of the stressor prioritization process – each species' or race's freshwater lifecycle was broken up into six commonly acknowledged lifestages. These lifestages 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 lifestages was then assigned a temporal component reflecting the best available knowledge of the timing and duration of that lifestage in the lower Yuba River.

Potential stressors (also referred to as limiting factors) were then identified for each species' or race's lifestage. 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.

- ☐ 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

These potential stressors were not necessarily considered to be an exhaustive list of all stressors, but were the major perceived stressors, based on information current at that time. 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.

Geographic and temporal considerations then were assigned to each stressor, further defining the extent of the potential stressor's effect on each species and lifestage. The result was a stressor matrix, which 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 for each month to help guide 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 lifestage rankings, lifestage periodicities, and geographical considerations developed for the Stressor Matrix), flow-habitat relationships (i.e., WUA) for Chinook salmon and steelhead spawning, and an understanding of the lower Yuba River flow-water temperature relationship was utilized in this process.

The development of the “optimal” flow schedule resulted in a “high” (Schedule 1) and a “low” (Schedule 2) range of ideal flows. 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.

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% 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 would permit survival of the year’s cohort during very dry hydrological conditions.

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) between the “optimal” flows and the “survival” flows to be used during intermediate hydrological conditions. The step size between each successive flow schedule was adjusted to be large enough to cover the ranges of water availability without 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.

Ultimately, six flow schedules, plus conference year provisions, were developed to cover the entire range of Yuba River Basin water availabilities. The flow schedules were developed to maximize fisheries benefits during wetter years, and to maintain fisheries benefits to the greatest extent possible for drier years while taking into account other key considerations such as water supply demands, flood control operations, and hydrologic constraints of the system (NMFS 2007). Conference Years are predicted to occur during the 1% driest hydrological conditions. The Yuba Accord contains provisions regarding the minimum flows, reductions in diversions for irrigation and consultations among representatives of interested parties and regulatory agencies that will occur during Conference Years.

The Yuba Accord flow schedules were developed between 2001 and 2004, and formalized in a set of proposed agreements in 2005. In April of 2005, a statement of support for the proposed Fisheries Agreement was signed by YCWA, CDFW, NMFS, USFWS, SYRCL, FOR, TU, and the Bay Institute. NMFS played a vital role in the development, and subsequent implementation, of the Yuba Accord.

In January 2006, the parties to the Proposed Yuba Accord signed the 2006 Pilot Program Fisheries Agreement, which contained minimum instream flow requirements for the lower Yuba River for the period of April 1, 2006 through February 28, 2007 (YCWA 2006). On April 5, 2006, the SWRCB issued Order WR 2006-0009, which granted YCWA’s petition to extend the effective date of the RD-1644 interim instream flow requirements from April 21, 2006 to March 1, 2007. On April 10, 2006, the SWRCB’s Division of Water Rights issued WR-2006-0010-DWR, which approved YCWA’s petition for the 2006 Pilot Program water transfer. Due to hydrologic conditions in the Delta (e.g., unbalanced conditions), YCWA was not able to transfer water to DWR for use in the EWA Program in 2006. However, the 2006 Pilot Program Fisheries Agreement flow schedules remained in effect through February 28, 2007 (YCWA 2006).

In August 2006, YCWA also filed two petitions to temporarily amend its water right permits so that YCWA could implement the 2007 Pilot Program. The first petition (the Extension Petition) requested a change in the effective date of the SWRCB RD-1644 long-term instream flow requirements from March 1, 2007 to April 1, 2008. The second petition (the Transfer Petition), filed pursuant to Water Code Section 1725, requested approval of the temporary changes in YCWA’s water right permits that were necessary for a one-year water transfer from YCWA to DWR. The SWRCB approved these petitions in February 2007.

The 2006 and 2007 Pilot Programs closely followed the proposed Yuba Accord flow regimes, accounting rules, management framework and other aspects of the Yuba Accord. Additionally, implementation of the 2006 and 2007 Pilot Programs allowed real-world tests of several of the principal elements of the Yuba Accord, including the proposed lower Yuba River flow schedules, transfer accounting rules, and compliance provisions (YCWA et al. 2007).

In 2008, the SWRCB approved the water-rights petitions necessary to implement the Yuba Accord on a long-term basis. The six flow schedules for specific types of water years are based on hydrologic conditions represented by the North Yuba Index (NYI). The NYI is an indicator of the amount of water available in the North Yuba River at New Bullards Bar Reservoir that is used to achieve the flow schedules on the lower Yuba River through operations of the reservoir. The estimated frequencies of occurrence of year-type designations under the NYI are shown below.

Flow Schedule	North Yuba Index (TAF)	Percent Occurrence (%)	Cumulative (%)
1	≥ 1,400	56	56
2	1,040 – 1,399	22	78
3	920 – 1,039	7	85
4	820 – 919	5	90
5	693 – 819	5	95
6	500 – 692	4	99
Conference	< 500	1	100

In addition to the six types of water years for the flow schedules, Conference Years are predicted to occur at a frequency of 1% or less (during the driest years). Conference Years are defined as water years for which the NYI is less than 500 TAF.

As part of the Yuba Accord, YCWA operates the YRDP and manages lower Yuba River instream flows according to the revised instream flow requirements, and according to specific flow schedules, numbered 1 through 6 (measured at the Marysville Gage) and lettered A and B (measured at the Smartsville Gage), based on water availability (see **Table 5-1** for Schedules 1 through 6 and **Table 5-2** for Schedules A and B). The specific flow schedule that is in effect at any time is determined by the value of the NYI and the rules described in the Fisheries Agreement.

Table 5-1. Yuba Accord lower Yuba River minimum instream flows (cfs) for Schedules 1 through 6, measured at the Marysville Gage.

Schedule[a]	Oct 1-31	Nov 1-30	Dec 1-31	Jan 1-31	Feb 1-29	Mar 1-31	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun 1-15	Jun 16-30	Jul 1-31	Aug 1-31	Sep 1-30
1	500	500	500	500	500	700	1,000	1,000	2,000	2,000	1,500	1,500	700	600	500
2	500	500	500	500	500	700	700	800	1,000	1,000	800	500	500	500	500
3	500	500	500	500	500	500	700	700	900	900	500	500	500	500	500
4	400	500	500	500	500	500	600	900	900	600	400	400	400	400	400
5	400	500	500	500	500	500	500	600	600	400	400	400	400	400	400
6 [b, c]	350	350	350	350	350	350	350	500	500	400	300	150	150	150	350

[a] For the Yuba Accord Alternative (using the NYI): Schedule 1 years are years with the NYI ≥ 1,400 TAF, Schedule 2 are years with NYI 1,040 to 1,399 TAF, Schedule 3 are years with NYI 920 to 1,039 TAF, Schedule 4 are years with NYI 820 to 919 TAF, Schedule 5 are years with NYI 693 to 819 TAF, Schedule 6 are years with NYI 500 to 692 TAF, and Conference Years are years with NYI < 500 TAF.

[b] Indicated flows represent the average flow rate at the Marysville Gage for the specified time periods listed above. Actual flows may vary from the indicated flows according to established criteria.

[c] Indicated Schedule 6 flows do not include an additional 30 TAF available from groundwater substitution to be allocated according to the criteria established in the Fisheries Agreement.

Table 5-2. Yuba Accord lower Yuba River minimum instream flows (cfs) for Schedules A and B, measured at the Smartsville Gage

Schedule [a]	Oct 1-31	Nov 1-30	Dec 1-31	Jan 1-31	Feb 1-29	Mar 1-31	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun 1-15	Jun 16-30	Jul 1-31	Aug 1-31	Sep 1-30
A[a]	700	700	700	700	700	700	700	[c]	[c]	[c]	[c]	[c]	[c]	[c]	700
B[b]	600	600	550	550	550	550	600	[c]	[c]	[c]	[c]	[c]	[c]	[c]	500

[a] Schedule A flows are to be used concurrently with Schedules 1, 2, 3, and 4 at Marysville.

[b] Schedule B flows are to be used concurrently with Schedules 5 and 6 at Marysville.

[c] During the summer months, flow requirements at the downstream Marysville Gage always will control, and thus, Schedule A and Schedule B flows were not developed for the May through August period. Flows at the Smartsville Gage will equal or exceed flows at Marysville.

Implementation of the flow schedules contained in the Yuba Accord has addressed many of the flow-related stressors that existed previously, and represents relatively recent improvement to Environmental Baseline conditions. The NMFS (2009) Draft Recovery Plan states that "*For currently occupied habitats below Englebright Dam, it is unlikely that habitats can be restored to pre-dam conditions, but many of the processes and conditions that are necessary to support a viable independent population of spring-run Chinook salmon can be improved with provision of appropriate instream flow regimes, water temperatures, and habitat availability. Continued implementation of the Yuba Accord is expected to address these factors and considerably improve conditions in the lower Yuba River*."

The Yuba Accord had not been approved or implemented on a long-term basis at the time that the 2007 NMFS BO was prepared. The 2007 NMFS BO generally treated effects resulting from flow regime changes on the lower Yuba River as part of the Environmental Baseline, but also discussed flow- and water temperature-related effects on critical habitat as part of the Proposed Action.

For this BA, previous regulatory requirements, including previous instream flow requirements and the Yuba Accord instream flows and associated water temperatures that have been implemented since 2006, which have led to the current status of the listed species in the lower Yuba River, are included in the Environmental Baseline.

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6.0 Effects Assessment Methodology

The effects assessment in this BA addresses the presence of listed species in the Action Area and includes an analysis of the likely effects of the Proposed Action on the listed species and their habitat. One of the purposes of this BA is to provide information for the Corps to determine whether the Proposed Action is "likely to adversely affect" listed species and critical habitat (USFWS and NMFS 1998).

To inform NMFS' jeopardy analysis and conclusion, population analyses are included in this BA to assist NMFS in their determination of whether the Proposed Action would reasonably be expected *"…directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species*." 50 C.F.R. §402.02; 16 U.S.C.S. §1536(a)(2). The population analysis applies the VSP concept, including considerations of abundance, productivity, spatial structure and diversity, for listed species in the appropriate ESU/DPS, as well as in the Action Area, including the lower Yuba River.

For the critical habitat effects analysis, an evaluation was conducted on the effects of the Proposed Action on the PCEs of critical habitat and, in particular, on the essential features of that critical habitat in the Action Area, by comparing the conditions of the habitat with and without the Proposed Action. In addition, for the lower Yuba River, an evaluation was conducted as to whether the Proposed Action would affect the VSP parameter of spatial structure. This BA includes information to assist the Corps as it makes its determination whether the Proposed Action is likely to adversely affect the PCEs of critical habitat. It also is anticipated that NMFS will use the Corps' analysis of potential effects to determine whether the Proposed Action would result in the destruction or adverse modification of critical habitat for each listed ESU/DPS.

6.1 Effects Assessment Framework

In conducting analyses of habitat-altering actions under Section 7 of the ESA, NMFS uses the consultation regulations and combines them with the following steps specified in the document titled *The Habitat Approach, Implementation of Section 7 of the Endangered Species Act for Actions Affecting the Habitat of Pacific Anadromous Salmonids* (NMFS 1999): "(1) *consider the status and biological requirements of the affected species; (2) evaluate the relevance of the environmental baseline in the action area to the species' current status; (3) determine the effects of the proposed or continuing action on the species; (4) consider cumulative effects; (5) determine whether the proposed action, in light of the above factors, is likely to appreciably reduce the likelihood of species survival in the wild or adversely modify its critical habitat*." According to NMFS (1999), the analytical framework described above is consistent with the ESA Consultation Handbook (USFWS and NMFS 1998) and builds upon the Handbook framework to better reflect the scientific and practical realities of salmon conservation and management on the West Coast. This BA is prepared within this analytical framework.

An Assessment Framework for Conducting Jeopardy Analyses Under Section 7 of the Endangered Species Act (NMFS 2004c) describes a nine-step approach that NMFS uses for evaluating the potential effects of a proposed action on listed species (**Figure 6-1**). This BA addresses the first seven steps of this approach. NMFS will complete steps 8 and 9 in their BO for the Proposed Action.

Using the completed description of the Proposed Action, the next step in the evaluation process is to "deconstruct" the Proposed Action (**Figure 6-2**) into its constituent parts to identify the environmental stressors (physical, chemical, or biotic stressors that are directly or indirectly caused by the Proposed Action and, for indirect effects, are "reasonably certain to occur") and any environmental subsidies (i.e., environmental changes that improve conditions for taxa that prey on, compete with, or serve as pathogens for one or more of the listed species) caused by the Proposed Action (NMFS 2004c).

The next step of the assessment framework focuses on those aspects of the Proposed Action that were conceptually identified to have potential adverse or beneficial effects, and the extent of those potential preliminary effects were then applied to identify the

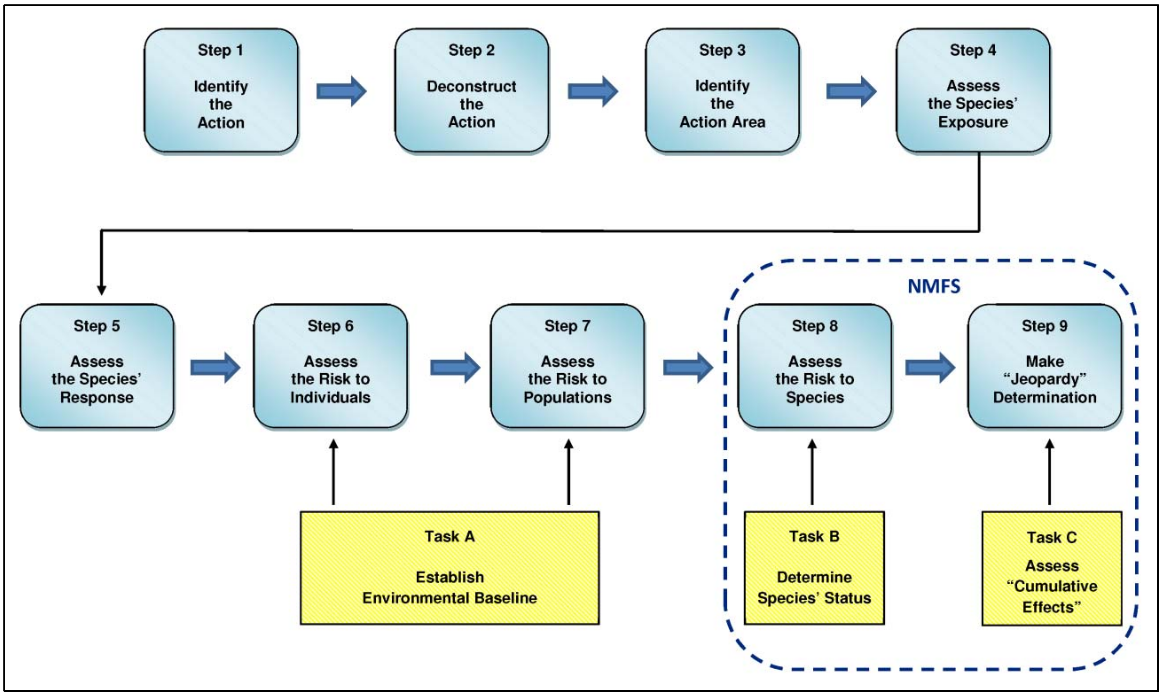

Figure 6-1. Conceptual model of the assessment framework (Modified from NMFS 2004).

Action Area for this ESA consultation. The effects assessment framework then proceeds by considering the extent of physical, chemical and biological stressors associated with the Proposed Action, the potential for species' exposure to those stressors, and species' potential responses to exposure. These assessments are conducted within the context of "aggregate effects" and "net effects" of the Proposed Action.

6.1.1 Aggregate Effects Assessment Approach and "Net Effects" Analysis

This BA examines the Proposed Action in relation to each of the listed species' current status and the effects of past, present, and reasonably certain future non-Federal projects on the species (i.e. cumulative effects). The ESA's implementing regulations define NMFS' responsibilities in consulting with another Federal agency. Among other things, NMFS must evaluate the current status of the listed species or critical habitat; evaluate the effects of the action and cumulative effects on the listed species or critical habitat; and formulate its biological opinion as to whether the action, taken together with

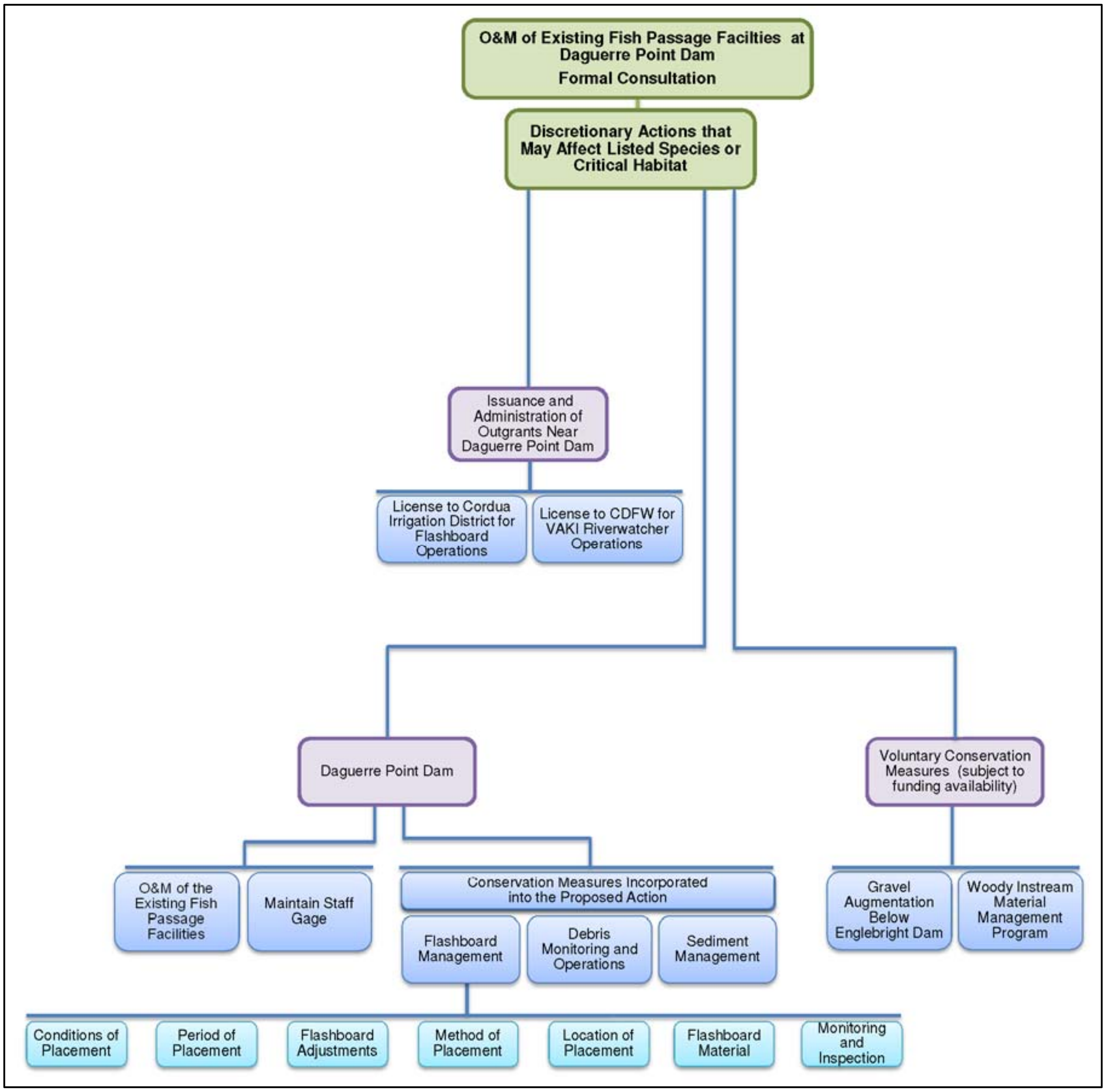

Figure 6-2. "Deconstructed" activities comprising the Proposed Action (i.e., discretionary actions that may affect listed species).

cumulative effects, is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat (50 C.F.R. §402.14(g)). Furthermore, the regulations state that the "effects of the action" refers to "*…the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline.*"

This approach addresses whether the effects of the Proposed Action (the Corps' authorized discretionary O&M activities of the fish passage facilities at Daguerre Point

Dam, administration of licenses to CDFW and Cordua Irrigation District, and specified conservation measures) viewed in context with the Environmental Baseline (including the continued presence of Daguerre Point Dam) and any cumulative effects, has the potential to adversely affect spring-run Chinook salmon, steelhead or green sturgeon or their critical habitats.

The significance of the effects of the Proposed Action will be driven in part by the current status of the species and the Environmental Baseline. As the NMFS (1999) policy document states: "[i]*f the species' status is poor and the baseline is degraded at the time of consultation, it is more likely that any additional adverse effects caused by the proposed or continuing action will be significant"*.

The current status of the listed species and the stability of their populations, as presented in Chapter 4 of this BA, demonstrate that although the spring-run Chinook salmon population in the Yuba River may be stable, populations of steelhead and green sturgeon in the lower Yuba River are data deficient, and consequently cannot be concluded to be stable. Moreover, within the Central Valley Domain, the spring-run Chinook salmon ESU, the steelhead DPS and the Southern DPS of green sturgeon are not currently stable, and are subject to some risk of extinction. Therefore, additional evaluations are provided in this BA to inform NMFS' jeopardy analyses and conclusions.

The additional evaluations in this BA consist of performing a "net effects" analysis to assist NMFS in determining whether the Proposed Action will cause "…*some deterioration in the species' pre-action condition*" (*National Wildlife Federation v. NMFS, 524 F.3d 917 (9th Cir. 2008*). The net effects analysis in this BA considers guidance provided by *National Wildlife Federation v. NMFS, 524 F.3d 917, 930 (9th Cir. 2008)*, which stated **"**…*an agency's action only "jeopardize[s]" a species if it causes some new jeopardy*." The Court went on to say NMFS must "…*consider the effects of [the agency's actions] 'within the context of other existing human activities that impact the listed species'*. Most importantly, in quoting *Pacific Coast Federation of Fishermen's Associations v. U.S. Bureau of Reclamation*, 426 F.3d 1082, (9th Cir. 2005), the Court stated "…'[t]*he proper baseline analysis is not the proportional share of responsibility the federal agency bears for the decline in the species, but what jeopardy* *might result from the agency's proposed actions* *<u>in the present and future human and natural contexts.</u>*'" (emphasis in original). This approach to the evaluation of effects is consistent with the preamble in NMFS' proposed rule for interagency cooperation issued on June 29, 1983 (48 FR 29990). The preamble states:

> "*…In determining whether an action is likely to jeopardize the continued existence of a species or result in the destruction or adverse modification of critical habitat, the Director first will evaluate the status of the species or critical habitat at issue. This will involve consideration of the present environment in which the species or critical habitat exists, as well as the environment that will exist when the action is completed, in terms of the totality of factors affecting the species or critical habitat.*

To identify potential stressors affecting listed species within the Action Area, the next step in the assessment approach involves: (1) the identification of specific stressors (physical, biological, and chemical) to which individual members of listed species are exposed; (2) where exposure may occur; (3) potential pathways of exposure, including the timing, magnitude, duration and frequency of exposure; and (4) characterization of how exposure may vary depending upon the characteristics of the environment, stressor intensity and individual behavior (NMFS 2004c).

After determining whether individual members of listed species would be exposed to one or more physical, biological or chemical stressors resulting from the Proposed Action, species' responses to exposure are considered to determine how individuals would respond to the exposure, and whether the potential exposure would be sufficient to evoke particular responses (NMFS 2004c). As part of this assessment step, the analysis attempts to identify causal pathways that connect species' exposure to responses, as well as latent periods between exposure and the onset of a species' response (NMFS 2004c).

With respect to a habitat-based assessment, habitat modification represents the mechanism by which the Proposed Action has potential demographic effects on individuals or populations of listed species. Habitat modification also may serve as an indirect pathway by which listed species are exposed to potential effects of the Proposed Action (NMFS 2004c).

For each stressor identified under the Environmental Baseline or the Proposed Action, the magnitude of each stressor was ascertained by generally applying the stressor prioritization (“Very High”, “High”, “Medium”, and “Low”) used by NMFS (2009) in Appendix B (Threats Assessment) updated with information obtained since 2009 in the lower Yuba River.

For each stressor that emanates from or is exacerbated by the Proposed Action, the net effects analysis addresses the following: (1) the magnitude of effect of each stressor, to the extent possible; (2) the listed species’ ability to tolerate each stressor; and (3) and the reason why each stressor will, or will not, contribute to the overall likelihood that the listed species or its critical habitat will be adversely affected by the Proposed Action. For this BA, it is recognized that incrementally assessing the magnitude of an individual stressor, or the incremental ability of the listed species to tolerate an individual stressor, is rendered problematic due to the interconnectivity of individual stressors and the inherent variation in biological response to suites of stressors. Nonetheless, to the extent possible, the net effects analysis addresses the magnitude of individual stressors associated with the Proposed Action, and evaluates whether such effects are likely to increase risks to the listed species.

6.1.1.1 Environmental Baseline Assessment

The Environmental Baseline identifies the antecedent conditions for individuals and populations before considering any new stressors associated with the Proposed Action (NMFS 2004c).

Applying steps six and seven of the assessment approach described in NMFS (2004), the Environmental Baseline assessment consists of evaluating potential risks to individuals and populations (see Task A in Figure 6-1).

Past, present, and future stressors associated with the physical presence of existing facilities are included in the Environmental Baseline for this BA, unless the Corps has authority and discretion to: (1) remove the facilities; or (2) alter the operations of the facilities in a manner that would reduce harm to listed species involved in the consultation. With the exception of stressors related to fish ladder performance associated with authorized routine maintenance activities, the Corps does not have the authority to lessen other stressors associated with Daguerre Point Dam (see Chapter 1). Therefore, stressors associated with the ongoing existence of Daguerre Point Dam are appropriately attributed to the Environmental Baseline (see Chapter 5). The Environmental Baseline has led to the current status of the species. The main difference between the Environmental Baseline and a species' status is scale. While the Environmental Baseline is limited to the Action Area, a species' status encompasses the base condition of the entire species (ESU/DPS), given the species' exposure to human activities and natural phenomena throughout their geographic distribution. NMFS determines a species' status to identify its risk of extinction (or probability of persistence) at the time of consultation even if a proposed action did not occur. As a result, a species' status provides the point of reference for jeopardy determinations in a consultation (NMFS 2004c).

The limiting factors, threats and stressors associated with the Environmental Baseline that has led to the current status of listed species, are described in detail in Chapter 4 of this BA and are listed below.

Spring-run Chinook Salmon

ESU

- ☐ Habitat Blockage
- ☐ Water Conveyance and Flood Control
- ☐ Water Quality
- ☐ Hatchery Operations and Practices
- ☐ Water Development
- ☐ Land Use Activities
- ☐ Non-Native Invasive Species
- ☐ Disease and Predation
- ☐ Over Utilization (ocean commercial and sport harvest, inland sport harvest)
- ☐ Environmental Variation (natural environmental cycles, ocean productivity, global climate change, ocean acidification)

LOWER YUBA RIVER

- ☐ Passage Impediments/Barriers
- ☐ Poaching
- ☐ Entrainment
- ☐ Loss of Natural River Morphology and Function
- ☐ Harvest/Angling Impacts
- ☐ Physical Habitat Alteration
- ☐ Predation
- ☐ Loss of Floodplain Habitat
- ☐ Loss of Riparian Habitat and Instream Cover (riparian vegetation, instream woody material)
- ☐ Hatchery Effects (FRFH genetic considerations, straying into the lower Yuba River) and other genetic considerations

STEELHEAD

DPS

The aforementioned list of limiting factors and stressors pertinent to the spring-run Chinook salmon ESU also pertain to the steelhead DPS. Stressors that are unique to the steelhead DPS, or that substantially differ in the severity of a stressor for the previously described spring-run Chinook salmon ESU, include the following.

- ☐ Destruction, Modification, or Curtailment of Habitat or Range
- ☐ Overutilization for Commercial, Recreational, Scientific or Education Purposes (inland sport harvest)
- ☐ Inadequacy of Existing Regulatory Mechanisms (Federal efforts, non-Federal efforts)
- ☐ Other Natural and Man-Made Factors Affecting Its Continued Existence
- ☐ Non-Lifestage Specific Threats and Stressors (artificial propagation programs, small population size, genetic integrity and long-term climate change)

LOWER YUBA RIVER

The list of limiting factors and stressors for the spring-run Chinook salmon population in the lower Yuba River that are pertinent to the steelhead population in the lower Yuba River are not repeated here. Stressors that are unique to steelhead in the lower Yuba River, and stressors that substantially differ in severity for steelhead (see Chapter 4) include the following.

- ☐ Harvest/Angling Impacts
- ☐ Poaching
- ☐ Hatchery Effects (genetic considerations, straying into the lower Yuba River)

GREEN STURGEON

DPS

- ☐ Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range (reduction in spawning habitat, alteration of habitat - flows, water temperatures, delayed or blocked migration, impaired water quality, dredging and ship traffic, ocean energy projects)
- ☐ Commercial, Recreational, Scientific or Educational Overutilization
- ☐ Disease and Predation
- ☐ Inadequacy of Existing Regulatory Mechanisms
- ☐ Other Natural and Man-Made Factors Affecting Its Continued Existence (non-native invasive species)
- ☐ Entrainment

LOWER YUBA RIVER

As previously discussed, Daguerre Point Dam is a complete barrier to upstream passage for green sturgeon because they are unable to ascend the fish ladders on the dam, or otherwise to pass over or around the structure. NMFS (2007) stated that Daguerre Point Dam prevents green sturgeon from accessing potentially suitable spawning and rearing habitat located above the dam, and therefore potentially represents a stressor to green sturgeon. However, the ongoing and future effects of Daguerre Point Dam's blockage of green sturgeon are due to the presence of the dam and configuration of the fish ladders and are an existing condition, over which the Corps does not currently have the authority to make modifications to the structure to allow for green sturgeon passage. Therefore, the dam and the fish ladder configuration are part of the Environmental Baseline. In order to accommodate green sturgeon, a major modification to the existing structure would have to be authorized by Congress.

For this BA, the assessment of the Environmental Baseline within the Action Area will consider: (1) past, present and ongoing limiting factors, threats and stressors described in Chapter 4; (2) full implementation of the Yuba Accord, which has occurred since 2008; and (3) the results of available lower Yuba River fisheries monitoring data, which are included in the characterization of the current status of each species.

According to NMFS (1999), the Environmental Baseline represents the current basal set of conditions to which the effects of the Proposed Action are added, and does not include any future discretionary Federal activities in the Action Area that have not yet undergone ESA consultation. Each listed species' current status is described in relation to the risks presented by the continuing effects of all previous actions and resource commitments that are not subject to further exercise of Federal discretion (NMFS 1999). For an ongoing Federal action (such as the Proposed Action being evaluated in this BA), the effects of the action resulting from past unalterable resource commitments are included in the Environmental Baseline, and those effects that would be caused by the continuance of the Proposed Action are then analyzed for determination of effects (NMFS 1999).

6.1.1.2 Proposed Action Effects Assessment

In this step of the effects assessment, NMFS (1999) suggests examining the anticipated direct and indirect effects of the Proposed Action on each listed species and its habitat within the context of the species' current status and the Environmental Baseline. A two-part analysis is conducted as part of this step. The first analytical component focuses on the species itself, and describes the Proposed Action's potential effects on individual fish, populations, or both – and places that effect within the context of the ESU/DPS as a whole (NMFS 1999). The second analytical component focuses on the Action Area and defines the Proposed Action's effects in terms of each species' biological and habitat requirements in that area.

DIRECT AND INDIRECT EFFECTS

To evaluate potential direct and indirect effects of the Proposed Action, the following three factors are considered: (1) identify the probable risks to the individual organisms that are likely to be exposed to the Proposed Action's effects on the environment; (2) identify whether the consequences of changing the risks to those individuals for the populations those individuals represent would be sufficient to increase extinction risk (or reduce the probability of persistence); and (3) identify whether changes in the extinction risk (or probability of persistence) of those populations would be sufficient to increase the extinction risk (or reduce the probability of persistence) of the species that those populations comprise, given the species' status (NMFS 2004c).

For each component and subcomponent of the Proposed Action, the effects assessment first describes the stressors that are expected to result from each component/subcomponent and then describes each stressor in terms of its intensity, frequency, and duration. The analysis then assesses the likely responses of each listed species to the stressors, and the potential for specific stressors to affect critical habitat. Likely species responses are based upon the timing (when) and the location (where) potential stressors would occur, compared to the lifestage-specific spatial and temporal distributions of each listed species. Likely effects on the primary constituent elements of critical habitat for each listed species are assessed by describing changes in habitat suitability (e.g., flows and water temperatures), availability and accessibility for each specific lifestage. The assessment focuses on whether any of the possible responses are likely to result in the death or injury of individuals, reduced reproductive success or capacity, or the temporary or permanent blockage or destruction of biologically significant habitats (NMFS 2005).

These analytical steps comprise the assessment of potential "exposure" of each listed species and its critical habitat to the stressors resulting from the Proposed Action. According to NMFS (2005), this assessment of exposure is necessary to assess responses of the listed species and their effects on critical habitat resulting from stressors associated with the Proposed Action, and will serve in large part as the bases of "not likely to adversely affect" or "likely to adversely affect" conclusions included in this BA.

6.1.1.3 Cumulative Effects Assessment

Cumulative effects are defined by Federal regulations as "…*those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation*" (50 CFR §402.02). Cumulative effects must be considered in the analysis of the effects of the Proposed Action (50 CFR §402.12(f)(4)).

The cumulative effects assessment in this BA addresses changes in lower Yuba River flows and water temperatures resulting from increased diversions associated with implementation of the Yuba-Wheatland In-Lieu Groundwater Recharge and Storage Project (Wheatland Project). Increased diversions associated with the Wheatland Project represent a future state or private action reasonably certain to occur. These effects are considered in the cumulative effects analysis because the Corps has no authority to regulate water diversions associated with the South Yuba/Brophy Diversion Canal and Facilities. For this BA, the cumulative effects assessment does not address changes in exposure of juvenile spring-run Chinook salmon and steelhead to impingement, entrainment and predation rates at the South Yuba/Brophy Diversion Canal and Facilities, because these effects will be evaluated in a future action requiring separate ESA consultation.

Updated 2011 demand projections indicate that water deliveries to the Wheatland Project in the future are projected to increase up to about 35,000 to 36,000 acre-feet, depending on water year type, above those demands currently in place under the Environmental Baseline (i.e., current condition demands). For effects assessment purposes in this BA, updated Wheatland Project demands are represented through modeling simulations for the future Cumulative Conditions (for additional detail, see Appendix F of this BA).

The Environmental Baseline (i.e., current conditions simulation) includes the irrigation demands of the seven YCWA Member Units that receive water from the Yuba River in amounts and flow rates that represent 2005 land use conditions, because the most recent available land use survey data are from 2005. These Member Units are Hallwood Irrigation Company, Cordua Irrigation District, BVID, and Ramirez Water District (these Member Units divert water at or just upstream of Daguerre Point Dam to lands north of the Yuba River), and Brophy Water District, South Yuba Water District and Dry Creek Mutual Water Company (these Member Units divert water at Daguerre Point Dam to lands south of the Yuba River).

The Cumulative Condition scenario includes the irrigation demands for the Member Units listed previously plus the future irrigation demands of Wheatland Water District, which began receiving surface water through a new canal extension in 2010. The monthly amounts of irrigation demand for the Member Units were derived by taking DWR 2005 land use data for irrigated lands within these Member Units, and multiplying the various land use areas by their respective crop type applied water rates as determined by DWR for Yuba County. The applied water rates for two different years are used – 1999 to represent a wet year condition and 2001 to represent a dry year condition. Wet year conditions are assumed to occur in Wet and Above Normal years, and dry conditions are assumed for Below Normal, Dry and Critical years, where the year types are defined by the Yuba River Index (YRI) of SWRCB Decision 1644. Previously, the Lower Yuba River Accord EIR/EIS (YCWA et al. 2007) irrigation demands were derived based on 1995 land use data and field-adjusted, applied water rates published in DWR's Bulletin 113-4. In the previous calculation, the differentiation of wet and dry conditions was made by reducing the Bulletin 113 applied water rates for the spring months of wet years to represent the wetter soil conditions that occur in those years.

YCWA is presently in the process of developing a daily operations model and a water temperature model as part of the FERC relicensing process for the YRDP (FERC Project No. 2246). However, at the time of preparation of this BA, daily models were not available for the Cumulative Condition.

To evaluate potential changes to listed species critical habitat under the Cumulative Condition for this BA, two scenarios were modeled to characterize monthly average flows and water temperature changes in the lower Yuba River. The modeling was conducted using two models – a water balance/operations model and a water temperature model. The water balance/operations model simulates the hydrology of the lower Yuba River and YCWA's operations of the YRDP on a monthly time step. The water temperature model predicts average monthly water temperatures at three locations in the lower Yuba River, and uses statistically derived relationships between meteorology, flow, reservoir water storage levels and resulting water temperatures. Both of these models were used in the preparation of the Lower Yuba River Accord EIR/EIS, and are documented in the modeling technical appendix to the EIR/EIS, a copy of which is included in Appendix F to this BA.

The significant attributes of the water balance/operations model are described in Appendix F. For ESA assessment purposes, three of the assumptions and modeling conditions used for the Lower Yuba River Accord EIR/EIS (YCWA et al. 2007) were modified in this BA. These modifications are: (1) the maximum release capacity of Colgate Powerhouse, which is the primary release point for New Bullards Bar Reservoir, has been corrected to be 3,430 cfs whereas previously it was modeled as 3,700 cfs; (2) the hydrologic period of record used for the simulations evaluated in this BA has been extended to encompass Water Year (WY) 1922 to WY 2008, in contrast to the period extending from WY 1922 through WY 2005 that was previously used in the Lower Yuba River Accord EIR/EIS; and (3) the irrigation diversion demands were changed as described below and in Appendix F.

For the cumulative effects analysis of flows and water temperatures in the lower Yuba River in this BA, the two scenarios of the "Environmental Baseline" and "Cumulative Condition" were modeled. Only one simulation element – the irrigation diversion demand at Daguerre Point Dam – was varied between the two modeled scenarios.

Flow modeling output is provided at two locations in the lower Yuba River: (1) the Smartsville Gage, which is located a short distance downstream of Englebright Dam and represents flows in the lower Yuba River above Daguerre Point Dam; and (2) the Marysville Gage, located 5.6 miles upstream from the mouth of the lower Yuba River and represents flows in the lower Yuba River below the diversions at Daguerre Point Dam.

The long-term average flows, by month, occurring over the 1922 through 2008 simulation period under the Environmental Baseline and the Cumulative Condition were calculated. This 87-year period of record was used for cumulative effects assessment because that was the model output available at the time of preparation of this BA. Average monthly simulated flows also were calculated by water year type, as defined by the YRI, for the Environmental Baseline and the Cumulative Condition. Presented in tabular format, the data tables for the long-term average flows by month, and the average flows by water year type demonstrate the changes that could be expected to occur under the Cumulative Condition.

In addition, monthly flow exceedance curves were developed for the 1922 through 2008 simulation period and illustrate the distribution of simulated flows under the Cumulative Condition and the Environmental Baseline. The flow exceedance curves were developed utilizing the Weibull method (Weibull 1939), which historically has been used by hydrologists in the United States for plotting flow-duration and flood-frequency curves. In general, flow exceedance curves represent the probability, as a percent of time that modeled flow values would be met or exceeded at an indicator location during a certain time period. Therefore, exceedance curves demonstrate the cumulative probabilistic distribution of flows for each month at a given river location under a given simulation.

Water temperature assessments were conducted using outputs from the water temperature model, comprised of monthly average water temperatures occurring over the 1922 – 2008 simulation period. Simulated average monthly water temperatures are provided for the following locations: (1) the Smartsville Gage; (2) Daguerre Point Dam; and (3) the Marysville Gage. Although a monthly water temperature model is not able to assess day-to-day water temperature variability or diurnal water temperature fluctuations, a more discrete time-step water temperature model is not presently available for the Cumulative Condition.

Monthly water temperature cumulative probability distributions represent the probability, as a percent of time, that modeled water temperature values would be met or exceeded at a given location.

SPRING-RUN CHINOOK SALMON AND STEELHEAD

Changes in river flows and water temperatures during certain periods of the year have the potential to affect specific lifestages of each listed species. Therefore, changes in monthly mean river flows and water temperatures are used as impact indicators for months when specific lifestages of each listed fish species occur in the lower Yuba River.

Lifestage periodicities for spring-run Chinook salmon and steelhead were developed through review of previously conducted studies, as well as recent and currently ongoing data collection activities of the Yuba Accord M&E Program. The resultant lifestage periodicities encompass the majority of activity for a particular lifestage, and are not intended to be inclusive of every individual in the population. The lifestage-specific periodicities for spring-run Chinook salmon and steelhead, which are applied to evaluate potential effects on critical habitat in this BA, were obtained from RMT (2013) and are presented in **Table 6-1**.

Table 6-1. Lifestage-specific periodicities for spring-run Chinook salmon and steelhead in the lower Yuba River.

Lifestage	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Spring-run Chinook Salmon																								
Adult Immigration & Holding							■	■	■	■	■	■	■	■	■	■	■	■						
Spawning																	■	■	■					
Embryo Incubation																	■	■	■	■	■	■	■	■
Fry Rearing	■	■	■																			■	■	■
Juvenile Rearing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Juvenile Downstream Movement	■	■	■	■	■	■	■	■	■	■	■	■										■	■	■
Smolt (Yearling+) Emigration	■	■	■	■	■	■	■	■	■										■	■	■	■	■	■
Steelhead																								
Adult Immigration & Holding	■	■	■	■	■	■									■	■	■	■	■	■	■	■	■	■
Spawning	■	■	■	■	■	■	■	■																
Embryo Incubation	■	■	■	■	■	■	■	■	■	■														
Fry Rearing							■	■	■	■	■	■	■	■										
Juvenile Rearing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Juvenile Downstream Movement							■	■	■	■	■	■	■	■	■	■	■	■						
Smolt (Yearling+) Emigration	■	■	■	■	■	■	■												■	■	■	■	■	■

For the spring-run Chinook salmon and steelhead flow-related critical habitat assessments, changes in flows under the Cumulative Condition relative to the Environmental Baseline are examined in three steps.

First, long-term monthly average flows, monthly average flows by water year type, and monthly flow exceedance distributions under the Cumulative Condition relative to the Environmental Baseline are compared to the monthly minimum flows contained in the Yuba Accord flow schedules developed by the Yuba Accord Technical Team. Situations are identified where the Cumulative Condition results in average monthly flows less than the corresponding flow schedule achieved under the Environmental Baseline. Particular emphasis is placed on potential flow differences that would lead to decreases below the flow rates specified in Flow Schedules 1 and 2 (see Chapter 5), which represent the range of optimal flow conditions.

Second, the analyses consider individual monthly changes in flow of 10% or greater over the 1922-2008 simulation period under the Cumulative Condition relative to the Environmental Baseline. A decrease in monthly flow of 10% or greater has been previously identified by various environmental documents as an appropriate criterion to evaluate flow changes. For example, in the Trinity River Mainstem Fishery Restoration Draft EIS/EIR (USFWS et al. 1999), the USFWS identified reductions in flow of 10% or greater as changes that could be sufficient to reduce habitat quantity or quality to an extent that could significantly affect fish. The Trinity River EIS/EIR further states, "*…[t]his assumption [is] very conservative…[i]t is likely that reductions in streamflows much greater than 10 percent would be necessary to significantly (and quantifiably) reduce habitat quality and quantity to an extent detrimental to fishery resources*." Conversely, the Trinity River EIS/EIR considers increases in streamflow of 10% or greater, relative to the basis of comparison, to be "beneficial" to fish species.

In addition to the USFWS et al. (1999) criteria, the *San Joaquin River Agreement EIS/EIR* (Reclamation and SJRGA 1999) utilized USGS 1977 criteria thresholds, which were derived based on the ability to accurately measure stream flow discharges to ±10%. The criterion used to determine impacts associated with implementation of the San Joaquin Agreement was based on average percentage changes to stream flow relative to the basis of comparison. The *San Joaquin River Agreement EIS/EIR* considered flow changes of less than ±10% to be insignificant (Reclamation and SJRGA 1999).

The *Freeport Regional Water Project Draft EIS/EIR* (JSA 2003) used a similar rationale as the USGS documentation for selecting criteria to evaluate changes in flow. The Freeport EIS/EIR states: "*Relative to the base case, a meaningful change in habitat is assumed to occur when the change in flow equals or exceeds approximately 10 percent. The 10 percent criterion is based on the assumption that changes in flow less than 10 percent are generally not within the accuracy of flow measurements, and will not result in measurable changes to fish habitat area*."

The *Lower Yuba River Accord Draft EIR/EIS* (YCWA et al. 2007) also used a 10% change in flow as an indicator of potential impact.

These documents apparently have resulted in consensus in the use of 10% when evaluating the potential effects of flow changes on fish and aquatic habitat. Accordingly, the spring-run Chinook salmon and steelhead effects assessment in this BA relies on previously established information and, therefore, evaluates changes of 10% or greater in monthly mean flows under the Cumulative Condition relative to the Environmental Baseline.

Third, exceedance curves are particularly useful for examining flow changes occurring at lower flow levels. Because physical habitat simulation models oftentimes indicate that rearing habitat area tends to reach maximum abundance at low flows that inundate most of the channel area in a river (JSA 2003), estimates of rearing habitat area can decline as flows increase, primarily in response to increased average velocity. Because juvenile Chinook salmon and steelhead fry generally prefer low velocity areas, increasing flows can lead to reductions in estimated habitat area. However, this flow-habitat relationship may be misleading because it may not adequately reflect local habitat conditions (i.e., availability of low velocity) or the importance of flow-related habitat attributes (e.g., water temperature conditions or cover and prey availability). Given the vagaries of flow-habitat relationships associated with anadromous salmonid rearing, the effects assessment also includes specific evaluations of changes in low flow conditions. In accordance with the selected flow criteria (i.e., ≥ 10% change) described above, a change in the lowest quartile distribution (i.e., 25th percentile) of 10% or greater is considered in relation to the magnitude of flows under the Environmental Baseline. This approach is consistent with the methodology included in previous environmental documentation, including the Freeport Regional Water Project Draft EIS/EIR (JSA 2003) and the Lower Yuba River Accord Draft EIR/EIS (YCWA et al. 2007).

In summary, the spring-run Chinook salmon and steelhead flow-related effects assessment evaluates whether changes in mean monthly flow at the Smartsville and Marysville gages under the Cumulative Condition relative to the Environmental Baseline are of sufficient magnitude and frequency to appreciably diminish the value of critical habitat. Evaluation indicators used in the assessment include: (1) changes in monthly mean flows that would result in monthly mean flows less than the corresponding flow schedule achieved under the Environmental Baseline; (2) changes in monthly mean flows equal to or greater than 10%; and (3) changes in flows equal to or greater than 10% during low flow conditions (i.e., when flows are in the lowest 25% of the cumulative flow distribution).

In addition to flow-related assessments, water temperature-related effects also are evaluated. For this BA, the monthly cumulative probability distributions are examined to identify the probability that specified water temperature index values would be exceeded for the individual months within the identified lifestages, at given locations, for spring-run Chinook salmon and steelhead. A comprehensive review and compilation of available literature was conducted to identify water temperature index values for water temperature-related critical habitat assessment for spring-run Chinook salmon and steelhead, by lifestage, in the lower Yuba River. The thermal requirements of Chinook salmon and steelhead have been extensively studied in California and elsewhere and, therefore, allow a detailed and specific determination of desired water temperature index values for each lifestage (YCWA et al. 2007). Identification of water temperature index values is largely based on information provided in the Lower Yuba River Accord Draft EIR/EIS (YCWA et al. 2007), Appendix B to the Upper Yuba River Studies Program Technical Report (DWR 2007), Attachment A to the Yuba Accord River Management Team Water Temperature Objectives Technical Memorandum (RMT 2010b), additional updated information provided in Bratovich et al. (2012) and in RMT (2013).

These documents present the results of literature reviews that were conducted to: (1) interpret the literature on the effects of water temperature on the various lifestages of Chinook salmon and steelhead; (2) consider the impacts of short-term and long-term exposure to constant or fluctuating temperatures; and (3) establish water temperature index (WTI) values to be used as guidelines for evaluation. Previous efforts presented both the upper optimum and upper tolerable WTI values to examine water temperature suitabilities by lifestage for target species. More recent efforts including the RMT Interim Monitoring and Evaluation Report (RMT 2013) and the YRDP FERC Relicensing BA have focused on comparing water temperature (model outputs as well as monitoring) to lifestage-specific upper tolerance WTIs for impact assessment purposes. Specifically, this present evaluation adopts the same approach for water temperature-related effects assessment for listed species in the lower Yuba River. Use of WTI values in the impacts assessments are not meant to be significance thresholds, but instead provide a mechanism by which to compare the suitability of the water temperature regimes associated with the Cumulative Condition. Spring-run Chinook salmon lifestage-specific upper tolerance WTI values are provided in **Table 6-2**, and in **Table 6-3** for steelhead. The lifestages and periodicities presented in Table 6-2 and Table 6-3 differ from those presented in Table 6-1 due to specific lifestages that have the same or distinct upper tolerable WTI values, and/or the same or distinct geographic application.

Water temperature index values were determined by placing emphasis on the results of laboratory experiments and field studies that examined how water temperature affects spring-run Chinook salmon and steelhead, as well as by considering regulatory documents and other BOs 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 numbers (°F) were selected as index values.

The water temperature-related critical habitat assessment for this BA is based upon comparing the probability of exceeding the lifestage-specific (month and location) selected water temperature index values under the Cumulative Condition with the Environmental Baseline.

Table 6-2. Spring-run Chinook salmon lifestage-specific upper tolerance water temperature index values.

Lifestage	Upper Tolerance WTI	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult Migration	68°F							▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨						
Adult Holding	65°F							▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨						
Spawning	58°F																	▨	▨	▨					
Embryo Incubation	58°F																	▨	▨	▨	▨	▨	▨	▨	▨
Juvenile Rearing and Downstream Movement	65°F	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Smolt (Yearling+) Emigration	68°F	▨	▨	▨	▨	▨	▨	▨	▨	▨										▨	▨	▨	▨	▨	▨

Table 6-3. Steelhead lifestage-specific upper tolerance water temperature index values.

Lifestage	Upper Tolerance WTI	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult Migration	68°F	▨	▨	▨	▨	▨	▨									▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Adult Holding	65°F	▨	▨	▨	▨	▨	▨									▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Spawning	57°F	▨	▨	▨	▨	▨	▨	▨	▨																
Embryo Incubation	57°F	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨														
Juvenile Rearing and Downstream Movement	68°F	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Smolt (Yearling+) Emigration	55°F	▨	▨	▨	▨	▨	▨	▨												▨	▨	▨	▨	▨	▨

SPRING-RUN CHINOOK SALMON

- ☐ Adult immigration (April through September) – Smartsville, Daguerre Point Dam, and Marysville
- ☐ Adult holding (April through September) – Smartsville and Daguerre Point Dam
- ☐ Spawning (September through mid-October) – Smartsville
- ☐ Embryo incubation (September through December) – Smartsville
- ☐ Juvenile rearing (Year-round) – Smartsville and Daguerre Point Dam

- ☐ Juvenile downstream movement (Mid-November through June) – Daguerre Point Dam and Marysville
- ☐ Smolt (Yearling+) emigration (October through mid-May) – Daguerre Point Dam and Marysville

STEELHEAD

- ☐ Adult immigration (August through March) – Smartsville, Daguerre Point Dam, and Marysville
- ☐ Adult holding (August through March) – Smartsville and Daguerre Point Dam
- ☐ Spawning (January through April) – Smartsville and Daguerre Point Dam
- ☐ Embryo incubation (January through May) – Smartsville and Daguerre Point Dam
- ☐ Juvenile rearing (Year-round) – Smartsville and Daguerre Point Dam
- ☐ Juvenile downstream movement (April through September) – Daguerre Point Dam and Marysville
- ☐ Smolt (Yearling+) emigration (October through mid-April) – Daguerre Point Dam and Marysville

GREEN STURGEON

The Technical Team developed the Yuba Accord flow schedules based primarily on available information for spring-run Chinook salmon, steelhead, and fall-run Chinook salmon. Other fish species including green sturgeon were considered, but ultimately were not included in the stressor prioritization process. At the time of development of the Yuba Accord flow schedules, green sturgeon were neither listed nor proposed for listing. Hence, the green sturgeon flow-related critical habitat effects assessment cannot rely on reference to the Yuba Accord flow schedules, and is conducted in this BA as follows.

The critical habitat analysis for green sturgeon under the Cumulative Condition and the Environmental Baseline in the lower Yuba River addresses a unique specific PCE essential for the conservation of the Southern DPS of North American green sturgeon in freshwater riverine systems according to the document titled *Designation of Critical*

Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon - Final Biological Report (NMFS 2009e). According to NMFS (2009e), deep (≥ 5 m) holding pools for both upstream and downstream holding of adult or subadult green sturgeon, with adequate water quality and flow, are necessary to maintain the physiological needs of the holding adult or subadult fish. According to NMFS (2009e), deep pools of ≥ 5 meters depth with complex hydraulic features and upwelling are critical for adult green sturgeon spawning and for summer holding within the Sacramento River (Vogel 2008; Poytress et al. 2009). Adult green sturgeon in the Klamath and Rogue rivers also occupy deep holding pools for extended periods of time, presumably for feeding and/or energy conservation (Erickson et al. 2002; Benson et al. 2007).

According to NMFS (2009e), earlier papers suggested that spawning most likely occurs in fast, deep water (> 3 m deep) over substrates ranging from clean sand to bedrock, with preferences for cobble substrates (Emmett et al. 1991; Moyle et al. 1995). Recent studies have provided additional information. Monitoring of green sturgeon and behavior data in the Rogue River suggests spawning occurs in sites at the base of riffles or rapids, where depths immediately increase from shallow to about 5 to 10 meters, water flow consists of moderate to deep turbulent or eddying water, and the bottom type is made up of cobble to boulder substrates (D. Erickson, ODFW, pers. comm. September 3, 2008 as cited in NMFS 2009e). For the Sacramento River, NMFS (2009a) reports that adult green sturgeon prefer deep holes (≥ 5 m depth) at the mouths of tributary streams, where they spawn and rest on the bottom.

As previously discussed, over the many years of sampling and monitoring in the lower Yuba River, only one sighting of an adult green sturgeon was confirmed before 2011. A memorandum dated June 7, 2011 by Cramer Fish Sciences (2011) stated that they observed what they believed were 4–5 green sturgeon near the center of the channel at the edge of the bubble curtain below Daguerre Point Dam. The sturgeon were observed either on a gravel bar approximately 1.5 meters deep, or in a pool approximately 4 meters deep immediately adjacent to the gravel bar.

Given the extremely infrequent sightings, the lack of green sturgeon life history information for the lower Yuba River, and potential changes in PCEs associated with the Cumulative Condition, the critical habitat analysis for green sturgeon in this BA addresses the PCE of water depth in pools for both pre- and post-spawning and subadult holding of adult or subadult green sturgeon. Because the lower Yuba River is smaller than the Sacramento River or other rivers citing a depth criterion of >5 meters (16.4 feet), use of that criterion may be overly restrictive and not account for local opportunistic habitat utilization by green sturgeon. Therefore, to provide a more rigorous and inclusive analysis, water depth is evaluated by identifying all pools located downstream of Daguerre Point Dam characterized by water depths of >10.0 feet over the general range of flow conditions where changes in monthly mean flows were observed in the lower Yuba River between the Cumulative Condition and the Environmental Baseline. These pools were identified by application of the RMT's SRH2D 2-dimensional (SRH-2D) model.

Deepwater habitats were identified downstream of Daguerre Point Dam in ArcGIS. Polygons were constructed of deepwater habitats greater than 10.0 feet in depth in the Yuba River downstream of Daguerre Point Dam at a baseflow of 530 cfs at the Marysville Gage, which represents the baseflow[1] used to delineate morphological units in the geomorphologic investigations conducted for the Yuba River downstream of Englebright Dam. Deepwater habitat polygons, with a minimum inter-nodal spacing of 5 feet, were developed by YCWA through application of the DEM and the SRH-2D model.

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[1] The final baseflow regime used in the report titled *Landforms of the Lower Yuba River* (Wyrick and Pasternack 2012) was the condition with a Smartsville Gage flow of 880 cfs, no discharge out of Deer Creek (whose outflow tends to be 0-5 cfs in the absence of rain or upstream reservoir maintenance), no discharge out of Dry Creek (whose outflow tends to be 0-5 cfs in the absence of rain or upstream reservoir maintenance), and an agricultural withdrawal of 350 cfs at Daguerre Point Dam, yielding a Marysville Gage flow of 530 cfs.

Identified deepwater pools downstream of Daguerre Point Dam were further analyzed using the following flows (cfs) at the Marysville Gage.[2]

- ☐ 300
- ☐ 350
- ☐ 400
- ☐ 450
- ☐ 530
- ☐ 600
- ☐ 622
- ☐ 700
- ☐ 800
- ☐ 880
- ☐ 930
- ☐ 1,000
- ☐ 1,300
- ☐ 1,500
- ☐ 1,700
- ☐ 2,000
- ☐ 2,500
- ☐ 3,000
- ☐ 4,000
- ☐ 5,000
- ☐ 7,500
- ☐ 10,000
- ☐ 15,000
- ☐ 21,100
- ☐ 30,000
- ☐ 42,200

The areal extent of the deepwater pools was calculated for each of the above-specified flows by calculating the difference between the DEM and the SRH-2D model results in ArcGIS, consistent with the methodology employed in Technical Memorandum 7-10, *Instream Flow Downstream of Englebright Dam* for the YRDP FERC Relicensing process.

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[2] The relationship between the areal extent of deepwater pool habitat and flow was not based on flows exceeding 42,200 cfs at the Marysville Gage. At flows higher than 42,200 cfs, specifically at the flows of 84,400 and 110,400 cfs specified in YCWA's Study 7.10, *Instream Flow Downstream of Englebright Dam*, the lower portion of the river spills far out onto the floodplain, and the necessary topographic data to map and model these flows are not currently available (G. Pasternack, pers. comm. 2012). For the analyses of the areal extent of deepwater pools in the lower portion of the river over the evaluation period (WY 1970 through WY 2010) for the "Base Case" (see Technical Memorandum 2-2, *Water Balance/Operations Model*), the areal extent of deepwater pool habitat at flows exceeding 42,200 cfs was assumed to equal the extent at that flow level.

Estimates of the areal extent of the deepwater pools were subsequently calculated for the modeled mean monthly flows under the Environmental Baseline simulation for each individual month from February through November (over the entire simulation period from WY 1922 through WY 2008) using linear interpolation between the flow values specified above and the associated areas of deepwater pool habitat. The period of February through November represents the months when adult green sturgeon may potentially be holding, including the pre-spawning holding, spawning, and post-spawning periods (Adams et al. 2002; Klimley et al. 2007).

Based on the estimated deepwater pool habitat areas calculated for each mean daily flow of the simulated hydrologic period of record for the Environmental Baseline, deepwater adult holding habitat duration curves were developed for each month of the evaluation period (i.e., February through November). The deepwater adult holding habitat duration curves were constructed in the same manner as a flow duration curve, but used estimates of deepwater adult holding habitat availability instead of flows as the ordered data. The product of the deepwater adult holding habitat duration analysis served as a record of mean monthly deepwater habitat availability in acres, presented as an exceedance curve, for each month of the year over the hydrologic period of record. The duration analysis also included generating deepwater habitat availability duration metrics.

In addition to areal extent of deepwater pool habitat availability, analyses were conducted to examine the change in depth of pools downstream of Daguerre Point Dam associated with change in flow at the Marysville Gage. The average and maximum change in water depth of the pools associated with change in discharge were normalized and expressed as inches per 100 cfs between each specified flow.

In addition to flow-related effects assessments, water temperature-related effects also are evaluated for green sturgeon. The evaluation of water temperature-related effects on critical habitat for green sturgeon in this BA utilizes water temperature index values identified by Yuba Accord RMT (2013). The following discussion regarding water temperature requirements for the various lifestages of green sturgeon is taken from Yuba Accord RMT (2010b).

The habitat requirements of green sturgeon are not well known. In the Klamath River, the water temperature tolerance of immigrating adult green sturgeon reportedly ranges from 44.4°F to 60.8°F. Reportedly, no green sturgeon were found in areas of the river outside this surface water temperature range (USFWS 1995a).

Green sturgeon reportedly tolerate spawning water temperatures ranging from 50°F to 70°F (CDFG 2001). Water temperatures tolerances for green sturgeon during spawning and egg incubation also have been reported to range between 46° to 57°F (NMFS 2009c), although eggs have been artificially incubated at temperatures as high as 60°F (Deng 2000 as cited in NMFS 2009c). Suitable water temperatures for egg incubation in green sturgeon reportedly ranges between 52°F and 63°F (optimally between 57-61°F) with lethal temperatures approaching 73°F (Van Eenennaam et al. 2005). Water temperatures above 68°F are reportedly lethal to North American green sturgeon embryos (Cech et al. 2000; Beamesderfer and Webb 2002).

Water temperatures not exceeding 62.6°F have been reported to permit normal North American green sturgeon larval development (Van Eenennaam et al. 2005 as cited in Heublein et al. 2009). Werner et al. (2007) suggests temperatures remain below 68°F for larval development. Temperatures of about 59°F are believed to be optimal for larval growth, whereas temperatures below about 52°F or above about 66°F may be detrimental for growth (Cech et al. 2000).

NMFS (2009c) reports optimal water temperatures for the development of green sturgeon egg, larval, and juvenile lifestages ranging between 52°F and 66°F. Growth of juvenile green sturgeon is reportedly optimal at 59°F and reduced at both 51.8°F and 66.2°F (Cech et al. 2000). According to NMFS (2009c) suitable water temperatures for juvenile green sturgeon should be below about 75°F. At temperatures above about 75°F, juvenile green sturgeon exhibit decreased swimming performance (Mayfield and Cech 2004) and increased cellular stress (Allen et al. 2006).

Consistent with Yuba Accord RMT (2013), the water temperature-related assessment for green sturgeon critical habitat evaluates the differences in the probability of occurrence that water temperatures at Daguerre Point Dam and at the Marysville Gage in the lower

Yuba River are within reported suitable ranges for each of the lifestages (**Table 6-4**), under the Cumulative Condition relative to the Environmental Baseline.

Table 6-4. Green sturgeon lifestage-specific water temperature index value ranges and associated periodicities.

Lifestage	Water Temperature Range	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult Immigration and Holding	44°F – 61°F				▨	▨	▨	▨	▨																
Spawning and Embryo Incubation	46°F – 63°F					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨										
Post-Spawning Holding	44°F – 61°F					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		
Juvenile Rearing and Outmigration	52°F – 66°F	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨

OTHER FUTURE NON-FEDERAL ACTIVITIES

The cumulative effects assessment includes identification of other future non-Federal activities that are reasonably certain to occur in the Action Area, with particular reference to the lower Yuba River. Identified activities will be evaluated as to whether they have the potential to affect listed species or their critical habitat including any effects related to instream flows and water temperatures.

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7.0 Effects of the Proposed Action

Under the aggregate effects assessment approach, the Environmental Baseline and the status of the species are viewed together to determine the ability of each listed species to withstand additional stressors or the exacerbation of existing stressors. As the NMFS (1999) policy document states: "[i]*f the species' status is poor and the baseline is degraded at the time of consultation, it is more likely that any additional adverse effects caused by the proposed or continuing action will be significant*".

7.1 Assessment of the Environmental Baseline

Past, present, and future effects associated with the physical presence of the existing facilities at Daguerre Point Dam are included in the Environmental Baseline. With the exception of potential effects related to fish ladder performance associated with authorized discretionary operations and maintenance activities at Daguerre Point Dam, the Corps does not have the authority or discretion to lessen other stressors associated with these facilities. Therefore, it is appropriate that the ongoing impacts from the stressors associated with the continued existence of Daguerre Point Dam are included in the Environmental Baseline. The limiting factors, threats and stressors associated with the Environmental Baseline, which have led to the current status of each of the listed species, are described in detail in Chapter 4 of this BA and are summarily discussed by ESU and DPS below, followed by Environmental Baseline stressors in the Action Area of the lower Yuba River, to provide context for the aggregate effects analysis.

7.1.1 Spring-run Chinook Salmon ESU

The key limiting factors, threats and stressors associated with the Environmental Baseline affecting the spring-run Chinook salmon ESU include the following.

- ☐ Habitat Blockage
- ☐ Water Development

☐ Water Conveyance and Flood Control

☐ Land Use Activities

☐ Water Quality

☐ Non-Native Invasive Species

☐ Hatchery Operations and Practices

☐ Disease and Predation

☐ Overutilization (ocean commercial and sport harvest, inland sport harvest)

☐ Environmental Variation (natural environmental cycles, ocean productivity, global climate change, ocean acidification)

The Central Valley spring-run Chinook salmon ESU continues to display broad fluctuations in abundance. According to NMFS (2011a), recent anomalous conditions in the coastal ocean, along with consecutive dry years affecting inland freshwater conditions, have contributed to statewide spring-run Chinook salmon escapement declines. As a species' abundance decreases, and spatial structure of the ESU is reduced, a species has less flexibility to withstand changes in the environment.

The BO for the CVP/SWP OCAP consultation (NMFS 2009a) covered CVP and SWP facilities and potentially affected waterbodies. The lower Yuba River is not included in the CVP or SWP, and spring-run Chinook salmon would not be affected by CVP/SWP operations while in the lower Yuba River. However, the Yuba River spring-run Chinook salmon population would be subject to CVP/SWP operational and ESU-wide effects associated with the Environmental Baseline while in their migratory lifestages in the lower Feather River, lower Sacramento River, and the Delta, as well as in the Pacific Ocean. The NMFS (2009a) BO, therefore, is used in this BA for an assessment of the entire Central Valley spring-run Chinook salmon ESU.

NMFS' evaluation of potential effects of the CVP/SWP OCAP (NMFS 2009a) included an assessment of the VSP parameters of abundance, productivity, spatial structure, and diversity. Regarding abundance, NMFS (2009a) stated that long-term CVP/SWP system-wide operations are expected to result in substantial mortality to juvenile spring-run Chinook salmon, and that CVP/SWP-related entrainment into the Central and South

Delta greatly increase the risk of mortality from direct (entrainment and impingement at the pumps) and indirect (predation) effects. NMFS (2009a) also stated that population growth rate of spring-run Chinook salmon would be expected to decline in the future.

According to NMFS (2009a), operations of the CVP and SWP reduce the population's current spatial structure (by reducing habitat quantity and quality) and negatively affect the diversity of spring-run Chinook salmon in the mainstem Sacramento River. CVP/SWP operations are expected to continue these effects. The operations of the DCC, and historical operations of RBDD have affected the temporal distribution of adult spring-run on their spawning migration to mainstem Sacramento River spawning grounds, and potentially result in introgression with fall-run Chinook salmon and continues the pattern of genetic introgression and hybridization that has occurred since RBDD was built in the late 1960s (CDFG 1988; NMFS 2004b; TCCA 2008 as cited in NMFS 2009a). In addition, the FRFH program has affected the diversity of the Central Valley spring-run Chinook salmon and, together with the loss of the San Joaquin River Basin spring-run populations, the diversity of the Central Valley spring-run Chinook salmon ESU has been reduced (NMFS 2004).

Critical habitat for spring-run Chinook salmon is composed of PCEs that are essential for the conservation of the species, including but not limited to, spawning habitat, rearing habitat, migratory corridors, and estuarine areas. Most of the historic spawning and rearing habitat for the Central Valley spring-run Chinook salmon ESU is above impassable dams. According to NMFS (2009a), substantial habitat degradation and alteration also has affected the rearing, migratory, and estuarine areas used by spring-run Chinook salmon. Some general examples of how spring-run Chinook salmon critical habitat has been degraded include the loss of natural river function and floodplain connectivity through levee construction, and direct losses of floodplain and riparian habitat, effects to water quality associated with agricultural, urban, and industrial land use, and substantial changes to Delta estuarine habitat (NMFS 2009a).

Due to past and ongoing effects, the current condition of spring-run Chinook salmon critical habitat is considered to be highly degraded, and does not provide the conservation value necessary for the survival and recovery of the species (NMFS 2009a). In addition, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley et al. 2007).

According to NMFS (2009a), all of the above factors, which reduce the spatial structure, diversity, and abundance, compromise the capacity for the spring-run Chinook salmon ESU to respond and adapt to environmental changes. NMFS' VSP analysis at the population and diversity group scales showed reduced viability of extant spring-run Chinook salmon populations and diversity groups. Additionally, high quality critical habitat containing spawning sites with adequate water and substrate conditions, or rearing sites with adequate floodplain connectivity, cover, and water conditions (i.e., key PCEs of critical habitat that contribute to its conservation value) is considered to be limited. Future projections over the duration of evaluated long-term CVP/SWP operations (i.e., through 2030), considering both increasing water demands and climate change, exacerbate risks to the Central Valley spring-run Chinook salmon ESU. NMFS (2009a) stated that the Central Valley spring-run Chinook salmon ESU is at moderate risk of extinction.

NMFS (2009a) concluded that long-term CVP/SWP operations are likely to jeopardize the continued existence of Central Valley spring-run Chinook salmon, and are likely to destroy or adversely modify critical habitat for Central Valley spring-run Chinook salmon.

NMFS (2009a) initially attempted to devise a RPA for spring-run Chinook salmon and its critical habitat by modifying CVP/SWP project operations (e.g., timing/magnitude of releases from dams, closure of operable gates and barriers, and reductions in negative flows). In some cases, however, altering CVP/SWP project operations was not sufficient to ensure that the CVP and SWP projects would be likely to avoid jeopardizing the species or adversely modifying critical habitat. Consequently, NMFS (2009a) developed focused actions designed to compensate for particular stressors, considering the full range of authorities that Reclamation and DWR may use to implement these actions. NMFS concentrated on actions that have the highest likelihood of alleviating the stressors with the most significant effects on the species, rather than attempting to address every project stressor for each species or every PCE for critical habitat.

The NMFS (2009a) RPA is composed of numerous elements for each of the various CVP/SWP project divisions and associated stressors. NMFS recognized that the RPA must be an alternative that is likely to avoid jeopardizing listed species or adversely modifying their critical habitats, rather than a plan that will achieve recovery. Short-term actions are presented in NMFS (2009a) for each division of the CVP/SWP, and are summarized for each species to ensure that the likelihood of survival and recovery is not appreciably reduced in the short term (i.e., one to five years). In addition, because evaluated long-term CVP/SWP system-wide operations extend until 2030, the consultation also included long-term actions that NMFS identified as being necessary to address CVP/SWP project-related adverse effects on the likelihood of survival and recovery of the species over the next two decades. However, the Federal Court for the Eastern District of California held that the jeopardy conclusion of the 2009 NMFS BO was correct, but that the RPA actions were not adequately justified or supported by the record. The NMFS 2009 BO was remanded (Consol. Salmonid Cases, 791 F. Supp. 2d 802 (E.D. Cal. 2011)).

For the ESU-wide Environmental Baseline effects assessment of the spring-run Chinook salmon, NMFS (2009a) found that the entire suite of limiting factors, threats and stressors associated with the Environmental Baseline result in an unstable ESU at moderate risk of extinction.

7.1.2 Steelhead DPS

The aforementioned list of limiting factors and stressors pertinent to the spring-run Chinook salmon ESU also pertain to the steelhead DPS. Stressors that are unique to the steelhead DPS, or substantially differ in the severity from the stressor for the previously described spring-run Chinook salmon ESU, are discussed in Chapter 4 of this BA and include the following.

- ☐ Destruction, Modification, or Curtailment of Habitat or Range

- ☐ Overutilization for Commercial, Recreational, Scientific or Education Purposes (inland sport harvest)
- ☐ Disease and/or Predation
- ☐ Inadequacy of Existing Regulatory Mechanisms (Federal efforts, non-Federal efforts)
- ☐ Other Natural and Man-Made Factors Affecting the Continued Existence of the DPS
- ☐ Non-Lifestage Specific Threats and Stressors for the DPS (artificial propagation programs, small population size, genetic integrity and long-term climate change)

As previously discussed for the Central Valley spring-run Chinook salmon ESU, the BO for the CVP/SWP OCAP consultation (NMFS 2009a) covered CVP and SWP facilities and potentially affected waterbodies, which did not include the lower Yuba River.

NMFS (2009a) stated that CVP/SWP system-wide operations are expected to result in direct mortality to steelhead, including: (1) increased predation of juveniles when the RBDD gates are down; (2) entrainment of juveniles into the Central and South Delta; (3) entrainment and impingement of juveniles at the CVP/SWP pumps in the South Delta (both direct and indirect loss); and (4) loss associated with the collection, handling, trucking and release program.

According to NMFS (2009a), steelhead habitat conditions in the mainstem Sacramento River and the Delta have been adversely affected by long-term CVP/SWP system-wide operations in several ways, including but not limited to: (1) delaying the upstream migration of adult steelhead through RBDD operations; (2) reducing the availability of quality rearing habitat through the seasonal creation of Lake Red Bluff; and (3) creating improved feeding opportunities at RBDD for predators such as pikeminnow and striped bass. In these ways, the CVP/SWP system-wide operations reduced the population’s spatial structure (by reducing habitat quantity and quality), which increases the risk of extinction of the mainstem Sacramento River steelhead population (NMFS 2009a). Beginning in September 2011 and implemented in response to the NMFS OCAP BO (2009a), the RBDD gates were permanently raised, which has likely improved fish passage conditions at the RBDD. The Red Bluff Fish Passage Improvement Project, which included construction of a pumping plant to allow for diversion of water from the Sacramento River without closing the RBDD gates, was completed in 2012 (Tehama-Colusa Canal Authority 2012).

NMFS (2009a) stated that the diversity of mainstem Sacramento River steelhead also may be affected by CVP/SWP system-wide operations due to changed thermal regimes and food web structures in the Sacramento River such that a resident life history strategy may have fitness advantages over anadromous forms, although little is known about the relationship of resident and anadromous forms of *O. mykiss*. Without knowing the roles that resident *O. mykiss* play in population maintenance and persistence of anadromous *O. mykiss*, it is difficult to assess whether the current conditions on the Sacramento River, which may favor residency, are detrimental to the anadromous population in the Sacramento River or not (Lindley et al. 2007). In addition, widespread hatchery steelhead production within this DPS also raises concerns about the potential ecological interactions between introduced stocks and native stocks (Corps 2007).

According to NMFS (2009a), critical habitat for steelhead is composed of PCEs that are essential for the conservation of the species including, but not limited to, spawning habitat, rearing habitat, migratory corridors, and estuarine areas. Based on the host of stressors to spawning, rearing, migratory, and estuarine habitats in the Central Valley, it is apparent that the current condition of steelhead critical habitat is degraded, and does not provide the conservation values necessary for the survival and recovery of the species (NMFS 2009a).

NMFS (2009a) stated that CVP/SWP system-wide operations are expected to place critical habitat for mainstem Sacramento River steelhead at considerable risk. The status of steelhead critical habitat, within the mainstem Sacramento River is suggested by NMFS (2009a) to be substantially degraded due to factors such as warm water temperatures and low flows, loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, loss of tidal wetland habitat, a collapsed pelagic community in the Delta, and poor water quality associated with agricultural, urban, and industrial land use. Additionally, NMFS (2009a) stated that climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions. Estuarine habitats also have been substantially degraded (e.g., Sommer et al. 2007) and climate change is expected to further alter these habitats through sea level rise and hydrological changes.

As described by NMFS (2009a), there are few data with which to assess the status of Central Valley steelhead populations. According to NMFS (2009a), data are lacking to suggest that the Central Valley steelhead DPS is at low risk of extinction, or that there are viable populations of steelhead anywhere in the DPS. Conversely, NMFS (2009a) states that there is evidence to suggest that the Central Valley steelhead DPS is at moderate or high risk of extinction. Most of the historical habitat once available to steelhead has been lost, and the observation that anadromous *O. mykiss* are becoming rare in areas where they were probably once abundant indicates that an important component of life history diversity is being suppressed or lost (NMFS 2009a). Lindley et al. (2007) stated that even if there were adequate data on the distribution and abundance of steelhead in the Central Valley, approaches for assessing steelhead population and DPS viability might be problematic because the effect of resident *O. mykiss* on the viability of steelhead populations and the DPS is unknown.

NMFS (2009a) concluded that long-term CVP/SWP operations are likely to jeopardize the continued existence of Central Valley steelhead and are likely to destroy or adversely modify critical habitat for Central Valley steelhead.

NMFS (2009a) developed RPA actions for each of the various CVP/SWP project divisions and associated waterbodies to avoid jeopardy and adverse modification of critical habitat. However, as previously discussed, the Federal Court for the Eastern District of California held that the jeopardy conclusion of the 2009 NMFS BO was correct, but that the RPA actions were not adequately justified or supported by the record. The NMFS 2009 BO was remanded (Consol. Salmonid Cases, 791 F. Supp. 2d 802 (E.D. Cal. 2011)).

For the DPS-wide Environmental Baseline effects assessment of steelhead, NMFS (2009a) found that the entire suite of limiting factors, threats and stressors associated with the Environmental Baseline result in an unstable DPS at moderate or high risk of extinction.

7.1.3 Southern DPS of North American Green Sturgeon

The key limiting factors, threats and stressors associated with the Environmental Baseline affecting the Southern DPS of North American green sturgeon, discussed in Chapter 4 of this BA, include the following.

- ❑ Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range (reduction in spawning habitat, alteration of habitat – flows, water temperatures, delayed or blocked migration, impaired water quality, dredging and ship traffic, ocean energy projects)
- ❑ Commercial, Recreational, Scientific or Educational Overutilization
- ❑ Disease and Predation
- ❑ Inadequacy of Existing Regulatory Mechanisms
- ❑ Other Natural and Man-Made Factors Affecting the Species' Continued Existence (non-native invasive species, entrainment)

As discussed in Chapter 4, about 217 green sturgeon have been acoustically-tagged in the Central Valley (CFTC 2012 as cited in YCWA 2013a). However, the current status of Southern DPS of North American green sturgeon abundance and productivity is unknown (NMFS 2009a). CVP/SWP system-wide operations, including closures of the ACID dam and the RBDD gates historically resulted in increased loss of individual fish and reduced abundance of adult fish in the green sturgeon population (NMFS 2009a). Closure of the gates at RBDD from May 15 through September 15 previously precluded all access to green sturgeon spawning grounds above the dam during that time period. However, as previously discussed, the RBDD gates were permanently raised during September 2011. With the RBDD gates raised, Vogel (2011) reports that green sturgeon have unimpeded access to upstream reaches as far as the ACID dam near Redding, CA.

Larval and juvenile green sturgeon entrainment or impingement from screened and unscreened agricultural, municipal, and industrial water diversions along the Sacramento River and within the Delta also are considered important threats (71 FR 17757).

The Southern DPS of North American green sturgeon is at substantial risk of future population declines (NMFS 2009a). The potential threats faced by green sturgeon include increased vulnerability due to the reduction of spawning habitat into one concentrated area on the Sacramento River, lack of good empirical population data, vulnerability of long-term cold water supply for egg incubation and larval survival, loss of juvenile green sturgeon due to entrainment at the project fish collection facilities in the South Delta and agricultural diversions within the Sacramento River and Delta systems, alterations of food resources due to changes in the Sacramento River and Delta habitats, and exposure to various sources of contaminants throughout the basin to juvenile, sub-adult, and adult lifestages (NMFS 2009a).

According to NMFS (2009a), past RBDD gate closures blocking access to upstream spawning areas decreased the productivity and spatial structure of the green sturgeon population. Fish forced to spawn below RBDD were believed to have a lower rate of spawning success compared to those fish that spawned above the RBDD. Furthermore, NMFS (2009a) stated that reductions in genetic diversity may occur due to the separation of upstream and downstream populations created anthropogenically by the closure of the RBDD. When the gates were down, RBDD precluded access to 53 miles of spawning habitat for 35-40 percent of the spawning population of green sturgeon. NMFS (2009a) mandated an RPA action for RBDD that required the gates to be raised year-round by 2012. As previously discussed, the Red Bluff Diversion Dam Fish Passage Improvement Project was completed in 2012. At the time that NMFS conducted the consultation for the CVP/SWP OCAP, green sturgeon critical habitat had been proposed but a final rule designating critical habitat had not yet been adopted. NMFS (2009a) therefore referred to “proposed” green sturgeon critical habitat in its evaluations.

According to NMFS (2009a), the proposed critical habitat at that time for the Southern DPS of North American green sturgeon is degraded over its historical conditions. It does not provide the full extent of conservation values necessary for the recovery of the species, particularly in the upstream riverine habitat. In particular, passage and water flow PCEs have been impacted by human actions, substantially altering the historical river characteristics in which green sturgeon evolved. In addition, the alterations to the Delta may have a particularly strong impact on the survival and recruitment of juvenile green sturgeon due to the protracted rearing time in the delta and estuary. Loss of individuals during this phase of the life history of green sturgeon represents losses to multiple year classes rearing in the Delta, which can ultimately impact the potential population structure for decades to come (NMFS 2009a).

NMFS (2009a) stated that CVP/SWP system-wide operations are expected to reduce the conservation value of green sturgeon critical habitat. The principal factor for the decline of green sturgeon reportedly comes from the reduction of green sturgeon spawning habitat to a limited area of the Sacramento River (70 FR 17391). The potential for catastrophic events to affect such a limited spawning area increases the risk of the green sturgeon’s extirpation. The value of the upstream migration corridor is currently degraded mainly by the installation of the ACID dam (NMFS 2009a). Elevated water temperatures in the spawning and rearing habitat likely also pose threats to this species (70 FR 17391). The effects of future CVP/SWP system-wide operations under climate change scenarios would likely further degrade the water quality PCE.

As described by NMFS (2009a), there are few data with which to assess the status of green sturgeon in the Central Valley domain. NMFS (2009a) stated that the green sturgeon DPS is data deficient. Nonetheless, NMFS (2009a) concluded that the Southern DPS of North American green sturgeon remains vulnerable to becoming endangered in the future. Key factors upon which this conclusion was based include: (1) the DPS is comprised of only one spawning population, which has been blocked from a considerable portion of its potential spawning range by dams; (2) the DPS has a risk associated with catastrophes and environmental perturbations (i.e., water temperatures from Shasta Dam) affecting current spawning areas; and (3) mortality rates have significant effects on the adult and sub-adult life history phases of this long-lived species (NMFS 2009a).

NMFS (2009a) concluded that continued operations of the CVP/SWP would be expected to have population level consequences for the single extant population in the mainstem

Sacramento River, and greatly increase the extinction risk of the species (NMFS 2009a). Additionally, NMFS (2009a) concluded that the conservation value of the critical habitat, as designated for the conservation of green sturgeon, would be reduced.

NMFS (2009a) developed a RPA for green sturgeon in order to avoid jeopardy and adverse modification of critical habitat. The green sturgeon RPA specifies many significant actions that will reduce the adverse effects of the continued operation of the CVP/SWP and bring about the proper functioning of PCEs of its proposed critical habitat (NMFS 2009a).

The entire suite of limiting factors, threats, and stressors associated with the Environmental Baseline are likely to jeopardize the continued existence of the Southern DPS of North American green sturgeon (NMFS 2009a).

7.1.4 Lower Yuba River

The vast majority of the available information for the lower Yuba River addresses spring-run Chinook salmon where specifically identified, Chinook salmon in general where runs are not specifically identified, and *O. mykiss* (anadromous and resident forms). There is a paucity of information available regarding green sturgeon in the lower Yuba River.

Anadromous salmonid populations in the Yuba River watershed have endured nearly 150 years of intense human degradation of their riverine habitat, starting with hydraulic gold mining in the mid-nineteenth century, and continuing through the construction of dams and the ongoing development of water for hydropower and consumptive uses (NMFS 2007). According to UC Davis Professor Dr. Gregory Pasternack, "*the LYR is moving along on a path of natural, self-driven ecological recovery that is directly attributable to the existence of Englebright Dam. Englebright Dam protects the river from the vast wastes of a degraded watershed blocked upstream*" (see Appendix B, Attachment 3).

For this BA, the assessment of the Environmental Baseline within the Action Area for listed fish species considers: (1) past, present and ongoing limiting factors, threats and stressors described in Chapter 4; (2) full implementation of the Yuba Accord, which has occurred as a pilot program basis since 2006; and (3) the results of available lower Yuba

River fisheries monitoring data, current status of the listed species and the viability of these species as discussed in detail in Chapter 4.

It is problematic to incrementally assess the magnitude of an individual stressor because of the interconnectivity of individual stressors, and because the entire suite of limiting factors, threats and stressors associated with the Environmental Baseline has resulted in the current status and viability of the listed species within the Action Area. Nonetheless, based upon available information (see Chapter 4 of this BA) the following sections discuss, to the extent possible, each of the stressors associated with the Environmental Baseline regarding the relative magnitude of its contribution to the current status and viability of each listed species in the lower Yuba River.

7.1.4.1 Spring-run Chinook Salmon

The key limiting factors, threats and stressors associated with the Environmental Baseline affecting the spring-run Chinook salmon in the lower Yuba River include the following.

- ☐ Passage Impediments/Barriers
- ☐ Poaching
- ☐ Entrainment
- ☐ Loss of Natural River Morphology and Function
- ☐ Loss of Riparian Habitat and Instream Cover (riparian vegetation, instream woody material)
- ☐ Harvest/Angling Impacts
- ☐ Loss of Floodplain Habitat
- ☐ Predation
- ☐ Physical Habitat Alteration (including Waterway 13)
- ☐ Hatchery Effects (FRFH genetic considerations, straying into the lower Yuba River) and other genetic considerations

PASSAGE IMPEDIMENTS/BARRIERS

As described in Chapter 4 (Status of the Species), Englebright Dam presents an impassable barrier to the upstream migration of anadromous salmonids, and marks the upstream extent of currently accessible spring-run Chinook salmon habitat in the lower

Yuba River, whereas Daguerre Point Dam presents an impediment to upstream migration in the Action Area.

BARRIERS UPSTREAM OF THE ACTION AREA (ENGLEBRIGHT DAM)

Although located upstream of the Action Area, NMFS (2007, 2009) reports that the greatest impact to listed anadromous salmonids in the Yuba River watershed is the complete blockage of access for these species to their historical spawning and rearing habitat above Englebright Dam. Because this historic habitat is no longer accessible, spring-run Chinook salmon and steelhead are relegated to the 24 miles of the lower Yuba River from Englebright Dam to the confluence with the lower Feather River. Since construction of Englebright Dam in 1941, these species are required to complete all of their riverine lifestages in the 24 miles of the lower Yuba River, which previously served primarily as a migratory corridor to upstream spawning and rearing habitats.

The long-standing effects of Englebright Dam on the status of spring-run Chinook salmon and steelhead have affected the viability of these populations in the Yuba River. The lack of access to historic habitats upstream of Englebright Dam has reduced all four VSP parameters (abundance, productivity, spatial structure and genetic diversity) for spring-run Chinook salmon (and steelhead). Although the effects of the presence of Englebright Dam persist and continue to affect the status of the species in the Action Area, recent actions have ameliorated some of the stressors on these populations, which now are restricted to the lower Yuba River.

The NMFS (2009) Draft Recovery Plan states that, for currently occupied habitats below Englebright Dam, it is unlikely that habitats can be restored to pre-dam conditions, but many of the processes and conditions that are necessary to support viable independent populations of spring-run Chinook salmon and steelhead can be improved with provision of appropriate instream flow regimes, water temperatures, and habitat availability. Flow schedules specified in the Fisheries Agreement of the Yuba Accord were first implemented on a pilot program basis in 2006 and 2007, and then were implemented on a long-term basis in 2008, after the SWRCB made the necessary changes to YCWA's water right permits. Continued implementation of the Yuba Accord addresses flow-related major stressors, including flow-dependent habitat availability, flow-related habitat complexity and diversity, and water temperatures, and considerably improves conditions in the lower Yuba River (NMFS 2009).

Related to external influences in the upper Yuba River watershed that have the potential to affect the status of listed species present in the Action Area, NMFS (2007) identified the following non-flow related stressors associated with Englebright Dam: (1) blocking access of listed salmonids to the habitat above the dam; (2) forcing overlapping use of the same spawning areas by spring and fall-run Chinook salmon below the dam; (3) forcing fish to spawn in a limited area without the benefit of smaller tributaries, which can provide some level of refuge in the event of catastrophic events; and (4) preventing the recruitment of spawning gravel and LWM from upstream of the dam into the lower river.

Information developed since 2007 provides clarification regarding the fourth component in the foregoing list of stressors, as well as the influence of fluvial geomorphological processes affecting PCEs in the Action Area of the lower Yuba River.

The fluvial geomorphology of the Yuba River is so unique that it is crucial to evaluate it on its own terms and not to apply simple generalizations and concepts from other rivers with dams (Pasternack 2010). First, unlike most other rivers below dams, lack of spawning gravel is not limiting in the lower Yuba River, with the localized exception of the Englebright Dam Reach of the river, which extends from immediately downstream of Englebright Dam to the vicinity of the confluence with Deer Creek. In this reach, no rounded river gravels/cobbles, suitable for spawning, were present until a small amount (about 500 tons) of gravel was injected artificially by the Corps in the Narrows II pool area of the Englebright Dam Reach during November 2007 and the subsequent injections by the Corps of: (1) 5,000 tons of suitable spawning substrate downstream of the Narrows I powerhouse during the fall of 2010 extending to January 2011; (2) 5,000 tons of suitable spawning substrate downstream of the Narrows I powerhouse during July and August of 2012; and (3) 5,000 tons in the Englebright Dam Reach during July and August of 2013.

In the Timbuctoo Bend area of the lower Yuba River, Pasternack (2008) reported that there is adequate physical habitat to support spawning of Chinook salmon and steelhead. Farther downstream, spawning habitat does not appear to be limited by an inadequate supply of gravel within the Parks Bar and Hammon Bar reaches of the lower Yuba River, due to ample storage of mining sediments in the banks, bars, and training walls (cbec and McBain & Trush 2010). For the remainder of the lower Yuba River, Beak Consultants, Inc (1989) stated that the spawning gravel resources in the river are considered to be excellent based on the abundance of suitable gravels, and that the tremendous volumes of gravel remaining in the river as a result of hydraulic mining make it unlikely that spawning gravel will be in short supply in the foreseeable future.

Pasternack (2010) concluded that because of the pre-existing, unnatural condition of the river corridor influenced by mining debris, Englebright Dam… "*is actually contributing to the restoration of the river toward its historical geomorphic condition, in the truest meaning of the term - going back to the pre-existing state prior to hydraulic gold mining*." He further concluded that most of the lower Yuba River is still geomorphically dynamic and the river has a diversity of in-channel physical habitats, and that because Englebright Dam prevents residual mining wastes from moving downstream into the Action Area, channel complexity and habitat diversity in the lower Yuba River have been re-emerging, and that process continues.

Regarding the recruitment of woody material, some woody material may not reach the lower Yuba River due to collecting on the shoreline and sinking in Englebright Reservoir, or due to New Bullard's Bar Dam blocking natural downstream migration. However, Englebright Dam does not functionally block woody material from reaching the lower Yuba River because any accumulated woody material either spills over the dam during uncontrolled flood events or otherwise is pushed over the dam by the Corps.

In conclusion, the lack of spawning gravel (or recruitment thereof) is not a significant stressor to spring-run Chinook salmon in the lower Yuba River, with the exception of the Englebright Dam Reach. Moreover, the abundance of LWM in the lower Yuba River is not substantively attributable to the presence of Englebright Dam. Ongoing effects associated with Englebright Dam include the loss of historical spawning and rearing habitat above Englebright Dam, resultant loss of reproductive isolation and subsequent hybridization with fall-run Chinook salmon, restriction of spatial structure and associated vulnerability to catastrophic events. Although the genesis of these stressors emanate upstream of the Action Area at Englebright Dam, the manifestation of these stressors affect the current status of the species in the Action Area in the lower Yuba River.

IMPEDIMENTS WITHIN THE ACTION AREA (DAGUERRE POINT DAM)

Adult Upstream Migration

Daguerre Point Dam has been reported to be an impediment to upstream migration of adult salmon and steelhead under certain conditions. When high flow conditions occur during winter and spring, adult spring-run Chinook salmon (and steelhead) have been reported to experience difficulty in finding the entrances to the ladders because of the relatively low amount of attraction flows exiting the fish ladders, compared to the magnitude of the sheet-flow spilling over the top of Daguerre Point Dam. The angles of the fish ladder entrance orifices and their proximities to the plunge pool also increase the difficulty for fish to find the entrances to the ladders. Periodic obstruction of the ladders by sediment and woody debris may temporarily block passage or reduce attraction flows at the ladder entrances.

Other configuration and design features of the fish ladders and passage facilities that reportedly could either delay or impede access to spawning and rearing areas above the dam include: (1) the fish ladder control gate entrance, acting as a submerged orifice, is more passable at low flows (actual flow data are unavailable) during the summer and fall than at high flows during winter and spring; (2) unfavorable within-bay hydraulic characteristics, particularly associated with debris collection; (3) "masking" of the entrances to the ladders when overflow over the spillway occurs; (4) insufficient attraction flows during non-overflow operational conditions; (5) unfavorable fish ladder geometric configurations; (6) proximity of the ladder exits to the spillway, potentially resulting in adult fish exiting the ladder being immediately swept by flow back over the dam; and (7) sediment accumulation and unfavorable habitat conditions at the upstream exits of the fish ladders, resulting in reduced unimpeded passage from the ladders to the main channel, and the potential for fish to "fall-back" into the ladders. In addition, it has been suggested that poaching within the fish ladders and downstream of the dam occurs when fish become concentrated in the area due to delayed passage (NMFS 2005a), although grates have been installed over most of the ladder bays during 2011.

NMFS (2007) suggested that the biological consequences of blockage or passage delays include changes in spawning distribution, increased adult pre-spawning mortality, and decreased egg viability, which may result in the reduction of the abundance and productivity of spring-run Chinook salmon and steelhead. Each of these potential biological consequences is discussed below in consideration of information that has become available since 2007 (also see the discussion regarding fish ladders and fish passage in Chapter 5).

Recent information (2009, 2010 and 2011 acoustic tracking) demonstrates that phenotypic spring-run Chinook salmon (Chinook salmon that enter the lower Yuba River during spring months) display variable upstream migration and holding patterns, and that some fish may remain in the lower Yuba River in areas downstream (and proximate) to Daguerre Point Dam for extended periods of time during the spring and summer. It is uncertain whether, or to what extent, the duration of residency in the large pool located downstream of Daguerre Point Dam is associated with upstream passage impediment and delay, or volitional habitat utilization prior to spawning in upstream areas.

The RMT (2013) examined passage and flow data to evaluate whether upstream passage could be associated with either an ascending or descending hydrograph, or that the fish ladders may impede or prohibit passage at high or low flow levels. Examination of the daily number of adult Chinook salmon passing upstream of Daguerre Point Dam obtained by the VAKI Riverwatcher system from 2004 through 2011, and mean daily flows at the Marysville Gage did not reveal any consistent trend or relationship between adult Chinook salmon passage upstream of Daguerre Point Dam and flow rate. Chinook salmon passage was observed over a variety of flow conditions, including ascending or descending flows, as well as during extended periods of stable flows.

The RMT (2013) further evaluated whether adult Chinook salmon upstream passage through the ladders at Daguerre Point Dam is associated with specific flow levels. They reported that Chinook salmon upstream passage through the ladders at Daguerre Point Dam not only occurs over a wide range of flows but that, at least to some degree, passage occurs during the upstream migration period irrespective of flow rates (over the range of flows examined). In other words, passage occurs at higher flows during “wetter” years characterized by high flows from spring into summer, and at lower flows during "drier" years characterized by low flows from spring into summer. Flow thresholds prohibiting passage of Chinook salmon through the ladders at Daguerre Point Dam were not apparent in the data.

The RMT's 3-year acoustic telemetry study of adult Chinook salmon tagged during the phenotypic adult spring-run Chinook salmon upstream migration period has provided new information to better understand adult spring-run Chinook salmon temporal and spatial distributions in the Yuba River. The results from the acoustic telemetry study found past characterizations of temporal and spatial distributions to be largely unsupported, as adult spring-run Chinook salmon were observed to exhibit a much more diverse pattern of movement, and holding locations in the lower Yuba River were more expansive than has been previously reported (RMT 2013). Observations from the telemetry study identified that a large longitudinal extent of the lower Yuba River was occupied by the tagged spring-run Chinook salmon during immigration and holding periods. Also, temporal migrations to areas upstream of Daguerre Point Dam occurred over an extended period of time. A longitudinal analysis of acoustic tag detection data indicated that distributions were non-random, and that the tagged spring-run Chinook salmon were selecting locations for holding.

Flows under the Yuba Accord have provided adult spring-running Chinook salmon migratory access to areas located throughout the lower Yuba River, as well as a broad expanse of longitudinally distributed areas selected for holding. In general, acoustically-tagged spring-run Chinook salmon exhibited an extended holding period, followed by a rapid movement into upstream areas (i.e., the upper Timbuctoo Reach, Narrows Reach, and Englebright Dam Reach) during September (RMT 2013).

Regarding potential changes in spawning distribution, it is not possible to assess if, or the manner in which, extended duration of holding below Daguerre Point Dam could potentially change spawning distribution, because no base data are available for conditions without the presence of Daguerre Point Dam.

During the RMT's pilot redd survey conducted from the fall of 2008 through spring of 2009, the vast majority (i.e., 96%) of fresh Chinook salmon redds constructed by the first week of October 2008, potentially representing spring-run Chinook salmon, were observed upstream of Daguerre Point Dam. Similar distributions were observed during the other two years of redd surveys, when weekly redd surveys were conducted. About 97% and 96% of the fresh Chinook salmon redds constructed by the first week of October were observed upstream of Daguerre Point Dam during 2009 and 2010, respectively.

The similar percentage distribution of Chinook salmon redds, potentially representing spring-run Chinook salmon, located upstream of Daguerre Point Dam occurred despite considerable differences in flow (monthly average cfs) that occurred from late spring into fall prior to each of the redd survey periods, as indicated below.

	June	July	August	September
Marysville Gage				
2008	597	866	882	622
2009	1,846	1,737	1,715	768
2010	4,067	2,698	1,991	768
Smartsville Gage				
2008	1,334	1,621	1,490	868
2009	2,065	1,992	1,866	832
2010	4,516	3,104	2,273	896

Regarding increased adult prespawning mortality, one way that adult prespawning mortality could occur is the potential for fish to jump out of the fish ladders. Because this phenomenon has rarely been observed or reported historically, and potential effects have been further eliminated/reduced following the installation of locking metal grates over 25 of the 33 unscreened bays of the fish ladders during the summer of 2011, it has likely represented a low impact to Yuba River spring-run Chinook salmon, but nonetheless has been identified as a stressor that could harm adult fish. Another way that adult prespawning mortality could occur is associated with anecdotal reported observations of Chinook salmon (run unspecified) leaping into the downstream face of Daguerre Point Dam, although no information is available regarding the potential extent or frequency of this reported phenomenon. It is possible that prespawning adult mortality could occur from repeated attempts to pass over the dam and injuries resulting from contact with the rough concrete surface of the dam face. However, it is unlikely that this represents a significant source of mortality to spring-run Chinook salmon.

Adult prespawning acute or latent mortality also could occur due to exposure to elevated water temperatures, which could also affect egg viability. The RMT (2013) included evaluation of water temperatures during the spring-run Chinook salmon adult upstream immigration and holding lifestage, which addressed considerations regarding both water temperature effects to pre-spawning adults and egg viability. They found that available water temperature monitoring data at all three gages (i.e., Smartsville, Daguerre Point Dam, Marysville) were always below the upper tolerance WTI values for adult immigration and holding. Thus, it is unlikely that this represents a significant source of mortality to spring-run Chinook salmon.

Juvenile Downstream Migration

Concern has been expressed that if emigrating salmon and steelhead juveniles encounter high water temperatures in the reach below Daguerre Point Dam, they cannot return to the lower-temperature habitat upstream because their passage is blocked by the dam (DWR and Corps 2003). However, this concern was raised prior to implementation of the Yuba Accord minimum flow schedules and associated water temperatures (initiated as a Pilot Program in 2006 and continuing to present). The RMT (2013) also included evaluation of water temperatures in the lower Yuba River during the year-round juvenile rearing period for spring-run Chinook salmon (and steelhead), and found that water temperatures at all three gages (i.e., Smartsville, Daguerre Point Dam, Marysville) were always below the upper tolerance WTI values for the juvenile rearing and outmigration lifestage. Thus, it is unlikely that this represents a significant source of mortality to spring-run Chinook salmon.

Daguerre Point Dam may influence predation rates on emigrant juvenile anadromous salmonids. Although it is recognized that there is a paucity of information regarding predation rates on juvenile salmonids in the lower Yuba River, predation likely represents a stressor of relatively high magnitude to the juvenile rearing lifestage of Yuba River spring-run Chinook salmon. The presence of Daguerre Point Dam may influence predation rates above Daguerre Point Dam compared to below Daguerre Point Dam. The higher abundance of juvenile anadromous salmonids above Daguerre Point Dam may be due to larger numbers of spawners, greater amounts of more complex, high-quality cover, and lower densities of predators such as striped bass and American shad, which reportedly are generally restricted to areas below the dam due to their limited ability to pass through the fish ladders, relative to anadromous salmonids (YCWA et al. 2007). Daguerre Point Dam also may influence localized predation rates by increased predation of juveniles in the plunge pool located immediately downstream of the dam.

Summary

Given the entire suite of considerations associated with the design configuration and features of Daguerre Point Dam and its associated fish ladders that reportedly could either delay or impede adult upstream migration, as well as issues identified regarding juvenile downstream passage, the effects associated with the presence of Daguerre Point Dam likely represent a medium to high stressor to Yuba River spring-run Chinook salmon under the Environmental Baseline.

HARVEST/ANGLING IMPACTS

Angling regulations on the lower Yuba River are intended to protect sensitive species, in particular spring-run Chinook salmon (and wild steelhead). The lower Yuba River from its confluence with the lower Feather River up to Englebright Dam is closed year-round to salmon fishing, and no take or possession of salmon is allowed.

Fishing for hatchery trout or hatchery steelhead is allowed on the lower Yuba River from its confluence with the lower Feather River up to the Highway 20 Bridge year-round. Incidental impacts have the potential to occur to spring-run Chinook salmon through physical disturbance of salmonid redds, and incidental hooking and catch-and-release stress or mortality. However, the lower Yuba River, between the Highway 20 Bridge and Englebright Dam, is closed to fishing from September through November to protect spring-run Chinook salmon spawning activity and egg incubation.

Harvest/angling likely represents a negligible impact to Yuba River adult spring-run Chinook salmon. Hence, harvest/angling is characterized as a stressor of low magnitude to spring-run Chinook salmon.

POACHING

Poaching of adult Chinook salmon at the fish ladders and at the base of Daguerre Point Dam has been previously suggested to represent a stressor to spring-run Chinook salmon. NMFS' Draft Recovery Plan (NMFS 2009) identified poaching as a stressor of "low" importance to spring-run Chinook salmon in the lower Yuba River. The only actual account of documented poaching was provided in a declaration by Nelson (2009) in which he stated that during his tenure at CDFW (which extended until 2006) he personally observed people fishing illegally in the ladders, and further observed gear around the ladders used for poaching. It is not clear regarding the time period to which he was referring, although it may have been referring to the period prior to 2000. The VAKI Riverwatcher infrared and videographic sampling system began operations in 2003. CDFW monitored VAKI Riverwatcher operations at Daguerre Point Dam seasonally from 2003 through 2005, and CDFW and/or PSMFC have monitored the system on an approximate every other day basis, year-round, since 2006. Over this 10-year period, neither CDFW nor PSMFC staff has reported poaching in the ladders, or immediately downstream of Daguerre Point Dam.

More recently, in a July 2011 Court Order, the Federal Court of the Eastern District of California concluded that "*installation of locked metal grates over the Daguerre fish ladders is necessary to prevent irreparable harm to the survival and recovery of the species during the interim period*". In response to the Court's Order, the Corps installed locking metal grates over the Daguerre Point Dam fish ladder bays[1] in August/September 2011 to prevent fish from jumping out of the ladders and to prevent poaching in the fish ladders.

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[1] Excluding the eight bays on the lowermost section of the south fish ladder at Daguerre Point Dam so that CDFW can maintain continued access to the flow modification equipment that is located in the fish ladder and designed to improve fish passage conditions.

The extent to which spring-run Chinook salmon are targeted for poaching in the lower Yuba River is unknown, and it is unclear whether the previous reports of poaching were directed toward spring-run or fall-run Chinook salmon. With the installation of the metal grates over the Daguerre Point Dam fish ladders, poaching likely represents a low (or negligible) stressor to Yuba River adult spring-run Chinook salmon.

PHYSICAL HABITAT ALTERATION

According to NMFS (2009), the stressor associated with physical habitat alteration specifically addressed the issue of return flows and attraction of anadromous salmonids into the Yuba Goldfields through Waterway 13. As previously discussed in Chapter 5, efforts have been undertaken to prevent anadromous salmonids from entering the Goldfields via Waterway 13 during the mid-1980s, 1997, and 2003. In May 2005, heavy rains and subsequent flooding breached the structure at the east (upstream facing) end. Subsequently, the earthen “plug” was replaced with a "leaky-dike" barrier intended to serve as an exclusion device for upstream migrating adult salmonids (AFRP 2010). During July of 2011, it was confirmed that the "leaky-dike" barrier had been washed out, presumably due to high flood flows that occurred during May of 2011. Because of the episodic occurrence of attraction flows emanating from Waterway 13, it likely represents a relatively low stressor to the adult lifestage of Yuba River spring-run Chinook salmon.

In addition to Waterway 13 issues, physical habitat alternation stressors include Lake Wildwood operations, which are controlled by the Lake Wildwood Association, and the potential for stranding of adult Chinook salmon in Deer Creek, near its confluence with the lower Yuba River, due to changes in Lake Wildwood operations. Given the infrequent observation of this phenomenon and the relative magnitude compared to the lower Yuba River, Lake Wildwood operations likely represent a relatively low stressor to the adult lifestage of Yuba River spring-run Chinook salmon.

ENTRAINMENT

Water diversions at and in the vicinity of Daguerre Point Dam in the lower Yuba River generally occur during two seasons. The agricultural irrigation season generally extends from approximately April 1 through mid-October. Additional diversions occur during the waterfowl/straw management season which generally extends from mid-October through January. Overall, diversions are relatively low from January through March, and diversions are highest from May through August.

As described in Chapter 5, a new state-of-the-art fish screen that meets NMFS and CDFW screening criteria was installed at the BVID Pumpline Diversion Facility in 1999 (SWRCB 2001; NMFS 2002; CALFED and YCWA 2005). The SWRCB (2001) determined that the new fish screen at the BVID diversion facility provided adequate protection for juvenile salmonids, and that BVID should continue to operate and maintain the fish screen in compliance with NMFS and CDFW criteria. The BVID diversion is not licensed by the Corps and it has no direct physical link to Corps property.

Under the Environmental Baseline, ongoing effects of diversions at the Hallwood-Cordua and South Yuba/Brophy diversion facilities represent potential threats to juvenile salmonids (NMFS 2009). The relatively recent fish screen constructed at the Hallwood-Cordua diversion is considered a notable improvement over the previous design, and likely has eliminated any significant entrainment at the Hallwood-Cordua diversion.

The issues of impingement and entrainment at the South Yuba/Brophy Diversion Canal and Facilities have been the subject of numerous evaluations over the past many years. NMFS (2007) noted that several studies have suggested that the structure does not exclude juvenile salmonids from being entrained into this diversion. However, Bergman et al. (2013) concluded that present operations at the diversion facility provide adequate bypass flows to create positive sweeping velocities along the rock gabion, and measured approach velocities satisfied NMFS approach velocity standards except at a bend at the upstream end of the rock gabion, where an eddy draws water up-river. The end of the gabion where an eddy draws water up-river was identified because this anomalous area of higher approach velocities did not meet the NMFS (2011d) criteria of providing “nearly uniform” flow distribution along the face of a screen and, thus, may increase susceptibility of juvenile salmonids to impingement or entrainment.

Spring-run Chinook salmon spawn upstream of Daguerre Point Dam, but only a portion of the annual year-class of outmigrant juvenile spring-run Chinook salmon pass Daguerre Point Dam during the diversion season, particularly during the relatively high diversion period extending from May through August. Based on analysis of RST data, most (over 85 percent) of outmigrant juvenile Chinook salmon are captured during the relatively low diversion period extending from late fall through March and therefore would be reasonably assumed to be subjected to commensurate relatively low amounts of entrainment. Also, many of these fish exceed fry size, which is the size most susceptible to entrainment. Consequently, entrainment likely represents a stressor of low to medium magnitude to the juvenile lifestage of Yuba River spring-run Chinook salmon.

PREDATION

The extent of predation on juvenile Chinook salmon in the lower Yuba River is not well documented (NMFS 2009). Although predation is a natural component of salmonid ecology, it has been suggested that the rate of predation of salmonids in the lower Yuba River has potentially increased through the introduction of non-native predatory species such as striped bass, largemouth bass and American shad, and through the alteration of natural flow regimes and the development of structures that attract predators (NMFS 2009).

Daguerre Point Dam creates a large plunge pool at its base, which may provide ambush habitat for predatory fish in an area where emigrating juvenile salmonids may be disoriented after plunging over the face of the dam into the deep pool below (NMFS 2002). It has been suggested that the rate of predation of juvenile salmonids passing over dams in general, and Daguerre Point Dam in particular, may be unnaturally high (NMFS 2007). It also has been suggested that unnaturally high predation rates may also occur in the diversion channel associated with the South Yuba/Brophy diversion (NMFS 2007). Demko and Cramer (2000a) reviewed all studies previously performed at the South Yuba/Brophy diversion, and found that none of the research by USFWS, CDFW, or fisheries consultants had indicated that juvenile Chinook became disoriented upon entering the diversion channel, or that abnormally high predation on juvenile Chinook salmon occurred. Nonetheless, SWRCB (2001) stated that there was no way to prevent water from entering the diversion channel when water was not being diverted into the South Canal for irrigation, and that therefore losses due to predation occur even when no water is being diverted for beneficial use.

Other structure-related predation issues in the Environmental Baseline include the potential for increased rates of predation of juvenile salmonids: (1) in the entryway of the Hallwood-Cordua diversion canal upstream of the fish screen; and (2) at the point of return of fish from the bypass pipe of the Hallwood-Cordua diversion canal into the lower Yuba River. The relatively recent fish screen constructed at the Hallwood-Cordua diversion is considered a notable improvement over the previous design, but the configuration of the bypass return pipe and predation losses of emigrating fry and juvenile Chinook salmon, including spring-run Chinook salmon, remain a concern.

As previously discussed, most juvenile Chinook salmon and steelhead rearing has been reported to occur above Daguerre Point Dam. The higher abundance of juvenile salmonids above Daguerre Point Dam may be due to larger numbers of spawners, greater amounts of more complex, high-quality cover, and lower densities of predators such as striped bass and American shad, which reportedly are generally restricted to areas below the dam (YCWA et al. 2007).

For the purpose of stressor identification in this BA, predation includes the predation associated with increases in predator habitat and predation opportunities for piscivorous species created by major structures and diversions, and predation resulting from limited amounts of prey escape cover in the lower Yuba River. Consequently, predation of juvenile salmonids by introduced and native piscivorous fishes occurs throughout the lower Yuba River potentially at relatively high rates. Therefore, predation likely represents a high stressor to the juvenile lifestage of Yuba River spring-run Chinook salmon.

Loss of Natural River Morphology and Function

The loss of natural river morphology and function is the result of river channelization and confinement, which leads to a decrease in riverine habitat complexity and, thus, to a decrease in the quantity and quality of adult and juvenile anadromous salmonid habitat. This is a particularly operative stressor affecting juvenile anadromous salmonid rearing habitat availability.

From a floodplain meander perspective, braided channels, side channels, and channel sinuosity are created through complex hydraulic-geomorphic interactions. Attenuated peak flows and controlled flow regimes emanating from the upper Yuba River watershed, and the influence of gravel berms along portions of the lower Yuba River have affected the natural meandering of the lower Yuba River in the Action Area. As stated by UC Davis Professor Greg Pasternack (see Appendix B, Attachment 3) "… *the morphology of the LYR is self-determined, dynamic, and increasing habitat complexity over time due to the restorative role of Englebright Dam relative to the vast reservoir and continuing influx of hydraulic mining waste upstream of that barrier. It is true that the LYR's morphology is altering, but all the evidence indicates that the alterations are beneficial, not harmful, and are driven by understandable and beneficial natural processes*". Nonetheless, loss of natural river morphology and function presently continues to represent a relatively high stressor to Yuba River spring-run Chinook salmon under the Environmental Baseline.

LOSS OF FLOODPLAIN HABITAT

Off-channel habitats such as floodplains, riparian, and wetland habitats have been suggested to be of major importance for the growth and survival of juvenile salmon (Moyle 2002). These habitats also promote extended rearing and expression of the stream-type rearing characteristic of spring-run Chinook salmon. Within the Yuba Goldfields area (RM 8–14), confinement of the river by massive deposits of cobble and gravel derived from hydraulic and dredge mining activities resulted in a relatively simple river corridor dominated by a single main channel and large cobble-dominated bars, with little riparian and floodplain habitat (DWR and PG&E 2010).

For this BA, a distinction is made between floodplain habitat and the previously discussed stressors of physical habitat alteration and loss of natural morphology and function, both of which focused on habitat and complexity in the lower Yuba River. Considerations of those stressors included adult and juvenile lifestages. Floodplain habitat, as considered in this section of the BA, is more narrowly focused on the inundation of floodplain habitat and associated effects on juvenile rearing. In consideration that this stressor primarily addresses one lifestage, that inundation of floodplain habitat occurs relatively frequently compared to other Central Valley streams (see Chapter 4), that inundation of floodplain habitat would not necessarily occur each year even under unaltered hydrologic conditions, and that the lower Yuba River floodplain is comprised of unconsolidated alluvium without an abundance of characteristics associated with increased juvenile salmonid growth, loss of floodplain habitat availability likely represents a medium stressor to Yuba River juvenile spring-run Chinook salmon.

LOSS OF RIPARIAN HABITAT AND INSTREAM COVER (RIPARIAN VEGETATION, INSTREAM WOODY MATERIAL)

Mature riparian vegetation is relatively sparse and intermittent along the lower Yuba River, leaving much of the bank areas unshaded. It has previously been reported that relatively low amounts of LWM occur in the lower Yuba River because of the general paucity of riparian vegetation throughout much of the lower Yuba River, and because some of the upstream dams in the upper Yuba River watershed reduce the downstream transport of LWM (cbec and McBain & Trush 2010).

In 2012, YCWA conducted a riparian habitat and woody material studies in the Yuba River from Englebright Dam to the confluence with the Feather River. In the lower Yuba River, although woody material was found to be relatively ubiquitous (see Appendix B, Attachment 3), it was generally found in bands of willow (*Salix sp.*) shrubs near the wetted edge, dispersed across open cobble bars, and stranded above normal high-flow indicators. Most (77-96%) pieces of wood found in each reach surveyed were smaller than 25 feet in length and smaller than 24 inches in diameter, which is the definition of LWM (RMT 2013). The largest size classes of LWM (i.e., longer than 50 feet and greater than 24 inches in diameter) were rare or uncommon (i.e., fewer than 20 pieces total) with no discernible distribution. Pieces of this larger size class were counted as “key pieces”, as were any pieces exceeding 25 inches in diameter and 25 feet in length and showing any morphological influence (e.g., trapping sediment or altering flow patterns). A total of 15 key pieces of LWM were found in all study sites, including six in the Marysville study site. Few of the key pieces were found in the active channel or exhibiting channel forming processes. As previously discussed, the abundance of LWM in the lower Yuba River is not substantively attributable to the presence of Englebright

Dam upstream of the Action Area because accumulated woody material spills over the dam during uncontrolled flood events and otherwise is pushed over by the Corps.

LWM creates both micro- and macro-habitat heterogeneity by forming pools, back eddies and side channels and by creating channel sinuosity and hydraulic complexity. This habitat complexity provides juvenile salmonids numerous refugia from predators and water velocity, and provides efficient locations from which to feed. Snorkeling observations in the lower Yuba River have indicated that juvenile Chinook salmon had a strong preference for near-shore habitats with instream woody material (JSA 1992).

In consideration of the importance that riparian vegetation and LWM play in the habitat complexity and diversity which potentially limits the productivity of juvenile salmonids, the abundance and distribution of these physical habitat characteristics in the lower Yuba River, and the fact that the present availability of riparian habitat and instream cover (in the form of LWM) is a stressor that is manifested every year, it represents a stressor of relatively high magnitude to Yuba River juvenile spring-run Chinook salmon.

HATCHERY EFFECTS (FRFH GENETIC CONSIDERATIONS, STRAYING INTO THE LOWER YUBA RIVER) AND OTHER GENETIC CONSIDERATIONS

FRFH hatchery spring-run Chinook salmon straying into the lower Yuba River and interbreeding with naturally-spawning Yuba River spring-run Chinook salmon has been suggested to represent a threat to the genetic integrity of the naturally-spawning spring-run Chinook salmon population in the lower Yuba River. This suggested threat raises the question of the present genetic integrity of the fish expressing phenotypic characteristics of spring-run Chinook salmon in the lower Yuba River.

Between 1900 and 1941, debris dams constructed on the lower Yuba River by the California Debris Commission completely or partially blocked the migration of Chinook salmon and steelhead to historic spawning and rearing habitats. Upstream of the Action Area, Englebright Dam (constructed in 1941) continues to completely block spawning runs of Chinook salmon and steelhead, and is the upstream limit of anadromous salmonid migration. CDFG (1991) reported that a small spring-run Chinook salmon population historically occurred in the lower Yuba River, but the run virtually disappeared by 1959.

Since the completion of New Bullards Bar Reservoir in 1970 by YCWA, higher, colder flows in the lower Yuba River have improved conditions for over-summering and spawning of spring-run Chinook salmon in the lower Yuba River downstream of Englebright Dam (YCWA et al. 2007). As of 1991, a remnant spring-run Chinook salmon population reportedly persisted in the lower Yuba River downstream of Englebright Dam, maintained by fish produced in the lower Yuba River, fish straying from the Feather River, or fish previously and infrequently stocked from the FRFH (CDFG 1991).

If spring-run Chinook salmon were extirpated from the lower Yuba River in 1959 and, as reported by CDFG (1991), a population of spring-run Chinook salmon became reestablished in the 1970s due to improved habitat conditions and fish straying from the Feather River or stocked and straying from the FRFH, then it is likely that spring-run Chinook salmon on the lower Yuba River do not represent a “pure” ancestral genome. In fact, in the report titled *Salmonid Hatchery Inventory and Effects Evaluation* (NMFS 2004), through an analysis of Yuba River Chinook salmon tissues, NMFS genetically linked the spring-run and fall-run Chinook salmon populations, which exhibit a merged run timing similar to that found in the Feather River. More recently, NMFS Southwest Fisheries Science Center conducted a preliminary genetic analysis of tissues collected from adult Chinook salmon downstream of Daguerre Point Dam in the lower Yuba River during May 2009 (i.e., phenotypic spring-run Chinook salmon). Of the 43 samples, 28 were positively identified as Feather River spring-run Chinook salmon. The remaining 15 samples were all identified as Central Valley fall-run Chinook salmon, primarily from the Feather River. These preliminary results are presented with the strong cautionary note that the genetic analyses have somewhat limited ability to distinguish Central Valley fall-run Chinook salmon from Feather River spring-run Chinook salmon due to past introgression, and due to incomplete databases for some Central Valley populations.

Available information indicates that the phenotypic spring-run Chinook salmon in the lower Yuba River actually represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, and hybridization with Feather River stocks including the FRFH spring-run Chinook salmon stock, which itself represents a hybridization between Feather River fall- and spring-run Chinook salmon populations (RMT 2013).

The FRFH “spring-run” stock is dominated by fall-run ancestry (Garza et al. 2008). However, the FRFH "spring" run retains remnants of the phenotype and ancestry of the Feather River spring-run Chinook salmon that existed prior to the Oroville Dam and the FRFH, but has been heavily introgressed by fall-run Chinook salmon through some combination of hatchery practices and hybridization induced by lack of access to spring-run Chinook salmon habitat above Oroville Dam. This suggests that it may be possible to preserve some additional component of the ancestral Central Valley spring-run Chinook salmon genomic variation through careful management of this stock, although it will not be possible to reconstitute a “pure” spring-run stock from these fish (Garza et al. 2008).

The FRFH spring-run Chinook salmon population is part of the Central Valley spring-run Chinook salmon ESU (NMFS 2005d) and, therefore, is protected by the applicable provisions of the ESA. At the time of issuance of the final rule regarding the listing status of the Central Valley ESU of spring-run Chinook salmon, NMFS (2005d) recognized that naturally spawning spring-run Chinook in the Feather River are genetically similar to the FRFH spring-run Chinook stock, and that the hatchery stock shows evidence of introgression with Central Valley fall-run Chinook salmon. However, NMFS also stated that FRFH stock should be included in the ESU because the FRFH spring-run Chinook salmon stock may play an important role in the recovery of spring-run Chinook salmon in the Feather River Basin, as efforts progress to restore natural spring-run populations in the Feather and Yuba Rivers (NMFS 2005d).

In summary, available information indicates the following.

- ❑ Two fishways, one for low water and the other for high water, were constructed at Daguerre Point Dam prior to the floods of 1927-1928. The ladders were destroyed by floods in 1927 and 1928.
- ❑ Fish passage was not provided until a new ladder was constructed on the south end of the dam in 1938.
- ❑ Between 1928 through 1934, there was a 10-year drought, which raised water temperatures below Daguerre Point Dam much higher than those tolerated by Chinook salmon and may have caused the extirpation of spring-run Chinook salmon from the lower Yuba River.

- ☐ A small spring-run Chinook salmon population historically occurred in the lower Yuba River, but the run virtually disappeared by 1959.
- ☐ By 1991, a small spring-run Chinook salmon population became reestablished in the lower Yuba River due to improved habitat conditions and due to recolonization by fish straying from the Feather River, fish previously and infrequently stocked from the FRFH, or possible production from a remnant population in the lower Yuba River.
- ☐ The phenotypic spring-run Chinook salmon in the lower Yuba River actually represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, and hybridization with Feather River stocks including the FRFH spring-run Chinook salmon stock.
- ☐ The FRFH spring-run Chinook salmon stock itself represents a hybridization between Feather River fall- and spring-run Chinook salmon populations.
- ☐ Straying from FRFH origin "spring-run" Chinook salmon into the lower Yuba River has and continues to occur, and this rate of straying is associated with "attraction flows" – the relative proportion of lower Yuba River flows to lower Feather River flows (see Chapter 4 of this BA).
- ☐ The FRFH spring-run Chinook salmon is included in the ESU, and is therefore afforded protection under the ESA, in part because of the important role this stock may play in the recovery of spring-run Chinook salmon in the Feather River Basin, including the Yuba River (NMFS 2005d).
- ☐ Although the FRFH spring-run Chinook salmon population is part of the Central Valley spring-run Chinook salmon ESU, concern has been expressed that straying of FRFH fish into the lower Yuba River may represent an adverse impact to the genetic integrity of lower Yuba River stocks. This concern is due to the potential influence of previous hatchery management practices on the genetic integrity of FRFH spring-run Chinook salmon.

Straying of FRFH "spring-run" Chinook salmon into the lower Yuba River has oftentimes been suggested to represent an adverse impact on lower Yuba River "spring-run" Chinook salmon stocks. It is reasonable to assume that such straying would represent an impact if the lower Yuba River stocks represented a genetically distinct, independent population. However, given the foregoing available information, spring-run Chinook salmon on the lower Yuba River do not represent a "pure" ancestral genome.

In conclusion, past hatchery practices and straying of FRFH fish into the lower Yuba River have resulted in a stressor of a relatively high magnitude on the potential for the lower Yuba River to support a genetically distinct, independent population of spring-run Chinook salmon. The continued and ongoing influx of FRFH-origin fish under the Environmental Baseline would represent a relatively high stressor if the management goal is to reestablish a genetically distinct, independent population of spring-run Chinook salmon in the lower Yuba River. However, data obtained through the course of implementing the M&E Program demonstrate that phenotypically "spring-running" Chinook salmon in the lower Yuba River do not represent an independent population – rather, they represent an introgressive hybridization of the larger Feather-Yuba river regional population (RMT 2013). Continued influx of FRFH-origin fish into the lower Yuba River contributes to the present and ongoing maintenance of phenotypic spring-run Chinook salmon populations in the lower Yuba River.

SUMMARY OF ENVIRONMENTAL BASELINE STRESSORS ON SPRING-RUN CHINOOK SALMON

The Yuba Accord RMT prepared an interim report of the Monitoring and Evaluation Program in April 2013, which assessed the VSP parameters using all information available up to that time. Given the information presently available, following is a summary of Environmental Baseline stressors on spring-run Chinook salmon.

Intermittently from the early 1900s until 1941, and consistently since 1941 with the construction of Englebright Dam by the California Debris Commission, access to historic habitats upstream of Englebright Dam has been blocked and has therefore reduced all four VSP parameters (abundance, productivity, spatial structure and genetic diversity) for spring-run Chinook salmon in the Yuba River watershed. Although the stressors associated with the presence of Englebright Dam persist and continue to affect the status of the species in the Action Area, recent actions have ameliorated flow-related stressors on the spring-run Chinook salmon population now restricted to the lower Yuba River.

This BA has presented available information regarding the present status of the VSP parameters of abundance, productivity, spatial structure and diversity of spring-run Chinook salmon in the lower Yuba River. Additionally, available information regarding the PCEs and characteristics of critical habitat in the Action Area (i.e., the lower Yuba River extending from the upstream extent of where in-river gravel placement has occurred (an area that is located within the first 300 feet below Englebright Dam) downstream to the mouth of the lower Yuba River) has been described and discussed, including the relative magnitude of the stressors affecting the Yuba River spring-run Chinook salmon population associated with the Environmental Baseline. The entire suite of information and analyses indicates that the phenotypic spring-run Chinook salmon annual abundance in the lower Yuba River over the evaluated time period (2004-2011) is stable, and is not exhibiting a significant declining trend (RMT 2013). Under the Environmental Baseline, these abundance and trend considerations would correspond to low extinction risk according to NMFS criteria (Lindley et al. 2007). However, the RMT (2013) questions the applicability of any of these criteria addressing extinction risk, because they presumably apply to independent populations and, as previously discussed, lower Yuba River anadromous salmonids represent introgressive hybridization of larger Feather-Yuba river populations, with substantial contributions of hatchery-origin fish to the annual runs.

7.1.4.2 Steelhead

Many of the most important stressors specific to steelhead in the Action Area of the lower Yuba River correspond to the stressors described for spring-run Chinook salmon. These stressors include passage impediments and barriers, harvest and angling impacts, poaching, physical habitat alteration, loss of riparian habitat and instream cover (e.g., riparian vegetation, LWM), loss of natural river morphology and function, loss of floodplain habitat, entrainment, predation, and hatchery effects. The foregoing discussion in this BA addressing stressors for the phenotypic spring-run Chinook salmon population in the lower Yuba River that are pertinent to the steelhead population in the lower Yuba River is not repeated here. Stressors that are unique to steelhead in the lower Yuba River, and stressors that substantially differ in severity for steelhead, include harvest/angling impacts, poaching, and hatchery effects were specifically described in Chapter 4 of this BA. The remainder of this section summarily discusses each of the stressors associated with the Environmental Baseline, regarding the relative magnitude of the stressor and its contribution to the current status of steelhead in the lower Yuba River.

PASSAGE IMPEDIMENTS/BARRIERS

BARRIERS UPSTREAM OF THE ACTION AREA (ENGLEBRIGHT DAM)

Lack of spawning gravel (or recruitment thereof) is not a significant stressor to steelhead, and the reported restricted abundance of LWM in the lower Yuba River is not substantively attributable to the presence of Englebright Dam. Some of the other upstream dams in the upper Yuba River watershed reduce the downstream transport of LWM, and Englebright Dam does not functionally block woody material from reaching the lower Yuba River because accumulated woody material spills over the dam during uncontrolled flood events and otherwise is pushed over by the Corps. Nonetheless, the loss of historical spawning and rearing habitat above Englebright Dam, restriction of spatial structure and associated vulnerability to catastrophic events, represent very high stressors to Yuba River steelhead. Although the genesis of these stressors emanate upstream of the Action Area at Englebright Dam, the manifestation of these stressors affect the current status of the species in the Action Area in the lower Yuba River.

IMPEDIMENTS IN THE ACTION AREA (DAGUERRE POINT DAM)

Given the entire suite of considerations associated with the design configuration and features of Daguerre Point Dam and its associated fish ladders that reportedly could either delay or impede adult upstream migration, as well as issues identified regarding juvenile downstream passage, the presence of Daguerre Point Dam likely represents a medium to relatively high stressor to Yuba River steelhead under the Environmental Baseline.

HARVEST/ANGLING IMPACTS

Angling regulations on the lower Yuba River are intended to protect sensitive species, including wild steelhead. Possession of wild steelhead (characterized by an intact adipose fin) is prohibited. Harvest/angling likely represents a low stressor to Yuba River adult and sub-adult steelhead.

POACHING

By contrast to the previous discussion regarding the potential for poaching to be a stressor to spring-run Chinook salmon, no occurrences have been reported regarding the potential poaching of steelhead at the fish ladders, or at the base of Daguerre Point Dam. The NMFS Draft Recovery Plan (NMFS 2009) identified poaching as a stressor of "low" importance to steelhead in the lower Yuba River. In response to the Court's order, the Corps installed locking metal grates over the Daguerre Point Dam fish ladder bays in August/September 2011, in part, to prevent poaching in the fish ladders. Consequently, poaching likely represents a low (or negligible) stressor to Yuba River adult steelhead.

PHYSICAL HABITAT ALTERATION

No references have been reported specifically regarding the attraction of adult steelhead into the Yuba Goldfields through Waterway 13. Nonetheless, because of the episodic occurrence of attraction flows emanating from Waterway 13, it likely represents a relatively low stressor to the adult lifestage of Yuba River steelhead.

Lake Wildwood operations changes are primarily associated with annual maintenance activities during the fall (e.g., October) and changed inflows to Deer Creek. The potential for stranding of adult steelhead in Deer Creek, near its confluence with the lower Yuba River, due to changes in Lake Wildwood operations likely represents a negligible to low stressor to the adult lifestage of Yuba River steelhead due to disjunct temporal periodicity.

ENTRAINMENT

Because the BVID diversion is not licensed by the Corps, water rights are not regulated by the Corps, and it has no direct physical link to Corps property, the BVID diversion facility and associated effects of diversion on the listed species and their habitat in the lower Yuba River are in the Environmental Baseline. As described above, a new state-of-the-art fish screen was installed at the BVID diversion facility in 1999, and BVID continues to operate and maintain the fish screen in compliance with NMFS and CDFW criteria. Consequently, the BVID diversion facility represents a low or negligible stressor to juvenile steelhead outmigration.

The relatively recent fish screen constructed at the Hallwood-Cordua diversion is considered a notable improvement over the previous design, and likely has eliminated any significant entrainment at the Hallwood-Cordua diversion.

As previously discussed, an anomalous area of higher approach velocities at the South Yuba/Brophy Diversion Canal and Facilities where an eddy draws water up-river was found to not meet the NMFS (2011d) criteria of providing "nearly uniform" flow distribution along the face of a screen (Bergman et al. 2013) and, thus, may increase susceptibility of juvenile salmonids to impingement or entrainment. However, only a portion of the annual year-class of outmigrant juvenile steelhead passes Daguerre Point Dam during the diversion season, particularly during the relatively high diversion period extending from May through August. Based on analysis of RST data, the percentage of steelhead fry from May through August, relative to the total annual number of outmigrant steelhead juveniles, potentially susceptible to entrainment is 26% (although actual entrainment is much lower than potential susceptibility to entrainment). Consequently, entrainment likely represents a relatively low stressor to Yuba River juvenile steelhead.

PREDATION

It is recognized that there is a paucity of information regarding predation rates on juvenile salmonids in general, and juvenile steelhead in particular, in the lower Yuba River. However, steelhead primarily spawn upstream of Daguerre Point Dam, and most juvenile steelhead must at some time pass over the spillway at Daguerre Point Dam, through the fish ladders, or past the diversion structures located in the vicinity of Daguerre Point Dam and are subject to predation at this location. As previously discussed in Chapter 5, field studies were conducted during 2012 to investigate potential sources of juvenile salmonid mortality, including predation due to a concentration of predators in the diversion canal, associated with the South Yuba/Brophy Diversion Canal and Facilities located immediately upstream of Daguerre Point Dam. Contrary to that which has been previously reported, the data suggest that the diversion channel does not support a unique concentration of predators (Bergman et al. 2013). Adult pikeminnow densities were not significantly different between the diversion channel and the mainstem lower Yuba River adjacent to the diversion. However, predation of juvenile salmonids by introduced and native piscivorous fishes occurs throughout the lower Yuba River at potentially relatively high rates. Therefore, predation likely represents a high stressor to the juvenile lifestage of Yuba River steelhead.

LOSS OF NATURAL RIVER MORPHOLOGY AND FUNCTION

The loss of natural river morphology and function and resultant decrease in riverine habitat complexity affects steelhead very similarly as was previously described for spring-run Chinook salmon in the lower Yuba River. Consequently, it likely represents a relatively high stressor to Yuba River steelhead under the Environmental Baseline.

LOSS OF FLOODPLAIN HABITAT

Floodplain habitat considerations previously presented for spring-run Chinook salmon also pertain to steelhead in the lower Yuba River. Consequently, loss of floodplain habitat availability likely represents a medium stressor to Yuba River juvenile steelhead under the Environmental Baseline.

LOSS OF RIPARIAN HABITAT AND INSTREAM COVER (RIPARIAN VEGETATION, INSTREAM WOODY MATERIAL)

The previous assessment of the importance that riparian vegetation and LWM play in the habitat complexity and diversity that potentially limits the productivity of juvenile spring-run Chinook salmon, is applicable to steelhead. Therefore, the present availability of riparian habitat and instream cover (in the form of LWM) is a stressor of relatively high magnitude to Yuba River juvenile steelhead under the Environmental Baseline.

HATCHERY IMPACTS (FRFH GENETIC CONSIDERATIONS STRAYING INTO THE LOWER YUBA RIVER) AND OTHER GENETIC CONSIDERATIONS

As previously discussed, the experimental fish hatchery on a tributary (i.e., Fiddle Creek) of the North Fork Yuba River was reported to hatch and rear trout, including steelhead, from 1929 to 1950 (CDNR 1931; Leitritz 1969). From 1970 to 1979, CDFW annually stocked 27,270–217,378 fingerlings, yearlings, and sub-catchable steelhead from

Coleman National Fish Hatchery into the lower Yuba River (CDFG 1991). CDFW stopped stocking steelhead into the lower Yuba River in 1979.

The observation of adipose fin clips on adult steelhead passing upstream through the VAKI Riverwatcher system at Daguerre Point Dam demonstrates that hatchery straying into the lower Yuba River has occurred, and continues to occur. Although no information is presently available regarding the origin of adipose-clipped steelhead observed at the VAKI Riverwatcher system at Daguerre Point Dam, it is reasonable to surmise that these fish most likely originate from the FRFH.

As previously discussed in Chapter 4 of this BA, only two years of data (2010/2011 and 2011/2012) are available identifying adipose fin-clipped *O. mykiss* passing through the VAKI Riverwatcher system at Daguerre Point Dam, during which extensive inoperable periods did not occur during the adult steelhead upstream migration period. Analysis of the VAKI Riverwatcher data indicates that the percent contribution of hatchery-origin adult upstream migrating fish (represented by the percentage of adipose fin-clipped adult steelhead relative to the total number of adult upstream migrating steelhead, because 100% of FRFH-origin steelhead have been marked since 1996) was approximately 43% for the 2010/2011 biological year, and about 63% for the 2011/2012 biological year (RMT 2013).

Past hatchery practices, including the Yuba River experimental fish hatchery until 1950, FRFH hatchery practices from 1967 to present, and straying of FRFH fish into the lower Yuba River have likely resulted in a stressor of relatively high magnitude on the potential for the lower Yuba River to support a genetically distinct, independent population of steelhead. As previously discussed for spring-run Chinook salmon, the continued and ongoing straying of hatchery-origin fish would represent a relatively high stressor if the management goal is to reestablish a genetically distinct, independent population of steelhead in the lower Yuba River. However, data obtained through the course of implementing the M&E Program demonstrate that continued influx of FRFH-origin fish into the lower Yuba River contributes to the present and ongoing maintenance of steelhead populations in the lower Yuba River (RMT 2013).

SUMMARY OF ENVIRONMENTAL BASELINE STRESSORS ON STEELHEAD

This BA has presented available information regarding the present status of the VSP parameters, the PCEs and characteristics of critical habitat in the lower Yuba River, and the stressors affecting the Yuba River steelhead population associated with the Environmental Baseline. The data limitations previously discussed, particularly in Chapter 4 of this BA, preclude multi-year abundance and trend analyses and therefore application of the extinction risk criteria. Consequently, the steelhead population in the lower Yuba River is categorized as data deficient, and therefore cannot be concluded to be stable or at a specific risk of extinction.

7.1.4.3 Green Sturgeon

As previously discussed, Daguerre Point Dam was not constructed for green sturgeon passage, and it is a complete barrier to the upstream migration of green sturgeon because they are unable to ascend the fish ladders on the dam, or otherwise pass over or around the structure. The existing fish ladders at Daguerre Point Dam were constructed to provide passage for Chinook salmon and steelhead.

Moreover, in 1938, a biological study was financed by the U.S. Army Corps of Engineers, under the supervision of the U.S. Bureau of Fisheries, to determine the effects of mining debris dams and hydraulic mining on fish life in the Yuba and American rivers. The survey was conducted by F.H. Sumner, Assistant Aquatic Biologist with the U.S. Army Corps of Engineers and Osgood R. Smith, Assistant Aquatic Biologist with the U.S. Bureau of Fisheries, in accordance with methods used by the U.S. Bureau of Fisheries. The 1939 survey report included a list of native and introduced fishes known or presumed to occur in the Yuba and American River basins at that time - which did not list the green sturgeon (Sumner and Smith 1939).

The scarcity of information on green sturgeon in the lower Yuba River makes it difficult to determine how these fish are utilizing the habitat in the river, or for what purpose green sturgeon are entering the river (NMFS 2007). However, because the ongoing stressors associated with Daguerre Point Dam's blockage of green sturgeon are due to the presence of the dam and configuration of the fish ladders, the Corps does not have the ability to lessen the potential passage/blockage stressors, and therefore they are part of the Environmental Baseline.

Despite the fact that historical accounts of fish species known or presumed to occur in the lower Yuba River do not include reference to green sturgeon (Sumner and Smith 1939), NMFS (2007) suggested that the abundance, productivity, spatial structure and diversity of the green sturgeon population in the lower Yuba River could be improved if green sturgeon had access to areas upstream of Daguerre Point Dam. Mora et al. (2009) suggest that Daguerre Point Dam blocks approximately 4 ± 2 km (~2.5 miles ± 1.2 miles) of potential green sturgeon habitat in the lower Yuba River. Regardless, designated critical habitat for green sturgeon does not extend upstream of Daguerre Point Dam.

Over the many years of sampling and monitoring in the lower Yuba River, only one sighting of an adult green sturgeon was confirmed before 2011, although studies specifically designed to search for green sturgeon in the lower Yuba River have not been implemented until the past few years. Sampling conducted during May 2011 with underwater videography indicated the presence of four or five adult green sturgeon just downstream of Daguerre Point Dam (Cramer Fish Sciences 2011). During 2012, underwater videography also was used in an attempt to document the presence of green sturgeon downstream of Daguerre Point Dam, although no green sturgeon were observed.

Under the Environmental Baseline, a total of 26 general pool locations exhibiting deepwater pool habitat potentially available to green sturgeon (i.e., greater than 10.0 feet in depth) was identified within the Yuba River downstream of Daguerre Point Dam (YCWA 2013a). **Table 7-1** shows: (1) the total wetted area of the pool habitats for each flow; and (2) the incremental increase in the wetted pool area compared to the previous flow value.

The period of February through November represents the months when adult green sturgeon may potentially be holding, including the pre-spawning holding, spawning, and post-spawning periods (Adams et al. 2002; Klimley et al. 2007). Examination of Table 7-1 demonstrates that a Marysville flow of 500 cfs would provide about 295,218 square

Table 7-1. Areal extent of deepwater pool habitat availability in the Yuba River downstream of Daguerre Point Dam (YCWA 2013a).

Marysville Flow (cfs)	Wetted Pool Area (sq. ft.)	Incremental Increase in Pool Area (%)
300	249,453	--
350	261,441	4.8%
400	274,005	4.8%
450	284,508	3.8%
530	301,644	6.0%
600	316,044	4.8%
622	320,400	1.4%
700	335,484	4.7%
800	354,501	5.7%
880	370,296	4.5%
930	380,070	2.6%
1,000	395,181	4.0%
1,300	456,930	15.6%
1,500	499,626	9.3%
1,700	548,487	9.8%
2,000	634,266	15.6%
2,500	804,861	26.9%
3,000	1,000,071	24.3%
4,000	1,400,292	40.0%
5,000	1,579,815	12.8%
7,500	1,859,247	17.7%
10,000	1,920,357	3.3%
15,000	1,936,989	0.9%
21,100	1,938,600	0.1%
30,000	1,938,465	0.0%
42,200	1,938,600	0.0%

feet of deepwater pool habitat downstream of Daguerre Point Dam. Modeled mean monthly flows under the Environmental Baseline simulation for each individual month from February through November (over the entire simulation period from WY 1922 through WY 2008) demonstrates that mean monthly flows at the Marysville Gage exceed 500 cfs nearly all of the time from February through June, and equal or exceed 500 cfs about 85-90% of the time from July through November (see the Cumulative Condition analysis, below). Consequently, a substantial amount of deepwater pool habitat is generally available for the relatively low numbers of green sturgeon that may be present downstream of Daguerre Point Dam under the Environmental Baseline. According to

NMFS (2009a), the current population status of the Southern DPS of North American green sturgeon is unknown. For the Central Valley Domain, currently there are limited data on population sizes, population trends, or productivity of green sturgeon (NMFS 2009e). No information regarding these topics is available for the lower Yuba River, due to the rarity of even sighting green sturgeon in the river.

Hence, it is not practicable to attempt to apply the VSP concepts developed for salmonids to green sturgeon in the lower Yuba River. Moreover, the lack of information pertaining to abundance, productivity, habitat utilization, life history and behavioral patterns in the lower Yuba River, due to infrequent sightings over the past several decades, does not provide the opportunity for reliable alternative methods of viability assessment of green sturgeon in the lower Yuba River. Data limitations preclude application of the extinction risk criteria to green sturgeon in the lower Yuba River. Consequently, green sturgeon in the lower Yuba River cannot be concluded to be stable or at a specific risk of extinction.

The foregoing discussion indicates that the potential stressor of flow-related habitat availability is low or negligible for green sturgeon in the Action Area below Daguerre Point Dam in the lower Yuba River.

The other potential flow-related stressor to green sturgeon in the Action Area below Daguerre Point Dam in the lower Yuba River is water temperature suitability. Water temperature monitoring over the past six years demonstrated that water temperatures remain below the upper WTI values for all lifestages of green sturgeon at Daguerre Point Dam, and for most lifestages at the Marysville Gage. The upper end of the WTI value range for post-spawning adult holding (i.e., 61°F) was exceeded at the Marysville Gage during a portion of this lifestage evaluation period (see Chapter 4).

Water temperature modeling demonstrated similar results as water temperature monitoring. Modeled mean monthly water temperatures under the Environmental Baseline (i.e., current conditions simulation) for each individual month from February through November (over the entire simulation period from WY 1922 through WY 2008) demonstrates that mean monthly water temperatures at Daguerre Point Dam always remain below the upper WTI value range for all lifestages of green sturgeon. Modeled water temperatures at the Marysville Gage also remained below the upper WTI value range for all lifestages of green sturgeon with the exception of post-spawning holding. The upper end of the WTI value range for post-spawning adult holding (i.e., 61°F) was exceeded at the Marysville Gage during variable portions of time from June through September (see the Cumulative Condition analysis, below).

7.2 Effects of the Proposed Action

The Proposed Action is comprised of the Corps' authorized discretionary O&M activities of the existing fish passage facilities at Daguerre Point Dam, including the administration of two outgrants associated with O&M of the facilities, and specified conservation measures. The two outgrants administered by the Corps that are associated with Daguerre Point Dam include: (1) a license issued to CDFW for VAKI Riverwatcher operations; and (2) a license issued to Cordua Irrigation District for flashboard installation, removal and maintenance.

Of the stressors associated with the Environmental Baseline affecting the spring-run Chinook salmon in the lower Yuba River, the Proposed Action (including protective conservation measures) does not have the capability of affecting poaching, entrainment, loss of natural river morphology and function, harvest/angling impacts, physical habitat alteration (including Waterway 13), loss of floodplain habitat, and hatchery and other genetic considerations. The remaining stressors are evaluated below.

7.2.1 Operation and Maintenance Activities of Fish Passage Facilities at Daguerre Point Dam

In this BA, a distinction is made between effects on listed species attributable to the current design of the Daguerre Point Dam facilities that have been operational since 1965 – which are part of the Environmental Baseline, and effects associated with the Corps' authorized discretionary O&M activities associated with the fish ladders as part of the Proposed Action. The Corps has the authority and discretion to lessen adverse effects associated with O&M of the fish ladders and sediment removal upstream of Daguerre Point Dam, removal of sediment and woody debris from the fish ladders themselves, and minor adjustments to the hydraulic performance of the ladders, as described in Section

2.1.1. The Corps' authorized discrectionary O&M activities associated with the fish ladders include making minor modification as necessary to maintain and improve the existing fish ladder performance. Additionally, conservation measures incorporated into the Proposed Action and associated with discretionary O&M activities of existing fish passage facilities are considered to be authorized, discretionary actions by the Corps. Therefore, effects to listed species associated specifically with these activities are characterized as effects of the Proposed Action. All other stressors associated with design and on-going existence of the ladders and other Daguerre Point Dam facilities are part of the Environmental Baseline.

7.2.1.1 Fish Ladder Operations

The Corps' fish ladder operations consist of adjusting the fishway gates, within-ladder flashboards, and the fish ladder gated orifices. Fishway gates allow water to enter the fish ladders, and the fish ladder gated orifices regulate the point where upstream migrating fish can most easily enter the ladders (Corps 1966). The Proposed Action also includes continued collaboration with CDFW regarding adjustment of the within-ladder flashboards that were installed in the lower bays of the south fish ladder during June 2010. Adjustment of these within-ladder flashboards influence hydraulics and have been shown to improve adult anadromous salmonid attraction flows to the south ladder (Grothe 2011). As part of these activities, the Corps also will continue to coordinate with CDFW and NMFS regarding operations at the existing ladders and fishway structure to provide passage opportunities for anadromous salmonids.

RELATED STRESSORS AND EFFECTS

Operations-related passage impediments associated with upstream migration of adult spring-run Chinook salmon and steelhead include: (1) intermittent passage ability due to closure of the fish ladder control gates at high flow levels; (2) unfavorable within-ladder hydraulics resulting in passage impediment or delay; and (3) insufficient attraction flows exiting the fish ladders.

The stressors related to this component of the Proposed Action include the potential for blockage or passage delays in the upstream migration of adult spring-run Chinook salmon and steelhead. The Proposed Action will: (1) improve passage ability due to continuing to keep the fish ladder control gates open at high flow levels; (2) improve within-ladder hydraulics and attraction flows by adjustment of within-ladder flashboards and fish ladder gated orifices. Operations-related components of the Proposed Action are not expected to substantively affect stressors associated with juvenile downstream migration. The operations-related components of the Proposed Action will not substantively affect these stressors. Consequently, with implementation of the operations-related components of the Proposed Action, these stressors remain characterized as "medium to high".

7.2.1.2 Fish Passage Facility Maintenance

Corps and CDFW joint maintenance activities include cleaning the bays of the fish ladders, cleaning the grates covering the fish ladder bays, and other minor maintenance activities. Presently, PSMFC staff, in collaboration with CDFW, operating the VAKI Riverwatcher devices, make observations of the fish ladders on an approximately daily basis, and the Corps coordinates with them regarding observations of debris or blockages, and/or adult salmonid upstream passage observations. Since August 2010, the Corps also has conducted sub-surface inspections of the ladders, after NMFS advised the Corps of the possibility of sub-surface blockage. The Proposed Action includes continuation of the routine maintenance of removal of debris from the fish ladders.

Additionally, the Corps and NMFS have been holding monthly meetings to coordinate regarding maintenance activities and other issues pertaining to the lower Yuba River since the spring of 2010. These meetings would continue as part of the Proposed Action.

RELATED STRESSORS AND EFFECTS

The stressors related to fish passage facility maintenance activities also include the potential for blockage or passage delays in the upstream migration of adult spring-run Chinook salmon and steelhead. Potential impediments to upstream migration of adult salmon and steelhead may include: (1) sediment accumulation at the upstream exits of the fish ladders, potentially resulting in blockage of egress from the ladders and/or upstream migration routes, and "fall-back" of adults into the ladders; and (2) obstruction of the ladders by sediment and woody debris that can block passage or substantially reduce attraction flows to the fish ladder entrances.

In recognition of the ongoing maintenance-related potential impediments to upstream migration of adult salmon and steelhead, the Corps has identified protective conservation measures and incorporated them into the Proposed Action. These maintenance-related protective conservation measures are: (1) implementation of the Daguerre Point Dam Fish Passage Sediment Management Plan; and (2) implementation of a Debris Monitoring and Maintenance Plan at Daguerre Point Dam. Consequently, evaluation of the manner in which the Proposed Action influences stressors associated with maintenance-related activities at the fish passage facilities at Daguerre Point Dam includes consideration of these measures, and is presented below.

7.2.2 Staff Gage Maintenance

The Proposed Action includes continuation of maintaining, reading, and filing all records obtained from the staff gage located on the right abutment of Daguerre Point Dam. No stressors to the listed species or their critical habitats have been identified associated with this component of the Proposed Action.

7.2.3 Administration of a License Issued to CDFW for VAKI Riverwatcher Operations at Daguerre Point Dam

The Proposed Action includes continued administration of the license to CDFW (DACW05-3-03-550) to install and operate electronic fish counting devices, referred to as a VAKI Riverwatcher infrared and photogrammetric system, in the fish ladders at Daguerre Point Dam, which remains in effect until 2018. The only potential stressor identified to be associated with the VAKI Riverwatcher system is the potential collection of debris and resultant impediments to passage. However, the Debris Monitoring and Maintenance Plan at Daguerre Point Dam specifies that CDFW is responsible for inspecting and clearing the portion of the ladders containing the VAKI device, and that the Corps is responsible for all other parts of the ladders. Implementation of this plan is included in the evaluation of that protective conservation measure, below.

7.2.4 Administration of a License Issued to Cordua Irrigation District for Flashboard Installation, Removal and Maintenance at Daguerre Point Dam

In 2011, the Corps, NMFS and CDFW collaborated in the development of the Daguerre Point Dam Flashboard Management Plan. The Flashboard Management Plan was incorporated into the September 27, 2011 license amendment issued by the Corps to Cordua Irrigation District. The Proposed Action includes continued administration of the license issued to Cordua Irrigation District which incorporates the Flashboard Management Plan, until the license expires in 2016. Implementation of this plan is included in the evaluation of that protective conservation measure, below.

7.2.5 Protective Conservation Measures

The Corps has committed to incorporate several conservation measures into its activities for this Proposed Action. These measures are intended to improve conditions for listed salmonids in the lower Yuba River.

7.2.5.1 Implementation of the Daguerre Point Dam Fish Passage Sediment Management Plan

The Proposed Action includes continued implementation of the Daguerre Point Dam Fish Passage Sediment Management Plan. The Corps, through collaboration with NMFS, CDFW, and USFWS, developed an updated Daguerre Point Dam Fish Passage Sediment Management Plan in February 2009 (Corps 2009). The purpose of the plan is to describe the methods used to manage the sediment that accumulates upstream of Daguerre Point Dam in order to improve flows to the ladders at Daguerre Point Dam, to provide suitable adult salmonid migratory habitat conditions upstream of the Daguerre Point Dam fish ladders, and to provide attraction to the ladders downstream of Daguerre Point Dam.

RELATED STRESSORS AND EFFECTS

Sediment accumulation results in unfavorable habitat conditions at the upstream exits of the fish ladders, which impedes the upstream migration of adult spring-run Chinook salmon and steelhead. Resultant stressors include reduced unimpeded passage from the ladders to the main channel, the potential for adult fish exiting the ladder being immediately swept by flow back over the dam, and the potential for fish to “fall-back” into the ladders.

Implementation of the Daguerre Point Dam Fish Passage Sediment Management Plan will provide passage ability of spring-run Chinook salmon and steelhead due to the maintenance of migratory pathways upstream of the dam. Because the plan was developed in February 2009 and has been implemented since that time, implementation of this protective conservation measure will maintain the status quo relative to the Environmental Baseline. However, stressors associated with sediment accumulation upstream of the face of Daguerre Point Dam have occurred over the many years that have led to the current status of the species. Hence, this component of the Proposed Action may be considered to improve conditions, and lessen stressors associated with sediment accumulation at Daguerre Point Dam. Consequently, stressors specifically associated with sediment accumulation at Daguerre Point Dam are characterized as remaining "low" under the Proposed Action.

This component of the Proposed Action will reduce stressors associated with the PCE of "freshwater migratory corridor" of critical habitat for spring-run Chinook salmon and steelhead. With improvements to passage at Daguerre Point Dam resulting from implementation of this protective conservation measure, it is reasonable to expect improved accessibility for adult spring-run Chinook salmon and steelhead to critical habitat located upstream of Daguerre Point Dam when compared with the totality of the temporal effect of the Environmental Baseline.

7.2.5.2 Management of a Long-term Flashboard Program at Daguerre Point Dam

The Proposed Action includes implementation of the Flashboard Management Plan (see Section 2.1.4) through the administration of a license issued to Cordua Irrigation District.

If the Corps does not renew the license to Cordua Irrigation District or another entity when it expires in 2016, then the Corps will assume responsibility for implementing the operations and maintenance activities addressing the placement, timing and configuration of the flashboards at Daguerre Point Dam that are described in the Flashboard Management Plan, on a long-term basis.

RELATED STRESSORS AND EFFECTS

Sheet flow over the top of Daguerre Point Dam can "mask" the ability of upstream migrating adult salmonids to find the entrance to the fish ladders. Resultant stressors include potential delay or disruption of upstream migration. The purpose of the plan is to benefit spring-run Chinook salmon and steelhead by directing sheet flow that spills over the top of Daguerre Point Dam into the fish ladders, thereby improving the ability of adult fish to locate the fish ladders and migrate upstream to spawning and rearing habitats.

Additional potential stressors associated with sheet flow over the top of Daguerre Point Dam include physical injury to juveniles spilling over the top of the dam onto the concrete apron at the downstream base of the dam, and increased susceptibility to predation in the plunge pool below Daguerre Point Dam due to disorientation.

Ancillary benefits include directing downstream migrating juvenile spring-run Chinook salmon and steelhead into the fish ladders, and thereby avoiding physical injury from spilling over the dam, and avoiding potentially increased predation due to disorientation in the plunge pool below the dam.

The Flashboard Management Plan was incorporated into the September 27, 2011 license amendment issued by the Corps to Cordua Irrigation District. Thus, continued implementation of this protective conservation measure will maintain the status quo relative to the Environmental Baseline. However, relative to stressors associated with sheet flow over Daguerre Point Dam that occurred prior to 2011 that have led to the current status of the species, this component of the Proposed Action may be considered to improve conditions, and lessen stressors (masking adult attraction flows, physical injury and predation of juveniles) associated with sheet flow over Daguerre Point Dam.

This component of the Proposed Action will reduce stressors associated with the PCE of "freshwater migratory corridor" of critical habitat for each listed species. With improvements to passage at Daguerre Point Dam resulting from implementation of this protective conservation measure, it is reasonable to expect improved accessibility for adult spring-run Chinook salmon and steelhead to critical habitat located upstream of Daguerre Point Dam when compared with the totality of the temporal effect of the Environmental Baseline.

In addition, because the Proposed Action includes the commitment that, if necessary, the Corps will assume responsibility for implementing the Flashboard Management Plan on a long-term basis, this component provides an assurance that related stressors also will be reduced on a long-term basis. Consequently, stressors specifically associated with sheet flow over Daguerre Point Dam are characterized as "medium" under the Proposed Action.

7.2.5.3 Implementation of a Debris Monitoring and Maintenance Plan at Daguerre Point Dam

The Proposed Action includes implementation of the Debris Monitoring and Maintenance Plan for clearing accumulated debris and blockages in the fish ladders at Daguerre Point Dam. The plan specifies the frequency and conduct of routine inspection and clearing of debris from the two fish ladders at Daguerre Point Dam, and debris maintenance associated with specific flow events.

RELATED STRESSORS AND EFFECTS

Accumulation of debris and sediment within the bays of the ladders at Daguerre Point Dam can result in unfavorable within-bay hydraulic characteristics and resultant passage delay or blockage of upstream migrating adult salmonids. Debris and sediment accumulation within the ladder bays also can affect flow through the ladders and resultant attraction flow for upstream migrating adult spring-run Chinook salmon and steelhead.

The purpose of the Debris Monitoring and Maintenance Plan is to benefit spring-run Chinook salmon and steelhead by improving the ability of adult fish to locate the fish ladders and successfully pass through the ladders to upstream spawning and rearing habitats. To the extent that reduced debris accumulation in the fish ladders would potentially increase flow through the ladders and reduce sheet flow over Daguerre Point Dam, ancillary benefits include reducing the severity of the stressors on downstream migrating juvenile spring-run Chinook salmon and steelhead, susceptibility to physical injury from spilling over the dam, and potentially increased predation due to disorientation in the plunge pool below the dam.

This component of the Proposed Action will reduce stressors associated with the PCE of "freshwater migratory corridor" of critical habitat for each listed species. With improvements to passage at Daguerre Point Dam resulting from implementation of this protective conservation measure, it is reasonable to expect improved accessibility for adult spring-run Chinook salmon and steelhead to critical habitat located upstream of Daguerre Point Dam when compared with the totality of the temporal effect of the Environmental Baseline.

Continued implementation of the Debris Monitoring and Maintenance Plan would be expected to reduce the severity of the stressors associated with debris and sediment accumulation within the bays of the fish ladders at Daguerre Point Dam on a long-term basis. Consequently, stressors specifically associated with debris and sediment in the fish passage facilities at Daguerre Point Dam are characterized as "low" under the Proposed Action.

7.2.6 Voluntary Conservation Measures

In addition to protective measures integrated into the Proposed Action, the Corps proposes to implement additional conservation measures to avoid or minimize potential effects and to improve conditions for listed salmonids in the lower Yuba River through implementation of voluntary conservation measures. These voluntary conservation measures are subject to the availability of funding.

7.2.6.1 Gravel Injection in the Englebright Dam Reach of the Lower Yuba River

The Proposed Action includes continued implementation of a spawning gravel injection program in the Englebright Dam Reach of the lower Yuba River. Four separate gravel injection efforts have been undertaken from 2007-2013, with approximately 15,500 tons of gravel/cobble placed into the Englebright Dam Reach. The Corps is using the Gravel/Cobble Augmentation Implementation Plan (GAIP) (Pasternack 2010) to provide guidance for a long-term gravel injection program. The purpose of the program is to provide Chinook salmon, and spring-run Chinook salmon in particular, spawning habitat in the bedrock canyon downstream of Englebright Dam.

RELATED STRESSORS AND EFFECTS

The stressor related to this conservation measure is lack of suitable spawning gravels in the Englebright Dam Reach. Implementation of this voluntary conservation measure is expected to expand available spawning habitat, primarily for spring-run Chinook salmon. No anticipated increased adverse effects associated with lack of suitable spawning gravel would be expected to occur. By contrast, the intensity, frequency, and duration of stressors associated with the lack of spawning habitat in the Englebright Dam Reach would be reduced relative to the Environmental Baseline. Expansion of suitable spawning habitat in the Englebright Dam Reach may encourage additional behavioral segregation between spawning spring-run and fall-run Chinook salmon, because spring-run Chinook salmon tend to spawn in the uppermost reaches of the Yuba River whereas fall-run Chinook salmon spawning is more spread throughout downstream locations.

This voluntary conservation measure will beneficially affect the PCEs of critical habitat of "freshwater spawning sites" for spring-run Chinook salmon, as well as for steelhead. With the addition of suitable spawning gravels in the Englebright Dam Reach, habitat suitability and availability will be improved for the spawning lifestages of spring-run Chinook salmon and steelhead, and a likely response will be increased reproductive success or capacity.

Consequently, the stressor of the lack of suitable spawning gravels in the Englebright Dam Reach would be lessened relative to the Environmental Baseline. However, spawning habitat is abundant and readily available throughout the lower Yuba River, and available spawning habitat is not considered to be limiting to the spring-run Chinook salmon population in the lower Yuba River. Hence, this voluntary conservation measure is intended to contribute to an increased likelihood of recovery of spring-run Chinook salmon, with ancillary benefits to steelhead spawning habitat availability. With continued implementation of the gravel injection program in the Englebright Dam Reach, subject to available funding, stressors specifically associated with the lack of suitable spawning gravels in the Englebright Dam Reach are characterized as "low".

7.2.6.2 Large Woody Material Management Program

The Corps has prepared a LWMMP, which includes the implementation of a pilot study in order to enhance juvenile rearing conditions for spring-run Chinook salmon and steelhead (Corps 2012d). The Corps proposed to initiate a pilot study to determine an effective method of replenishing the supply of LWM back into the lower Yuba River. The pilot study will use LWM from existing stockpiles at New Bullards Bar Reservoir for placement at selected sites along the lower Yuba River, and will include monitoring of placed materials, which will be used to assess the effectiveness of LWM placement in the lower Yuba River to develop a long-term program (Corps 2012d). Based upon the outcome of the pilot study, the Corps will refine the draft plan, consistent with recreation safety needs and findings from the pilot study, and implement a long-term LWMMP for the lower Yuba River, subject to available funding.

RELATED STRESSORS AND EFFECTS

The stressors related to this voluntary conservation measure are associated with the reported relative paucity of habitat complexity and diversity associated with structural elements in the lower Yuba River. LWM plays a significant role in determining the suitability of aquatic habitats for juvenile salmonids, including providing concealment from predators, shelter from fast current, feeding stations and nutrient inputs, as well as for other organisms upon which salmonids depend for food.

Under the Environmental Baseline, reduced abundance of LWM was identified as a "high" stressor to the juvenile rearing lifestage of Yuba River spring-run Chinook salmon and steelhead. Implementation of this voluntary conservation measure would reduce the intensity, frequency, and duration of stressors associated with the reduced abundance of LWM providing habitat complexity and diversity (and therefore predator escape cover, velocity, shelter, and feeding stations) for rearing juvenile salmonids, relative to the Environmental Baseline.

This voluntary conservation measure will beneficially affect the PCE of "freshwater rearing sites" of critical habitat for spring-run Chinook salmon, as well as for steelhead. With the addition of LWM, habitat suitability and availability will be improved for the juvenile rearing lifestages of spring-run Chinook salmon and steelhead. Likely responses include the potential for reduced predation on juvenile spring-run Chinook salmon and steelhead in the lower Yuba River.

Consequently, stressors associated with relatively low abundance of LWM would be lessened relative to the Environmental Baseline. With continued implementation of the LWMMP, stressors specifically associated with the abundance of LWM in the Action Area of the lower Yuba River are characterized as "medium to high" due to lack of certainty of benefit associated with results of the pilot study, uncertainty of specific elements as yet undefined in the long-term plan, and uncertainty associated with funding availability.

7.3 Interrelated Actions

Interrelated actions are defined by the Federal regulations as "…*those that are part of a larger action and depend on the larger action for their justification*" (50 CFR 402.02). The effects of "interrelated actions" (i.e., actions that would not occur "but for" a larger action) (Federal Register 19957; USFWS and NMFS 1998), along with the direct and indirect effects of the Proposed Action, are compared to the Environmental Baseline in determining whether the Proposed Action will jeopardize the continued existence of a listed species (50 CFR 402.02, 402.12(f)(4)).

7.3.1 Potential Effects Associated with Interrelated Actions

There are no interrelated actions associated with the Proposed Action.

7.4 Interdependent Actions

Interdependent actions are defined by the Federal regulations as "…*those that have no independent utility apart from the action under consideration*" (50 CFR 402.02). The effects of "interdependent actions" (i.e., other actions would not occur "but for" this action (USFWS and NMFS 1998)), along with the direct and indirect effects of the Proposed Action, are compared to the Environmental Baseline to determine whether the Proposed Action will jeopardize the continued existence of a listed species (50 CFR 402.02, 402.12(f)(4)).

7.4.1 Potential Effects Associated with Interdependent Actions

There are no interdependent actions associated with the Proposed Action.

7.5 Cumulative Effects

Cumulative effects are defined by Federal regulations as "…*those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation*" (50 CFR 402.02). Cumulative effects must be considered in the analysis of the effects of the Proposed Action (50 CFR 402.12(f)(4)).

7.5.1 Wheatland Project

7.5.1.1 Cumulative Effects Flow Analysis

Overall, the Cumulative Condition would generally result in higher flows above Daguerre Point Dam (as measured at the Smartsville Gage) and lower flows below Daguerre Point Dam (as measured at the Marysville Gage), primarily during the summer months of July, August and September. Comparisons of model simulations of monthly mean flows at each of these gages under the Cumulative Condition, relative to the current conditions, are provided below.

FLOW AT THE SMARTSVILLE GAGE

Examination of model output presented in Appendix F of this BA demonstrates that over the 87-year simulation period, long-term average monthly flows at the Smartsville Gage would increase slightly from May through October (ranging from a 0.6% flow increase in May to a 2.4% flow increase in July), would decrease slightly from December through April (ranging from a 0.7% flow reduction in March to a 1.7% flow reduction in December), and would not change during November under the Cumulative Condition, relative to the current conditions. None of the minor reductions in long-term average monthly flows from December through April under the Cumulative Condition, relative to the current conditions, would result in long-term average monthly flows below the monthly minimum instream flows of Flow Schedule A, and therefore would remain above the corresponding optimum flow level.

For Wet and Above Normal water years, flow at the Smartsville Gage changed slightly during most months of the year, with no reductions in average monthly flow exceeding 10% under the Cumulative Condition relative to the current conditions. The largest average monthly flow increase (2.2%) occurred in July and the largest flow reduction (4.3%) occurred during February of Above Normal water years under the Cumulative Condition relative to the current conditions. Average monthly flow values under the Cumulative Condition and the current conditions remained well above the monthly minimum instream flows of Flow Schedule A, and therefore remained above the corresponding optimum flow level.

For Below Normal water years, average monthly flows at the Smartsville Gage changed slightly during most months of the year, with no reductions in average monthly flow exceeding 10%. The largest average monthly flow increase (2.3%) occurred in July and the largest flow reduction (4.1%) occurred during March under the Cumulative Condition relative to the current conditions. Average monthly flow values under the Cumulative Condition and the current conditions remained well above the monthly minimum instream flows of Flow Schedule A, and therefore remained above the corresponding optimum flow level.

For Dry and Critical water years, no change or relatively minor reductions in average monthly flow occur during winter (January, February and March), but flow increases occur during all other months of the year with the largest increases in average monthly flow occurring from May through September. During Dry water years, average monthly flow changes ranged from an 8.6% flow increase during July to a 3.7% flow reduction during January of Dry water years. Changes in flows did not result in average monthly flow values below the monthly minimum instream flows of Flow Schedule A, and therefore remained above the corresponding optimum flow level. During Critical water years, average monthly flows generally increased, and flow changes ranged from an 8.4% flow increase during August to a 0.6% flow reduction during January. Except for September, flow changes did not result in average monthly flow values below the monthly minimum instream flows of Flow Schedule A and therefore remained above the corresponding optimum flow level. Although average monthly flows under the Cumulative Condition increased by 5.4% during September, the average monthly flows under both the Cumulative Condition (689 cfs) and the current conditions (653 cfs) were below the corresponding monthly minimum instream flow (700 cfs) identified for September in Flow Schedule A.

Examination of monthly mean flow exceedance distributions over the 87-year simulation period at the Smartsville Gage indicate minor differences in flow reductions between the Cumulative Condition and the current conditions. Relatively minor flow decreases would occur during winter months. The greatest reduction in monthly mean flows would occur during January, although reductions of 10% or more would be expected with less than a 6% probability of occurrence under the Cumulative Condition relative to the current conditions. However, this reduction and other minor reductions primarily would occur at high flow levels (above the corresponding optimum flow level of 700 cfs). Conversely, flow increases of 10% or more would be expected to occur during July and August with a 1% and 9% probability of occurrence, respectively, under the Cumulative Condition relative to the current conditions.

Low flow conditions are defined as flows in the lowest 25 percent of the cumulative flow distribution, which for this period of simulation represents the 22 lowest ranked flow values each month. During low flow conditions, a flow reduction of 10% or more would be expected to occur only once out of the 22 years during November. Flow increases of 10% or more at Smartsville would occur once out of the 22 years during July, and 8 out of the 22 years during August under the Cumulative Condition, relative to the current conditions.

FLOW AT THE MARYSVILLE GAGE

Examination of model output presented in Appendix F of this BA demonstrates that over the 87-year simulation period, the long-term average monthly flows at the Marysville Gage would be reduced slightly from October through June (ranging from a 0.4% flow reduction in April to a 3.2% flow reduction in June) under the Cumulative Condition relative to the current conditions. Long-term average monthly flows at the Marysville Gage would be reduced by 7.1%, 9.2% and 8.7% during July, August and September, respectively under the Cumulative Condition relative to the current conditions. However, none of the reductions in long-term average monthly flows under the Cumulative Condition relative to the current conditions would result in long-term average monthly flow below the monthly minimum instream flows of Flow Schedule 1 and therefore remained above the upper optimum flow levels.

For Wet and Above Normal water years, average monthly flows at the Marysville Gage changed slightly during most months of the year, with no reductions in average monthly flow exceeding 10% with the exceptions of September (10.5%) during Wet water years, and August (13.0%) and September (10.3%) during Above Normal water years under the Cumulative Condition relative to the current conditions. However, these reductions during August and September under the Cumulative Condition relative to the current conditions did not result in average monthly flow values below the monthly minimum instream flows of Flow Schedule 1 and therefore remained above the upper optimum flow levels.

For Below Normal water years, average monthly flows at the Marysville Gage changed slightly during most months of the year, with no reductions in average monthly flow exceeding 10% with the exception of July (12.2%). However, this reduction during July under the Cumulative Condition relative to the current conditions did not result in average monthly flow values below the monthly minimum instream flows of Flow Schedule 2 and therefore remained above the lower optimum flow level.

Even less change in average monthly flow at the Marysville Gage would be expected to occur during Dry and Critical water years under the Cumulative Condition relative to the current conditions. Flow changes would range from a 1.1% flow increase during December of Dry water years to a 4.1% flow reduction during January of Dry water years. During Critical water years, flow changes would range from a 0.7% flow increase during April to a 3.4% flow reduction during November.

Examination of monthly mean flow exceedance distributions over the 87-year simulation period at the Marysville Gage indicates minor differences between the Cumulative Condition and the current conditions from October through June. During these months, flow decreases of 10% or more would be expected with less than a 6% probability of occurrence. Larger differences in flow would be expected to occur during July, August and September, with flow decreases of 10% or more with about a 32%, 28% and 53% probability of occurrence, respectively, under the Cumulative Condition relative to the current conditions. However, these differences primarily would occur at high flow levels (above the upper optimum flow level of 700 cfs during July, 600 cfs during August and 500 cfs during September). Resultant flows under the Cumulative Condition generally remain above the lower optimum flow levels during July, August and September.

Low flow conditions are defined as flows in the lowest 25 percent of the cumulative flow distribution, which for this period of simulation represents the 22 lowest ranked flow values each month. During low flow conditions, a flow reduction of 10% or more would be expected to occur only twice out of the 22 years during November, and once out of the 22 years during each month from May through September.

The aforementioned examination of model simulation of monthly mean flows indicates that flow reductions at the Marysville Gage primarily would occur during the months of July, August and September under the Cumulative Condition, relative to the current conditions. However, when reductions in flow occurred during July, August and

September, resultant flows under the Cumulative Condition nearly always remained at or above the lower optimum flow levels.

FLOW-RELATED EFFECTS ON SPRING-RUN CHINOOK SALMON

From the spatial and temporal distribution information presented in Chapter 4 of this BA, the lifestage-specific periodicities used for this evaluation of monthly mean flows for spring-run Chinook salmon are as follows.

- ☐ Adult immigration and holding (April through September)
- ☐ Spawning (September through mid-October)
- ☐ Embryo incubation (September through December)
- ☐ Juvenile rearing (Year-round)
- ☐ Juvenile downstream movement (Mid-November through June)
- ☐ Smolt (yearling+) emigration (October through mid-May)

ADULT IMMIGRATION AND HOLDING

Spring-run Chinook salmon immigrate up through the lower Yuba River from early spring into July, August, or as late as September, and primarily hold upstream or just downstream of Daguerre Point Dam until initiation of spawning during September. Overall, monthly mean flows at the Smartsville Gage are increased during April though August and are similar during September of the adult immigration and holding time period under the Cumulative Condition relative to the current conditions. It is expected that these changes in flow would result in very minor differences in holding pool depth and areal extent upstream of Daguerre Point Dam. The magnitude of flow reductions during July, August and September below Daguerre Point Dam (as indicated by the Marysville Gage) under the Cumulative Condition relative to the current conditions also would result in very minor differences in holding pool depth or areal extent.

These relatively minor reductions in flow would not be expected to significantly affect passage at Daguerre Point Dam. RMT (2013) found that passage at Daguerre Point Dam occurs over a wide range of flows, and generally occurs irrespective of flow rates over the range of flows examined. No flow thresholds prohibiting passage of Chinook salmon through the ladders at Daguerre Point Dam were apparent in the 8 years of VAKI Riverwatcher data (RMT 2013).

These relatively minor reductions in flow also would not be expected to significantly affect attraction flows. As described in Chapter 4 of this BA, a positive and significant relationship was identified between the percentage of adipose fin-clipped Chinook salmon passing Daguerre Point Dam during the spring-run Chinook salmon upstream migration period, and the ratio of lower Yuba River flow relative to lower Feather River flow and the ratio of lower Yuba River water temperature relative to lower Feather River water temperature, four weeks prior to the time of passage at Daguerre Point Dam. However, the relatively minor reductions in flow under the Cumulative Condition relative to the current conditions also would not be expected to significantly affect attraction of adipose fin-clipped Chinook salmon for two reasons.

First, the time series of Chinook salmon moving daily upstream of Daguerre Point Dam illustrated in Chapter 4 exhibit a plurality of modes with large inter-annual variation in timing and magnitude. The phenotypic adult spring-run Chinook salmon upstream migration period generally began during May or June of each year, although the end date of the annual migration period varied among years. For the eight years of available VAKI Riverwatcher data, the phenotypic spring-run Chinook salmon upstream migration period end date ranged from early July to early September. However, most phenotypic spring-run Chinook salmon passed upstream of Daguerre Point Dam by the end of July or August during all eight years. Because the attraction flow and water temperature relationship with the percentage of adipose fin-clipped Chinook salmon passing Daguerre Point Dam occurs four weeks prior to passage at the dam, the potentially affected "attraction" period primarily occurs during May and June for most years, and into July of some years.

Second, and perhaps more importantly, the relatively minor changes in flow at the Marysville Gage under the Cumulative Condition, relative to the current conditions, would result in flow reductions and therefore would not be expected to additionally contribute to the attraction of adipose fin-clipped (hatchery) spring-run Chinook salmon into the lower Yuba River from the lower Feather River.

SPAWNING AND EMBRYO INCUBATION

During the spring-run Chinook salmon spawning and embryo incubation period (September through December), relatively minor changes in flow occur at the Smartsville Gage, generally remain above those flow levels specified in Flow Schedule A and thus remain above the corresponding upper optimum flow level. Consequently, monthly mean flow changes under the Cumulative Condition relative to the current conditions would not be expected to substantively affect the spring-run Chinook salmon spawning and embryo incubation lifestage.

JUVENILE REARING

Most juvenile spring-run Chinook salmon rearing occurs above Daguerre Point Dam. In general, juvenile Chinook salmon have been observed throughout the lower Yuba River, but with higher abundances above Daguerre Point Dam (SWRI et al. 2000). This may be due to larger numbers of spawners, greater amounts of more complex, high quality cover, and lower densities of predators such as striped bass and American shad, which reportedly are restricted to areas below the dam (YCWA et al. 2007; NMFS 2009). Therefore, although flow changes under the Cumulative Condition relative to the current conditions at the Smartsville Gage have the potential to affect most juvenile spring-run Chinook salmon rearing in the lower Yuba River, the relatively minor changes in flow would not be expected to substantively affect juvenile rearing physical habitat.

Flow changes under the Cumulative Condition relative to the current conditions at the Marysville Gage would not affect most juvenile spring-run Chinook salmon rearing in the lower Yuba River. Moreover, changes in juvenile spring-run Chinook salmon rearing habitat under the Cumulative Condition relative to the current conditions would have the highest potential to affect habitat suitability by changes in water temperature (described below).

JUVENILE DOWNSTREAM MOVEMENT

As previously discussed, juvenile spring-run Chinook salmon downstream movement (and outmigration) occurs from mid-November through June. During these months, flow decreases of 10% or more would be expected with less than a 6% probability of occurrence at both the Smartsville and Marysville gages. The minor reductions in long-term average monthly flows at the Marysville Gage under the Cumulative Condition relative to the current conditions would not result in long-term average monthly flow below the monthly minimum instream flows of Flow Schedule 1 and therefore would remain above the upper optimum flow levels. Relatively minor changes in flow at the Smartsville and Marysville gages under the Cumulative Condition relative to the current conditions would not be expected to substantively affect the spring-run Chinook salmon juvenile downstream movement (and outmigration) lifestage.

SMOLT (YEARLING+) EMIGRATION

The RMT (2013) recently identified the spring-run Chinook salmon smolt (yearling+) outmigration period as extending from October through mid-May. Relatively minor reductions in long-term average monthly flows, low probabilities of flow reductions of 10% or more, and retention of flows above the optimum specified flow levels at the Marysville Gage during the smolt (yearling+) emigration period under the Cumulative Condition relative to the current conditions would not be expected to substantively affect the spring-run Chinook salmon smolt (yearling+) emigration lifestage.

SUMMARY OF FLOW-RELATED EFFECTS ON SPRING-RUN CHINOOK SALMON

Relatively minor flow changes would occur under the Cumulative Condition relative to the current conditions. In general, under the Cumulative Condition seasonal (summer) flow increases would occur upstream of Daguerre Point Dam, and seasonal (summer) flow decreases would occur downstream of Daguerre Point Dam. The foregoing evaluation of changes in flow under the Cumulative Condition relative to the current conditions indicates no substantive effects for any of the spring-run Chinook salmon lifestages in the Action Area of the lower Yuba River.

FLOW-RELATED EFFECTS ON STEELHEAD

From the spatial and temporal distribution information presented in Chapter 4 of this BA, the lifestage-specific periodicities used for this evaluation of monthly mean flows for steelhead are as follows.

- ☐ Adult immigration and holding (August through March)
- ☐ Spawning (January through April)
- ☐ Embryo incubation (January through May)
- ☐ Juvenile rearing (Year-round)
- ☐ Juvenile downstream movement (April through September)
- ☐ Smolt (yearling+) emigration (October through mid-April)

ADULT IMMIGRATION AND HOLDING

The immigration of adult steelhead in the lower Yuba River occurs from August through March, with peak immigration from October through February. Overall, increases in flow during August and September and the relatively minor reductions in flow during the winter (January, February and March) at the Smartsville Gage under the Cumulative Condition relative to the current conditions: (1) would not be expected to affect the physical ability of adult steelhead to migrate through the upper portion of the Yuba River; and (2) would be expected to result in very minor differences in holding pool depth or areal extent.

Changes in flow at the Marysville Gage during July, August and September would not occur during the peak immigration period and would only be potentially relevant to a relatively small amount of the annual adult steelhead run. Also, the relatively minor changes in flow below Daguerre Point Dam would not be expected to affect the physical ability of adult steelhead to migrate through the lower portion of the Yuba River.

SPAWNING AND EMBRYO INCUBATION

During the steelhead spawning and embryo incubation period (January through May), relatively minor changes in flow at the Smartsville Gage would generally remain above those flow levels specified in Flow Schedule A and therefore remain above the corresponding optimum flow level. Consequently, monthly mean flow changes under the Cumulative Condition relative to the current conditions would not be expected to substantively affect the steelhead spawning and embryo incubation lifestage.

JUVENILE REARING

Most juvenile steelhead rearing occurs above Daguerre Point Dam. Juvenile trout (age 0 and 1+) abundances were substantially higher upstream of Daguerre Point Dam, with decreasing abundance downstream of Daguerre Point Dam (NMFS 2009). In fact, Kozlowski (2004) reported that approximately 82 percent of juvenile *O. mykiss* were observed upstream of Daguerre Point Dam. Therefore, although flow changes under the Cumulative Condition relative to the current conditions at the Smartsville Gage have the potential to affect most juvenile steelhead rearing in the lower Yuba River, the relatively minor changes in flow would not be expected to substantively affect juvenile rearing physical habitat.

Flow changes under the Cumulative Condition relative to the current conditions at the Marysville Gage would not affect most juvenile steelhead rearing in the lower Yuba River. Moreover, changes in juvenile steelhead rearing habitat under the Cumulative Condition relative to the current conditions would have the highest potential to affect habitat suitability by changes in water temperature (described below).

JUVENILE DOWNSTREAM MOVEMENT

The juvenile downstream movement (and outmigration) period extends from April through September and, therefore, flow changes at the Marysville Gage under the Cumulative Condition relative to the current conditions have the potential to affect a restricted portion of this lifestage. Moreover, RST sampling at Hallwood Boulevard over several years has not indicated a relationship between flow magnitude and the rate of juvenile steelhead outmigration *per se*. As previously discussed, some YOY *O. mykiss* are captured in RSTs during late-spring and summer, indicating movement downstream. However, the RMT’s (2013) analysis of the cumulative temporal distribution of *O. mykiss* observed catch at the Hallwood Boulevard RST site revealed that most emigration generally occurred from March through July, with approximately 95 percent of the observed catch generally occurring by early August. Moreover: (1) at least some of this downstream movement may be associated with the pattern of flows in the river; (2) increases in juvenile *O. mykiss* downstream movement appear to be associated with rapid, large ramp-ups of flows; and (3) increased downstream movement is not observed during gradual ramping up of flows. Therefore, it is unlikely that downstream movement of juvenile *O. mykiss* would be substantively affected by the relatively minor reductions in flows at the Marysville Gage primarily occurring during July, August, and to some extent, during September under the Cumulative Condition relative to the current conditions.

SMOLT (YEARLING+) EMIGRATION

Relatively minor changes in flow at the Marysville Gage occur during the October through April steelhead smolt (yearling+) emigration period. Relatively minor reductions in long-term average monthly flows, low probabilities of reductions of average monthly flows of 10% or more, and retention of flows above the optimum specified flow levels at the Marysville Gage during the smolt (yearling+) emigration period under the Cumulative Condition relative to the current conditions would not be expected to substantively affect the steelhead smolt (yearling+) emigration lifestage. Changes in steelhead smolt (yearling+) emigration habitat under the Cumulative Condition relative to the current conditions would have the highest potential to affect habitat suitability by changes in water temperature (described below).

SUMMARY OF FLOW-RELATED EFFECTS ON STEELHEAD

Relatively minor flow changes would occur under the Cumulative Condition relative to the current conditions. In general, under the Cumulative Condition seasonal flow increases would occur upstream of Daguerre Point Dam, and seasonal flow decreases would occur downstream of Daguerre Point Dam. The foregoing evaluation of changes in flow under the Cumulative Condition relative to the current conditions indicates no substantive effects to any of the steelhead lifestages in the lower Yuba River.

FLOW-RELATED EFFECTS ON GREEN STURGEON

The critical habitat analysis for green sturgeon under the Cumulative Condition addresses the unique specific PCE of deepwater pool habitat - essential for the conservation of the green sturgeon in freshwater riverine systems according to NMFS (2009e). Two analyses were conducted for identified pools downstream of Daguerre Point Dam in the lower Yuba River: (1) change in depth; and (2) change in the areal extent of deepwater pool habitat. These analyses are conducted for the February through November period, which represents the potential green sturgeon adult holding, spawning and post-spawning holding periods.

Using the RMT's SRH-2D model, a total of 26 pool locations were identified between Daguerre Point Dam and the mouth of the lower Yuba River, with water depths greater than 10.0 feet deep at the nominal flow of 530 cfs at the Marysville Gage. The mean depth of deepwater pool areas ranges from approximately 12.2 feet at flows from 300 to 800 cfs, to 25.4 feet at 42,200 cfs at the Marysville Gage (see **Appendix G**). The rate of change in pool depth varies depending upon the range of flows at the Marysville Gage. The mean depth of deepwater pool areas increases by only about 0.3 inches per 100 cfs on average, when flows increase from 300 cfs to 42,200 cfs.

Examination of model output presented in Appendix G of this BA demonstrates that over the 87-year simulation period, long-term average monthly depth of deepwater pool areas below Daguerre Point Dam would be equivalent or decrease only 0.1% during any month of the February through November period under the Cumulative Condition relative to the current conditions.

For Wet and Above Normal water years, average monthly depth of deepwater pool areas changed slightly over the February through November period. The greatest average monthly depth reduction during any month of the evaluation period was -0.2% under the Cumulative Condition relative to the current conditions.

For Below Normal water years, average monthly depth of deepwater pool areas changed even less over the evaluation period, with no reductions in average monthly depth exceeding -0.1% under the Cumulative Condition relative to the current conditions.

For Dry and Critical water years, average monthly depth of deepwater pool areas did not change during any month of the entire March through November period.

Application of the RMT's SRH-2D hydraulic model resulted in estimates of the total wetted area (ft^2) of pools > 10 feet deep (i.e., deepwater pool habitat) from Daguerre Point Dam to the confluence with the lower Feather River at various flow rates ranging from 300 to 42,200 cfs at the Marysville Gage. The areal percentage of the wetted channel comprised of deepwater pools ranges from 2.6% at 300 cfs, to 10.3% at 5,000 cfs, to 44.8% at 42,200 cfs (see Appendix G).

Appendix G of this BA displays monthly exceedance curves of the areal extent of deepwater pool habitat associated with the simulated mean monthly flows at the Marysville Gage over the entire modeled hydrologic period of record (i.e., 1922 through 2008) for the Cumulative Condition and current conditions. These exceedance curves are presented monthly for the February through November period, which represents the potential green sturgeon adult holding, spawning and post-spawning holding periods.

Examination of model output presented in Appendix G demonstrates that over the 87-year simulation period, the long-term average monthly deepwater pool habitat exceedance distributions would vary only slightly during February through May, October and November, and would generally be similar during June and September. The largest differences in the monthly deepwater habitat exceedance distributions occur during July and August. However, monthly deepwater habitat exceedance distributions under the Cumulative Condition differ by less than 10% over 93-100% of the monthly distributions over the entire February through November evaluation period, relative to the current conditions. Moreover, the largest reductions in deepwater pool habitat occur during July and August when deepwater pool habitat availability remains above 300,000 square feet downstream of Daguerre Point Dam. Over the quartile of the monthly deepwater pool habitat exceedance distributions representing the lowest amounts of habitat availability, deepwater pool habitat is essentially equivalent most of the time during all months, and does not differ by 10% or more during any year of any month of the evaluation period.

SUMMARY OF FLOW-RELATED EFFECTS ON GREEN STURGEON

In summary, the relatively minor flow reductions under the Cumulative Condition relative to the current conditions would be expected to result in corresponding minor reductions in deepwater pool depth and habitat availability below Daguerre Point Dam during the February through November evaluation period. During low flow conditions, deepwater pool habitat availability under the Cumulative Condition would be essentially equivalent during all months of the evaluation period, relative to the current conditions. Minor flow-related changes to depth or areal extent of deepwater pool habitat under the

Cumulative Condition relative to the current conditions indicate no substantive effects to the unique specific PCE of deepwater pool habitat associated with green sturgeon critical habitat in the lower Yuba River.

7.5.1.2 Cumulative Effects Water Temperature Analysis

WATER TEMPERATURE AT THE SMARTSVILLE GAGE

Over the 87-year simulation period, long-term average monthly water temperatures, as well as average monthly water temperatures by water year type at the Smartsville Gage would not change or would change only very slightly under the Cumulative Condition relative to the current conditions. Changes in average monthly water temperatures over all water year types would range only from an estimated 0.1°F decrease to a 0.2°F increase under the Cumulative Condition relative to the current conditions.

Examination of monthly mean water temperature exceedance distributions over the 87-year simulation period at the Smartsville Gage indicate no or minor differences between the Cumulative Condition and the current conditions during each month of the year.

WATER TEMPERATURE AT DAGUERRE POINT DAM

Over the 87-year simulation period, the long-term average monthly water temperatures, as well as average monthly water temperatures during Wet, Above Normal and Below Normal water year types at Daguerre Point Dam would not change or would change only very slightly under the Cumulative Condition relative to the current conditions. Changes in average monthly water temperatures over these water year types would range only from a 0.1°F decrease to a 0.2°F increase under the Cumulative Condition relative to the current conditions.

For Dry and Critical water year types, average monthly water temperatures at Daguerre Point Dam change slightly during most months of the year, with no change or changes of 0.1°F occurring from October through April. However, relative to the current conditions, the Cumulative Condition results in decreases in water temperature from May through September, with the largest decreases in temperature occurring during July (0.4°F and 0.3°F during Dry and Critical years, respectively) and August (0.4°F during both Dry and Critical years).

Examination of monthly mean water temperature exceedance distributions over the 87-year simulation period at Daguerre Point Dam indicate no or minor differences between the Cumulative Condition and the current conditions from October through June. Differences in the monthly mean water temperature exceedance distributions generally occur during July and August, with the Cumulative Condition exhibiting somewhat lower water temperatures over approximately the warmest one-half of the distributions, and to a lesser extent during September.

WATER TEMPERATURE AT THE MARYSVILLE GAGE

Examination of model output presented in Appendix F of this BA demonstrates that over the 87-year simulation period, the long-term average monthly water temperatures at the Marysville Gage would increase slightly during August and September (0.4°F) and either would not change or would change only very slightly from October through July under the Cumulative Condition relative to the current conditions.

For Wet water year types, average monthly water temperatures at the Marysville Gage are changed slightly during most months of the year, with no change or changes of 0.1°F occurring from October through June. Relative to the current conditions, the Cumulative Condition results in water temperature increases during July (0.2°F), August (0.4°F) and September (0.5°F).

For Above Normal water year types, average monthly water temperatures at the Marysville Gage change slightly during most months of the year, with no change or changes of 0.1°F during seven months of the year, excluding November, February and July through September. Water temperature increases occur in November, February and July (0.2°F), August (0.6°F) and September (0.5°F) under the Cumulative Condition, relative to the current conditions.

For Below Normal water year types, average monthly water temperatures at the Marysville Gage change slightly during most months of the year, with no change or changes of 0.1°F occurring from October through April. The Cumulative Condition results in water temperature increases of 0.2°F (May through July), 0.5°F (August) and 0.4°F (September) at the Marysville Gage, relative to the current conditions.

For Dry and Critical water year types, average monthly water temperatures at the Marysville Gage change slightly during most months of the year, with changes in average monthly water temperatures during these water year types ranging from a 0.4°F decrease (July of Dry water years) to a 0.1°F increase (May, August and September in Dry water years and October, November and May in Critical water years) under the Cumulative Condition, relative to the current conditions.

Examination of monthly mean water temperature exceedance distributions over the 87-year simulation period at the Marysville Gage indicate no or minor differences between the Cumulative Condition and the current conditions from October through June. Differences in the monthly mean water temperature exceedance distributions generally would occur during July, August and September, with the Cumulative Condition exhibiting somewhat lower water temperatures over approximately the warmest one-half of the distribution during July, and generally similar water temperatures over approximately the warmest one-half of the distribution during August and September, with slightly higher temperatures over the other half of the distributions.

WATER TEMPERATURE-RELATED EFFECTS ON SPRING-RUN CHINOOK SALMON

From the spatial and temporal distribution information presented in Chapter 4 of this BA, the spring-run Chinook salmon lifestage-specific periodicities used for this evaluation of monthly mean water temperatures under the Cumulative Condition relative to the current conditions are as follows.

- ☐ Adult immigration and holding (April through September)
- ☐ Spawning (September through mid-October)
- ☐ Embryo incubation (September through February)
- ☐ Juvenile rearing and downstream movement (Year-round)[2]

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[2] Water temperature suitabilities for the juvenile rearing and downstream movement lifestages are evaluated together because they have the same upper tolerance WTI.

- ☐ Smolt (yearling+) emigration (October through mid-May)

ADULT IMMIGRATION AND HOLDING

As previously discussed, adult spring-run Chinook salmon immigrate up through the lower Yuba River from early spring into July, August, and as late as September, and hold upstream and just downstream of Daguerre Point Dam until initiation of spawning during September. Examination of monthly mean water temperatures over the 87-year simulation period at the Smartsville Gage indicates that monthly mean water temperatures during the April though September adult immigration and holding time period would not approach the WTI value of 65°F at the Smartsville Gage under either the Cumulative Condition or the current conditions.

At Daguerre Point Dam, monthly mean water temperatures during April through June would not exceed the WTI value of 65°F under either the Cumulative Condition or the current conditions. From July through September water temperatures remain below the 65°F WTI value about 99% of the time under both the Cumulative Condition and the current conditions.

Relatively minor differences would occur between monthly mean water temperatures at the Marysville Gage under the Cumulative Condition and the current conditions during all months with the exception of June and July. The Cumulative Condition results in about a 9% lower probability of exceeding the 65°F index value during June, and about a 1% higher probability of exceeding the 65°F index value during July. The WTI value of 68°F would not be exceeded during October through June under either the Cumulative Condition or current conditions. The 68°F WTI value would be exceeded with the same probability (< 5%) during July, August and September at the Marysville Gage under the Cumulative Condition and the current conditions.

SPAWNING AND EMBRYO INCUBATION

During the September through December spring-run Chinook salmon spawning and embryo incubation period, mean monthly water temperatures at the Smartsville Gage would remain below the WTI value of 58°F under the Cumulative Condition and the current conditions.

JUVENILE REARING AND DOWNSTREAM MOVEMENT

Although the WTI value of 65°F was established for both the juvenile spring-run Chinook salmon rearing and downstream movement lifestages, the index value is applied at Smartsville and Daguerre Point Dam for rearing (year-round), and at Daguerre Point Dam and Marysville for juvenile downstream movement (Mid-November through June). Consequently, the probability of exceeding the 65°F index value is evaluated year-round for all three locations for these combined lifestages.

Examination of monthly mean water temperatures over the 87-year simulation period at the Smartsville Gage indicates that monthly mean water temperatures during the year-round juvenile rearing and downstream movement combined lifestages remain below the WTI value of 65°F at the Smartsville Gage under both the Cumulative Condition and the current conditions.

At Daguerre Point Dam, monthly mean water temperatures from October through June would not exceed the WTI value of 65°F under either the Cumulative Condition or the current conditions. From July through September, water temperatures remain below the 65°F WTI value about 99% of the time under both the Cumulative Condition and the current conditions.

At the Marysville Gage, during the (mid-)November through June downstream movement lifestage of juvenile spring-run Chinook salmon, monthly mean water temperatures remain below the WTI value of 65°F under both the Cumulative Condition and the current conditions. During June, water temperatures exceed the 65°F WTI value with an equal probability (< 5%) under both the Cumulative Condition and the current conditions.

SMOLT (YEARLING+) EMIGRATION

The RMT (2013) identified the spring-run Chinook salmon smolt (yearling+) outmigration period as extending from October through mid-May in the lower Yuba River. Examination of monthly mean water temperatures over the 87-year simulation period at Daguerre Point Dam and at Marysville indicates that monthly mean water temperatures would remain below the WTI value of 68°F from October through May under both the Cumulative Condition and the current conditions.

SUMMARY OF WATER TEMPERATURE-RELATED EFFECTS ON SPRING-RUN CHINOOK SALMON

Minor water temperature changes would occur under the Cumulative Condition relative to the current conditions. The foregoing evaluation of changes in water temperatures under the Cumulative Condition relative to the current conditions indicates no substantive effects for any of the spring-run Chinook salmon lifestages in the Action Area of the lower Yuba River.

WATER TEMPERATURE-RELATED EFFECTS ON STEELHEAD

The steelhead lifestage-specific periodicities used for this evaluation of monthly mean water temperatures under the Cumulative Condition relative to the current conditions are as follows.

- ☐ Adult immigration and holding (August through March)
- ☐ Spawning (January through April)
- ☐ Embryo incubation (January through May)
- ☐ Juvenile rearing and downstream movement (Year-round)[3]
- ☐ Smolt (yearling+) emigration (October through mid-April)

ADULT IMMIGRATION AND HOLDING

The immigration of adult steelhead in the lower Yuba River occurs from August through March, with peak immigration from October through February (RMT 2013). Examination of monthly mean water temperatures over the 87-year simulation period at the Smartsville Gage indicates that monthly mean water temperatures during the August through March adult immigration and holding time period would remain below the WTI

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[3] Water temperature suitabilities for the juvenile rearing and downstream movement lifestages are evaluated together because they have the same upper tolerance WTI.

value of 65°F at the Smartsville Gage under either the Cumulative Condition or the current conditions.

At Daguerre Point Dam, monthly mean water temperatures remain below the 65°F WTI value from October through March. Water temperatures remain below the 65°F and 68°F WTI values with about a 98% probability during August. During September, water temperatures remained below the 65°F WTI value with about a 98% probability, and remained below the 68°F WTI value under both the Cumulative Condition and the current conditions.

At the Marysville Gage, monthly mean water temperatures would remain below the WTI value of 65°F from October through March. The 65°F and 68°F WTI values would be exceeded with the same probability (< 5%) during August and September at the Marysville Gage under the Cumulative Condition and the current conditions.

SPAWNING AND EMBRYO INCUBATION

During the January through May steelhead spawning and embryo incubation period, mean monthly water temperatures at the Smartsville Gage remain below the WTI value of 57°F under both the Cumulative Condition and the current conditions. At Daguerre Point Dam, water temperatures remain below the 57°F WTI value during January through April under both the Cumulative Condition and the current conditions. During May, water temperatures at Daguerre Point Dam would remain below the 57°F WTI value about 97% of the time under both the Cumulative Condition and the current conditions.

JUVENILE REARING AND DOWNSTREAM MOVEMENT

Although the WTI value of 68°F was established for both the juvenile spring-run Chinook salmon rearing and downstream movement lifestages, the index value is applied at Smartsville and Daguerre Point Dam for rearing (year-round), and at Daguerre Point Dam and Marysville for juvenile downstream movement (April through September). Consequently, the probability of exceeding the 68°F index value is evaluated year-round for all three locations for these combined lifestages.

Examination of monthly mean water temperatures over the 87-year simulation period at the Smartsville Gage indicates that monthly mean water temperatures during the year-round juvenile rearing and downstream movement combined lifestages remain below the WTI value of 68°F at the Smartsville Gage under both the Cumulative Condition and the current conditions.

At Daguerre Point Dam, monthly mean water temperatures from October through June would not exceed the WTI value of 68°F under either the Cumulative Condition or the current conditions. From July through September, water temperatures remain below the 68°F WTI value about 99% of the time under both the Cumulative Condition and the current conditions.

At the Marysville Gage, during the April through September downstream movement lifestage of juvenile steelhead, monthly mean water temperatures remain below the WTI value of 68°F under both the Cumulative Condition and the current conditions from April through June. During July, August and September, water temperatures exceed the 68°F WTI value with an equal probability (< 5%) under both the Cumulative Condition and the current conditions.

SMOLT (YEARLING+) EMIGRATION

The RMT (2010b; 2013) review of all available data indicate that steelhead smolt (yearling+) emigration may extend from October through mid-April. Examination of monthly mean water temperatures over the 87-year simulation period at both Daguerre Point Dam and the Marysville Gage indicates that monthly mean water temperatures would remain below the WTI value of 55°F with about a 99-100% probability from November through April under both the Cumulative Condition and the current conditions. Water temperatures during October are essentially equivalent under the Cumulative Condition and the current conditions, and would nearly always exceed the 55°F index value.

SUMMARY OF WATER TEMPERATURE-RELATED EFFECTS ON STEELHEAD

Minor water temperature changes would occur under the Cumulative Condition relative to the current conditions. The foregoing evaluation of changes in water temperatures under the Cumulative Condition relative to the current conditions indicates no substantive effects for any of the steelhead lifestages in the Action Area of the lower Yuba River.

WATER TEMPERATURE-RELATED EFFECTS ON GREEN STURGEON

Consistent with RMT (2013), the water temperature-related assessment for green sturgeon critical habitat evaluates the differences in the probability of occurrence that water temperatures at Daguerre Point Dam and at the Marysville Gage in the lower Yuba River are outside of reported suitable ranges for each of the lifestages, under the Cumulative Condition relative to the current conditions, as follows:

- ☐ Adult immigration/holding/post-spawning holding (February through November) (44°F to 61°F)
- ☐ Adult spawning and embryo incubation (March through July) (46°F to 63°F)
- ☐ Juvenile rearing and outmigration (Year-round) (52°F to 66°F)

ADULT IMMIGRATION, HOLDING, AND POST-SPAWNING HOLDING

Water temperatures from 44°F to 61°F are used to represent the suitable range for the adult immigration, holding, and post-spawning holding lifestages. The combination of these lifestages encompasses late February through November. At Daguerre Point Dam, water temperatures remain within this range with 100% probability from February through May, and during October and November. Water temperatures would remain within this range with about 98% probability from June through September under both the Cumulative Condition and the current conditions.

At Marysville, water temperatures would remain within this range with a 100% probability from March, April, October and November, and with about 98% probability during February and May. Water temperatures would exceed the upper end of the range with about equal probability of occurrence (about 40%) during June under both the Cumulative Condition and the current conditions. Water temperatures would exceed the upper end of the range with an additional probability of occurrence under the Cumulative Condition of about 5%, 6%, and 13% during July, August and September, respectively.

SPAWNING AND EMBRYO INCUBATION

Water temperatures from 46°F to 63°F are used to represent the suitable range for the spawning and embryo incubation lifestages, which occur from March through July. At

Daguerre Point Dam, water temperatures would remain within this range with 100% probability during April and May, and would remain within this range during March, June and July with about a 98% probability.

At Marysville, water temperatures would remain at or below the upper value (63°F) of the suitability range with 100% probability during March through May under both the Cumulative Condition and the current conditions. Water temperatures would exceed the upper end of the range with about an equal probability during June under both the Cumulative Condition and the current conditions. During July, water temperatures would exceed the upper end of the range with an additional ~3% probability under the Cumulative Condition.

JUVENILE REARING AND OUTMIGRATION

The juvenile rearing and outmigration lifestages used the same WTI value range (52°F to 66°F). At Daguerre Point Dam, water temperatures would remain below the upper value of the suitability range (66°F) with a 100% probability from October through June, and with about a 98% probability from July through September under both the Cumulative Condition and the current conditions.

At Marysville, water temperatures would remain below the upper value of the suitability range (66°F) with a 100% probability from October through May. From June through September, water temperatures would remain below the upper value of the suitability range (66°F) with about a 95% probability or more under both the Cumulative Condition and the current conditions.

SUMMARY OF WATER TEMPERATURE EFFECTS ON GREEN STURGEON

Minor water temperature changes would occur under the Cumulative Condition relative to the current conditions. The foregoing evaluation of changes in water temperatures under the Cumulative Condition relative to the current conditions indicates no substantive effects for any of the green sturgeon lifestages in the lower Yuba River.

7.5.2 Other Future Non-Federal Activities

The following activities may affect flows or other conditions in the lower Yuba River. For the reasons discussed below, none of these activities is likely to have any adverse cumulative effects on any of the listed species discussed in this BA or their critical habitats.

7.5.2.1 BVID Agricultural Return Flow Recapturing Project

Browns Valley Irrigation District is planning to construct a pumping plant and a pipeline to recapture and recycle irrigation return flows that the district is discharging into Dry Creek (BVID 2011). BVID will convey recycled flows from a pumping plant on Dry Creek to rice fields presently irrigated exclusively by diversions from the lower Yuba River. The warmer reclaimed water will be delivered into BVID's Pipeline Canal and applied by its customers to rice lands where the elevated water temperature benefits rice production. Application of tailwater recaptured from Dry Creek to the agricultural lands within BVID's service area will reduce the district's demand for water diverted directly from the lower Yuba River, thus balancing the reduction in inflow to the river that results from pumping from Dry Creek with an equivalent reduction in diversion. The project is of regional significance because it will reduce diversions from the lower Yuba River (Yuba County 2007).

The project proposes to recapture up to a maximum of 10 cfs of irrigation return flow from Dry Creek during the irrigation season, which typically runs from April through October (BVID 2011). It is estimated that the influx of irrigation return flow raises Dry Creek's temperature by an average of 4–5ºC and introduces sediment, nutrients, and other constituents into the Dry Creek approximately 1.8 miles upstream of its confluence with the lower Yuba River (BVID 2009). By pumping water from Dry Creek downstream of the confluence with Little Dry Creek when Dry Creek flows are primarily comprised of return water from irrigated lands, the project is expected to improve water quality by removing some of the thermal and pollutant load from Dry Creek before it reaches the lower Yuba River. BVID will continue to meet existing minimum flow requirements with releases of cool, good quality water from Collins Lake. Any time that BVID is recapturing irrigation return water, there will be an equal and concurrent reduction in BVID's diversions from the Yuba River at its Pumpline facilities (BVID 2009). Use of the recaptured return water for the rice fields will reduce BVID diversions of cool surface water from the lower Yuba River, and this substitution will retain cool water in the lower Yuba River, which will benefit fisheries resources and aquatic habitat (BVID 2009).

7.5.2.2 The Trust for Public Lands Excelsior Project

The Excelsior Project is a collaborative conservation effort on the lower Yuba River, featuring 924 acres of wetlands, oak woodlands, gold-rush archeological remnants, and miles of critical riparian salmon spawning habitat (Excelsior Chronicles 2010). As many as 60 homes were planned along the lower Yuba River on the property once owned by the Excelsior Mining Company. The Trust for Public Lands, in collaboration with CDFW, intends to turn part of the land over to the University of California Sierra Field Research Station for salmon studies and restoration work before eventually opening it to the public (Fimrite 2009). Recently, the California Wildlife Conservation Board, in concert with the Trust for Public Lands, voted to acquire the 528-acre Yuba Narrows Ranch, ensuring that this property would be permanently protected as open space. In July of 2011, CDFW acquired the Yuba Narrows Ranch, which includes frontage along almost two miles of critical salmon spawning habitat along the lower Yuba River, and will be managed and permanently protected as open space. The conservation easement will permit access from Highway 20 into the Yuba Narrows Ranch, providing miles of hiking and acres of recreational opportunities. It is anticipated that portions of the property, including the Miner's Ditch Trail, will become open to public access. Additionally, it is anticipated the acquisition of the historic 157-acre Black Swan Ranch portion of the Excelsior property, which is located near the confluence of Deer Creek and overlooks Englebright Reservoir and the lower Yuba River, will be completed during 2013 (Excelsior Project 2013).

Beginning in the fall of 2011, conservation easements were placed on parcels of the Excelsior Ranch. The blue oak woodlands that occupy the large majority of the Excelsior Ranch will be permanently protected as open space, and managed jointly by the Ranch's steward-owners, who will also play a significant role in oversight of the Black Swan and

Yuba Narrows conservation areas. In this way, more than 870 acres (over 95%) of the Excelsior property will be permanently protected as open space.

7.5.2.3 Yuba Goldfields Sand and Gravel Mining Operations

The Yuba Goldfields area is designated and zoned “Extractive Industrial” under the Yuba County General Plan, which allows surface mining as a permitted use. Operators within and adjacent to the Yuba Goldfields currently supply construction materials, including asphaltic concrete, to projects within southern Placer and Yuba counties.

TEICHERT AGGREGATES

The Teichert Aggregate’s operation mines and processes sand and gravel deposits in addition to hard rock, immediately adjacent to the Yuba Goldfields approximately five miles northeast of Marysville, California, and two miles south of the Yuba River. The mine operates on an approximately 590-acre site and mines to depths of approximately 200 feet (Placer County 2007). Mining operations use a dragline to excavate mined materials in saturated conditions (below groundwater levels). According to Placer County (2007), production is 500,000 tons per year to 1 million tons per year (mty) depending on specific market demands. For purposes of assessing cumulative effects, it was previously assumed that this facility would be operating at its maximum estimated production rate of 1 mty (Placer County 2007).

According to SMGB (2010), mineral production at Teichert Aggregate’s Marysville facility was curtailed by more than 90 percent of the operation’s previous maximum annual mineral production due to economic conditions in 2009. However, the operator submitted an Interim Management Plan (IMP) to the California State Mining and Geology Board (SMGB) for review and approval in 2010, and the operator indicated intent to resume surface mining operations at a future date. The SMGB recommended approval of the IMP for the Teichert Marysville Facility for a period of up to five years (SMGB 2010).

WESTERN AGGREGATES

The Western Aggregates facility mines and processes sand and gravel deposits within the Yuba Goldfields south of the Yuba River and north of Hammonton-Smartville Road

(Placer County 2007). The mine operates on approximately 2,000 acres, excavating sand and gravel deposits from previous gold dredger tailings. Mined aggregate material is hauled to an onsite processing plant that includes crushers, screeners, and a conveyor. The mitigated negative declaration for the mine (adopted March 23, 1977) estimated the mining rate to be about 600,000 tons per year (Placer County 2007).

In 2008, Western Aggregates and SYRCL, along with the Yuba River Preservation Foundation and Yuba Outdoor Adventures signed an Agreement in Principle to establish a conservation easement along three miles of river frontage of the Yuba River downstream of the Parks Bar Bridge (YubaNet 2008). The easement area, consisting of approximately 180 acres of land owned by Western Aggregates, will be used by the four signatories for habitat restoration for salmon, trout, and other native Yuba River species.

The conservation easement will prohibit development or mining on the encumbered lands (except for disturbance that may be necessary for habitat restoration), and will outline a range of potential prescriptions for habitat restoration (YubaNet 2008). The project also will incorporate pedestrian access to the lower Yuba River through several walk-through gates to be established at locations to be agreed upon at a future date.

The parties plan to implement the project in three phases. Initially, the project will protect and conserve land from vehicular damage to habitat. Concurrently, SYRCL will lead design and feasibility studies for physical habitat restoration. In the second phase, habitat for salmon and riparian wildlife will be restored through a series of projects over the encumbered lands. Finally, the project contemplates implementing long-term enhancement and monitoring of these restored habitats. The timing of the completion of the three phases is unknown at this time because of the funding needs of the project (YubaNet 2008). Western has initiated a Yuba Salmon Enhancement Fund through a "challenge grant" to SYRCL of $50,000, and Western has agreed to match SYRCL's fund-raising of the project dollar - for dollar for the first $50,000 raised by SYRCL (YubaNet 2008). The four parties to the Agreement in Principle also must obtain the consent of certain third parties who have varying interests in some of the lands contemplated for the conservation easement (YubaNet 2008).

BALDWIN CONTRACTING COMPANY AND SPRINGER FAMILY TRUST HALLWOOD AGGREGATE FACILITY

The Baldwin Contracting Company, Incorporated and Springer Family Trust has proposed to expand its aggregate mining operations in the Hallwood area of east-central Yuba County, just west of the Yuba Goldfields off SR 20 (Placer County 2007). Baldwin Contracting conducts mining operations on 275 acres and is planning a phased expansion of about 200 acres over a period of 14 to 20 years, with expansion occurring 30 acres at a time. The expansion would result in mining of an additional 500,000 tons per year to 1 million tons per year. Applications were submitted to Yuba County for a change of zone, a General Plan amendment, and a Yuba County surface mining permit, and to the California State Office of Mines and Geology for a permit amendment (Placer County 2007). The existing excavation area in the Yuba Goldfields was previously mined for aggregate and gold, and the expansion area is currently in fruit orchards and has not been mined (California RWQCB 2010). Aggregate reserves exist to a depth of approximately 75 feet in both areas (California RWQCB 2010). A Report of Waste Discharge was submitted to the Central Valley Regional Water Quality Control Board for expansion of an existing aggregate facility, which was approved in 2010.

7.5.2.4 Yuba County General Plan Update Draft EIR

The Yuba County General Plan Update Final EIR, in part, evaluated cumulative biological impacts in 2030 associated with implementing the general plan (Yuba County 2011). The cumulative effects assessment stated that past development in Yuba County, ranging from conversion of land to agricultural production to recent expansion of urban development, has resulted in a substantial loss of native habitat to other uses. This land conversion has benefited a few species, such as those adapted to agricultural, urban, and rural-scale developed uses, but the overall effect on native plants, animals, and habitat has been negative. Although many future projects and plans included in the cumulative scope of this analysis would be required to mitigate those impacts, in compliance with the CEQA, Federal ESA, California ESA, and other State, local, and Federal statutes, many types of habitats and species are provided no protection. Therefore, it can be expected that the net loss of native habitat for plants and wildlife, agricultural lands, and open space areas that support important biological resources in Yuba County and related areas will continue (Yuba County 2011). The cumulative loss of habitat for special status species, such as habitat for riparian and aquatic species (e.g., California red-legged frog, giant garter snake, and western yellow-billed cuckoo) have already resulted in drastic declines in numbers of these species (Yuba County 2011). The evaluation focused on terrestrial species and their habitats.

In Yuba County, most established riparian vegetation occurs along the largest rivers; the Feather River, Yuba River, and Bear River, and south Honcut Creek. Important riparian corridors also occur along Dry Creek and other tributaries to Honcut Creek and the Yuba River. Riparian vegetation is present in the surrounding region along the Sacramento River and in the Sutter Bypass. Agricultural, residential, and industrial water use and land development have resulted in a significant cumulative reduction in the extent of riparian habitats in the County and surrounding region. Implementing Action NR 5.3, which requires private and public projects to provide setbacks to protect riparian habitat as a condition of project approvals, is expected to substantially reduce impacts on riparian habitats, although complete avoidance may not be possible while still allowing full build out of the designated land uses. Therefore, the 2030 General Plan would have a cumulatively considerable contribution to this significant cumulative impact.

The County anticipates that implementation of the Yuba-Sutter Natural Community Conservation Plan (NCCP)/Habitat Conservation Plan (HCP) would reduce cumulative biological resources impacts. The Yuba-Sutter Regional NCCP/HCP will provide an opportunity to mitigate potential impacts to biological resources that may occur through implementation of the General Plan. The NCCP/HCP is still in draft form, but the County anticipates that it will be finalized and adopted before the 2030 General Plan is fully implemented.

7.5.2.5 Yuba-Sutter Regional Natural Community Conservation Plan/Habitat Conservation Plan

According to Yuba County et al. (2011), the Yuba-Sutter Regional NCCP/HCP will address actions associated with future urban development, irrigation improvements, local flood control projects, and road improvements within Yuba and Sutter counties. During the early planning stages, a group of independent science advisors provided recommendations in a document titled *Report of Independent Science Advisors for the Yuba and Sutter County Natural Community Conservation Plan/Habitat Conservation Plan* (Conservation Biology Institute 2006).

Fish species to be considered in the NCCP/HCP include spring-run Chinook salmon, fall-run Chinook salmon, steelhead, green sturgeon, white sturgeon, Sacramento splittail and Pacific lamprey (Conservation Biology Institute 2006). The reach of the lower Yuba River extending through and somewhat beyond the Yuba Goldfields was identified as having important Chinook salmon spawning habitat worthy of special attention in conservation, restoration, and enhancement measures. Fisheries-related recommendations included the need for additional information on the known distribution of fish species in local streams and associating these to the degree possible with information on flow regimes, known or suspected barriers, and other habitat quality variables (e.g., presence or absence of nonnative aquatic species; width and quality of riparian vegetation). This information would be used to identify potential actions that could aid in the recovery of local fish populations by removing physical passage barriers, removing water contaminants, altering the timing, duration, or magnitude of stream flows, or restoring riparian vegetation and/or adjacent upland buffering (Conservation Biology Institute 2006).

7.5.2.6 City of Wheatland, Reclamation District 2103, and Reclamation District 817 External Flood Source Flood Protection Projects

Four levee improvement alternatives have been identified as part of this project to mitigate the flooding issues associated with the City of Wheatland General Plan Area. The fourth alternative is the Reclamation District 2103 Bear River Levee Remediation, which is sponsored by local land developers and is designed to provide 200-year protection for the upper portion of the Bear River levee. This project would provide additional flood protection and management for the Upper Bear River and the City of Wheatland.

7.5.2.7 Trust for Public Land - Yuba River Acquisitions Plan

This project represents an historic opportunity to acquire three priority conservation areas along the Yuba River. The acquisition of these properties will help ensure the security of water quality in the Yuba River, protect threatened and endangered fisheries, create new recreational opportunities, and increase public access. These properties are part of the Yuba River Wildlife Area Conservation Conceptual Area Protection Plan (CAPP), which coordinates CDFW's acquisition and management activities on more than 81,000 acres of the Yuba River corridor.

Retain Flood Control Options: Protection of the project properties will increase long-term flood control options by protecting critical watershed lands in the river corridor and ensuring ownership and management patterns below and above stream of major water supply, power generation, and flood control facilities.

Restore and Protect Salmon and Steelhead Habitat: The project will protect, preserve and restore riparian and aquatic habitat for State and Federally listed Chinook salmon and steelhead trout and implement important conservation elements of the Yuba River CAPP, the Yuba River Conservancy, and the Lower Yuba Technical Work Group.

Create Habitat Connectivity: This project provides tremendous opportunities for habitat connectivity, including:

- ☐ East-West connectivity along the Yuba River. The properties included in this project will provide protection for up to 14.5 miles of Yuba River through a 21-mile corridor.

- ☐ Downstream river connectivity. Invaluable river corridor connectivity between Englebright Dam and Parks Bar necessary for the restoration of existing salmon and steelhead.

- ☐ Blue oak woodland corridor. The project also represents crucial properties in the center of a roughly twenty-mile north–south oak woodland corridor that stretches from the CDFW Daugherty Wildlife Area to the Spenceville Wildlife Area and Beale Air Force Base.

Protect Agricultural Lands**:** The project will preserve and protect important agricultural lands, including grassland and rangelands along the river corridor that provide important wildlife habitat, riparian zones and protect sensitive aquatic environments.

7.6 Aggregate and Net Effects of the Proposed Action

In addition to determining whether the Proposed Action is likely to adversely affect any listed species or their critical habitats, this BA provides information to assist NMFS in evaluating whether the "aggregate effects" of the Proposed Action are likely to "*reduce appreciably the likelihood of both the survival and recovery*" of each listed species, or "*appreciably diminish[] the value of critical habitat.*" Under the aggregate effects assessment approach, the Environmental Baseline and the status of the species are viewed together by NMFS to determine the ability of each listed species to withstand additional stressors associated with subsequent actions without jeopardizing the continued existence of the species. Thus, an assessment is made as to whether current conditions, measured against the status of a species, leave any "cushion" to accommodate additional adverse impacts without causing jeopardy to the species. As NMFS (2009a) indicates: "*if the species' status is poor and the baseline is degraded at the time of consultation, it is more likely that any additional adverse effects caused by the proposed or continuing action will be significant.*"

As detailed in this BA, ongoing and future activities and conditions not necessarily within the control of the Corps are likely to continue to place substantial stress on the species at the ESU/DPS level. For the ESU-wide Environmental Baseline effects assessment of the spring-run Chinook salmon, NMFS (2009a) found that the entire suite of limiting factors, threats and stressors associated with the Environmental Baseline result in an unstable ESU at moderate risk of extinction. For the DPS-wide Environmental Baseline effects assessment of steelhead, NMFS (2009a) found that the entire suite of stressors associated with the Environmental Baseline result in an unstable DPS at moderate or high risk of extinction. Although NMFS (2009a) did not clearly state whether or not the green sturgeon DPS was stable, they concluded that continued operations of the CVP/SWP would be expected to have population level consequences for the single extant population in the mainstem Sacramento River, and that the stressors associated with the Environmental Baseline are likely to jeopardize the continued existence of the Southern DPS of North American green sturgeon and greatly increase the extinction risk of the species (NMFS 2009a).

In the lower Yuba River, available information regarding the current status of phenotypic spring-run Chinook salmon indicates that under the Environmental Baseline their abundance and trend considerations would correspond to low extinction risk according to NMFS criteria (Lindley et al. 2007). However, the RMT (2013) questions the applicability of any of these criteria addressing extinction risk, because lower Yuba River anadromous salmonids represent introgressive hybridization of larger Feather-Yuba river populations, with substantial contributions of hatchery-origin fish to the annual runs. Populations of steelhead and green sturgeon in the lower Yuba River are data deficient, and consequently cannot be concluded to be stable or at a specific risk of extinction.

Under the aggregate effects assessment approach, evaluation of the Environmental Baseline and the inability to conclude that populations of the listed species are stable would suggest that each listed species would not be able to withstand additional stressors associated with subsequent actions, and that it is… "*more likely that additional adverse effects caused by the proposed or continuing action will be significant*."

However, regarding spring-run Chinook salmon and steelhead, the Proposed Action will: (1) improve passage ability due to continuing to keep the fish ladder control gates open at high flow levels; and (2) improve within-ladder hydraulics and attraction flows by adjustment of within-ladder flashboards and fish ladder gated orifices; (3) improve within ladder hydraulics by removal of debris and sediment accumulation within the fish ladder bays and thereby improve passage conditions; (4) direct sheet flow that spills over the top of Daguerre Point Dam into the fish ladders, and thereby improve the ability of adult fish to locate the fish ladders and migrate upstream to spawning and rearing habitats; and (5) direct downstream migrating juvenile spring-run Chinook salmon and steelhead into the fish ladders, and thereby reduce physical injury from spilling over the dam, and potentially reduce predation due to disorientation in the plunge pool below the dam. In addition, the Proposed Action will not introduce new stressors or substantially exacerbate ongoing stressors under the Environmental Baseline to green sturgeon in the lower Yuba River. The Proposed Action is not likely to increase risks to green sturgeon.

Implementation of voluntary conservation measures would: (1) expand suitable spawning habitat in the Englebright Dam Reach and may encourage additional behavioral segregation of spawning spring-run Chinook salmon; and (2) provide additional LWM and corresponding habitat complexity and diversity (and therefore predator escape cover, velocity shelter, feeding stations) for rearing juvenile spring-run Chinook salmon and steelhead, relative to the Environmental Baseline.

The net effects of the Proposed Action would not increase the risks to spring-run Chinook salmon and steelhead because the Proposed Action will improve conditions in the Action Area of the lower Yuba River relative to the Environmental Baseline. In addition, the net effects of the Proposed Action will not increase the risks to green sturgeon because the Proposed Action will not result in increased harm to the species over Environmental Baseline conditions in the Action Area of the lower Yuba River.

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8.0 Conclusions and Determinations

The following discussion provides the Corps' conclusions and determinations concerning whether the Proposed Action is likely to adversely affect spring-run Chinook salmon, steelhead and green sturgeon, or designated critical habitat within the Action Area. The conclusions in this BA are based on the best scientific and commercial data available, and are intended to assist NMFS in reaching its own determinations regarding project-related effects to listed species in the context of the formal ESA consultation process.

Three possible determinations exist regarding a proposed action's effects on listed species under the ESA (USFWS and NMFS 1998). These determinations are as follows:

- ☐ ***No effect*** - "*No effect*" is the appropriate conclusion when it is determined that the proposed action will not affect a listed species or designated critical habitat.
- ☐ ***May affect, but is not likely to adversely affect*** - "*May affect, but is not likely to adversely affect*" is the appropriate conclusion when effects on ESA protected species are expected to be discountable, insignificant, or completely beneficial. "*Insignificant effects relate to the size of the impact, and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur* (USFWS and NMFS 1998)."
- ☐ ***May affect, is likely to adversely affect*** - "*May affect, is likely to adversely affect*" is the appropriate conclusion if any adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not discountable, insignificant or beneficial. In fact, in the event the overall effect of the proposed action is beneficial to an ESA-protected species, but also is likely to cause some adverse effects, then the proposed action "*is likely to adversely affect*" the listed species. If incidental take is anticipated to occur as a result of the proposed action, an "*is likely to adversely affect*" determination should be made (USFWS and NMFS 1998).

The analyses presented in Chapter 7 of this BA was conducted to assist NMFS in determining whether the Proposed Action will cause "…*some deterioration in the* *species' pre-action condition*” (*National Wildlife Federation v. NMFS, 524 F.3d 917 (9th Cir. 2008*). Specifically for this consultation, the conservation measures associated with the Proposed Action have been implemented over the past few years, representing a reduction in stressors and improvement over the pre-action condition of spring-run Chinook salmon and steelhead.

8.1 Listed Species

The Proposed Action is comprised of the Corps’ authorized discretionary O&M activities at the existing fish passage facilities at Daguerre Point Dam, including the administration of two outgrants associated with O&M of the facilities, and specified conservation measures. The Proposed Action will improve pre-action Environmental Baseline conditions in the Action Area of the lower Yuba River for spring-run Chinook salmon and steelhead because it will: (1) improve passage ability due to continuing to keep the fish ladder control gates open at high flow levels; (2) improve within-ladder hydraulics and attraction flows by adjustment of within-ladder flashboards and fish ladder gated orifices; (3) improve within ladder hydraulics by removal of debris and sediment accumulation within the fish ladder bays and thereby improve passage conditions; (4) direct sheet flow that spills over the top of Daguerre Point Dam into the fish ladders, and thereby improve the ability of adult fish to locate the fish ladders and migrate upstream to spawning and rearing habitats; and (5) direct downstream migrating juvenile spring-run Chinook salmon and steelhead into the fish ladders, and thereby reduce physical injury and potential mortality from spilling over the dam, and potentially reduce predation due to disorientation in the plunge pool below the dam.

Implementation of voluntary conservation measures would: (1) expand suitable spawning habitat in the Englebright Dam Reach for spring-run Chinook salmon and steelhead, and may encourage additional behavioral segregation of spawning spring-run Chinook salmon; and (2) provide additional LWM and corresponding habitat complexity and diversity (and therefore predator escape cover, velocity shelter, feeding stations) for rearing juvenile spring-run Chinook salmon and steelhead, relative to the pre-action Environmental Baseline conditions.

In addition, the Proposed Action will not increase the long-term risks to green sturgeon because the Proposed Action will not introduce new stressors or substantially exacerbate ongoing stressors. Within the Action Area, the one known stressor to green sturgeon is Daguerre Point Dam, which was not designed to provide for green sturgeon passage upstream of the dam. However, the Proposed Action would not affect green sturgeon in the lower Yuba River because stressors on green sturgeon associated with Daguerre Point Dam are part of the Environmental Baseline. Consequently, the Proposed Action will not result in increased harm to the species over pre-action Environmental Baseline conditions in the Action Area of the lower Yuba River.

8.1.1 Incidental Take Considerations

Under the Federal ESA, take is defined as "*…to harm, harass, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct*" [ESA§3(19)]. Harass, pursue, hunt, shoot, wound, kill, trap, capture or collect can be classified as actions that would have a direct effect on a species, at the individual level. Conversely, harm, which is a form of take, is further defined to include "*…significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering*" (USFWS and NMFS 1998).

8.1.1.1 Sediment Management

There is some potential that sediment excavation activities directly upstream of Daguerre Point Dam may interfere with the egress of adult individuals from the fish ladders, causing temporary behavioral alteration. Sediment excavation also may result in temporary behavioral alteration of spring-run Chinook salmon and steelhead juvenile rearing and downstream migration. These potential temporary behavioral alterations could be considered to represent "harassment" as a form of take. Additionally, there is the more remote possibility of physical injury or direct mortality to juveniles from being contacted by the excavator bucket. Consequently, implementation of the sediment management plan has the limited potential to result in minor amounts of "take" of adult and juvenile spring-run Chinook salmon and steelhead individuals. Overall, however, the long-term benefits to listed anadromous salmonids resulting from continued implementation of sediment management activities at Daguerre Point Dam are expected to outweigh any potential occurrences of incidental take (or harm) that may occur to individual fish during sediment excavation activities. Therefore, the sediment management component of the Proposed Action represents an overall beneficial effect, but the Corps has determined that this component "*may affect, is likely to adversely affect*" because of the remote possibility of low amounts of incidental take of spring-run Chinook salmon and steelhead.

8.1.1.2 Flashboard Management

The Daguerre Point Dam Flashboard Management Plan was developed to benefit spring-run Chinook salmon and steelhead by improving the ability of adult fish to locate the fish ladders and migrate upstream to spawning and rearing habitats. Ancillary benefits include directing downstream migrating juvenile spring-run Chinook salmon and steelhead into the fish ladders, and thereby avoiding physical injury and potential mortality from spilling over the dam, and potentially increased predation due to disorientation in the plunge pool below the dam.

There is a potential that the flashboards may collect debris that have an associated limited potential to entrap downstream migrating spring-run Chinook salmon and steelhead, which might contribute to juvenile fish mortality. However, the plan specifies that the flashboards will be monitored at least once per week, and perhaps as frequently as daily in conjunction with CDFW and/or PSMFC monitoring of the VAKI systems, and that all adjustments to the flashboards will be made as necessary in coordination with NMFS and CDFW. During the period that flashboards are installed, the flashboards will be cleared within 24 hours of finding a blockage, or as soon as it is safe to clear them. Further, flashboards will be removed within 24 hours, if directed by the Corps, NMFS or CDFW. Consequently, implementation of the flashboard management plan has the limited potential to result in temporary, minor amounts of "take" of juvenile spring-run Chinook salmon and steelhead individuals. Overall, however, the long-term benefits to listed anadromous salmonids resulting from continued implementation of flashboard management at Daguerre Point Dam are expected to outweigh any potential occurrences of incidental take (or harm) that may occur to individual fish during flashboard installation, operation and removal activities. Therefore, the flashboard management component of the Proposed Action represents an overall beneficial effect, but the Corps has determined that this component "*may affect, is likely to adversely affect"* because of the remote possibility of low amounts of incidental take of juvenile spring-run Chinook salmon and steelhead.

8.1.1.3 Debris Maintenance and Removal

For this Proposed Action, debris maintenance and removal activities and maintenance of the VAKI Riverwatcher in the fish ladders at Daguerre Point Dam could temporarily disrupt adult spring-run Chinook salmon and steelhead undisturbed upstream migration behavior and be considered as a form of harassment. In addition, there is a remote possibility that juvenile spring-run Chinook salmon or steelhead could be within the bays of the fish ladders during debris maintenance activities. Consequently, there is a corresponding remote possibility that physical harm or mortality could occur to individual fish, which could represent minor amounts of "take" of adult and juvenile spring-run Chinook salmon and steelhead individuals, on a temporary basis. Overall, however, the long-term benefits to listed anadromous salmonids resulting from continued implementation of debris maintenance and removal at Daguerre Point Dam are expected to outweigh any potential occurrences of incidental take (or harm) that may occur to individual fish during implementation. Therefore, the debris maintenance and removal component of the Proposed Action represents an overall beneficial effect, but the Corps has determined that this component "*may affect, is likely to adversely affect*" because of the remote possibility of low amounts of incidental take of spring-run Chinook salmon and steelhead.

8.1.1.4 Voluntary Conservation Measures

Some relatively minor amounts of take have the potential to result from the construction/implementation phases of the voluntary conservation measures. Gravel injection has the potential to result in disturbance of individuals due to noise and vibration. It also could result in physical injury or direct mortality of juvenile spring-run

Chinook salmon and steelhead, although it is likely that individuals would vacate the area during construction activities. Similarly, construction and placement of LWM features also have the potential to result in relatively minor amounts of take due to physical injury or direct mortality of juvenile spring-run Chinook salmon and steelhead. If it is necessary to use heavy equipment close to the river, there is a potential for noise and vibration to disturb spring-run Chinook salmon and steelhead. It is not likely that adults of either species would be directly or indirectly impacted due to natural avoidance behavior. Therefore, the voluntary conservation measures of the Proposed Action represents an overall beneficial effect, but the Corps has determined that these components "*may affect, is likely to adversely affect*" because of the remote possibility of low amounts of incidental take of spring-run Chinook salmon and steelhead.

Voluntary conservation measures are not likely to result in incidental take of green sturgeon, because these measures would be located several miles upstream of Daguerre Point Dam, which represents the upstream extent of the potential presence of green sturgeon in the lower Yuba River.

8.2 Critical Habitat

The Proposed Action will not adversely affect the critical habitat PCEs or their management in a manner likely to appreciably diminish or preclude the role of that habitat in the recovery of the Central Valley spring-run Chinook salmon and steelhead.

The Proposed Action will not increase the risks to the spring-run Chinook salmon or steelhead critical habitat because it will improve pre-action Environmental Baseline conditions in the lower Yuba River. Specific conservation measures will increase the suitability and availability of critical habitat for spring-run Chinook salmon and steelhead in the lower Yuba River through the ongoing implementation of a gravel augmentation program in the Englebright Dam Reach, as well as development of a LWMMP for the lower Yuba River.

The Cumulative Condition would generally result in seasonal flow increases upstream of Daguerre Point Dam (as measured at the Smartsville Gage) and seasonal flow decreases downstream of Daguerre Point Dam (as measured at the Marysville Gage), primarily during the summer months of July, August and September. Seasonal reductions in flow under the Cumulative Condition would have the greatest potential to affect juvenile spring-run Chinook salmon and steelhead rearing habitat suitability through resultant changes in water temperature. However, analyses of both monthly mean flow- and water temperature-related changes under the Cumulative Condition, relative to the current conditions, would not be anticipated to adversely affect any of the spring-run Chinook salmon or steelhead lifestages in the lower Yuba River.

Green sturgeon critical habitat in the lower Yuba River extends from Daguerre Point Dam downstream to the confluence with the lower Feather River. A unique specific PCE essential for the conservation of the Southern DPS of North American green sturgeon is deepwater pool habitat. The Proposed Action will not adversely affect the critical habitat PCEs or their management in a manner likely to appreciably diminish or preclude the role of that habitat in the recovery of green sturgeon.

The relatively minor seasonal flow reductions under the Cumulative Condition relative to the current conditions would be expected to result in corresponding minor reductions in deepwater pool depth and habitat availability below Daguerre Point Dam. During low flow conditions, deepwater pool habitat availability under the Cumulative Condition would be essentially equivalent during all months of the evaluation period, relative to the current conditions. Minor flow-related changes to depth or areal extent of deepwater pool habitat under the Cumulative Condition relative to the current conditions indicate no substantive effects to the unique specific PCE of deepwater pool habitat associated with green sturgeon critical habitat in the lower Yuba River. Moreover, minor changes in water temperatures under the Cumulative Condition relative to the current conditions indicate no substantive effects for any of the green sturgeon lifestages in the lower Yuba River.

8.3 Conclusions and Determinations

Conclusions and determinations take into account both the magnitude and probability of occurrence of effects to listed species and their habitats resulting from the Proposed

Action. According to the ESA Consultation Handbook (USFWS and NMFS 1998) …"*Insignificant effects relate to the size of the impact, and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur*."

In consideration of the foregoing effects assessments, because some incidental take potentially could occur as a result of the Proposed Action, the Corps concludes that the the Proposed Action "*may affect, and are likely to adversely affect*" Central Valley spring-run Chinook salmon and steelhead. Potential adverse effects to critical habitat of spring-run Chinook salmon and steelhead in the Action Area due to the Proposed Action are expected to be discountable and/or insignificant.

As previously discussed, other than infrequent adult occupancy, no other lifestage of green sturgeon has ever been reported in the lower Yuba River. The ongoing stressors associated with Daguerre Point Dam's blockage of green sturgeon are due to the presence of the dam and configuration of the fish ladders, so they are part of the Environmental Baseline. The Corps does not currently have the authority to lessen the potential passage/blockage effects from these structures on green sturgeon.

The Proposed Action primarily includes physical activities within the fish ladders at Daguerre Point Dam and actions upstream. The LWMMP (Corps 2012d) reports that LWM placement sites are located in the approximate 4-mile reach of the lower Yuba River downstream of the Highway 20 Bridge, often referred to as the Parks Bar to Hammon Bar Reach, and that additional sites upstream of the Highway 20 Bridge also may be considered. Thus, LWM placement sites are located several miles upstream of Daguerre Point Dam. The only physical activities downstream of Daguerre Point Dam include placement of excavated sediment above the waterline along the shore approximately 1/4 mile downstream of Daguerre Point Dam. Physical injury or direct mortality to listed species associated with excavated sediment placement is not expected to occur. The foregoing effects evaluations indicate that potential adverse effects to critical habitat of green sturgeon in the Action Area due to the Proposed Action are expected to be discountable and/or insignificant. Therefore, the Corps concludes that the Proposed Action "*may affect, but is not likely to adversely affect*" green sturgeon and its critical habitat.

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APPENDIX A

Corps' Authorities

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1.0 Introduction

The purpose of this Appendix is to explain the Corps' statutory authorities for its maintenance and inspection activities at Englebright Dam and Daguerre Point Dam. The Appendix further identifies whether the Corps could modify either its operations/maintenance activities or modify the physical structure of the dam to address concerns related to threatened and endangered species. As explained below, the project statutory authorities themselves do not allow such modifications except to a limited extent with respect to the fish ladders at Daguerre Point Dam. This Appendix provides an overview of other statutory authorities evaluated for their potential use to address species concerns. As explained below, none of these other authorities provide a basis for making any changes to these projects without further Congressional authorization, a local cost share partner, and appropriations.

1.1 BACKGROUND

1.1.2 The California Debris Act

On March 1, 1893, the United States Congress passed the California Debris Act (Ch 183, § 1, 27 Stat. 507)[1] establishing the California Debris Commission ("Commission"). The Commission consisted of three members drawn from officers of the U.S. Army Corps of Engineers and appointed by the President.[2]

The California Debris Act provided that the jurisdiction of the Commission included all hydraulic mining processes "in the territory drained by the Sacramento and San Joaquin river

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[1] 33 U.S.C §661, *et seq*.
[2] 33 USC §661

systems in the State of California."[3] The Commission's duty was to restore the navigability of rivers in the Sacramento and San Joaquin river systems by adopting "…such plan or plans, from examinations and surveys already made [prior to March 1, 1893], and from such additional examinations and surveys as it may deem necessary, as will improve the navigability of all the rivers comprising said systems, deepen their channels, and protect their banks."[4] In order to carry out its duties, the California Debris Act required the Commission to determine the practicability of storage sites in the Sacramento and San Joaquin Rivers and their tributaries while also devising a method that allows hydraulic mining to continue, survey and note the condition of the navigable channels of the Sacramento and San Joaquin River systems, and submit annual reports to the Chief of Engineers and the Secretary of the Army, to include "plans for the construction, completion, and preservation of the public works outlined in this act…"[5]

Among other provisions, the California Debris Act authorized construction of restraining dams or settling reservoirs as appropriations or other funds became available.[6] Further, the Commission was authorized to cooperate and consult with the State of California in performance of its duties under the California Debris Act.[7] Before the Commission was abolished and its duties transferred to the Corps (see Section 1.1.5 below), two debris dams were constructed on the Yuba River – Daguerre Point Dam and Englebright Dam.

1.1.3 Daguerre Point Dam

In the River and Harbor Act of June 3, 1896 ("RHA 1896") (29 Stat. 202), Congress appropriated funds for "the construction, repair and preservation of certain public works on

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[3] 33 USC §663
[4] 33 USC §664
[5] 33 USC §§665 – 667
[6] 33 USC §685
[7] 33 USC §684

rivers and harbors, and for other purposes." The RHA 1896 also authorized funds provided by the State of California to be used for purposes set forth in the RHA 1896. The RHA 1896 stated in relevant part:

> "For the construction of restraining barriers for the protection of the Sacramento and Feather rivers in California, two hundred and fifty thousand dollars; such restraining barriers to be constructed under the direction of the Secretary of War in accordance with the recommendation of the California Debris Commission, pursuant to the provisions of and for the purposes set forth in, section twenty five of the Act of the Congress of the United States, entitled, "an Act to create the California Debris Commission and regulate hydraulic mining in the State of California," approved March first, eighteen hundred and ninety-three: *Provided*, That the Treasurer of the United States be, and he is hereby, authorized to receive from the State of California through the Debris Commission of said State , or other officer thereunto duly authorized, any and all sums of money that have been, or may hereafter be, appropriated by said State for the purposes herein set forth. And said sums when so received are hereby appropriated for the purposes above named, to be expended in the manner above provided."

Several years later, on February 13, 1900, the House of Representatives issued Document 431 which described construction of four barriers to retain debris in the bed of the Yuba River, one of which was to be constructed at Daguerre Point.[8] Thereafter on June 13, 1902, Congress passed the Rivers and Harbors Act of 1902, Public Law No. 154, 57th Congress ("RHA 1902") authorizing and appropriating funds for the construction of a structure to retain debris as previously described in House of Representatives Document Number 431. The RHA 1902 stated:

> *Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That the following sums of money be, and are hereby, appropriated, to be paid out of any money in the Treasury not otherwise appropriated, to be immediately available, and to be expended under the direction of the Secretary of War and the supervision of the Chief of Engineers, for the construction, completion, repair, and preservation of the public works hereinafter named:

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[8] H. Doc. Numbered 431, 56th Congress (February 14, 1900), pgs. 4 – 6.

> "…For carrying out the provisions of the Act of Congress providing. for the restraining or impounding- of mining debris in California, in accordance with the report submitted in House Document Numbered Four hundred and thirty-one, Fifty-sixth Congress, ·first session, one hundred and fifty thousand dollars in addition to the amount heretofore appropriated. And the Secretary of War, within the limit of the appropriations heretofore and now made by Congress and by the State of California, is authorized to make a. contract or contracts for such work and materials as may be necessary to carry out and complete the project, and may, out of said appropriations, purchase a site or sites in accordance with said project: *Provided,* That before entering on said work or making said contracts, the Secretary of War shall be satisfied that the State of California has appropriated for the prosecution of said project the sum of four hundred thousand dollars: *Provided further,* That contracts for the purchase of sites or for work and materials shall provide specifically that only one-half the compensation agreed to be paid shall be paid by the United States, and that the contractor or contractors shall look to the State of California for the remainder of the agreed compensation: *And provided further,* That if the work be done by the United States without contract, one-half the cost thereof shall be paid by the State of California, as the work progresses, upon estimates to be submitted from time to time by the Chief of Engineers." …

As authorized by RHA 1902, a 26-foot debris dam was constructed at Daguerre Point to retain hydraulic mining debris and prevent it from flowing into navigable waters and adversely impacting the navigable capacity of downstream waterbodies. Daguerre Point Dam was operationally completed in 1910. Two fishways one for low water and the other for high water, were constructed at Daguerre Point Dam prior to the floods of 1927-1928.[9] In the fall of 1938, a fish ladder was installed by the Corps at the southerly end of the dam. In August 1951, two new fish ladders were completed on the Daguerre Point Dam by the State of California, Division of Fish and Game.[10] In 1964, the Corps met with the U.S. Fish and Wildlife Service and the California Department of Fish and Game (now the California Department of Fish and Wildlife) to discuss and develop criteria for the reconstruction and modification of the existing fishways,

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[9] Division of Fish and Game of California Fish Bulletin 17 by G.H. Clark (1929)

[10] State of California Department of Fish and Game Forty-Second Biennial Report for the Years 1950 – 1952 (January 1953)

including the dimensions and depth of the fishway bays.[11] In October 1965, the Corps completed the repair of the fish ladders at Daguerre Point Dam using federal and State contributed funds.[12] Because the Daguerre Point Dam fish ladders were not designed or constructed for upstream passage of green sturgeon, the fish ladder entrances and bays are too small to accommodate green sturgeon, and there is no other means for green sturgeon to pass over or around the structure, it is and always has been a complete barrier for green sturgeon. (see Chapter 7 of the Biological Assessment). The fish ladders appear to have been designed and constructed solely for the purpose of facilitating upstream passage for salmon and trout, based on the dimensions and configurations of the bays and design flows. Furthermore, at least in 1961, trout and salmon were primary concerns of the State of California which was a cost share partner with the Corps in constructing Daguerre Point Dam and the fish ladders. In 1961, the State legislature enacted legislation to reduce the loss of salmon and trout habitat. [13] One of the areas the legislation targeted for management and protection was the Yuba River between Englebright Dam and a point approximately four miles east of Marysville.[14]

Under the Daguerre Point Dam project authority, the Corps is responsible for various discretionary and non-discretionary functions. The discretionary functions include monitoring and clearing debris from the fish ladders and managing sediment buildup across the upstream face of the dam. Non- discretionary functions include the inspection and maintenance of the dam

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[11] Memo for Record, Daguerre Point Dam – Conference for Reconstruction of Fishways Affecfted by Rehabilitation of Dam, dated 29 July 1964; Memo for Record, Daguerre Point Dam – Conferenc on Modification of Fishways, dated 13 August 1964.

[12] Report of the Secretary of the Army on Civil Works Activities for FY 2008, Projects Specifically Authorized Under the Former California Debris Commission

[13] Letter dated December 22, 1961 from the Corps to The Yuba River Control Association enclosing a letter dated October 20, 1961 from the State of California Department of Fish and Game advising agencies of newly enacted legislation enacted as a result of a State study that identified "a serious loss of salmon and trout habitat in California."

[14] Id.

structure and fish ladders to ensure they remain in good repair. More detail about the Corps' functions at Daguerre Point Dam can be found in Chapters 1 and 2 of the Biological Assessment.

1.1.4 Englebright Dam

The Rivers and Harbors Act of 1935 ("RHA 1935"), Public Law No. 409, 74th Congress, authorized construction of a project for debris control in accordance with the Rivers and Harbors Committee Document Numbered 50, 74th Congress (May 28, 1935) ("House Document 50"). The RHA 1935 stated:

> "…the following works of improvement of rivers and harbors, and other waterways are hereby adopted and authorized to be prosecuted under the direction of the Secretary of War and supervision of the Chief of Engineers, in accordance with the plans recommended in the respective reports hereinafter designated and subject to the conditions set forth in such documents…"
>
>> "…Sacramento River and tributaries, California (debris control); Rivers and Harbors Committee Document Numbered 50, Seventy-fourth Congress;…

House Document 50 concluded that debris storage at four locations on the Yuba River was economically justified. One of the locations was the Upper Narrows site on the Yuba River[15] which is the current location of Englebright Dam. House Document 50 also contained the Board of Engineers conclusion that although development of power at the Narrows site was "economically justified, a firm contract for sale of the power cannot be obtained at this time."[16]

Construction of Englebright Dam, as authorized under RHA 1935, was completed in 1941. Under the Englebright Dam project authority, the Corps is responsible for various discretionary and non-discretionary functions. The discretionary functions include activities

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[15] House Document 50, pages 3 and 8.

[16] House Document 50, page 5

related to the manner and frequency of maintaining the recreational facilities at the dam. Non-discretionary functions include the inspection and maintenance of the dam structure to ensure it remains in good repair. More detail about the Corps’ functions at Englebright Dam can be found in Chapters 1 and 2 of the Biological Assessment.

Controlled water releases from Englebright Dam are made through two hydroelectric power facilities, one of which (Narrows II) is located just below the base of the dam and the other (Narrows I), is located approximately 0.2 mile downstream of the dam. The hydroelectric power facilities are owned, operated and maintained by the Yuba County Water Agency ("YCWA") and the Pacific Gas and Electric Company ("PG&E") respectively. Water is released either through the Narrows I (PG&E) powerhouse (approximate capacity of 700 cubic feet per second {cfs}) or through the Narrows II (YCWA) powerhouse (approximate capacity of 3,400 cfs). The Corps has no discretionary authority or control over operation and maintenance of the powerhouses or the water releases through those facilities. When Englebright Reservoir is full, water in excess of what can be used by the hydroelectric powerhouses spills uncontrolled over the top of the dam.

The powerhouses operate pursuant to licenses issued by the Federal Energy Regulatory Commission ("FERC") which dictate the terms under which the hydropower facilities can operate. FERC originally licensed the PG&E facility ("Narrows I") in 1941. On February 11, 1993, FERC issued PG&E a new license for the continued operation of Narrows I. Thereafter, on March 28, 1994, the Corps entered into an agreement with PG&E granting permission for the powerhouse to continue to exist and operate on Corps managed-lands. Under the 1994 agreement, the Corps is responsible for maintaining Englebright Dam and its outlet facilities in good order and repair, while PG&E is responsible for the operation and maintenance of the hydroelectric facility.

Similarly, FERC initially issued a license to YCWA for operation of the hydropower facility knows as "Narrows II" on May 16, 1963. Subsequently, on May 6, 1966, FERC made the license effective from May 1, 1966 through April 30, 2016. On February 14, 1966, the Corps entered into a contract with YCW A allowing construction, operation and maintenance of Narrows II on Corps-managed lands. Under the 1966 contract, the operation and maintenance of Narrows II and its facilities are solely the responsibility of YCW A.

1.1.5 Transfer of Responsibility for Daguerre Point Dam and Englebright Dam

In the Water Resources Development Act of 1986 ("WRDA 1986"), Section 1106[17], Congress abolished the California Debris Commission and transferred "all authorities, powers, functions and duties" of the Commission to the Secretary of the Army. Pursuant to WRDA 1986, the Corps now has the responsibility for Daguerre Point Dam and Englebright Dam until such time that Congress passes further laws deauthorizing the facilities or granting authority to modify the facilities and/or their purposes. Section 1106 states:

> SEC. 1106. CALIFORNIA DEBRIS COMMISSION.
>
> (a) The California Debris Commission established by the first section of the Act of March 1, 1893 (33 U.S.C. 661) is hereby abolished.
> (b) All authorities, powers, functions, and duties of the California Debris Commission are hereby transferred to the Secretary.
> (c) The assets, liabilities, contracts, property, records, and the unexpended balance of appropriations, authorizations, allocations, and other funds employed, held, used arising from, available to, or to be made available in connection with the authorities, powers, functions, and duties transferred by this section, subject to section 202 of the Budget and Accounting Procedure Act of 1950, are hereby transferred to the Secretary for appropriate allocation. Unexpended funds

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[17] Public Law 99-662, Nov. 17, 1986, 100 Stat. 4082

> transferred pursuant to this subsection shall be used only for the purposes for which the funds were originally authorized and appropriated.
>
> (d) All acquired lands, and other interests therein presently under the jurisdiction of the California Debris Commission are hereby authorized to be retained, and shall be administered under the direction of the Secretary, who is hereby authorized to take such actions as are necessary to consolidate and perfect title; to exchange for other lands or interests therein which may be required for recreation or for existing or proposed projects of the United States; to transfer to other Federal agencies or dispose of as surplus property; and to release to the coextensive fee owners any easements no longer required by the United States, under such conditions or for such consideration as the Secretary shall determine to be fair and reasonable. Except as specifically provided herein all transactions will be in accordance with existing laws and procedures.

2.0 OPERATION AND MAINTENANCE OF THE PROJECTS

Pursuant to the above statutes, the Corps undertakes annual operations and maintenance of the Englebright Dam and Daguerre Point Dam Projects. Such activities include, but are not limited to, cleaning and repairing the existing Daguerre Point Dam fish ladders, removing sediment from the upstream of Daguerre Point Dam, and implementing a woody material management plan to help provide fish habitat in areas made accessible to listed salmon and steelhead due to the fish ladders.[18] These activities must be undertaken within existing Corps real estate and budgetary constraints, and relate solely to project purposes, which in the case of Daguerre Point Dam includes encouragement of steelhead and salmon migration in the immediate vicinity of that Project in accordance with the purposes for which the fish ladders were originally constructed. It is under this operation and maintenance authority that the Corps was able to add grates to the top of the fish ladders to reduce the likelihood of fish jumping out

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[18] The maintenance actions the Corps is currently implementing originated or were refined based on reasonable and prudent measures identified in various Biological opinions issued by NMFS since 2002. The sediment removal and debris removal/clearing was included in the suite of reasonable and prudent measures identified in the March 27, 2002 Biological Opinion. Additional refinements to the debris removal/clearing and sediment management actions were made as a result of Judge Karlton’s Order dated July 26, 2011. The woody material management plan was first identified in the November 21, 2007 Biological Opinion. With respect to all of these activities, the Corps has determined that its operation and maintenance authority for Daguerre Point Dam allows it to spend appropriated funds from the Operations and Maintenance account to implement conduct these activities.

of the ladder bays or poachers fishing for protected species as ordered by the Court in 2011.[19] This is an example of the type of minor modification the Corps can make consistent with its Operation and Maintenance authority.

2.1 PROJECT MODIFICATIONS

2.1.2 Authority to Construct In-Scope Modifications

The Chief of Engineers has authority to modify projects without further authorization from Congress within strictly defined limits, i.e., as long as the scope of the project, including the function and purpose of the project, and the area served by the project, is not materially changed.[20]. This understanding, set forth in detail in a 1951 report by the Chief of Engineers, was approved in the report of a special subcommittee to the House Public Works Committee in 1952, Report on the Civil Functions Program of the Corps of Engineers, United States Army to the House Committee on Public Works, 82d Congress, 2d Session 1 (1952).

Consistent with the authority to make minor modifications, the Corps may rely on its operations and maintenance authority under the Daguerre Point Dam and/or Englebright Dam to study in-scope construction modifications for the purpose of extending the life of a project feature or enhancing its operational efficiency, provided such modifications are economically justified, and to recommend to Congress the funding of such construction. For example, this authority may be utilized for studying the Daguerre Point Dam fish ladders to improve the function of the fish ladders in their current configuration or to improve access to habitat once fish

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[19] The Corps was required to add grates to the ladder bays pursuant to Court Order issued on July 26, 2011 in the case of *South Yuba River Citizens League, et. al. v. National Marine Fisheries Service, et. al.* (*SYRCL I*) (Case No. 2:06-cv-02845-LKK-JFM),(ECF No. 402).

[20] Engineer Regulation 1105-2-100, Appendix G, paragraph 13(c).

have navigated the fish ladders.[21] At Englebright Dam, the Corps performs very limited discretionary functions, primarily related to maintenance of recreational facilities. The dam does not "operate" in a traditional sense since it is a debris dam. Put another way, there are no water control maintenance and operations or releases by the Corps. The primary function of Englebright Dam is to store debris and prevent debris migration downstream. Thus, there is no opportunity to modify any Corps action at Englebright for purposes of protection of threatened or endangered species/habitat under the O&M authority.

2.1.3 Authority to Implement Mitigations Measures

The Corps also has authority under Section 906(b) of the Water Resources and Development Act of 1986, as amended ("WRDA 1986") (33 U.S.C. §2283(b)) to implement mitigation measures at completed water resources projects to address damages caused to fish and wildlife by the project. This authority is limited to measures that cost no more than $7,500,000 or 10 percent of the cost of the project whichever is greater.[22] The construction cost of the Daguerre Point Dam was $978,000, and the construction cost of Englebright Dam appears to have been approximately $4,300,000; thus the upper limit of any mitigation work at either project under this authority would be the $7,500,000 limit contained in the statute.[23] In addition, Section 906(c), as amended, requires that mitigation features be cost shared in proportion to other project features.[24] The Daguerre Point Dam, for example, was built at 50 percent non-Federal expense (see House Document Numbered 431, 56th Congress, February 14, 1900, page 6). Use of Section 906 authority would therefore require the Corps to obtain a cost share partner

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[21] Under its operation and maintenance authority for Daguerre Point Dam, the Corps could also acquire any necessary real estate interests to the extent such acquisition would be necessary to maintain the fish preservation purpose of the fish ladders that are a feature of the project.

[22] 33 U.S.C. §2283(b)(1)

[23] In addition to the cost cap on mitigation measures under 906(b), the provision also generally prohibits the Corps from obligating any more than $30,000,000 under the 906(b) authority in any fiscal year. 33 U.S.C. 2283(b)(1).

[24] 33 U.S.C. 2283(c)

for the appropriate non-Federal share. Section 906(b) also permits acquisition of real estate interests at completed projects as necessary for the implementation of the mitigation measures, except that the Corps is prohibited from acquiring such interests by condemnation. [25] Section 906(b) does not authorize mitigation which does not address damages caused by a Corps project itself, nor does it authorize mitigation measures requiring the Corps to acquire significant real estate outside a project's footprint or mitigation measures to be performed far afield of a Corps project, regardless of whether they might be environmentally beneficial.

2.1.4 Authority to Study Structural Modifications For Further Recommendations to Congress for New Project Construction Authority

The Corps has authority under the Flood Control Act of 1970, Section 216 (33 U.S.C. §549a) to review completed navigation, flood control and water supply projects for the purpose of determining whether, due to significantly changed physical or economic conditions, project modifications are advisable to improve the quality of the environment. Englebright and Daguerre Point Dams are both navigation projects; therefore, this authority would allow the Corps to prepare a report to Congress regarding the need to modify the structures due to changed physical or economic conditions. Section 216 states:

> The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due [*sic*] the significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest.

The Corps has already taken the first steps in the process of conducting the review contemplated by Section 216. In 2005, the Corps completed an Initial Appraisal Report

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[25] 33 U.S.C. 2283(b)(1)(A)

regarding the federal interest in improving fish passage facilities at Daguerre Point Dam. Since 2005, the Corps has sought funding approval to initiate a reconnaissance study to explore fish passage improvements, however, to date, Congress has not funded the reconnaissance study.

3.0 CORPS PROGRAMMATIC CONSTRUCTION AUTHORITIES

WRDA 1986 and the Water Resources Development Act of 1996 ("WRDA 1996") (P.L. 104-303) provide ecosystem restoration authorities under which the Corps can study the feasibility of project modifications and later construct or implement the modification. WRDA 1986 contains a general provision prohibiting the Corps from undertaking a feasibility study for a water resources project unless a non-Federal entity has agreed to contribute 50% of the cost of the study.[26]

Section 1135 of WRDA 1986 authorizes the Corps to study and construct modifications in the structures and operation of projects for the purpose of improving the quality of the environment. Specifically, Section 1135(a) states that the Secretary of the Army may:

> …review water resources projects…to determine the need for modifications in the structures and operations of such project for the purpose of improving the quality of the environment in the public interest and to determine if the operation of such projects has contributed to the degradation of the quality of the environment."[27]

However, the Corps' authority under Section 1135 has some constraints. Section 1135 imposes a $5,000,000 per-project cap on Federal expenditures for "any single modification or measure" and requires a non-Federal entity to fund 25 percent of the cost of any such

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[26] 33 U.S.C. 2215

[27] 33 U.S.C.2309a(a)

modifications.[28] Additionally, the non-Federal partner must agree to pay 100% of any operation and maintenance costs associated with a project modification under Section 1135.[29]

Section 206 of WRDA1996 33 U.S.C. 2330, generally gives the Corps the authority to study, design and construct projects to restore and protect an aquatic ecosystem. [30] Section 206 states that the Secretary of the Army may:

> …carry out a project to restore and protect an aquatic ecosystem or estuary if the Secretary determine that the (i) project will improve the quality of the environment and is in the public interest; or (ii)will improve the element and features of an estuary…and is cost-effective.[31]

Similar to Section 1135, Section 206 has several built-in constraints. Section 206 limits federal expenditures to $5,000,000 for "a project at any single locality"[32] and requires that a non-Federal entity fund 35 percent of the total project cost.[33] Finally, the non-Federal partner must agree to pay 100% of any operation and maintenance costs associated with a project under Section 206.[34] These authorities, which require study, implementation and operation and maintenance cost share partners, contemplate construction, and may not be used for purely study purposes, or solely providing conservation services such as monitoring, collecting and transporting fish species.

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[28] 33 U.S.C. 2309a(d)
[29] Engineer Regulation 1165-2-501
[30] 33 U.S.C. 2330
[31] 33 U.S.C. 2330(a)(1)
[32] 33 U.S.C. 2330(d)
[33] 33 U.S.C. 2330(b)(1)
[34] 33 U.S.C. 2330(c)(1)

APPENDIX B

July 3, 2012 Letter from the U.S. Army Corps of Engineers, Sacramento District, to the National Marine Fisheries Service Regarding the February 29, 2012 Biological Opinion

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DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, SACRAMENTO
CORPS OF ENGINEERS
1325 J STREET
SACRAMENTO CA 95814-2922

REPLY TO
ATTENTION OF

Operations and Readiness Branch

JUL 03 2012

Mr. Rod McInnis
Regional Administrator
National Marine Fisheries Service
501 West Ocean Boulevard, Suite 4200
Long Beach, CA 90802-4213

Dear Mr. McInnis:

The U.S. Army Corps of Engineers, Sacramento District (Corps) has received the National Marine Fisheries Service's Biological Opinion (Opinion) related to the effects of the Corps' long-term operation and maintenance of Englebright and Daguerre Point Dams and Englebright Reservoir on the Yuba River on threatened Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened California Central Valley steelhead (*O. mykiss*), threatened Southern distinct population segment of north American green sturgeon (*Acipenser medirositris*), and their designated critical habitat. I appreciate the time you and your staff have devoted to preparing the Opinion and your willingness to maintain a continuing dialogue regarding the content and conclusions in the Opinion, including meeting with my staff and me on March 14, May 29 and June 22, 2012.

As you are aware, based on the discussions we have had since NMFS issued the Opinion, the Corps has very serious concerns about various aspects of the Opinion such as the description of the action and action area, the scientific basis for the analysis and conclusions, and the scope and breadth of the Reasonable and Prudent Alternative (RPA), the reasonable and prudent measures (RPMs) associated with the Incidental Take Statement, and NMFS' approach to baseline effects among other things. Our concerns are described in more detail in three documents enclosed with this letter – Attachment 1, *U.S. Army Corps of Engineers, Sacramento District Itemized Comments on the NMFS' February 2012 Final Jeopardy Biological Opinion on the Lower Yuba River*, Attachment 2, *Comments on NMFS February 29, 2012 Biological Opinion* prepared by HDR Engineering, Inc and Attachment 3, *Comments on NMFS Biological Opinion of Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir* prepared by Dr. Gregory B. Pasternack, Ph.D., M.ASCE. Notwithstanding these serious concerns, the Sacramento District conditionally accepts the RPA. Nonetheless, we will we continue to review the RPA actions to determine which actions are within the scope of the Corps' existing authority and appropriations and which actions require additional authority or appropriations. We will also assess whether there may be opportunities for the Corps to participate in other federal or non-federal entities' processes to achieve the goals of the RPA.

The Corps is proceeding immediately to implement RPA measure NTFP 5 which involves maintaining the current fish passage facilities at Daguerre in accordance with the terms of Judge Karlton's July 25, 2011 order. We are also in the process of preparing two Environmental Assessments – one for the proposed injection of 5,000 tons of gravel into the Englebright Dam Reach in summer 2012 (RPA Measure GAP 1) and one for the placement of instream woody material during fall 2012.

The Corps shall work collaboratively with NMFS and other stakeholders in the Yuba River watershed to improve conditions for anadromous fish in the Yuba River. We look forward to having an open and continuing dialogue with NMFS as we further refine our approach to the RPA and RPMs. As we continue our discussions with NMFS and various stakeholders, we reserve the right to provide a supplement to these comments if necessary. If you have any questions regarding the Corps' approach to the RPA or RPMs, please contact Mr. Randy Olsen at (916)557-5275 or Mr. Doug Grothe at (530) 432-6427.

A copy of this letter is being furnished to Ms. Maria Rea, National Marine Fisheries Service, Mr. Curt Aikens, Yuba County Water Agency, and Mr. David Moller, Director, Power Generation, Pacific Gas and Electric Company.

Sincerely,

for William J. Leady, P.E.
Colonel, U.S. Army
District Commander

Enclosures

ATTACHMENT 1

U.S. Army Corps of Engineers, Sacramento District Itemized Comments on the NMFS' February 2012 Final Jeopardy Biological Opinion on the Lower Yuba River

I. INTRODUCTION

The formal section 7 consultation process between the U.S. Army Corps of Engineers, Sacramento District (Corps) and the National Marine Fisheries Service (NMFS) on the Englebright and Daguerre Point Dams has a long history dating back to March 2000, when the Corps first initiated formal consultation on its operation and maintenance activities at the Dams. Since then, NMFS has issued four Biological Opinions (BO) related to these projects, with the most recent opinion in February 2012 reaching a conclusion of "jeopardy". The long consultation history on these projects will not be repeated here as it is summarized in the NMFS BO. The Corps appreciates the time and effort that NMFS' staff has devoted to the various consultations on these projects. However, because the information and analysis in the BO on the Corps' action will likely be used in future opinions on other federal actions, the Corps thinks it is important that the technical and factual deficiencies with the February 2012 jeopardy BO be corrected.

The purpose of this document is to provide a discussion and analysis of the major concerns the Corps has with the February 29, 2012 jeopardy BO and Reasonable and Prudent Alternative (RPA) on the operation and maintenance of Englebright and Daguerre Point Dams on the Yuba River. (NMFS No. 2012/00238). This document, in addition to Attachments 2 and 3, discusses why the Corps believes the analysis in the BO is flawed and the RPA is inappropriate and inconsistent with the requirements of 50 CFR § 402.02. It also discusses concerns with the Incidental Take Statement and Conservation recommendations.

II. BACKGROUND

On October 14, 2011, the Corps submitted a comprehensive draft Biological Assessment (BA) to NMFS requesting formal consultation on the operation and maintenance of both Englebright and Daguerre Point Dams. The final BA was submitted in January 2012. The BA evaluated the effects of the operation and maintenance activities on 3 species listed as "threatened" under the Endangered Species Act (*16 U.S.C. 1531, et seq.*) (ESA) and their designated critical habitat. The BA determined that the proposed operation and maintenance activities "*may affect, and are likely to adversely affect*" Central Valley spring-run Chinook salmon and Central Valley steelhead, but concluded that these adverse effects would not appreciably reduce the likelihood of both the survival and recovery either species. The BA also concluded that operation and maintenance would not result in the destruction or adverse modification of spring-run Chinook salmon or Central Valley steelhead critical habitat. As for the Southern Distinct Population Segment (DPS) of North American green sturgeon, the BA determined that the Corps' actions "*may affect, but are not likely to adversely affect*" that species and its critical habitat. The conclusions in the Corps' BA are based on the best currently available science regarding the species and their habitat and the Yuba River. Chapter 3 of the Corps' BA provides a detailed description of the ongoing operation and maintenance activities at Englebright and Daguerre Point Dams. For purposes of this document, only a brief summary of the project authorizations and ongoing activities is provided.

Englebright Dam and Reservoir are located downstream of New Bullards Bar Dam on the Yuba River. Authorized by the Rivers and Harbors Act of August 30, 1935 (P. L. 409, 74th Congress, 1st Session, 49 Stat. p. 1028-1049), for the purpose of debris storage and power development, Englebright Dam was constructed by the California Debris Commission in 1941. Englebright Dam is 260 feet high, and the storage capacity of Englebright Reservoir was 69,700 acre-feet (AF) at the time of construction. When the California Debris Commission was decommissioned in 1986, administration of Englebright Dam passed to the Corps pursuant to Section 1106 of the 1986 Water Resources Development Act (P. L. 99-662, 99th Congress, 2nd Session, November 7, 1986).

Because Englebright Dam was constructed as a sediment retention facility, it does not contain a low-level outlet. Unregulated flood flows spill over Englebright Dam. Following construction of Englebright Dam in 1941 and extending until approximately 1970, controlled flow releases from Englebright Dam were made through the Pacific Gas & Electric (PG&E) Narrows I Project facilities. Since about 1970 to the present, controlled flow releases from Englebright Reservoir into the lower Yuba River have been made from the PG&E Narrows I and the Yuba County Water Agency (YCWA) Narrows II power plants.

The purpose for the Corps' ongoing maintenance of Englebright Dam pertains to dam infrastructure safety and security. The Corps does not have authority or discretion to control Narrows I, Narrows II or Englebright Reservoir operations; the Corps activities are restricted to coordination and cooperation with PG&E and YCWA. The water stored in Englebright Reservoir provides opportunities for recreation and hydroelectric power. YCWA and PG&E administer water releases for hydroelectric power, irrigation, and other beneficial uses (e.g., instream flow requirements) and is regulated and permitted for these activities by the Federal Energy Regulatory Commission (FERC).

Additionally, the Corps operates and maintains recreation-related facilities on and around Englebright Reservoir, as identified and described in the 2007 Harry L. Englebright Lake Operational Management Plan. Along the 24 miles of Englebright Reservoir's shoreline, the developed facilities include: (1) 96 campsites; (2) 9 picnic sites; (3) 1 group picnic shelter with 4 tables; (4) 2 boat launching ramps (Narrows and Joe Miller Ravine) maintained by the Corps; (5) a private marina operated by a concessionaire; and (6) 5 parking lots containing a total of 163 parking spaces.

Englebright Reservoir also has a trout fishery almost exclusively supported by planted catchable trout. The State of California Department of Fish and Game (CDFG) annually stocked approximately 22,000 catchable size (7 to 10 inch) rainbow trout in Englebright Reservoir from 1965 through 2007. CDFG ceased planting hatchery trout in Englebright Reservoir from 2007 to 2011, but has recently received approval to resume the planting program, which started in October 2011. The fish now being planted are a triploid strain that cannot interbreed with existing populations. PG&E is required to plant fish in Englebright Reservoir as a condition of PG&E's FERC license. Annually, PG&E plants 2,500 lbs of rainbow trout in Englebright Reservoir, and it is anticipated that PG&E will continue to stock Englebright Reservoir in the future.

Daguerre Point Dam is located on the lower Yuba River approximately 11.5 River Miles (RM) upstream from the confluence of the lower Yuba and lower Feather rivers and 10 RM downstream of Englebright Dam. The Rivers and Harbors Act of 1902 authorized the construction of the Yuba River Debris Control Project, of which Daguerre Point Dam is a part. Construction of Daguerre Point Dam was funded through a 50-50 cost share between the California Debris Commission and the State of California. Construction was completed, and Daguerre Point Dam became operational in 1910. As with Englebright Dam, upon decommissioning of the California Debris Commission, administration of Daguerre Point Dam was assumed by the Corps.

The original purpose of the Daguerre Point Dam was to retain hydraulic mining debris to protect navigation in the Feather and Sacramento Rivers. Although not an authorized project purpose, the dam provides head for diversions of water for irrigation, primarily between April and October. The dam and appurtenances consist of an overflow concrete ogee spillway with concrete apron and concrete abutments, concrete fishways on both abutments, and a locally owned and operated irrigation diversion structure at the northern end of the dam. Two fish ladders, and three licensed irrigation diversions, depend on either the hydraulic head created by the dam or the continuance of diversion capabilities due to the influence of the dam preventing additional channel incision above the dam. However, in the absence of the dam, the water diversions could still occur. The Corps' park personnel operate and maintain the structure, in coordination with CDFG, for the purpose of ensuring efficient operation of the fish ladders and maintenance, safety and security of the dam infrastructure.

III. SPECIFIC CONCERNS WITH THE FEBRUARY 29, 2012 BIOLOGICAL OPINION

A. Description of Proposed Action and Action Area

NMFS' BO incorrectly describes the Corps' proposed action and the purpose of the Corps' action. By expanding the action area far beyond what the Corps described in its BA and inappropriately including actions which have no causal connection to the Corps' action as interrelated and interdependent actions, NMFS has grossly overstated the species effects attributable to the Corps.

The BO states that the purpose of the Corps' ongoing operation and maintenance of Englebright and Daguerre Point Dams is to perpetuate the existence of the dams (*BO pages 166, 214, and 243*). This assertion is incorrect. As noted in Section II above, the Corps is required to operate and maintain the dams and has no discretion not to continue such operation and maintenance. The purpose of our operation and maintenance is to ensure the safety and security of the structures and to ensure the fish ladders at Daguerre Point Dam continue to operate. The dams continue to exist because they have been authorized by Congress and unless and until Congress deauthorizes the dams and appropriates funds to transfer or decommission the dams, they will remain in place. Thus, the Corps has no discretionary authority or control over their continued existence. [1]

The NMFS BO describes the action area as "the active stream channels and riparian corridors of the Yuba River starting at and including New Bullards Bar Dam and reservoir, Log Cabin Diversion Dam, Our House Diversion Dam and pool, Spaulding Dam, Lake Spaulding, Milton Reservoir, and Lake Bowman…extending past and through Englebright Dam and reservoir, and Daguerre Point Dam and pool; downstream to the lower Feather River and the Sutter Bypass to the confluence with the Sacramento River." (*BO, page 9*) NMFS further states that the action area includes what NMFS describes as "interrelated and interdependent" actions at hydropower facilities and water diversions facilities that influence or are influenced by Englebright and Daguerre Point dams and operations and the service areas supplied with water from diversion from the Daguerre Point Dam pool." (*BO, page 9*)

In describing what NMFS considers to be "interrelated and interdependent" actions, the BO states the following:

> NMFS considers the Yuba River Development Project to be interrelated and interdependent with operation and maintenance of Englebright and Daguerre Point dams, because: (1) Englebright and Daguerre Point dams are basic structural features used by the Yuba River Development Project and the Narrows II powerhouse; (2) the Yuba River Development is *[sic]* uses the dams to provide the hydraulic head for hydropower and water delivery; (3) the operation and maintenance activities that keep these dams in place are essential activities intended to perpetuate the status quo of conjunctive use on these dams; (4) easements, agreements, and licenses are issued and entered into by the Corps for the Yuba River Development Project; and (5) operational decisions made by the Corps at both dams are dependent upon operational decisions made by the YCWA in its operation of the Yuba River Development Project.

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[1] The Endangered Species Act consultation requirements only apply to "actions in which there is discretionary Federal involvement or control." 50 CFR § 402.03

> NMFS considers the Yuba-Bear/Drum-Spaulding Project to be interrelated and interdependent with operation and maintenance of Englebright and Daguerre Point dams, because: (1) operational decisions made by PG&E and Nevada Irrigation District affect flows and operational decisions at the PG&E Narrows I powerhouse and YCWA's Narrows II powerhouse; (2) the PG&E Narrows I powerhouse is dependent upon the baseline existence of the Englebright to provide the hydraulic head for hydropower; (3) the operation and maintenance activities that keep Englebright Dam in place are essential activities intended to perpetuate the status quo of conjunctive use at Englebright Dam; (4) Narrows I and Narrows II powerhouses have integrated operations administered by YCWA; (5) a licenses from the Corps is needed for PG&E to continue to utilize outlet facilities and storage space in its current manner; (6) mitigation for the PG&E license from FERC includes trout planting in Englebright Reservoir; and (7) operational decisions made by the Corps at both dams are dependent upon operational decisions made by the YCWA in its operation of the Narrows I powerhouse in conjunction with the Yuba River Development Project. (*BO, page 8*)

As an example of these "interrelated and interdependent" actions, the BO refers to "how operations of the dams and reservoirs (New Bullards, Our House, Log Cabin, Milton and Jackson Meadows) on the North Yuba River and Middle Yuba River affect which Lower Yuba River Accord flow schedule is implemented in a given year." (*BO, page 9*). This analytical framework incorrectly applies the terms "interrelated" and "interdependent" as those terms are defined in 50 CFR § 402.02 and as those terms are interpreted in the Endangered Species Consultation Handbook. The proper test for whether one action is "interrelated" or "interdependent" with another action is "but for" causation. The "but for" test considers whether an activity would occur but for the federal action. (*Endangered Species Consultation Handbook, pages 4-26 and 4-27*).

Contrary to NMFS assertions in the BO, the Yuba River Development Project is not interrelated or interdependent with the Corps' operation and maintenance of either Englebright Dam or Daguerre Point Dam. As explained in comments provided by YCWA on the draft BO in February 2012:

> While the Narrows II Powerhouse was constructed to take advantage of the existence of Englebright Dam, which had been constructed many years earlier, the Yuba River Development Project could continue to operate without Englebright Dam or Daguerre Point Dam as explained in the February 28,2012 Curt Aikens letter. For example, while the Narrows II Powerhouse provides approximately 10% of the power generated by the Project, the remaining 90% of the generation, which occurs at the New Colgate Powerhouse, could continue without Englebright Dam. Similarly, while Daguerre Point Dam provides the hydraulic head for two facilities

> that divert water from the Lower Yuba River, these facilities could be replaced with other facilities that did not depend on Daguerre Point Dam. Also, the removal of Daguerre Point Dam would not affect any water rights to, or long term water delivery contracts for, Yuba River water. (*Howard "Chip" Wilkins' letter to NMFS dated February 28, 2012, page 7; see also Curt Aikens' letter to NMFS dated February 28, 2012, pages 3-4*)

The practical effect of NMFS' improper definition of the action area is that activities over which the Corps has no discretionary authority or control have been included as part of the Corps' action and therefore included in the analysis of effects of the action on the listed species (*see generally BO, Section VI*). As is more fully described in the Corps' BA, the Corps has no discretionary control over YCWA's Yuba River Development Project or any management or operational decisions made in relation to that project. Nevertheless, the BO attempts to assign responsibility to the Corps for managing flows and prescribing flow conditions on the Yuba River (*BO, pages 166 – 188, 239, and 266*), even though Yuba River flows are already being managed through the lower Yuba River Accord process. Although the Corps is not a party to the Lower Yuba River Accord, it is our understanding that through the Accord process, "a comprehensive set of minimum instream flows for the lower Yuba River" have been established (*Curt Aikens' letter to NMFS dated February 28, 2012, page 9*).

In the absence of the Lower Yuba River Accord process, issues regarding water temperatures and flows should be addressed in the context of the FERC relicensing process. In fact, the Yuba River Development Project is currently undergoing relicensing. FERC is the federal agency with exclusive jurisdiction over development of hydro-power by non-federal entities and as such has a direct authority and obligation to prescribe flow conditions if necessary. Instead, NMFS has taken the position that the Corps, through its easements and licenses has to ability to impose conditions related not only to flows, but also fish passage and other measures. The easements and licenses that the Corps has issued for the non-federal hydropower facilities at Englebright Dam and downstream of Englebright Dam are simply ministerial. Without an approval and license from FERC, the hydro-power facilities could not operate regardless of any license or easement from the Corps. [2]

As part of the FERC relicensing process, the Corps expects that NMFS and FERC will engage in a consultation regarding the effects of the continued operation of the Yuba River Development Project. Through this consultation process, NMFS could prescribe flow and/or temperature requirements for the Yuba River Development Project should NMFS determine that such requirements are necessary. Contrary to statements made by NMFS' staff at a January 12, 2012 meeting between NMFS and the Corps, the fact that the Corps was the first federal agency to request consultation is not a basis for expanding

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[2] FERC's authority under the Federal Power Act is fully described in YCWA's comments on the draft BO and will not be repeated here. (*see Wilkins letter to NMFS, pages 7-9*)

the Corps' action to encompass private actions over which the Corps has no discretionary authority or control. The definition of the Corps' action is subject to the limitations specified in 50 CFR §402.03.

As with the Yuba River Development Project, the Corps does not control whether or not water is diverted from the Yuba River through the three agricultural diversions downstream of Englebright (Browns Valley, Hallwood-Cordua, and South Yuba-Brophy), the quantity and timing of those diversions, or the ultimate use of the water once diverted. Notwithstanding this fact, the NMFS BO includes the effects of water diversions as part of the Corps' action (*BO, pages 166 – 188*).

Similarly, the Corps has no discretionary authority or control over PG&E's Drum-Spaulding project or Nevada Irrigation District's (NID) Yuba-Bear project. Also there is no "but-for" causal connection between the Corps' ongoing operation and maintenance of Englebright and Daguerre Point Dams and PG&E's or NID's operations. In the BO, NMFS attempts to link Yuba-Bear and Drum-Spaulding operations to the Corps by claiming that operational decisions at Yuba-Bear and Drum-Spaulding affect PG&E's and YCWA's decisions at the Narrows I and Narrows II powerhouses. The Corps does not believe there is a causal connection between Yuba-Bear and Drum-Spaulding and Narrows I and II. But, even if such a causal connection existed, it does not follow logically that the Corps would have the ability to dictate operations and flows at either Yuba-Bear or Drum-Spaulding. The Corps does not make any operational decisions at either Englebright or Daguerre based on PG&E's or YCWA's operations on upstream projects.

NMFS will have an opportunity to address the effects of the Yuba-Bear and Drum-Spaulding projects during the FERC relicensing process for these projects. The Corps understands that PG&E has already initiated the relicensing process with FERC and that NMFS is aware of and participating in that process.

B. Baseline

The NMFS BO seems to include impacts that should be part of the environmental baseline as effects of the Corps' proposed action. Environmental baseline is defined in 50 CFR § 402.02 as "the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation and the impact of State or private actions which are contemporaneous with the consultation in process." But the BO includes the continued existence of Englebright and Daguerre Point Dams as part of the effects analysis for the proposed action rather than as part of the baseline (*BO, pages 168 – 188*), even though the BO seems to acknowledge that continued existence of the projects should be included in the environmental baseline . (*BO, pages 123 -124*).

Additionally, by improperly categorizing various non-federal actions as interrelated and interdependent with the Corps' action, NMFS has included what should be baseline effects due to non-federal actions, as effects of the Corps' action (*see generally, BO section VI*). As noted in footnote 1 above, the Corps has no discretionary authority or control over the continued existence of the dams and has no discretion to remove the dams. The BO acknowledges that the Corps has no authority or discretion for dam removal, so it is unclear why the continued existence of the dams is analyzed as part of the effects of the Corps' action.

C. Authorities

The NFMS' BO provides a summary of the authorities NMFS believes would allow the Corps to proceed with implementing the various measures described in the RPA (*BO page 211 – 214*).[3] However, in many instances, the BO fails to acknowledge or mention the significant constraints associated with the cited authorities that might preclude immediate action by the Corps. Below is a summary of the authorities the Corps believes are applicable to the various measures in the RPA, including the constraints and limitations of those authorities. The BO should be modified to include a discussion of these constraints and limitations.

1. Endangered Species Act (16 U.S.C. 1531, et seq.) – The BO summarizes the relevant and applicable sections of the ESA. However, Section 7(a)(2) states that agencies "shall…utilize their authorities in furtherance of the purposes of this chapter…". In other words, the ESA doesn't give an agency any authority that it doesn't already have. It authorizes federal agencies to use their *existing* authorities to carry out programs for the conservation of threatened and endangered species.

2. Federal Power Act, Section 4(e) (16 U.S.C. 797(e)) Allows federal agencies to prescribe conditions to ensure FERC licenses are not inconsistent with the purposes of a project. NMFS's BO asserts that section 4(e) allows the Corps' to require "upstream and downstream fish passage of the hydroelectric projects at Englebright Dam." (*BO, page 214*) However, fish passage is not an authorized purpose for Englebright. As noted above, Englebright Dam is a debris dam that was

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[3] NMFS improperly included "environmental stewardship" as an authority that would allow the Corps to implement fish passage at Englebright Dam. "Environmental stewardship" is not an authority separate and distinct from the various authorities mentioned in this section, rather it is an umbrella term designed to capture the full breadth and scope of legislative authorities and other environmental mandates applicable to Corps activities and programs. More information about the Corps' environmental stewardship can be found at: http://www.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/219/Article/173/environmental-stewardship-program-statistics.aspx

authorized for the purpose of retaining hydraulic mining debris and later for hydropower. The Corps is not aware of an example where Section 4(e) was used to add a *new* authorized purpose to an existing Corps facility.

3. Water Resources Development Act (WRDA) of 1990, Section 306 (33 U.S.C. 2316) – As the BO notes, this is a general authority that directs the Secretary of the Army to include environmental protection as one of the primary missions of USACE in planning, designing, operating and maintaining water resources projects. However, this section did not modify the Corps' *existing* authorities. In other words, Section 306 could not be used, for example, to add a *new* authorized purpose to Englebright Dam. Section 306 states:

> (a) General rule
>
> The Secretary [of the Army] shall include environmental protection as one of the primary missions of the Corps of Engineers in planning, designing, constructing, operating, and maintaining water resources projects.
>
> (b) Limitation
>
> Nothing in this section affects—
>
> (1) existing Corps of Engineers' authorities, including its authorities with respect to navigation and flood control;
>
> (2) pending Corps of Engineers permit applications or pending lawsuits involving permits or water resources projects; or
>
> (3) the application of public interest review procedures for Corps of Engineers permits.

4. Flood Control Act of 1962, Section 209 (Public Law 87-874) – Section 209 is a study authority that authorizes the Corps to:

> "cause surveys for flood control and allied purposes … in drainage areas of the United States…which include the following named localities: *Provided*, That after the regular or formal reports made on any survey are submitted to Congress, no supplemental or additional report or estimate shall be made unless authorized by law except that the Secretary of the Army may cause a review of any examination or survey to be made and a report thereon submitted to Congress, if such review is required by the national defense or by changed physical or economic conditions …
>
> Sacramento River Basin and streams in northern California draining into the Pacific Ocean

> for the purposes of developing, where feasible, multiple-purpose water resource projects…"

In the 1990s, the Corps used its authority under Section 209 to seek an appropriation to undertake a study of fish migration in the Sacramento River. Therefore, this authority may be applicable to one or more of the measures in the RPA that require the Corps to complete studies.

5. Flood Control Act of 1970, Section 216 (33 U.S.C. 549a) – Section 216 is a study authority that allows the Secretary of the Army to review completed navigation, flood control and water supply projects. Englebright and Daguerre Point Dams are both navigation projects, therefore, this authority would allow the Corps to prepare a report to Congress regarding the need to modify the structures due to changed physical or economic conditions. Section 216 states:

> The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due [*sic*] the significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest.

The Corps has already taken the first steps in the process of conducting the review contemplated by Section 216. In 2005, the Corps completed an "initial appraisal report" regarding the federal interest in improving fish passage facilities at Daguerre Point Dam. Since 2005, the Corps has sought authorization and approval to initiate a reconnaissance study to explore fish passage improvement at both Englebright and Daguerre Point Dams. To date, Congress has not authorized or funded the reconnaissance study.

6. Water Resources Development Act of 1986, as amended

    a) Section 105 (33 U.S.C. 2215) – Section 105 is a general provision that prohibits the Corps from undertaking feasibility studies unless a non-Federal entity has agreed to contribute 50% of the cost of the study.[4]
    b) Section 729 (33 U.S.C. 2267a) – Section 729 is a study authority that allows the Secretary of the Army to "assess the water resources needs of river basins and watersheds of the United

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[4] 33 U.S.C. 2215(a)(1)(A) states: "The Secretary [of the Army] shall not initiate any feasibility study for a water resources project after November 17, 1986, until appropriate non-Federal interests agree, by contract, to contribute 50 percent of the cost of the study."

States, including needs relating to ecosystem protection and restoration." (*33 U.S.C. 2267a(a)*). This authority does require the Secretary to give priority to ten specific watersheds "in selecting river basins and watersheds for assessment."[5] Finally, this authority has a non-federal cost share requirement of 25%. (*33 U.S.C. 2267a(f)*). Under this authority, the Corps can prepare an Initial Watershed Assessment using 100% federal funds (*Engineer Circular 1105-2-411, para. 7.b.(1)*). The Initial Watershed Assessment is typically funded at $100,000 with any costs in excess of $100,000 shared between the Corps and a non-federal entity (*Engineer Circular 1105-2-411, para. 7.b.(1)*). This authority may be useful for the measures in the RPA that require watershed or basin level studies.

c) Section 906(b)(1) (33 U.S.C. 2283(b)(1) – Section 906(b) authorizes the Secretary of the Army to "mitigate damages to fish and wildlife resulting from any water resources project…". However, this authority is not unlimited. Section 906(b)(1) states "[w]ith respect to any water resources project, the authority under this subsection shall not apply to measures that cost more than $7,500,000 or 10 percent of the cost of the project whichever is greater." (*33 U.S.C. 2283(b)(1)*). Furthermore, the Secretary may not obligate any more than $30,000,000 under this authority in any fiscal year. (*33 U.S.C. 2283(b)(1)*). Costs incurred under this authority are "allocated among authorized project purposes in accordance with applicable cost allocation procedures, and shall be subject to cost sharing or reimbursement to the same extent as such other project costs are shared or reimbursed…". (*33 U.S.C. 2283(c)*). The Corps believes this authority will allow us to move forward with some actions under the RPA, particularly actions related to the effects of Englebright Dam such as gravel augmentation.

d) Section 906(e) (33 U.S.C. 2283(e) – When the Secretary recommends fish and wildlife enhancement as part of a report to Congress, section 906(e) authorizes "first enhancement costs" to be a Federal cost in certain circumstances. Section 906(e) states:

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[5] 33 U.S.C. 2267a(d) states:

> In selecting river basins and watersheds for assessment under this section, the Secretary shall give priority to—
> (1) the Delaware River basin;
> (2) the Kentucky River basin;
> (3) the Potomac River basin;
> (4) the Susquehanna River basin;
> (5) the Willamette River basin;
> (6) Tuscarawas River Basin, Ohio;
> (7) Sauk River Basin, Snohomish and Skagit Counties, Washington;
> (8) Niagara River Basin, New York;
> (9) Genesee River Basin, New York; and
> (10) White River Basin, Arkansas and Missouri.

> In those cases when the Secretary, as part of any report to Congress, recommends activities to enhance fish and wildlife resources, the first costs of such enhancement shall be a Federal cost when—
>
> (1) such enhancement provides benefits that are determined to be national, including benefits to species that are identified by the National Marine Fisheries Service as of national economic importance, species that are subject to treaties or international convention to which the United States is a party, and anadromous fish;
>
> (2) such enhancement is designed to benefit species that have been listed as threatened or endangered by the Secretary of the Interior under the terms of the Endangered Species Act, as amended (16 U.S.C. 1531, et seq.), or
>
> (3) such activities are located on lands managed as a national wildlife refuge.
>
> When benefits of enhancement do not qualify under the preceding sentence, 25 percent of such first costs of enhancement shall be provided by non-Federal interests under a schedule of reimbursement determined by the Secretary. Not more than 80 percent of the non-Federal share of such first costs may be satisfied through in-kind contributions, including facilities, supplies, and services that are necessary to carry out the enhancement project. The non-Federal share of operation, maintenance, and rehabilitation of activities to enhance fish and wildlife resources shall be 25 percent.

The authority under 906(e) has been included in this list because it may be useful and applicable at a future time, when the Corps progresses to the point of submitting a final report to Congress. But this authority doesn't seem to have much applicability at this early stage.

e) <u>Section 1135</u> (33 U.S.C. 2309a) – Section 1135 is a study, design, and construction authority that allows the Secretary to "review water resources projects…to determine the need for modifications in the structures and operations of such project for the purpose of improving the quality of the environment in the public interest and to determine if the operation of such projects has contributed to the degradation of the quality of the environment." (*33 U.S.C. 2309a(a)*). There are certain limitations to this authority which were not addressed in the BO. A non-federal entity must agree to fund 25% of the costs of such modifications and "no more than $5,000,000 in Federal funds may be expended on any single modification or measure carried out or undertaken pursuant to this section." (*33 U.S.C. 2309a(d)*). Finally, the local sponsor must agree to pay 100% of any operation and maintenance costs associated with a project modification under Section 1135. (*Engineer Regulation 1165-2-501*).

7. <u>Water Resources Development Act of 1996, Section 206</u> (33 U.S.C. 2330) – Section 206 is a general study, design and construction authority that allows the Corps to "carry out a project to restore and protect an aquatic ecosystem or estuary if the Secretary determine that the (i) project will improve the quality of the environment and is in the public interest; or (ii)will improve the element and features of an estuary…and is cost-effective." (*33 U.S.C. 2330(a)(1)*) Projects under section 206 can include dam removal. (*33 U.S.C. 2330(a)(2)*) . Projects under section 206 are subject to certain limitations which were not identified in NMFS' BO. For example, a non-federal entity must agree to fund 35% of the costs of such projects (*33 U.S.C. 2330(b)(1)*) and "no more than $5,000,000 in Federal funds may be allotted under this section for a project at any single locality." (*33 U.S.C. 2330(d)*). Finally, the local sponsor must agree to pay 100% of any operation and maintenance costs associated with a project under Section 206. (*33 U.S.C. 2330(c)(1)*).

8. <u>Operation and Maintenance appropriation</u> – The Corps receives appropriated funds, which are used for the operation and maintenance of completed projects and associated staff labor costs. Under this appropriation, the Corps is able to proceed immediately with implementing RPA measure NTFP 5 – Fish Passage at Daguerre Point Dam.

D. <u>Technical/Scientific Concerns</u>

The Corps has significant scientific and technical concerns with the data NMFS used to support its analysis in the BO that lead NMFS to conclude that the Corps' action is jeopardizing the continued existence of the three listed species and adversely modifying critical habitat. One example that the Corps is particularly concerned with is NMFS' analysis of effects to the Southern DPS of North American green sturgeon. The Corps' technical and scientific concerns are provided in Attachment 2, *Comments on NMFS February 29, 2012 Biological Opinion* prepared by HDR Engineering, Inc and Attachment 3, *Comments on NMFS Biological Opinion of Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir* prepared by Dr. Gregory B. Pasternack, Ph.D., M.ASCE.

E. Reasonable and Prudent Alternative

The BO seems to suggest that even if the RPA is implemented, the Corps cannot avoid jeopardy unless the dams are removed (*BO, pages 244 – 245*). Yet NMFS acknowledges that the Corps does not have the discretion or authority to remove the dams. This conundrum clearly illustrates that NFMS analysis of effects is focused on the existence of the dams (a non-discretionary action) rather than the Corps' actual action of ongoing operation and maintenance. As part of the Corps' operation and maintenance, we have proposed several conservation measures which are helping to improve conditions for listed species. The analysis of the conservation measures and their effects is fully described in the Corps' biological assessment.

The Corps is also concerned with the scope and breadth of the actions required, the timeline for accomplishing the actions and that several of the RPA actions are outside the Corps' existing authority[6]. The RPA contemplates that all actions would be completed in eight years, which is a fairly short timeframe to complete what the Corps estimates to be several hundred million dollars worth of work. Additionally, it appears that in developing the timeframe for completing the various actions, NMFS did not consider that the Corps has to comply with other environmental requirements, such as the National Environmental Policy Act and the Clean Water Act. Further, many of the RPA actions require Congressional action and funding before they can be implemented. Finally, some RPA actions are not related to any effect caused by the Corps' ongoing operation and maintenance of the dams.

Notwithstanding the fact that we disagree with the jeopardy and conclusion and believe that the conclusion is based on flawed assumptions regarding the nature of the Corps' action, we are attempting to move forward with the RPA to the extent we have the authority and funding to do so. Some of our concerns with the RPA actions are itemized below; however we intend to continue discussions with NMFS to refine the Corps' approach to the RPA actions. Additional concerns regarding the RPA actions are provided in Attachment 2, *Comments on NMFS February 29, 2012 Biological Opinion* prepared by HDR Engineering, Inc and Attachment 3, *Comments on NMFS Biological Opinion of Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir* prepared by Dr. Gregory B. Pasternack, Ph.D., M.ASCE.

1. Steering Committees – The RPA requires the Corps to establish the Yuba Interagency Fish Passage Steering Committee (*BO, pages 220 and 222*) and the Green Sturgeon Steering Committee (*BO, page 238*). The RPA specifies that the steering committees will be composed of federal, state and academic members and will be responsible for providing "policy and management advice" to the Corps regarding the

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[6] 50 CFR § 402.04 requires the RPA to be "consistent with the scope of the Federal agency's legal authority and jurisdiction…".

implementation of the RPA. Furthermore, the RPA requires the Corps to fund the activities of the steering committees. The steering committees as described in the RPA could be considered advisory committees under the Federal Advisory Committee Act (FACA) (5 U.S.C. App. I) because they include non-federal participants. FACA defines an “advisory committee” as:

> …any committee, board, commission, council, conference, panel, task force, or other similar group, or any subcommittee or other subgroup thereof (hereafter in this paragraph referred to as "committee"), which is – …
>
> (C) established or utilized by one or more agencies, in the interest of obtaining advice or recommendations for the President or one or more agencies or officers of the Federal Government, except that such term excludes (i) any committee that is composed wholly of full-time, or permanent part-time, officers or employees of the Federal Government …

The Corps is willing to convene an interagency workgroup comprised of federal, state and academic participants; however, the Corps cannot fund the activities of the group nor can the Corps fund the participation of any individual member. Additionally, the Corps will not seek advice or recommendations from the workgroup or allow the workgroup to make management or policy decisions. Alternatively, it may be more efficient and beneficial for the Corps to join and participate on one or more of the existing groups involved in fish passage issues in the Yuba River watershed such as the River Management Team or the Yuba Salmon Forum. The Corps is already participating on the North Yuba Reintroduction Initiative organized by YCWA.

2. RPA 1, Yuba River Fish Passage Improvement Strategy and Plan (BO, pages 220 – 222) – RPA 1 requires the Corps to assess fish passage not only upstream of Englebright and Daguerre Point Dams, but also upstream of several dams over which the Corps has no control such as New Bullards Bar, Log Cabin, and Our House Dams. To the extent this action item requires the Corps to evaluate passage at dams it doesn’t own, control, operate or maintain, it is outside the Corps’ authority and does not seem calculated to address an effect of the Corps’ action. This RPA also states that dam removal is the preferred option for fish passage. The Corps does not have authority to remove either Englebright or Daguerre Point Dam.

With respect to fish passage at Englebright Dam and improved fish passage at Daguerre Point Dam, the Corps has initiated the process for studying fish passage options. As NMFS is aware, the Corps has requested Congressional approval and funding of a reconnaissance study which is the first step in developing a plan for fish passage. A reconnaissance study typically takes one year to complete. If a non-federal sponsor is identified during the reconnaissance phase, the next step is to prepare a feasibility study and environmental impact statement. The Corps' current policy is to complete the feasibility phase within 3 years. After the feasibility report is completed, the Corps would be able to submit a report to Congress to obtain further authorization and funding for project implementation. More information about the typical Corps' Civil Works process is available at the following link: http://www.sac.usace.army.mil/?action=programs.six_steps

The RPA requires that the fish passage plan to reintroduce listed species above Daguerre and Englebright be developed and implemented by December 1, 2013. In light of the need to seek authorization and funding for this major federal action and complete the NEPA process, December 1, 2013 does not seem like a reasonable goal for implementation.

3. RPA 2, Near Term Fish Passage Actions (BO, pages 222 – 230) – RPA 2 is a suite of actions that provide for study of the condition and suitability of upstream habitats, development/implementation of a pilot reintroduction program, construction of fish collection and handling facilities, and other measures related to developing near-term volitional fish passage upstream of Englebright and Daguerre Point Dam. The first step for the Corps is to begin a reconnaissance study. As noted above, we are seeking the necessary approval and funding for that study.

   RPA 2 also contains measures designed to maintain the current fish passage facilities at Daguerre Point Dam (NTFP 5) and develop/implement improved fish passage facilities (NTFP 6). The Corps is currently implementing the actions under NTFP 5. As for NTFP 6, the RPA requires that the feasibility study and preliminary design for improved fish passage facilities be completed by November 21, 2012. This timeframe is not reasonable given the need for the Corps to seek authorization and funding for such a study and the requirement for the Corps to comply with NEPA and other applicable environmental laws.

4. <u>RPA 3, Long Term Fish Passage Actions</u> (BO, pages 231 – 233) – RPA 3 is a suite of actions that relate to providing long term fish passage upstream and downstream of Englebright Dam and upstream of Daguerre Point Dam. As noted above, the Corps has sought approval and funding to begin a reconnaissance study. The Corps proposes to include consideration of long term and near term fish passage options in the reconnaissance study.

5. <u>RPA 4, Gravel Augmentation Program</u> (BO, pages 233 – 234) – The Corps has already begun to implement portions of the gravel augmentation program. Specifically, the Corps plans to inject 5,000 tons of gravel in the Englebright Dam Reach in summer 2012 as part of its ongoing implementation of the Gravel Augmentation Implementation Plan (GAIP). The Corps is preparing a draft Environmental Assessment for this action which will be released for public review and comment in July 2012.

   In addition to implementing the GAIP, RPA 4 also requires the Corps to inject 15,000 tons of gravel annually into the Englebright Dam Reach. The Corps questions whether it is technically feasible to inject 15,000 tons annually into the Englebright Dam Reach given the work window and the limited locations where the Corps has access to place gravel. The Corps also has concerns about whether implementation of this action as described in the BO would successfully achieve the outcome NMFS desires. It would be better to adaptively plan annual gravel injections based on monitoring results from the previous year (see also Attachment 3, *Comments on NMFS Biological Opinion of Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir* prepared by Dr. Gregory B. Pasternack, Ph.D.) .

6. <u>RPA 5, Channel Restoration Program</u> (BO pages 234 – 236) – RPA 5 requires the Corps to develop and implement a plan for removing of shot-rock and recontouring the channel in the Englebright Dam Reach and the Narrows Reach. The channel restoration measures do not seem to be related to any effects of the Corps' ongoing operation and maintenance at Daguerre. Dr. Pasternack has studied this issue and concluded that the river degradation in the Englebright Dam Reach and Narrows Reach is primarily due to mechanized gold mining. Also, RPA 5 is identical to measures proposed by PG&E and the California Department of Water Resources under the Habitat Expansion Plan developed as part of an agreement with NMFS and other stakeholders in

four FERC relicensings on the Feather River. Given that PG&E is ready, willing, and able to undertake these measures and these measures don't relate to any effect of the Corps' action, it is inappropriate to assign this responsibility to the Corps.

7. <u>RPA 6, Predator Control Program</u> (BO, pages 236 – 237) – NMFS conclusions regarding predation do not seem to be supported by current science (see HDR comments, Attachment 2, Chapter 7). Additionally, given the need to comply with NEPA, the timeframe for completing this item is unreasonable. Notwithstanding this concern, the Corps is exploring opportunities and options for implementing this action.

8. <u>RPA 7, Salmonid Monitoring and Adaptive Management Program</u> (BO, pages 237 – 238) – RPA 7 is a set of actions focused on gathering information about the trends and status of salmonids in the Yuba River watershed. The scope of this program is unclear and seems to go beyond what would be required to address effects of the Corps' ongoing operation and maintenance of its facilities. In addition, a fisheries monitoring and evaluation program is already ongoing under the Lower Yuba River Accord (*Curt Aikens' letter to NMFS dated February 28, 2012, pages 8-12*).

9. <u>RPA 8, Green Sturgeon Monitoring and Adaptive Management</u> (BO, pages 238 – 242) – RPA 8 is focused on conserving green sturgeon in the Yuba River when the BO provides no evidence or support for the contention that green sturgeon are using the lower Yuba River for spawning, reproduction, and rearing. There is no current or historical evidence that green sturgeon used the Lower Yuba River up to Englebright Dam. There is also uncertainty about the amount of usable spawning habitat above Daguerre Point Dam and passage above Daguerre Point Dam might facilitate an increased presence of predator fish. Through this RPA action, NMFS also assigns responsibility to the Corps for determining water temperature and flows on the Yuba River. The Corps has no control over flows or temperatures on the Yuba River. Those issues are being addressed through the Lower Yuba River Accord process and should also be addressed through the ongoing FERC relicensing processes for hydro-power facilities on the Yuba River. The jeopardy conclusion and RPA action for this species seem inappropriate.

10. <u>RPA 9, Training Walls</u> (BO, pages 242 – 243) – The intent of this RPA action is unclear. The Corps has no ongoing operation and maintenance responsibility for the training walls, therefore an RPA action associated with the training walls seems unnecessary and inappropriate. Furthermore, identifying and mapping the original training walls will be impossible. The Corps does not have any historical data or technical information regarding the original location or extent of the training walls. The training walls were not designed or surveyed and "as-built" drawings were not produced after construction.

F. <u>Economic and Technical Feasibility of the RPA</u>

NMFS' BO concludes that the RPA actions are technically and economically feasible (*BO, pages 248 – 249*). The Corps questions whether or not this is true given the timeframe in which the BO requires the RPA actions to be accomplished. For example, the RPA requires near term fish passage actions to be implemented within the next one - two years[7] and long-term fish passage actions to be implemented in the next eight years (*BO, pages 219 – 233*). Assuming it is possible to construct a fish ladder at Englebright Dam, the Corps estimates such construction to cost approximately $400 million.[8] It is unlikely that a project of that scale could be studied, authorized, funded, designed and constructed in only eight years.

The RPA (*BO, page 248*) also discusses several examples where the Corps has modified projects for fish passage, and then assumes that because the Corps has not implemented fish passage on the Yuba River, the Corps is "reluctant to pursue funding to address environmental issues on the Yuba River." NMFS is well aware of the Corps' efforts to pursue funding for actions on the Yuba River. The Corps has sought and obtained funding for gravel augmentation which has been ongoing since 2010. Similarly, the Corps has sought and obtained funding to begin a large woody material management program. More importantly, the Corps has requested approval and funding for a reconnaissance study, which is the first step in beginning to study options for fish passage at the Corps' facilities on the Yuba River.

Under its discussion of economic feasibility, the BO specifically references the estimated cost of passage for green sturgeon at Daguerre Point Dam. NMFS estimates this cost to be $351,000. This figure is somewhat misleading given the RPA requirement to provide improved passage for all listed species. In a 2003 study by the Department of Water Resources and the Corps, the estimated cost of the most optimal alternative for improved passage at Daguerre Point Dam was approximately $17.5

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[7] One of the near term fish passage actions (NTFP 6) requires preliminary design for improved passage at Daguerre be completed by November 2012.

[8] NMFS estimates the maximum cost of a fish ladder at Englebright is $100 million. The Corps believes this estimate is low.

million with operation and maintenance costs estimated to be $500,000 annually.[9] The Corps estimates the current cost of improved fish passage at Daguerre Point Dam for anadromous fish to be approximately $35 million.

One example the BO uses to demonstrate the Corps' ability to add fish passage facilities to a Corps project is the Howard Hanson Dam in Tacoma, Washington. Howard Hanson dam is an approximately 235 foot high earthen embankment dam that was originally authorized for flood control, downstream low-flow augmentation for fish, irrigation, and municipal and industrial water supply. The Howard Hanson Dam project is an excellent case study of the Corps' process for obtaining authorization and funding for project modifications and the timeline for that process. The process of modifying Howard Hanson Dam began in 1989 when the City of Tacoma requested the Corps to study how the dam could address water supply needs for Puget Sound residents. The City of Tacoma signed up to be a non-federal sponsor for the project and the Corps began the water supply study. In 1994, the Corps expanded the study to include ecosystem restoration. The Corps completed a feasibility study and environmental impact statement in 1998. Congress specifically authorized the project modifications in Section 101(b)(15) of the Water Resources and Development Act of 1999[10] subject to submission of a final Chief of Engineers' Report (Chief's Report). The Corps submitted a final Chief's Report to Congress in 1999 which described the Corps' proposal to construct upstream and downstream fish passage facilities, among other things. In July 2000, the Corps completed a Fish and Wildlife Mitigation and Restoration Conceptual Design Report. A Record of Decision for the Final EIS was signed in July 2001. Construction of the fish passage facility began in 2004 and was completed in 2009. More information about Howard Hanson Dam can be found at:

http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=HHD_AWSP&pagename=fish_passage2

If fish passage improvements are to occur at Englebright and Daguerre Point dams in a manner consistent with the intent of the RPA, such improvements will require specific Congressional authorization and funding and a non-federal sponsor similar to what occurred for the facilities at Howard Hanson Dam.

G. Incidental Take Statement

Section 7(o)(2) of the Endangered Species Act (16 USC §1536(o)(2)) exempts any take that meets the terms and conditions of an incidental take statement (ITS) from the take prohibitions in Section 9 of the Act. To be exempt, an agency must

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[9] Daguerre Point Dam Fish Passage Improvement Project Alternative Concepts Evaluation, September 2003 prepared by Wood Rodgers, Inc.

[10] The authorizing language in WRDA 1999 states "(15) HOWARD HANSON DAM, WASHINGTON.—The project for water supply and ecosystem restoration, Howard Hanson Dam, Washington, at a total cost of $75,600,000, with an estimated Federal cost of $36,900,000 and an estimated non-Federal cost of $38,700,000."

comply with the conservation measures described as part of the proposed action and the ITS' reasonable and prudent measures (RPMs) and associated terms and conditions (T&Cs). The BO includes an ITS (*BO, pages 249 – 267*) that authorizes a certain amount of take to occur as a result of the proposed action, as long as the Corps complies with the RPMs and T&Cs.

Many elements of the RPMs and T&Cs are the result of, and require the Corps to manage, activities and effects over which it has no discretionary authority or control. For example, RPM 5 and its associated T&Cs require the Corps to improve flow management on the Yuba River. Flow management issues are already being addressed by NMFS and other parties to the Lower Yuba River Accord (*Curt Aikens' letter to NMFS dated February 28, 2012, pages 8-12*). Minimum streamflows and a fisheries monitoring and evaluation program have already been established by parties participating in the Lower Yuba River Accord. Such issues should also be addressed through the ongoing FERC relicensing processes for the various hydropower facilities in the upper Yuba River.

The RPMs and T&Cs also mandate that the Corps plant a minimum of 30 acres of riparian vegetation annually downstream of Englebright Dam to the confluence of the Yuba River and the Feather River. There is no evidence to suggest that riparian vegetation is lacking in the Lower Yuba River. In fact evidence suggests that the presence of riparian vegetation has increased on the lower Yuba River over the last 60 years since Englebright Dam was constructed (see Attachment 3, *Comments on NMFS Biological Opinion of Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir* prepared by Dr. Gregory B. Pasternack, Ph.D., M.ASCE.). Even if the quantity of riparian vegetation had declined, there is no evidence to suggest that the Corps' operation and maintenance activities at Englebright Dam are the cause.

Additionally, some of the surrogates NMFS uses to measure take under the ITS are not related to the Corps' implementation of the RPMs and T&Cs. For example, one surrogate for take is the Corps' injection of 15,000 tons of gravel annually. Gravel injection is a conservation measure the Corps proposed and is an RPA action, but it is not included as one of the RPMs. Also, 15,000 tons is not an appropriate measure to use for "take". As noted in the discussion of RPA 4 above, 15,000 tons may not be achievable (or necessary) each year.

H. Conservation Recommendations

As recommended in the BO, the Corps will continue to work collaboratively with various stakeholders on the Yuba River to improve conditions for anadromous fish. However, as noted above, the Corps objects to NMFS' attempts throughout the BO (*see RPA 8 and RPM 5*) to assign responsibility to the Corps for managing water temperatures in the lower Yuba and Feather Rivers. The Corps has no control over flows and therefore no control over water temperatures.

IV. CONCLUSION

As described in detail above and in Attachments 2 and 3, the Corps believes the February 29, 2012 BO is deficient in many respects. Because NMFS has stated that the Corps' BO will become the baseline for future consultations, it is crucial that the inaccuracies and flaws in the BO be corrected. Ultimately, the Corps is concerned that the RPA and RPMs are based on flawed factual and scientific analyses that have led NMFS to impose requirements that the Corps has no legal authority to implement. Furthermore, the Corps is concerned the BO may have the unintended effect of impeding existing beneficial efforts being undertaken or proposed by other stakeholders on the Yuba River. The Corps requests that the BO be amended or supplemented to address the Corps' concerns.

Attachment 2

Comments on NMFS February 29, 2012 Biological Opinion

Prepared for the U.S. Army Corps of Engineers, Sacramento District

by HDR Engineering, Inc.

COMMENTS ON NMFS
FEBRUARY 29, 2012 BIOLOGICAL OPINION

CONTINUED OPERATION AND MAINTENANCE OF ENGLEBRIGHT DAM AND RESERVOIR, DAGUERRE POINT DAM, AND RECREATIONAL FACILITIES ON AND AROUND ENGLEBRIGHT RESERVOIR

Prepared for:

US Army Corps
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Sacramento District

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June 2012

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COMMENTS ON NMFS FEBRUARY 29, 2012 BIOLOGICAL OPINION

CONTINUED OPERATION AND MAINTENANCE OF ENGLEBRIGHT DAM AND RESERVOIR, DAGUERRE POINT DAM, AND RECREATIONAL FACILITIES ON AND AROUND ENGLEBRIGHT RESERVOIR

The National Marine Fisheries Service (NMFS) provided a copy of its Final Biological Opinion (BO) on the U.S. Army Corps of Engineers (Corps) Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir on February 29, 2012 (Final BO). This document provides comments on NMFS' Final BO. These comments, prepared for the Corps, were developed by HDR Engineering, Inc., who provided technical assistance to the Corps in the preparation of the Biological Assessment (BA) for the Ongoing Operation and Maintenance of Englebright Dam and Reservoir, and Daguerre Point Dam on the Lower Yuba River (Corps BA). Additional comments on statements in the Final BO regarding the topics of fluvial geomorphology, substrate and anadromous salmonid spawning habitat, large woody material, training walls and channel restoration are prepared separately by other technical experts for the Corps.

The Final BO is nearly 300 pages in length, and contains a substantial amount of technical information. Given the inherently complex issues associated with the listed species (i.e., spring-run Chinook salmon, steelhead, and green sturgeon) and their designated critical habitat in the lower Yuba River, these comments are organized by topical categories, including the following.

- ☐ **General Comments**. Effects assessment approach – viability and extinction risk of Yuba River anadromous salmonid populations.
- ☐ **Lower Yuba River Accord**. Flows, water temperatures, and habitat conditions associated with implementation of the Lower Yuba River Accord.
- ☐ **Genetic Considerations**. Spring-run Chinook salmon and steelhead.
- ☐ **Upper Yuba River Watershed Anadromous Salmonid Production, and Comparisons to the Lower Yuba River**. Issues pertaining to modeling habitat capacity and population productivity for spring-run Chinook salmon and steelhead in the Upper Yuba River Watershed, the manner in which the Final BO used RIPPLE model output to estimate production potential of the Yuba River Watershed upstream of Englebright Dam, and comparisons to the lower Yuba River.

- ☐ **Green Sturgeon Considerations**. Issues specific to green sturgeon.
- ☐ **Effects of the Proposed Action on Listed Species and Critical Habitat** (including Cumulative Effects associated with South Yuba/Brophy Diversion entrainment issues, flow and water temperature conditions).
- ☐ **Reasonable and Prudent Alternative (RPA) Actions**.
    - RPA Action No. 1. Yuba River Fish Passage Improvement Strategy and Plan – General fish passage considerations.
    - RPA Action No. 2. Near-term Fish Passage Actions – Distinct issues pertaining to both Englebright and Daguerre Point Dam.
    - RPA Action No. 3. Long-term Fish Passage Actions – Distinct issues pertaining to both Englebright and Daguerre Point Dam.
    - RPA Action No. 4. Gravel Augmentation Program.
    - RPA Action No. 5. Channel Restoration Program.
    - RPA Action No. 6. Predation and Predator Control Program.
    - RPA Action No. 7. Salmonid Monitoring and Adaptive Management Program (SMAMP) – Monitoring groups, organization membership and activities in the BO in consideration of other ongoing monitoring activities in the Yuba River Watershed.
- ☐ **Amount or Extent of Incidental Take**.

These comments recognize that NMFS prepared the Final BO under a restrictive timeline. If additional consultation meetings were able to have been held between NMFS and the Corps, it is anticipated that many of the following comments on the Final BO would not have been necessary. Consultation meetings between NMFS and the Corps would have facilitated NMFS inclusion of the best available scientific and commercial information, particularly regarding listed species and their habitats in the lower Yuba River, in the Final BO.

For example, the Final BO (pages 5 to 9) lists thirteen key consultation considerations. However, the Corps BA, which was prepared for consultation on the Proposed Action, was not identified as a key consultation consideration, nor was much of the relevant information contained therein incorporated into the Final BO. Also, many of the following comments are prepared in response to statements in the Final BO that attribute ongoing effects of the existence of Englebright Dam to the Proposed Action. This approach in the Final BO is contradictory to that which was described in the Corps BA.

1.0 General Comments

The Final BO contains numerous conclusionary statements that are not supported by analyses, citations or rationale, as well as contradictory information addressing specific issues. It also contains statements regarding the manner in which the effects assessment approach was conducted, although application of specific assessment approaches appear to deviate from the stated methodologies. Examples of these types of excursions from stated methodologies that pertain to viability and extinction risk of Yuba River anadromous salmonid populations are provided below, with emphasis added as underlined text.

1.1 Effects Assessment Approach

1.1.1 Viability and Extinction Risk of Yuba River Anadromous Salmonid Populations

The Final BO indicates that the extinction risk assessment pertains to populations, and that the Viable Salmonid Population (VSP) concept is applied to diversity group, Evolutionarily Significant Unit (ESU) or Distinct Population Segment (DPS) levels. Page 199 of the Final BO states "*…The criteria recommended for low risk of extinction for Pacific salmonids are intended to represent a species and populations…*" Page 200 of the Final BO states "*…the consequence of those effects is applied the VSP concept* [sic] *and used to establish risk to the diversity group, ESU, or DPS.*"

However, although the Final BO contains a considerable amount of discussion regarding VSP, it is unclear how NMFS actually applies the VSP concept and how the four VSP parameters of abundance, productivity, spatial structure, and diversity are used to determine viability of listed species ESU/DPS. Moreover, it is apparent that the extinction risk assessment criteria are not actually applied to the Yuba River anadromous salmonid populations. Provided below are excerpts of the analytical approach that NMFS describes in the Final BO, and comments on those excerpts.

FINAL BO STATEMENT (Pages 36 and 37)

"For the purposes of this analysis, NMFS equates a listed species' probability (or risk) of extinction with the likelihood of both the survival and recovery of the species in the wild for purposes of conducting jeopardy analyses under section 7(a)(2) of the ESA. In the case of listed salmonids, we use the Viable Salmonid Populations (VSP) framework (McElhany et al. 2000) as a bridge to the jeopardy standard."

COMMENT

The Final BO states that NMFS uses the VSP framework as "*a bridge to the jeopardy standard*." From an analytical perspective, it is unclear what is meant by the phrase "*a bridge to the jeopardy standard*" and how conceptual components of the VSP framework were specifically applied to assess the viability of listed species ESU/DPS. The Final BO (page 37) states that the VSP parameters of productivity, abundance, and population spatial structure are consistent with the "*reproduction, numbers, or distribution*" criteria found within the regulatory definition of jeopardy (50 CFR 402.02), and are used as surrogates for "*numbers, reproduction, and distribution*," although the specific application remains unclear.

FINAL BO STATEMENT (Page 37)

"NMFS is currently in the process of finalizing a recovery plan for the listed Central Valley salmon and steelhead species. During the drafting of the recovery plan a technical recovery team was established to assist in the effort. One of the technical recovery team products, Lindley et al. (2007), provides a "Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin." …Lindley et al. (2007) was relied on to establish the current status of the listed Central Valley salmon and steelhead species, and both Lindley et al. (2007) and the Draft Recovery Plan were utilized to evaluate whether the proposed action does not "reduce appreciably the likelihood of survival and recovery."

COMMENT

The Final BO cites VSP-related information described in the Public Draft Recovery Plan (NMFS 2009), the 5-Year Status Review of Central Valley Spring-Run Chinook Salmon ESU (NMFS 2011a), and the 5-Year Status Review of Central Valley Steelhead DPS (NMFS 2011b). However, the Final BO does not present any information to indicate that quantitative assessments of extinction risk were conducted for anadromous salmonid populations in the lower Yuba River, nor does the Final BO follow the extinction risk methodology described in Lindley et al. (2007).

By contrast to the Final BO, the Corps BA conducts an independent assessment of spring-run Chinook salmon extinction risk in the lower Yuba River using available data following the methodology described in Lindley et al. (2007) to evaluate population size, population decline, rate and effect of catastrophe, and hatchery influence (see Section 5.1.7.2 of the Corps BA on pages 5-93 through 5-129). The Corps BA also examines available data in an effort to follow the methodology described in Lindley et al. (2007) to conduct an independent assessment of lower Yuba River steelhead extinction risk (see Section 5.2.7.2 of the Corps BA on pages 5-183 to 5-203), but concludes that the population is data deficient, as Lindley et al. (2007) also conclude.

FINAL BO STATEMENT (Page 69)

"Although Lindley et al. (2007) did not provide numerical goals for each population of Pacific salmonid to be categorized at low risk for extinction, they did provide various quantitative criteria to evaluate the risk of extinction (Table IV-c). A population must meet all the low-risk thresholds to be considered viable."

COMMENT

By contrast to the statement in the Final BO, Lindley et al. (2007) do not specify that all four criteria must be met in order for a population to be considered "viable." Rather, Lindley et al. (2007) refer to extinction risk, and state *"Populations are classified as "data deficient" when there are not enough data to classify them otherwise. It is possible to classify a population as "high" risk with incomplete data… but a low risk classification must be met with all criteria."*

1.1.1.1 Spring-run Chinook Salmon

The Final BO contains numerous statements concluding "high extinction risk" or "low viability" following a narrative discussion of a specific stressor, or suite of stressors. According to NMFS' own stated impact assessment approach (see above), it is not appropriate to conclude extinction risk level or viability based upon a single stressor or suite of stressors – rather, such assessments should incorporate evaluation of the four VSP parameters for an ESU/DPS, and specifically follow the extinction risk assessment methodology provided by Lindley et al. (2007) for the lower Yuba River populations.

FINAL BO STATEMENT (Page 153)

"*The Yuba River spring-run Chinook salmon population has low productivity and abundance and is at high risk of extinction. The population is limited by complete barriers to migration at Englebright Dam and its related hydropower facilities, impaired passage at Daguerre Point Dam, superimposition with fall-run Chinook salmon, introgression with hatchery stock, lack of suitable habitat for run separation, a deficiency of spawning gravels, high exposure to predation, sub-optimal flow and temperature conditions during critical life-history stages, entrainment and impingement, lack of suitable cover for rearing, unstable food source from fluctuating aquatic macroinvertebrate populations, and low exposure to marine-derived nutrients."*

COMMENT

The above statement serves as an example of the deviation from the stated methodology in the Final BO regarding extinction risk assessment of the lower Yuba River salmonid populations. The extinction risk conclusion apparently is based upon a list of stressors, not upon the extinction risk criteria and analyses specified by Lindley et al. (2007). Moreover, this alliteration of potential stressors contains technical inaccurracies, and inference of adverse effects that are not supported by studies or references, in support of the conclusionary statement of "high extinction risk".

Some examples of conclusionary statements regarding extinction risk not associated or supported with specific applications of the Lindley et al. (2007) extinction risk assessment methodology are provided below.

FINAL BO STATEMENT (Page 157)

"*When measured at the simplest measurable level, the population is not viable because of excessive hatchery introgression. On the Yuba River, the 5 percent tolerance threshold for low extinction risk (Lindley et al. 2007) is far exceeded in most years and puts the population at high risk of extinction."*

COMMENT

This statement in the BO apparently reflects confusion regarding viability versus extinction risk, and what specifically was provided in Lindley et al. (2007).

- ☐ The *"5 percent tolerance threshold"* is in reference to an assumption in Lindley et al. (2007, page 3) that "*a 5 percent risk of extinction in 100 years is an acceptably low extinction risk for populations*".
- ☐ Lindley et al. (2007) do not specify that there is a *"5 percent tolerance threshold"* that is applied every year, or "most" years. In fact, Lindley et al. (2007) describe that the fraction of naturally spawning fish of hatchery origin is the mean fraction over one to four generations.
- ☐ Lindley et al. (2007) state *"Extinction risk levels correspond[ing] to different amount, duration and source of hatchery strays."* Lindley et al. (2007) describe that if hatchery strays are from the same ESU and diversity group, and the hatchery employs "best management practices" (BMP), then a population would be at low extinction risk if hatchery strays contributed up to 15% of the population over one or two generations, 10% over three generations, or 5% over four generations.
- ☐ Further, if BMP hatchery strays are from the same ESU and diversity group, then a population would be at moderate extinction risk if hatchery strays contributed up to 50% of the population over one or two generations, 30% over three generations, or 15% over four generations.

Moreover, Lindley et al. (2007, page 6) indicate that extinction risk assessments can result *"in a low risk classification even with moderate amounts of straying from best-practices hatcheries, so long as other risk measures are acceptable."*

By contrast to the BO, the Corps BA evaluated the extinction risk level to the Yuba River spring-run Chinook salmon population associated with hatchery influence pursuant to the criteria established in Lindley et al. (2007) (Corps BA, pages 5-78 through 5-85, and pages 5-128 and 5-129). Over the last seven years, the percentage of adipose fin-clipped fish observed during the spring-run Chinook salmon migration period was 21.4% (and 14.5% excluding 2010, which was a year characterized by unusually high attraction flows in the lower Yuba River relative to the lower Feather River) which, according to NMFS own criteria, represents a moderate (or low) extinction risk.

FINAL BO STATEMENT (Page 201)

Regarding the Yuba River spring-run Chinook salmon population, a statement in the Final BO is "*…The population has low viability and a high risk of extinction (NMFS 2011a)*."

COMMENT

The cited document is NMFS Southwest Region's 2011 5-Year Status Review for the Central Valley Spring-Run Chinook Salmon ESU.

Examination of the document (NMFS 2011a) cited in the Final BO does not confirm the statement that the spring-run population in the lower Yuba River *"has low viability and a high risk of extinction."* In fact, the actual statement in NMFS (2011a) is *"…The Yuba River spring-run Chinook salmon population satisfies the moderate extinction risk criteria for abundance, but likely falls into the high risk category for hatchery influence."*

Further, this statement in the Final BO is speculative regarding the risk category from hatchery influence, and does not utilize available scientific information, particularly that available within the Corps BA. Moreover, the statement is one example where by NMFS does not apply the methods to evaluate extinction risk provided in Lindley et al. (2007).

1.1.1.2 Steelhead

The Final BO does not use available data regarding steelhead abundance that is provided in the Corps BA. Rather, the Final BO uses partial information regarding steelhead abundance and productivity in the lower Yuba River to support conclusions regarding the population's viability and extinction risk.

The Corps BA examines available data in an effort to follow the methodology described in Lindley et al. (2007) to conduct an independent assessment of lower Yuba River steelhead extinction risk (see Section 5.2.7.2 of the Corps BA on pages 5-183 to 5-203), but concludes that the population is data deficient, and extinction risk cannot be quantitatively evaluated.

The Corps BA (pages 5-198 and 5-199) states *"…it is not reasonable to consider data gathered prior to 2010/2011 to be reliable estimates of the annual number of adult steelhead passing* *upstream of Daguerre Point Dam."* The Corps BA further states that *"This suite of improvements to the VAKI Riverwatcher systems at Daguerre Point Dam have resulted in much more reliable estimates of steelhead passing the dam…"* and that *"Continued implementation of the improved VAKI Riverwatcher systems at Daguerre Point Dam is likely to obtain some of the data necessary to allow abundance estimation and productivity evaluation of steelhead in the lower Yuba River. However, presently the lack of multi-year abundance data precludes the provision of quantitative values associated with extinction risk assessment, addressing abundance and productivity, as was done for spring-run Chinook salmon in this BA."*

Lindley et al. (2007) also conclude that steelhead populations are data deficient and preclude quantitative evaluation of extinction risk. Nonetheless, Lindley et al. (2007) further state that qualitative information, including loss of historical habitat and suppression or loss of life history diversity, *"…does suggest that the Central Valley steelhead ESU is at a moderate or high risk of extinction."*

Clarification needs to be provided regarding statements of viability or extinction risk in the Final BO attributed to abundance or productivity trends of lower Yuba River steelhead.

FINAL BO STATEMENT (Page 80)

"*Good et al. (2005) also indicated the decline was continuing as evidenced by new information from Chipps Island trawl data. Central Valley steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates, and the future of Central Valley steelhead is tentative due to limited data concerning their status."*

COMMENT

The information from Chipps Island trawl data referenced in Good et al. (2005) as being "new" is presently over seven years old. Monitoring and data collection efforts regarding Chipps Island trawl data and steelhead in the Central Valley have been ongoing since 2005, yet this information does not appear to have been considered in the Final BO.

FINAL BO STATEMENT (Page 80)

"Lindley et al. (2007) concluded that there is sufficient evidence to suggest that the DPS is at moderate to high risk of extinction."

COMMENT

This citation in the Final BO is not technically correct. Lindley et al. (2007, page 19) state "*For Central Valley steelhead, there are insufficient data to assess the risk of any but a few populations, and therefore, we cannot assess the viability of this ESU* [sic] *using the quantitative approach described in this paper."* However, Lindley et al. (2007) further state that qualitative information, including loss of historical habitat and suppression or loss of life history diversity,

"…does suggest that the Central Valley steelhead ESU is at a moderate or high risk of extinction."

FINAL BO STATEMENTS

- ☐ **Page 161** – *"Infrared and videographic sampling on both ladders at Daguerre Point Dam since 2003 has provided estimates O. mykiss numbers migrating up the Yuba River (figure V-b). However, these estimates should be considered as minimum numbers, as periodic problems with the sampling equipment have caused periods when fish ascending the ladders were not counted... It is therefore likely that the true numbers of steelhead passing Daguerre Point Dam are higher than those reported in Figure V-b. It is also important to note that the data collected after February, 2007, has not yet been re-checked for quality and accuracy and should be considered preliminary at this time (CDFG unpublished data)."*
- ☐ **Page 162** – *"…the short time period in which this* [Vaki Riverwatcher] *device has been in operation, coupled with the two to four year life cycle of these fish, make it difficult to determine decisive trends in the steelhead population."*

COMMENT

The Final BO relies on unpublished CDFG data from 2003 to 2007, and does not include more recently available data from the VAKI Riverwatcher that extends through 2010, which has been reviewed by the Yuba Accord River Management Team (RMT) and is publicly available on the RMT's website. Further, it is unclear as to why data only to November 2007 is used, when data presented in the Corps BA extends through 2010.

1.1.2 Abundance and Productivity of Yuba River Anadromous Salmonid Populations

Similar to viability and extinction risk, the Final BO contains numerous statements concluding "low abundance" or "low productivity" associated with a narrative discussion of a specific stressor, or suite of stressors. The Final BO (pages 52 and 71) states *"McElhany et al. (2000) suggested a population's natural productivity should be sufficient to <u>maintain its abundance above the viable level (a stable or increasing population growth rate</u>). In the absence of numeric abundance targets, <u>this guideline is used</u>."* However, for lower Yuba River populations of anadromous salmonids, the Final BO does not appear to adhere to its own stated impact assessment approach, and does not evaluate abundance and productivity following the extinction risk assessment methodology provided by Lindley et al. (2007). In addition, the Final BO does not utilize data and analyses provided in the Corps BA that assessed abundance and productivity that followed the extinction risk assessment methodology provided by Lindley et al. (2007).

Examples of conclusionary statements in the Final BO not supported by data analyses are provided below.

1.1.2.1 Spring-run Chinook Salmon

Review of the Final BO found at least 9 conclusionary statements regarding abundance and productivity of spring-run Chinook salmon in the lower Yuba River that were not supported by data analyses.

FINAL BO STATEMENTS

- ☐ **Page 153** – *"The Yuba River spring-run Chinook salmon population has low productivity and abundance and is at high risk of extinction."*
- ☐ **Page 156** – *"…as the Yuba River spring-run Chinook salmon population continues to decline. The combination of low numbers…"*
- ☐ **Page 201** – *"The Yuba River population of the spring-run Chinook has low abundance, low productivity, limited spatial structure, and is a population sink for other populations (NMFS 2011a, Schick and Lindley 2007)."*
- ☐ **Page 201** – *"The prevention of access to habitat upstream of Englebright Dam coupled with the downstream impacts of predation, entrainment, lack of cover, lack of forage, and unprotected outmigration temperatures reduces the capacity of the Yuba River to maintain population abundance and productivity*."
- ☐ **Page 201** – *"Project effects continue the pattern of low abundance, variable/declining growth rate, insufficient spawning substrate, spatial structure overlaps with fall-run Chinook salmon, hatchery introgression, and lack of habitat diversity."*
- ☐ **Page 202** – *"The very poor condition of the Yuba River population, in combination with project effects that continue the patterns causing the population to be at risk of extinction, reduces the likelihood that the Northern Sierra Nevada Diversity Group can become viable."*
- ☐ **Page 202** – *"Without any recovery actions to stabilize the Yuba River population and allow it to contribute to the recovery of the species, both the survival and recovery of the species are measurably diminished by the proposed action."*
- ☐ **Pages 202 and 203** – *"These environmental consequences also reduce the survival of individuals and ultimately impairs the long-term survival and viability of the local population by continuing to drive low population abundance rates, variable and declining production rates…"*

☐ **Page 206** – *"The limited amount of spawning habitat on the lower Yuba River, high predation and entrainment, lack of LWM, lack of riparian cover, and depressed foraging conditions prevent the critical habitat from having productivity that would contribute to a viable population."*

COMMENT

The Corps BA (pages 5-105 through 5-121) provides extensive analyses of VAKI Riverwatcher data for the period extending from 2004-2010 and discussion regarding abundance and productivity of spring-run Chinook salmon in the lower Yuba River, following the extinction risk assessment methodology provided by Lindley et al. (2007).

Abundance

According to NMFS, populations with a low risk of extinction are those with a minimum total escapement of 2,500 spawners in 3 consecutive years (mean of 833 fish per year) and populations with a moderate risk of extinction are those with a minimum total escapement of not less than 250 spawners in 3 consecutive years (mean of 83 fish per year) (Lindley et al. 2007).

For the entire (hatchery and non-hatchery) lower Yuba River spring-run Chinook salmon population, the Corps BA (page 5-106) states *"For the past four years, the abundance of in-river spawning spring-run Chinook salmon has steadily increased."* The Corps BA also states *"For the last three consecutive years, an estimated total of 4,130 spring-run Chinook salmon have passed upstream of Daguerre Point Dam, with an average of 1,377 fish per year. As previously described by NMFS (2011a), populations with a low risk of extinction (less than 5% chance of extinction in 100 years) are those with a minimum total escapement of 2,500 spawners in 3 consecutive years (mean of 833 fish per year)."*

For the non-hatchery lower Yuba River spring-run Chinook salmon population, the Corps BA (page 5-112) states *"For the last three consecutive years, an estimated total of 2,080 non-hatchery origin spring-run Chinook salmon have passed upstream of Daguerre Point Dam, with an average of 693 fish per year. As previously described by NMFS (2011a), populations with a low risk of extinction (less than 5% chance of extinction in 100 years) are those with a minimum total escapement of 2,500 spawners in 3 consecutive years (mean of 833 fish per year), and populations with a moderate risk of extinction are those with a minimum total escapement of not less than 250 spawners in 3 consecutive years (mean of 83 fish per year) (Lindley et al. 2007)."*

Productivity

According to Lindley et al. (2007), population growth (or decline) rate is estimated from the slope of the natural logarithm of spawners versus time for the most recent 10 years of spawner count data.

For the entire (hatchery and non-hatchery) lower Yuba River spring-run Chinook salmon population, the Corps BA (page 5-106) states *"The statistical approach recommended by Lindley et al. (2007) was followed to examine whether the abundance of lower Yuba River spring-run*

Chinook salmon exhibited a statistically significant linear trend over time during the seven most recent years for which VAKI Riverwatcher data are available.” … “*Figure 5-10 demonstrates that the abundance of spring-run Chinook salmon in the lower Yuba River has exhibited a very slight increase over the seven years examined. However, the coefficient of determination is very weak (r^2 = 0.01) and the slope is not statistically significantly different from zero (P = 0.878), indicating that the positive trend is not significant… Nonetheless, the relationship indicates that the population over this time period is at least stable, and is not exhibiting a declining trend.”*

For the non-hatchery lower Yuba River spring-run Chinook salmon population, the Corps BA (page 5-113) states *“Figure 5-11 displays the antilogarithmic transformation of the estimated annual number of spring-run Chinook salmon of hatchery and non-hatchery origin passing upstream of Daguerre Point Dam from 2004-2010. Figure 5-11 demonstrates a slightly decreasing trend in the abundance of spring-run Chinook salmon of non-hatchery origin in the lower Yuba River over the 7 years examined. However, the coefficient of determination is very weak (r^2=0.05) and the slope is not statistically significantly different from zero (P=0.634), indicating that the slight decreasing trend is not significant.”*

The Corps BA (page 8-33) states *“The entire suite of information and analyses indicates that spring-run Chinook salmon in the lower Yuba River are a relatively stable population, with a low to moderate risk of extinction under the Environmental Baseline.”*

1.1.2.2 Steelhead

As previously discussed, the Corps BA (page 5-199) examines available lower Yuba River steelhead data and states *“presently the lack of multi-year abundance data precludes the provision of quantitative values associated with extinction risk assessment, addressing abundance and productivity, as was done for spring-run Chinook salmon in this BA.”* Thus, the following statements in the Final BO need to be clarified to indicate the basis for their conclusions.

FINAL BO STATEMENTS

- ☐ **Pages 160 and 161** – “*The Yuba River Central Valley steelhead population has low productivity and abundance and is at high risk of extinction*.”
- ☐ **Page 203 –***“Project effects continue the pattern of low abundance, variable/declining growth rate…”*
- ☐ **Page 204 –** *“The very poor condition of the Yuba River population, in combination with project effects that continue the patterns causing the population to be at risk of extinction, reduces the likelihood that the Northern Sierra Nevada Diversity Group can become viable.”*

☐ **Page 207 –** *"Central Valley steelhead productivity is low in critical habitat in the Yuba River downstream to the Sacramento River."*

☐ **Page 207 –** *"Productivity is so low that global warming and climate change could cause the population to go extinct. The critical habitat from the lower Yuba River to the Feather River confluence with the Sacramento River does not support productivity of the DPS."*

☐ **Page 208 –** *"The Central Valley steelhead population downstream of Englebright Dam is too low, introgressed, and at risk extinction* [sic] *to support conservation of the DPS."*

1.1.3 Diversity "Stratum"

As previously discussed, according to NMFS' own stated impact assessment approach (see above), the Final BO suggests that the effects assessment incorporates evaluation of the four VSP parameters for an ESU/DPS, and specifically follows the extinction risk assessment methodology provided by Lindley et al. (2007) for the lower Yuba River populations. Therefore, it is difficult to try to interpret the manner in which the concept of "diversity strata" is, or is not, actually applied in the Final BO, and whether that is in conflict with the previously stated effects assessment approach. The following examples of statements in the Final BO reflect this apparent confusion. These and related statements regarding diversity stratum should be clarified.

FINAL BO STATEMENT (Page 38)

"NMFS uses a conceptual model of the species and its critical habitat to evaluate the impact of proposed actions. For this consultation, this conceptual model is structured around the listed spring-run Chinook salmon ESU, Central Valley steelhead DPS, green sturgeon Southern DPS, and critical habitat for these species… The guiding principle behind this conceptual model is that the likelihood of survival and recovery of a species is dependent on the likelihood of survival and recovery of populations which comprise the species (organized by diversity strata comprising the species, ESU, or DPS)…"

COMMENT

Regarding diversity stratum or strata, the Final BO cites the document Williams et al. (2007). Unfortunately, this document was not provided in the Literature Cited Section of the Final BO. A comprehensive search revealed: (1) Williams et al. (2006) NMFS Technical Memorandum titled *"Historical Population Structure of Coho Salmon in the Southern Oregon/Northern California Coasts Evolutionarily Significant Unit"*; (2) Williams et al. (2008) NMFS Technical Memorandum titled *"Framework for Assessing Viability of Threatened Coho Salmon in the Southern Oregon/Northern California Coast Evolutionarily Significant Unit"*; and (3) Williams et al. (2011) titled *"Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Southwest."*

In the most recent document, Williams et al. (2011) define diversity strata as *"…groups of populations that likely exhibit genotypic and phenotypic similarity due to exposure to similar environmental conditions or common evolutionary history (Williams et al. 2006)."*

FINAL BO STATEMENTS

- ☐ **Page 52** – *"However, for the purposes of the jeopardy analysis, NMFS also assesses whether the proposed action is expected to reduce the likelihood of an affected diversity stratum contributing to the viability of the species by impacting the ability of one or more of the stratum's member populations to fulfill their intended role in stratum viability."*
- ☐ **Page 52** – *"The intended roles of all the populations in the ESU have not yet been defined through a recovery strategy for the species, however… the Northern Sierra Diversity Group of the spring-run Chinook salmon ESU will need at least four viable independent populations for the stratum to be viable."*

COMMENT

First, the foregoing statements in the Final BO apparently assume that diversity groups within the spring-run Chinook salmon ESU are synonymous with "diversity strata." However, given the definition of diversity strata provided by Williams et al. (2011), this assumption may be incorrect. The Final BO (page 37) states *"…both Lindley et al. (2007) and the Draft Recovery Plan were utilized to evaluate whether the proposed action does not "reduce appreciably the likelihood of survival and recovery."* The Draft Recovery Plan (NMFS 2009, pages 28 and 29) states "*…The only known streams that currently support viable populations of spring-run Chinook salmon in the Central Valley are Mill, Deer and Butte creeks (CDFG 1998)… these populations are genetically distinct from other populations classified as spring-run in the Central Valley (e.g., Feather River) (DWR 2004)."* Moreover, the Final BO (page 72) states that the Yuba River spring-run Chinook salmon population is "heavily impacted" by Feather River fish hatchery fish straying into the lower Yuba River. According to the Final BO and its relied upon documents, the Northern Sierra Nevada Diversity Group is not synonymous with diversity stratum, as defined.

Second, the statement that *"the Northern Sierra Diversity Group of the spring-run Chinook salmon ESU will need at least four viable independent populations for the stratum to be viable"* directly conflicts with the statement in the Public Draft Recovery Plan (page 99) that *"…In consideration of the foregoing, the recovery scenarios include the objectives of a minimum of two viable populations of spring-run Chinook salmon within each of the four spring-run Chinook salmon Diversity Groups"* and on page 73 that recovery would require *"…Three populations in the Northern Sierra Diversity Group (because of their geographic proximity, Mill and Deer Creek are considered part of the same meta population at low risk of extinction…"*

The apparent confusion in the Final BO regarding definition or consideration of diversity stratum as distinguished from diversity group, and the associated viability requirements for each structure (diversity stratum or diversity group) should be clarified. Further, in consideration of clarification of diversity stratum and diversity group as used to assess jeopardy, the Final BO should directly address how these clarifications affect the "*likelihood of survival and recovery*".

FINAL BO STATEMENT (Page 53)

"For the spring-run Chinook salmon ESU, steelhead DPS, and green sturgeon Southern DPS to be viable, each stratum must be viable (Williams et al. 2007). Following on the example above, if the effects of the proposed action reduce the likelihood that the Northern Sierra Nevada Diversity Group becomes viable through increases in the risk of extinction of one or more of its member populations, the likelihood that the Central Valley steelhead DPS could be viable is reduced based on the proposed viability criteria. Therefore, reductions in the likelihood of Northern Sierra Nevada Diversity Group achieving viability are also reasonably likely to reduce the likelihood the Central Valley steelhead DPS would achieve viability; which is to say that the likelihood of both the survival and recovery of the species would be appreciably reduced."

COMMENT

The foregoing paragraph includes a conclusionary statement regarding extinction risk which was not assessed using the stated effects assessment approach for Yuba River anadromous salmonid populations, apparent confusion regarding the specific viability criteria and how or if it was applied in the effects assessment, suppositional probability of outcome ("*reasonably likely to reduce the likelihood*"), and a purported logical rationale that the magnitude of viability of Yuba River populations is sufficient to affect the Northern Sierra Nevada Diversity Group which, in turn, is sufficient to affect the entire ESU/DPS to an undefined level in which *"both the survival and recovery of the species would be appreciably reduced."*

1.1.4 Spatial Structure

The Final BO includes numerous statements regarding the constriction of available habitat to anadromous salmonids (and green sturgeon) in the Central Valley today below impassable barriers, relative to historical available habitats. These statements correctly reflect that much of the historical habitat is no longer accessible due to construction of dams, including the Yuba River watershed and Englebright Dam. However, the Final BO does not use information available from the Corps BA regarding characterization of habitat and spatial structure in the lower Yuba River, and the analyses of that spatial structure and its ability to support listed species.

The Corps BA presents spatial structure analyses for the lower Yuba River on pages 5-87, 5-121, 5-122 to 5-124, 5-199, and 5-200. Spatial structure evaluations presented in the Corps BA include examination of maintenance of watershed processes and regulatory management practices to create and maintain suitable habitat for all freshwater lifestages of spring-run and fall-run Chinook salmon, and steelhead/rainbow trout. Spatial structure assessments in the lower Yuba River are based on morphological units, defined as topographic forms within the channel and floodplain that represent distinct form-process associations. The Corps BA describes evaluations to determine whether morphological units are spatially organized or randomly distributed by conducting a longitudinal distribution analysis, an adjacency probability analysis, and a lateral variability analysis. The Corps BA states that the sequence of morphological units in the lower Yuba River is non-random, indicating that the channel has been self-sustaining of sufficient duration to establish an ordered spatial structure. By contrast, highly disturbed systems often degrade into homogeneity or randomness.

In addition, the Final BO includes numerous statements regarding spatial structure that are unsupported by analyses or citation, and/or are confusing in nature and require clarification. Some examples of these types of statements are provided below.

FINAL BO STATEMENT (Page 201)

"The spatial structure of spring-run Chinook salmon spawning is limited to sparsely available of spawning substrate [sic], *and superimposition pressure is high in some years. The river temperatures during outmigration may be too high in some years to allow for successful smoltification and outmigration. The lack of access to historical spawning habitat is the primary driver for the stressors of superimposition by fall-run Chinook salmon and low abundance relative to FRFH fish."*

COMMENT

First, the contention that spring-run Chinook salmon spawning in the lower Yuba River is limited to *"sparsely available of spawning substrate* [sic]" is technically incorrect, and is not supported by analyses in the Final BO. By contrast, the Corps BA provides thorough discussion regarding spawning gravel and habitat availability in the lower Yuba River and, with the exception of the Englebright Dam Reach where gravel augmentation is continuing, the lower Yuba River contains an abundance of suitable spawning gravel and spawning habitat does not appear to be limited by an inadequate supply of gravel.

Second, the statement that *"superimposition pressure is high in some years"* is not supported by any data analyses or reference demonstrating the rates of superimposition or types of years it might occur.

Third, the unsupported contention that water temperatures may exceed those suitable for smoltification and outmigration of juvenile spring-run Chinook salmon is technically incorrect (see comments below).

Fourth, careful review of the Final BO did not result in identifying any specific analyses relating abundance (annual escapement estimates) of spring-run Chinook salmon in the lower Yuba River to returns to the Feather River Fish Hatchery (FRFH).

FINAL BO STATEMENT (Page 201)

"The Yuba River population of the spring-run Chinook has low abundance, low productivity, limited spatial structure..."

COMMENT

This statement in the Final BO implies that spatial structure is limiting to the lower Yuba River population of spring-run Chinook salmon. However, review of the Final BO does not indicate that analyses were conducted assessing population abundance relative to habitat availability.

FINAL BO STATEMENTS

- ☐ **Page 208 –** *"The* [steelhead] *critical habitat from the lower Yuba River to the Feather River confluence with the Sacramento River does not support spatial structure of the DPS."*
- ☐ **Page 209 –** *"The* [green sturgeon] *habitat downstream of Daguerre Point Dam is too limited in flow, depth, and substrate to support a population that would support the spatial structure of the DPS."*

COMMENT

The intent or meaning of these statements is unclear.

1.1.5 Natural Flow Regime

The Final BO contains several statements discussing the concept of "natural flow regime." More specifically, the Final BO contains statements indicating that natural flow regime was used in the analysis of the effects of the Proposed Action. However, clarification should be provided how the natural flow regimes concepts were actually used in the analysis in the Final BO. Examples of statements in the Final BO regarding the natural flow regime are provided below.

FINAL BO STATEMENT (Page 48)

"*Throughout the sections of the biological opinion, NMFS uses the concepts of a natural flow regime to guide the analytical approach. The natural flow regime of a river is the characteristic pattern of flow quantity, timing, rate of change of hydrologic conditions, and variability across time scales (hours to years), all without the influence of human activities (Poff et al. 1997)."*

COMMENT

It would be helpful if NMFS could provide additional explanation of how the natural flow regime concepts described in Poff et al. (1997) were applied to the analytical approach used for the BO, including examples of how it was applied to evaluate potential effects of the Proposed Action.

FINAL BO STATEMENT (Pages 48 and 49)

"There are four components of a natural flow regime (NRC 2005): (1) Subsistence flow is the minimum flow needed during critical drought periods to maintain tolerable water-quality conditions and to provide minimal aquatic habitat space for the survival of aquatic species; (2) Base flow is the "normal" flow condition between storms; (3) High-flow pulses are short duration flows following storms; and (4) Overbank flow is an infrequent, high-flow event that breaches riverbanks."

COMMENT

Although this paragraph provides some description of components of the natural flow regime, it is unclear how the effects assessment in the Final BO uses or considers these components.

FINAL BO STATEMENT (Page 100)

"The current suitability of these flow requirements is almost entirely dependent on releases from Shasta Dam. High winter flows associated with the natural hydrograph do not occur within the section of the river utilized by green sturgeon with the frequency and duration that was seen in pre-dam conditions. Continued operations of the project are likely to further attenuate these high flow events. Rearrangement of the river channel and the formation of new pools and holes are unlikely to occur given the management of the river's discharge to prevent flooding downstream of the dam."

COMMENT

First, the Final BO speculates regarding dynamic fluvial geomorphology and habitat creation without conducting or referencing any specific analyses relating flow levels and habitat formations.

Second, and more importantly, it is unclear what is being referred to as "the project" – presumably Central Valley Project (CVP) operations at Shasta Dam. However, an important clarification is that the Proposed Action in this consultation is not *"likely to further attenuate these high flow events"* in the Sacramento River.

2.0 Lower Yuba River Accord

In numerous locations throughout the Final BO, statements were made regarding the inadequacy or unsuitability of flows and water temperatures in the lower Yuba River. Many of these types of conclusionary statements were not supported by analyses, citations or rationale. Some of these statements were technically incorrect, and others were contradicted within the Final BO itself. Of particular concern and in need of clarification is the manner in which implementation of the Yuba Accord, and resultant flows and water temperatures, was mischaracterized and inappropriately implied to result in stressors to listed species. Following are specific examples in the Final BO addressing inappropriate flow and water temperature-related statements.

2.1 Flow and Habitat Conditions

FINAL BO STATEMENTS

- ☐ **Pages 136 and 137** – "*…the flows under the Yuba Accord have improve*[d] *habitat in recent years, however, the flows in below average water years can be below the optimal depths for spawning and rearing spring-run Chinook salmon...*"
- ☐ **Page 148** – "*Flows are generally below optimal conditions for all life-history stages of salmon…*"
- ☐ **Page 202** – "*…juvenile rearing and outmigration conditions on the Yuba River are so poor*."
- ☐ **Page 207** – "*…in the Yuba River… Spawning and rearing conditions are so degraded for Central Valley steelhead that there may be cohort failure in some years.*"

COMMENT

These statements were unsupported by any analysis in the Final BO. By contrast, previous evaluations and documents (e.g., Lower Yuba River Accord Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) (YCWA et al. 2007) and the Corps BA) have examined the effects of flow conditions on all of the lifestages of anadromous salmonids in the lower Yuba River. These documents concluded that flow regimes resulting from the implementation of the Yuba Accord were protective of the public trust and aquatic resources of the lower Yuba River, including listed species, for all lifestages over the entire range of water year types and conditions. In fact, of the six flow schedules in the Yuba Accord, flow schedules 1 and 2 represent the upper and lower optimal flow schedules developed by the Yuba Accord Technical Team, and are estimated to occur with a 78% probability.

The Yuba Accord flow schedules were developed by the Lower Yuba River Accord Technical Team, which included NMFS (see pages 6-83 through 6-90 of Corps BA). On December 11, 2006 and on December 5, 2007, NMFS presented policy statements of support before the State Water Resources Control Board (SWRCB) regarding Yuba County Water Agency's (YCWA) petitions for the lower Yuba River Accord. As declared by NMFS in the 2007 Policy Statement:

- ☐ "*NMFS was actively engaged in development of the flow schedules, River Management Team provisions and biological studies program that are all key elements of the Yuba Accord package.*"
- ☐ *"NMFS believes that implementation of the provisions of the Accord's Fisheries Agreement will provide a level of protection for salmonids and green sturgeon in the lower Yuba River that is equal to or greater than the provided under RD-1644. Key elements of the Accord such as implementation of flow schedules and funding of biological studies in the Lower Yuba River are important steps in the recovery of listed anadromous fish which occur the lower Yuba River*."
- ☐ *"In addition to the specific benefits of the Yuba Accord to Yuba River fisheries, NMFS believes that the basic concepts underlying the Accord and the cooperative process through which the Accord was developed represent a unique and important breakthrough in the critical interface of fisheries protection and water management in the State of California. We believe that successful implementation of the Yuba Accord could act as a template for future, similar agreements across the state resulting in significant benefits to both the fisheries resources and the water uses of California."*

Additionally, NMFS 2009 Draft Recovery Plan (pages 116 and 140) states: (1) *"In order to secure a viable independent population of spring-run Chinook salmon in the lower Yuba River, several key near-term and the long-term habitat restoration actions have been identified, including the following …Continue implementation of the Yuba Accord flow schedules to provide suitable habitat (flow and water temperature) conditions for all life stages"*; and (2) *"For currently occupied habitats between below Englebright Dam, it is unlikely that habitats can be restored to pre-dam conditions, but many of the processes and conditions that are necessary to support a population of steelhead can be improved with improvements to instream flow regimes, water temperatures, and habitat availability. Continued implementation of the Yuba Accord is expected to address these factors and considerably improve conditions in the lower Yuba River."*

2.2 Water Temperatures

In addition to the foregoing issues regarding flow and habitat conditions associated with implementation of the Yuba Accord, the Final BO includes several statements regarding water temperature effects on listed anadromous salmonids in the lower Yuba River, which merit specific comment.

FINAL BO STATEMENT (Page 147)

"*Due to the Yuba Accord flows, water temperatures during the summer months are generally colder than they would be under the natural hydrograph due to of cold water releases from New*

Bullards Bar Reservoir. While the lower Yuba River does have generally cool water temperatures, they are not consistently suitable for salmonids throughout the year."

COMMENT

Available evaluations and documents (e.g., Yuba Accord Draft EIR/EIS (YCWA et al. 2007), the Corps BA, and the Yuba Accord RMT's Lower Yuba River Water Temperature Objectives Technical Memorandum (RMT 2010)) have examined the effects of water temperature conditions resulting from implementation of the Yuba Accord on all of the lifestages of anadromous salmonids in the lower Yuba River. These documents concluded that water temperature regimes resulting from the implementation of the Yuba Accord were protective of the public trust and aquatic resources of the lower Yuba River, including listed species, for all lifestages over the entire range of water year types and conditions.

In particular, the RMT, comprised of representatives of NMFS, U. S. Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG), California Department of Water Resources (DWR), YCWA, Pacific Gas and Electric Company (PG&E) and Non-governmental Organizations (NGOs) reviewed the appropriateness of the water temperature regime in the lower Yuba River associated with implementation of the Yuba Accord (RMT 2010). They concluded "*…Given the entire suite of considerations in this Technical Memorandum, the RMT concludes that implementation of the Yuba Accord provides a suitable thermal regime for target species* [spring-run Chinook salmon, steelhead, fall-run Chinook salmon, and green sturgeon] *in the lower Yuba River, and does not recommend water temperature-related operational or infrastructure modifications at this time.*"

Moreover, the statement that water temperatures "*are not consistently suitable for salmonids throughout the year*"is contradictory to the statement on page 174 of the Final BO "*…During the summer months, temperatures in the lower Yuba River are generally colder than they would be under the natural hydrograph due to cold water releases from New Bullards Bar Reservoir. These colder temperatures provide optimal temperature conditions for spring-run Chinook salmon.*"

FINAL BO STATEMENTS

- ☐ **Page 152** – "*If increased water deliveries lead to temperatures downstream of Daguerre Point Dam being over 55°F from December through March, both successful outmigration of spring-run Chinook salmon and attraction of green sturgeon for spawning will decline.*"
- ☐ **Page 189** – "*A major potential thermal stressor in the lower Yuba River would be temperatures over* 55°F *during the spring-run Chinook salmon outmigration period. During normal and above normal water years, this thermal stressor is not likely to be of significant concern; however, the lower Yuba River, downstream of Daguerre Point Dam, does not provide cold enough temperatures in January and February for spring-*

> *run Chinook salmon smoltification in dry years (C. Mesick, pers. comm.). Some proportion of outmigrating spring-run Chinook salmon exposed to this stressor will die."*

COMMENT

Comments on the Draft Biological Opinion on the U.S. Army Corps of Engineers Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir (Draft BO) were provided specifying that these statements were technically incorrect, speculative, and unsupported by any analyses. Not only were the comments on the Draft BO not addressed, the additional statement was made in the Final BO that "*Some proportion of outmigrating spring-run Chinook salmon exposed to this stressor will die.*" Clarification should be provided as to why the previously submitted comments were not addressed, and particularly why the additional inflammatory speculation was included in the Final BO.

As previously provided to NMFS as a comment on the Draft BO, these statements were not supported. As thoroughly described in the Corps BA, anadromous salmonid outmigration periods extend over many months of the year. Other than a personal communication, no analyses or documentation were presented to support these conclusionary statements in the Final BO. In fact, results presented in the RMT (2010) document, which included NMFS and was available to NMFS in the preparation of the BO, did indicate that yearling + steelhead smolt emigration and spring-run Chinook salmon smolt emigration occurs during January and February. However, by contrast to the statement in the BO, the RMT (2010) reported that in the examination of water temperature model results over the period of record, including dry and critical years, 55°F would be exceeded with a 0% probability of occurrence from the Smartsville Gage in the upper section of the lower Yuba River all the way down to the Marysville Gage located approximately 5 miles upstream from the confluence of the lower Yuba River and the Feather River. Moreover, RMT (2010) presented actual data monitored since the Yuba Accord has been implemented (October 2006 to May 2010) (Figure 4 in RMT 2010), and that same figure was provided to NMFS as a comment on the Draft BO. That figure demonstrated that water temperatures at all of the three reported monitoring locations in the lower Yuba River (Smartsville, Daguerre Point Dam, Marysville) actually remained at about or below 50°F during January and February.

FINAL BO STATEMENT (Page 190)

"*The winter temperature standard of 63°F under the Yuba Accord is likely to result in reversal of smoltification of spring-run Chinook salmon and could result in a complete cohort-failure...*"

COMMENT

The above statement is incorrect. The Yuba Accord does not include a "winter temperature standard" at all. Further, the above statement does not accurately reflect water temperature evaluations conducted in the Yuba Accord Draft EIR/EIS (YCWA et al. 2007), the Corps 2012 BA, or the Yuba Accord RMT's Lower Yuba River Water Temperature Objectives Technical

Memorandum (RMT 2010). As demonstrated in the previous comment, the RMT (2010) reported that examination of water temperature model results over the period of record, including dry and critical years, 55°F would be exceeded with a 0% probability of occurrence throughout the lower Yuba River, and that since the Yuba Accord has been implemented (2006), water temperatures at any of the three reported monitoring locations in the lower Yuba River actually remained at about or below 50°F during January and February.

Moreover, inflammatory speculation regarding biologic impact (*"complete cohort-failure"*) based upon incorrect assumption or interpretation is particularly inappropriate, and requires clarification.

FINAL BO STATEMENT (Page 190)

"*Any winter temperature standard above 55°F does not contribute to the conservation of spring-run Chinook salmon*."

COMMENT

The above statement is incorrect. The Yuba Accord does not include a "winter temperature standard" at all.

FINAL BO STATEMENT (Page 201)

"High predation, entrainment, and lack of thermal protection for winter outmigrants all reduce the number of spring-run Chinook salmon that leave the river, enter the Delta, and forage in the marine environment."

COMMENT

This statement is not correct, particularly regarding "*lack of thermal protection for winter outmigrants."* See previous comments.

FINAL BO STATEMENT (Page 207)

"Temperatures below Daguerre Point Dam may cause residualization of Central Valley steelhead when outmigration would result in higher survivorship, particularly when Central Valley steelhead trout are exposed to unsuitable temperatures and an unstable prey base."

COMMENT

This statement is speculative and unsupported by any independent analyses or referenced literature or studies.

First, the speculation that "*Temperatures below Daguerre Point Dam may cause residualization of Central Valley steelhead"* is unsupported. In fact, this issue was addressed by RMT (2010), which included NMFS. The following excerpts are taken directly from RMT (2010).

> *"In general, Satterthwaite et al. (2010) do not predict that a warm summer with low food availability will strongly favor anadromy relative to a baseline condition, nor do they predict that a cool summer with high flow will strongly favor residency."*
>
> *"O. mykiss life history evolution is driven by an interacting network of growth rates, freshwater survival, and emigrant survival, along with limits on the asymptotic sizes achievable in freshwater (Satterthwaite et al. 2010). They state that it is difficult and perhaps misleading to try to summarize the effects of any one of multiple variables in isolation on predicted changes in steelhead life history in response to management actions."*

Second, the statement that *"outmigration would result in higher survivorship"* is speculative and unsupported by any independent analyses or referenced literature or studies.

Third, the statement that *"particularly when Central Valley steelhead trout are exposed to unsuitable temperatures,"* presumably in reference to the lower Yuba River, is not supported and, in fact, is technically incorrect as demonstrated in previous comments.

2.3 Yuba Accord and the NMFS Draft Recovery Plan

FINAL BO STATEMENT (Page 5)

"*These* [Yuba Accord] *improvements most certainly have increased protections for federally listed anadromous fish, but the NMFS Draft Recovery Plan recognizes that they may not be substantial enough to restore the viability of Yuba River anadromous fish populations*."

COMMENT

This citation in the Final BO is not technically correct. For clarification purposes, the NMFS Draft Recovery Plan (page 115 and page 140) states – "*For currently occupied habitats between below Englebright Dam, it is unlikely that habitats can be restored to pre-dam conditions, but many of the processes and conditions that are necessary to support a population of spring-run Chinook salmon* [page 115] / *steelhead* [page 140] *can be improved with improvements to instream flow regimes, water temperatures, and habitat availability. Continued implementation of the Yuba Accord is expected to address these factors and considerably improve conditions in the lower Yuba River. Additional habitat improvements and restoration actions are anticipated to be addressed in the forthcoming Yuba County Water Agency FERC relicensing process*."

3.0 Genetic Considerations

Several statements in the Final BO allege that effects of the Proposed Action will produce stressors and exacerbate genetic introgression of spring-run Chinook salmon and steelhead in the lower Yuba River. These statements range from concluding that the consequences would be to impair long-term survival and viability of the Yuba River populations to the *"…Yuba River population of spring-run Chinook salmon is not likely to survive the conditions perpetuated by the proposed action"* (Final BO, page 201). These statements imply that there are genetically distinct lower Yuba River spring-run Chinook salmon and steelhead populations that will be adversely affected by the Proposed Action. Following are some examples of these types of statements in the Final BO.

FINAL BO STATEMENTS

- ☐ **Page 201 –** *"Flow conditions in the Yuba River provide greater attraction flow than the Feather River during some years, causing spring-run Chinook salmon from the Feather River to be preferentially attracted into the Yuba River to spawn. This exacerbates baseline hatchery effects and genetic introgression, because it results in an increase in genetic mixing of Feather River wild and hatchery spring-run Chinook salmon with natal Yuba River spring-run Chinook salmon…The Yuba River population of spring-run Chinook salmon is not likely to survive the conditions perpetuated by the proposed action."*
- ☐ **Pages 202 and 203** – *"The proposed action is likely to produce stressors that adversely affect the environment of spring-run Chinook salmon* [and steelhead] *by …continued hybridization with fall-run Chinook salmon and FRFH salmon downstream from Englebright Dam… These environmental consequences also reduce the survival of individuals and ultimately impairs the long-term survival and viability of the local population by … impaired spatial and genetic diversity, and continued exposure to hatchery populations. Recognizing that the spring-run Chinook salmon ESU is currently at a moderate to high risk of extinction, any reduction in the viability to the Yuba River population is likely to reduce the viability and increase the extinction risk of the ESU."*

COMMENT

Comprehensive information and discussion regarding issues pertaining to genetic introgression and integrity of lower Yuba River anadromous salmonids, particularly spring-run Chinook salmon, was available to NMFS in the preparation of the Final BO in the Corps BA, and in the two documents submitted to the United States District Court for the Eastern District of California, Sacramento Division, Case 2:06-cv-02845-LKK-JFM titled: (1) *"Technical Memorandum: Lower Yuba River, California, Segregation Weir Considerations"* Exhibit 1 to the August 23, 2011 Declaration of Brian M. Mulvey (Corps 2011); and (2) *"Responses to the*

January 31, 2012 Letter from Environmental Advocates on behalf of the South Yuba River Citizens League to the National Marine Fisheries Service Regarding Comments on the Draft Biological Assessment for the United States Army Corps of Engineers Operations on the Yuba River" (HDR 2012).

As previously provided in these documents, the Corps BA goes to great lengths to describe the genetic considerations associated with Chinook salmon expressing the phenotypic characteristics of spring-run Chinook salmon in the lower Yuba River, as listed below.

- ☐ Pages 5-75 to 5-78 – Feather River Fish Hatchery Genetic Considerations
- ☐ Pages 5-78 to 5-82 – Straying into the Lower Yuba River
- ☐ Pages 5-83 to 5-85 – Lower Yuba River Genetic Considerations
- ☐ Pages 5-105 to 5-111 – Annual Separation of Spring-Run and Fall-Run Chinook Salmon
- ☐ Pages 5-111 to 5-117 – Abundance and Productivity of Spring-run Chinook Salmon Spawners of Natural and Hatchery Origin Upstream of Daguerre Point Dam

A summary of relevant information discussed in the above documents is provided below.

- ☐ A small spring-run Chinook salmon population historically occurred in the lower Yuba River, but the run virtually disappeared by 1959.
- ☐ By 1991, a small spring-run Chinook salmon population became reestablished in the lower Yuba River due to improved habitat conditions and due to recolonization by fish straying from the Feather River, fish previously and infrequently stocked from the FRFH, or possible production from a remnant population in the lower Yuba River.
- ☐ The phenotypic spring-run Chinook salmon in the lower Yuba River actually represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, and hybridization with Feather River stocks including the FRFH spring-run Chinook salmon stock.
- ☐ The FRFH spring-run Chinook salmon stock itself represents a hybridization between Feather River fall- and spring-run Chinook salmon populations.

Straying of FRFH "spring-run" Chinook salmon, as well as hybridization between spring-run and fall-run Chinook salmon in the lower Yuba River, have oftentimes been suggested to represent an adverse effect on lower Yuba River "spring-run" Chinook salmon. It is reasonable to assume that these two phenomena would represent an impact if the lower Yuba River stock represented a genetically distinct, independent population. However, given the foregoing available information, spring-run Chinook salmon in the lower Yuba River do not represent a "pure" ancestral genome. Moreover, the continued and ongoing influx of FRFH-origin fish and hybridization between fall-run and spring-run Chinook salmon would represent an adverse effect if the management goal is to establish a genetically distinct, independent population of spring-run Chinook salmon in the lower Yuba River. However, as reported on page 5-85 of the Corps BA, it is questionable whether the phenotypic spring-run Chinook salmon in the lower Yuba River represents an independent population, or should be considered as a meta-population along with lower Feather River stocks. Regardless, it is unlikely, even after multiple generations, that it will be possible to reconstruct an ancestrally "pure" spring-run stock of Chinook salmon in the lower Yuba River.

In addition to the foregoing comment on issues associated with genetic structure of lower Yuba River anadromous salmonid populations that was available to NMFS in preparation of the Final BO, the Final BO also includes several statements regarding genetic issues, which merit specific comment.

FINAL BO STATEMENT (Page 192)

"*Some level of hybridization with hatchery O. mykiss from planted trout at Englebright Reservoir adversely affects spawning conditions of Central Valley steelhead in the lower Yuba River*."

COMMENT

This conclusionary statement is not supported by presentation of data or referenced citation, nor is it clear what is meant by *"adversely affects spawning conditions."*

FINAL BO STATEMENT (Page 203)

"The [steelhead] *population has very high hatchery introgression and is not genetically viable."*

COMMENT

It is unclear what metric or analyses are used in the Final BO to conclude that the lower Yuba River steelhead population is *"not genetically viable."* Clarification should be provided.

FINAL BO STATEMENT (Page 206)

"These environmental consequences also reduce the survival of individuals and ultimately impairs the local [green sturgeon] *population's long-term survival viability by …impaired spatial and genetic diversity, and continued exposure to hatchery populations. Recognizing that the green sturgeon DPS is currently at a moderate to high risk of extinction, any reduction in the viability to the Yuba River population is likely to reduce the viability and increase the extinction risk of the DPS."*

COMMENT

First, it is unclear what *"local population"* of green sturgeon in the lower Yuba River is being referred to in the above statement (see comments provided below).

Second, the Final BO does not provide evidence of "*impaired spatial diversity*," or whether green sturgeon ever historically even utilized habitat located above Daguerre Point Dam.

Third, this conclusionary statement appears to be an editorial mistake, copied from anadromous salmonid discussions, because there are no green sturgeon hatchery populations in the lower Yuba River, let alone the Central Valley.

4.0 Upper Yuba River Watershed Anadromous Salmonid Production, and Comparisons to the Lower Yuba River

To characterize potential habitat availability and production capacity for anadromous salmonids in the Upper Yuba River Watershed, NMFS relied on information and assumptions presented in two documents, including: (1) *"Upper Yuba River Watershed Chinook Salmon and Steelhead Habitat Assessment"* (UYRSPST 2007); and (2) *"Modeling Habitat Capacity and Population Productivity for Spring-run Chinook Salmon and Steelhead in the Upper River Watershed"* (Stillwater Sciences 2012). The latter document relies upon output from a model referred to as "RIPPLE." Following are comments pertaining to specific statements in the Final BO regarding aquatic habitat and production capacity in the Upper Yuba River Watershed. **Attachment 1** to this document provides additional comments on the report titled *"Modeling Habitat Capacity and Population Productivity for Spring-run Chinook Salmon and Steelhead in the Upper River Watershed"* and application of the RIPPLE model.

A fundamental concern associated with potential misapplication or misinterpretation of the RIPPLE model results stems from the fact that it does not account for conditions that change over time, which is an inherently important consideration regarding abundance and productivity of anadromous salmonids. In fact, Stillwater Sciences (2012, page ES-2) state "*One of the guiding principles of RIPPLE is the assumption that physical processes and the resulting environment… are <u>essentially time invariant</u> compared with ecosystems and the animal and plant populations supported by these ecosystems."* Clearly, flow and water temperatures are not "*time invariant*", but change year-to-year based on hydrologic and meteorological conditions. Model output presented in Stillwater Sciences (2012) does not account for abiotic variables that change over time (e.g., flows and water temperatures), does not address resultant variability in salmonid habitat availability and suitability, and consequently does not represent reliable long-term estimates of population production. Applications of model output inferring long-term habitat capacity or population production are, therefore, inappropriate.

Numerous assumptions are embedded in the Stillwater Sciences (2012) report that inject bias and result in higher estimates of habitat carrying capacity and population productivity in the South and Middle Yuba rivers, and in the North Yuba River below New Bullards Bar Dam, relative to the North Yuba River upstream of New Bullards Bar Reservoir.

Examples of these bias-inducing assumptions/approaches include:

- ☐ Relaxed ("expanded") water temperature suitability criteria (standard = 20°C (68°F), "relaxed" = 23.2°C (73.8°F) for the Middle Yuba River and 25.2°C (77.4°F) for the South Yuba River) for steelhead, which significantly increase the amounts of suitable habitat in the South and Middle Yuba rivers, and no relaxed water temperature criteria for the North Yuba River.
- ☐ "Augmented" flow conditions for the South and Middle Yuba rivers, and NBB, which represent speculative increased releases out of upstream storage facilities, to improve habitat conditions (particularly water temperature). By contrast, the North Yuba River above New Bullards Bar Reservoir is unimpaired, and most accurately represents a hydrologically undisturbed watershed, and no "augmented" releases are presented.
- ☐ Anadromous salmonid passage barriers, particularly barriers that block the upstream passage of fish during low-flow conditions, were assumed to either be nonexistent or some unidentified passage facilities provided on the South and Middle Yuba rivers, which vastly increases the estimated amount of habitat available and resultant population production. No such passage barriers exist on the North Yuba River upstream of New Bullards Bar Reservoir.
- ☐ Appropriate spawning gravels are not present in the North Yuba River downstream from New Bullards Bar Dam. In fact, this reach is characterized by very large boulders. However, a "gravel augmentation" assumption was made for this reach under the Alternative Management Scenarios, which transforms completely unsuitable spawning habitat into suitable and usable habitat in the comparison among reaches.

NMFS used the RIPPLE model as the basis for determining potential habitat availability and production capacity in the Upper Yuba River Watershed. In addition to questions regarding the veracity of the RIPPLE model itself and its current application to the Upper Yuba River Watershed, there appear to be several errors in the Final BO associated with incorporating statements from the separate RIPPLE document (Stillwater Sciences 2012).

FINAL BO STATEMENT (Page 160)

"Stillwater Sciences (2012) predicted that the holding capacity of the North Yuba River upstream of New Bullards Bar Reservoir is 17,500 spring-run Chinook salmon."

COMMENT

This statement appears to be factually incorrect. A thorough review of Stillwater Sciences (2012) did not locate reference to the North Yuba River having a spring-run Chinook salmon holding capacity of 17,500 under current conditions, or any other river in the Upper Yuba River Watershed, for that matter. Table 6-5 in Stillwater Sciences (2012, page 44) does provide a holding capacity value of 17,100, but that was for the Middle Yuba River under Alternative Management Scenario 2 (additional 100 cfs from Milton Dam).

The predicted holding capacity for spring-run Chinook salmon in the North Yuba River upstream of New Bullards Bar Reservoir under current conditions that is actually presented in Stillwater Sciences (2012, page 44) is 15,597. Clarification should be provided.

FINAL BO STATEMENT (Page 160)

"…the Middle Yuba River has a predicted holding capacity of 126 (Stillwater Sciences 2012)."

COMMENT

This statement appears to be factually incorrect. According to Table 6-5 in Stillwater Sciences (2012, page 44), the predicted holding capacity for spring-run Chinook salmon in the Middle Yuba River under current conditions is 2,613 – not 126 as presented in the BO. It is unclear how the value of 126 was determined for the Final BO, and clarification should be provided or inaccuracies corrected.

FINAL BO STATEMENT (Pages 164 and 165)

"…Middle Yuba River has a predicted summer capacity of 36,227 (Stillwater Sciences 2012)."

COMMENT

For the Middle Yuba River under current conditions, the predicted summer capacity estimate of 36,227 steelhead was identified using a "relaxed" 23.2°C (73.8°F) water temperature criterion. Application of the standard water temperature criterion of 20°C (68°F) presented in Stillwater Sciences (2012) resulted in a predicted summer capacity estimate of 17,077 steelhead (summer 1+), or a reduction of about 53% compared to the 36,227 value.

FINAL BO STATEMENT (Page 160)

"Although there are currently no spring-run Chinook salmon upstream of Englebright Dam, studies done in 2004, under slightly warmer conditions than today, the thermally suitable habitat for spring-run Chinook salmon was estimated to extend approximately 5.6 miles downstream of the natural barrier at RM 35.4. Within the 5.6 mile reach considered thermally suitable, 15 pools were identified with suitable holding habitat for adult spring-run Chinook salmon. Based on the

size and configuration of the available pools, a *<u>minimum of 750 to 1,500 adult spring-run Chinook salmon</u>* *could hold in the habitat."*

COMMENT

First, because no citation was provided, it is unclear what "studies done in 2004" are being referred to in the above statement. Presumably, the studies referred to in the Final BO are described in UYRSPST (2007), but clarification should be provided.

Second, it is unclear what area in the Upper Yuba River Watershed was being referred to in the Final BO statement that *"…a minimum of 750 to 1,500 adult spring-run Chinook salmon could hold in the habitat"*. Also, no reference to "*a minimum of 750 to 1,500*" adult spring-run Chinook salmon could be located in Stillwater Sciences (2012).

<u>FINAL BO STATEMENT (Page 160)</u>

"<u>Holding conditions downstream of Daguerre Point Dam degrade rapidly</u>, due to lack of riparian shading and from water diversions upstream of the Daguerre Point Dam pool."

COMMENT

No analyses were located in the Final BO to support these conclusionary statements. Regarding the abundance and distribution of riparian vegetation, see the attached comments provided by Dr. Pasternack. The lack of substantive effect on pool habitats downstream of Daguerre Point Dam associated with water diversions under the Cumulative Condition was thoroughly discussed in the Corps' BA (see Chapter 8). These two sources provide information and analyses that do not support these statements in the Final BO.

<u>FINAL BO STATEMENT (Page 158)</u>

"<u>Lack of adequate habitat for juvenile rearing</u> is a very high stressor for the Yuba River spring-run Chinook population, although suitable rearing habitat exists in the watershed. <u>There are 46. 8 miles of suitable rearing habitat upstream of Englebright Dam….</u>"

COMMENT

The Final BO does not provide evidence supporting the statement that juvenile spring-run Chinook salmon rearing habitat is "lacking" in the lower Yuba River. The statement then goes on to imply that there is much more suitable habitat available in the upper watershed than in the lower Yuba River. However, no evaluations of juvenile salmonid rearing habitat were undertaken in the Final BO for the lower Yuba River, and no comparative assessments were presented comparing the lower Yuba River and the Upper Yuba River Watershed.

FINAL BO STATEMENT (Page 162)

Regarding steelhead, the Final BO states *"…Stillwater Sciences …found that under current conditions: the South Yuba River could support 3,745 redds; the Middle Yuba River could support 3,284 redds; the North Yuba River could support 16,352 redds..."*

COMMENT

This representation in the Final BO of results in the Stillwater Sciences (2012) report is inaccurate and misleading. In the RIPPLE model, specific water temperature thresholds were used to identify the downstream extent of thermally suitable habitat for steelhead. Later in the document (page 25) Stillwater Sciences established a relaxed or "expanded" water temperature criterion for the Middle Yuba River (23.2°C), and 25.2°C for the South Yuba River, but not for the North Yuba River.

The Final BO statement that the "*South Yuba River could support 3,745 redds*" is referring to the model-predicted number resulting from the relaxed water temperature criteria. The actual estimate for the South Yuba River under current conditions is 393 redds (Stillwater Sciences 2012).

The Final BO statement that the "*Middle Yuba River could support 3,284 redds*" also is referring to the model-predicted number resulting from the relaxed water temperature criteria. The actual estimate for the Middle Yuba River under current conditions is 1,503 redds (Stillwater Sciences 2012).

Even the Final BO statement that the "*North Yuba River could support 16,352 redds*" appears to be incorrect because the actual estimate for the North Yuba River under current conditions is 15,626 redds (Stillwater Sciences 2012).

Not surprisingly, when these much more lenient water temperature criteria are applied to the South and Middle Yuba rivers (25.2°C and 23.2°C, versus 20°C), the estimated carrying capacity was significantly increased.

The utility of using the expanded criteria of 23.2°C on the Middle Yuba River and 25.2°C on the South Yuba River is of questionable value. Using different criteria on different reaches does not present an equitable basis of comparison of thermal suitability among rivers and reaches compared.

FINAL BO STATEMENT (Page 163)

"Lack of adequate habitat for juvenile rearing is a very high stressor for the Yuba River Central Valley steelhead population, although suitable rearing habitat exists in the watershed. There are 143.2 miles of suitable rearing habitat upstream of Englebright Dam..."

COMMENT

Similar to the previous comment regarding juvenile spring-run Chinook salmon rearing habitat, the Final BO does not provide evidence supporting the statement that juvenile steelhead rearing habitat is "lacking" in the lower Yuba River. The statement then goes on to imply that there is much more suitable habitat available in the upper watershed than in the lower Yuba River. However, no evaluations of juvenile salmonid rearing habitat were undertaken in the Final BO for the lower Yuba River, and no comparative assessments were presented comparing the lower Yuba River and the Upper Yuba River Watershed.

FINAL BO STATEMENT (Page 207)

"The very low Central Valley steelhead numbers in critical habitat on the lower Yuba River, compared to the high amount of occupied O. mykiss habitat in the upper Yuba River watershed, demonstrates that the critical habitat in the lower Yuba River contributes very little to Central Valley steelhead DPS abundance."

COMMENT

These conclusionary statements are unsupported by any analyses or citations in the Final BO.

5.0 Green Sturgeon Considerations

FINAL BO STATEMENTS (Pages 55, 58, 81)

COMMENT

In several locations of the Final BO (e.g., pages 55, 58, 81), the statement is made that successful spawning of green sturgeon occurs in the lower Feather River downstream of Oroville Dam, referencing documentation by DWR during spring of 2011. Although stated several times in the NMFS BO, NMFS does not provide a study reference to support the new finding that confirmed green sturgeon successfully spawn in the Feather River.

FINAL BO STATEMENT (Page 100)

"An adequate flow regime (i.e., magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) is necessary for normal behavior, growth, and survival of all life stages in the upper Sacramento River… Sufficient flow is also needed to reduce the incidence of fungal infestations of the eggs, and to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in and to maintain surfaces for feeding. Successful migration of adult green sturgeon to and from spawning grounds is also dependent on sufficient water flow."

COMMENT

If the green sturgeon habitat requirements discussion in the Final BO is intended to serve the purpose of establishing a basis for effects assessment, then it would be helpful if some of the vagaries were further defined. For example, it is not clear what constitutes an "adequate" flow regime, "normal behavior," "sufficient flow," and "sufficient water flow" for adult migration. Additional specificity should be provided.

FINAL BO STATEMENT (Page 101)

Due to the temperature management of the releases from Keswick Dam for winter-run Chinook salmon in the upper Sacramento River, water temperatures in the river reaches utilized currently by green sturgeon appear to be suitable for proper egg development and larval and juvenile rearing. Suitable salinity levels range from fresh water (< 3 parts per thousand) for larvae and early juveniles [about 100 days post hatch (dph)] to brackish water (10 parts per thousand) for juveniles prior to their transition to salt water... Salinity levels are suitable for green sturgeon in the Sacramento River and freshwater portions of the Delta for early life history stages. Adequate levels of DO are needed to support oxygen consumption by early life stages (ranging from 61.78 to 76.06 mg O2 hr-1 kg-1 for juveniles, Allen and Cech 2007). Current mainstem DO levels are suitable to support the growth and migration of green sturgeon in the Sacramento River.

COMMENT

The above text is under a heading titled "*d. Freshwater Riverine Water Quality*", but the text is confusing because first water temperature is discussed, then salinity in the Delta is discussed, followed by a discussion of dissolved oxygen levels in the Sacramento River.

Further, it is unclear what analyses were conducted or are relied upon for NMFS' conclusion that water temperatures and dissolved oxygen levels in the Sacramento River and salinity conditions in the Sacramento River and the Delta are "suitable" for green sturgeon. Additional clarification should be provided.

FINAL BO STATEMENT (Page 107)

"…due to dam construction, access to 38 percent of all [steelhead] *spawning habitat has been lost as well as access to 80 percent of the historically available habitat. Green sturgeon populations have been similarly affected by these barriers and alterations to the natural hydrology."*

COMMENT

It is unclear what is meant by *"similarly affected,"* although the statement implies that similar amounts of historically available steelhead and green sturgeon habitat are no longer accessible due to dam construction. However, this statement appears to be in conflict with the previous statement in the Final BO (page 88) *"…While dams block only 9 percent of the species* [green sturgeon] *habitat, it is likely that the blocked areas contain relatively high amounts of spawning habitat due to their upstream location in the river systems."*

FINAL BO STATEMENT (Pages 127 and 128)

"Although no historical accounts exist for identified green sturgeon spawning occuring upstream of the current dam sites [including Daguerre Point Dam and Englebright Dam], *suitable spawning habitat existed and, based on habitat assessments done for Chinook salmon, the geographic extent of spawning has been reduced due to the impassable barriers constructed on the river. The narrows gorge provides optimal spawning conditions and it is likely that good spawning habitat existed in the upper Yuba River upstream of Englebright Dam. Lack of access to this habitat is likely to have depressed the local population of green sturgeon."*

COMMENT

There are several issues associated with this statement.

First, the statement speculating that green sturgeon habitat extended in the Yuba River upstream of Englebright Dam is in direct conflict with the previous statement in the Final BO (page 88) *"…Historically, the green sturgeon southern DPS likely spawned in the Sacramento, Feather, and San Joaquin rivers, judged upon the characteristics of the local habitats (Adams et al. 2007)... The total amount of habitat blocked includes Keswick Dam: 39 km +/- 14 km, Oroville Dam: 16 km +/- 4 km, Daguerre Point Dam: 4 +/- 2 km, and Friant Dam: 12 +/- 2 km."* From this statement, it seems clear that the Final BO acknowledges that historically green sturgeon spawning did not occur upstream of Englebright Dam.

Second, the Final BO does not provide information or cite references identifying what constitutes "optimal" green sturgeon habitat, or what surveys or studies were conducted to assess habitat upstream of Daguerre Point Dam or Englebright Dam in the lower Yuba River.

Third, the phrase *"Lack of access to this habitat* [upstream of Englebright Dam] *is likely to have depressed the local population of green sturgeon"* is speculative and unsupported. In fact, the Final BO (page 143) states *"…The lack of information on green sturgeon utilization of the Yuba River makes it difficult to determine how this* [Daguerre Point Dam] *blockage might affect green sturgeon…"* and on page 126 states *"…historical spawning records do not occur for green sturgeon in the upper Yuba River..."* No documentation is provided in the Final BO to support the suggestion that spawning may have occurred historically in the lower Yuba River, let alone in the areas upstream of Englebright Dam.

FINAL BO STATEMENT (Page 142)

"Green sturgeon occupy the lower Yuba River up to Daguerre Point Dam, and based on observations of green sturgeon at the dam and spawning behavior of adults during the spawning

season, green sturgeon currently use the lower Yuba River for spawning, reproduction, and rearing. Daguerre Point Dam blocks North American green sturgeon from accessing the area between Daguerre Point and Englebright Dams, where deep pools and colder water provide more suitable habitat for spawning and rearing of green sturgeon than the area below the dam."

COMMENT

The Corps provided comment on this identical statement in the Draft BO. The comment was not addressed, and therefore is repeated here.

The Final BO does not provide any analysis to support these statements. As described in the Corps BA (page 5-245), "*…over the many years of sampling and monitoring in the lower Yuba River, only one sighting of an adult green sturgeon was confirmed before 2011… sampling conducted during May 2011 with underwater videography indicates the presence of 4 to 5 adult green sturgeon just downstream of Daguerre Point Dam (Cramer Fish Sciences 2011).*"

In a memorandum dated June 7, 2011, Cramer Fish Sciences reported that roving underwater video surveys ranging from 33 to 109 minutes each were conducted immediately below Daguerre Point Dam on three days during May 2011. Cramer Fish Sciences (2011) state "*On two passes of the video camera, 2 sturgeon appeared to be exhibiting spawning behavior, and were holding in the current (facing upstream) next to one another on the gravel bar. Although no literature exists documenting the spawning behavior of green sturgeon, male sturgeon of a similar species, lake sturgeon Acipensar fulvescens, have been observed to swim alongside female sturgeon, facing against the current in preparation for spawning (Priegal and Wirth 1971).*"

Aside from the fact that Cramer Fish Sciences (2011) themselves admit that no literature is available to document the actual spawning behavior of green sturgeon, the field crew apparently made an assumption that fish were exhibiting "spawning behavior" because they were located in proximity to one another. Anecdotal observations and no documented accounts of spawning or rearing of green sturgeon in the lower Yuba River brings into question the appropriateness of the conclusion that "*green sturgeon currently use the lower Yuba River for spawning, reproduction, and rearing".*

In addition to the foregoing comment, the above conclusion is contradictory to the statement provided in the Final BO (page 165*) "…The extremely limited information on North American green sturgeon on the lower Yuba River indicates that small numbers of adults occur sporadically below Daguerre Point Dam. Although spawning behavior was observed in 2011, it is not known whether green sturgeon spawning attempts are successful."*

Additionally, no comparative analyses are provided in the Final BO to support the statement that *"…between Daguerre Point and Englebright Dams …deep pools and colder water provide more suitable habitat for spawning and rearing of green sturgeon than the area below the dam…".*

FINAL BO STATEMENT (Page 148)

"Green sturgeon hold in deep (> 5m), low velocity pools during the summer months (Erickson et al. 2002, Benson et al. 2007). Because the lower Yuba River is smaller than the Sacramento River or other rivers citing a depth criterion of > 5 meters (16.4 feet), use of that criterion may be overly restrictive and not account for local opportunistic habitat utilization by green sturgeon… However, green sturgeon adults prefer deep turbulent waters at the mouths of tributary streams. Monitoring of green sturgeon and behavior data in the Rogue River in Oregon suggests spawning occurs in sites at the base of riffles or rapids, where depths immediately increase from shallow to about 5 to 10 meters, water flow consists of moderate to deep turbulent or eddying water, and the bottom type is made up of cobble to boulder substrates (D. Erickson, ODFW, pers. comm. September 3, 2008 in NMFS 2009b). Currently accessible habitat that meets this description is limited to the Daguerre Point Dam plunge pool."

COMMENT

This statement appears to be somewhat contradictory and logically confining. First, the statement is made acknowledging the potential for green sturgeon local opportunistic habitat utilization in the lower Yuba River, taking into account differences between the lower Yuba River and the Sacramento River, where green sturgeon spawning is known to occur. This statement further implies that the only potentially suitable holding and spawning habitat for green sturgeon in the lower Yuba River is the area *"limited to the Daguerre Point Dam plunge pool."* In actuality, this specific location does not conform to the Rogue River habitat description, because this is not a location characterized as immediately downstream of a rapid or riffle, or the mouth of a tributary stream. Moreover, if the contention is that the description of habitat requirements based on Rogue River observations is necessary for green sturgeon in the lower Yuba River, then the statement further implies that there is no additional suitable habitat in the lower Yuba River downstream of Daguerre Point Dam. However, as stated on pages 5-213 and 5-214 of the Corps BA, green sturgeon critical habitat in the lower Yuba River extends from Daguerre Point Dam downstream to the confluence with the lower Feather River and primary constituent elements (PCEs) *"…present in the lower Yuba River include water flow, water quality, depths, and migratory corridors to support adult, and possibly sub-adult, migration."* By definition, therefore, green sturgeon critical habitat downstream of Daguerre Point Dam in the lower Yuba River *"…include sufficient habitat necessary for each riverine life stage"* (74 FR 52300).

FINAL BO STATEMENT (Page 165)

"The [green sturgeon] *spawning conditions are very poor below Daguerre Point Dam, but spawning behavior was observed during the high flows of 2011."*

COMMENT

First, the conclusionary statement that *“spawning behavior was observed”* is not actually supported, as indicated in foregoing comments.

Second, no analyses or evaluations are presented in the Final BO to support the conclusionary statement that *“The spawning conditions are very poor below Daguerre Point Dam.”* In fact, the Final BO (page 148) recognizes the potential for green sturgeon local opportunistic habitat utilization in the lower Yuba River, and the analyses conducted in the Corps BA that identified 26 pool locations *“below Daguerre Point Dam with water depths greater than 10.0 feet deep at the nominal flow of 530 cfs at the Marysville Gage.”* The conclusionary statement regarding *“very poor”* spawning conditions appears to be based on the foregoing contentions in the Final BO (page 148) regarding the requirement/preference for deep turbulent or eddying water at the base of riffles or rapids, or at the mouths of tributary streams – conditions which generally do not occur in the lower Yuba River under the Environmental Baseline.

FINAL BO STATEMENT (Page 166)

“A large amount of moderate to high quality spawning habitat exists upstream of Daguerre Point Dam. Daguerre Point Dam blocks access to this habitat and forces green sturgeon to spawn at the Daguerre Point Dam plunge pool.”

COMMENT

First, the Final BO does not provide any analyses or citations specifying what constitutes moderate or high quality spawning habitat, or evaluations regarding the quantity of such habitat upstream of Daguerre Point Dam.

Second, the Final BO does not provide support for the conclusionary statement that green sturgeon are forced to spawn at the Daguerre Point Dam plunge pool (see previous comment).

FINAL BO STATEMENT (Page 166)

“Because green sturgeon are long lived, it will take years to determine a trend in the adult population; however, with a the largest observed sub-population of only five fish, and little to no suitable spawning habitat in most years, it is below levels that would be considered viable.”

COMMENT

The Final BO does not provide analyses or documentation supporting the statement that the lower Yuba River provides *little to no suitable spawning habitat in most years.”*

FINAL BO STATEMENT (Page 194)

"The Yuba River downstream of Daguerre Point Dam does not provide sufficient water flow rates for green sturgeon spawning and rearing under most water-year types. Water diverted out of the river and watershed is the primary reason for the insufficient flows. Only very wet years are likely to provide sufficient flows for spawning and rearing."

COMMENT

No analyses of evaluations are presented in the Final BO to support the conclusionary statement that flows are not sufficient for green sturgeon spawning and rearing under most water year types. It is particularly unclear what evaluation was conducted to support the conclusionary statement that *"Only very wet years are likely to provide sufficient flows for spawning and rearing."* Moreover, the Final BO does not utilize analyses of the areal extent and depth of pools conducted in the Corps BA (pages 8-80 to 8-90) evaluating green sturgeon habitat availability over range of water year types.

FINAL BO STATEMENT (Page 205)

"The Yuba River may be a population sink for the only population in the DPS. The combined impacts of the project and environmental baseline increase the risk of extinction of the DPS."

COMMENT

The negative implication that the lower Yuba River is a "population sink" for green sturgeon in the above text is unsupported by any technical analyses and in fact, is contradictory to other literature authored by NMFS on the Southern DPS of North American green sturgeon. For example, NMFS' Final Biological Report on the Designation of Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon (NMFS 2009a, page 50) states "*…although the Yuba River is part of the Sacramento River drainage basin, it is separated spatially from the current, single spawning population on the Sacramento River such that if a catastrophic mortality event were to occur in the Sacramento River, a Yuba River population could safeguard the species from extinction…"*.

Also, page 206 of the Final BO states *"Recovery planning for green sturgeon recognizes that expanding the current range of spawning and reproduction to areas beyond the Sacramento River will be necessary to recover the species"*. This statement seems to be contradictory to the statement on page 205 of the Final BO.

FINAL BO STATEMENTS

- ☐ **Page 209** – "*The spawning, rearing, and foraging conditions in the Yuba River are too poor and degraded to support productivity of the* [green sturgeon] *DPS.*"

☐ **Page 209 –** *"The poor condition of critical habitat on the Yuba River, combined with the very low green sturgeon population numbers indicates that this population is experiencing depensation and may be a population sink."*

COMMENT

As illustrated by the foregoing examples, the Final BO includes unsupported, conclusionary statements regarding the quality of aquatic habitat conditions in the lower Yuba River that may be used by green sturgeon, and resultant effects on the productivity of green sturgeon.

The Final BO does not indicate what analyses was conducted by NMFS that serves as the basis for these conclusions regarding flow and water temperature effects to green sturgeon, as well as the implication that the population is experiencing depensation and may be a population sink.

Additionally, the impact assessment presented in the Yuba Accord Draft EIR/EIS evaluated potential flow and water temperature effects on green sturgeon. The Yuba Accord Draft EIR/EIS is listed as a reference on page 298 of the Final BO. Clarification should be provided by referring to the analyses conducted for green sturgeon in the Yuba Accord Draft EIR/EIS and Chapter 8 of the Corps BA.

FINAL BO STATEMENT (Pages 214 and 215)

"*Poor fish passage at Daguerre Point Dam is another stressor, through delay of spring-run Chinook and steelhead, blockage of green sturgeon, and likely increased predation for downstream migrating juveniles. The continued operation of Englebright Dam has resulted in decreased productivity of spawning and rearing through interruption of ecosystem processes."*

COMMENT

Statements such as these are contradictory to other sections of the Final BO, as shown in the following example located on page 143 of the Final BO.

> "*The lack of information on green sturgeon utilization of the Yuba River makes it difficult to determine how this blockage might affect green sturgeon abundance, productivity, spatial structure and genetic diversity, but there is the potential that all of these viability factors could be improved if green sturgeon had access to the areas upstream of Daguerre Point Dam."*

FINAL BO STATEMENT (Page 243)

"*It is likely that Yuba River historically provided optimal spawning habitat for green sturgeon in areas both upstream of the dams and where reservoirs are today.*"

COMMENT

See previous comments regarding the lack of information regarding historical distribution and habitat utilization of green sturgeon in the lower Yuba River.

6.0 Effects of the Proposed Action on Listed Species and Critical Habitat

Many of the following comments are prepared in response to statements in the Final BO that attribute ongoing effects of the existence of Englebright Dam to the Proposed Action. This approach in the Final BO is contradictory to that which was described in the Corps BA.

FINAL BO STATEMENT (Page 166)

"*The purpose of the project is to maintain and perpetuate the existence of the Daguerre Point Dam with impaired fish passage (and no passage for green sturgeon) and Englebright Dam without fish passage. These dams are the primary drivers of baseline conditions that have resulted in the Yuba River populations of spring-run Chinook salmon, Central valley steelhead, and green sturgeon to be in the condition they are in today. Migration blockage and impairment, little to no access to refugia, high predation, extraordinarily poor conditions for reproduction, and a depauperate food web are all mortality factors resulting in low viability and high risk of local extinction of these species.*"

COMMENT

These statements concluding "*low viability and high risk of local extinction of these species*", presented as the conclusive statement of the effects analysis of the Proposed Action, are illustrative examples of the deviation from the stated methodology in the Final BO regarding viability and extinction risk assessment of the lower Yuba River populations.

According to NMFS' own stated effects assessment approach, viability and extinction risk assessment should not be based upon recitation of a suite of stressors. Rather, such assessments should incorporate evaluation of the four VSP parameters for an ESU/DPS, and specifically follow the extinction risk assessment methodology provided by Lindley et al. (2007) for the lower Yuba River populations.

Moreover, the assertions of "effect" in these statements are not supported in the Final BO by data analyses, and inappropriately conclude adverse conditions without supporting analyses or documentation. For example, the Final BO:

- ☐ Does not present conclusive evidence regarding predation rates.

- ☐ By contrast to the statement in the Final BO "*extraordinarily poor conditions for reproduction*", the Yuba Accord EIR/EIS, the Corps BA and other previously referenced documentation demonstrate that not only is there an abundance of spawning habitat for anadromous salmonids in the lower Yuba River, there also are numerous pools downstream of Daguerre Point Dam which could serve as green sturgeon spawning habitat.
- ☐ The statement "*little to no access to refugia*" is unclear. If the statement is in reference to coldwater refugia, then it has been clearly demonstrated in this document, and technically documented in the Yuba Accord EIR/EIS, RMT (2010) Water Temperature Objectives Memorandum, and the Corps BA, that water temperatures in the lower Yuba River are suitable for all lifestages of anadromous salmonids and green sturgeon. If the statement is in reference to predator escape refugia, then the Final BO did not present credible studies or analyses supporting the statement. By contrast, this statement is refuted by recent technical evaluations of the lower Yuba River (see Dr. Pasternack's comments on the Final BO).
- ☐ The statement regarding "*a depauperate food web*" is not supported in the Final BO. [NOTE: The Draft BO contained reference to a single anectdotal observation reporting a suspected macroinvertebrate mortality event. Comments on the Draft BO were provided to NMFS regarding the lack of substantiation, and that discussion appears to have been removed for the Final BO. However, the Final BO still includes several references (e.g., pages 175, 183, 184, 189, 205) alluding to a macroinvertebrate "die-off" occurring in the lower Yuba River, which should be removed and related conclusions revised appropriately.]

FINAL BO STATEMENT (Pages 167 and 168)

"Life stage-specific responses to specific stressors related to the proposed action are summarized in the last two columns of Tables VI-a, VI-b, and VI-c…"

COMMENT

Review of the Final BO demonstrates that not only does the Final BO not contain Tables VI-a, VI-b and VI-c, but no other tables in the Final BO provide the information referred to in this statement. Clarification and/or editorial revision is necessary.

6.1 Spring-Run Chinook Salmon

Previously presented comments on the Final BO that addressed technical issues that also arise in Chapter 5 of the Final BO – "Effects of the Action on Listed Species" are not repeated in this section of the technical review. Comments on statements in the Final BO regarding spring-run Chinook salmon that are unique to this chapter are presented below. Also, statements in Chapter

5 of the Final BO that address spring-run Chinook salmon and other species (e.g., steelhead and green sturgeon) are addressed below.

6.1.1 Lifestage-specific Effects of the Action

6.1.1.1 Adult Immigration and Holding

FINAL BO STATEMENT (Page 168)

"The purpose of the proposed action is to maintain Englebright Dam, and the proposed action does not provide access to suitable, historical habitat upstream of the dam that is important for the survival of the Yuba River populations of spring-run Chinook salmon and Central Valley steelhead."

COMMENT

This statement regarding the purpose of the Proposed Action is incomplete. As stated in the Corps BA (pages 3-1 and 3-3), the Proposed Action includes the Corps' continued operation and maintenance of Englebright and Daguerre Point dams on the lower Yuba River, and recreational facilities on and around Englebright Reservoir. Operations also include the issuance and administration of new and existing permits, licenses and easements. The Corps' responsibilities associated with ongoing maintenance of Englebright Dam infrastructure pertain to dam maintenance, safety and security. As presented in the Corps BA, the existence and ongoing effects of Englebright Dam are part of the Environmental Baseline, and are not attributable to the Proposed Action. Therefore, passage of anadromous salmonids above Englebright Dam was not proposed in the Corps BA as part of the Proposed Action.

FINAL BO STATEMENT (Page 168)

"*Migration barriers and false attraction flows constitute a very high risk to ability* [sic] *of spring-run Chinook salmon, Central Valley steelhead, and green sturgeon populations to survive in the Yuba River.*"

COMMENT

First, the statement that migration barriers (presumably Englebright Dam, which is the only complete barrier to anadromous salmonid passage) constitute a very high risk to the survival of anadromous salmonids in the lower Yuba River is an over-statement. The lower Yuba River continues to support persistent populations of anadromous salmonids, although Englebright Dam has been in place since 1941.

Second, the statement in the Final BO regarding green sturgeon is unsupported and contradictory to statements elsewhere in the Final BO. The Final BO (page 143) states "…*The lack of* *information on green sturgeon utilization of the Yuba River makes it difficult to determine how this* [Daguerre Point Dam] *blockage might affect green sturgeon…"*. Further, the Final BO does not present any analysis or referenced citations regarding attraction flows and the relative distribution of green sturgeon among the lower Yuba River and lower Feather River.

FINAL BO STATEMENT (Page 169)

"The purpose and effect of the proposed action is to maintain Daguerre Point Dam into the future, and the proposed action will only partial remediate effects of the dam. Daguerre Point Dam presents stressors from the proposed action and from the continuation of baseline conditions."

COMMENT

This statement in the Final BO appropriately acknowledges that Daguerre Point Dam presents stressors from the continuation of baseline conditons. The Corps operations and maintenance activities at Daguerre Point Dam, as described in the Corps BA, are intended to alleviate stressors associated with Daguerre Point Dam. However, the effects assessment in the Final BO does not clearly separate effects of the Proposed Action from the ongoing effects of the Environmental Baseline.

FINAL BO STATEMENT (Page 169)

"Migration blockage and impairment during high and low flows, fish ladder operations that cannot overcome design deficiencies, inconsistent fish ladder maintenance, fall-back over the dam after exiting the fish ladder, dam design that leads to spring-run Chinook and Central Valley steelhead jumping into the dam apron all contribute to reduced individual survivorship and fitness of spring-run Chinook salmon and Central Valley steelhead. Flashboard placement, new ladder gate operations, and improved maintenance reduces the structural stressors from the dam, but inconsistent maintenance, directly and indirectly affects individual survival and fitness of spring-run Chinook salmon and Central Valley steelhead."

COMMENT

This statement in the Final BO acknowledges that inconsistent maintenance at Daguerre Point Dam could affect individual survival and fitness of spring-run Chinook salmon and Central Valley steelhead. As stated in the Corps BA, implementation of the protective measures included in the Proposed Action as components of the Daguerre Point Dam Flashboard Management Plan, the Fish Ladder Debris Monitoring and Operations Plan, and the Daguerre Point Dam Sediment Management Plan, in conjunction with minor modification of the fish passage facilities (e.g., fish ladder bay grate installation) improve the individual survival and fitness of spring-run Chinook salmon and steelhead in the lower Yuba River, relative to the Environmental Baseline.

FINAL BO STATEMENT (Page 171)

"The proposed action does not include a firm commitment to inspect the channel after a "high flow event."

COMMENT

This statement does not appear to be technically correct. The Proposed Action in the Corps BA (page 3-24) included a Fish Ladder Debris Monitoring and Operations Plan. That plan incorporated Interim Measure Nos. 3 and 4 in the Interim Remedy Order issued by the Court on July 25, 2011 that stated that the Corps is to conduct weekly manual inspections of the ladders for surface and subsurface debris during routine flows during the interim period until a new biological opinion is prepared by NMFS. During flows of 4,200 cfs or greater, the Corps is to conduct daily manual inspections. Upon discovering debris in the ladders, the Corps is required to remove it within twelve hours, even if the Corps determines that flow levels are adequate for fish passage. If conditions do not allow for safe immediate removal of the debris, the Corps must remove the debris within twelve hours after flows have returned to safe levels. The Proposed Action also stated that through coordination with CDFG and NMFS, the Corps will develop a protocol for clearing accumulated debris and blockages in the fish ladders at Daguerre Point Dam.

FINAL BO STATEMENT (Page 171)

"Impaired passage from inadequate or inconsistent fish ladder operations and management will force migrating spring-run Chinook salmon to spawn in sub-optimal habitat downstream of Daguerre Point Dam. This is likely to result in reproductive failure of spawning pairs through increased competition for spawning sites and increased superimposition with fall-run Chinook salmon…"

COMMENT

There are several issues associated with these statements.

First, spring-run Chinook salmon will not be "forced" to spawn downstream of Daguerre Point Dam. The Final BO (page 169 and 170) states that the Corps has not consistently maintained the fish ladders at Dagurre Point Dam. However, this baseline condition has not resulted in a lack of spawning upstream of Daguerre Point Dam. As stated in the Corps BA (pages 5-16 and 5-17) "*…the earliest spawning (presumed to be spring-run Chinook salmon) generally occurs in the upper reaches of the highest quality spawning habitat (i.e., below the Narrows pool) and progressively moves downstream throughout the fall-run Chinook salmon spawning season (NMFS 2007). Spring-run Chinook salmon spawning in the lower Yuba River is believed to occur upstream of Daguerre Point Dam. USFWS (2007) collected data from 168 Chinook salmon redds in the lower Yuba River on September 16-17, 2002 and September 23-26, 2002, considered to be spring-run Chinook salmon redds. The redds were all located above Daguerre*

Point Dam. During the pilot redd survey conducted from the fall of 2008 through spring of 2009, the Yuba Accord RMT (2010a) report that the vast majority (96%) of fresh Chinook salmon redds constructed by the first week of October 2008, potentially representing spring-run Chinook salmon, were observed upstream of Daguerre Point Dam."

The Corps BA (page 8-19) also states "*…during the extensive pilot redd survey conducted during 2008-2009 (RMT 2010a), 33% of all Chinook salmon redds were observed by the first week of October, compared with 37% of all Chinook salmon redds observed by the first week of October during the redd surveys conducted in 2009-2010 (Campos and Massa 2010). Moreover, 74% of all Chinook salmon redds were observed upstream of Daguerre Point Dam during the extensive pilot redd survey conducted during 2008-2009, and the same exact percentage (74%) of all Chinook salmon redds were observed upstream of Daguerre Point Dam during the redd surveys conducted in 2009-2010. The similar distribution in timing and the same percentage distribution of Chinook salmon redds located upstream of Daguerre Point Dam occurred despite considerable differences in flow (monthly average cfs) that occurred from late spring into fall of 2008 compared to flow during 2009.*"

Second, the contention that spawning habitat downstream of Daguerre Point Dam is "sub-optimal" is not supported by any analyses or referenced citations in the Final BO. To the contrary, the Corps BA, the Yuba Accord EIR/EIS, and RMT studies have demonstrated the suitability of spawning habitat downstream of Daguerre Point Dam.

Third, the speculation of reproductive failure "*…through increased competition for spawning sites and increased superimposition with fall-run Chinook salmon…*" is not supported by any analyses or referenced citations in the Final BO.

FINAL BO STATEMENT (Page 172)

"Lack of free passage at the Daguerre Point Dam fish ladders leads to injury, delayed migration, and/or pre-spawning mortality. Delays resulting from adult spring-run Chinook salmon adult passage impediments are likely to weaken fish by requiring additional use of fat stores prior to spawning, and could potentially result in reduced spawning success (i.e., production) from reduced resistance to disease, increased pre-spawning mortality, and reduced egg viability."

COMMENT

These statements in the Final BO concluding biological effects associated with fish passage issues at Daguerre Point Dam are not supported by studies or literature referenced in the BO, and do not consider information and analyses presented in the Corps BA describing and evaluating potential effects of Daguerre Point Dam and fish passage issues. The Corps BA (pages 6-48 to 6-51, and 8-19 to 8-21) provides a thorough discussion of the potential biological effects on anadromous salmonids associated with fish passage issues at Daguerre Point Dam. As an example, an excerpt is provided below.

The Corps BA (pages 8-20 and 8-21) states "*Adult prespawning acute or latent mortality also could occur due to exposure to elevated water temperatures, which could also affect egg viability. The RMT (2010b) included evaluation of water temperatures at Daguerre Point Dam during the spring-run Chinook salmon adult upstream immigration and holding lifestage, which addressed considerations regarding both water temperature effects to pre-spawning adults and egg viability. They concluded that during this lifestage, characterized as extending from April through August, water temperatures at Daguerre Point Dam are suitable and remain below the lowest water temperature index value of 60°F at least 97% of the time over all water year types during these months. Thus, it is unlikely that this represents a significant source of mortality to spring-run Chinook salmon.*"

Moreover, a figure depicting actual data monitored since the Yuba Accord has been implemented (October 2006 to May 2010) was provided to NMFS as a comment on the Draft BO. That figure demonstrated that water temperatures at Daguerre Point Dam actually remained at about or below 60°F during the April through August period each of the three years.

FINAL BO STATEMENT (Page 191)

"*…the Narrows I and Narrows II powerhouses provide false attraction flows that disrupt Yuba River spring-run Chinook salmon and Central Valley steelhead migration...*"

COMMENT

First, this statement in the Final BO is based upon reported observations of Chinook salmon congregated near the Narrows II outlet. The Final BO does not provide evidence that "false attraction flows" lure adult spring-run Chinook salmon into the powerhouse outlet, nor does the Final BO address the frequency of occurrence of such a phenomenon. Moreover, Narrows II is designed to operate at up to 3,400 cfs, a flow rate associated with high velocity discharges that likely exceed suitable holding conditions for adult Chinook salmon.

Second, it is unclear what is meant by "*disrupt Yuba River spring-run Chinook salmon and Central Valley steelhead migration*" because the lower Yuba River only extends an additional 0.1 miles upstream of Narrows II to Englebright Dam, and that area does not provide suitable spawning habitat.

FINAL BO STATEMENT (Page 202)

"*The attraction flows presented by the Yuba River attract spring-run Chinook salmon from the Feather River.*"

COMMENT

This is a misleading statement, and does not reflect the extensive analyses presented in the Corps BA. The Corps BA (pages 5-79 to 5-82) thoroughly discusses the manner in which the available data extending from 2004 through 2010 were included in a regression analysis, which analyzed the relationship between the differences in weekly flows in the lower Yuba River and the lower Feather River, and the proportion of hatchery strays passing Daguerre Point Dam. The Corps BA found that the rate of straying of adipose fin-clipped spring-run Chinook salmon into the lower Yuba River (indicated by fish passing Daguerre Point Dam) during the spring-run adult Chinook salmon upstream migration period can be accounted for by the rate of lower Yuba River flow relative to the rate of lower Feather River flow. In other words, the rate of straying of adipose fin-clipped spring-run Chinook salmon into the lower Yuba River during the spring-run adult Chinook salmon upstream migration period may be associated with relatively high rates of flow in the lower Yuba River, or relatively low rates of flow in the lower Feather River.

FINAL BO STATEMENT (Page 175)

"The location and configuration of the Daguerre Point Dam fish ladders attract poachers. The existing design and configuration of the fish ladders also affects the holding behavior of migrating fish, exposing them to higher rates of poaching. The lower bays on the fish ladders at Daguerre Point Dam have not been covered, per recommendations from CDFG to reduce debris in the ladders during high flows; therefore, some level of poaching is likely to continue to occur. The biological assessment documented the ladder modifications in 2011, which are likely to have reduced this stressor. Poaching is likely to result in death to both Spring-run Chinook salmon..."

COMMENT

These statements are speculative and unsupported by information provided in the Final BO.

6.1.1.2 Spawning and Embryo Incubation

FINAL BO STATEMENT (Page 169)

"*Time spent by spring-run Chinook salmon and Central Valley steelhead attempting to enter project works will delay spawning. Delayed spawning is likely to force spring-run Chinook salmon and Central Valley steelhead to either spawn in suboptimal habitat near Englebright Dam, return downstream where they are not likely to find optimal spawning habitat or suitable mates, or remain in place and fail to spawn. Delayed spawning results in harm to individual spring-run Chinook salmon and Central Valley steelhead and a loss of genetic contribution to the populations. The Narrows I Powerhouse is a chronic, low-level stressor to Yuba River spring-run Chinook salmon and is likely to reduce the reproductive fitness of individual adult salmon that spend time attempting to migrate upstream through the project works. The Narrows II Project has greater attraction flow than the Narrows I Project; therefore, this is a chronic, medium-level stressor to Yuba River spring-run Chinook salmon that is likely to reduce the reproductive fitness of individual adult salmon that spend time attempting to migrate upstream through the project works."*

COMMENT

See previous comment.

FINAL BO STATEMENT (Page 176)

"The proposed action will continue to block spring-run Chinook salmon from access to 46.8 miles of suitable spawning habitat upstream of Englebright Dam …based on habitat availability modeled by Stillwater Sciences (2012)."

COMMENT

This statement in the Final BO is misleading. The quoted number of miles (46.8) of "suitable" spawning habitat is not correct. Spawning habitat consists of discrete patches of suitable substrate for spawning, and is not presented in terms of linear distance (miles). Review of Stillwater Sciences (2012) did report linear distances of entire sub-basins that would be thermally suitable for spawning, irrespective of substrate suitability. Review of Stillwater Sciences (2012) was unable to verify that even 46.8 miles of thermally suitable spring-run Chinook salmon spawning habitat is available upstream of Englebright Dam. Clarification, or correction, should be provided.

FINAL BO STATEMENT (Page 177)

"Lack of adequate spawning substrate presents a high risk to salmonids. The proposed action will continue to result in chronic spawning gravel deficiencies downstream from Englebright Dam."

COMMENT

The statement in the Final BO of "*lack of adequate spawning substrate*" and "*chronic spawning gravel deficiencies*" in the lower Yuba River are technically incorrect, and are not supported by analyses in the Final BO. By contrast, the Corps BA provides thorough discussion regarding spawning gravel and habitat availability in the lower Yuba River and, with the exception of the Englebright Dam Reach where gravel augmentation is continuing, the lower Yuba River contains an abundance of suitable spawning gravel and spawning habitat does not appear to be limited by an inadequate supply of gravel. Furthermore, see the attached comments by Dr. Pasternack.

FINAL BO STATEMENT (Page 179)

"The proposed action will ensure the impaired fish passage conditions that will perpetuate the baseline conditions that prevent and impair successful egg incubation and fry emergence of spring-run Chinook salmon and Central Valley steelhead."

COMMENT

It is unclear what baseline conditions are being refer to that allegedly "*prevent and impair successful egg incubation and fry emergence of spring-run Chinook salmon and Central Valley steelhead*". No explanation is provided in the Final BO. By contrast, this statement in the Final BO does not consider analyses and information presented in the Yuba Accord EIR/EIS, the Corps BA and the RMT (2010) documents that demonstrate the suitability of water temperatures for spawning and embryo incubation, including locations downstream of Daguerre Point Dam.

FINAL BO STATEMENT (Page 179)

"During low-flow years, spring-run Chinook salmon eggs downstream of Daguerre Point Dam are likely to be exposed to sub-optimal temperatures and increased disease rates."

COMMENT

This statement in the Final BO is technically incorrect, and does not consider analyses and information presented in the Yuba Accord EIR/EIS, the Corps BA and the RMT (2010) documents that demonstrate the suitability of water temperatures for spawning and embryo incubation, including locations downstream of Daguerre Point Dam.

FINAL BO STATEMENT (Page 180)

"Motorized land vehicles on spawning beds can have a deleterious effect on successful reproduction. BLM has seasonal closures to the affected areas where off-road vehicles enter the water; however, recreation and trespass on public lands can be difficult to control. Loss of spawning beds continues to be a threat to spring-run Chinook salmon and Central Valley steelhead adjacent to the Yuba Gold Fields."

COMMENT

The Final BO does not present any analyses or the results of surveys to estimate the magnitude of this potential stressor. Moreover, it is unclear how recreational vehicular activity on public lands is the result of the Proposed Action.

FINAL BO STATEMENT (Page 180)

"Stocking of hatchery trout is expected to have adverse effects on spring-run Chinook salmon through exposure to disease. …Even though listed salmonids are not currently found in Englebright Reservoir, flows from the reservoir to the river could expose the downstream spring-run Chinook salmon and Central Valley steelhead to disease, resulting in injury or death to eggs, larvae, and juvenile fish."

COMMENT

The Final BO does not present any analyses or the results of surveys to estimate the magnitude of this potential stressor. Moreover, it is unclear how stocking of hatchery trout in Englebright Reservoir is the result of the Proposed Action.

6.1.1.3 Juvenile Rearing

FINAL BO STATEMENTS

- ☐ **Page 184 –***"Recreational activities could introduce non-native species into the Yuba River. Recent threats in California are Quagga and zebra mussels, and New Zealand mud snails (CDFG 2008, CDFG 2011). If these non-native species become established in the Yuba River watershed, they would reduce the invertebrate prey of spring-run Chinook salmon... There is a moderate risk of mussels and mud snails entering the watershed, but a high risk to the fitness and reproductive capacity of spring-run Chinook salmon …if these organisms also enter the Yuba River watershed."*
- ☐ **Page 193 –** *"Lack of inspections of boats at Englebright Reservoir and no gear inspections at river accesses increases the threat of non-native invertebrates entering critical habitat on the lower Yuba River. Establishment New Zealand snails or quagga or zebra mussels could have catastrophic effects on the ability of the critical habitat to conserve spring-run Chinook salmon and Central Valley steelhead."*

COMMENT

The Final BO appropriately provides cautionary statements regarding the adverse effects associated with the introduction of non-native species. However, Table XI-a in the Final BO lists the key species stressors and associated short- and long-term actions in the RPA, and does not include introduction of non-native species at Englebright Reservoir.

6.1.1.4 Outmigration

FINAL BO STATEMENT (Pages 184 and 185)

"Outmigration mortality is estimated to be 55 percent of the annual outmigration of both the spring-run Chinook salmon and Central Valley steelhead at Daguerre Point Dam and the conjunctive use water diversions, based upon mortality calculations done on the RBDD (USFWS 1988)."

COMMENT

This statement in the Final BO is misleading and not supported by logical rationale. A thorough description of the inadequacy of this statement is presented in the comments later in this document in Section 8.6 – RPA Action No. 6, Predation and Predator Control Program.

FINAL BO STATEMENT (Pages 185 to 188)

Statements in the Final BO regarding the effects of the Hallwood-Cordua water diversion and the South Yuba/Brophy water diversion are addressed in comments on the cumulative effects in this document.

6.1.2 Effects of the Action on Critical Habitat

FINAL BO STATEMENT (Pages 178 and 179)

"Reduced flows downstream of Daguerre Point Dam, from water diversions, reduce the amount of available spawning and rearing habitat for spring-run Chinook salmon and Central Valley steelhead that do not pass upstream at the Daguerre Point Dam fish ladders. Although the downstream spawners are an unstudied part of the spring-run Chinook salmon and Central Valley steelhead populations, in years where there are maintenance problems on the fish ladders, downstream spawners represent a significant portion of the populations. Conditions downstream of Daguerre Point Dam are so inadequate for spring-run Chinook salmon and Central Valley steelhead that these fish are not likely to successfully contribute to the population."

COMMENT

These statements are an misrepresentation of anadromous salmonid spawning habitat conditions downstream of Daguerre Point Dam. Extensive discussion and disclosure of studies, analyses and results have been presented in previously completed documents that were available to NMFS at the time of preparation of the Final BO. A few examples of these documents include the Yuba Accord EIR/EIS, the RMT (2010) Water Tempeature Objectives Memorandum, the Corps BA and various RMT documents published on the public website - http://www.yubaaccordrmt.com. These statements warrant the following specific comments.

First, the statement that "*downstream spawners are an unstudied part of the spring-run Chinook salmon and Central Valley steelhead populations*" is not correct. The RMT has conducted Chinook salmon and steelhead redd surveys, including downstream of Daguerre Point Dam in the lower Yuba River, for the past four years. Related reports available on the RMT public website include: (1) 2008 Pilot Redd Survey Report; (2) Redd Report 2009-2010; (3) Redd Report 2010-2011.

Second, this statement is implying that there is a relationship between annual maintenance activities and the spatial distribution of spring-run Chinook salmon and steelhead spawning. No such relationship has been documented or presented in the Final BO, nor have any studies or reports been referenced that document such a relationship. Also, as presented in previous comments, the spatial distribution of Chinook salmon redds (upstream and downstream of Daguerre Point Dam) has been very similar during years of different flow conditions. The Corps BA (page 8-19) states "*…74% of all Chinook salmon redds were observed upstream of Daguerre Point Dam during the extensive pilot redd survey conducted during 2008-2009, and the same exact percentage (74%) of all Chinook salmon redds were observed upstream of Daguerre Point Dam during the redd surveys conducted in 2009-2010. The similar distribution in timing and the same percentage distribution of Chinook salmon redds located upstream of Daguerre Point Dam occurred despite considerable differences in flow (monthly average cfs) that occurred from late spring into fall of 2008 compared to flow during 2009.*"

Third, if "*downstream* [of Daguerre Point Dam] *spawners are an unstudied part of the spring-run Chinook salmon and Central Valley steelhead populations*", then how was it determined that "*downstream spawners represent a significant portion of the populations*"? Moreover, review of the Redd Survey Annual Reports demonstrated that 74%, 74%, and 81% of all Chinook salmon redds were located upstream of Daguerre Point Dam during 2008-2009, 2009-2010 and 2010-2011, respectively. Review of these reports also demonstrated that 65%, 93%, and 90% of all steelhead trout redds were located upstream of Daguerre Point Dam during 2008-2009, 2009-2010 and 2010-2011, respectively.

Fourth, the Final BO statement that "*Conditions downstream of Daguerre Point Dam are so inadequate for spring-run Chinook salmon and Central Valley steelhead that these fish are not likely to successfully contribute to the population*" is completely unfounded. All of the previous reference documents demonstrate the suitability of conditions downstream of Daguerre Point Dam.

FINAL BO STATEMENT (Page 152)

"Yuba County Water Agency is proposing to study effects of the fish screen at the existing Hallwood-Cordua diversion, to provide information for license renewal of the Narrows II Powerhouse in 2016. No studies are proposed for the effects of increase water deliveries through the South Yuba/Brophy diversion. If increased water deliveries lead to temperatures downstream of Daguerre Point Dam being over 55°F from December through March, both successful outmigration of spring-run Chinook salmon and attraction of green sturgeon for spawning will decline."

COMMENT

The statement on page 152 of the Final BO is not correct, is misleading and does not even reference the commitment made in the Corps BA to install a new screening diversion facility for the South Yuba/Brophy diversion by the year 2018.

As described in Chapter 3 of the Corps BA, and as a condition of the Corps' issuance of a long-term easement to YCWA (applicant), the Corps will require that YCWA construct, operate and maintain a fish screen and associated appurtenances for the South Yuba/Brophy diversion that is compliant with current NMFS and CDFG fish screening criteria or other criteria equally protective of the listed species acceptable to NMFS and CDFG prior to June 2018.

Second, potential impacts associated with the Wheatland Project were fully evaluated in the Yuba Accord EIR/EIS (YCWA et al. 2007), as described in Section 7.1.1.3 (pages 7-12 through 7-28). Supplemental analyses were conducted as part of the Cumulative Effects assessment in the Corps BA, and incorporated updated water demand projections (see previous comment on the Final BO statements. Additional information regarding the Wheatland Project was provided in Section 6.2.2.2 (pages 6-68 to 6-69) and Section 8.5.1.2 (pages 8-77 to 8-103) of the Corps BA.

Third, the statement that "*If increased water deliveries lead to temperatures downstream of Daguerre Point Dam being over 55°F from December through March, both successful outmigration of spring-run Chinook salmon and attraction of green sturgeon for spawning will decline*" is technically unsupported. As reported in Table 1 of the Lower Yuba River Water Temperature Objectives Technical Memorandum (RMT 2010), which was available to NMFS at the preparation of this Final BO, examination of water temperature model results over the period of record, including dry and critical years, 55°F would be exceeded with a 0% probability of occurrence from the Smartsville Gage in the upper section of the lower Yuba River all the way down to the Marysville Gage located approximately 5 miles upstream from the confluence of the lower Yuba River and the Feather River from December through March.

FINAL BO STATEMENT (Page 189)

"Critical habitat impacted by the proposed action includes the lower Yuba River and the Feather River from the confluence with the Yuba River to the confluence with the Sacramento River."

COMMENT

Review of the Final BO did not locate analyses demonstrating adverse affects to habitat in the lower Feather River from the confluence with the Yuba River to the confluence with the Sacramento River resulting from the Proposed Action.

FINAL BO STATEMENT (Pages 189 and 190)

"Critical habitat has been designated downstream of Englebright Dam, to include currently occupied areas. Extension of critical habitat upstream of Englebright Dam was deemed premature until recovery planning determines a need for these areas in the recovery of the spring-run Chinook salmon ESU …(September 2, 2005, 70 FR 190 52488)… Since the 2005 determination of critical habitat for spring-run Chinook salmon …draft recovery planning has identified habitat upstream of Englebright Dam as essential for the recovery of these species (NMFS 2009). The critical habitat designation has not been revised to reflect the outcome of recovery planning, so upstream habitat is not considered in this analysis."

COMMENT

The Final BO statement that habitats upstream of Englebright Dam are "*essential for the recovery of these species*" implicitly designates these reaches as critical habitats without any rulemaking proceeding, as required by ESA §4. In fact, according to the USFWS and NMFS ESA Consultation Handbook (1998), critical habitat for listed species consists *of "…specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of the Act, upon a determination by the Secretary that such areas are essential for the conservation of the species. [ESA §3 (5)(A)] Designated critical habitats are described in 50 CFR §17 and 226."*

FINAL BO STATEMENT (Page 190)

"Migratory habitat conditions for spring-run Chinook salmon and Central Valley steelhead are impaired by continuance of the proposed action."

COMMENT

This statement in the Final BO is not supported by any analyses or referenced citations, nor are migratory habitat conditions specifically characterized.

FINAL BO STATEMENT (Page 190)

"Daguerre Point dam limits the ability of the critical habitat to support spring-run Chinook salmon and Central Valley steelhead because they can be forced to spawn in unsuitable habitat downstream of Daguerre Point Dam or have reduced reproductive fitness resulting from migration delays while attempting to pass Daguerre Point Dam."

COMMENT

See the previous comments addressing the lack of supporting documentation regarding being "forced" to spawn downstream of Daguerre Point Dam, spawning conditions and reproductive fitness.

FINAL BO STATEMENT (Page 190)

"The winter temperature standard of 63 °F under the Yuba Accord is likely to result in reversal of smoltification of spring-run Chinook salmon and could result in a complete cohort-failure (Mesick pers. comm.). Any winter temperature standard above 55 °F does not contribute to the conservation of spring-run Chinook salmon."

COMMENT

As previously noted, these statements misrepresent the Yuba Accord, are technically incorrect, and do not support the conclusionary statement regarding conservation of species.

FINAL BO STATEMENT (Page 190)

"Under the proposed action, the freshwater migration corridors in the Yuba River will continue to be compromised by exposure of juvenile spring-run Chinook salmon and Central Valley steelhead to predator-rich diversion structures and dam features, incised channels that limit channel complexity, and water temperatures that may be physiologically lethal or sublethal."

COMMENT

These statements in the Final BO are not supported by technical analyses or referenced studies. Previous comments have addressed the lack of information supporting statements regarding the abundance of predators or predation rates in the lower Yuba River. Regarding the statement concluding channel incision, the attached comments by Dr. Pasternack actually include quantification and application of metrics that demonstrate that a general statement that the lower Yuba River channel is incised is not supported.

The Final BO statement that "*water temperatures that may be physiologically lethal or sublethal*" is unfounded. As previously noted, available evaluations and documents (e.g., Lower Yuba River Accord Draft EIR/EIS (YCWA et al. 2007), the Corps BA, and the Yuba Accord RMT's Lower Yuba River Water Temperature Objectives Technical Memorandum (RMT 2010)) have examined the effects of water temperature conditions resulting from implementation of the Yuba Accord on all of the lifestages of anadromous salmonids in the lower Yuba River, including juvenile outmigration, and found them to be suitable.

FINAL BO STATEMENT (Pages 190 and 191)

"Entrainment, impingement, and predation at the South Yuba/Brophy and Hallwood-Cordua diversions reduce the numbers of outmigrating juvenile spring-run Chinook salmon and outmigrating juvenile Central Valley steelhead by up to 229,800 individuals of each species annually…"

COMMENT

Comments regarding the inaccuracies associated with the estimates in the Final BO regarding entrainment, impingment and predation at the South Yuba/Brophy and Hallwood-Cordua diversions are presented below under Section 6.1.3 - Cumulative Effects. As noted in those comments, the estimation was for spring-run Chinook salmon only, and for the South Yuba/Brophy diversion only. It is unclear how that estimation of *"by up to 229,800 individuals"* (albeit technically incorrect) somehow also became applied to steelhead, and also became applied to the Hallwood-Cordua diversion, inclusive.

FINAL BO STATEMENT (Page 191)

"Interrelated and interdependent water deliver and hydropower actions lead to increases in Yuba River flows during the time period when Feather River flows are low. The "flow disconnect" between the Yuba and Feather rivers causes spring-run Chinook salmon from the Feather River to be preferentially attracted into the Yuba River. This results in migrating Feather River wild and hatchery spring-run Chinook salmon having reduced fitness, by exposing them to the poor reproductive conditions in the Yuba River, and it reduces the contribution of those individuals to the conservation of the ESU."

COMMENT

First, there is no "flow disconnect" between the Yuba and Feather rivers.

Second, spring-run Chinook salmon from the Feather River are not preferentially attracted into the Yuba River. Rather, as noted in previous comments, when lower Yuba River flows are low relative to the Feather River fish are not "attracted" into the lower Yuba River, and when flows in the lower Yuba River are high relative to the lower Feather River, an increased percentage of FRFH fish are attracted into the lower Yuba River.

Third, this statement alleges harm to Feather River wild and hatchery spring-run Chinook salmon that spawn in the lower Yuba River. This allegation is completely unsupported in the Final BO, and there is no documentation regarding "*poor reproductive conditions in the Yuba River"*. By contrast, as noted in previous comments, numerous previously prepared documents, available to NMFS at the time of preparation of the Final BO, demonstrated the suitability of conditions downstream of Daguerre Point Dam.

6.1.3 Cumulative Effects

Increased future diversions through the South Yuba/Brophy rock gabion associated with the Wheatland Project are characterized in the Final BO (page 196) as "*The total future projected annual agricultural water demand that could be served by the Wheatland Project is about 41,000 acre-feet."*

This characterization of increased future demands associated with the Wheatland Project is a remnant from NMFS (2007a). The Final BO did not use information provided in the Corps BA, which updated future demand characterizations, and was available to NMFS at the time of their preparation of the Final BO.

As described in the Corps BA (page 7-13) "*The 2007 NMFS BO characterized the Wheatland Project as part of the Cumulative Condition, with annual diversions of an additional 41,000 acre-feet more than the Environmental Baseline. Updated 2011 demand projections indicate that water deliveries to the Wheatland Project in the future are projected to increase up to about 35,000 to 36,000 acre-feet, depending on water year type, above the demands that were in place at the time that the 2007 NMFS BO was completed, as well as those demands presently in place under the Environmental Baseline*."

Following are comments on statements in the cumulative effects section of the Final BO that address increased levels of impingement and entrainment at the South Yuba/Brophy Diversion Facilities, and habitat conditions (i.e., flow and water temperature) expected to result from increased future diversions associated with the Wheatland Project. Supporting statements in other sections of the Final BO associated with these statements also are addressed below.

6.1.3.1 South Yuba/Brophy Facilities - Entrainment

FINAL BO STATEMENTS

- ☐ **Page 152 –** *"Water deliveries from the Daguerre Point Dam pool are expected to increase in the future. The historical and current conditions of entrainment and impingement are expected to increase."*
- ☐ **Page 187** – "*Outmigrating spring-run Chinook salmon and Central Valley steelhead that seek the cover of interstitial spaces along the rock weir are likely to be impinged within the weir and killed. Impingement at the South Yuba/Brophy rock weir is difficult to quantify, because the juvenile fish simply disappear into the gravel, so a metric is needed. Because mortality associated with fish screens has been studied, we used the established Hallwood-Cordua metric in this analysis."*
- ☐ **Page 197 – "***We therefore expect that the effects of stream flows associated with the Wheatland project lead to increased entrainment at the South Yuba-Brophy diversion that is expected to cause a reduction in survival of juvenile steelhead and spring-run Chinook salmon in the Yuba River."*
- ☐ **Page 197 –** "*The increase in diversion rates at the South Yuba-Brophy diversion associated with the proposed Wheatland project is likely to expose juvenile spring-run Chinook salmon to greater rates of predation and entrainment during the critical*

> *outmigration period. This potential increase in entrainment could be avoided if a fish screen meeting CDFG and NMFS screening criteria is installed."*

COMMENT

The Final BO includes these qualitative statements regarding potential increased impingement and entrainment, although a thorough quantitative discussion was provided in the Corps BA and was available at the time of preparation of the Final BO.

The Corps BA (pages 8-68 to 8-75) presents a thorough evaluation of the potential increased entrainment and impingement of outmigrant juvenile spring-run Chinook salmon and steelhead associated with future Wheatland Project increased diversions. The Corps BA includes an updated assessment of the potential exposure of juvenile spring-run Chinook salmon and steelhead to increased rates of impingement and entrainment at the South Yuba/Brophy diversion facilities, based upon expected monthly rates of diversion through the rock gabion and the temporal distribution of juveniles based on rotary screw trapping (RST) data from the lower Yuba River.

The expected annual total increase in impingement and entrainment of juvenile Chinook salmon is 0.2%, and the estimate for juvenile spring-run Chinook salmon would be less than the estimates presented for all juvenile Chinook salmon, because juvenile spring-run Chinook salmon have an earlier outmigration season. The expected annual total increase of juvenile steelhead susceptible to impingement and entrainment is 3.0%. These estimates pertain to 2018, when modification of the South Yuba/Brophy Diversion Canal and Facilities fish screen and appurtenant facilities would be completed to meet NMFS and CDFG approval of screening, or other criteria equally protective of anadromous salmonids acceptable to NMFS and CDFG. The Corps BA concluded that these temporary conditions would not be expected to be of a magnitude that would reduce appreciably the likelihood of both the survival and recovery of steelhead in the lower Yuba River.

FINAL BO STATEMENTS

- ☐ **Page 159 –** *"Given that the length of the rock weir at the South Yuba/Brophy Diversion is 2.52 times longer than the Hallwood-Cordua fish screen, and absent any site specific information at South Yuba/Brophy we applied information from the Hallwood-Cordua entrainment study to estimate that between 90,900 and 229,800 outmigrating juvenile spring-run Chinook salmon are entrained, impinged, or preyed upon at the South Yuba/Brophy Diversion annually."*
- ☐ **Page 185 –** *"…The 1999-2000 entrainment study by CDFG of the Hallwood-Cordua fish screen (IFC Jones and Stokes 2008) estimated that 36,144 and 91,113 O. mykiss were entrained in 1999 and 2000 respectively. To estimate entrainment, the study used spring-run Chinook salmon juveniles from the FRFH to test the screen mortality and make entrainment estimations using a Chinook salmon model from a similar facility in*

Washington State. Considering that the model used Chinook salmon numbers to calculate O. mykiss numbers, it is therefore an excellent model for estimating for both spring-run Chinook salmon and Central Valley steelhead entrainment estimates."

- ☐ **Page 186 –** "*Given that the length of the rock weir at the South Yuba/Brophy Diversion is 2.52 times longer than the Hallwood-Cordua fish screen, we estimate that between 90,900 and 229,800 outmigrating juvenile spring-run Chinook salmon and between 90,900 and 229,800 outmigrating juvenile Central Valley steelhead are likely to be entrained, impinged, or preyed upon at the South Yuba/Brophy Diversion annually*."
- ☐ **Pages 190 and 191 –**"*Entrainment, impingement, and predation at the South Yuba/Brophy and Hallwood-Cordua diversions reduce the numbers of outmigrating juvenile spring-run Chinook salmon and outmigrating juvenile Central Valley steelhead by up to 229,800 individuals of each species annually. Increased water deliveries during the winter migration period, as a result of the interrelated Wheatland Project, exposes additional outmigrating juvenile spring-run Chinook salmon to entrainment, impingement, and predation."*
- ☐ **Page 197 –**"*The increase in diversion rates at the South Yuba-Brophy diversion associated with the proposed Wheatland project is likely to expose juvenile spring-run Chinook salmon to greater rates of predation and entrainment during the critical outmigration period. This potential increase in entrainment could be avoided if a fish screen meeting CDFG and NMFS screening criteria is installed."*

COMMENT

There are numerous technical errors associated with these statements in the Final BO.

First, the Final BO refers to (incorrect) estimates of entrainment at the South Yuba/Brophy diversion of between 90,900 and 229,800 outmigrating juvenile spring-run Chinook salmon and steelhead. Thereafter, references in the Final BO regarding effects of the Proposed Action are to entrainment of 229,800 outmigrating juvenile spring-run Chinook salmon and steelhead, and no longer incorporate the lower end of the range.

Second, the basis for the estimates of between 90,900 and 229,800 outmigrating juvenile spring-run Chinook salmon and steelhead entrained at the South Yuba/Brophy Diversion is fundamentally flawed, technically incorrect, and is a misinterpretation of the actual study (ICF Jones and Stokes 2008) upon which the estimates were based.

The Final BO (page 185) states *"The 1999-2000 entrainment study by CDFG of the Hallwood-Cordua fish screen (IFC Jones and Stokes 2008) estimated that 36,144 and 91,113 O. mykiss were entrained in 1999 and 2000 respectively*. On page 159, the final BO states *"Given that the length of the rock weir at the South Yuba/Brophy Diversion is 2.52 times longer than the Hallwood-Cordua fish screen, and absent any site specific information at South Yuba/Brophy we applied information from the Hallwood-Cordua entrainment study to estimate that between*

90,900 and 229,800 outmigrating juvenile spring-run Chinook salmon are entrained, impinged, or preyed upon at the South Yuba/Brophy Diversion annually."

All numeric estimates in the above statements are incorrect, for the following reasons (see Section 9.6.1 for further discussion).

- The 1999-2000 CDFG entrainment study in the literature review conducted by ICF Jones and Stokes (2008) did not estimate that 36,144 and 91,113 *O. mykiss* were entrained in 1999 and 2000, as stated in the Final BO.
- The 1999-2000 CDFG study (ICF Jones and Stokes 2008) reported the numbers of juvenile *O. mykiss* that were "salvaged" at the Hallwood-Cordua fish screen, which represent the number of fish that encountered the screen but were redirected into a bypass pipe and returned to the lower Yuba River. Review of ICF Jones and Stokes (2008) did not result in locating any substantiation of the statement "*To estimate entrainment, the study used spring-run Chinook salmon juveniles from the FRFH to test the screen mortality and make entrainment estimations…"*.
- *O. mykiss* catch (i.e., "salvage") data at the Hallwood-Cordua screen was applied to regression equations developed for juvenile spring-run Chinook salmon entrainment rates at Prosser Dam located on the Yakima River, Washington. ICF Jones and Stokes (2008) used the regression equations to predict the total production (i.e., the total number of juvenile *O. mykiss* passing Daguerre Point Dam) based on entrainment rates (predicted by the percent of flow diverted into a canal relative to total river flow at Prosser Dam).
- Thus, the relatively low "salvage" numbers of *O. mykiss* at the Hallwood-Cordua fish screen were expanded by application of the regression equations (e.g., the estimated salvage during 2000 of 12,672 *O. mykiss* (Drury 2001) became an estimate of 91,113 *O. mykiss*).
- However, the estimate of 91,113 *O. mykiss* was not of entrained fish as stated in the Final BO. Rather, that estimate was of total production in the lower Yuba River passing Daguerre Point Dam.
- Thus, the Final BO misinterpreted the hypothetical total production (i.e., total number of juveniles) of *O. mykiss* passing Daguerre Point Dam as estimates of the total number entrained at the Hallwood-Cordua fish screen.
- Then, the Final BO used this incorrect misinterpretation of "entrainment" of *O. mykiss*, applied it to juvenile spring-run Chinook salmon, and stated that these numbers (actually representing total production) would be "*lost*".
- Finally, the Final BO stated that because the length of the rock weir at the South Yuba/Brophy Diversion is 2.52 times longer than the Hallwood-Cordua fish screen, and because no site-specific information was available for the South Yuba/Brophy Diversion, the (incorrectly) estimated entrainment numbers of 36,144 and 91,113 were multiplied by

2.52 to estimate that between 90,900 (36,144 X 2.52 = 90,900 [sic]) and 229,800 (91,113 X 2.52 = 229,800 [sic]) outmigrating juvenile spring-run Chinook salmon are entrained, impinged, "or preyed upon" at the South Yuba/Brophy Diversion annually. In addition to the technical inaccuracies identified in the foregoing comments, simple multiplication of screen length represents another technical inaccuracy because the length of the screen does not represent: (1) entrainment rates into an off-channel diversion structure; (2) rates of impingement, which are actually associated with approach and sweeping velocities; and (3) predation rates.

☐ Additionally, it should be noted that the phrase "or preyed upon" in this statement of the Final BO does not make sense given that the subject matter was entrainment.

☐ The statement that *"Considering that <u>the model used Chinook salmon numbers to calculate O. mykiss numbers, it is therefore an excellent model</u> for estimating for both spring-run Chinook salmon and Central Valley steelhead entrainment estimates."* is of particularly poignant interest, for the following reasons: (1) Chinook salmon "numbers" were not used to calculate *O. mykiss* entrainment. Rather, *O. mykiss* salvage estimates were applied to juvenile Chinook salmon-based regression relationships in order to estimate *O. mykiss* abundance; (2) the conclusion that "*…it is therefore an excellent model for… entrainment estimates*" appears to be based on a misunderstanding of what was actually used, and a further misunderstanding assuming that the regressions are predictors of entrainment, when they actually were used to predict total production passing a point and not entrainment; and (3) the conclusion of "an excellent model" appears to be entirely subjective, and not based on any actual evaluation of model performance (e.g., a residuals analysis of the differences between expected and observed estimations).

<u>**FINAL BO STATEMENT** (Pages 190 and 191)</u>

"Entrainment, impingement, and predation at the South Yuba/Brophy and Hallwood-Cordua diversions reduce the numbers of outmigrating juvenile spring-run Chinook salmon and outmigrating juvenile Central Valley steelhead by up to 229,800 individuals of each species annually. Increased water deliveries during the winter migration period, as a result of the interrelated Wheatland Project, exposes additional outmigrating juvenile spring-run Chinook salmon to entrainment, impingement, and predation. The Wheatland Project could result in the <u>cumulative loss of up to 321,720 outmigrating spring-run Chinook salmon</u> at the South Yuba/ Brophy diversion annually."

COMMENT

On page 151 of the February 27, 2012 Draft BO, the statement was made that "…*The changes in flow levels associated with implementation of the Wheatland project may be of sufficient magnitude, timing, or duration to adversely affect critical habitat and listed salmonids in the* *lower Yuba River. Limiting lower Yuba River flows to minimum Yuba Accord flows will it cause a net reduction in the quality of critical habitat within the Yuba River. The expected 40 percent increase in entrainment at the South Yuba/Brophy diversion is expected to cause a reduction in survival of juvenile steelhead and spring-run Chinook salmon in the Yuba River."*

On February 28, 2012, the Corps provided comments on the Draft BO. The comments included the following statement – "*Because the statement regarding an "expected 40 percent increase in entrainment at the South Yuba/Brophy diversion is expected to cause a reduction in survival of juvenile steelhead and spring-run Chinook salmon in the Yuba River" in the Draft BiOp was taken directly from the 2007 NMFS BiOp, it does not appear that NMFS considered new information and new analyses regarding Wheatland diversions presented in the Corps 2012 BA. The assumption that there would be an expected 40 percent increase in entrainment is not substantiated, pursuant to Chapter 8 of the BA, which was available to NMFS at the time of preparation of the Draft BiOp."*

The Final BO removed reference to a *"expected 40 percent increase in entrainment at the South Yuba/Brophy diversion"*. Therefore, it is curious why the Final BO removed the words, but used a 40 percent increase to the Final BO's (incorrectly) estimated present amount of entrainment at the South Yuba/Brophy diversion (229,800 fish X 1.4 = 321,720 fish).

FINAL BO STATEMENT (Page 187)

"Outmigrating spring-run Chinook salmon and Central Valley steelhead that seek the cover of interstitial spaces along the [South Yuba/Brophy] *rock weir are likely to be impinged within the weir and killed."*

COMMENT

This statement is not supported by any analyses or referenced studies in the Final BO. By contrast, the Corps BA (page 6-67) states "*On July 8, 2004, representatives of CDFG and NMFS made a series of water velocity measurements along the face of the permeable rock gabion that separates the lower Yuba River from the headgates for the South Yuba/Brophy diversion. The purpose of the flow measurements was to characterize the flow conditions along the upstream face of the rock gabion. The flow along the upstream face of the rock gabion appeared to be irregular and complex in all three components of the velocity measurements (NAFWB 2004). According to NAFWB (2004), this was probably due to roughness of the gravel/cobble surface, irregularities in the rock gabion profile, differences in the permeability along the length of the rock gabion, and variations in the plugging of the upstream face of the rock gabion. Approach velocities varied from -0.054 fps to 0.686 fps with mean velocity of 0.052 fps. One approach velocity measurement exceeded 0.33 fps. Sweeping velocities varied from -0.167 fps to 1.034 fps with mean velocity of 0.260 fps. Two sweeping velocity measurements exceeded 0.67 fps. The head loss across the rock gabion was approximately 0.9 feet on the day of the measurements (NAFWB 2004).*"

Further examination of NAFWB (2004) describing the field data collection at the South Yuba/Brophy rock gabion structure, in which NMFS participated, demonstrates that of the 32 approach velocity measurements taken, only one exceeded the NMFS and CDFG screening criterion approach velocity of 0.33 fps. This approach velocity criterion is intended to protect juvenile salmonids from impingement or entrainment at fish screens. Given the information provided in the Corps BA, and that only one of 32 approach velocity measurements exceeded the NMFS and CDFG criterion, it does not seem appropriate for the Final BO to state "*Outmigrating spring-run Chinook salmon and Central Valley steelhead that seek the cover of interstitial spaces along the* [South Yuba/Brophy] *rock weir <u>are likely to be impinged within the weir and killed</u>.*"

6.1.3.2 Wheatland Project

<u>**FINAL BO STATEMENTS**</u>

- ☐ **Page 148 –** "*The changes in flow levels associated with implementation of the Wheatland project is expected to be of sufficient magnitude, timing, or duration to adversely affect the survival of juvenile steelhead and spring-run Chinook salmon and the conservation value of certain critical habitat primary constituent elements (i.e., freshwater rearing and migration habitat).*"
- ☐ **Page 148 –** "*Increased water exports lead to a reduction in flows within the mainstem of the river, and reduction in flows exacerbates the impacts of inadequate water depth, lack of access to the floodplain.*"
- ☐ **Page 187 –** "*Water diversion at the South Yuba/Brophy Diversion removes water from the Yuba River that would otherwise be utilized by spring-run Chinook salmon for basic life history behavior. Water diversions at Daguerre Point Dam reduce the amount of downstream outmigration habitat available for spring-run Chinook salmon and Central Valley steelhead.*"
- ☐ **Page 191** – "*Increased water deliveries during the winter migration period, as a result of the interrelated Wheatland Project… would also result in lower outmigration flows downstream of Daguerre Point Dam.*"
- ☐ **Page 193 –** "*The changes in flow levels associated with implementation of the interrelated Wheatland project are of sufficient magnitude, timing, or duration to adversely affect freshwater rearing habitat for spring-run Chinook salmon and Central Valley steelhead in the lower Yuba River down to the confluence of the Feather River with the Sacramento River. The changes in flow levels associated with implementation of the Wheatland project is expected to be of sufficient magnitude, timing, or duration to adversely affect the survival of juvenile steelhead and spring-run Chinook salmon*"

- ☐ **Page 196 –**“*The Wheatland Project is expected increase water diversions from the Yuba River and to increase the level of impacts to listed salmonids associated with increased exposure to the South Yuba/Brophy diversion. Results of model simulations for changes in flows in the lower Yuba River for the reach from Englebright Dam to Daguerre Point Dam show that during many summer months, flows would be higher with the Wheatland Project due to increased storage releases from Englebright Reservoir for the additional irrigation diversion deliveries downstream. Flows throughout the river during the winter would be somewhat lower with the Wheatland Project during some occasions. This reduction in flows would occur because of delay or reduction in spill amounts caused by lower storage levels, which, in turn, are the result of increased summer releases (YCWA 2002).*”
- ☐ **Page 196 –**“*The new flow levels associated with the Wheatland project are expected to be of sufficient magnitude, timing, or duration to adversely affect critical habitat and listed salmonids in the lower Yuba River.*”

COMMENT

These statements regarding the potential impacts on habitat conditions in the lower Yuba River associated with increased future diversions resulting from implementation of the Wheatland Project are qualitative and are not supported by any data analyses or referenced studies in the Final BO. Nonetheless, the Final BO contains speculative results that the Wheatland Project would result in flows that “*are expected to be of sufficient magnitude, timing, or duration to adversely affect critical habitat and listed salmonids in the lower Yuba River.*” The Final BO, however, does not provide any information actually addressing or evaluating the “*magnitude, timing, or duration*” of flows. The only reference to an evaluation is a statement on page 196 of the Final BO referring to model output. However, that statement appears to be copied directly from the 2007 NMFS BO which itself was referencing modeling conducted in 2002.

By contrast, updated flow and water temperature modeling was conducted for the Corps BA. The Corps BA provided a detailed evaluation and analyses of flow and water temperature conditions, both upstream and downstream of Daguerre Point Dam, anticipated to occur as a result from future implementation of the Wheatland Project. This evaluation in the Corps BA encompassed 36 pages (pages 8-68 to 8-103), and included Appendix C of the Corps BA, which itself encompassed 172 pages describing the modeling that was conducted and presentation of model output. The Corps BA included lifestage-by-lifestage analyses and evaluations for both flow and water temperature, separately for spring-run Chinook salmon and steelhead, associated with future diversions for the Wheatland Project in the lower Yuba River. Separate analyses were conducted for green sturgeon. Based on these detailed, quantitative evaluations, the Corps BA concluded that future implementation of the Wheatland Project would not result in substantive impacts affecting any of the spring-run Chinook salmon, steelhead, or green sturgeon lifestages in the lower Yuba River.

6.1.4 Integration and Synthesis

The integration and synthesis section of the Final BO, for both spring-run Chinook salmon and steelhead, is intended to consider the effects of the Proposed Action in concert with the status of the species and their habitats resulting from the Environmental Baseline. However, the Final BO does not distinguish between ongoing effects of the existence of Englebright and Daguerre Point dams, and potential effects specifically attributable to the Proposed Action. In fact, numerous statements in the Final BO attribute ongoing effects of the existence of Englebright Dam to the Proposed Action. This approach in the Final BO is contradictory to that which was described in the Corps BA.

Regarding viability of the lower Yuba River populations of spring-run Chinook salmon and steelhead, as previously noted, the Final BO deviates from its stated methodology regarding extinction risk assessment of the lower Yuba River salmonid populations. The extinction risk conclusions are apparently based upon a list of stressors, not upon the extinction risk criteria and analyses specified by Lindley et al. (2007). Moreover, the reoccurring alliteration of potential stressors contains technical inaccurracies, and inference of adverse effects that are not supported by studies or references, in support of conclusionary statements of "high extinction risk".

The Final BO (page 202) states that "*Without any recovery actions to stabilize the Yuba River population and allow it to contribute to the recovery of the species, both the survival and recovery of the species are measurably diminished by the proposed action*." However, review of the Final BO did not indicate any integration and/or synthesis of quantitative estimation or measurement of diminishment attributable to the Proposed Action.

The Final BO (page 203) states "*The proposed action needs to provide adequate potential for recovery, or recovery is appreciably reduced*." The interpretation of this statement is unclear. Moreover, the Proposed Action does not "appreciably reduce" potential for recovery. By contrast, the Proposed Action including the conservation measures clearly described in the Corps BA, increase the potential for recovery relative to the Environmental Baseline.

6.2 Steelhead

Many of the comments addressing effects of the Proposed Action, cumulative effects and integration and synthesis of effects previously presented either address spring-run Chinook salmon and steelhead, or are redundant as specifically applied to steelhead. Thus, previous comments that are pertinent to steelhead are not repeated in this section of comments on the Final BO. Comments on statements that are unique to steelhead, or that substantially differ regarding steelhead, are addressed below.

6.2.1 Effects of the Action

FINAL BO STATEMENT (Page 176)

"The proposed action will continue to …block Central Valley steelhead from 143.2 miles of suitable spawning habitat upstream of Englebright Dam, based on habitat availability modeled by Stillwater Sciences (2012)."

COMMENT

This statement in the Final BO is misleading. The quoted number of miles (143.2) of "suitable" spawning habitat is not correct. Spawning habitat consists of discrete patches of suitable substrate for spawning, and is not presented in terms of linear distance (miles). Review of Stillwater Sciences (2012) did report linear distances of entire sub-basins that would be thermally suitable for spawning, irrespective of substrate suitability. Review of Stillwater Sciences (2012) was unable to verify that 143.2 miles of thermally suitable steelhead spawning habitat is available upstream of Englebright Dam. However, using the "relaxed" water temperature criteria for juvenile steelhead rearing in the South Yuba River (25.2°C) and Middle Yuba River (23.2°C), a modeled total linear distance of 143.7 miles was calculated. Clarification, or correction, of the statements in the Final BO should be provided.

6.3 Green Sturgeon

6.3.1 Lifestage-Specific Effects of the Action

6.3.1.1 Adult Immigration

FINAL BO STATEMENT (Page 173)

"Green sturgeon are exposed to low flow conditions in the lower Yuba River as a result of water exports that are a conjunctive use at Daguerre Point Dam. Water removed from the aquatic ecosystem, from interrelated and interdependent actions, reduces the flows and water depths in the river and reduces that number of years that the Yuba River could support green sturgeon migration. The suboptimal migration habitat conditions downstream of Daguerre Point Dam can be overcome in years with high, uncontrolled flows; however, increased water diversions associated with the proposed action are likely to further reduce the number of years that green sturgeon can successfully migrate up the Yuba River."

COMMENT

These statements in the Final BO are not supported by any analyses or referenced studies. In addition, the Final BO provides no analyses regarding "*number of years that the Yuba River could support green sturgeon migration*", does not describe what characterizes (e.g., water depths and velocities) green sturgeon migration habitat specific to the lower Yuba River, or how migration habitat changes with different flow levels.

FINAL BO STATEMENT (Page 173)

"Green sturgeon repeatedly leaping into the concrete apron at Daguerre Point dam are likely to be harmed by loss of energy reserves needed for reproduction or wounded by the dam."

COMMENT

Review of all available information on the lower Yuba River did not find any reference documenting, or even suggesting, that green sturgeon are "*repeatedly leaping into the concrete apron at Daguerre Point dam*".

FINAL BO STATEMENT (Page 174)

"Although these pools can be used by green sturgeon during migration, they are downstream from historic spawning habitats upstream of Daguerre Point Dam."

COMMENT

No documentation is provided in the Final BO to support the suggestion that spawning may have historically occurred upstream of Daguerre Point Dam in the lower Yuba River.

FINAL BO STATEMENT (Page 174)

"The recent returns of green sturgeon to the lower Yuba River are most likely the result of recent weather events and climatic conditions resulting in high flows, rather than prescribed management flows on the river. This response of green sturgeon to higher water flows is an indication of a positive biological response to relief from a habitat stressor."

COMMENT

The Final BO provides no evidence supporting the contention that recent observations of green sturgeon in the lower Yuba River below Daguerre Point Dam were associated with high flows. Moreover, this statement reflects a basic misunderstanding of instream flow requirements. The instream flow requirements associated with the Yuba Accord are minimum flow requirements based on indices of water availability, and previous analyses (e.g., 2007 Yuba Accord EIR/EIS) of the veracity of the instream flow requirements include recognition that higher flows would continue to occur associated with storm or runoff events. Finally, this statement implies that flows in the lower Yuba River represent a "stressor" to green sturgeon, which is not factually supported in the Final BO.

FINAL BO STATEMENT (Page 174)

"If sufficient flows are coming out of Waterway 13, they may attract green sturgeon into the Yuba Goldfields. There is no spawning or rearing habitat for green sturgeon in the Yuba Goldfields. Individual green sturgeon exposed to Waterway 13 may enter it and become disoriented as they follow Yuba River flows up into the Yuba Goldfields. Because there is no spawning or rearing habitat in the Yuba Goldfields, green sturgeon are likely to have reduced reproductive fitness as a result of migration delay. There is little to no food available to green sturgeon in the Yuba Goldfields, and individual green sturgeon will not find adequate nutrients to enhance or support spawning. If the Yuba river flows are reduced after green sturgeon enter Waterway 13, stranding and thermal stress are likely to result in death of individuals."

COMMENT

These statements in the Final BO provoke several comments.

First, review of all available information on the lower Yuba River did not find any reference documenting, or even suggesting, that green sturgeon enter the Yuba Goldfields or are attracted into Waterway 13 when the barrier has not been in place.

Second, as suggested in the Final BO, green sturgeon likely utilize the deep pools as a migration pathway from the lower Feather River upstream to Daguerre Point Dam. Thus, it would be equally likely to speculate that green sturgeon would not be migrating along the shoreline of the lower Yuba River and be attracted into the Waterway 13 entrance.

Third, these statements and discussion regarding green sturgeon in the Final BO are completely speculative and unfounded. For example, "…*If sufficient flows… may attract… may enter* [Waterway 13]… *likely to have reduced reproductive fitness… If the Yuba river flows are reduced… likely to result in death of individuals"*.

This section of the Final BO should be modified to more accurately represent the potential for flows emanating from Waterway 13 to act as a stressor on green sturgeon reproduction.

FINAL BO STATEMENT (Page 175)

"The proposed action affects green sturgeon by supporting water diversions upstream of Daguerre Point Dam that result in lack of sufficient flows in the lower Yuba River. Interrelated and interdependent actions that include water exports throughout the Yuba River watershed result in insufficient flows to support successful holding of green sturgeon on the lower Yuba River."

COMMENT

Because the Final BO does not identify or characterize what flow levels are "*sufficient*" for green sturgeon holding in the lower Yuba River, it is unclear how this statement concludes a "*lack of sufficient flows*". The Final BO does not provide any analyses or cite studies that identify the quality of holding habitat with flow levels in the lower Yuba River. By contrast, the Corps BA (pages 8-88 to 8-90) includes a thorough discussion of pool habitat in the lower Yuba River downstream of Daguerre Point Dam, which potentially could be utilized by holding green sturgeon.

FINAL BO STATEMENT (Page 175)

"The cause of the macroinvertebrate die-offs in the lower Yuba River is unknown, but lack of sufficient food resources, combined with insufficient flows is likely to result in reduced reproductive fitness in the years that green sturgeon hold in the Yuba River."

COMMENT

Previous comments address the lack of substantiation associated with alleged macroinvertebrate "*die-offs*" in the lower Yuba River. Additionally, the foregoing comment addressed the lack of substantiation of "*insufficient flows*". Hence, the speculative conclusion of "*likely to result in reduced reproductive fitness"* is unfounded.

FINAL BO STATEMENT (Page 175)

"Poaching sturgeon in fish ladders is a common stressor on the Sacramento River, but the fish ladders at Daguerre Point Dam have not been shown to trap sturgeon; however, green sturgeon holding in the plunge pool at Daguerre Point Dam could be gaffed or speared by poachers, resulting in capture, death, wounding, or injury."

COMMENT

This statement in the Final BO is not supported by any reports of green sturgeon poaching in the lower Yuba River.

6.3.1.2 Spawning

FINAL BO STATEMENT (Page 179)

"The plunge pool downstream of Daguerre Point Dam provides suitable spawning habitat for green sturgeon spawning in some years, and a small number of green sturgeon are likely to utilize this pool for spawning. Although there are 26 pools that are deeper than 10 feet downstream of Daguerre Point Dam, 25 of these pools lack the features that green sturgeon prefer for spawning (e.g., turbulent or convergent river flows)."

COMMENT

First, it is unclear what is meant by the statement "in some years". The Final BO does not provide any analyses regarding water year types or specific flow conditions associated with spawning habitat for green sturgeon downstream of Daguerre Point Dam. By contrast, the Corps BA (pages 8-88 to 8-90) provides an analysis of changes in pool depth and areal extent associated with changes in flow downstream of Daguerre Point Dam in the lower Yuba River.

Second, the statement that "*25 of these pools* lack *the features that green sturgeon prefer for spawning (e.g., turbulent or convergent river flows)"* should not be interpreted to mean that suitable spawning habitat does not occur in the lower Yuba River downstream of Daguerre Point Dam. As stated in Chapter 7 of the Corps BA, according to NMFS (2009e), earlier papers suggested that spawning most likely occurs in fast, deep water (> 3 m deep) over substrates ranging from clean sand to bedrock, with preferences for cobble substrates (Emmett et al. 1991; Moyle et al. 1995). Recent studies have provided additional information. Monitoring of green sturgeon and behavior data in the Rogue River in Oregon suggests spawning occurs in sites at the base of riffles or rapids, where depths immediately increase from shallow to about 5 to 10 meters, water flow consists of moderate to deep turbulent or eddying water, and the bottom type is made up of cobble to boulder substrates (D. Erickson, ODFW, pers. comm. September 3, 2008 in NMFS 2009e). For the Sacramento River, NMFS (2009a) reports that adult green sturgeon prefer deep holes (≥ 5 m depth) at the mouths of tributary streams, where they spawn and rest on the bottom.

The statement in the Final BO infers a lack of "preferred" green sturgeon spawning habitat in the lower Yuba River downstream of Daguerre Point Dam, but does not acknowledge the potential for green sturgeon local opportunistic habitat utilization in the lower Yuba River, taking into account differences between the lower Yuba River and the Sacramento or Rogue rivers, where green sturgeon spawning is known to occur.

This statement further implies that the only potentially suitable holding and spawning habitat for green sturgeon in the lower Yuba River is the area limited to the Daguerre Point Dam plunge pool. In actuality, this specific location does not conform to the Rogue River or Sacramento River habitat descriptions, because this is not a location characterized as immediately downstream of a rapid or riffle, or the mouth of a tributary stream.

Moreover, as stated on pages 5-213 and 5-214 of the Corps BA, green sturgeon critical habitat in the lower Yuba River extends from Daguerre Point Dam downstream to the confluence with the lower Feather River and primary constituent elements (PCEs) *"…present in the lower Yuba River include water flow, water quality, depths, and migratory corridors to support adult, and possibly sub-adult, migration."* By definition, therefore, green sturgeon critical habitat downstream of Daguerre Point Dam in the lower Yuba River *"…include sufficient habitat necessary for each riverine life stage"* (74 FR 52300).

FINAL BO STATEMENT (Page 179)

"It is also possible that green sturgeon spawn in the Feather River and are then attracted by the cooler waters of the Yuba River to swim up to Daguerre Point Dam and over-summer while waiting for downstream temperatures to cool to the point that they can return to the ocean. Another possibility is that green sturgeon are attracted into the Yuba River to spawn, but do not find suitable habitat downstream of Daguerre Point Dam, and therefore do not spawn, or spawn with a reduced level of success."

COMMENT

This statement in the Final BO is speculative and not supported by analyses or reference studies. Moreover, this statement appears to contradict what was stated previously in the Final BO. One of the assumptions used in the Final BO (page 55) states: "*Based on the confirmed presence and observed spawning behavior of adult green sturgeon downstream of Daguerre Point Dam during the green sturgeon spawning season and the confirmed successful spawning of adult green sturgeon nearby in the Feather River, green sturgeon spawn in the Yuba River*."

FINAL BO STATEMENT (Page 179)

"The Yuba River alluvial fan provides substrate for the majority of pools downstream of Daguerre Point Dam. The lower Yuba River alluvial fan does not provide the substrate conditions or flow conditions of suitable green sturgeon spawning habitat."

COMMENT

This statement in the Final BO requires clarification. It appears to be in direct conflict with other statements in the Final BO. For example, on page 142 of the Final BO the statement is made that *"Green sturgeon occupy the lower Yuba River up to Daguerre Point Dam, and based on observations of green sturgeon at the dam and spawning behavior of adults during the spawning season, green sturgeon currently use the lower Yuba River for spawning, reproduction, and rearing."* Although the Final BO does not provide any evidence supporting the contention that green sturgeon "*currently use the lower Yuba River for spawning, reproduction, and rearing"*, the Final BO should be consistent regarding statements of habitat suitability and utilization by green sturgeon in the lower Yuba River.

FINAL BO STATEMENT (Page 181)

"At the one spawning location in the lower Yuba River thermal conditions are probably optimal during spawning and embryo incubation. Water temperatures directly downstream of Daguerre Point dam are controlled by the interrelated and interdependent with water diversions that will continue to be supported by the proposed action."

COMMENT

Although the Final BO contends that there is only one spawning location in the lower Yuba River (without any supporting analyses), the Final BO correctly notes that water temperatures are suitable for green sturgeon spawning and embryo incubation.

6.3.1.3 Juvenile Rearing

FINAL BO STATEMENT (Page 184)

"The lower Yuba River does not provide optimal conditions for juvenile green sturgeon rearing, because of low prey availability and lack of cover. Juvenile green sturgeon exposed to low prey availability and predation in the Yuba River downstream of Daguerre Point Dam are likely to be harmed or killed."

COMMENT

The Final BO does not provide any documentation supporting the contention that prey availability for juvenile green sturgeon is low in the lower Yuba River. Moreover, the Final BO also does not provide any documentation associated with juvenile green sturgeon predation in the lower Yuba River. Thus, the contention that juvenile green sturgeon downstream of Daguerre Point Dam "*are likely to be harmed or killed*" is an unsupported, subjective conclusionary statement.

6.3.1.4 Outmigration

FINAL BO STATEMENT (Page 189)

"The lower Yuba River does not provide optimal conditions for juvenile green sturgeon outmigration, because of low prey availability and lack of cover. Juvenile green sturgeon exposed to low prey availability and predation in the Yuba River downstream of Daguerre Point Dam are likely to be harmed or killed during outmigration."

COMMENT

See previous comment.

6.3.2 Effects of the Action on Critical Habitat

FINAL BO STATEMENT (Page 193)

"The proposed action and interrelated and interdependent actions are likely to reduce food availability for green sturgeon by perpetuating the conditions that have resulted in unstable invertebrate populations in the lower Yuba River."

COMMENT

First, it is unclear what is meant by "unstable" invertebrate populations.

Second, if this statement is building upon the previous contention in the Final BO regarding "macroinvertebrate die-offs", then previous comments have addressed the lack of substantiation regarding this contention.

6.3.3 Cumulative Effects

Review of the cumulative effects section of the Final BO did not find any reference to cumulative effects analysis on green sturgeon or their habitat in the lower Yuba River.

By contrast, the Corps BA conducted a cumulative effects analysis associated with future South Yuba/Brophy diversions at Daguerre Point Dam. The Corps BA (page 8-90) found that … "*flow reductions under the Cumulative Condition relative to the current conditions would be expected to result in minor reductions in pool depth averaging less than 1 inch (relative to a nominal depth of 10.0 feet) over the range of exceedance probabilities year-round. Also, the Cumulative Condition would be expected to result in minor decreases (reductions of between 0.1% and 0.3%) in the areal extent of pools located below Daguerre Point Dam. These minor flow-related changes under the Cumulative Condition relative to the current conditions indicate no substantive impacts affecting green sturgeon in the lower Yuba River*." The Corps BA (page 8-101) also found that "*Minor water temperature changes would occur under the Cumulative Condition relative to the current conditions. The foregoing evaluation of changes in water temperatures under the Cumulative Condition relative to the current conditions indicates no substantive impacts affecting any of the green sturgeon lifestages in the lower Yuba River*."

6.3.4 Integration and Synthesis

FINAL BO STATEMENT (Page 205)

"With only five green sturgeon detected in 2011 and infrequent historical sightings by anglers, the population is likely to have been low for some time, probably since construction of Daguerre Point Dam. Green sturgeon continue to be blocked from suitable spawning habitat by Daguerre

Point Dam and its impassable fish ladders. The population has a continued lack of habitat availability and diversity; perpetually blocked access to spawning habitat upstream from Daguerre Point Dam; lack of suitable spawning substrate, deep pools, and flows; potentially low food availability for juveniles, due to macroinvertebrate die-offs; and low viability and high risk of extinction."

COMMENT

Previous comments demonstrate the lack of substantiation of the list of stressors included in the foregoing statement in the Final BO.

FINAL BO STATEMENT (Page 205)

"The Yuba River may be a population sink for the only population in the DPS. The combined impacts of the project and environmental baseline increase the risk of extinction of the DPS. Without any recovery actions to stabilize the Yuba River population and allow it to contribute to the recovery of the species, both the survival and recovery of the DPS are measurably diminished by the proposed action. Any green sturgeon spawning in the Yuba River would contribute to the viability of the DPS because there are very few green sturgeon in the DPS and very little spawning habitat within the range of the DPS."

COMMENT

This statement in the Final BO is perplexing. First, it states that there is only one population in the entire DPS, which is in reference to the Sacramento River population. If the only population in the entire DPS is the Sacramento River population, then it is unclear why any statements or conclusions are made in the Final BO regarding a "Yuba River population".

Second, the basis for the speculation that the lower Yuba River "*may be a population sink*" is unclear. Presumably, this statement implies that green sturgeon would be drawn from the Sacraemento River into the lower Feather River, then from the lower Feather River into the lower Yuba River, due to flows in the lower Yuba River that are not part of the Proposed Action. It further implies that such green sturgeon would die in the lower Yuba River, ergo "*population sink*". This line of reasoning is of questionable logic.

Third, the statement in the Final BO that "*Without any recovery actions to stabilize the Yuba River population and allow it to contribute to the recovery of the species, both the survival and recovery of the species are measurably diminished by the proposed action.*" However, review of the Final BO did not indicate any integration and/or synthesis of quantitative estimation or measurement of diminishment attributable to the Proposed Action.

FINAL BO STATEMENT (Page 205)

"The proposed action is likely to produce stressors that adversely affect the environment of green sturgeon by completely blocking upstream migration to historic spawning habitat related to the operations and maintenance of dams without fish passage, predation of juveniles downstream from Daguerre Point Dam, and continued degradation of adult holding, spawning and juvenile rearing habitat downstream from dams. Individuals that are exposed to one or more of these environmental stressors respond with adverse consequences called take, that occurs in the form of injury, death, or harm from habitat degradation that actually kills or injures individuals through significant impairment to their breeding, feeding, sheltering, migration, spawning."

COMMENT

First, the Final BO confuses effects associated with the Environmental Baseline with those of the Proposed Action, as described in the Corps BA.

Second, as previously noted, there is no documentation that spawning habitat historically occurred upstream of Daguerre Point Dam.

Third, previous comments on the Final BO have demonstrated the lack of substantiation for the contentions that "*continued degradation*" of habitat is occurring in the lower Yuba River for any of the listed lifestages.

Fourth, "*exposure*" of one or more lifestages to a "*stressor*" would not necessarily automatically result in "*take*".

FINAL BO STATEMENT (Page 206)

"These environmental consequences also reduce the survival of individuals and ultimately impairs the local population's long-term survival viability by continuing to drive low population abundance rates, variable and declining production rates, impaired spatial and genetic diversity, and continued exposure to hatchery populations. Recognizing that the green sturgeon DPS is currently at a moderate to high risk of extinction, any reduction in the viability to the Yuba River population is likely to reduce the viability and increase the extinction risk of the DPS."

COMMENT

Regarding the Final BO statement *"continuing to drive low population abundance rates, variable and declining production rates"*, there are no established "abundance viability criteria" for green sturgeon, by contrast to the extinction risk criteria developed for anadromous salmonids (Lindley et al. 2007). Moreover, the Corps BA reported available information regarding abundance of the Southern DPS of green sturgeon, as well as for the lower Yuba River.

The Corps BA (pages 5-241 to 5-242) described that, currently, there are no reliable data on population sizes, and population trends are lacking for green sturgeon in the Central Valley (NMFS 2009d). There is insufficient information to evaluate the productivity of green sturgeon (NMFS 2009d), and recruitment data for green sturgeon are essentially nonexistent (NMFS 2009a). Essentially no information regarding these topics is available for the lower Yuba River. Hence, it is not practicable to attempt to apply the VSP concepts developed for salmonids to green sturgeon in the lower Yuba River. Moreover, the limited information pertaining to abundance, productivity, habitat utilization, life history and behavioral patterns in the lower Yuba River, due to infrequent sightings over the past several decades, does not provide the opportunity for reliable alternative methods of viability assessment of green sturgeon in the lower Yuba River (Corps BA page 5-246).

As discussed in a previous comment, the conclusionary statement in the Final BO regarding green sturgeon "*continued exposure to hatchery populations*", appears to be an editorial mistake, copied from anadromous salmonid discussions, because there are no green sturgeon hatchery populations in the lower Yuba River, let alone the Central Valley.

FINAL BO STATEMENT (Page 209)

"The habitat downstream of Daguerre Point Dam is too limited in flow, depth, and substrate to support a population that would support the spatial structure of the DPS."

COMMENT

As previously noted, the Final BO does not provide scientific evidence regarding the alleged "*limited flow, depth and substrate*". Moreover, this contention in the Final BO directly contradicts NMFS' recent designation of green sturgeon critical habitat in the lower Yuba River downstream of Daguerre Point Dam. As stated on pages 5-213 and 5-214 of the Corps BA, green sturgeon critical habitat in the lower Yuba River extends from Daguerre Point Dam downstream to the confluence with the lower Feather River and PCEs *"…present in the lower Yuba River include water flow, water quality, depths, and migratory corridors to support adult, and possibly sub-adult, migration."* By definition, therefore, green sturgeon critical habitat downstream of Daguerre Point Dam in the lower Yuba River *"…include sufficient habitat necessary for each riverine life stage"* (74 FR 52300).

FINAL BO STATEMENT (Page 209)

"The poor condition of critical habitat on the Yuba River, combined with the very low green sturgeon population numbers indicates that this population is experiencing depensation and may be a population sink. The critical habitat cannot support the conservation of the DPS."

COMMENT

First, previous comments note the lack of substantiation for conclusionary statements regarding habitat conditions in the lower Yuba River.

Second, the statement in the Final BO that "*The critical habitat cannot support the conservation of the DPS*" seems to directly contradict statements in NMFS' designation of green sturgeon critical habitat. The NMFS document titled "*Designation of Critical Habitat for the Southern Distinct Population Segment of Green Sturgeon, Section 4(b)(2) Report*" (2008, page 19) report concludes that the lower Yuba River downstream of Daguerre Point Dam has a "Medium" conservation value rating. PCEs present in the lower Yuba River downstream of Daguerre Point Dam include water flow, water quality, depths, and migratory corridors to support adult, and possibly sub-adult, migration were identified in the NMFS document titled "*Proposed Designation of Critical Habitat for the Southern Distinct Population Segment of North American Green Sturgeon, Draft Biological Report*" (NMFS 2008a, page 22). It is interesting to note, however, that the discussion of PCEs does not include spawning. In fact, NMFS (2008a, page 23) states that *"Spawning is possible in the river, but has not been confirmed and is less likely to occur in the Yuba River than in the Feather River"*.

7.0 RPA Actions

FINAL BO STATEMENT (Page 214)

"There are a number of stressors associated with the Corps' operation and maintenance of Englebright Dam and reservoir, and Daguerre Point Dam. These include operation and maintenance of the dams which perpetuates the existence of the dams and the effects on ESA listed fish species."

COMMENT

As previously discussed, and as presented in the Corps BA, effects on listed species associated with the existence of Englebright and Daguerre Point dams are part of the Environmental Baseline and are not attributable to the Proposed Action.

FINAL BO STATEMENT (Page 215)

"This RPA is composed of numerous elements for each of the various project associated stressors and must be implemented in its entirety in order to avoid jeopardy and adverse modification."

COMMENT

This statement appears to be contradictory with text on the same page (see quoted text in the previous comment) that states "*rather than attempting to address every project stressor for each species or every PCE for critical habitat*".

FINAL BO STATEMENT (Page 217)

Component of Table XI-a. Key species stressors and associated short- and long-term actions in the RPA.

Stressor	*Actions*	*Short-term*	*Long-term*
Lack of data and information to assess and monitor the condition of salmonids	*Monitor, compile, and assess salmonid information*	*X*	*X*
Lack of data and information to assess and monitor the condition of green sturgeon	*Monitor, compile, and assess green sturgeon information and implementation of adaptive management*	*X*	*X*

COMMENT

Regarding the last two items presented in Table XI-a, it is unclear how a "*lack of data and information to assess and monitor the condition of salmonids*" and a "l*ack of data and information to assess and monitor the condition of green sturgeon*" would constitute "*key species stressors and associated short- and long-term actions in the RPA*".

7.1 RPA Action No. 1 – Yuba River Fish Passage Improvement Strategy and Plan

FINAL BO STATEMENT (Page 215)

"NMFS' interest is in reducing the negative effects of the stressors in order for the Corps' proposed action to avoid jeopardizing the continued existence and impairing the viability of the ESA listed species. There may be several approaches that can address a stressor or multiple stressors. NMFS interest is that the approaches that are selected have a high likelihood of success in avoiding impairing ESA listed species' viability."

COMMENT

This statement in the RPA correctly indicates that there may be numerous approaches that can address existing stressors. NMFS' interest in selecting approaches that have a high likelihood of success of avoiding jeopardy and increasing the viability of the ESA listed species is appropriate. However, given this interest, the consideration of the RPA in the Final BO does not appear to explore the possibility that habitat improvement measures in the lower Yuba River may actually have a higher likelihood of success than speculative measures associated with reintroduction of anadromous salmonids into the Upper Yuba River Watershed.

Presently, it is uncertain as to whether spring-run Chinook salmon or steelhead could be successfully reintroduced into the Upper Yuba River Watershed. Moreover, it is presently uncertain whether reintroduced populations could be self-sustaining and how many individuals could be produced. These uncertainties are acknowledged in the Final BO. For example, on page

225 of the Final BO the statement is made that "*The extent to which habitats upstream of Englebright Dam can be successfully utilized for the survival and production of anadromous fish is currently unknown*." On page 223 of the Final BO, the additional statement is made that "*The location, quantity, and condition of habitat must be inventoried and assessed in order to evaluate the current carrying capacity and restoration potential*." Therefore, it is uncertain as to whether or not a reintroduction program could produce enough individuals to significantly contribute to the ESU/DPS and whether that contribution would be sufficient to "avoid jeopardy".

By contrast, an entire suite of habitat evaluations have been conducted regarding the ability of the lower Yuba River to support ESA listed species (see http://www.yubaaccordrmt.com) and numerous habitat improvement projects have been identified (e.g., see the DWR and PG&E Habitat Expansion Plan (www.water.ca.gov/environmentalservices/docs/habitat/Final_HEP_Nov2010.pdf) and continue to be developed through the Yuba Accord RMT.

In addition, the Final BO (page 216) states "*An RPA must avoid jeopardy to listed species in the short term, as well as the long term.*" It is likely that many of these habitat improvement actions on the lower Yuba River could be implemented in a timely fashion.

7.2 RPA Action No. 2 – Near-term Fish Passage Actions

FINAL BO STATEMENT (Page 222)

"In the near term, reestablishing wild populations of spring-run Chinook salmon and steelhead in the North Yuba River upstream of New Bullards Bar Dam prior to providing volitional fish passage at Englebright Dam would provide a reliable source stock for reestablishing wild populations in the various reaches upstream of Englebright Dam. Assisted fish passage is to be considered for near-term fish passage implementation upstream of Englebright Dam, and for the long-term in the event that volitional fish passage is not feasible."

COMMENT

Again, these statements in the Final BO clearly indicate a pre-decision regarding dam removal and volitional passage at Englebright Dam.

Also, on page 216 of the Final BO, NMFS defines the near-term as 1 to 5 years. It does not seem logistically feasible to be able to complete reestablishment of anadromous salmonids in the near-term duration of 1 to 5 years given the need to secure funding, conduct required studies and analyses, develop site specific engineering designs, complete National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) regulatory compliance requirements, and then construct the needed infrastructure components that would be necessary to implement an assisted fish passage option.

7.3 RPA Action No. 3 – Long-term Fish Passage Actions

FINAL BO STATEMENT (Page 222)

"*Ultimately, volitional fish passage at Englebright Dam and Daguerre Point Dam is the preferred approach for fully seeding historic salmonids habitats and reestablishing viable populations of spring-run Chinook salmon, steelhead, and green sturgeon in the Yuba River Watershed. Restoring volitional fish passage at Englebright Dam and Daguerre Point Dam and reestablishing viable populations will greatly contribute to the continued existence and restore the viability of all three of these species… dam removal is the most preferred approach because it provides unimpeded passage for numerous aquatic species and best restores the natural processes of the river ecosystem. Volitional passage through dam removal or modification of Englebright Dam and/or Daguerre Point Dam shall be addressed in the process to determine how to best achieve fish passage upstream of these dams. NMFS recognizes that volitional fish passage over dams the height of Englebright Dam have not previously been successful, thus short-term actions are included herein until long-term solutions that provide fish passage can be formulated.*"

COMMENT

First, this RPA action appears to be attributing the effects of the existence of Englebright Dam as part of the Proposed Action, which is not the case as presented in the Corps BA.

Second, the suggestion that "volitional" passage for anadromous salmonids at Englebright Dam via "*dam removal is the most preferred approach*" appears to be pre-decisional. If reintroduction of anadromous salmonids into the Upper Yuba River Watershed is the objective, then the appropriate process would be to identify a number of potential alternatives/components, potential effects resulting from implementation of various alternatives, and to identify the most efficacious means of accomplishing reintroduction in the Upper Yuba River Watershed.

Third, presently it is uncertain as to whether spring-run Chinook salmon or steelhead could be successfully reintroduced into the Upper Yuba River Basin Watershed. Moreover, it is presently uncertain whether reintroduced populations could be self-sustaining and how many individuals could be produced. Therefore, it is uncertain as to whether or not a reintroduction program could produce enough individuals to significantly contribute to the ESU/DPS and whether that contribution would be sufficient to "avoid jeopardy", as indicated in the Final BO.

Presently, there are several initiatives addressing the issues surrounding reintroduction of anadromous salmonids into the Upper Yuba River Watershed. These initiatives include preparation of the Final Recovery Plan, other efforts being undertaken by NMFS, and two multi-party/agency collaborative stakeholder groups – the Yuba Salmon Forum, and the North Yuba Reintroduction Initiative. Biological issues being examined include lifestage-specific water temperature suitability in upstream areas, migration barriers, adult holding habitat availability, spawning gravel availability and distribution, and rearing habitat availability. Clearly, to suggest at this time that "volitional" passage at Englebright Dam is required to "avoid jeopardy" without being informed regarding biological and other (e.g., infrastructure and technical feasibility) issues is inappropriately pre-deterministic.

7.4 RPA Action No. 4 – Gravel Augmentation Program

As previously discussed, and as presented in the Corps BA, effects on listed species associated with the existence of Englebright and Daguerre Point dams are part of the Environmental Baseline and are not attributable to the Proposed Action.

Specific comments regarding this RPA and statements in the Final BO regarding substrate and anadromous salmonid spawning habitat have been prepared by Dr. Pasternack.

7.5 RPA Action No. 5 – Channel Restoration Program

Specific comments regarding this RPA and statements in the Final BO regarding the topics of channel restoration and related considerations regarding fluvial geomorphology, substrate and anadromous salmonid spawning habitat, and large woody material have been prepared by Dr. Pasternack.

7.6 RPA Action No. 6 – Predation and Predator Control Program

Numerous statements are made throughout the Final BO regarding predation of juvenile anadromous salmonids. Following are statements, and comments in response to statements, throughout the Final BO followed by comments on RPA Action No. 6 – Predator Control Program.

7.6.1 Predation

Numerous statements are made in the Final BO regarding the magnitude of predation associated with Daguerre Point Dam or specific water diversion facilities near or at Daguerre Point Dam. The Final BO (page 151) acknowledges the statement in the Corps BA (page 5-74) that "*Predatory fish are known to congregate around structures in the water including dams, diversions and bridges, where their foraging efficiency is improved by shadows, turbulence and boundary edges (CDFG 1998).*" However, the Final BO includes several statements that require clarification. Examples of these types of statements follow.

FINAL BO STATEMENTS

- ☐ **Page 144 –** *"No predator control program is in place at the South Yuba/Brophy Diversion and salmonid loss at this facility is likely to have been a severe and chronic stressor on outmigrating salmonids."*
- ☐ **Page 151 –** *"…unnaturally high predation rates may also occur in the diversion channel associated with the South Yuba/Brophy diversion."*

COMMENT

These statements are speculative, do not define what is meant by "severe" and "unnaturally high", and are not supported by referenced literature. By contrast, the Corps BA (pages 6-64 to 6-68) reported all of the available studies that have previously been conducted regarding predation at the South Yuba/Brophy Diversion Facilities. As described in the Corps BA, previous attempts have been made to quantify predation rates at this location including CDFG (1988), USFWS (1990), Cramer (1992), Demko and Cramer (1993), and Cramer (2000). As reported in the Corps BA, "*...Cramer (2000) reviewed all studies performed at the South Yuba/Brophy diversion, and found that none of the research by USFWS, CDFG or fisheries consultants had indicated that juvenile Chinook became disoriented upon entering the diversion channel, or that abnormally high predation on juvenile Chinook salmon occurred in the diversion channel."*

FINAL BO STATEMENT (Page 151)

"*High-density predator fields are likely to occur at the South Yuba/Brophy Diversion rock weir and return channel, Hallwood-Cordua Diversion canal, Hallwood-Cordua fish return pipe, Daguerre Point Dam face and fish ladders, and the Browns Valley Diversion channel."*

COMMENT

This statement does not take into account the several different water diversion structures, differences among them that may influence predator abundance, and the distinction of "high-density". Further clarification should be provided regarding predatory densities at each of the specific facilities, or the statement should be modified appropriately.

FINAL BO STATEMENT (Page 151)

"*…native predators, such as the Sacramento pikeminnow are documented to forage heavily on salmonids approaching the Hallwood-Cordua fish screen."*

COMMENT

No literature is cited or documentation referenced supporting this statement.

FINAL BO STATEMENT (Page 164)

"*Similar entrainment studies in California have found that predation is a primary mortality factor at fish screens (JSA 2004, Vogel 2008). Given that the length of the rock weir at the South Yuba/Brophy Diversion is 2.52 times longer than the Hallwood-Cordua fish screen, we estimate that between 90,900 and 229,800 outmigrating juvenile and adult Central Valley steelhead are entrained, impinged, or preyed upon at the South Yuba/Brophy Diversion annually*."

COMMENT

The Final BO presents no discussion, evaluation, or analysis indicating that previous entrainment studies conducted elsewhere are applicable to the specific South Yuba/Brophy diversion. Moreover, the statement that *"and adult Central Valley steelhead are entrained, impinged, or preyed upon"* [emphases added] does not make sense.

FINAL BO STATEMENT (Page 179)

"Downstream spawning will also lead to higher rates of predation on spring-run Chinook salmon eggs, larvae, and juvenile fish, because downstream of Daguerre Point Dam lacks cover from predators and has enhanced predator habitat."

COMMENT

This conclusionary statement is speculative, and does not reflect the spatial distribution of spring-run Chinook salmon spawning provided in RMT reports, YCWA et al. (2007), or the Corps BA – all of which report that spring-run Chinook salmon spawning occurs upstream of Daguerre Point Dam. Moreover, it is not reasonable to suggest that incubating eggs and larvae within the substrate have the ability to utilize cover and escape from predators.

Also, it is unclear what is meant by the phrase "enhanced predator habitat"?

FINAL BO STATEMENTS

- ☐ **Page 185** – *"Based on studies at Red Bluff Diversion Dam (Vogel 1988), between 16 and 55 percent of Chinook salmon under the gates are killed. NMFS assumes that mortality at Daguerre Point Dam plunge pool is similar, due to disorientation of downstream migrants and the high predator field below the dam."*
- ☐ **Pages 184 and 185** – "*Outmigration mortality is estimated to be 55 percent of the annual outmigration of both the spring-run Chinook salmon and Central Valley steelhead at Daguerre Point Dam and the conjunctive use water diversions, based upon mortality calculations done on the RBDD (USFWS 1988)."*
- ☐ **Page 254** – *"Year round at the plunge pool downstream from Daguerre Point Dam through November 1, 2012. Up to 55 percent of individuals are expected to be killed*

through November 1, 2012. Upon NMFS-approval and Corps implementation of a predator reduction and monitoring plan on November 1, 2012, NMFS will review and modify the take exemption as necessary."

- ☐ **Page 257 –** *"Year round at the scour pool downstream from Daguerre Point Dam through November 1, 2012. Up to 55 percent of individuals are expected to be killed through November 2012. Upon NMFS-approval and Corps implementation of a predator reduction and monitoring plan on November 1, 2012, NMFS will extend the take exemption as necessary."*

- ☐ **Page 259 –** *"Year round at the scour pool downstream from Daguerre Point Dam through November 1, 2012. Up to 55 percent of* [<u>green sturgeon</u>] *individuals are expected to be killed through November 2012. Upon NMFS-approval and Corps implementation of* a predator reduction and monitoring plan on November 1, 2012, NMFS will extend the take exemption as necessary."

COMMENT

Several issues are associated with the foregoing statements.

First, the Final BO (page 185) initially refers to the citation of "*between 16 and 55 percent*" mortality at RBDD. Thereafter, all references in the Final BO are to an estimated 55 percent mortality, or up to 55 percent mortality at Daguerre Point Dam.

Second, the assumption in the Final BO that mortality at the pool located immediately downstream of Daguerre Point Dam is similar to predation and the RBDD gates due to "*disorientation of downstream migrants and the high predator field below the dam*" requires additional justification. The actual statement in USFWS (1988) is "*…disorientation of downstream migrants due to passage under the dam gates and through the Tehama-Colusa Canal headworks fish bypass system causes increased vulnerability to predators*." There are no gates at Daguerre Point Dam which juvenile anadromous outmigrant salmonids would pass under and thereby become disoriented. At Daguerre Point Dam, the potential for juvenile downstream migrant salmonids to become "disorientated" by passing over Daguerre Point Dam occurs when water is spilling over the dam – otherwise, juveniles pass through the fish ladders or around the dam through the Hallwood-Cordua diversion canal (which contains a fish bypass pipe) or the South Yuba/Brophy diversion canal (which does not contain a fish bypass pipe). This combination of passage routes does not inherently appear to be similar to passing under the diversion gates at RBDD. Also, the assumption in the Final BO would be further supported if a comparison of the abundance of pikeminnow was made between downstream of RBDD and downstream of Daguerre Point Dam.

Third, the statements in the Final BO reference Vogel (1988) and USFWS (1988). There is no Vogel (1988) in the Final BOs literature cited section, although there is a Vogel et al. (1988), which is the same report as USFWS (1988).

Fourth, the Final BO does not provide discussion regarding the similarities, or particularly the lack thereof, between the gates at RBDD and the plunge pool below Daguerre Point Dam.

FINAL BO STATEMENT (Pages 185 and 186)

"The estimated loss of between 36,144 and 91,113 juvenile spring-run Chinook salmon and between 36,144 and 91,113 juvenile Central Valley steelhead annually constitutes a long-term, high level stressor for the both the Yuba River spring-run Chinook salmon and Central Valley steelhead populations and measurably contributes to the risk of extinction of the Yuba River population."

COMMENT

See the foregoing comment regarding the manner in which mortality is estimated at the Hallwood-Cordua fish screen.

FINAL BO STATEMENT (Page 187)

"*The 300 to 600 cfs flows coming into the diversion pool, with only five cfs returning to the river, does not allow for sweeping flows to let the outmigrating juveniles pass."*

COMMENT

It is unclear what the basis is to "*only five cfs returning to the river*". In fact, the Corps BA (page 6-63) thoroughly describes conditions in the diversion channel, the situation that the 10 percent bypass flow (by agreement with CDFG) has not always been met historically (NMFS 2002) but that recently YCWA replaced the two 48-inch culverts located at the downstream terminus of the bypass channel with a concrete box culvert and then restored the site. The project was undertaken to improve water flow at various river stages, reduce debris loading, reduce maintenance and to accommodate new flow metering equipment to measure the flow returning to the Yuba River from the diversion channel.

FINAL BO STATEMENT (Page 187)

"*No predator control program is in place at the South Yuba/Brophy Diversion and salmonid loss at this facility is likely to have been a severe and chronic stressor on outmigrating salmonids."*

COMMENT

The statement above is speculative, does not define what is meant by "severe", and is not supported by referenced literature. By contrast, the Corps BA (pages 6-64 to 6-68) reported all of the available studies that have previously been conducted regarding predation at the South Yuba/Brophy Diversion Facilities. As described in a previous comment, the Corps BA reported that "*...Cramer (2000) reviewed all studies performed at the South Yuba/Brophy diversion, and found that none of the research by USFWS, CDFG or fisheries consultants had indicated that* *juvenile Chinook became disoriented upon entering the diversion channel, or that abnormally high predation on juvenile Chinook salmon occurred in the diversion channel."*

FINAL BO STATEMENT (Page 188)

"The diversion subjects salmonids to the high stressors of predation, impingement, and entrainment. Therefore, the South Yuba/Brophy diversion facility is a high stressor to spring-run Chinook salmon and Central Valley steelhead outmigrants."

COMMENT

See foregoing comments and recognition of lack of documentation supporting the actual magnitude of potential predation, impingement and entrainment. The contention that "*the South Yuba/Brophy diversion facility is a high stressor*" should be clarified, and put in appropriate context.

FINAL BO STATEMENT (Page 189)

"Juvenile green sturgeon exposed to low prey availability and predation in the Yuba River downstream of Daguerre Point Dam are likely to be harmed or killed during outmigration."

COMMENT

The Final BO does not provide independent study or reference to literature documenting "low prey availability" for outmigrant juvenile green sturgeon. The contention that they are "*likely to be harmed or killed during outmigration*" is speculative, contradictory and inconsistent with previous comments demonstrating a complete lack of evidence that juvenile green sturgeon occupy the lower Yuba River.

7.6.2 RPA Action No. 6 – Predator Control Program

FINAL BO STATEMENT (Pages 236 and 237)

Addressing a short-term predatory control plan, the Final BO states "*Five areas have been identified associated with Daguerre Point Dam that have populations of predators. These areas are: (a) just downstream of Daguerre Point Dam at the plunge pool; (b) at the South Yuba/Brophy diversion; (c) at the Hallwood-Cordua diversion canal and fish screens; (d) at the outlet of the Hallwood-Cordua fish screen fish return pipe, and just downstream; and (e) at the entrance of the Browns Valley Irrigation District diversion. The Corps shall provide a predator reduction and monitoring plan to NMFS for approval by September 1, 2012. The plan shall address the predator population monitoring, and timing and methods for predator reduction at the five locations. The Corps shall implement a predator reduction program by November 1, 2012. The predator reduction and monitoring plan shall be updated annually, by August 1 of* *each year. A report will be provided to NMFS August 1 of each year providing information about the predator population, and the results of the predator deduction efforts.*

COMMENT

First, this component of the RPA is requiring the Corps to take action and implement programs associated with diversion facilities that are not part of the Proposed Action, as described in the Corps BA. Thorough discussions regarding diversions and diversion facilities and infrastructure are provided in Sections 3.3 and 6.0 of the Corps BA. For example, on page 3-30 of the Corps BA, it is stated that "…*The Proposed Action does not include operation and maintenance of the irrigation diversion facilities located at or in the vicinity of Daguerre Point Dam. Operation and maintenance responsibilities associated with each of the diversion facilities are, and will remain, the responsibility of each of the respective individual non-federal irrigation districts. The Corps is not responsible for continued operations and maintenance of these facilities*." From information provided in the Corps BA, it is questionable whether NMFS can direct the Corps to implement the stated predator control actions, particularly those involving the two locations identified associated with the Hallwood-Cordua diversion, and Browns Valley Irrigation District (BVID).

Second, to prepare a scientifically credible plan that would effectively address each of the three concerns identified by NMFS in the Final BO – "*predator population monitoring, and timing and methods for predator reduction*" and other technical issues, it would be difficult for the Corps to meet the date (September 2012) imposed by the Final BO.

Third, the Final BO states that the "*immediate predator control plan*" is to be updated annually, by August 1 of each year and a report is to be provided to NMFS by August 1 of each year. Therefore, it is unclear what the duration of this RPA action is intended to be, and how it would differ from or be integrated into RPA action PC 2. – Predator Control Plan, which requires a long-term plan be implemented by December 2013.

Fourth, the Final BO does not refer to or establish a date for development or review of the long-term predator control plan. Rather, the Final BO simply states that the long-term plan be implemented by December 2013.

FINAL BO STATEMENT (Page 247)

"Removal of predators at the South Yuba/Brophy Diversion rock weir and return channel, Hallwood-Cordua Diversion canal, Hallwood-Cordua fish return pipe, Daguerre Point Dam face and fish ladders, and the Browns Valley Diversion channel is likely to reduce predation at these structures by between 90 and 95 percent. This reduction in predation could allow for survivorship of up to 250,000 outmigrating spring-run Chinook and Central Valley steelhead annually"

COMMENT

This statement is particularly perplexing, due to lack of substantiation in the Final BO.

First, careful review of the Final BO did not discover any basis to speculate that a predator removal program at the specified locations would reduce predation by 90 to 95 percent.

Second, no reliable quantification of predation currently occurring at any of these structures is presently available.

Third, no discussion or assessment are provided in the Final BO regarding the potential effectiveness of a predator removal program.

Fourth, to suggest that a specific number of additional outmigrating juveniles (such as 250,000) would result from an unspecific action, with unknown potential effectiveness, addressing an un-quantified stressor provides a false sense of quantification that has no credible scientific basis, as presented in the Final BO.

7.7 RPA Action No. 7 - Salmonid Monitoring and Adaptive Management Program

Action number seven under the RPA requires the Corps to establish a Salmonid Monitoring and Adaptive Management Program (SMAMP). As presented in the Final BO (page 238) the program is comprised of two components – SMAMP 1 and SMAMP 2.

COMMENT

Clarification is required clearly distinguishing between SMAMP 1 and SMAMP 2. As written, the distinction between these two components of the SMAMP is not clear.

FINAL BO STATEMENTS

- ☐ **Page 221 –** *"NMFS also recognizes that the Yuba River Management Team (RMT) established in the Lower River Yuba Accord has been an effective forum for addressing fish issues in the lower Yuba River."*
- ☐ **Pages 237 and 238 –** *"Immediately after the issuance of this biological opinion the Corps shall establish this program. The program shall be staffed by the Corps and will be guided by the policy and management advice of an interagency steering committee. The steering committee will be comprised of salmonid experts and representative from the Corps, NMFS, USFWS, CDFG and academic or other agency science programs or steering committees. The program also shall establish a salmonid technical sub-committee. The committees may also have members from other organizations."*

COMMENT

In the above statements, the Final BO recognizes the effectiveness of the Yuba Accord RMT, which has been primarily funded by YCWA. YCWA is an applicant for this consultation. The manner in which composition of the steering committee as described appears to exclude YCWA. Clarification should be provided regarding this issue.

Moreover, additional clarification should be provided regarding the manner in which ongoing activities of the Yuba Accord RMT would be integrated/coordinated with the newly established SMAMP steering committee, the salmonid technical sub-committee, and ongoing data collection and analyses.

8.0 Amount or Extent of Incidental Take

This section of the review of the Final BO first provides comments on the introductory language for Section XII – Incidental Take Statement, then comments are provided on specific statements within the three tables (XII-a, XII-b, and XII-c), which provide a summary of the incidental take statement for spring-run Chinook salmon, steelhead and green sturgeon.

FINAL BO STATEMENT (Page 250)

"The expected effects of the proposed action in the Yuba River will result in potential death, injury, or harm to the freshwater life stages of spring-run Chinook salmon, Central Valley steelhead, and/or the Southern DPS of North American green sturgeon in the Yuba and occasionally the lower Feather River downstream from the confluence with the Yuba River. These effects are the result of continued operation of the proposed action."

COMMENT

First, the statement in the Final BO that the Proposed Action will occasionally "*result in potential death, injury, or harm*" to listed species in the lower Feather River downstream from the confluence with the Yuba River is not supported. Careful review of the Final BO did not locate analyses or discussion in the effects assessment of how the Proposed Action would kill, injure or harm listed species in the lower Feather River.

Second, the summaries of incidental take of spring-run Chinook salmon, steelhead and green sturgeon including the identified stressor, type of incidental take, and the amount or extent of take are mostly associated with the Environmental Baseline. As stated in the Corps BA (pages 3-1 and 3-3), the Proposed Action includes the Corps' continued operation and maintenance of Englebright and Daguerre Point dams on the lower Yuba River, and recreational facilities on and around Englebright Reservoir. Operations also include the issuance and administration of new and existing permits, licenses and easements. As presented in the Corps BA, the existence and ongoing effects of Englebright Dam, in particular, are part of the Environmental Baseline and are not attributable to the Proposed Action.

8.1 Spring-run Chinook Salmon

FINAL BO STATEMENT (Page 252)

Component from Table XII-a. Summary of incidental take of Central Valley spring-run Chinook salmon.

Life Stage	Stressor	Type of Incidental Take CV Spring-run Chinook Salmon	Amount or Extent of Take (Take Exemption)
Adult Migration and Holding	Englebright Dam and associated hydroelectric Facilities	Harm: Adult fish attempting to migrate upstream at Englebright Dam Hydroelectric Facilities. This significantly impairs normal migration behavior and prevents fish from reaching upstream migration corridors, spawning habitat and rearing habitat.	Up to 100 adult fish per year at Narrows II tailrace from February to August though year 2016. Once NMFS-approved assisted fish passage is implemented as described in the RPA, the exemption will be extended through January 31, 2020.

COMMENT

First, the potential harm referenced in this component of Table XII-a is based upon reported observations of Chinook salmon congregated near the Narrows II outlet in the lower Yuba River. Those observations did not specifically report that spring-run Chinook salmon were attempting to migrate into the powerhouse facilities.

Second, it is unclear what analyses or evaluation served as the basis to determine that "normal" migratory behavior would be "*significantly*" impaired.

Third, this issue is being studied as part of the Yuba River Development Project FERC relicensing process, which is undergoing a separate ESA consultation.

Fourth, as presented in the Corps BA, the existence and ongoing effects of Englebright Dam, in particular, are part of the Environmental Baseline and are not attributable to the Proposed Action. Under existing conditions, the lower Yuba River only extends an additional 0.1 mile upstream of Narrows II to Englebright Dam, and that area does not provide suitable spawning habitat.

FINAL BO STATEMENT (Page 253)

Component from Table XII-a. Summary of incidental take of Central Valley spring-run Chinook salmon.

Life Stage	Stressor	Type of Incidental Take CV Spring-run Chinook Salmon	Amount or Extent of Take (Take Exemption)
Spawning And Egg Incubation	Limited spawning habitat available downstream from Englebright Dam. Includes bedload and spawning gravel depletion, habitat compression and forced relocation of spawning adults downstream from Englebright Dam	Harm: Limited spawning habitat availability and reproductive failure downstream from Englebright Dam that significantly contributes to a reduction of available spawning habitat (reduces population abundance) and increased levels of redd superimposition (results in the death of incubating CV spring-run Chinook salmon eggs)	The annual number of adult fish that are affected by spawning gravel depletion and superimposition per year through the first seven years of the gravel augmentation action in the RPA. The physical indicator of take during this period is associated with the difference between the total spawning gravel depletion in the reach (60,000 – 100,000 tons) and the amount of gravel required in the RPA (15,000 tons per year). The exemption will be reviewed and extended by NMFS on an annual basis depending based on performance of RPA (i.e., placement of required gravel amounts). Once NMFS-approved assisted fish passage is implemented as described in the RPA, the exemption will be extended through January 31, 2020 as necessary.

COMMENT

The potential harm referenced in this component of Table XII-a is associated with the existence of Englebright Dam. As presented in the Corps BA, the existence and ongoing effects of Englebright Dam are part of the Environmental Baseline and are not attributable to the Proposed Action. Also, previous comments have demonstrated the abundance of suitable spawning habitat in the lower Yuba River, and also acknowledged that the relatively short (i.e., 0.89 mile) Englebright Dam Reach did not provide suitable spawning gravel, until the Corps initiated their gravel augmentation program. This and related issues are more fully addressed in comments provided by Dr. Pasternack.

FINAL BO STATEMENT (Page 254)

Component from Table XII-a. Summary of incidental take of Central Valley spring-run Chinook salmon.

Life Stage	Stressor	Type of Incidental Take CV Spring-run Chinook salmon	Amount or Extent of Take (Take Exemption)
Spawning And Egg Incubation	Limited spawning habitat available downstream from Englebright Dam Hybridization with fall-run Chinook salmon and hatchery Chinook salmon	Harm: Limited spawning habitat availability downstream from Englebright Dam also significantly contributes to increased levels of hybridization with fall-run Chinook salmon and Feather River hatchery salmon, which injures individuals by reducing their reproductive fitness and fecundity	91 percent of spawning adults in all years and water year types from Englebright dam downstream to Deer Creek, from September through November until 2018 when the NMFS-approved assisted fish passage is in place and implemented as implemented as described in the RPA. Once a NMFS-approved assisted fish passage is implemented as described in the RPA, the exemption will be extended through December 31, 2020.

COMMENT

It is unclear how "reduced reproductive fitness and fecundity" of individuals would result from hybridization, as suggested by the statement of harm referenced in this component of Table XII-a. It is also unclear what is meant by "*reproductive fitness*". Clarification should be provided.

It also is unclear how the amount of take referenced in this component of Table XII-a was determined. Review of the Final BO found the following two references regarding 91 percent of adults:

- ☐ **Page 177** – "*Introgression with all other populations of Chinook salmon has resulted in 91 percent hybridization (Barnett-Johnson el al. 2011), which diminishes the independent genetic contribution of the Yuba River population.*"
- ☐ **Page 202** – "*Given that an estimated 91 percent of spawning spring-run Chinook salmon in the Yuba River represent hatchery fish or wild spring-run Chinook salmon with natal origins outside of the Yuba River, these fish are not likely to contribute to the success of other populations in the Northern Sierra Diversity Group.*"

These references pertain to preliminary data resulting from microchemistry analyses of otoliths obtained from spawned-out Chinook salmon carcasses in the lower Yuba River during the fall of 2009. Because both phenotypic spring-run and fall-run Chinook salmon spawned during the fall, otoliths taken from the carcasses contained an unknown mixture of both runs. Therefore, it would be more accurate to state that for the one year of sampling, 91 percent of sampled Chinook salmon carcasses were determined to be of non-natal Yuba River origin.

Nonetheless, it is unclear how this information pertains to determination of the amount or extent of incidental take, and why the take statement specifically is restricted to the 0.89-mile reach extending from Englebright Dam downstream to Deer Creek, which represents a relatively small portion of the total spawning area in the lower Yuba River.

FINAL BO STATEMENT (Page 254)

Component from Table XII-a. Summary of incidental take of Central Valley spring-run Chinook salmon.

Life Stage	Stressor	Type of Incidental Take CV Spring-run Chinook salmon	Amount or Extent of Take (Take Exemption)
Juvenile rearing and downstream migration	Predation associated with Daguerre Point Dam	Death: Individuals are eaten and killed by predatory fish downstream from Daguerre Point Dam	Year round at the plunge pool downstream from Daguerre Point Dam through November 1, 2012. Up to 55 percent of individuals are expected to be killed through November 1, 2012. Upon NMFS-approval and Corps implementation of a predator reduction and monitoring plan on November 1, 2012, NMFS will review and modify the take exemption as necessary.

COMMENT

The amount or extent of take referenced in this component of Table XII-a is associated with predation at the plunge pool downstream of Daguerre Point Dam. As stated in the Final BO (page 251) "*Specific predation rates are not available at Daguerre, so predation rates from RBDD prior to gate management improvements were applied with the assumption that they are similar.*"

The need for additional justification for the amount of 55 percent of all spring-run Chinook salmon juveniles included in this take statement is described in a previous comment. In summary, the actual statement in USFWS (1988) is "*…disorientation of downstream migrants due to passage under the dam gates and through the Tehama-Colusa Canal headworks fish bypass system causes increased vulnerability to predators*." There are no gates at Daguerre Point Dam which juvenile anadromous outmigrant salmonids would pass under and thereby become disoriented. At Daguerre Point Dam, the potential for juvenile downstream migrant salmonids to become "disorientated" by passing over Daguerre Point Dam occurs when water is spilling over the dam – otherwise, juveniles pass through the fish ladders or around the dam through the Hallwood-Cordua diversion canal (which contains a fish bypass pipe) or the South Yuba/Brophy diversion canal (which does not contain a fish bypass pipe). This combination of passage routes does not inherently appear to be similar to passing under the diversion gates at RBDD. Also, the Final BO does not provide discussion regarding the similarities, or particularly the lack thereof, between the gates at RBDD and the plunge pool below Daguerre Point Dam.

8.2 Steelhead

FINAL BO STATEMENT (Pages 255 through 257)

Table XII-b, "*Summary of incidental take of California Central Valley steelhead*", is essentially the same as Table XII-a that summarized incidental take for spring-run Chinook salmon. Hence, the foregoing comments on the summary of spring-run Chinook salmon incidental take also pertain to steelhead. The one notable exception regards the amount or extent of take of spawning and egg incubation, where 91 percent of all spawning adults was specified for spring-run Chinook salmon, by contrast to all steelhead adults.

8.3 Green Sturgeon

<u>**FINAL BO STATEMENT** (Page 258)</u>

The title of Table XII-c is "*Summary of incidental take of green sturgeon. The table is organized by life stage <u>then by the number of populations affected</u> by a particular stressor*." [emphasis added]

COMMENT

It is unclear why the table indicates that a number of green sturgeon populations are potentially affected by a particular stressor associated with the Proposed Action. Further, contents of the table do not address multiple populations of green sturgeon. Clarification should be provided.

<u>**FINAL BO STATEMENT** (Page 258)</u>

Component from Table XII-c. Summary of incidental take of green sturgeon. The table is organized by life stage then by the number of populations affected by a particular stressor.

Life Stage	Stressor	Type of Incidental Take of Green Sturgeon	Amount or Extent of Take (Take Exemption)
Adult Migration	Blocked upstream passage at Daguerre Point Dam	Injury: Wounded individuals that leap onto the concrete dam apron of Daguerre Point Dam or unsuccessfully attempt to migrate through the fish ladders Harm: Access to historic upstream habitat is blocked by Daguerre Point Dam. Adult fish are not able to ascend the ladder or swim over the dam. This significantly impairs essential behaviors including upstream migration, and spawning	Annual between March and June through 2018 when fish passage improvements are approved by NMFS and implemented pursuant to the RPA, upon which time NMFS will review and amend the take exemptions as necessary.

COMMENT

Previous comments noted that no documentation or reports exist of green sturgeon leaping onto the concrete apron at Daguerre Point Dam, or attempting to enter the fish ladders. Previous comments also have documented that there have been no historical accounts of green sturgeon spawning in the lower Yuba River, particularly upstream of Daguerre Point Dam. Clarification should be provided.

FINAL BO STATEMENT (Page 258)

Component from Table XII-c. Summary of incidental take of green sturgeon.

Life Stage	Stressor	Type of Incidental Take of Green Sturgeon	Amount or Extent of Take (Take Exemption)
Holding	Impacts to quantity and quality of holding habitat related to flow and habitat diversity and lack of preferred habitat in the lower Yuba River.	Harm: Degradation of holding habitat from flows that minimizes the holding habitat availability of post-spawned adults downstream from Daguerre Point Dam.	Annual between June and November downstream from Daguerre Point Dam, until 2015, when fish passage improvements described in the RPA are met. Upon NMFS approval of the fish passage improvement plan and its implementation, the take exemption will be reviewed and extended as necessary.

COMMENT

First, it is unclear how the expected effects of the Proposed Action include lack of "preferred" habitat in the lower Yuba River. Previous comments have noted that reference to "preferred" green sturgeon habitat include moderate to deep turbulent or eddying water, and deep holes (≥ 5 m depth) at the mouths of tributary streams. Clarification should be provided how the Proposed Action potentially affects these conditions.

Second, the potential harm referenced in this component of Table XII-c infers that the Final BO conducted some analyses relating holding habitat to flow rates. However, no such analyses were found in the Final BO. By contrast, as previously noted, the Corps BA did conduct an analysis of the relationship between pool depth (and pool areal extent), water temperature and flow rates in the lower Yuba River and found (page 8-90) that the Cumulative Condition would result in minor changes in pool depth, areal extent or water temperature over a range of exceedance probabilities year-round, and would not result in substantive impacts affecting green sturgeon in the lower Yuba River.

FINAL BO STATEMENT (Page 259)

Component from Table XII-c. Summary of incidental take of green sturgeon.

Life Stage	Stressor	Type of Incidental Take of Green Sturgeon	Amount or Extent of Take (Take Exemption)
Spawning	Impacts to quantity and quality of spawning habitat	Harm: Degradation of spawning habitat from flows that minimize the holding habitat availability of post-spawned adults downstream from Daguerre Point Dam.	Annual between March and June downstream from Daguerre Point Dam, until 2015, when fish passage improvements described in the RPA are met. Upon NMFS approval of the fish passage improvement plan and its implementation, the take exemption will be reviewed and extended as necessary

COMMENT

First, the potential harm statement in this component of Table XII-c appears to be a copying error from the previous component, referencing post-spawned adults rather than spawning.

Second, the previous comment pertains to this component as well.

FINAL BO STATEMENT (Page 259)

Component from Table XII-c. Summary of incidental take of green sturgeon.

Life Stage	Stressor	Type of Incidental Take of Green Sturgeon	Amount or Extent of Take (Take Exemption)
Juvenile rearing and downstream migration	Predation downstream from Daguerre Point Dam	Death: Individuals are eaten and killed by predatory fish downstream from Daguerre Point Dam.	Year round at the scour pool downstream from Daguerre Point Dam through November 1, 2012. Up to 55 percent of individuals are expected to be killed through November 2012. Upon NMFS-approval and Corps implementation of a predator reduction and monitoring plan on November 1, 2012, NMFS will extend the take exemption as necessary.

COMMENT

It is recognized that it is difficult to quantify or estimate predation rates on green sturgeon juveniles in the lower Yuba River, particularly in consideration that they have never been observed or documented in the river. On page 251 of the Final BO, the statement is made that "*Specific predation rates are not available at Daguerre, so predation rates from RBDD prior to gate management improvements were applied with the assumption that they are similar. Also, absent predation rates specific to green sturgeon, we applied the salmonid predation rates from RBDD.*"

However, clarification and/or modification of the amount or extent of take of green sturgeon juveniles due to predation should be provided because green sturgeon do not occur upstream of Daguerre Point Dam, and therefore it may not be appropriate to assume anadromous salmonid predation rates associated with potential disorientation from passing through, over or around a dam.

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ATTACHMENT 1

TECHNICAL REPORT REVIEW

MODELING HABITAT CAPACITY AND POPULATION PRODUCTIVITY FOR SPRING-RUN CHINOOK SALMON AND STEELHEAD IN THE UPPER YUBA RIVER WATERSHED (STILLWATER SCIENCES 2012)

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1.0 Overview

The National Marine Fisheries Service (NMFS) contracted Stillwater Sciences to develop an exploratory application of a model, referred to as RIPPLE, to quantify habitat carrying capacity and freshwater productivity potential for spring-run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) in the Upper Yuba River Watershed. This effort was conducted as part of the Habitat Assessment and Reintroduction Implementation Plan for Central Valley spring-run Chinook salmon and steelhead (Stillwater Sciences 2012). The culmination of this effort resulted in a report titled "*Modeling Habitat Capacity and Population Productivity for Spring-run Chinook Salmon and Steelhead in the Upper Yuba River Watershed*" prepared by Stillwater Sciences (2012). This document provides a technical review of the Stillwater Sciences (2012) report.

Stillwater Sciences made an intrepid effort to develop a spatially explicit model to quantify species-specific habitat carrying capacity and freshwater productivity potential in the Yuba River Watershed upstream of Englebright Dam. As stated by Stillwater Sciences (2012), the RIPPLE model application for the Upper Yuba River Watershed is best suited to explore watershed-scale habitat conditions. Considerable effort was expended to develop and parameterize the RIPPLE model. However, the model is constrained by the limited availability of empirical data to parameterize the model, and by assumed model inputs.

One of the major concerns associated with Stillwater Sciences (2012) is the potential for inappropriate application or interpretation of the results presented. For example, Stillwater Sciences (2012, page ES-1) provide a cautionary note by referring to their report as "*an <u>exploratory application</u> of the spatially explicit model, RIPPLE, to quantify habitat carrying capacity and freshwater productivity potential for these two salmonid species in the upper Yuba River watershed*." Undue specificity should not be attributed to model results, nor should the results be relied upon as accurate predictions of habitat carrying capacity or productivity. Rather, if the various assumptions and inputs to the RIPPLE model are consistently applied among rivers and reaches examined, then the results could provide initial relative indications of carrying capacity and productivity among areas compared, and help inform the decision-making process. However, as stated by NMFS in their February 29, 2012 Biological Opinion on the U.S. Army Corps of Engineers Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir (NMFS 2012, page 223) *"The location, quantity, and condition of habitat must be inventoried and assessed in order to evaluate the current carrying capacity and restoration potential. This information is essential to determine where passage and reintroduction are most likely to improve reproductive success for listed fish."*

A fundamental concern associated with the potential misapplication or misinterpretation of the RIPPLE model results stems from the fact that it does not account for conditions that change over time, which is an inherently important consideration regarding abundance and productivity of anadromous salmonids. In fact, Stillwater Sciences (2012, page ES-2) state "*One of the guiding principles of RIPPLE is the assumption that physical processes and the resulting environment… are essentially time invariant compared with ecosystems and the animal and plant populations supported by these ecosystems.*" [emphasis added] Clearly, flow and water temperatures are not "*time invariant*", but change year-to-year based on hydrologic and meteorological conditions. Model output presented in Stillwater Sciences (2012) does not account for abiotic variables that change over time (e.g., flows and water temperatures), does not address resultant variability in salmonid habitat availability and suitability, and consequently does not represent reliable long-term estimates of population production. Applications of model output inferring long-term population production, or the veracity of a long-term reintroduction program into the Upper Yuba River Watershed are, therefore, inappropriate.

Comments on Stillwater Sciences (2012) are provided below. The following comments are organized to address general categories first, followed by specific comments.

Numerous assumptions are embedded in the Stillwater Sciences (2012) report that inject bias and result in higher estimates of habitat carrying capacity and population productivity in the South and Middle Yuba rivers, and in the North Yuba River below New Bullards Bar Dam, relative to the North Yuba River upstream of New Bullards Bar Reservoir. Examples of these bias-inducing assumptions/approaches include:

- ☐ Relaxed ("expanded") water temperature suitability criteria for steelhead in the South and Middle Yuba rivers, which significantly increase the amounts of potentially suitable habitat, and no relaxed water temperature criteria for the North Yuba River.
- ☐ "Augmented" flow conditions for the South and Middle Yuba rivers, which represent speculative increased releases out of upstream storage facilities, to improve habitat conditions (particularly water temperature). By contrast, the North Yuba River above New Bullards Bar Reservoir is unimpaired, and most accurately represents a hydrologically undisturbed watershed, and no "augmented" releases are presented.
- ☐ Anadromous salmonid passage barriers, particularly barriers that block the upstream passage of fish during low-flow conditions, were assumed to either be nonexistent or some unidentified passage facilities provided on the South and Middle Yuba rivers, which vastly increases the estimated amount of habitat available and resultant population production. No such passage barriers exist on the North Yuba River upstream of New Bullards Bar Reservoir.
- ☐ Appropriate spawning gravels are not present in the North Yuba River downstream from New Bullards Bar Dam. In fact, this reach is characterized by very large boulders. However, a "gravel augmentation" assumption was made for this reach, which transforms unsuitable spawning habitat into suitable and usable habitat in the comparison among reaches.

2.0 General Comments

Stillwater Sciences (2012) state "*The upstream and downstream extent of potential habitat under each modeled scenario was defined for modeling purposes by applying four criteria: (1) known natural barriers (Yoshiyama el al. (2001) and Vogel (2006), (2) channel gradient thresholds, (3) channel width thresholds, and (4) water temperature thresholds*."

The following issues and comments pertain to information presented in Stillwater Sciences (2012), and the manner in which the longitudinal extent of potential habitat was estimated for each of the rivers and reaches evaluated through application of the four criteria.

2.1 Longitudinal Extent of Potential Habitat – Four Criteria

2.1.1 Natural Barrier Criteria

ISSUE

Stillwater Sciences (2012, page ES-3) state "*For purposes of this assessment it was assumed that passage by salmon and steelhead would be possible in the mainstem reaches of each sub-basin up to existing natural passage barriers…"* Stillwater Sciences (2012, page 16) also state *"The current upstream extent of accessible habitat in the mainstem North Yuba, Middle Yuba, and South Yuba rivers is defined by existing natural fish passage barriers (Table 4-2). As discussed previously, all modeling scenarios, including current conditions, assumed that upstream and downstream passage would be provided up to these absolute barriers."*

COMMENT

Stillwater Sciences (2012) state that the river miles of potential habitat available in the South, Middle and North Yuba rivers represent the location of natural barriers to migration based on Vogel (2006) and Yoshiyama et al. (2001). However, the locations provided in Stillwater Sciences (2012) do not represent all of the salient information provided in the referenced documents. Rather, Stillwater Sciences (2012) used the most upstream located barriers represented as absolute barriers to fish passage.

Stillwater Sciences (2012) did not consider that some of the barriers have been reported to be flow-dependent. The documents referenced by Stillwater Sciences (2012) were reviewed for historical accounts of migration barriers in the Upper Yuba River Watershed, including Yoshiyama et al. (2001) and the Upper Yuba River Watershed Chinook Salmon and Steelhead Habitat Assessment Technical Report (DWR 2007), to which Vogel (2006) is an appendix. This review yielded the following information regarding flow-dependent migration barriers. [Note: As acknowledged in Stillwater Sciences (2012, page 13), river mile numbering is not consistent among reports.]

- ☐ South Yuba River. Yoshiyama et al. (2001) consider a cascade, with at least a 12-foot drop, located 0.5 miles below the juncture of Humbug Creek as essentially the historical upstream limit of salmon during most years of natural streamflows. This cascade is located at approximately river mile 19.6. According to Yoshiyama et al. (2001), steelhead may have been able to ascend upstream as far as the confluence with Poorman Creek located at approximately river mile 28.5, near the present town of Washington (Yoshiyama et al. 2001). DWR (2007) considered 3 sites to be barriers under low-flow (< approx. 100-200 cfs) conditions, and 12 sites to be total barriers at both low and high river flows. The most downstream low-flow barriers are located at approximately 5.1 and 5.9 river miles upstream from the confluence with the North Yuba River (DWR 2007). The most downstream located total barrier is at approximately river mile 35.4.

  Stillwater Sciences (2012) did not address the issue that a barrier to upstream migration is located as far downstream as river mile 5.1 on the South Yuba River during low-flow conditions. Given that upstream habitats are not accessible under low-flow conditions, and that habitat inaccessibility will prohibit functional carrying capacity with a certain probability of occurrence associated with hydrologic variation, results presented in Stillwater Sciences (2012) do not represent long-term habitat availability or population productivity. It is not possible to estimate long-term population abundance and trends in abundance (in the POP sub-model) without addressing these limitations.

- ☐ Middle Yuba River. Yoshiyama et al. (2001) concluded that direct information was lacking on historic abundance and distribution of salmon, and they conservatively considered the 10-foot falls located 1.5 miles above the mouth of the Middle Yuba River as the effective upstream limit of salmon distribution, although steelhead may have been able to ascend upstream as far as the mouth of Bloody Run Creek. DWR (2007) considered 6 sites to be barriers to upstream passage only during low-flow (< approx. 100-200 cfs) conditions, and 2 additional sites to be total barriers, regardless of flow conditions. The most downstream located low-flow barrier is at approximately 0.4 river miles upstream from the mouth of the Middle Yuba River (DWR 2007). The most downstream located total barrier is at approximately river mile 12.

  See the above comment regarding limitations associated with long-term population productivity.

- ☐ North Yuba River. Yoshiyama et al. (2001) reported that there were no natural barriers above the New Bullards Bar Dam site, so Chinook salmon and steelhead presumably had been able to ascend upstream potentially as far as Downieville at the mouth of the Downie River. Yoshiyama et al. (2001) further suggest that: (1) there were no natural obstructions from Downieville upstream to Sierra City, where Salmon Creek enters, and

> spring-run Chinook salmon and steelhead most likely were able to traverse that distance; (2) spring-run Chinook salmon and steelhead probably ascended the higher-gradient reaches up to about two miles above the juncture of Salmon Creek; and (3) the absolute upstream limit on the North Yuba River would have been Loves Falls for spring-run Chinook salmon and steelhead. The Upper Yuba River Watershed Chinook Salmon and Steelhead Habitat Assessment Technical Report (DWR 2007) did not investigate the North Yuba River. However, NMFS (2011) states that a potential natural barrier to upstream migration of anadromous salmonids is considered to be Love's Falls, located approximately 1 mile upstream of the Haypress Creek confluence, resulting in 35 miles of potential salmonid habitat accessible along the mainstem of the North Yuba River above New Bullards Bar Reservoir.

The fact that barriers in the South and Middle Yuba rivers would prohibit upstream migration of anadromous salmonids during low-flow conditions is particularly relevant to steelhead. For example, Stillwater Sciences (2012, page 8) report that adult steelhead migrate upstream during summer, fall and winter months, and that for the Sacramento River, steelhead migration begins in July and peaks during September. Stillwater Sciences (2012) (Figure 1-1, page 4) also demonstrate, however, that low-flow conditions occur from July through mid-November. Thus, results presented in Stillwater Sciences (2012) do not account for the more downstream-located low-flow barriers and the resultant limitations on long-term habitat availability and population productivity.

ISSUE

Stillwater Sciences (2012, page 20) states "*For modeling purposes it was assumed that a passage solution would be provided to facilitate upstream and downstream fish passage past the small dam at the mouth of Canyon Creek* [tributary to the South Yuba River]."

COMMENT

Similar to the unstated assumption that anadromous salmonid upstream adult passage would always occur at low-flow barriers in the South and Middle Yuba rivers, the foregoing assumption is speculative and biases the amount of habitat availability and population productivity for this tributary to the South Yuba River.

2.1.2 Channel Gradient Threshold Criteria

ISSUE

Stillwater Sciences (2012, page 16) state "*It was assumed that adult spring-run Chinook salmon migrating to holding areas in the spring and early summer could not pass any portion of the* *channel network with a gradient of 12% or greater, or with a sustained (> 300 m) gradient of 8% or greater (CDFG 2003).”*

Additionally, Stillwater Sciences (2012, page 38) state “*Gradients greater than 12% were not considered passable by spring-run Chinook salmon or steelhead and therefore were not included in the modeled channel network*.”

COMMENT

First, Stillwater Sciences (2012) reference CDFG (2003) as the basis for establishing any portion of a stream with a gradient of 12% or greater as impassible for spring-run Chinook salmon. However, review of CDFG (2003) does not support this criterion. No reference to 12% as a passage criterion was found in CDFG (2003). Stillwater Sciences (2012) does not provide any basis for using 12% as a fish passage criterion for adult spring-run Chinook salmon or steelhead.

Second, Stillwater Sciences (2012) reference CDFG (2003) as the basis for establishing any portion of a stream with a sustained (> 300 m [984 ft]) gradient of 8% or greater as impassible for spring-run Chinook salmon. CDFG (2003, page IX-45) states “*...define the upper limit of anadromous habitat when the channel exceeds a sustained eight to ten percent slope for approximately 1,000 feet*.” However, CDFG (2003) does not provide any rationale or referenced studies or literature to support this statement. Additional support for this criterion application in the RIPPLE model should be provided.

ISSUE

Stillwater Sciences (2012, page 18) state *“To define the upstream extent of modeled steelhead habitat in tributaries in each sub-basin it was assumed that adult steelhead migrating to spawning areas in the winter and spring could not pass any portion of the channel network with a gradient of 20% or greater, or with a sustained (> 300 m [984 ft]) gradient of 8% or greater (CDFG 2003).”*

COMMENT

First, Stillwater Sciences (2012) reference CDFG (2003) as the basis for establishing any portion of a stream with a gradient of 20% or greater as impassible for steelhead. However, review of CDFG (2003) does not necessarily support this criterion. Rather, CDFG (2003) actually refers to resident trout or “fish”, not steelhead, and use a gradient of 20% to define resident trout habitat or reaches, not a criterion for steelhead passage, according to the following:

- ☐ CDFG (2003, page IX-45) states “*Upper limits of resident fish habitat may include channel reaches with slopes up to 20 percent.”*
- ☐ CDFG (2003, page IX-8) states “*Resident trout reaches are defined as channels with gradients up to 20 percent (Robison et al. 2000, SSHEAR 1998)*.”

Second, Stillwater Sciences (2012) reference CDFG (2003) as the basis for establishing any portion of a stream with a sustained (> 300 m [984 ft]) gradient of 8% or greater as impassible for steelhead. See above comment.

ISSUE

Stillwater Sciences (2012, page 55) state "*Although rearing can occur at gradients up to 12%, we assumed steelhead spawning did not occur in reaches with gradients > 8%.*"

COMMENT

No basis for this assumption was located in Stillwater Sciences (2012).

2.1.3 Channel Width Threshold Criteria

ISSUE

Stillwater Sciences (2012, page 16) state "*Channels with a summer low-flow width less than 8.5 m (28 ft) were assumed to be too narrow to provide* [spring-run Chinook salmon] *holding pools with suitable depth (≥ 1.2–2.4 m [4–8 ft]; Grimes 1983, Airola and Marcotte 1985, as cited in Vogel 2006) or spawning habitat. This assumption was based on the channel dimensions in the upper portions of the North and South forks of Antelope Creek where holding spring-run Chinook salmon are commonly observed (C. Harvey Arrison, CDFG, Red Bluff, California, pers. comm., 21 June 2011). This channel width also corresponds with the upstream-most spawning location in Butte Creek (Quartz Bowl) (McReynolds et al. 2005, Stillwater Sciences 2007a).*"

COMMENT

Application of the 28-foot minimum channel width criterion to provide pools with suitable depth (greater than or equal to 4-8 feet) for holding spring-run Chinook salmon does not appear to be justified. Stillwater Sciences (2012) did not provide any rationale or discussion regarding the applicability of Antelope Creek channel dimensions (width-to-depth ratios) to the Upper Yuba River Watershed, and the identical application of those dimensions to the different rivers and reaches in the Upper Yuba River Watershed, which themselves differ. In fact, Stillwater Sciences (2012) does not provide any information suggesting that a channel must be at least 28 feet wide to provide a depth of 4 to 8 feet in any river or reach of the Upper Yuba River Watershed. Also, it should be noted that justifying the 28-foot width criterion by stating that it "… *also corresponds with the upstream-most spawning location in Butte Creek (Quartz Bowl)*" is questionable, because Quartz Bowl represents a barrier to spring-run Chinook salmon upstream passage, with the exception of high flow years.

ISSUE

Stillwater Sciences (2012, page 18) state *"Channels with a winter baseflow width less than 2 m (6.6 ft) were assumed to be too narrow to provide suitable steelhead spawning habitat. This minimum spawning width threshold was based on professional judgment and unpublished observations."*

COMMENT

Stillwater Sciences (2012) did not provide any rationale or discussion regarding the applicability of the assumed 6.6 ft winter baseflow width steelhead spawning criterion. Given the importance of this criterion in establishing the upstream limit for steelhead habitat, additional support should be provided. At a minimum, the report should describe the bases for "*professional judgment and unpublished observations.*"

2.1.4 Water Temperature Threshold Criteria

2.1.4.1 Application of 2009 Model Output and 2010 Monitoring Data

To determine the downstream extent of thermally suitable habitat for spring-run Chinook salmon and steelhead in the South and Middle Yuba rivers, modeled mean daily water temperatures obtained from the Hydrocomp Forecast and Analysis Modeling (HFAM) water temperature model during 2009 summer months (i.e., June through the end of September) were used in the RIPPLE model.

By contrast to the South and Middle Yuba rivers where 2009 modeled water temperature output was applied, monitored data collected during the summer of 2010 (from July through mid-October) were applied for the North Yuba River.

COMMENT 1

Hydrologic conditions (i.e., critical, dry, below normal, normal, above normal, wet) and meteorological conditions (hot, warm, cool) in the Yuba River Watershed vary inter-annually. However, the current RIPPLE application was based on only one year of summer water temperatures. Consequently, results presented in Stillwater Sciences (2012) do not address the inter-annual variation in the downstream extent of thermally suitable habitat for Chinook salmon and steelhead in the South, Middle and North Yuba rivers. Therefore, results presented in Stillwater Sciences (2012) provide, at best, a "snapshot" of potentially suitable thermal conditions for the specific hydrologic and meteorological conditions evaluated, and do not necessarily reflect thermal suitabilities over a range of conditions that would be expected to occur in the watershed.

COMMENT 2

The extent of the thermally suitable habitats for spring-run Chinook salmon and steelhead under current conditions in the South and Middle Yuba rivers are not directly comparable to those in the North Yuba River. For the South and Middle Yuba rivers, 2009 model output were used in the evaluation, although 2010 monitoring data were used for the North Yuba River. These datasets are not comparable. Stillwater Sciences (2012, page 17) appropriately acknowledge that "*…2009 was a year with relatively high air temperatures and low stream flows…*" and "*…2010 was a year with above average stream flow and slightly cooler than average air temperatures…"*

2.1.4.2 HFAM Water Temperature Modeling

Review of Stillwater Sciences (2012), and in particular Appendix B, which presents water temperature model output for the South and Middle Yuba rivers, is insufficient to determine what specific water temperature model output was actually utilized. Simply stating that HFAM model output was used is inadequate, due to the fact that the referenced HFAM model developed by Pacific Gas and Electric Company (PG&E) and Nevada Irrigation District (NID) actually includes eight different models and complicated interactions among them to characterize specific scenarios. Given the information provided, it is not possible to identify the specific water temperature model output data used to characterize the current condition, or each of the Alternative Management Scenarios. [Additional discussion regarding the Alternative Management Scenarios is provided below.]

2.1.4.3 Application of Species-Specific Water Temperature Criteria

Of particular concern in assessing thermally suitable habitat is the manner in which water temperature is analyzed and/or reported. Stillwater Sciences (2012) report water temperature criteria for spring-run Chinook salmon (Table 2-1) and steelhead (Table 2-2) for the Upper Yuba River Watershed. These criteria are presented according to the categories of "*optimal*", "*suboptimal*" and "*chronic and acute stress*". It is inferred that the "chronic and acute stress" water temperatures would be appropriate to characterize the upper water temperature values characterizing some level of suitability for each of the species and lifestage-specific considerations. However, this does not appear to be the case, as demonstrated by the following observations.

- ☐ Review of the Stillwater Sciences (2012) did not yield an evaluation of the thermal suitability for the upstream migration lifestage of spring-run Chinook salmon, although criteria for this lifestage are presented in Table 2-1.
- ☐ It is unclear how potential spring-run Chinook salmon spawning habitat was evaluated associated with water temperature suitability. Spring-run Chinook salmon spawning water temperature criteria (15.6°C) are presented in Table 2-1. However, Stillwater

Sciences (2012, page 17) state "*The downstream extent of spring-run Chinook salmon spawning habitat was modeled to extend a fixed distance* [3 mi] *downstream from holding habitat*." Based on the narrative presented in Stillwater Sciences (2012), it is unclear how spawning thermal suitability evaluations were conducted for spring-run Chinook salmon.

☐ Stillwater Sciences (2012, page 17) report that for RIPPLE modeling purposes 19°C was used to define the extent of thermally suitable habitat for rearing juvenile spring-run Chinook salmon instead of 18.3°C which was recommended in a previous report by Stillwater Sciences (2006b). Stillwater Sciences (2012, page 17) recognize that the use of 19°C as a threshold "*likely result*[ing] *in an overestimate of juvenile rearing habitat*" and that "*…may help account for the effect of cold water refugia from groundwater or tributary inputs…*" that… *"can allow successful rearing in reaches that would otherwise be deemed too warm*."

The justification is speculative in the sense that no information is provided in Stillwater Sciences (2012) documenting the occurrence of coldwater refugia. In fact, surveys conducted during the summer of 2011 in the North Fork Yuba River found that water temperature vertical stratification in pools did not occur, nor did "coldwater refugia" occur at tributary mouths (see Yuba Salmon Forum Habitat Reports).

☐ Stillwater Sciences (2012, page 20) state that tributaries to the Middle Yuba River and the South Yuba River (with the exception of Canyon Creek) "*…were not considered potential habitat for spring-run Chinook salmon due to channel gradient, channel width, water temperature, or a combination of these factors.*" However, it is not apparent in the report what analyses were conducted or which of these factors contributed to this "lack of suitability." Regarding water temperature, it is curious why tributary water temperatures apparently were evaluated for steelhead, but not for spring-run Chinook salmon.

☐ Review of the Stillwater Sciences (2012) did not yield an evaluation of the thermal suitability for the adult upstream migration lifestages of spring-run Chinook salmon and steelhead, although criteria for these lifestages are presented in Tables 2-1 and 2-2.

☐ Stillwater Sciences (2012, pages ES-4 and 19) states "*The downstream extent of potential spawning habitat in the SY, MY, and NY sub-basins under current conditions was assumed to be the same as the downstream extent of rearing habitat*." If this assumption was actually applied to develop results, then the results would be illogical because Stillwater Sciences (2012, page 9) report that "*…During spawning and egg incubation, steelhead require water temperatures less than 12.8°C to ensure successful embryonic development*" whereas Stillwater Sciences (2012, page 10) state "*Juvenile steelhead generally require water temperatures lower than 20°C to avoid physiological stress.*"

☐ Stillwater Sciences (2012, page 21) states *"Based on …the target MWAT for steelhead spawning and rearing of* $\leq$ *20°C…"* This is an illogical statement because in Table 2-2 on page 9, a water temperature of 12.8°C is listed as providing “chronic to acute stress” for steelhead spawning and egg incubation. It should be clarified that a water temperature criterion of ≤ 20°C was not used to identify suitable steelhead spawning habitat, because 20°C would be lethal to steelhead eggs.

- When describing the downstream extent of thermally suitable habitat for steelhead juvenile rearing habitat under current conditions Stillwater Sciences (2012, page 18) state “*The downstream extent of potential steelhead rearing habitat under current conditions was defined by a water temperature suitability limit of ≤ 20°C MWAT…”* Later in the document (page 25) Stillwater Sciences established a relaxed or “expanded” water temperature criterion for potential juvenile steelhead rearing habitat based on observations of resident rainbow trout distribution during summer 2004 (Gast et al. 2005) in the Middle Yuba River (23.2°C), and 25.2°C on the South Yuba River.

  The utility of using the “expanded” criteria of 23.2°C on the Middle Yuba River and 25.2°C on the South Yuba River is of questionable value. Using different criteria on different reaches does not present an equitable basis of comparison of thermal suitability among rivers and reaches compared.

  Not surprisingly, when these much more lenient water temperature criteria are applied to the South and Middle Yuba rivers (25.2°C and 23.2°C, versus 20°C), the reported linear extent of suitable juvenile steelhead rearing habitat was significantly increased.

- Statements in Stillwater Sciences (2012) regarding results associated with the “expanded” water temperature criteria for the South and Middle Yuba rivers (25.2°C and 23.2°C, versus 20°C) are particularly confusing because these criteria pertain to juvenile steelhead rearing, yet appear to be applied to spawning (redds). For example:

  - Stillwater Sciences (2012, page 64) states “*In the SY sub-basin under current conditions, the number of steelhead redds predicted using the 25.2°C temperature criterion was approximately 10 times higher than the more conservative estimate using the 20°C temperature criterion.”*

  - Stillwater Sciences (2012, pages 64 and 65) states “*In the MY sub-basin under current conditions, the predicted number of steelhead redds based on the 23.2°C temperature criterion was about twice as high as under the more conservative 20°C temperature criterion.”*

- Stillwater Sciences (2012) identify the downstream extent of thermally suitable habitat as the location in each sub-basin where the Mean Weekly Average Temperature (MWAT) was measured or predicted to exceed a specified value.

  The MWAT is found by calculating the mathematical mean of multiple, equally spaced, daily water temperatures over a 7-day consecutive period. The MWAT is defined as the highest value calculated for all possible 7-day periods (the maximum 7-day running average of daily mean temperature) over a given time period, which usually extends over the summer or is commensurate to the duration of a salmonid lifestage.

Water temperature data used in the RIPPLE evaluations are presented in Appendix B, Figures B-1 and B-2 as HFAM water temperature model output plotted as the 7-day average of the daily average temperature for the South and Middle Yuba rivers. Similarly, water temperature data for the North Yuba River are presented in Figure C-1 as the 7-day average of the daily average temperature. However, MWAT is not specified in these figures in the sense that for any given day, it is not clear what 7-day period that specific value represents.

Also, the use of a single water temperature measurement such as MWAT is convenient from a monitoring and regulatory standpoint, but oversimplifies the complex interactions between water temperature regimes and fish health that are affected by the duration of peak and daily average temperatures.

- ☐ Stillwater Sciences (2012, page 18) – "*For modeling purposes it was assumed that all tributaries are thermally suitable for steelhead rearing...*"

  By contrast, a review of Stillwater Sciences (2012) did not find any similar statement regarding the thermal suitability of tributaries for spring-run Chinook salmon rearing. It is unclear why the above assumption of thermal suitability for steelhead rearing also was not made for spring-run Chinook salmon. The only indication in the report were statements on pages 20 and 21 that, in general, tributaries to the South and Middle Yuba rivers and small tributaries to the New Bullards Bar sub-basin were not considered potential habitat for spring-run Chinook salmon due to channel gradient, channel width, water temperature, or a combination of these factors. However, the report does not indicate which of these factors limit potential habitat. Clarification should be provided.

2.2 Alternative Management Scenarios

ISSUE

As described in Stillwater Sciences (2012, page 14), *"Alternative management scenarios were developed based on the ability of water storage projects (Yuba River Development Project [YRDP] and the Yuba Bear/Drum Spaulding [YBDS] Project) to alter instream flow releases to improve habitat for anadromous salmonids. ...The alternative management scenarios were [therefore] targeted toward reducing water temperatures in the critical summer months through additional instream flow releases below Project dams..."*

COMMENT

The comments provided below generally pertain to the methodology and assumptions that Stillwater Sciences (2012) used to define and model the RIPPLE alternative management scenarios "Alternative Scenario 1" and "Alternative Scenario 2".

The manner in which the Alternative Management Scenarios are presented in Stillwater Sciences (2012) is particularly perplexing. Stillwater Sciences (2012, page 35) "*In the MY sub-basin, Alternative Management Scenarios 1 and 2 were assumed to represent increased summer releases from Milton Dam of 50 and 100 cfs, respectively. In the SY sub-basin, Alternative Management Scenario 1 was assumed to represent increased summer releases of 50 cfs from Spaulding Dam and 50 cfs from Bowman Dam, equating to an increase of 100 cfs in the South Yuba River downstream of Canyon Creek. Alternative Management Scenario 2 was assumed to represent increased summer releases of 100 cfs from Spaulding Dam and 100 cfs from Bowman Dam, equating to a total increase of 200 cfs in the South Yuba River downstream of Canyon Creek.*"

From the preceding statements, it is unclear how these Alternative Management Scenarios were developed. From the text, it appears as if Stillwater Sciences (2012) used output from a sensitivity analysis that was conducted for PG&E and NID, identified downstream locations for specific water temperature values based upon that analysis, then used those results and assumed specific, constant rates of increased releases year-round from the upstream projects of the amounts specified in the sensitivity analysis. There are several concerns with this approach.

First, Stillwater Sciences (2012) is indirectly stating that it is irrelevant what the "augmented" flow releases actually are and, instead, simply assumed that target water temperatures are achieved at downstream locations. This is an unrealistic operational assumption.

Second, the apparent utilization of a sensitivity analysis included an assumption that the upstream reservoirs are full at the beginning of every water year as an annual boundary condition, which may not be correct. The "augmented" rates of releases would result in carryover storage conditions less than full on frequent occasions.

Third, assumed releases at the "augmented" rates would deplete reservoir storage and could result in zero storage over a multi-year time series. This, in turn, would prohibit achieving the downstream water temperature targets due to a diminished coldwater pool that was not taken into account in the "sensitivity analyses".

ISSUE

Stillwater Sciences (2012, page 21) state *"The small tributaries in this sub-basin were not suitable for spring-run Chinook salmon due to channel gradient, channel width, water temperature, or a combination of these factors. Under this scenario it was assumed that water* *temperature would be suitable for all life stages of spring-run Chinook salmon at all times of year."*

COMMENT

The foregoing statement regarding water temperature suitability for spring-run Chinook salmon in the New Bullards Bar sub-basin under Scenario 1 is contradictory, and clarification should be provided.

Moreover, review of the Stillwater Sciences (2012) report was unable to find the location of the point in the tributaries at which suitability or unsuitability was identified, nor the reason for such a determination.

ISSUE

Stillwater Sciences (2012, page 15) state *"Alternative Management Scenario 2 approaches a reasonable upper limit on the extent of habitat that could be usable under optimal conditions."*

COMMENT

This conclusionary statement regarding the "reasonableness" of Alternative Management Scenario 2 is not supported in Stillwater Sciences (2012). In fact, the "reasonableness" of Alternative Management Scenario 2 is very much in question [see previous comments regarding the ability to sustain the assumed flow release rates, reservoir storage depletion, and inability to achieve downstream target water temperatures].

ISSUE

When presenting the expected effects of Alternative Management Scenario 1 on the downstream extent of thermally suitable habitat for steelhead spawning and summer rearing in the South Yuba sub-basin, Stillwater Sciences (2012, page 21) state that Scenario 1 "*…would provide thermally suitable habitat in 11.0 miles of the mainstem South Yuba River*", and describe the method used by stating *"A 'warming rate' (°C/river mile) was used to determine the downstream extent of suitable steelhead summer rearing in the mainstem. The downstream extent of spring-run Chinook salmon holding under Alternative Management Scenario 1 was used as a starting point. Based on the target MWAT for spring-run Chinook salmon holding of ≤ 19°C and the target MWAT for steelhead spawning and rearing of ≤ 20°C, the warming rate was used to determine the mainstem location downstream of the spring-run Chinook salmon holding extent where a 1°C increase in MWAT would occur. The warming rate for Alternative Management Scenario 1 was calculated using the HFAM water temperature model output on August 1, 2009 (the date on which the approximate annual daily maximum occurred) at upstream and downstream model nodes."*

COMMENT

Besides the foregoing general statements, Stillwater Sciences (2012) does not actually describe the methodology that was used to determine the downstream extent of thermally suitable habitat for spring-run Chinook salmon under Alternative Management Scenario 1 and Alternative Management Scenario 2. Nor does Stillwater Sciences (2012) describe methodology used to determine the downstream extent of thermally suitable habitat for steelhead under Alternative Management Scenario 1 and Alternative Management Scenario 2.

ISSUE

As described in Stillwater Sciences (2012, page 14), *"In the NBB sub-basin, the alternative management scenarios also include augmenting spawning gravel, which is currently limited below New Bullards Bar Dam (Nikirk and Mesick 2006)."*

Stillwater Sciences (2012, page ES-4) states *"In the NBB sub-basin, the alternative management scenarios also include augmenting spawning gravel, which is currently limited below New Bullards Bar Dam..".*

Stillwater Sciences (2012, page 21) states *"Scenario 1 also assumes that a gravel augmentation program would be implemented to restore spawning habitat to approximately 50% of its unimpaired extent… approximated based on the usable spawning habitat fraction calculated from the total spawning gravel area in the SY and MY sub-basins. It was assumed that the fraction of suitable spawning habitat in the SY and MY sub-basins provides a reasonable approximation of the spawning gravel that would be available in the mainstem river in the NBB sub-basin following gravel augmentation."*

COMMENT

The gravel augmentation program for the North Yuba River downstream of New Bullards Bar Dam evaluated in Stillwater Sciences (2012) is speculative, and unsupported. Stillwater Sciences (2012) assume that the Alternative Management Scenarios include a gravel augmentation program, assume that it would be implemented by an unidentified agency, assume a value of "*approximately 50% of its unimpaired extent*", which was assumed to be equivalent to the usable spawning habitat fraction (of total spawning gravel area) in the South Yuba and Middle Yuba rivers. Moreover, it was assumed that the introduction of gravel would result in spawning habitat, although this reach is characterized by very large boulders which may necessitate sculpting and restructuring of the streambed to actually provide spawning habitat.

3.0 Specific Comments

In addition to the major concerns presented above, review of Stillwater Sciences (2012) identified numerous specific comments. Specific comments are provided below, generally organized by sections provided in the Stillwater Sciences (2012) report.

3.1 Hydraulic Geometry in the North Yuba River Sub-basin

ISSUE

Stillwater Sciences (2012, page 30) state that the GEO module hydraulic geometry relationships for the North Yuba sub-basin under current conditions were developed "*from channel widths and depths at 25 sites in the NY sub-basin (Appendix D and Appendix E).*" The relationships developed for the North Yuba sub-basin were presented in Table 5-1 and Figures 5-1, 5-2 and 5-3. These relationships were based on the calculated drainage areas (km²), and the widths and depths (m) of 25 sites measured under bankfull and summer low flow conditions displayed in Table D-1 (Appendix D). Table E-1 (Appendix E) displays mean daily flows (cfs), drainage areas (km²), GIS slopes, surveyed reach length (m), the widths and depths under bankfull and summer low flow condition and habitat type characteristics for a subset of 12 sites out of the 25 sites displayed in Table D-1.

COMMENT

First, for the North Yuba sub-basin, Stillwater Sciences (2012) does not explain the basis for selecting the subset of 12 sites as a subsample from the 25 sites. Such an explanation should be provided.

Second, the 12 reach sites displayed in Table E-1 are a subset from the 25 sites reported in Table D-1 (the sites with an ID beginning in H). However, the reach lengths of those sites displayed in Table D-1 do not coincide with the measured reach lengths displayed in Table E-1. Clarification should be provided regarding these differences.

Third, it is unclear what length measurements were used to estimate the percent of length for pools, riffles and runs, which are displayed in Table E-1.

ISSUE

Stillwater Sciences (2012, page 30) explain that "*Surveys did not include estimates of width or depth at winter baseflow. Winter baseflow width at the NY survey sites was therefore estimated by scaling the bankfull width by 0.85, <u>the ratio of winter baseflow width and bankful width at the NY gage site below Goodyear's Bar</u> (USGS gage # 11413000).*"

COMMENT

Examination of Table E-1 indicates a rather large variation in bankfull widths among sites in the North Yuba sub-basin, particularly between the tributary sites and the mainstem sites. Stillwater Sciences (2012) does not provide any information regarding the appropriateness of applying the ratio at the North Yuba gage site below Goodyear's Bar to all sites in the North Yuba River. Such an explanation should be provided.

Also, Table D-2 displays model flows and drainage area for USGS gage #11413000 but it does not display the baseflow and bankfull widths. The values of the baseflow and bankfull widths at USGS gage #11413000 should be provided.

3.2 Hydraulic Geometry in the Middle and South Yuba River Sub-basins under Current Conditions

ISSUE

Stillwater Sciences (2012, page 32) state "*Channel widths and depths at the model flows were predicted at each of the 12 survey sites in the MY and SY using best fit power law regressions relating reported widths and depths to modeled discharges at a cross section within each site (USGS unpubl. data) (Appendix D, Table D-4).*"

COMMENT

The coefficients α and β of these power relationships ($W = \alpha\, Q^{\beta}$ and $D = \alpha\, Q^{\beta}$) were displayed in Table D-4. However, the coefficients of determination and levels of significance for the "*best fit power law regressions*" of the 12 South and Middle River sites in Table D-4 were not provided. They should be provided in order to evaluate these predictive relationships.

ISSUE

Stillwater Sciences (2012, page 32) explain that "*Channel widths and depths at the model flows were predicted at each of the 12 survey sites in the MY and SY using best fit power law regressions relating reported widths and depths to modeled discharges at a cross section within each site (USGS unpubl. data). Bankfull hydraulic geometry relationships for the MY and SY sub-basins were then developed from best fit power law functions relating drainage area to estimated bankfull widths and depths at the 12 MY and SY sites, as well as seven small drainage area sites in the NY sub-basin surveyed by NMFS (Appendix D, Table D-1). Data from the NY sub-basin were included in the bankfull hydraulic geometry relationships for the MY and SY sub-basins because these NY sites have small drainage areas typical of unimpaired tributaries throughout the upper Yuba project area.*"

COMMENT

First, inclusion of North Yuba River sites with those of the South and Middle Yuba rivers is of questionable appropriateness given that the data from the 7 North Yuba River sites were measured depths and widths, whereas the South and Middle Yuba river sites were depths and widths derived from regression equations.

Second, inclusion of the North Yuba River sites in the predicted equations for the South and Middle Yuba rivers changes the relationship predicting bankfull width (response variable) from drainage area (explanatory variable). **Figure 1** below, generated using the data presented in Tables D-1, D-2, D3 and D-4, illustrates the importance of the added data from the 7 North Yuba River sites to the 12 South and Middle Yuba river sites in the best fit power law function relating bankfull widths to drainage area in the South and Middle Yuba rivers.

In Figure 1, the red line is the best fit power law function obtained with the addition of the 7 North Yuba River sites (akin to the line represented in Figure 5-4 of Stillwater Sciences (2012)).

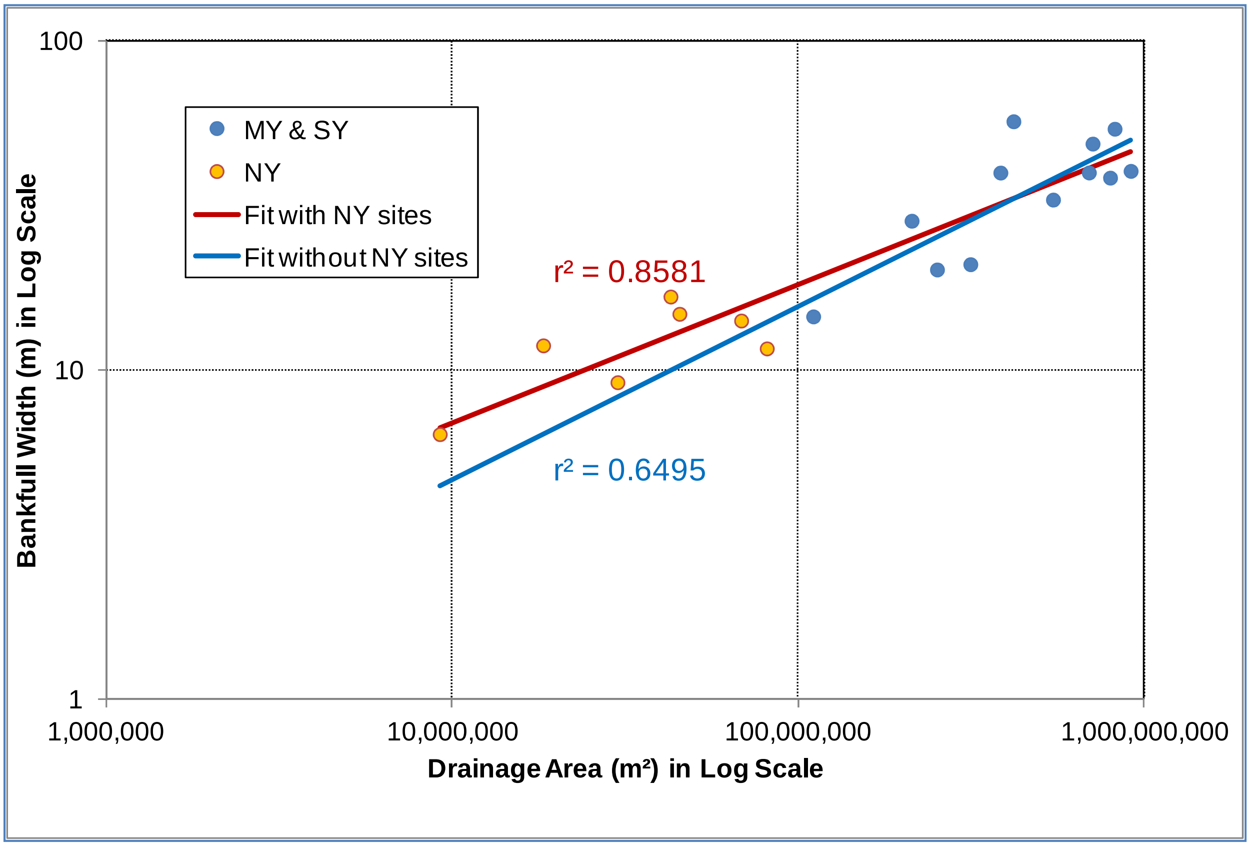

Figure 1. Relationships of bankfull width expressed as function of drainage area obtained from data for 12 Middle Yuba and South Yuba sites (blue circles, blue line) and with the addition of 7 North Yuba sites (orange circles, red line).

ISSUE

Stillwater Sciences (2012, page 32) states *"Linear functions were developed to relate hydraulic geometry at winter baseflow and summer low flow to that at bankfull flow (Table 5-1 and Figures 5-5 and 5-6)."*

COMMENT

First, the methodology in Stillwater Sciences (2012) appears to be inconsistent. By contrast to the regressions estimating bankfull widths and depth to drainage area, where the 7 North Yuba River sites were added to the 12 South and Middle Yuba River sites, the North Yuba River sites were not included in the linear regressions estimating: (1) winter baseflow and summer low flow widths (response variables) from bankfull width (explanatory variable) (Figure 5-5 in Stillwater Sciences (2012)); and (2) summer low flow depths (response variables) from bankfull depth (explanatory variable) (Figure 5-6 in Stillwater Sciences (2012)). Stillwater Sciences (2012) does not provide any explanation regarding this apparent discrepancy.

Second, the linear functions relating winter baseflow and summer low flow widths to bankfull width (Figure 5-5 in Stillwater Sciences (2012)) and those relating summer low flow depth to bankfull depth (Figure 5-6 in Stillwater Sciences (2012)) were based on only 11 South and Middle Yuba river sites. Stillwater Sciences (2012) provides no explanation addressing why a data point was dropped for the analyses.

- ☐ What was the reason for dropping one data point from the calculations that resulted in the regressions illustrated in Figure 5-5 and Figure 5-6?
- ☐ What site was dropped from the regression calculations?
- ☐ Did the authors evaluate the implications of such action on the RIPPLE model's predictions of spring-run Chinook salmon holding and juvenile rearing habitats and steelhead spawning and juvenile rearing habitats in the South and Middle Yuba sub-basins?

Figure 2 was created to illustrate some issues associated with dropping one site from the data used to estimate the linear relationship between summer low flow width and bankfull width in the South Yuba and Middle Yuba sub-basins. To generate Figure 2, it was assumed that data from the Jones Bar Gage site in the South Yuba River was excluded from the regression calculation. This assumption is supported by taking the summer low flow and bankfull flow values presented in Table D-3 and applying the regressing equations in Table D-4 for all of the 12 sites, then identifying which one was excluded from Figure 5-5 in Stillwater Sciences (2012). In Figure 2, the blue line represents the linear relationship between summer low flow width and bankfull width that would be expected from using the data for all 12 sites, whereas the red line represents the linear relationship obtained from using data from only 11 sites akin to the regression used in the current implementation of the RIPPLE model (Figure 5-5).

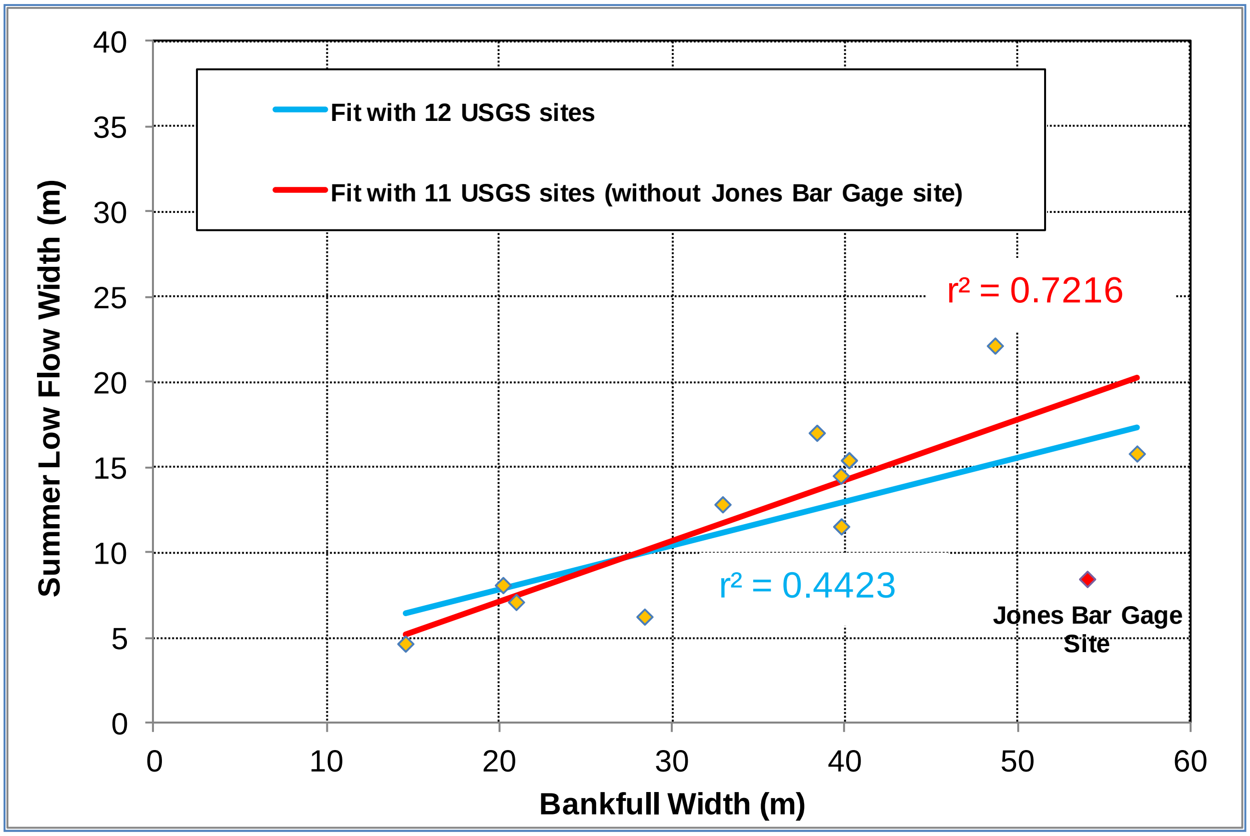

Figure 2. Relationships of summer low flow width expressed as function of bankfull width obtained with data from 12 Middle Yuba River and South Yuba River sites (blue line) and with data from only 11 sites (red line).

The Stillwater Sciences (2012) exclusion of the one data point increased the coefficient of determination (r^2) by 28%. In other words, using all 12 data points only 44% of the variation in summer low flow width could be accounted for by bankfull width, by contrast to exclusion of the Jones Bar Gage site whereby 72% of the variation in summer low flow width could be accounted for by bankfull width. In regression analyses, some data points identified as outliers can be excluded from the estimation, but only after careful consideration of its impact on the resulting regression line and for reasons other than those purely statistical (*e.g.*, suspected bad measurement). No explanation, statistical or otherwise, is provided in Stillwater Sciences (2012) for the exclusion of one data point from the regressions in Figure 5-5 or Figure 5-6.

The implications of Stillwater Sciences (2012) using the 11-point regression line rather than the 12-point regression line can be inferred by comparing the summer low flow widths predicted by both regressions (see Figure 2). The 11-point regression line predicts narrower summer low flow widths than the 12-point regression line for bankfull widths less than 29.6 m. Therefore, under current conditions, Stillwater Sciences (2012) use of the 11-point regression line influences the RIPPLE model's habitat predictions. Relative to the full (12-point) data set, the Stillwater Sciences (2012) regression equation predicts narrower summer low flow widths for bankfull widths less than 29.6 m, and predicts wider summer low flow widths for bankfull widths more than 29.6 m. One example of the implications of using the Stillwater Sciences (2012) regression is that the prediction of narrower summer low flow widths (for areas with bankfull widths less than 29.6 m) may eliminate some areas of suitable habitat, because the RIPPLE model assumes that channels with summer low flow widths less than 8.5 m are too narrow to provide holding pools with suitable depths or spawning habitat for spring-run Chinook salmon (Stillwater Sciences 2012, page 16).

3.3 Hydraulic Geometry in the Middle and South Yuba River Sub-basins under Alternative Management Scenarios

ISSUE

Stillwater Sciences (2012, page 34) state "*to model the potential benefits of Alternative Management Scenarios 1 and 2 on aquatic habitat in the mainstem Middle Yuba and South Yuba rivers using RIPPLE, unique hydraulic geometry relationships were developed for augmented summer low flows at the 12 USGS survey sites located in the MY and SY sub-basins (Appendix D, Table D-6).*" Table D-6 was reproduced in **Table 1** below. The values for the estimated summer low flow discharges corresponding to the table columns labeled "+50 cfs", "+100 cfs" and "+200 cfs" were calculated as the summer low flows under current conditions plus additional 50 cfs, 100 cfs and 200 cfs. The estimated summer low flow widths were then calculated by applying the power relationships in Table D-4 in Stillwater Sciences (2012) to the estimated summer low flow discharges. Linear functions relating width and depth at summer low flow to bankfull width and depth were then developed for use in the RIPPLE model (Figure 5-7 and Figure 5-8 in Stillwater Sciences (2012)).

COMMENT

First, there are errors in Table D-6 in Stillwater Sciences (2012) (see area highlighted in yellow in Table 1).

Second, the methodology in Stillwater Sciences (2012) appears to be inconsistent. By contrast to the regressions that regulate the hydraulic geometry relationships in the South and Middle Yuba sub-basins under current conditions based upon 11 data points, 12 data points were used to develop the linear functions relating width and depth at summer low flow to bankfull width and depth under Alternative Management Scenarios (Figure 5-7 and Figure 5-8 in Stillwater Sciences (2012)). Stillwater Sciences (2012) does not provide any explanation regarding this discrepancy.

Table 1. Estimated summer low flow discharge and corresponding channel width at 12 USGS survey sites under current conditions (CC) and for the additional flow releases specified under Alternative Management Scenarios 1 and 2. Source: Table D-6 in Stillwater Sciences (2012).

Cross section locations	Sub-basin	Estimated summer low discharge (cfs)				Estimated summer low width (m)			
		CC	+50 cfs	+100 cfs	+200 cfs	CC	+50 cfs	+100 cfs	+200 cfs
Laing's Crossing	SY	18	68	118	218	7.1	9.8	11.1	12.9
Lower Golden Quartz Picnic Ground	SY	23	73	123	223	14.6	18.9	21.2	24.2
Downstream of Humbug Creek	SY	41	141	241	241	11.6	14.4	16.3	18.8
Edwards Crossing below Kenebek Creek	SY	42	142	242	242	22.2	25.4	27.4	30.1
Upstream of Hwy 49 above Hoyt Crossing	SY	47	147	247	247	17.1	19.4	21.0	23.0
Jones Bar Gage	SY	48	148	248	248	8.5	11.4	13.5	16.6
Below Bridgeport	SY	54	154	254	254	15.5	17.8	19.3	21.5
Downstream of Milton Reservoir (#1)	MY	12	62	112	212	4.7	7.3	8.6	10.2
Upstream of Gates of Antipodes (#1)	MY	23	73	123	223	6.3	9.5	11.5	14.3
Gold Canyon at Seven Spot Mine	MY	27	77	127	227	8.1	10.2	11.4	12.9
Upstream of Oregon Creek	MY	45	95	145	245	15.8	19.9	22.7	26.6
Upstream of MY confluence	MY	59	109	159	259	12.9	14.8	16.1	18.0

This discrepancy introduced bias in the estimated summer low flow widths and depths of the different mainstem reaches of the South Yuba River, Canyon Creek and Middle Yuba River under current conditions, compared to the Alternative Management Scenarios. Under the Alternative Management Scenarios, using the three regression lines that were derived using 12 data points can be expected to predict relatively wider summer flow widths for bankfull widths less than 29.6 m relative to those that would have been obtained from using 11-point regression lines.

Third, the modeling of the Alternative Management Scenarios assumes that the additional releases from upstream reservoir storage remain constant over the entire longitudinal distribution of each river/reaches evaluated without taking into account depletion (e.g., bank storage, etc.). This assumption overestimates stream width in downstream areas, and thereby overestimates habitat availability.

3.4 Habitat Module (HAB)

3.4.1 Stratification of HAB Parameters by Gradient Class

ISSUE

Five gradient classes (0-1%, 1-2%, 2-4%, 4-8% and 8-12%) were used to stratify the HAB model parameters and model habitat for both spring-run Chinook salon and steelhead. Stillwater

Sciences (2012, page 38) state that gradients greater than 12% were not included in the modeled channel network because "*gradients greater than 12% were not considered passable by spring-run Chinook salmon or steelhead.*" [emphasis added]

COMMENT

First, the ranges of gradients for the five gradient classes are different – smaller for the first two classes and larger for the last gradient class. Clarification should be provided regarding the basis for the selection of these particular five gradient classes.

Second, the explanation that gradients greater than 12% were not included in the modeled channel network because "*gradients greater than 12% were not considered passable by spring-run Chinook salmon or steelhead*" is not consistent with the explanations provided earlier in Stillwater Sciences (2012, page 18) where it is stated that "*to define the upstream extent of modeled steelhead habitat in tributaries in each sub-basin it was assumed that adult steelhead migrating to spawning areas in the winter and spring could not pass any portion of the channel network with a gradient of 20% or greater, or with a sustained (> 300 m [984 ft]) gradient of 8% or greater (CDFG 2003).*" Clarification should be provided regarding why a gradient class of 12-20% apparently was not used to model the channel network for steelhead.

3.4.2 Habitat Type Fractions for the South and Middle Yuba River Sub-basins

ISSUE

Stillwater Sciences (2012, page 38) state that "*habitat typing data collected in the upper Yuba River basin were used to calculate habitat type fraction as parameters for each model sub-basin*" and present the resulting habitat type fractions per gradient class in Appendix F (Table F-1). The values in Table F-1 were used to parameterize the HAB module for both spring-run Chinook salmon and steelhead under the current conditions and both Alternative Management Scenarios.

Stillwater Sciences (2012, page 38) state that "*for the SY and MY sub-basins, remotely derived and field-verified habitat typing data collected as part of the UYRSP rearing habitat assessment from approximately 69 km (43 mi) of mainstem South Yuba River and 73 km (45 mi) of the mainstem Middle Yuba River (Stillwater Sciences 2006b) were used to parameterize habitat type fraction.*"

In Stillwater Sciences (2006b) it is stated that the assessment was based on aerial photographs taken on October 16, 2002 and on digital aerial video taken during helicopter overflights on October 22, 23, and 24, 2002 when river flows were low (42 cfs in the South Yuba River at Jones Bar and 32 cfs in the Middle Yuba River below Our House Dam). Furthermore, Stillwater Sciences (2006b) state that the office-based habitat assessment resulted in approximately 1,100 unique habitat units each for the South Yuba and Middle Yuba rivers and provide a table (Table

1) indicating the 20 attributes recorded for each channel segment. These 20 attributes do not include measures of elevation or gradient.

COMMENT

First, it is unclear how many of the South Yuba and Middle Yuba mainstem reaches for which Stillwater Sciences (2006b) provided habitat typing data were actually used for the current RIPPLE application. Did the South Yuba and Middle Yuba mainstem reach demarcation in Stillwater Sciences (2006b) coincide with that used in the current RIPPLE application?

Second, given that elevation or gradient was not among the 20 attributes recorded for each of the approximately 1,100 unique habitat units identified by Stillwater Sciences (2006b) in the South Yuba and Middle Yuba mainstems, how were these habitat units stratified into the five gradient classes used by the current RIPPLE application to generate the habitat type fractions displayed in Table F-1?

Third, given that Stillwater Sciences (2006b) did not present tables or appendices summarizing the information for the approximately 1,100 habitat units each identified in the South Yuba and Middle Yuba mainstems, why did the current RIPPLE report not include a table or tables summarizing the relevant South Yuba and Middle Yuba habitat type information, as was done for the information on the North Yuba sub-basin (e.g., Table E-1)?

Fourth, Stillwater Sciences (2006b) assessed habitat type in approximately 69 km of the mainstem South Yuba River and in approximately 73 km of the mainstem Middle Yuba River. Map 3 in Stillwater Sciences (2012) indicates that most reaches along the South Yuba and Middle Yuba mainstem have low gradients (0-2%) while the South Yuba and Middle Yuba tributaries have gradients greater than 2%. Were the South Yuba and Middle Yuba habitat type fractions per gradient class in Table F-1 used to parameterize habitat type fractions in tributary reaches of the South and Middle Yuba? If so, wouldn't the habitat type fractions in Table F-1 in Stillwater Sciences (2012) that were based on the sampling of South Yuba and Middle Yuba mainstem reaches be unreliable to parameterize the habitat type fractions in South Yuba and Middle Yuba tributary reaches?

3.4.3 Habitat Type Fractions for the North Yuba River Sub-basin

ISSUE

Stillwater Sciences (2012, page 38) state "*for the NY sub-basin, habitat typing data collected by NMFS in fall 2010 were used to parameterize the HAB module*." The NMFS data consisted of 12 sites, each with 10 to 15 habitat units selected specially for the present RIPPLE study from a range of North Yuba drainage areas and gradient classes (0 to 8%). The surveyed sites did not include sites with gradients higher than 8%.

The data for the 12 North Yuba sites was summarized in Table E-1 in Stillwater Sciences (2012), while Tables E-2 to E-13 provided site-specific information. The resulting North Yuba habitat type fractions per gradient class were displayed in Table F-1. As a note to Table F-1, Stillwater Sciences (2012, page F-1) state that "*NMFS did not collect data at sites with gradients greater than 8% in the NY; therefore combined MY and SY data were used*" to represent the North Yuba habitat type fractions for the 8-12% gradient class.

COMMENT

The 12 North Yuba sites summarized in Table E-1 consist of 7 mainstem sites and 5 tributary sites, 3 sites per gradient class with the exception of the 8-12% gradient class.

- ☐ What procedure was used for the selection of the 12 sites (e.g., simple random selection, random selection stratified by gradient class, random selection stratified by general location – mainstem vs. tributaries)?
- ☐ Were all reaches included in the selection or only those logistically more accessible?

ISSUE

The North Yuba habitat fractions displayed in Table F-1 were based on information from the 12 North Yuba sites summarized in Table E-1. The 12 surveyed sites corresponded to a total sampled length of 5.4 km (4.0 km in the mainstem and 1.4 km in tributaries). Stillwater Sciences (2012, page 38) used the assessment of approximately 69 km of mainstem South Yuba River and 73 km of mainstem Middle Yuba River to generate the South Yuba and Middle Yuba habitat fractions displayed in Table F-1. All the habitat fractions in Table F-1 are expressed as percent channel length.

COMMENT

Given that such a small percentage of the entire North Yuba River was surveyed, by contrast to the large area used to estimate habitat fractions for the South and Middle Yuba rivers as indicated in Stillwater Sciences (2012), was any assessment conducted to determine whether this biased the results?

ISSUE

Table E-1 displays the habitat type fractions for pool, riffle and run expressed as percent length (and percent area) for each of the 12 North Yuba sites surveyed by NMFS. Table F-1 displays the North Yuba habitat type fractions as percent length for pool, riffle, run and cascade for the gradient classes 0-1%, 1-2%, 2-4% and 4-8%. The values in Table F-1 are not the simple average per gradient class of the habitat type fractions in Table E-1.

COMMENT

Stillwater Sciences (2012) does not provide an explanation of the methods of how the fractions in Table F-1 may have been generated from those in Table E-1.

What procedure was used? Were the fractions in Table E-1 scaled by the length of the corresponding gradient class for the entire sub-basin? Explanation should be provided.

ISSUE

As a note to Table F-1, Stillwater Sciences (2012) state that "*NMFS did not collect data at sites with gradients greater than 8% in the NY; therefore combined MY and SY data were used*" to represent the North Yuba habitat type fractions for the 8-12% gradient class.

COMMENT

Stillwater Sciences (2012) does not provide an explanation of the methods of how the Middle Yuba and South Yuba habitat typing data was "combined".

What procedure (e.g., average, weighted average) was used to "combine" the Middle Yuba and South Yuba habitat typing data to produce the North Yuba habitat type fractions displayed in Table F-1 for the 8-12% gradient class?

ISSUE

In Table E-1, the Upper Lavezolla Creek habitat type fractions (by length) are 27.1%, 59.1% and 13.8% for pool, riffle and run, respectively. Table E-2 displays the detailed information for Upper Lavezolla Creek that presumably was used to obtain the percentages in Table E-1. Calculations based on the lengths of the Upper Lavezolla Creek habitat units in Table E-2 produced habitat type fractions of 24.0%, 43.9% and 32.1% for pool, riffle and run, respectively. Additional habitat type fraction calculation discrepancies occur in other reaches, in addition to Upper Lavezolla Creek.

COMMENT

Why were the Upper Lavezolla Creek habitat type fractions presented in Table E-1 as 27.1%, 59.1% and 13.8% for pool, riffle and run, respectively, when the detailed data (Table E-2) yield fractions of 24.0%, 43.9% and 32.1%, respectively?

Are the percentages in Table E-1 just a typographical error, or an error that was passed on and affected the habitat type fractions of the North Yuba sub-basin in Table F-1?

If the habitat type fractions in Table E-1 are erroneous and were passed on to Table F-1, wouldn't other subsequent calculations and the HAB results also be erroneous?

3.4.4 Habitat Type Fractions for the New Bullards Bar Sub-basin

ISSUE

Stillwater Sciences (2012, page 38) state "*for the NBB sub-basin, habitat typing data provided by HDR/DTA from field survey of approximately 1.6 km (1 mi) upstream and downstream of Colgate Powerhouse were utilized (K. Peacock, HDR/DTA, Bellingham, Washington, pers. comm., 1 December 2010).*" Stillwater Sciences (2012, page 38) state that because the New Bullards Bar data were not gradient class-specific, equal fractions of each habitat type (pool = 0.496, riffle = 0.163, run = 0.341 and cascade = 0) were assigned to the five gradient categories in Table F-1.

COMMENT

Why were equal fractions of each habitat type assigned to the five gradient categories? Was it not possible to estimate the location of the habitat units and derive the local gradient?

The New Bullards Bar habitat typing data came from a field survey approximately 1 mile upstream and downstream of Colgate Powerhouse. Based on Map 3, this surveyed habitat units likely corresponded to the gradient classes 0-1% or 1-2%. Consequently, the assumption that the five gradient classes have the same habitat type fractions is questionable. The current New Bullards Bar habitat type fractions (pool = 0.496, riffle = 0.163, run = 0.341 and cascade = 0) are likely appropriate for the 0-2% gradient classes, but may not be appropriate for gradient classes greater than 2%.

3.5 Spring-Run Chinook Salmon Densities and Usable Fractions

3.5.1 Holding Density and Usable Fraction

ISSUE

Stillwater Sciences (2012, page 38) state "…*Spring-run Chinook salmon holding density values were parameterized based on examination of photographs of spring-run Chinook salmon holding at high density in Butte Creek, California. From these photographs, it was our professional judgment that spring-run Chinook salmon can hold at densities ranging from 0.5–1.5 fish/m2 (Stillwater Sciences 2003).*"

COMMENT

Stillwater Sciences (2012) should describe or provide an explanation of the basis for "professional judgment" in assumed holding densities. Examination of the referenced document (Stillwater Sciences 2003) did not yield any additional discussion of specific methodology to support the assumed holding densities. Were the photographs overlayed by a grid, and densities calculated? Was the total pool area estimated and the total number of fish counted to derive holding density? Explanation should be provided.

ISSUE

Stillwater Sciences (2012, page 38) state "*…The portion of each holding pool suitable for holding was then calculated by applying a scaling factor*." Stillwater Sciences (2012) further state "*The suitable area of each holding pool was assumed to be, on average, 50% under current conditions and 75% under the two alternative management scenarios (Scenarios 1 and 2)… it was assumed that increased flow would provide more substantial increases in pool depth, the extent of the bubble curtain and whitewater at the pool head, the length of the pool tail, and the concentration of dissolved oxygen. All of these factors could increase the amount of suitable holding habitat in each pool. Holding pool area was therefore multiplied by 0.5 (for current conditions) or 0.75 (for the two alternative management scenarios) to derive the total amount of holding habitat in the MY and SY sub-basins (Appendix F, Table F-2)*." [emphasis added]

COMMENT

First, the assumption that increased flow would provide more substantial increases in pool depth (relative to pool area) is not necessarily a valid assumption. Pool depth can change very little with change in flow.

Second, Stillwater Sciences (2012) acknowledge that the "scaling factors" were based on a series of assumptions that are not supported by data analyses or referenced documents. However, the assumed scaling factor (0.75) for the Alternative Management Scenarios increased the estimates of suitable spring-run Chinook salmon holding habitat by an additional 50%, relative to the current condition (0.75/0.5 = 1.5). Thus, not only do these assumptions increase holding habitat by an additional 50% in the Middle and South Yuba rivers under the Alternative Management Scenarios compared to the current conditions, these assumptions also inflate habitat values in the Middle and South Yuba rivers relative to the North Yuba River.

ISSUE

Stillwater Sciences (2012) state that for the mainstem Middle Yuba and South Yuba rivers the fraction of usable holding habitat was determined "*by comparing the number of suitable holding pools (Vogel 2006) to the total number of pools (Stillwater Sciences 2006b) located in the mainstem Middle Yuba and South Yuba rivers*." The intermediate and final values in the calculation of the usable fraction of pools in South Yuba and Middle Yuba reaches under current conditions and the two alternative scenarios were displayed in Table F-2 (see **Table 2**, below).

Stillwater Sciences (2012, page 39) state "*No data on the number of holding pools were available for the NY or NBB sub-basins; therefore data from the SY and MY were stratified by gradient category and used to derive usable holding fraction parameters for the NY and NBB sub-basins (Appendix F, Table F-3). Additional detail on the methods and results of the usable fraction analysis for holding habitat are provided in Appendix F, Tables F-2 and F-3*." Table F-3 is reproduced below as **Table 3**.

COMMENT

There are several concerns associated with calculation and representation of "usable fractions" of spring-run Chinook salmon holding habitat, particularly in the North Yuba River.

First, Stillwater Sciences (2012) statement that no data on the number of holding pools were available for the North Yuba River is not correct. As part of the Yuba Salmon Forum process, a draft habitat mapping report titled "*Study 1.0 Yuba River Salmon Forum Studies Habitat Mapping Report*" was available as of September 2011 (YCWA 2011a), in advance of Stillwater Sciences (2012) report which was issued during February 2012.

Second, methods used in Stillwater Sciences (2012) for the Middle and South Yuba rivers appear to be different than the methods used for the North Yuba River and New Bullards Bar sub-basin. Consequently, it is questionable whether the resulting spring-run Chinook salmon holding carrying capacities among these river/reaches can be compared.

The method presented in Stillwater Sciences (2012) to derive the usable fractions of pools applied to the South Yuba and Middle Yuba sub-basins (Table F-2 in Stillwater Sciences (2012), reproduced as Table 2 below) is not comparable to the method used to derive the usable fractions of pools applied to the North Yuba and New Bullards Bar sub-basins (Table F-3 in Stillwater Sciences (2012), reproduced as Table 3 below).

- ☐ Why were the usable fractions of pools applied to the South Yuba and Middle Yuba sub-basins (see Table 2) derived from the number of holding pools and total pools that are "thermally suitable for holding", by contrast to the North Yuba and New Bullards Bar sub-basins where it does not appear that this was done?
- ☐ Why weren't the usable fractions of pools in Table 2 stratified by gradient class for application in the South Yuba and Middle Yuba sub-basins, as was done for the North Yuba and New Bullards Bar sub-basins? Does this inconsistency influence the resulting estimates of spring-run Chinook salmon holding capacity?
- ☐ Do the usable fractions of pools in Table 3 represent the usable holding fraction in the New Bullards Bar sub-basin under current conditions only? Was some other estimate of usable fraction of pools used for the New Bullards Bar sub-basin under the Alternative Management Scenarios?

Table 2. Usable fraction data and calculations for spring-run Chinook salmon holding habitat in the MY and SY sub-basins under each alternative scenario. The values in the last column were used to parameterize the RIPPLE HAB module for the SY and MY sub-basins. The same usable fraction values were applied to each gradient class since the data reflect the actual number of holding pools documented in each SY and MY reach. Source: Table F-2 in Stillwater Sciences (2012).

Sub-basin	Scenario[a]	River miles thermally suitable for holding[b]	Number of holding pools[c]	Number of total pools[d]	Fraction of pools that are holding pools	Fraction of each holding pool usable for holding	Usable fraction of pools in reach
SY	S1	7.0	7	57	0.12	0.75	0.09
SY	S2	15.3	12	117	0.10	0.75	0.08
MY	CC	2.3	12	32	0.38	0.50	0.19
MY	S1	11.9	17	117	0.15	0.75	0.11
MY	S2	22.5	21	209	0.10	0.75	0.08

[a] No habitat would be thermally suitable for holding in the SY under current conditions.

[b] Mainstem channels only.

[c] Source: Vogel (2006)

[d] Source: Stillwarer Sciences (2006b)

Table 3. Usable fraction of and calculations for spring-run Chinook salmon holding habitat for each channel gradient category in the SY and MY sub-basins. The values in the last column were used to parameterize the RIPPLE HAB module for the NY and NBB sub-basins. No data on the number of holding pools were available for the NY or NBB sub-basins; therefore data from the SY and MY were stratified by gradient category and used to derive usable holding fraction parameters for the NY and NBB sub-basins. Source: Table F-3 in Stillwater Sciences (2012).

Gradient Category	Number of holding pools in SY and MY	Number of total pools in SY and MY	Fraction of pools that are holding pools	Fraction of each holding pool usable for holding	Usable fraction of pools
0-1%	16	158	0.10	0.50	0.051
1-2%	25	348	0.07	0.50	0.036
2-4%	40	235	0.17	0.50	0.085
4-8%	14	83	0.17	0.50	0.084
8+%	5	16	0.31	0.50	0.156

3.5.2 Spawning Density and Usable Fraction

ISSUE

Stillwater Sciences (2012, page 39) state that "*spawning density data from the upper Yuba River basin were not available; therefore spawning density was calculated based on the mean redd size measured in the McKenzie River, Oregon: 5.4 m² (Stillwater Sciences 2006c).*" The report then goes on to justify the use of this value for mean redd size by stating *"... The redd size value of 5.4 m^2 was comparable to the mean redd size reported for spring-run Chinook salmon in a variety of published and unpublished sources (Table 6-2).*"

COMMENT

In July 2010 correspondence from Stillwater Sciences to NMFS regarding lower Yuba River components of the Habitat Expansion Plan, Stillwater Sciences state that an appropriate mean redd size estimate for spring-run Chinook salmon in the lower Yuba River would be derived "*…from a Sacramento River tributary with a spawning population of SRCS. The average size of SRCS redds in Mill Creek is 9.7 sq. m (C. Harvey, as cited in Ward et al. 2003).*"

As part of the Yuba Accord Monitoring and Evaluation (M&E) Program, the Yuba Accord River Management Team (RMT) has performed redd surveys in the lower Yuba River that included measurement of Chinook salmon redd sizes. Why weren't redd sizes obtained from these redd surveys in the lower Yuba River used to derive the spawning density estimate?

Also, it seems inconsistent that Stillwater Sciences would infer that a mean redd size of 9.7 m^2 should be assumed for the Habitat Expansion Plan, and then actually use a value of 5.4 m^2 to estimate carrying capacity of the Upper Yuba River Watershed. Clarification should be provided.

ISSUE

Stillwater Sciences (2012, page 40) state "*The estimated amount of spawning gravel area in 0–4% gradients was then apportioned among habitat types by assuming 80% of spawning gravel is in pools, 10% in riffles, 10% in runs, and 0% in cascades. This assumption was based on professional opinion and evidence from the literature that most spawning occurs in pool tails (Barnhart 1991, CDFG 1998a, b).*"

COMMENT

Definition of what constitutes spawning habitat is extremely important in the eventual estimation of carrying capacity. Stillwater Sciences (2012) assumption that "*…80% of spawning gravel is in pools, 10% in riffles, 10% in runs, and 0% in cascades*" was attributed to professional opinion and evidence from the literature that most spawning occurs in pool tails (Barnhart 1991, CDFG 1998a, b).

In this review of Stillwater Sciences (2012), Barnhart (1991) was not available. However, from the reference section provided in Stillwater Sciences (2012, page 70) it appears that the reference document addresses steelhead.

- ☐ Barnhart, R. A. 1991. Steelhead *Oncorhynchus mykiss*. Pages 324–336 in J. Stolz and J. Schnell, editors. The Wildlife Series: Trout. Stackpole Books. Harrisburg, Pennsylvania.

The "evidence" provided in CDFG (1998a) actually referred to a previous document as follows…*"Spawning occurs in gravel beds that are often located at tails of holding pools (USFWS 1995a)."* Review of USFWS (1995a) provided no additional evidence, data, reference to specific surveys or other information, but simply includes this exact quotation. Hence, this document does not state that most spawning occurs in pool tails – rather that spawning gravel beds are often located at the tails of holding pools.

Review of CDFG (1998b) resulted in identifying no reference to spring-run Chinook salmon spawning habitat.

Moreover, Stillwater Sciences (2012) does not provide scientific basis or rationale for assuming in their calculations that "*…80% of spawning gravel is in pools, 10% in riffles, 10% in runs, and 0% in cascades*" – quantifications that influence subsequent estimation of carrying capacity.

ISSUE

Stillwater Sciences (2012, page 40) state "*We assumed spring-run Chinook salmon spawning did not occur in riffles or runs with gradients ≥ 4%."*

COMMENT

Clarification should be provided regarding the basis for the assumption that spring-run Chinook salmon spawning did not occur in cascades and in rifles or runs with gradients greater or equal to 4% (Stillwater Sciences 2012, page 40 and Tables F-4 and F-5).

ISSUE

Stillwater Sciences (2012, pages 39 and 40) describe how the spring-run Chinook salmon spawning usable fractions displayed in Table F-4 were derived.

COMMENT

The explanation provided by Stillwater Sciences (2012) is not very clear particularly with respect to:

- ☐ The type of information contained in the gravel data collected by Nikirk and Mesick (2006) in the South Yuba, Middle Yuba and New Bullards Bar that was actually used in the calculations of spawning usable fractions (e.g., number of surveyed sites, measured variables per site, spawning area per site, etc).
- ☐ The procedure used to allocate the gravel data collected by Nikirk and Mesick (2006) in the South Yuba, Middle Yuba and New Bullards Bar sub-basins into the four gradient classes, three sub-basins and three habitat types in Table F-4.

3.5.3 Juvenile Rearing Density and Usable Fraction

ISSUE

Stillwater Sciences (2012) display the spring-run Chinook salmon summer juvenile densities and juvenile rearing usable fractions for each habitat type and channel gradient combination in Table F-6 (reproduced below as **Table 4**).

Stillwater Sciences (2012, page 40 through 41 and footnote to Table F-6) explain that, to obtain the juvenile densities in Table F-6, "*…juvenile spring-run Chinook salmon densities reported by Everest and Chapman (1972) (1.8 fish/m^2 and 0.5 fish/m^2 in 0-1% and 1-2% gradients, respectively) were apportioned by habitat type in proportion to mean habitat-specific (i.e., pool, riffle, and run) densities of juvenile spring-run Chinook salmon in 22 Idaho streams reported by Bjornn and Reiser (1991) (mean pool densities = 0.215 fish/m^2; mean riffle densities = 0.030 fish/m^2; mean run densities = 0.130 fish/m^2).*"

Table 4. Spring-run Chinook salmon juvenile summer rearing density and usable fraction values for each habitat type and channel gradient combination used to parameterize the RIPPLE HAB module for all sub-basins and scenarios. Source: Table F-6 in Stillwater Sciences (2012).

Gradient Category	Pool		Riffle		Runs	
	Density (fish/m^2)[a]	Usable fraction[2]	Density (fish/m^2)[a]	Usable fraction[2]	Density (fish/m^2)[a]	Usable fraction[b]
0-1%	2.829	1	0.395	1	1.711	1
1-2%	0.772	1	0.108	1	0.467	1
2-4%	0.772	0.75	0.108	0.75	0.467	0.75
4-8%	0.772	0.25	0.108	0.25	0.467	0.25

[a] Juvenile spring-run Chinook salmon densities reported by Everest and Chapman (1972) (1.8 fish/m^2 and 0.5 fish/m^2 in 0-1% and 1-2% gradients, respectively) were apportioned by habitat type in proportion to mean habitat-specific (i.e., pool, riffle, and run) densities of juvenile spring-run Chinook salmon in 22 Idaho streams reported by Bjornn and Reiser (1991) (mean pool densities = 0.215 fish/m^2; mean riffle densities = 0.030 fish/m^2; mean run densities = 0.130 fish/m^2).

[b] The 2–4% and 4–8% gradient classes were parameterized with the same density values as the 1–2% gradient class, but usable fractions were lowered to 0.75 and 0.25, respectively, to reflect the lower carrying capacity expected at higher gradients. Juvenile rearing densities and usable fractions were not changed between model scenarios.

COMMENT

Bjornn and Reiser (1991) reported the densities of juvenile spring-run Chinook salmon in four habitat types (pools, runs, pocket water and riffles) as a bar figure (Figure 4.35). The y-axis of this figure was scaled in units of 0.02 fish/m^2, and each bar indicates the average juvenile density and number of habitat units surveyed for each habitat type sampled in 1985 and 1986.

☐ Were the mean habitat-specific juvenile densities (mean pool densities = 0.215 fish/m²; mean riffle densities = 0.030 fish/m²; mean run densities = 0.130 fish/m²) used to calculate the juvenile densities in Table F-6 derived by approximating the values displayed in Figure 4.35 of Bjornn and Reiser (1991), or by processing the original data in Bjornn and Reiser's paper?

☐ In either case, were the mean juvenile spring-run Chinook salmon densities reported by Bjornn and Reiser (1991) for pocket water used in the calculation of the juvenile densities in Table F-6?

☐ Stillwater Sciences (2012) explained that the juvenile densities in Table F-6 were calculated by "*apportioning*" the 1.8 fish/m² and 0.5 fish/m² of 0-1% and 1-2% gradients from Everest and Chapman (1972) by habitat type (i.e., pool, run and riffle) in proportion to the mean habitat-specific densities obtained from Bjornn and Reiser (1991). Stillwater Sciences (2012) does not explain the methods associated with this "apportioning".

☐ The methodology in Stillwater Sciences (2012) of using the gradient-specific juvenile rearing densities from Johnson Creek, Idaho (Everest and Chapman 1972), "apportioned" by habitat type (i.e., pool, run and riffle) in proportion to the mean habitat-specific densities obtained from Bjornn and Reiser (1991) from 22 streams in Idaho, results in very high densities applied in the RIPPLE HAB module. This brings into question whether the carrying capacity estimates for the Upper Yuba River Watershed are overestimated. For example, examination of Table 6-3 in Stillwater Sciences (2012, page 41) demonstrates that the juvenile rearing densities (fish/m^2) used by Stillwater Sciences (2012) for the Upper Yuba River Watershed greatly exceed those of the 22 streams in Idaho – in fact, the values used for low gradient (0-1%) in the Upper Yuba River Watershed are 10 times higher for each habitat type than those in the referenced 22 Idaho streams.

ISSUE

Stillwater Sciences (2012, page 41) state "*The 2–4% and 4–8% gradient classes were parameterized with the same density values as the 1–2% gradient class, but usable fractions were lowered to 0.75 and 0.25, respectively, to reflect the lower carrying capacity expected at higher gradients (Appendix F, Table F-6). Higher gradient reaches have higher water velocities, thus reducing usability by juvenile Chinook salmon, especially those of smaller size (Everest and Chapman 1972).*"

COMMENT

Other than the qualitative statement referenced in Everest and Chapman (1972), no basis is provided in Stillwater Sciences (2012) why the specific usable fractions of 0.75 and 0.25 are used for the higher gradient classes. Specifically, what is the basis for assuming that the usable fraction in a 2-4% gradient class is ¾th of the lower gradient class, and that the usable fraction in a 4-8% gradient class is ¼th of the lower gradient class. At a minimum Stillwater Sciences (2012) should provide some explanation of that relative representation.

ISSUE

Stillwater Sciences (2012, page 41) state the Johnson Creek juvenile density data were selected…"*The Johnson Creek juvenile spring-run Chinook salmon summer densities reported by Everest and Chapman (1972) are within the range of those from other river systems containing high quality summer habitat (Table 6-3)*."

COMMENT

This statement does not appear to be correct. Review of Table 6-3 indicates that of the 17 juvenile spring-run Chinook salmon rearing densities reported, the density for Johnson Creek (1.80 fish/m2) was the highest of all reported densities and, therefore, was not "*within the range of those from other river systems containing high quality summer habitat.*"

ISSUE

Stillwater Sciences (2012, page 41) state "*The Johnson Creek juvenile density data were selected for two reasons: (1) the data presumably represent fully-seeded, high quality summer rearing habitat in a river system containing both juvenile Chinook salmon and steelhead and with a summer base flow similar in magnitude to the North Yuba River (~150 cfs), and (2) we could not locate gradient-stratified summer juvenile density data for northern California spring-run Chinook salmon that could be considered to represent fully-seeded rearing habitat conditions in the upper Yuba River watershed*."

COMMENT

Examination of the juvenile spring-run Chinook salmon rearing densities reported in Table 6-3 in Stillwater Sciences (2012, page 41) demonstrates that at least three other stream/gradient combinations provided densities from "fully-seeded" reaches. Stillwater Sciences (2012) does not provide any explanation as to why these other reaches were not used in the assuming juvenile rearing densities.

3.5.4 Carrying Capacity Estimates

ISSUE

Carrying capacity estimates are presented on pages 43 to 46 in Stillwater Sciences (2012). Given the various assumptions and inputs to the model, and issues previously discussed, the results of the model should be considered as gross relative indications of carrying capacity among areas compared. Undue specificity should not be attributed to predictions of habitat carrying capacity.

Stillwater Sciences (2012, page 44) presents predicted habitat carrying capacities of spring-run Chinook salmon holding, spawning (redds), and summer rearing lifestages for each modeled sub-basin and scenario in the Upper Yuba River Watershed in Table 6-5.

Stillwater Sciences (2012, page 44) states "*…when adult female escapement to freshwater and survival during holding are high enough to produce female spawners in excess of the redd carrying capacity, the quantity of spawning habitat likely limits production of juvenile and smolt emigrants from the upper Yuba River watershed.*"

COMMENT

As previously discussed, the Alternative Management Scenarios may represent unrealistic operational assumptions associated with the ability to sustain the assumed flow release rates, reservoir storage depletion, and inability to achieve downstream target water temperatures. Hence, the speculative nature of the Alternative Management Scenarios restricts the utility of habitat carrying capacity estimates among scenarios. The most appropriate comparisons would be among rivers/reaches under the current conditions although, even under current conditions, the estimated carrying capacities for the various sub-basins are questionable given all of the previously mentioned issues.

Examination of Table 6-5 (page 44) indicates that under current conditions, redd carrying capacity is 0 for the South Yuba River, 123 for the North Yuba River downstream of New Bullards Bar Dam, 126 for the Middle Yuba River, and 2,696 for the North Yuba River upstream of New Bullards Bar Reservoir. Given all of the assumptions and methods employed by Stillwater Sciences (2012) the North Yuba River upstream of New Bullards Bar Reservoir provides about 21 to 22 times the carrying capacity than the Middle Yuba River and the North Yuba River downstream of New Bullards Bar Dam.

In addition, given all of the assumptions and methods employed by Stillwater Sciences (2012), the predicted juvenile summer rearing carrying capacity for the North Yuba River greatly exceeds the other sub-basins. Examination of Table 6-5 (page 44) indicates that under current conditions, juvenile summer rearing carrying capacity is 0 for the South Yuba River, 282,393 for the North Yuba River downstream of New Bullards Bar Dam, 8,493 for the Middle Yuba River, and 766,391 for the North Yuba River upstream of New Bullards Bar Reservoir. Hence, according to Stillwater Sciences (2012) the North Yuba River upstream of New Bullards Bar Reservoir provides about 90 times the carrying capacity than the Middle Yuba River, and about 2.7 times the carrying capacity of the North Yuba River downstream of New Bullards Bar Dam.

However, the estimated juvenile rearing spring-run Chinook salmon carrying capacity for the New Bullards Bar sub-basin may be erroneously overestimated. The predicted habitat carrying capacities of spring-run Chinook salmon summer rearing carrying capacity estimates in Table 6-

5 (page 44) are based on the habitat availabilities presented in Table 4-3 (page 15) (along with the estimated usable densities and usable fractions). Stillwater Sciences (2012, page ES-4) state "*For modeling purposes we assumed that rearing only occurs downstream of spawning. In the NBB sub-basin, potential spawning habitat in the mainstem Yuba River under current conditions was assumed to be present only downstream of New Colgate Powerhouse because of a lack of spawning gravel from New Bullards Bar Dam downstream to the powerhouse.*" Stillwater Sciences (2012, pages ES-5 and 15) state that under current conditions, in the New Bullards Bar sub-basin, 3.2 miles of the mainstem North Yuba River was identified as suitable summer rearing habitat for spring-run Chinook salmon. The distribution of juvenile spring-run Chinook salmon summer rearing habitat is depicted in Map 4 of Stillwater Sciences (2012). Examination of Map 4 indicates that the 3.2 mile area included as suitable juvenile spring-run Chinook salmon holding and summer rearing habitat includes about 1.2 miles immediately downstream of New Bullards Bar Dam. However, this depicted juvenile spring-run Chinook salmon summer rearing habitat is several miles upstream of suitable spawning habitat. Therefore, if "*rearing only occurs downstream of spawning*", then this area should not be depicted as suitable juvenile summer rearing habitat, and the estimated juvenile rearing spring-run Chinook salmon carrying capacity for the New Bullards Bar sub-basin may be overestimated.

3.6 Chinook Salmon Population Dynamics (POP)

Stillwater Sciences (2012, page ES-3) report that the RIPPLE model includes a population dynamics module ("POP") that employs biological parameters and stock-production relationships to estimate equilibrium population sizes at variable spatial scales and locations throughout the Upper Yuba River Watershed. Stillwater Sciences (2012, page 46) state that "*the POP module uses reach-specific carrying capacity (K) values for holding, spawning, and summer rearing in conjunction with biological input parameters and life stage-specific stock-production curves, to estimate equilibrium population sizes for individual channel arcs and the entire watershed. The equilibrium population is reached after multiple iterations of the model are run and a stable, long-term average population structure is reached.*"

In Figure 6-2, Stillwater Sciences (2012, page 47) display a schematic diagram showing the relationships between each lifestage in the POP and the point at which each carrying capacity (K) is applied to the population over 7 brood years and 3 spatial areas, including: Upper Yuba Basin, Lower River through Estuary, and Ocean. The lifestages represented in the spring-run Chinook salmon POP module are defined in Table 6-6, with brief explanations on the modeled relationships between lifestages provided in pages 48 through 49.

In Appendix G (Table G-1), Stillwater Sciences (2012) provide the names, definitions and values for the various biological parameters input into the spring-run Chinook salmon POP module, together with the sources or rationale used for each selected value.

Stillwater Sciences (2012, page 52) state that the accuracy of model projections is affected by how data availability, data quality and model structure affect the degree of uncertainty in model parameters. With respect to the POP module however, the description of the various module components and the parameterization process presented in Stillwater Sciences (2012) do not provide sufficient information to allow a reader to understand: (1) how the various technical components of the POP module structure are integrated; or (2) how each of the lifestage-specific biological parameters for Chinook salmon were applied as inputs to the POP module, and more specifically, how they were used to obtain resultant model outputs. Therefore, the comments presented below on the topic of Chinook salmon and steelhead population dynamics primarily focus on the underlying assumptions and analytical methodologies described for the POP module in Stillwater Sciences (2012), rather than on the species and lifestage-specific results generated by the POP module for each of the rivers/reaches under current conditions and the Alternative Management Scenarios. Moreover, the following comments do not unduly emphasize the results generated by the POP module because of the foregoing comments regarding assumptions, inputs and methodologies pertaining to the GEO and HAB modules.

3.6.1 Lifestage-specific Stock-Production Curves

ISSUE

The descriptions of the methodology actually used in the POP module, as well as descriptions of POP module parameterization, do not provide the reader with sufficient information. For example, the statement (page 46) that "*the POP module uses reach-specific carrying capacity (K) values for holding, spawning, and summer rearing in conjunction with biological input parameters and life stage-specific stock-production curves*" does not clearly indicate where stock-production curves are applied. Review of Figure 6-2 (page 47) indicates that there are three lifestage-specific stock-production curves used in conjunction with carrying capacity estimates in the spring-run Chinook salmon POP module:

(1) The relationship between ***escape*** (*i.e.*, total number of immature adults of all ages leaving the ocean to search for holding habitat) and ***holder*** (*i.e.*, the number of male and female adults occupying holding habitat) that uses the holding carrying capacities estimated through the HAB module.

(2) The relationship between ***spawner*** (*i.e.*, total number of females leaving holding habitat in search of spawning habitat) and ***redd*** (*i.e.*, the effective number of redds that contribute to egg production after accounting for the effects of superimposition) that uses the spawning carrying capacities estimated through the HAB module and assumes 1 redd per female.

(3) The relationship between ***summer0*** (*i.e.*, juvenile population that remain in the channel network to rear during the summer) and ***winter1*** (*i.e.*, the number of juveniles that found

over-summering habitat) that uses the summer juvenile rearing carrying capacities estimated through the HAB module.

COMMENT

In a footnote on page 46 Stillwater Sciences (2012) state that only two stock-production functions are currently used in the Chinook model: (1) the "hockey-stick function" and (2) the "Skellam function". For a starting population $\boldsymbol{x}$, and ending population $\boldsymbol{y}$, a carrying capacity $\boldsymbol{K}$ and a density-independent survivorship $\boldsymbol{r}$, Stillwater Sciences (2012) define the "hockey stick function" as: $\boldsymbol{y} = \begin{cases} \boldsymbol{r} \times \boldsymbol{x} & \text{if } \boldsymbol{r} \times \boldsymbol{x} \leq \boldsymbol{K} \\ \boldsymbol{K} & \text{if } \boldsymbol{r} \times \boldsymbol{x} > \boldsymbol{K} \end{cases}$. Stillwater Sciences (2012) define the "Skellam function" as: $\boldsymbol{y} = \boldsymbol{K} \times \left(1 - \exp\left(\frac{\boldsymbol{r} \times \boldsymbol{x}}{\boldsymbol{K}}\right)\right)$ adding that "*the Skellam function is used only for calculating superimposition losses*" and that "*all other density-dependent mortality calculations in the model use hockey-stick functions.*" The following questions arise from the provided information and explanations.

- ☐ Stillwater Sciences (2012) provides no explanation as to why the "hockey-stick" function and the "Skellam" function were selected as stock-production functions. Why were no other commonly used stock-production functions (e.g., Beverton and Holt) selected for model application?
- ☐ What is meant by "*calculating superimposition losses"*? Stillwater Sciences (2012) provides no explanation of how "superimposition losses" were actually calculated. The formula of the "Skellam function" as cited in Stillwater Sciences (2012) returns negative redd values. Is this an error? Should the formula have been written as $\boldsymbol{y} = \boldsymbol{K} \times \left(1 - \exp\left(\frac{-\boldsymbol{r} \times \boldsymbol{x}}{\boldsymbol{K}}\right)\right)$ to provide positive redd values? How were the results of this function applied to the number of females in order to estimate the effective number of redds?
- ☐ Although Stillwater Sciences (2012, page 48) refers to Appendix G for a description of each parameter and values provided as input to the POP model, the presentation is unclear and difficult to ascertain. For example, the lifestage-specific stock-production functions implemented for the Chinook salmon POP module (i.e., presumably the relationships between ***escape*** and ***holder,*** and between ***spawner*** and ***redd***, and ***summer0*** and ***winter1***) require values for the density-independent survivorship ***r***. However, the ***r*** values are not clearly presented for any of the stock-production models, which limits the ability to evaluate POP module performance.

3.6.2 POP Module Assumptions and Results

ISSUE

Stillwater Sciences (2012) state that the POP module *"estimate equilibrium population sizes for individual channel arcs and the entire watershed. The equilibrium population is reached after multiple iterations of the model are run and a stable, long-term average population structure is reached.*" Interpretation of Figure 6-2 (page 47) and the explanation provided in Stillwater Sciences (2012, page 48) indicate that each model iteration starts with a particular value of escapement (i.e., the total number of adults of all ages leaving the ocean to search for holding habitat) that, after passing through the POP module calculations, generates numbers of ***esmolt0***, ***smolt0*** and ***smolt1*** for each sub-basin. These smolt values after being multiplied by specific smolt-to-adult survival rates (i.e., 0.01 for ***esmolt0*** and ***smolt0***, and 0.05 for ***smolt1***) originate the values for the escapement in the next iteration.

COMMENT

With respect to the iterative process of the model described above:

- ☐ What was the initial (or starting) escapement value?
- ☐ How many iterations were required to achieve "*a stable, long-term average population structure*"?
- ☐ What was the criterion used to measure that "*a stable, long-term average population structure*" had been achieved?
- ☐ At what population lifestage was the criterion applied (e.g., smolt lifestages, escapement)?

ISSUE

Stillwater Sciences (2012, page 49) states "*Notably, spawning habitat, which is more limiting than holding habitat, was fully seeded in all model runs*."

COMMENT

This statement does not appear to technically be correct. Examination of Table 6-5 (page 44) demonstrates that the North Yuba River estimated redd capacity is 2,696. However, POP module results presented in Table 6-7 (page 49) indicate predicted equilibrium redds of 2,591. Clarification should be provided.

ISSUE

As previously noted, Stillwater Sciences (2012, page 49) states "*Notably, spawning habitat, which is more limiting than holding habitat, was fully seeded in all model runs*."

COMMENT

Review of Table 6-7 in Stillwater Sciences (2012, pages 49 and 50) indicates that the RIPPLE model is producing results which predict that spawning habitat carrying capacity is limiting for all model runs. This is a particularly poignant model result, which appears to be counter to anticipated outcomes.

In July 2010 correspondence from Stillwater Sciences to NMFS regarding lower Yuba River components of the Habitat Expansion Plan, Stillwater Sciences emphasize the importance of juvenile rearing habitat, by contrast to spawning habitat, with the statement "*...more often than not, it is the absence of adequate rearing habitat that limits a population's production rather than the absence of spawning habitat.*" It is unclear why this specific application of the RIPPLE model produces these apparently unusual results. Discussion addressing this issue should be provided.

ISSUE

Stillwater Sciences (2012, page 53) state "*Model results are also particularly sensitive to smolt-to-adult survival parameters. For example, very poor delta and ocean conditions could result in escapement levels lower than that required to fully seed spawning habitat in all years. ...Refinement of adult escapement estimates will be possible following additional modeling outside of RIPPLE to simulate more realistic survival estimates downstream of Englebright Dam.*"

COMMENT

This statement brings into question why the RIPPLE model is predicting such high adult return rates, which are a function of smolt-to-adult return survival rates.

Biological parameters input into the POP module are provided in Table G-1 of Stillwater Sciences (2012). These parameters include:

- ☐ An assumed 1% *Smolt0* to adult survival, which includes the fraction of *smolt0* that survive from Englebright Dam to adult return to freshwater, and the fraction of *esmolt0* that survive from the estuary until adult return to freshwater. The assumed 1% survival was based on survival values of smolt-0-sized juvenile Chinook salmon released at Coleman and Nimbus hatcheries from 1968–1970.
- ☐ An assumed 5% *Smolt1* to adult survival, which includes the fraction of *smolt1* that survive from Englebright Dam to adult return to freshwater. The assumed 5% survival was based on survival values of smolt-1-sized juvenile Chinook salmon released at Feather River Hatchery from 1967–1970 and Nimbus Hatchery in 1955.

Although it is recognized that there is a relative paucity of reliable smolt outmigration to adult return survival rate information, the rates used in the RIPPLE model may be unrealistically high. The assumed rates were based on data from 1955 and 1967 to 1970. Since then, conditions have changed considerably due to increased development and water diversions in the Central Valley, Delta pumping, and variable ocean conditions, all of which would contribute to lower smolt-to-adult returning survival rates.

Climate and its impact on ocean currents and temperatures is so important to salmon survival, particularly during their vulnerable first year in the ocean, that NOAA's Northwest Fisheries Science Center can predict adult salmon returns to the Columbia River based on the ocean conditions the year they migrated out to sea. For the past three years, the system has been a very good predictor of returning adult fish (http://www.salmonrecovery.gov/RME/Ocean.aspx). NMFS (2011a, pages 25 and 26) state *"Ocean conditions, such as sea-surface temperatures and upwelling are major factors influencing west coast salmon populations (Wells et al. 2008), including those from the Central Valley (Lindley et al. 2009)."*

Given the foregoing comments, the appropriateness of the assumed smolt-to-adult return survival rates should be examined.

ISSUE

Stillwater Sciences (2012, page 53) state that "*...preliminary model gaming suggests there would be sufficient adult escapement to fully seed available spawning habitat at much lower smolt-to-adult survival values than those used; thus estimates of smolt and juvenile production potential are deemed reliable."*

COMMENT

First, no details are provided regarding "preliminary model gaming".

Second, it is logically unclear as to how smolt-to-adult survival values lower than those used in the RIPPLE model result in the conclusion regarding the reliability of smolt and juvenile production estimates.

ISSUE

Stillwater Sciences (2012, page ES-3) state "*For purposes of this assessment it was assumed that passage by salmon and steelhead would be possible in the mainstem reaches of each sub-basin up to existing natural passage barriers, and in smaller tributaries upstream to a point at which either channel gradient is too steep for passage or the channel is too narrow to provide suitable habitat*."

As a future model refinement, Stillwater Sciences (2012, page 69) identify the need to "*Conduct a literature review to provide estimates of trap and truck mortality associated with the specific* *operations proposed for fish passage in the upper Yuba River watershed. Refine outmigrant survival estimates accordingly.*"

COMMENT

Review of Stillwater Sciences (2012) indicates that other than the statements above, no assumptions regarding volitional or assisted passage at Englebright Dam on the lower Yuba River, New Bullards Bar Dam on the North Yuba River, or Our House Dam on the Middle Yuba River are provided in the document.

Presumably, the RIPPLE model does not consider the very real issues associated with passage at these facilities, and assumes no passage-related mortality of either upstream migrating adults or outmigrating juveniles. Clearly, high stress and mortality can be expected to be associated with the capture, loading, transport, and release of upstream migrating adults, and the same mechanisms (plus predation) affecting downstream migrating juveniles. Consequently, the POP module results must be viewed with some skepticism regarding numeric estimation.

ISSUE

Stillwater Sciences (2012, page ES-7) reference a statistical model that is used to model Chinook salmon survival downstream of Englebright Dam in several sections of the document, as follows: (1) page ES-7 states "*The model results and discussion will serve as data inputs to a statistical model downstream of Englebright Dam to characterize Delta and ocean conditions*"; (2) page 2 states that one of the study goals and objectives is to "*Couple juvenile production potential generated by RIPPLE to a statistical model of downstream survival*"; and (3) page 52 states "*The model results and discussion will serve as data inputs to a statistical model downstream of Englebright Dam to characterize Delta and ocean conditions.*"

COMMENT

It is unclear what statistical model downstream of Englebright Dam is being referred to by the above statements, and whether it is separate from the POP module. If so, it does not appear that a statistical model downstream of Englebright Dam is described in Stillwater Sciences (2012), and clarification should be provided. Moreover, if a statistical model is to be used to evaluate outmigrant to returning adult survival, then it additionally brings into question the utility of the POP module.

ISSUE

Stillwater Sciences (2012, page 68) identity one of the model challenges as "*…Downstream (i.e., lower river, estuary, ocean) survival of spring-run Chinook salmon and steelhead. These largely unknown parameters will be simulated by additional modeling downstream of Englebright Dam.*"

COMMENT

Given the importance of characterizing the number of returning fish (i.e., the total number of all ages of adults leaving the ocean to search for holding habitat, as represented by the "escape" lifestage in Figure 6-2) appropriately in the POP module, and if simulations of aquatic habitat conditions downstream of Englebright Dam (i.e., in-river, estuary and ocean) are to be performed by a subsequent statistical model (status unknown), then this seems to be a major issue of the POP module and poses concerns regarding the reliability of results estimating Chinook salmon production potential.

ISSUE

As previously discussed, the most appropriate comparisons of model results would be among rivers/reaches under the current conditions. However, given the challenges associated with parameterization of biological inputs, in addition to those presented for carrying capacity estimation, even under current conditions the estimated carrying capacities and production potential for the various sub-basins are uncertain. For example, Stillwater Sciences (2012, page 52) appropriately acknowledge that "*…The adult escapement estimates ("escape") generated by the POP module (Table 6-7) provide only a rough estimate of the number of adults that likely to return to each sub-basin under equilibrium population conditions.*" Given all of the limitations associated with lifestage-specific numeric estimation and quantification, the following comment is provided.

COMMENT

Examination of Table 6-7 (pages 49 and 50) indicates that under current conditions, no (0) individuals for any lifestage are predicted for the South Yuba River. Given all of the assumptions and methods employed by Stillwater Sciences (2012), the North Yuba River upstream of New Bullards Bar Reservoir provides about 31 times the equilibrium number of annually returning adults than the Middle Yuba River, and about 14 times that of the North Yuba River downstream of New Bullards Bar Dam. Note, however, that the predicted estimate for North Yuba River downstream of New Bullards Bar Dam may be erroneously inflated given the comment provided on page 37 of this document addressing a potential error in the estimated juvenile rearing spring-run Chinook salmon carrying capacity for the New Bullards Bar sub-basin.

3.7 Steelhead

Comments previously provided in this document that pertain to the GEO or HAB modules, or the input parameters and assumptions that are pertinent to both spring-run Chinook salmon and steelhead are not repeated here. Following are additional comments specific to the manner in which steelhead are assessed in the RIPPLE model.

ISSUE

Stillwater Sciences (2012 pages 53 and 54) state "*We made the simplifying assumption that juvenile habitat for age 1+ would be more limiting than age-0 juvenile habitat in both seasons… in the winter, smaller age-0 fish can utilize a wider range of substrate sizes for refuge. For this reason, in the winter, habitat is expected to become unsuitable for age 1+ steelhead at lower magnitudes of sedimentation than for age-0 steelhead.*"

COMMENT

This discussion implies that substrate size and "sedimentation" for all habitat types in all rivers/reaches was evaluated and/or considered in RIPPLE application for steelhead, but no descriptions of such considerations were located in the RIPPLE report, particularly regarding substrate size metrics for "refuge", or specifically how they may have been applied. This discussion appears to be irrelevant to that which was actually done in the steelhead carrying capacity estimation process.

ISSUE

Stillwater Sciences (2012, page 54) state that *"…we made the simplifying assumption for the model that the majority of the steelhead population in the upper Yuba River watershed will emigrate as 2-year-olds following their second winter in freshwater."*

COMMENT

Review of Stillwater Sciences (2012) did not reveal specifically what "the majority" represented (e.g., percentage) or how it was applied in the modeling exercise.

3.7.1 Channel Gradient and Habitat Type Composition

ISSUE

Stillwater Sciences (2012, page 54) states "*Table 6-1 describes the HAB module input parameters required for steelhead*." The additional statement was made that "*The same habitat type fraction values used for the spring-run Chinook salmon model were also used to parameterize the steelhead model for each sub-basin. Section 6.2.1.1 describes the methods used to derive habitat type fraction values and Appendix F, Table F-1 shows the values used*."

COMMENT

There are several concerns regarding these statements.

First, Table 6-1 on page 37 narratively describes the HAB module input parameters used for the upper Yuba River RIPPLE model, but does not provide any specific values.

Second, the statement that "*The same habitat type fraction values used for the spring-run Chinook salmon model were also used to parameterize the steelhead model for each sub-basin…",* appears to contradict the discussion on page 55 "*We omitted all gravel patches with median grain size less than 10 mm and greater than 50 mm from estimates, assuming they were unsuitable for steelhead spawning (Kondolf and Wolman 1993)."* Thus, it is unclear what actually was used to model steelhead spawning habitat.

Third, Stillwater Sciences (2012) state "*Section 6.2.1.1 describes the methods used to derive habitat type fraction values."* However, review of Stillwater Sciences (2012) demonstrated that there is no Section 6.2.1.1 included in the report.

3.7.2 Steelhead Spawning Density and Usable Fractions

ISSUE

In Stillwater Sciences (2012), the first lifestage density and usable fraction discussion begins on page 55 titled "Spawning density and usable fraction".

COMMENT

It is unclear why Stillwater Sciences (2012) ignore the holding lifestage for steelhead in description of densities. This is particularly perplexing because in the description of physical habitat thresholds for steelhead (page 59), Stillwater Sciences state "*As described in Section 6.2.1.5, physical thresholds can be used in the HAB module to identify channel reaches suitable for holding, spawning, and rearing and exclude all other reaches*." [emphasis added].

ISSUE

Stillwater Sciences (2012, page 55) describe the methods to derive the values for steelhead spawning density and fraction of the channel usable for spawning that are displayed in Table H-1. Stillwater Sciences (2012, page 55) state "*In contrast to the methods used to calculate spring-run Chinook salmon spawning gravel area, we included gravel area measured on the floodplain adjacent to pools, which was expected to be inundated during the steelhead spawning season. The estimated amount of spawning gravel area was then apportioned among habitat types in the 0–4% gradient classes by assuming 80% of spawning gravel was in pools, 10% in riffles, 10% in runs, and 0% in cascades. This assumption was based on professional opinion and evidence from the literature that most spawning occurs in pool tails (Barnhart 1991, CDFG 1998a, b) in lower gradient reaches. In gradients of 4–8% we assumed 100% of spawning occurs in pools."*

COMMENT

These assumptions directly influence dependent estimates of steelhead spawning carrying capacity. However, these assumptions are not supported in Stillwater Sciences (2012).

Barnhart (1991) was not available for this review of Stillwater Sciences (2012). However, review of CDFG (1998b) resulted in identifying no reference to steelhead spawning in pools or pool tails. The "evidence" provided in CDFG (1998a) actually referred to a previous document as follows…*"Spawning occurs in gravel beds that are often located at tails of holding pools (USFWS 1995a)."* However, this was in reference to spring-run Chinook salmon, not steelhead. Review of USFWS (1995a) provided no additional evidence, data, reference to specific surveys or other information, but simply includes this exact quotation. Hence, this document does not state that most spawning occurs in pool tails – rather that spawning gravel beds are often located at the tails of holding pools.

Moreover, Stillwater Sciences (2012) do not provide scientific basis or rationale for assuming in their calculations that "*…in the 0–4% gradient classes …80% of spawning gravel was in pools, 10% in riffles, 10% in runs, and 0% in cascades." In gradients of 4–8% we assumed 100% of spawning occurs in pools."* Also, it is unclear how assumptions regarding percentage spawning in certain pool types became translated into percentage distribution of spawning gravels.

Stillwater Sciences (2012) provide no support for the assumption that *"we included gravel area measured on the floodplain adjacent to pools, which was expected to be inundated during the steelhead spawning season."* Apparently, analyses were not conducted to determine the probability that floodplains would be inundated, or the duration of inundation and concomitant usability for spawning. This assumption has the potential to result in an overestimate of carrying capacity. In addition, it is unclear as to how floodplain habitat was incorporated, because: (1) it is unclear if gravel size surveys were conducted in the floodplains; and (2) if "*The estimated amount of spawning gravel area was then apportioned among habitat types…",* then this would imply that habitat typing occurred within the extent of the floodplains, which is not clear in the report.

ISSUE

Stillwater Sciences (2012, page 55) state "*Since spawning habitat data were not available for the North Yuba, the usable fraction values calculated from South and Middle Yuba spawning habitat data were applied to the North Yuba*."

COMMENT

The Stillwater Sciences (2012) report is dated February 2012. This report was prepared for NMFS. NMFS has been a participant in the Yuba Salmon Forum (YSF). A YSF report on spawning habitat in the North Yuba River upstream of New Bullards Bar Reservoir was available to YSF participants, including NMFS, during November 2011 (YCWA 2011b).

ISSUE

Stillwater Sciences (2012, page 55) state *"Alternative Management Scenarios 1 and 2 assume gravel augmentation would take place in the Yuba River below New Bullards Bar Dam."*

COMMENT

As previously discussed for spring-run Chinook salmon, the gravel augmentation program for the North Yuba River downstream of New Bullards Bar Dam evaluated in Stillwater Sciences (2012) is speculative, does not address the venue, cost, jurisdictional authorities, responsible parties or implementing agencies.

3.7.3 Steelhead Summer Juvenile Rearing Density and Usable Fraction

ISSUE

Stillwater Sciences (2012, pages 56 and 57) explain the derivation of the juvenile rearing density values for pools, riffles and runs in channel gradient classes 0-1% and 1-2% that were used in the calculations of carrying capacity for summer juvenile rearing of age 1+ steelhead. The resulting densities were 0.085, 0.157 and 0.149 fish/m², for pools, riffles and runs, respectively (Table H-3).

Stillwater Sciences (2012) explain that these values were the result of "*apportioning*" the average fish density (0.121 fish/m²) from seven electrofishing surveys conducted in the upper Yuba River (two in the South Yuba, three in the Middle Yuba and 2 in the North Yuba) during the summer of 2008 (NID and PG&E 2009, as cited in Stillwater Sciences 2012) by habitat type, by applying the proportion of the mean habitat-specific density values of 4-8" *O. mykiss* from Gast et al. (2005) snorkel data for the South Yuba and Middle Yuba rivers (mean of pool densities = 0.013 fish/m², mean of riffle densities = 0.023 fish/m², mean of run densities = 0.022 fish/m²).

COMMENT

Stillwater Sciences (2012) explained that the juvenile rearing density values for pools, riffles and runs in channel gradient classes 0-1% and 1-2% were calculated by "*apportioning*" 0.121 fish/m² by habitat type (i.e., pool, run and riffle) in proportion to the mean habitat-specific densities obtained from Gast et al. (2005) snorkel data. However, Stillwater Sciences (2012) does not explicitly state the manner in which "*apportioning*" was actually conducted.

ISSUE

Stillwater Sciences (2012) mention that the NID and PG&E (2009, as cited in Stillwater Sciences 2012) electrofishing data presented considerable variation among sub-basins (North Yuba average density 0.310 fish/m², South Yuba and Middle Yuba combined average density 0.045 fish/m²) and state that the overall mean density of the seven electrofishing sites was used because they had "*no basis by which to determine whether the differences among sub-basins* [density means] *were truly representative of different carrying capacities or rather were anomalies resulting from low sample sizes, relatively poor spatial coverage of each sub-basin, and a single year of data.*"

COMMENT

Stillwater Sciences (2012) rationalized that the procedure they selected was appropriate because there was no basis to determine whether density means among sub-basins reflected different carrying capacities or were anomalous due to sampling.

The procedure used by Stillwater Sciences (2012) to calculate juvenile steelhead summer rearing densities resulted in the exact same density values, by gradient class, for the South, Middle, North and New Bullards Bar sub-basins. The result of using the same values among sub-basins completely eliminates sub-basin specific population values or habitat-abundance relationships, which may actually be reflective of the suitability and/or carrying capacities of each individual sub-basin.

Stillwater Sciences (2012) could have used an alternative procedure that is equally justifiable given the rationale that there was no basis to determine whether density means among sub-basins reflected different carrying capacities or were anomalous due to sampling. For example:

- ☐ The average electrofishing density of the two South Yuba River sites in NID and PG&E (2009, as cited in Stillwater Sciences 2012) could have been "apportioned" by habitat type using Gast et al. (2005) habitat-specific snorkel mean density for the South Yuba sub-basin (pool = 0.020 fish/m², riffle = 0.017 fish/m², run = 0.022 fish/m²).
- ☐ The average electrofishing density of the three Middle Yuba River sites in NID and PG&E (2009, as cited in Stillwater Sciences 2012) could have been "apportioned" by habitat type using Gast et al. (2005) habitat-specific snorkel mean density for the Middle Yuba sub-basin (pool = 0.006 fish/m², riffle = 0.030 fish/m², run = 0.022 fish/m²).
- ☐ The average electrofishing density of the two North Yuba River sites in NID and PG&E (2009, as cited in Stillwater Sciences 2012) could have been "apportioned" by habitat type using Gast et al. (2005) habitat-specific snorkel mean density for the Middle Yuba and South Yuba sub-basins combined (pool = 0.013 fish/m², riffle = 0.023 fish/m², run = 0.022 fish/m²).

In fact, this alternative approach is analogous to that which Stillwater Sciences (2012) used when trying to apply sub-basin specific biological information regarding water temperature tolerance thresholds. As reported in Stillwater Sciences (2012, Section 2.2.1 and page 64), the locations and the temperatures at which juvenile *O. mykiss* were observed were different in the South and Middle Yuba rivers, and therefore used different water temperatures to define tolerance thresholds independently for each of the two sub-basins.

3.7.4 Carrying Capacity Estimates

ISSUE

Stillwater Sciences (2012, page 62) presents predicted habitat carrying capacities of steelhead spawning (redds), and summer 1+ and winter 1+ rearing lifestages for each modeled sub-basin and scenario in the Upper Yuba River Watershed in Table 7-4.

COMMENT

As previously discussed for spring-run Chinook salmon, the Alternative Management Scenarios may represent unrealistic operational assumptions. Hence, the speculative nature of the Alternative Management Scenarios restricts the utility of habitat carrying capacity estimates among scenarios, and even under current conditions, given all of the previously mentioned issues.

Examination of Table 7-4 (page 62) indicates that under current conditions, steelhead redd carrying capacity is 393 for the South Yuba River, 1,503 for the Middle Yuba River, and 121 for the North Yuba River downstream of New Bullards Bar Dam, and 15,626 for the North Yuba River upstream of New Bullards Bar Reservoir. Given all of the assumptions and methods employed by Stillwater Sciences (2012), the North Yuba River upstream of New Bullards Bar Reservoir provides about 40, 10, and 129 times the carrying capacity of the South Yuba River, the Middle Yuba River, and the North Yuba River downstream of New Bullards Bar Dam, respectively.

In addition, given all of the assumptions and methods employed by Stillwater Sciences (2012), the predicted juvenile summer 1+ rearing carrying capacity for the North Yuba River upstream of New Bullards Bar Reservoir under current conditions greatly exceeds the other sub-basins, providing approximately 26, 12, and 11 times the carrying capacity of the South Yuba River, the Middle Yuba River, and the North Yuba River downstream of New Bullards Bar Dam, respectively.

However, as for spring-run Chinook salmon, the estimated juvenile steelhead summer rearing carrying capacity for the New Bullards Bar sub-basin may be erroneously overestimated. Stillwater Sciences (2012, page ES-4) states "*For modeling purposes we assumed that rearing only occurs downstream of spawning.*" In the New Bullards Bar sub-basin, Stillwater Sciences

(2012, page 55) state that because suitable steelhead spawning habitat does not occur in the New Bullards Bar reach upstream of the Middle Yuba confluence, spawning capacity of this reach was set to zero for current conditions.

Stillwater Sciences (2012, page 16) state that under current conditions, in the New Bullards Bar sub-basin, 3.7 miles were identified as suitable summer rearing habitat for steelhead. The distribution of juvenile steelhead summer rearing habitat is depicted in Map 5 of Stillwater Sciences (2012). Examination of Map 5 indicates that the 3.7 mile area included as suitable juvenile steelhead summer rearing habitat includes about 1.2 miles immediately downstream of New Bullards Bar Dam. However, this depicted juvenile steelhead summer rearing habitat is several miles upstream of suitable spawning habitat. Therefore, if "*rearing only occurs downstream of spawning",* then this area should not be depicted as suitable juvenile steelhead summer rearing habitat, and the estimated juvenile rearing steelhead carrying capacity for the New Bullards Bar sub-basin may be overestimated.

ISSUE

Stillwater Sciences (2012, page 62) state "*Results of the RIPPLE HAB module indicate that, for each model sub-basin and scenario, assuming sufficient adult spawning escapement, there was ample spawning habitat (redd carrying capacity) to fully seed the thermally suitable age 1+ juvenile summer rearing habitat (Table 7-4).*"

COMMENT

This statement actually encompasses the series of assumptions that: (1) adult spawning escapement is sufficient to fully seed the redd carrying capacity; (2) the redd carrying capacity is sufficient to fully seed summer age-0 carrying capacity; (3) summer age-0 carrying capacity is sufficient to fully seed winter age-0 carrying capacity; (4) winter age-0 carrying capacity is sufficient to fully seed summer 1+ carrying capacity. This litany of assumptions is not fully justified or rationalized in Stillwater Sciences (2012). In particular, Stillwater Sciences (2012) does not provide explanation or justification that an annual return rate of 35,286 adult steelhead (given the model estimated redd carrying capacity and assuming 2 fish per redd, which is a minimalist assumption) under current conditions could actually occur, or is a reasonable assumption.

ISSUE

Stillwater Sciences (2012, page 62) demonstrate modeled carrying capacity for steelhead lifestages in Table 7-4. For the North Yuba River, the model estimates 15,626 steelhead redds but only estimated 2,696 spring-run Chinook salmon redds (Table 6-5). Clearly, there is a large difference between the estimated carrying capacity for steelhead redds versus spring-run Chinook salmon redds in the North Yuba River.

COMMENT

The tremendous discrepancy in the carrying capacity of steelhead redds versus spring-run Chinook salmon redds (in the North Yuba River) can partially be explained by the assumed area required per redd for the two different species. For spring-run Chinook salmon, each redd was assumed to encompass 5.4 m^2. For steelhead, each redd was assumed to encompass 2.0 m^2 in low gradient sections and 1.5 m^2 in high gradient sections. Consequently, according to the assumptions in Stillwater Sciences (2012), spring-run Chinook salmon redds require 2.7 to 3.6 times the area that steelhead redds require. However, the carrying capacity for steelhead redds is 5.8 times higher than that for spring-run Chinook salmon. Additional investigation should be conducted to determine why such a relatively high carrying capacity for the number of steelhead redds is predicted, relative to spring-run Chinook salmon redds.

ISSUE

Stillwater Sciences (2012, page 62) report model carrying capacity estimates for redds, summer age 1+ and winter age 1+ juvenile rearing in Table 7-4 for the current condition and Alternative Management Scenarios 1 and 2.

COMMENT

Examination of Table 7-4 demonstrates that the carrying capacity estimates for winter age 1+ juvenile rearing does not change between the current condition and Alternative Management Scenario 1 or Alternative Management Scenario 2 for the South and Middle Yuba rivers. This is not an intuitive result, given that: (1) Alternative Management Scenarios 1 and 2 were assumed to represent an increased summer release of 50 cfs and 100 cfs, respectively, in the Middle Yuba River; and (2) Alternative Management Scenarios 1 and 2 were assumed to represent an increased summer release of 100 cfs and 200 cfs, respectively, in the South Yuba River. Additional investigation should be conducted to determine why no change occurs in carrying capacity of winter age 1+ steelhead among scenarios, and if the model is operating as intended.

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Attachment 3

Comments on NMFS Biological Opinion of Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir

Prepared for the U.S. Army Corps of Engineers, Sacramento District

by Dr. Gregory B. Pasternack, Ph.D.

Assessment of Geomorphology and Habitat Related Statements in the NMFS Biological Opinion of Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir

(31 photos of ubiquitous large woody material occurring on the lower Yuba River)

Prepared By
Dr. Gregory B. Pasternack, Ph.D., AM.ASCE

Prepared for the United States Army Corps of Engineers
Sacramento District, Englebright/Marlis Creek Lakes

May 09, 2012

EXECUTIVE SUMMARY

In this report I provide evidence-driven professional expert commentary regarding a set of specific statements made in the National Marine Fisheries Service's (NMFS) Biological Opinion (BO) on continued operation and maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and recreational facilities on and around Englebright Reservoir. My comments are limited to just some of the text of the BO, but that should not be taken to mean that I agree or disagree with anything else in the document. In my review, I found that NMFS used little reference to previously published documents about the geomorphology of the lower Yuba River (LYR) and did not access data and analyses at their disposal as participants in the Yuba Accord River Management Team (RMT) to address the topics they covered in the BO. In my review I found that the statements in the BO do not accurately characterize the fluvial geomorphology of the LYR. I found examples of specific concepts about unrelated and inappropriate reference types of rivers applied to the LYR. In other instances I found statements that blend and apply generic concepts about diverse types of rivers in diverse settings to the LYR in a dogmatic fashion that did not account for the specific evidence available for the LYR. The most egregious problem is the unsupported conjecture in the BO that the LYR channel and floodplain are disconnected. Building on that false claim, the BO envisions a long chain of ecological problems that are also not substantiated by data. Instead, an abundance of evidence shows that in fact the LYR has a strong connection between its bankfull channel and its floodplain. Furthermore, the evidence shows that the hydrology of the LYR involves more frequent floodplain inundation on this regulated river than is commonly reported even for pristine temperate rivers and significantly more so than reported for other semi-arid rivers. Numerous other false statements that are obviously contrary to available data and conclusions of peer-reviewed literature exist throughout the reviewed BO statements and are addressed in this report. In contrast, to the extent possible, the claims made in this report are substantiated with numerous data, analyses, citations, and photographs.

The headers of key sections of the BO related to fluvial geomorphology and habitat as well as the associated text of those sections include incorrect statements. For instance, contrary to the headers, there is in fact a systemic abundance of (1) spawning substrates, (2) natural river morphology, processes, and functions, (3) habitat complexity consistent with the river's landscape position, (4) large woody materials, (5) cobble and boulder cover, and (6) riparian vegetation, especially stream-side vegetation, in the LYR. For example, along the banks in the 1,000 to 5,000 cfs inundation band, the river has 3.54 million square feet of vegetation (excluding the Narrows Reach). Bank-side vegetation averages 12-35’ high (downstream of SR20 where there exists LiDAR data to estimate canopy height), depending on reach. Further, the alluvial valley within the 42,200 cfs inundation zone is 25% vegetated, with the geomorphic Daguerre Reach being 33% vegetated in that same inundation zone. The height of this vegetation in the 42,200 cfs inundation area varies by reach, but is not insignificant, with reach-scale averages between 17.5 to 33.6’ (downstream of SR20 where there exists LiDAR data to estimate canopy height) and individual tree heights up to a maximum of ~150 feet. Given the preponderance and mixture of sandbar willow and cottonwood, the reach-scale average heights are in the range expected of a blended mature canopy. These heights were found to generate shade cover in aerial images of the river, as illustrated in the report. Preliminary historical analysis found that the amount of riparian cover appears to have increased significantly since 1942 and there is good reason to think that the growth in vegetated cover will keep increasing.

Contrary to the statements in the BO, the LYR is moving along on a path of natural, self-driven ecological recovery that is directly attributable to the existence of Englebright Dam. Englebright Dam protects the river from the vast wastes of a degraded watershed blocked upstream. Downstream, training berms protect the river from breaking out into the Yuba Goldfields wasteland; flowing through that region would ruin the river. It is imperative to establish an ecological baseline consistent with the landscape position of the LYR and not amalgamate idealized attributes of rivers from around the world spanning mountaintop to ocean. Despite the fact that virtually all of the BO statements commented on below were found to be wrong, there are opportunities to improve the LYR, such as carrying out the USACE’s gravel augmentation implementation plan, rehabilitating the lower half of the Englebright Dam Reach, and other potential river rehabilitation schemes under consideration by the RMT.

FLUVIAL GEOMORPHOLOGY

BO STATEMENT (Pages 136 and 137)

The Yuba River below Englebright Dam still experiences a dynamic flood regime because uncontrolled winter and spring flows (Moir and Pasternack 2008) in above normal and normal water years, and the flows under the Yuba Accord have improve habitat in recent years, however, the flows in below average water years can be below the optimal depths for spawning and rearing spring-run Chinook salmon, as demonstrated by the flow habitat relationships modeled by Gallagher and Gard (1999).

COMMENT

The claim that "the flows in below average water years can be below the optimal depths for spawning and rearing spring-run Chinook salmon" is incorrect based on the extensive data for the lower Yuba River (LYR). It would have been better had the statement isolated spawning and rearing independently to be clear and specific as to exactly which one was impacted by which conditions. As a conjunctive sentence, the statement requires that both life stages are impacted for this to be true. Unfortunately, the biological opinion cites Gallagher and Gard (1999), but does not list it in the references section to allow readers to find out what that is and how it relates to an evaluation of the LYR. A literature search found a study of Chinook salmon by those authors that addressed the lower American and Merced Rivers, but it is not about the lower Yuba River (LYR). Considering that there have been several studies evaluating Chinook salmon spawning on the LYR directly (as well as a couple on rearing), it is peculiar that the Biological Opinion (BO) would not reference the spawning-related information in those studies when evaluating spawning conditions. These available studies include Beak Consultants, Inc. (1989), CDFG (1991), Pasternack (2008), Moir and Pasternack (2008), Moir and Pasternack (2010), and the RMT's annual redd survey reports for 2009-2010 and 2010-2011.

According to the Yuba Accord flow schedule, in below-average and drier water years, the instream flow requirement at the Smartville Gage (schedule B) that covers the corridor upstream of Daguerre Point Dam (DPD) is 500-600 cfs for the entire potential spawning period of September-March. Meanwhile, for the corridor downstream of DPD, the Accord provides for flows of 400-500 cfs for September-March in below-average water years (schedules 4 and 5) and 350 cfs for September-March in the driest years (schedule 6). Therefore, the claim involves assessing what the water depths are like in those flows and how those depths relate to the depth range requires for Chinook salmon spawning. The claim should have been assessed using Yuba data and flow-habitat relationships, both of which exist and were available to NMFS.

In 2009-2011, the RMT developed and validated a 2D hydrodynamic model of the entire LYR, excluding the inaccessible Narrows Reach. Several reports and presentations about the model have been provided to members of the RMT, including NMFS. Table 1 below provides the reach-average water depths for the LYR, excluding the Englebright Dam and Narrows Reach that have little gravel or spawning at this time. The reach-average depth is computed by averaging the water depth in all wet 3'x3' cells in the reach at a given flow, so it is a near- census of depths, not a limited sampling such as performed in the past by all previous studies on the LYR. The minimum reach-average depth is 1.8'. Figure 1 below provides three depth habitat suitability curves (HSCs) for Chinook salmon spawners (including spring run) from three different studies relevant to the lower Yuba River. According to the Gard curve, the optimal depth for Chinook salmon spawning is ~1.5', while for the other curves there is a range of optimal depths spanning from at least 1-2'. Combining the depth table and the HSC plots, none of the reaches have average depths that are "below the optimal depth" for Chinook salmon spawning for their spawning period of the year. This evidence-based finding drawing on a near-census of the river, not a highly limited sampling of a few sites, is contrary to the claim in the biological opinion. Based on a review of depths in the LYR considering the full spatial pattern of depths in the 2D model over the range of flows shown in Table 1, the optimal range of ~1-2' is widely available for Chinook salmon spawners during below-average and drier water years. Looking beyond the data to the past literature, there is no evidence that insufficient depth is a problem facing Chinook salmon spawners in below-average water years on the LYR under the Yuba Accord flow schedule.

In terms of Chinook salmon rearing, the BO does not directly state what the desired depths should be, but there is information from Beak Consultants, Inc. (1989). According to that LYR study, “Fry were observed in water depths that averaged 1.22 ft… Juvenile chinook salmon used an average water depth of 1.06 ft”. According to Table 1, none of the low flows associated with below-average or drier conditions have reach-average depths below those values. Depths of ~1-1.2’ are actually widespread around the periphery of the wetted channel at any flow on the LYR, including these low flows. As explained in a comments below, those 1-1.2’ deep areas along the wetted periphery are adjacent to vegetation for ~20-35% of the streambank area (zone between 1,000 to 5,000 cfs). Further, as illustrated below in Figures 10-13 and explained in the associated text, streambank vegetation is typically tall and dense enough to provide shading and it has enough roots in the water to provide in-stream cover. The near-bank wetted area in the Marysville Reach contains a significant abundance of large wood that also serves as cover, as illustrated in comments below.

A more detailed assessment of Chinook salmon spawning conditions on the LYR that includes not only depth, but also velocity and substrate, was recently done by the RMT. According to the 2009-2010 and 2010-2011 Yuba Accord River Management Team (RMT) redd survey annual reports that have been accessible to NMFS, 74.2% and 81.3% of redds in those respective years occurred above DPD. Meanwhile, for the spawning period each year that yields the vast majority of redds (October-November), the flow is 600 cfs. According to the RMT’s preliminary 2D microhabitat analysis of Chinook salmon spawning on the LYR (which was presented to NMFS in January and February 2012), the peak weighted usable area (WUA) for the LYR is at 600 cfs. At this flow, the census-based analysis yields an estimate of >3.39 million ft^2 of spawning habitat on the lower Yuba River, again accounting for the joint distribution of substrate, depth, and velocity.

Table 1. Reach-average water depth (ft) computed using the RMT’s LYR 2D model.

	Above Daguerre Point Dam			Below Daguerre Point Dam		
Flow (cfs)	TBR	PBR	DCR	DPDR	HR	MR
350	2.8	1.9	1.9	1.8	2.0	5.0
400	2.8	1.9	2.0	1.9	2.1	5.1
450	2.9	2.0	2.0	2.0	2.2	5.1
530	2.9	2.1	2.1	2.1	2.3	5.2
600	3.0	2.2	2.1	2.2	2.4	5.2

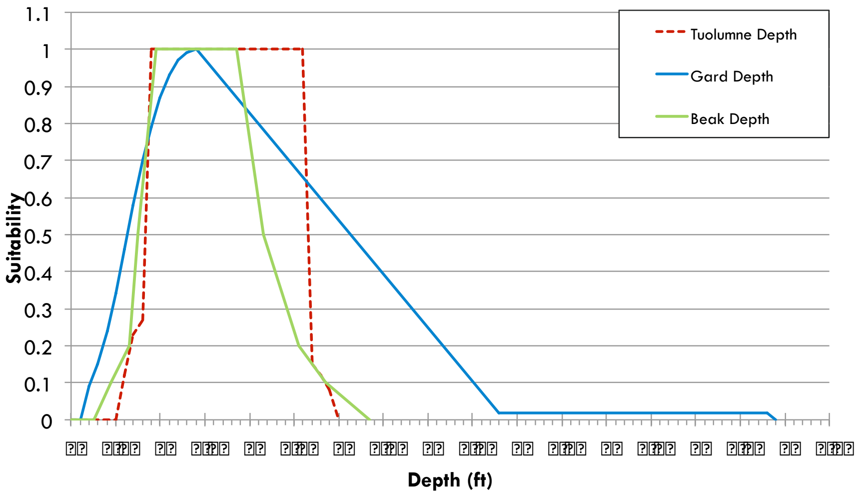

Figure 1. Three of the habitat suitability curves (HSCs) that have been evaluated for use on the Lower Yuba River.

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BO STATEMENT (Page 137)

Managed river flows also reduce the amount of rearing habitat available for both spring-run Chinook salmon and Central Valley steelhead. The low flows disconnect the river from the *floodplain rearing habitat reducing juvenile survival by decreasing cover and food availability and increasing competition and predation.*

COMMENT

According to this statement, (1) the channel and floodplain are disconnected from each other by “low flows” caused by management of the river and (2) rearing habitat exists on the floodplain where there is cover and food availability. Wyrick and Pasternack made available to NMFS and all other RMT participants a Google Earth .kml file with a map of the LYR’s morphological units for both in-channel and overbank areas. Further, at any time, the freeware HEC-SSP may be used to compute the widely used statistical metric for bankfull discharge (Q1.5) for either the Smartville or Marysville USGS flow gages. Therefore, complete information was available to NMFS by autumn 2011 to assess the status of floodplain connectivity, yet there is no indication that these tools were actually employed to produce this conjecture in the biological opinion. To be clear a *floodplain* is commonly defined as *a low-lying, overbank, depositional surface*. Thus, the questions arises as to whether the LYR has such an area with those conditions that we might deem it a floodplain?

By definition, alluvial river corridors such as exists for the majority of the LYR (excluding Englebright Dam and Narrows reaches) consist of in-channel areas and overbank areas. The channel itself is a geometric shape carved by water. Classic geomorphic literature demonstrated that channels are sized to accommodate a flow termed the “bankfull discharge”. There are numerous methods to identify what this discharge is for any river reach, but the most commonly used ones are (1) geometric indicators observable in the field, (2) a statistical metric obtain from flood frequency analysis of a multi-decadal daily discharge record from the river, and (3) regional regression equations. According to classic fluvial geomorphology, floodplains are normally inundated every ~1.5-2 years in a humid, temperate climate and every ~2-5 years in a semi-arid climate. Pasternack (2008) investigated geometric bankfull indicators associated with (a) overtopping river banks and (b) inundating islands in Timbuctoo Bend. As shown in Figure 2 below, banks and islands in Timbuctoo Bend are inundated by ~5000 cfs, and in some locations banks are inundated at a lower discharge. Pasternack (2008) also reported a statistically determined bankfull ($Q_{1.5}$) discharge estimate of ~5600 cfs using the 1971-2004 peak annual discharge series for the Smartville USGS flow gage. Subsequently, Wyrick and Pasternack (2011) used the LYR 2D hydrodynamic model to determine, map, and analyze the areas of inundation for a representative baseflow (880cfs above DPD and 530 cfs below DPD), a representative bankfull flow (5000 cfs), and a representative floodplain filling flow (21,100 cfs). These inundation maps provide the topographic evidence necessary to evaluate BO claims.

One thing that LYR topographic and inundation analysis has found is that there exist “swales” within the 5000 cfs inundation level, where a swale is a topographic bench out of the geometric channel that inundates at a significantly lower discharge than the overbank floodplain (Wyrick and Pasternack, 2011). These could be ideal rearing areas, because they are inundated frequently, adjacent to the main channel (and accessible to fish), and they are moderately vegetated. The LYR has an estimated 3.56 million ft^2 of swales, and of that total area, 34 % is covered with vegetation. It is highly likely that swales play a prominent role in fish rearing, and that deserves further investigation.

Given a well-established threshold of ~5000 cfs to begin to inundate the floodplain, the question comes down to how often does that occur on the LYR relative to what occurs in non-regulated rivers? According to classic literature, floodplains of natural rivers do not normally flood every year. By definition, floodplains are sedimentary surfaces that inundate only every ~1.5 to 5 years, depending on climate. Therefore, for the biological opinion statement to be correct, the managed flows on the LYR must yield overbank flows less frequently than natural. That is easy to assess. According to HEC-SSP analysis of the 1970-2010 annual peak discharge series for flows at the Marysville gage, there is an 80% change in any given year that discharge will exceed 5,612 cfs and a 50% chance that discharge will exceed 16,464 cfs. Therefore, the exact discharge at which flow spills out of the channel is unimportant, because in any given year there is a 50:50 chance that a flow of >16,000 cfs will occur, and that flow is more than sufficient to not only go overbank, but to actually inundate a large amount of the floodplain. For the Smartville gage, the same 80% and 50% exceedence flows are 4,085 and 12,343 cfs, respectively. Once again, the 50% value is well above the geometric bankfull threshold indicating high probability in any given year. Thus, the topographic and hydrologic evidence shows that the LYR experiences floodplain inundating flows at least as frequently as expected for a natural river.

By definition, when a river's floodplain is disconnected from its channel, a river is "*entrenched*". The BO states therefore that the LYR is entrenched. According to Rosgen (1996), the "entrenchment ratio" (ER) of a river is the ratio of the floodprone width to the bankfull width. The floodprone width is defined as the width of the river at a discharge that yields a water depth that is twice bankfull depth. The *lower* ER is, the *more entrenched* a channel is. Rosgen (1996) termed any river with an ER <1.4 to be an entrenched river. Therefore, it is possible to test the conjecture in the BO using the data available to RMT participants. According to Pasternack (2008) and Wyrick and Pasternack (2011), flows of >5000 cfs fully inundate the LYR's channel and already spill out of that and onto swales at a lower flow. Wyrick and Pasternack stationed the river's centerline with cross-sections every 20' using ArcGIS and clipped the cross-sections to the wetted-area boundary for 5000 cfs to obtain the longitudinal distribution of wetted width for the river at this flow. This was also done for every other flow the RMT analyzed. The mean depth of all 3'x3' wetted cells in the whole LYR was computed using 2D model results for 5,000 cfs and found to be 4.67'. Doubling that value, it was found that the discharge of 42,200 cfs previously simulated with the 2D model yielded a depth very close to double the bankfull depth and could be used to represent the floodprone condition. Therefore, Wyrick and Pasternack (2011) stationed the river's centerline with cross-sections every 20' using ArcGIS and clipped the cross-sections to the wetted-area boundary for 42,200 cfs to obtain the longitudinal distribution of wetted width for the river at this flow. Although the next step was not done in that report, the data was available to RMT members, so Wyrick and I went ahead and analyzed the ER. The ER was computed for every stationed cross-section using the width ratio for 42,200 cfs and 5,000 cfs. That yielded a longitudinal distribution of ER. Finally, the reach-averaged ER value was computed to determine if any reach is entrenched (i.e. ER<1.4). *Based on this dataset using data available to RMT participants since summer 2011, no reaches in the LYR are entrenched*.

On the basis of topographic, hydrologic, and entrenchment analysis of the LYR, there is no evidence whatsoever that the LYR's floodplain is disconnected from its channel. The geometric channel is shaped to allow water to spill out onto swales at flows in the 1000-5000 cfs range, flows on the LYR easily exceed the geometric threshold to inundate floodplains more often than expected in nature, and the entrenchment ratio shows that the reaches of the LYR are not entrenched.

The second part of the conjecture in this BO statement is that the floodplain provides rearing habitat with cover and food availability. The conjecture further states that without access to the floodplain, there is decreased cover for rearing fish. Gard (2008) sampled 32,095 feet of near-bank stream length and 7,496 feet of mid-channel stream length. The key result from the study was that out of the 468 locations where young-of-the-year Chinook salmon and steelhead/rainbow trout were observed, all but 8 (that is 98.3%) occurred near riverbanks. The explanation is that dense vegetation exists as a polyline on the channel bank and swales at an elevation between baseflow and bankfull as well as around slackwaters in embayments and partially connected side channels with only a downstream connection to the mainstem, limiting the velocity there. Figure 3 shows an underwater photo of a juvenile fish using riverbank habitat- note the abundance of small plant material characteristic of the microhabitat. The significance of this evidence is salmonids rearing in the LYR prefer vegetated areas, such as riverbank habitat, and that dense cover is widely available in the bankfull channel along the banks. Considering the bank area between the baseflow and bankfull flow (1,000 to 5,000 cfs inundation band), analysis of the RMT's vegetation map finds that there exists 3.54 million ft^2 of vegetation, which covers 28% of that bank area for the whole LYR. Unfortunately, I do not have linear estimate right along the baseflow water's edge, so this number is deflated relative to a linear estimate.

The question arises as to whether the LYR's floodplain is also vegetated and thus potentially providing a lot of habitat when inundated? Because of unprecedented amounts of hydraulic mining sediment filling the LYR's river corridor and dredgers reworking that sediment, the LYR's floodplain consists of vast, partially vegetated, unconsolidated sediment. Based on the RMT's vegetation map, there exists 23.2 million square feet of vegetation within the 42,200 cfs inundation zone, which covers 25% of the surface. White (2010) analyzed where vegetation occurs in Timbuctoo Bend and reported that lines of vegetation (primarily sandbar willow) on the floodplain exist because those are the pathways of previously inundated channels (what Wyrick and Pasternack (2011) define as "flood runners"). Thus, the majority of vegetation on the floodplain of Timbuctoo Bend is associated with modern or recently abandoned channels. Visual inspection of the rest of the LYR found this same phenomenon to hold systemically- vegetation predominantly occurs in lines along modern and recently abandoned channels or around protected slackwaters. A vegetation map of the whole LYR (excluding Narrows) has been available to the RMT since spring 2011.

Combining the evidence from the rearing study and simple vegetation analysis, river banks, not floodplains constitute the optimal fish rearing habitat on the LYR, because that is where the densest and most abundant cover exists and because depths and velocities are low there. It is also proximal to the aquatic insects that the fish eat. Studies of remarkable fish rearing on the "agriplains" of the Yolo Bypass and Cosumnes River (e.g. Sommer et al., 2001) have shown that floodplains can be important rearing habitat. However, a comparison of landscape position shows that those sites are much farther downstream close to the Sacramento-San Joaquin Delta where the valley floor has a lower slope and more stagnant conditions. Also, historical mining debris and dredging operations pre-Englebright Dam rendered the floodplain of the LYR totally different from those lush settings (Fig. 4). We do not know what the overbank area was like prior to those impacts, but given the proximity of the valley walls upstream of DPD, it is unlikely that wide off-channel rearing areas existed there. It is imperative that NMFS establish a sensible environmental baseline relative to the LYR's landscape position. For the LYR, rearing fish get the most abundance and frequency of cover along the riverbanks and on vegetated swales, not on the floodplain. During floods when rearing fish move onto the floodplain, they would likely find refuge in the polylines of vegetation lining flood runners, among other locations.

In conclusion, data and literature accessible to NMFS in 2011 show that this BO statement is incorrect. Floodplains are not disconnected from the channel, rearing fish can get out onto vegetated swales and the floodplain in more years than expected in pristine semi-arid river conditions, but the floodplains may not optimal fish rearing habitat, as that is associated with a different landscape position close to the estuary. Instead, riverbanks inundated between 1000-5000 cfs are the optimal rearing habitat, because they have abundant and dense vegetation, which is the cover that rearing fish have been observed to seek on the LYR.

Figure 2. February 2004 photo of the apex of Timbuctoo Bend showing inundated island and banks at a flow of 5000 cfs.

Figure 3. October 7, 2007 photo taken in the submerged vegetation along the river bank by snorkeler Aaron Fulton showing a juvenile fish using low-velocity cover habitat.

Figure 4. An example of one location where the river lacks a vegetated floodplain. Opposite the floodplain is a steep hillside that is a source for large boulders, which are evident all along that bank on the left side of the photo. Boulders provide cover for rearing.

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BO STATEMENT (Page 137)

Downcutting in the Yuba River, by as much as 30 feet, disconnects the river from a dynamic interaction with the floodplain by lowering the water table and reducing the amount of water available for the roots of riparian vegetation.

COMMENT

Pasternack (2010a) reviewed the LYR literature about geomorphic change. It is true that the LYR has been and continues to downcut, which is defined as a lowering in elevation. It is also true that the presence of Englebright Dam is responsible for causing the downcutting, because in fact that is exactly what the purpose of the dam is- to block the passage of hydraulic mining sediment into the LYR corridor and beyond, which would be devastating to the environment and society if it was allowed to pass unabated. That is where the facts of the BO statement end. The BO then claims that downcutting is disconnecting the river from a dynamic interaction with the floodplain, lowering the water table, and reducing water available for the roots of riparian vegetation. Given this chain of logic, if it can be shown that the channel and floodplain are not disconnecting, then the rest of the statement is also falsified.

As already demonstrated above using analysis of the entrenchment ratio, no reaches in the LYR are entrenched. Furthermore, as previously demonstrated, the river floods onto the floodplain with a >50% chance in any given year. These lines of evidence demonstrate that the downcutting is not disconnecting the floodplain from the channel. How can that be?

Yes the LYR is downcutting, but no, the river is not disconnected or disconnecting from its floodplain. The idea that downcutting necessitates disconnection is wrong. The reason is that rivers, including the LYR, exhibit processes that allow them to remove all material in the river corridor, not just from within the channel. Processes such as lateral migration, avulsion, vegetation stripping, and overbank flooding are responsible for downcutting on the floodplain. These processes are all occurring on the LYR. How do we know? Pasternack (2008) performed digital elevation model (DEM) differencing for Timbuctoo Bend for 1999-2006 and showed that the floodplain is lowering there. Subsequently, Carley et al. (submitted) did a complete census of decadal channel change on the LYR, producing a map of scour and deposition as well as a report. This RMT-sponsored report has been available to all RMT participants since spring 2011. In the decadal change map, there are areas of floodplain scour associated with fore-mentioned processes. In fact, the data show that relative to the LYR's channel in 1999, overbank areas experienced a net of ~200,000 m^3 of scour, while the channel itself experienced a net of 141,000 m^3 of fill. Consequently, the data from the last decade show that as a whole, the river channel is filling in and the area that was overbank in 1999 is downcutting. *Avulsion*- the process by which the river breaks out of its current channel and carves a new one down the floodplain- and lateral migration are key to rapid downcutting of the overbank area. Overall, there is a net export of sediment out of the LYR, but internally, sediment is being redistributed with deposition focused in the channel, below Daguerre Point Dam, and in vegetation.

The conclusion is that the BO statement is wrong, because three lines of evidence- entrenchment ratio analysis, hydrological analysis, and 1999-2009 DEM differencing all show that the floodplain is connected to the river. Given that this first part of the statement is false, then the rest of it has to be false too, because it is conditional on the false concept that the floodplain is disconnected from the channel.

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BO STATEMENT (Page 146)

"Other important components of habitat structure at the micro-scale include large boulders, coarse substrate, undercut banks and overhanging vegetation. These habitat elements offer juvenile salmonids concealment from predators, shelter from fast current, feeding stations and nutrient inputs. At the macro-scale, streams and rivers with high channel sinuosity, multiple channels and sloughs, beaver impoundments or backwaters typically provide high-quality rearing and refugia habitats (Spence et al. 1996). The lower Yuba River can be generally characterized as lacking an abundance of such features."

COMMENT

Rivers come in an extremely diverse array of morphologies. Under pristine natural conditions, there are rivers that are (a) straight, meandering, braided, or anastomosing, (b) have any size substrate from clay to boulder as well as any mixture of sizes, (c) have any degree of entrenchment, and (d) have any slope, sinuosity, or width/depth ratio. The BO statement claims that at the macro-scale, streams lacking certain characteristics do not provide high-quality rearing and refugia habitat. That is wrong. Anadromous salmonids have used many different types of rivers with and without those macro-scale attributes. The idea that all salmonid streams should have or be re-engineered to have the exact same macro-scale properties is wrong and misguided. Each river should be evaluated for its own unique attributes to determine what its physical structure and processes are as well as its ecological functions. One aspect of diversity is to ensure that each river have a unique set of attributes and functions, not exist as clones all fixed to one idealization of a salmon stream.

There is very little evidence about what the LYR was like before the gold mining era, and what is available is disputed as biased anecdote and imagery intended to present a false advertisement to entice pioneers and settlers. The scientific evidence that is available about historical conditions comes from Gilbert (1917) and James (2005, 2009). Evidence about current landforms comes from Pasternack (2008) and Wyrick and Pasternack (2011).

Let us look at what is known about the macro-scale attributes of the LYR, in contrast to the conjecture of the BO statement. According to Wyrick and Pasternack (2011), the LYR does contain slackwaters, vegetated swales, and backswamps that can serve as rearing habitat along with the forementioned optimal rearing zone at the vegetated riverbanks. Wyrick and Pasternack recently used the available baseflow thalweg polyline and valley centerline to compute the river's sinuosity as an additional analysis to characterize reach-scale attributes of the LYR. It is true that on average the river does have low sinuosity, but the sinuosities of reaches above DPD are largely constrained by the natural valley walls. Also, the river exhibits multiple channels in some stretches, including at the confluence with Dry Creek. In the Marysville Reach, sinuosity is limited by flood levees. In the remaining reaches, sinuosity exists and is increasing, but the rate of increase is is limited by training berms and the northern valley wall. Studies by Allan James reported that the LYR prehistorically had multiple channels going to the south, but the hydraulic mining sediment, dredging, and river training ended that. The average bed channel slope of the LYR thalweg from the upstream end of Timbuctoo Bend to the confluence with the Feather River is 0.16%. This value is relatively high, because it is far upstream (~100 miles) from the ocean, so it cannot be expected to have attributes of low-lying coastal rivers, such as many diverse sloughs. The LYR has been reported to have some have beaver activity and impoundments, but it has not been investigated systematically. Regionally, beavers were decimated long before Englebright Dam was built: According to Tappe (1942), "Much of the early exploration of California was done by traders and trappers in their search for new areas in which to take beavers. The intensive and continued trapping by these men soon led to a great decrease in the beaver population. Although there was relatively little trapping done in the last half of the nineteenth century, the beaver population remained at a comparatively low level; the population even became so reduced that the animal for a time was threatened with extinction." Thus, there is no reason to expect the LYR to have beaver impoundments, regardless of USACE facilities, flows, hydraulic mining debris, or other local anthropogenic factors. Overall, the LYR does have many macro-scale features beneficial to salmonid rearing, but its landscape position yields a relatively high slope and long sections of valley-constrained, gently meandering channels. Not all rivers can or should have identical macro-scale attributes. Many pristine rivers are straight or transitional between straight and meandering.

In terms of micro-scale attributes, the BO statement opines that the LYR is generally lacking an abundance of large boulders, coarse substrate, undercut banks and overhanging vegetation. The BO statement provides no evidence or citations related to these features for the LYR and no benchmark values as to what would constitute abundant features. Without a benchmark for "abundant", it comes down to professional judgment, perhaps based on maps and observations of the river, but the BO provides no indication that any surveys of these features was undertaken. In contrast, I have nine years of experience of working on the LYR and I have evaluated the presence of such features as part of my expertise on assessing and rehabilitating salmonid microhabitat. Large in-channel boulders are nearly ubiquitous throughout the LYR. As shown in Figure 4, wherever the hillside contacts the wetted channel, large boulders fall in, and such contacts are widespread in the LYR. The bedrock adjacent to the LYR consists of highly friable basic metavolcanic rocks, which explains why there are so many boulders along the river bank where it contacts the hillside. Even downstream of Daguerre Point Dam where there is no bedrock contact, there are a lot of submerged boulders, perhaps because large floods can transport them downstream. In terms of overhanging vegetation, it has already been explained that there exists a significant amount of vegetation along riverbanks. This creates substantial overhanging vegetation. The extent of overhanging vegetation is easily determined by intersecting the vegetation map with the wetted area map for any specific flow. Considering the bank area between the baseflow and bankfull flow (1,000 to 5,000 cfs inundation band), there exists 3.54 million ft^2 of vegetation, which covers 28% of that bank area for the whole LYR. That analysis shows a large amount of overhanging area, recognizing that the river is highly dynamic, changing its channel pattern every ~7-10 years. In terms of undercut banks, these generally require either erodible but strong bedrock or highly cohesive alluvium. As Figure 4 illustrates, there are many places where there is bedrock on the bank and there are undercuts, but because the bedrock is so friable, it may not be possible for undercuts to be as widespread as in rivers with different geology. That is a natural characteristic of the LYR. Undercuts do exist downstream of DPD where there are steep cutbanks. Wyrick and Pasternack (2011) mapped and analyzed cutbanks in the LYR. In terms of coarse substrate, the RMT did a census of substrate in the LYR in 2010 and produced a map. Pasternack (2008) did a longitudinal survey of substrates in Timbuctoo Bend. Fine sediment is defined as sand, silt and clay sizes (i.e. < 2mm), while coarse substrate is defined as gravel, cobble, and boulder sizes (>2 mm). According to the RMT's substrate map, the LYR has nearly ubiquitous gravel and cobble-sized substrates.

In conclusion, the evidence shows that the LYR has an abundance of micro-scale habitat features, including large boulders, coarse sediment, and overhanging vegetation. The quantity of these features is consistent with the landscape position, proximity of valley walls, dynamic flood regime, and history of deposition of hydraulic mining sediment. There is a high degree of certainty that salmonid rearing in the LYR is not stressed or limited by an inadequate supply of these elements, as they are widespread, and this habitat evidence is substantiated by the actual observations of outmigrant salmon reported in rotary screw trap surveys. Although the macro-scale attributes of the LYR may naturally deviate from one perspective on what a perfect salmonid rearing river ought to be, Wyrick and Pasternack (2011) found that the LYR does have an abundance and diversity of natural macro-scale landforms at the reach and morphological-unit scales. There may be opportunities to expand off-channel habitats in the LYR beyond what is available, but that should be done with careful geomorphic analysis of the resilience of such projects in light of the river's dynamic flood regime. The BO statement presents no evidence and is wrong about the macro- and micro-habitat conditions in the LYR.

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BO STATEMENT (Page 146)

"Loss of natural river morphology and function is the result of river channelization and confinement, which leads to a decrease in riverine habitat complexity, and thus, a decrease in the quantity and quality of juvenile rearing habitat. This primary stressor category includes the effect that dams have on the aquatic invertebrate species composition and distribution, which may have an effect on the quality and quantity of food resources available to juvenile salmonids."

COMMENT

It was already shown through topographic, hydrologic, entrenchment, and DEM differencing analyses that the LYR's in-channel and floodway landforms are all in good connection with each other. Now the BO makes a statement about loss of natural river morphology and function as well as a decrease in riverine complexity, and these are attributed to the effect of the dams in the LYR. Again, these conjectures are made without supporting evidence or citations, despite a large amount of data and reports covering this topic. Let's look at the conjecture about river morphology first and riverine habitat complexity second.

Wyrick and Pasternack (2011) conducted a complete census of river morphology in the LYR (except for the bedrock Narrows Reach, but the river morphology there was assessed by Pasternack, 2010b). They found that (1) the LYR river corridor contains 31 distinct morphological units, (2) in-channel and floodway units do not have random abundances, (3) in-channel units have a natural (i.e. not man-made) and organized, non-random structure, (4) in-channel units show affinity and avoidance in terms of be adjacent to one another, (5) point bars are spaced every 11.7 channel widths, which matches the expectation from classical meander wavelength datasets, (6) swales are naturally spaced to occur in conjunction with roughly every other riffle-induced backwater, (7) riffles are somewhat more abundant on the LYR than in classic literature datasets, and (8) there are an average of 9 morphological units across the channel at 20’-spaced cross-section down the river. These eight conclusions yield a detailed perspective on the landforms of the LYR. Based on this evidence, it is concluded that the LYR has a diversity of landforms and they are distributed to yield abundant lateral and longitudinal diversity.

Contrary to the BO statement, the LYR has a natural river morphology in which the landforms are adjusted to flow, sediment supply, and topography. The river has a natural river morphology, because it has natural river processes and functions. Specifically, Pasternack (2008), White et al. (2010), Sawyer et al. (2010), and Carley et al. (submitted) reported natural processes on the LYR, including lateral migration, avulsion, vegetation stripping, vegetation capture of sediment, overbank flooding, knickpoint migration, natural levee formation, and flow convergence routing. Thus, even though the river was bounded with training berms historically, the river exhibits a remarkable degree of self-determined, natural fluvial dynamism that has resulted in morphological diversity.

The claim in the BO statement that the river is unnaturally confined is only partially correct. It is true that in the past the river was able to have anastomosing channels farther to the south and now training berms block that route. However, Tables 3-4 and Figure 15 of Wyrick and Pasternack (2011) present information about active alluvial valley width and floodway width (i.e. inundated by flows up to 21,100 cfs) for the whole LYR corridor (excluding the Narrows Reach). Those tables and plot show that the LYR’s active alluvial valley and floodway are actually widest in the region of the Yuba Goldfields where the training berms are present. Therefore, relative to the other reaches lacking artificial berms, there is more opportunity for meandering and floodplain dynamism than elsewhere in the LYR corridor. Thus, while the Yuba Goldfields do bound the active river corridor, the bounds are so wide that there is a lot of opportunity for dynamic fluvial geomorphology and complex habitat development. That is something that has been under-reported and under-investigated until recent geomorphic studies by the RMT.

In terms of riverine habitat complexity, that can be addressed by looking at three spatial scales in decreasing size- reach, morphological unit, and hydraulic unit. At the reach scale, Wyrick and Pasternack (2011) reported that there are 8 different LYR reaches, with significant different attributes. Bankfull width varies from 169-427’, while floodway width varies from 237-1028’. Bed slope ranges over a factor of six from 0.052-0.31%. The Dry Creek Reach has multiple channels and a large backwater complex with beaver activity and impoundment. The Daguerre Point Dam Reach has an actively meandering mainstem channel as well as a ~2 mile long parallel side channel that activates at flows somewhere between 10,000-20,000 cfs, which can occur in any given year with a ~40-50% chance. Marysville Reach is narrow and deeper, with pools and slackwater landforms that have a lot of tall bank vegetation on the levees, while Englebright Dam reach is a narrow bedrock/boulder section with a lot of pool, slackwater, and run landforms. Each of the eight reaches is really quite distinct, indicative of significant reach-scale diversity over a relatively short distance of ~24.5 miles.

At the morphological-unit scale, the previous summary of morphological units provides abundant evidence that there is diverse and complex habitat. For example, the census by Wyrick and Pasternack (2011) found that there is an average of 9 morphological units across the channel at any cross-section. An example lateral pattern would be lateral bar, slackwater, slow glide, riffle, chute, riffle, slackwater, slow glide, lateral bar. Another would be lateral bar, slackwater, pool, fast glide, slow glide, slackwater, swale. Figure 5 shows one section of the river that has three different patterns of cross-channel landforms with different densities of morphological units. When considered at the morphological-unit scale, conditions suitable for ecological functions are termed meso-habitat. Meso-habitat is sensitive to flow, whereas morphological units are independent of flow; they are the landforms under the flow. Each morphological unit is indicative of at least one meso-habitat type at low flow, but as flow increases, longitudinally distributed hydraulics tend to even out and habitat conditions become more uniform (a characteristic of most rivers), but lateral meso-habitat conditions become more diverse. This is the case for the LYR, as illustrated by Pasternack (2008) and Sawyer et al. (2010). It also holds for the whole LYR, based on the RMT's 2D model simulations for flows ranging from 300-110,400 cfs. The morphological-unit evidence for the LYR shows that there is an abundance of morphological units and meso-habitats at all flows as well as an abundance of meso-habitat complexity in the LYR.

At the micro-habitat scale, it was already explained that the LYR has diverse and abundant boulders, large substrates, and overhanging vegetation. Notably, on page 146 the BO makes a statement that the LYR in the Yuba Goldfields region is dominated by cobble-dominated bars, so this other statement in the BO is in direct contradiction to the BO statement being made here. In addition, the LYR has diverse hydraulics over a range of flows in terms of depths and velocities. There are widespread depths in the 0-6' range and widespread velocities in the 0-4 ft/s range, which is the common range for many salmonid lifestages.

Notably, if juvenile rearing habitat had "decreased" due to the USACE's operation and maintenance of Englebright and Daguerre Point Dams and Englebright Reservoir on the Yuba River, then that could only be determined in relation to an understanding of pre-existing better conditions. However, as illustrated in Figure 6, habitat complexity was at an all-time low prior to Englebright Dam due to the suffocation imposed by vast volumes of hydraulic mining debris, whereas after 70 years of restorative sediment blockage and river-valley downcutting, there does now exist abundant habitat complexity. We may never know what the condition of the river was prior to the gold-mining era, but based on reports by Gilbert (1917), Adler (1980), Pasternack (2008), James et al. (2009), Pasternack (2010a), and Carley (submitted), we know that the river has been on a trajectory toward geomorphically recovering its historical longitudinal profile. Although the river is channelized and confined now, it is highly dynamic and its landforms are self-organized within the available river corridor.

In conclusion, the evidence about river morphology and habitat complexity for the LYR shows that the river has natural, self-determined fluvial landforms with abundant, diverse, and distinct landforms providing diverse meso-habitat conditions. If there is a case to be made that the LYR lacks habitat complexity in terms of some key factor, then this BO statement fails to make it. I am aware of an interest to have stagnant off-channel conditions, such as exists on the lowest floodplains near estuaries, but that is not appropriate for the landscape position of the LYR. Further, there is no evidence of a worsening of conditions associated with USACE's operation and maintenance of Englebright and Daguerre Point Dams and Englebright Reservoir on the Yuba River, whereas in contrast there is substantial evidence that the facilities have promoted geomorphic recovery. Because the conjecture about river morphology and habitat complexity is wrong, the chain of logic falls apart and the remaining conjecture about decreased quantity and quality of juvenile rearing habitat is unsubstantiated and conjecture about food resources is unsubstantiated.

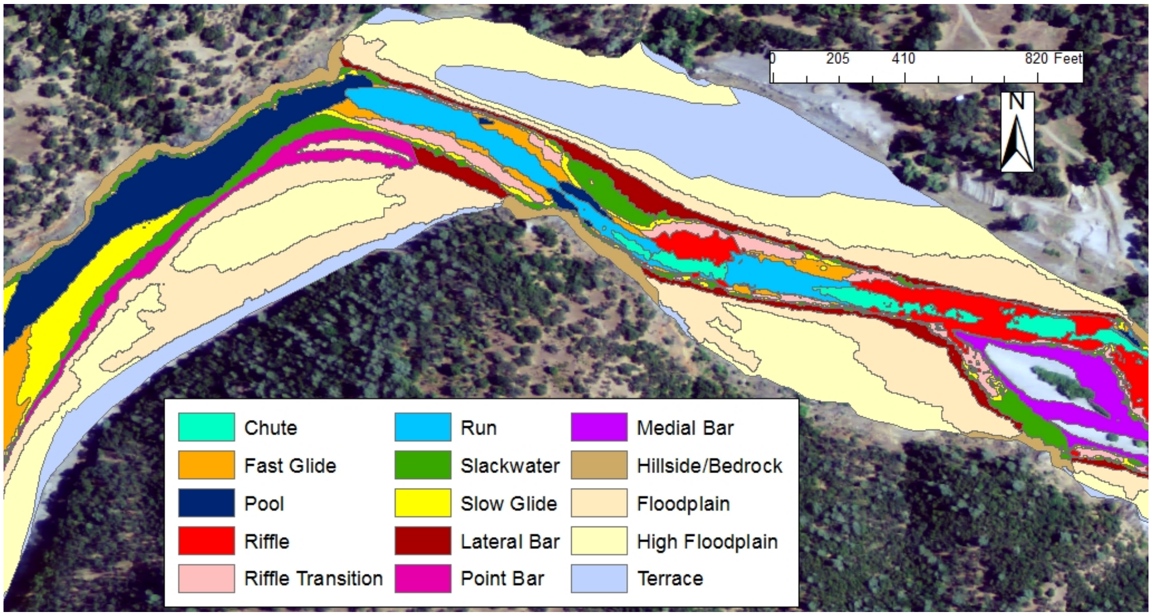

Figure 5. Example section of the LYR morphological unit map for the whole alluvial river corridor. The area on the left of the photo shows some larger landforms where there is a lower diversity with 6 bankfull-channel landforms cross-channel, while the area in the middle of the photo shows highly complex landforms with ~8-10 landforms cross-channel. At the right side there is any island-riffle complex. Thus, in this one view there is a large amount of channel complexity, providing diverse meso-scale habitat options for anadromous salmonids in different lifestages.

Figure 6. Comparison of (left) 1905 photo of the LYR showing lower river diversity caused by hydraulic mining sediment overwhelming the valley prior to construction of Englebright Dam and (right) 2011 photo of the LYR showing high channel diversity today (e.g. large woody material and submerged aquatic vegetation as well slackwater, chute, and riffle morphological units) after 70 years of sediment blockage and restorative river downcutting due to Englebright Dam.

References:

Adler, L.L. 1980. Adjustment of the Yuba River, California, to the influx of hydraulic mining debris, 1849-1970. MA Thesis, University of California, Los Angeles.

Pasternack, G.B. 2010b. Estimate Of The Number Of Spring-Run Chinook Salmon Supportable By River Rehabilitation in the Narrows Reach Of The Lower Yuba River. Prepared for the PG&E and DWR Habitat Evaluation Agreement Steering Committee.

Sawyer, A. M., Pasternack, G. B., Moir, H. J., Fulton, A. A. 2010. Riffle-Pool Maintenance and Flow Convergence Routing Confirmed on a Large Gravel Bed River. Geomorphology 114:143-160.

BO STATEMENT (Page 146)

"Attenuated peak flows and controlled flow regimes have altered the lower Yuba River's geomorphology and have affected the natural meandering of the river downstream of Englebright Dam (NMFS 2009). The channel is incised over 20 feet in some areas on the low Yuba River. Planned and unplanned flow reductions may cause side channels and backwaters of the lower Yuba River to become disconnected from the main channel."

COMMENT

As explained above, a large amount of evidence from topographic, hydrologic, DEM differencing, and entrenchment ratio analyses prove this BO statement to be wrong.

The BO statement claims that the rivers is "incised over 20' in some areas", presumably indicating the regulated flows are disconnected between channel and floodplain. This topic was covered extensively above and the conclusion of all the evidence is that the LYR's floodplain and channel are not disconnected.

This BO statement attributes an effect on natural meandering to flow regulation. In fact it is dredging, river training, and leveeing that confined the river corridor where those activities were done, and that direct channel intervention largely occurred prior to and independent of Englebright Dam and flow regulation. In other reaches the river is naturally confined by narrow and undulating valley walls. There is no evidence that flow regulation has harmed river meandering, and in fact several lines of evidence demonstrate that the river is actively meandering. DEM differencing of the river corridor for 1999-2009 shows lateral migration in many places as well as 312,000 m^3 of sediment removed from tailing berms in just 10 years. Newspapers and technical reports have documented that the LYR is meandering at such a rapid rate through training berms that it is jeopardizing the lowlands outside the berms. This is all driven by a dynamic flood regime with overbank floods having a ~70-80% chance of occurrence in any given year and larger floodplain filling floods >21,000 cfs having a ~40% chance of occurrence in any given year. These statistics based on historical data since 1970 account for the role of New Bullards Bar as well, so even with that facility's large storage capacity, the LYR still exhibits frequent overbank flows.

In contrast to this BO statement, the morphology of the LYR is self-determined, dynamic, and increasing habitat complexity over time due to the restorative role of Englebright Dam relative to the vast reservoir and continuing influx of hydraulic mining waste upstream of that barrier. It is true that the LYR's morphology is altering, but all the evidence indicates that the alterations are beneficial, not harmful, and are driven by understandable and beneficial natural processes. The LYR exhibits self-determined lateral migration and avulsion commonly along its length caused by extensive and frequent flooding as well as topographic steering induced by multiple scales of landform heterogeneity that drive the process of stage-dependent flow convergence routing (Pasternack, 2008; White et al. (2010); Sawyer et al. (2010); Carley et al. (submitted)). Historical aerial photo analysis and reports (e.g. Adler (1980), Beak Consultants, Inc. (1989), and White et al. (2010)) show that since 1942 the LYR river corridor has increased its vegetation abundance and habitat complexity. For example, in the Daguerre Point Dam reach, there is a long parallel channel named Daguerre Alley that is being scrutinized by the RMT. Historical photos from before 1960 show that this section was devoid of vegetation. However, over time aerial photos show increasing vegetation in Daguerre Alley and today there is a large region of swamp-like condition including submerged vegetation and riparian vegetation. Similarly, aerial photos of Timbuctoo Bend published in White et al. (2010) show that from 1952 to 2006, the amount of vegetation in the reach increased significantly.

The BO statement also claims that, "planned and unplanned flow reductions may cause side channels and backwaters of the lower Yuba River to become disconnected from the main channel". However, Englebright Dam cannot hold back any of the flow that normally overtop the LYR's banks. Englebright Dam has a limited storage capacity and its controlled releases do not exceed 4,500 cfs. However, in any given year there is >77.5% chance that a flow higher than 4,500 cfs will overtop Englebright Dam. In addition to that water, there is also the significant contributions from Dry Creek and Deer Creek that yield substantially higher flows to overtop the LYR's banks than what comes from upstream of Englebright Dam. According to the USGS annual peak flow record for the Smartville gage below Englebright Dam, between 1993 and 2011, the flow exceeded 4,500 cfs in 15 out of 19 years. Thus, the evidence is that overbank floods can and do occur nearly annually, inundating floodway landforms.

Backwaters and side channels may be conceived of consisting of perennially inundated areas within the bankfull channel and/or overbank areas inundated naturally during floods, which was previously defined as occurring less than once ever 1.5-5 years according to classic literature. LYR floodway features that might be interpreted as being those entities would be flood runner and backswamp. The previous hydrological analysis demonstrates that these two floodway landforms flood nearly annually. For in-channel features, these would include slackwater and swale. These landforms are within the inundation zone subjected to regular to perennial flow as part of the regulated regime specified by the Yuba Accord. The stage-dependent hydraulics of these in-channel units has been calculated and analyzed for flows ranging from 300-5000 cfs, but that has not yet been written up. Any potential affects of flow regulation on these morphological unit at this time is not evidence based, but just speculative, except for the single issue of true disconnection of the units. The one fact that is certain about the inundation of these units is that the water entering partially isolated slackwater and swale units not only comes in from the open connection, but is also coming from abundant hyporheic inflow that emerges at the top and sides of these units. Anecdotal reports (including my own direct observations) suggest that such hyporheic inflows are commonly in the ~1-10 cfs range. I have personally observed adult Chinook salmon spawning in the currents generated by these inflows. Further, where these units are located adjacent to training berms with mining ponds on the other side, there is such much lateral hyporheic inflow that it sounds like a torrent. At one such site in Daguerre Alley, I measured the temperature of the inflowing hyporheic water and found it to be measurably cooler. Consequently, the evaluation of hydraulic conditions in these morphologic units requires detailed analysis and careful interpretation. Speculation based on experience in other rivers lacking such hyporheic influx or rote recitation of literature is not appropriate. The conclusion from direct observation of the LYR is that partially isolated slackwaters in the bankfull channel, also referred to as backwaters by others, do not completely disconnect from the river under commonly occurring low flows, because the hyporheic inflow supplies enough water to keep the downstream connection open. Whether there is some extremely low flow below which such disconnection occurs has not been investigated as of yet.

BO STATEMENT (Page 146)

"In the lower Yuba River, controlled flows and decreases in peak flows has reduced the frequency of floodplain inundation resulting in a separation of the river channel from its natural floodplain."

COMMENT

This BO statement conjectures that there is a controlling relation between peak flow and frequency of floodplain inundation. That is not true. It is possible to rarely or never have enormous floods (say >100·Qbf) and still have many, many overbank floods that connect the channel and floodplain. Frequency of floodplain inundation is a different hydrologic metric from magnitude of peak flows, especially on the lower Yuba River where the hydrologic data show that overbank floods occur in almost every year, with a 77.5% chance of having an overbank flood in any given year. This is a high frequency that is higher than normal for semi-arid rivers, which are normally thought to only flood overbank every 2-5 years.

The BO statement conjectures that controlled flows have reduced frequency of floodplain inundation. However, it was previously explained that Englebright Dam has little impact on flows >5,000 cfs that come out of the watershed, so no such control exists. New Bullards Bar can have an impact, but as already reported, the flood data show that there is a 77.5% chance of an overbank flood in any given year and in fact from 1993-2011 the river did flood overbank in 15 out of 19 years. Again, by definition, a semi-arid river is only supposed to naturally flood overbank every 2-5 years, so the fact that the LYR is doing much more frequently than that natural baseline suggests that flow regulation has not hurt fluvial geomorphology. Previously explained evidence showed that the channel is not separated from its floodplain.

In many other rivers draining the Sierra Nevada and around the semi-arid and arid western United States, dams have a big negative impact on rivers. It seems that NMFS assumes that is the same for the LYR. That generalization is wrong. There are many reasons for that. First, two of the three major tributaries entering Englebright Reservoir have unabated winter floods. Second, Englebright Dam has little water storage capacity, so floods overtop the dam almost every year. Third, the channel in the lower Yuba River is not entrenched or oversized, so water can spill out of the channel. The lack of entrenchment is likely due to (a) the large amount of unconsolidated sediment in the river corridor, which makes the sediment easy for the water to push around and remove from across the whole corridor width, (b) the high slope and width/depth ratio associated with the unconsolidated sediment that helps prevent entrenchment and floodplain disconnection, and (c) the role of approximately decadal large (>20·Qbf) overbank floods in causing avulsions and ripping out bank vegetation, thereby preventing channel constriction by vegetation (for example, as reported for the Trinity River below Lewiston in northern California).

In conclusion, the evidence shows that the LYR's flood regime provides floodplain inundation at a higher frequency than expected for natural flood conditions and the channel and floodplain are not disconnected.

BO STATEMENT (Page 146)

"Within the Yuba Goldfields area (RM 8–14), confinement of the river by massive deposits of cobble and gravel derived from hydraulic and dredge mining activities resulted in a relatively simple river corridor dominated by a single main channel and large cobble-dominated bars, with little riparian and floodplain habitat (DWR and PG&E 2010)."

COMMENT

In the Yuba Goldfields region of the LYR, the normal river corridor (excluding events that break through training berms) is bounded by training berms composed of mine tailings. However, the claim that river confinement in that region has resulted in "a relatively simple river corridor dominated by a single main channel and large cobble-dominated bars, with little riparian and floodplain habitat" is only partially correct. Prior to addressing this claim, it is notable that earlier in this report there was a BO statement review that said that the LYR was lacking in an abundance of micro-habitat attributes, including large substrate, but now the BO claims that there is an excess of cobble-dominated bars. The fact is that the river has an abundance of surficial cobble, as quantified by the RMT's substrate survey and map.

It is true that there are alluvial bars in the bankfull channel and on the floodplain with a surface veneer of cobble on them (e.g. Fig. 4). That is the part of the BO statement that is confirmed by the RMT's substrate survey and map. However, Pasternack (2008) reported data from digging down into cobble-topped bars as well as visual evidence from cutbanks. In both setting, the evidence showed that underlying the surface the sediment is well-mixed with gravel, sand, and silt, as presented in the report. Specifically, three large McNeil core samples were collected by Dr. Hamish Moir as part of the Pasternack (2008) study. The combined grain size distribution for those samples yielded a mixture with 47% of particles < 32 mm and an additional 30% of particles between 32-64 mm, so 77 % of material was < 64 mm. The presence of cobbles >65 mm creates a strong visual impression to the casual observer, but the data tells a different story: the alluvial bars on the LYR are rich with diverse particle sizes, including large cobble, gravel, and other relevant sizes. The one think lacking is sufficient clay to create cohesion, but that is beyond what the BO statement claims. With respect to the BO claim of cobble-dominated bars, the statement is only partially correct and in fact the structure of the bars is dominated by material <64 mm.

At the time the DWR and PG&E (2010) report was written, the RMT was in the midst of modeling and analyzing the LYR's landforms and an independent overview of conditions in the region from Highway 20 down to DPD was underway by CBEC et al. (2010). Consequently, that study did not have the scope of detailed information available to NMFS for writing the BO in 2011 and 2012. In direct contrast to the BO statement that the river is confined in the Yuba Goldfields, it has already been explained that Wyrick and Pasternack (2011) provided the actual evidence, which in fact shows that the alluvial river valley and floodway in the LYR are at their widest in the Yuba Goldfields region, despite being bounded by training berms. Thus, although the berms do provide confinement in order to protect the floodway from interaction with the ruined Yuba Goldfields lands dating to pre-1942 cumulative impacts unassociated with flow regulation and dam impoundment, the river exhibits fluvial dynamism within the available wide corridor. The DEM-differencing study by Carley et al. (submitted) demonstrated that the floodplains have received substantial deposition downstream of DPD since 1999, indicative of both (a) geomorphically significant floodplain inundation and (b) deposition of non-cobble grain sizes that were being transported over the floodplain.

According to CBEC et al. (2010) and Wyrick and Pasternack (2011), there is significant channel floodplain, slackwater, backswamp, and swale habitat as well as reach-scale and morphological-unit scale channel complexity in the Dry Creek Reach, which is in the Yuba Goldfield area. Furthermore, downstream in the Daguerre Point Dam Reach, which is entirely within the Yuba Goldfields region, Wyrick and Pasternack (2010) identified a ~2-mile parallel area outside the main channel, now called Daguerre Alley, that has significant and abundant baseflow habitat complexity as well as a large floodplain and flood runner that inundates at some discharge between 10,000-20,000 cfs. Notably, Daguerre Alley runs almost the full length of the Yuba Goldfields that is downstream of DPD. Figure 7 illustrates the morphological units in a small part of the DPD Reach, including a small section of Daguerre Alley. Besides these two major areas, there is also a wide region of complex islands and multiple channels just upstream of DPD that is highly dynamic during floods and there is a divided channel at Long Bar up at the onset of the Yuba Goldfields area. Taken together, these four areas show that majority of the LYR in the Yuba Goldfields region is actually much more diver and complex than NMFS is aware of.

In addition, on the basis of sets of historical areal photos of the LYR, all of these areas of channel and floodway complexity within the Yuba Goldfields area have experienced an increase in abundance of riparian vegetation since 1942. The lower section of Daguerre Alley is particularly dense with riparian vegetation and swamp-like conditions.

One of the systemic problems in the BO and in the understanding that some people seem to have about the LYR is that they have chosen to render final judgments about a river without reading the available literature or actually conducting the necessary research to evaluate their ideas. This incorrect BO statement is the perfect example. The evidence now shows that within the Yuba Goldfields area the LYR is actually abundantly diverse and complex, including a bifurcated, perennially inundated channel, two areas of multiple channels that change during frequent floods, and a long parallel floodplain-flood runner complex. These are the facts about the LYR that have come to light due to the extensive geomorphic research that has been undertaken by the RMT since 2008.

In conclusion, the evidence shows that the LYR in the Yuba Goldfields area is not simple, not dominated by a single main channel, not lacking in hydrologically connected floodplains, and not having alluvial bars whose composition is dominated by large cobble. There is no baseline to compare what the river would be like if the Yuba Goldfields was not present, but within the wide bounds presented by the training berms, the LYR exhibits dynamic fluvial processes and abundant, diverse, and organized fluvial landforms.

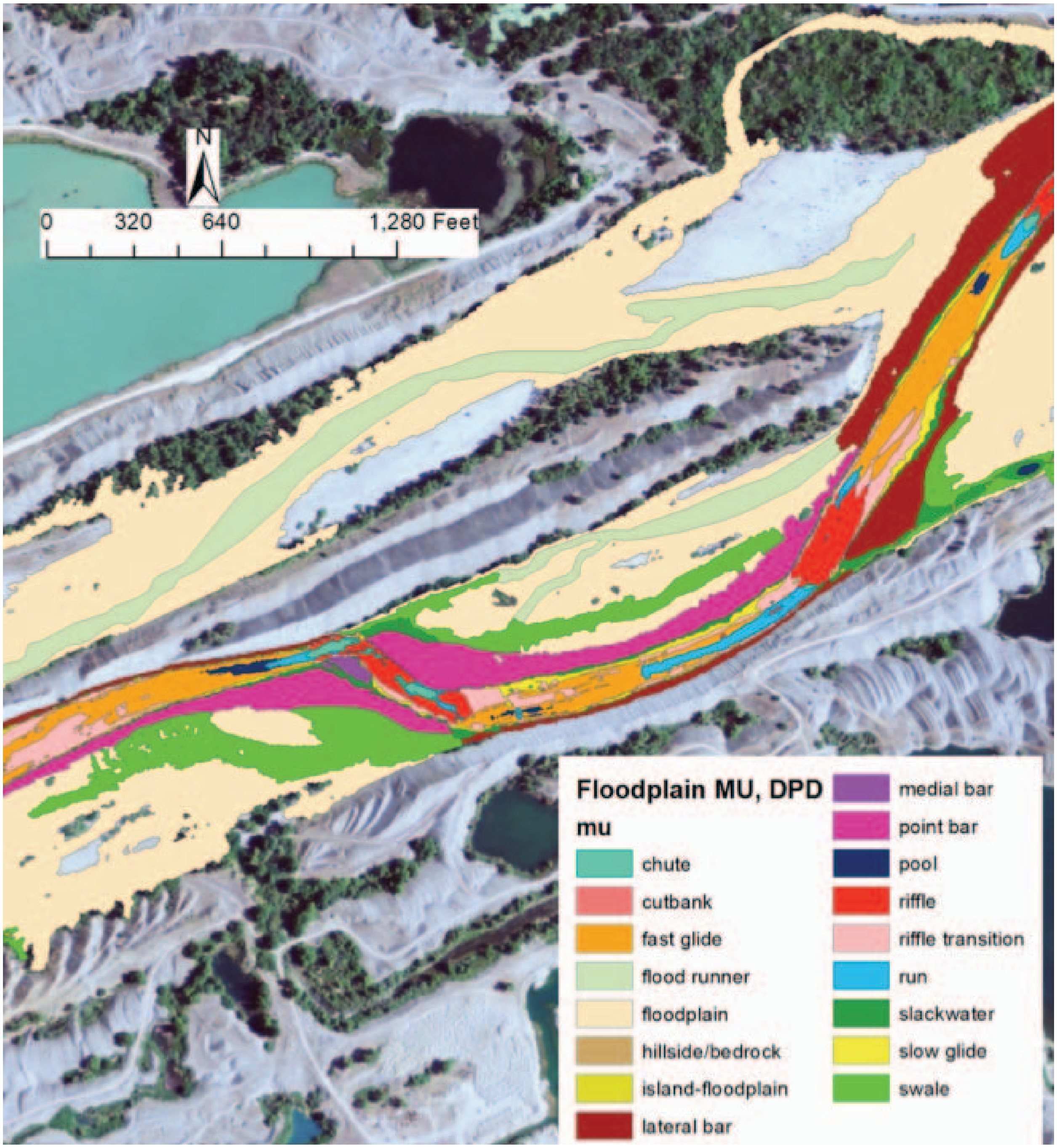

Figure 7. Morphological-unit map for a small part of the DPD Reach, including a small section of the Daguerre Alley parallel floodplain-flood runner region. Note the high lateral landform complexity in the mainstem channel as well, include diverse features such as flood runner, swale, slackwater, medial bar, point bar, and riffle units.

References:

CBEC, Inc., South Yuba River Citizens League, and McBain & Trush, Inc. 2010. Rehabilitation concepts for the Parks Bar to Hammon Bar reach of the lower Yuba River. Funded by the USFWS-Anadromous Fish Restoration Program.

BO STATEMENT (Page 146)

"Above 20,000 cfs the only exposed alluvial surfaces in the river valley are terraces and artificial berms."

COMMENT

Wyrick and Pasternack (2011) investigated and mapped the alluvial river-valley morphological units beyond the 21,100 cfs floodway. There are ten such units, including terrace, high floodplain, island-high floodplain, levee, hillside/bedrock, bank, cutbank, agriplain, tailings, and tributary delta. Notably, the high floodplain, island-high floodplain, and agriplain units are areas that would provide potential habitat and refugia during large floods. The difference between a terrace and these plains has to do with the presence of a vertical topographic riser evident in the LYR's topographic map that distinguishes terraces. The plains lack that topographic feature and are simply differentiated from the floodplains inundated by 21,100 cfs by their higher elevation.

BO STATEMENT (Page 184)

"Controlled flows and decreases in peak flows will continue to reduce the frequency of floodplain inundation and separation of the river channel from its natural floodplain."

COMMENT

This is a repeat conjecture that was already addressed earlier in this report. The statement is false.

BO STATEMENT (Page 193)

"The proposed action and interrelated and interdependent actions perpetuate the flow conditions that result in lack of connectivity with the floodplain, perpetuate the existence of the training walls that separate the Yuba River from its flood plain and cause further down-cutting

of the river, and make LWM contributions that are insufficient to relieve the stressor of lack of food resources."

COMMENT

This is largely a repeat conjecture that was already shown to be false earlier in this report, but there are further corollary conjectures that need to be addressed here. There is no lack of connectivity between channel and floodplain. There is a significant floodplain within the training berms, with a peak floodway width of ~1750'. It is true that prior to the berms, the lowland valley was wider- James (2005) and James et al. (2009) addressed that, but somehow the BO does not cite any research or publications by James, including these, so the relevance of that information to the BO was not characterized. The training berms have lost 312,000 m^3 of sediment in the last decade due to flow-induced scour. The channel is meandering through the berms via lateral migration at several of the channel's outer bends. One berm between the main channel and Daguerre Alley is only ~120' wide at this time, while one narrow berm on the opposite side of the river is only ~140' wide. There exist reports about this process as well as widely available historical aerial photos that could have been analyzed directly by NMFS to address the river's processes. Left to its own natural dynamism without any future intervention, the LYR will successfully cut through the berms. However, there is no environmental benefit to that under the current landscape condition given the extremely degraded state of the Yuba Goldfields, which has nothing to do with the USACE's operation and maintenance of Englebright and Daguerre Point Dams and Englebright Reservoir on the Yuba River.

The BO statement says that there will be further downcutting in the LYR. To the extent the statement relates to NMFS' incorrect conclusion that the river in entrenched, the statement is wrong. However, based on the evidence, it is highly beneficial to the environment and society that the LYR continue to downcut its river valley (while retaining strong floodplain-channel connectivity), as that is the natural restorative dynamic necessary and desirable. This is the reason Englebright Dam was built- to hold back the vast deposits and continuing supply of wastes and allow the LYR to recover itself. At present, I do not know what the LYR will look like decades into the future if left to its own continued rehabilitation, so I see it as an imperative goal for NMFS and other stakeholders to collaborate to establish a viable vision for the river consistent with its landscape position, valley topography, sediment supply, and flow regime (among other "genetic" controls).

The BO statement says that there will be insufficient contributions of large wood materials (LWM). LWM is scientifically defined as wood pieces or assemblages >1 m long and >10 cm in diameter (Senter and Pasternack, 2010). I have reconnoitered LWM on the LYR. Contrary to the BO statement, in my professional judgment LWM is not only abundant on the LYR at present, but ubiquitous, as exemplified by Figure 8. The reasons why there is so much LWM present is explained by these factors: (a) LWM is abundantly stored in the Middle and South Yuba River tributaries due to natural sources and land uses, such as logging, (b) the supply of LWM from those tributaries is transported to Englebright Lake during winter floods and perhaps during spring snowmelt (yet to be quantified), (c) by the time discharge is sufficient to inundate, entrain, and transport LWM to Englebright Lake, the reservoir is very likely to already be full and spilling over Englebright Dam, because the reservoir's storage is so limited, (d) LWM easily passes over Englebright Dam and transport through the narrows into the alluvial valley of the LYR. In my experience, LWM in the LYR exists ubiquitously racked behind flow obstructions, racked throughout vegetation patches, lining the water's edge demarking peak flood stages (especially those from 2006 and 1997 floods), scattered widely all over floodway morphological units, and along the banks in the Hallwood and Marysville Reaches. According to LWM literature, in order to form a massive jam of LWM, it is necessary for there to be LWM pieces sized at about the channel width. However, as previously reported, reach-average bankfull and floodway widths are 169-427' and 237-1028, respectively. These dimensions are simply too large to allow channel or floodway spanning jams to form, no matter what the volume of LWM could be in the absence of any potential upstream channel barriers. Unfortunately, there is little to no information about what LWM was like in the major rivers draining the western Sierra Nevada prior to any post-European settlement logging and stream impacts. Thus, the BO statement that LWM is decreased and insufficient is unsubstantiated relative to the available evidence. Pending and on-going LWM studies on the LYR will go further to clarifying the details of LWM conditions and processes in the Yuba watershed and on the LYR.

In conclusion, the BO's characterization of current conditions and the conjecture about future condition associated with the proposed action and interrelated and interdependent actions in this BO statement is incorrect. The evidence shows that the LYR is dynamic, connected, and complex. In the absence of further direct intervention outside the scope of the USACE's operation and maintenance of Englebright and Daguerre Point Dams and Englebright Reservoir on the Yuba River, the LYR will break out of its training berms and expand its domain into the Yuba Goldfields and beyond.

CollageIt for Mac
www.collageitfree.com

Figure 8. Collage of photos showing 31 different locations of LWM on the LYR.

References:

Senter, A. E. and Pasternack, G. B. 2010. Large wood aids spawning Chinook salmon (Oncorhynchus tshawytscha) in marginal habitat on a regulated river in California. River Research and Applications, DOI: 10.1002/rra.1388.

GRAVEL AND ANADROMOUS SALMONID SPAWNING HABITAT

BO STATEMENT (Page 56)

"Gravel availability is a limiting factor for salmon reproduction in the Yuba River downstream of Englebright Dam (Pasternack 2010a). Because the Yuba River downstream of Englebright Dam, down to Deer Creek, is devoid of spawning gravel (other than that placed by the Corps), and the Timbuctoo Bend reach is cutting down, spawning gravel is a limiting factor in the Englebright Dam reach, and a concern in other reaches."

COMMENT

As a result of RMT's 2010 survey of substrate and the resulting data and map, there is no longer any concern about the availability of anadromous salmonid spawning habitat beginning at the entrance of Timbuctoo Bend and going further downstream all the way to the confluence with the Feather River. As documented above, the RMT's recent analysis presented to NMFS and other RMT participants report that at 600 cfs there exists >3.39 million ft^2 of spawning habitat on the lower Yuba River. Spawning habitat for *O. mykiss* is still under investigation by the RMT, but smaller substrates in the preferred size range of these fish are available and as reported by Moir and Pasternack (2010), sufficient and diverse velocities are available to assist fish in creating egg pockets. The only concern regarding Chinook salmon spawning habitat has to do with the little abundance of it in the Englebright Dam and Narrows Reaches. Fish have been observed in those reaches attempting to spawn on bedrock. All activity related to addressing Chinook spawning habitat should be focused solely on those reach from this time forward.

BO STATEMENT (Page 145)

"The existing condition of salmonid spawning gravel is depleted downstream of Englebright Dam to the Highway 20 reach. The reach immediately downstream of Englebright Dam is devoid of spawning substrate. Downstream of Deer Creek, the channel is actively incising. This lack of spawning substrate limits spawning habitat and fish production. There has been a general coarsening of bed material. Lack of adequate spawning substrate presents a high risk to salmonids."

COMMENT

The BO statement that the LYR is devoid of salmonid spawning gravel between Englebright Dam and Highway 20 is false. Pasternack (2008), Moir and Pasternack, (2008), and Moir and Pasternack (2010) presented substantial data, analyses, and conclusions on this matter. Surprisingly, the BO does not cite either work co-authored by Moir in relation to spawning habitat (only the 2008 article is cited and only pertaining to the hydrology of the LYR). Those studies reported that there is abundant spawning habitat in Timbuctoo Bend. According to the RMT's annual redd survey reports for 2009-2010 and 2010-2011, 34.1% and 42.2% of all redds found on the LYR (in those years respectively) occurred in the Timbuctoo Bend Reach. Further, the RMT's substrate map shows ample gravel abundance on the bed surface in the Timbuctoo Bend Reach. Finally, the RMT's preliminary microhabitat analysis of this reach considering depth, velocity, and substrate combined found that there is > 800,000 ft^2 of Chinook spawning habitat at just 300 cfs, with a peak of >940,000 ft^2 of it at 700 cfs. These abundances exceed the amount necessary for the population of adult Chinook salmon entering the LYR each year, a fact also corroborated by the healthy spawner:redd ratio of 4:1 reported for this reach by Pasternack (2008).

With regard to the claim that the river is incising, that has already been addressed. However, in this specific context of a BO statement regarding spawning, consider the following text from Pasternack (2008): “The Timbuctoo Bend Reach is downcutting, there is absolutely no question about that. It is systematically incising, but even though it is incising, it is self-sustaining its morphological units over decades, renewing its substrates, and maintaining its level of ecological functionality.” Further, as explained by Pasternack (2008), incision is not a problem with respect to the availability of preferred spawning substrate, and is in fact a significant environmental benefit, because the river is incising into gravel-rich material that is optimal for spawning. As quantified earlier in this report, tests by Moir found that 77 % of subsurface material was < 64 mm in size. Pasternack (2008) reported that riffle morphological units were the predominant landforms used by Chinook spawners, and this has also been found in the RMT’s recent annual redd surveys. Has incision hurt the riffles in Timbuctoo Bend where much of the spawning takes place? White et al. (2010), another important LYR geomorphic study that was not cited in the BO, answered this question using a historical aerial photo analysis. They found that despite incision in Timbuctoo Bend, the reach has several persistent riffle complexes going back at least to 1984, very likely to 1952, and possibly to 1937 (with the uncertainty due to georeferencing limitations for those older images). The persistence of these riffle complexes is explained by the dominant controlling influence of valley wall undulations steering the dynamic flow regime via the mechanism of stage-dependent flow convergence routing, which Sawyer et al. (2010) demonstrated mechanistically exists in Timbuctoo Bend. Therefore, the negative implications of incision with respect to spawning habitat on the LYR conjectured by the BO statement contradict the science that has been done. In fact, the conclusion by Pasternack (2008) is even more certain now than before: Timbuctoo Bend is self-sustaining its morphological units, renewing its abundant salmon spawning substrates, and maintaining its level of ecological functionality. This last phrase of the conclusion is based on the results of the journal article evaluating the ecological functionality of flows in Timbuctoo Bend by Escobar-Arias and Pasternack (2011), another relevant study that was not cited by NMFS in the BO. This significant study includes the following relevant conclusion: “the lower Yuba River also presents geomorphic functionality that is complemented by a hydrologic functionality that comes from ample flow availability for an optimal combination of hydrologic and geomorphologic conditions for ecological functionality.”

The BO statement says that there has been a general coarsening of bed material, but provides no evidence. Pasternack (2008) reported that there is ~8-21 million yds^3 of sediment filling the TBR corridor at this time. As previously explained, this fill material is composed of a large percentage of preferred spawning gravel/cobble. Therefore, the BO statement is unsubstantiated and contrary to evidence about Timbuctoo Bend.

In conclusion, the claims in this BO statement and the conjecture that there is a dangerous lack of spawning substrate is false. The only evidence-based statement that can be made and should be made is that Englebright Dam and Narrows Reaches are severely limited in their spawning substrate, Timbuctoo Bend has no such limitation whatsoever.

References:

Escobar-Arias, M. I. and Pasternack, G. B. 2011. Differences in River Ecological Functions Due to Rapid Channel Alteration Processes in Two California Rivers Using the Functional Flows Model, Part 2: Model Applications. River Research and Applications 27:1-22, doi: 10.1002/rra.1335.

BO STATEMENT (Pages 176 and 177)

"Englebright Dam was designed to hold back sediment and gravel. The existence of the dam retains spawning gravel, causing the lower Yuba River to be gravel-deficient downstream of Englebright Dam to the Highway 20 reach. This lack of spawning substrate limits spawning habitat and fish production. There has been a general coarsening of bed material. Lack of adequate spawning substrate presents a high risk to salmonids. The proposed action will continue to result in chronic spawning gravel deficiencies downstream from Englebright Dam."

COMMENT

Figure 41 of Pasternack (2008) shows that Englebright Dam holds back an estimated 61,600 yds^3 of gravel/cobble each year. Taken alone and relative to conditions on other regulated rivers, this might commonly be interpreted to mean that there is a gravel deficit downstream of Englebright Dam to Highway 20 (note that there is no such thing as the "Highway 20 reach" according to any study I know that has delineated geomorphic reaches for the LYR). However, the fact is that the LYR river corridor stores vast quantities of coarse sediment. As mentioned above, Pasternack (2008) reported that Timbuctoo Bend alone holds an estimated ~8-21 million yds^3 of sediment filling the TBR corridor at this time. Furthermore, as previously explained, this fill material is composed of a large percentage of preferred spawning gravel/cobble. Therefore, beginning at the entrance to the Timbuctoo Bend Reach, there is no such gravel deficiency whatsoever and no temporal or longitudinal coarsening. The BO statement is wrong on this point.

The only domain where Englebright's barrier to sediment passage harms the LYR at this time is in the Englebright Dam and Narrows Reaches (Pasternack, 2008). This is being addressed through the USACE's gravel augmentation implementation plan (GAIP) and the Habitat Expansion Plan (HEP) proposed by DWR and PG&E.

BO STATEMENT (Pages 176 and 177)

"This area has a deficit of 63,000 to 101,000 tons of spawning gravel (Pasternack 2010a). Gravel augmentation under the proposed action has provided a small incremental improvement above the baseline conditions that Englebright Dam is designed to maintain. As of October 6, 2011, PSMFC staff has identified 16 Chinook salmon redds in the Englebright Dam Reach where previously suitable spawning gravels did not exist prior to the Corps' 2010 gravel injection program."

COMMENT

The deficit referred to in the BO statement only relates to the Englebright Dam Reach. There is no estimate of a spawning gravel/cobble deficit for the Narrows Reach, because there is presently no topographic map and 2D model of that reach.

In 2007 USACE injected 500 short tons of gravel/cobble and in 2010-2011 they injected another 5000 short tons of it. This represents a mere 5.4-8.7 % of the deficit. Further, in winter and spring 2011 high flows moved all of the injected material out of the local injection area as desired and virtually none of it moved out of the reach, so it was retained and available. The design hypotheses related to spawning habitat in the GAIP have to do with habitat formed in the injection area when no such high flows occur. Formation of significant spawning habitat downstream of that area but still within EDR would require filling a significant percentage of the storage deficit, not a mere 5-9 %.

Let me clarify this expectation with a simple example that contrasts the difference between gravel volume and surface area of habitat. Imagine a vast, deep hole in a river. One could dump millions of tons of gravel into that and get zero habitat. Conversely, imagine a shallow glide. One could place a few tens of tons of gravel/cobble on that and get lots of spawning habitat. This example illustrates the concept of "gravel efficiency" in river rehabilitation, which is a metric consisting of the ratio of the area of surficial spawning of habitat created by gravel addition to the volume of gravel added. Gravel volume does not make habitat; surficial gravel area does. Filling holes has low gravel efficiency, while converting glides to riffles has a high gravel efficiency. In the case of the Englebright Dam Reach, Wyrick and Pasternack (2011) reported that 40.8% of the baseflow wetted area consists of bedrock pools. Figure 122 of Pasternack (2008) shows the locations of 3 large pools that were predicted to trap the majority of the injected sediment. Pasternack (2008) concluded that the remaining residual of injected material would get caught up by roughness elements in the reach, and that is exactly what has happened. Thus, until the volume of these holes in the river is filled in, there cannot be sizable gravel/cobble landforms, and without the appropriate landforms, there cannot be habitat for salmonids (other than holding in the pools).

The BO's judgment about spawning on a small fraction of preliminarily injected and flushed gravel/cobble augmented in the deep Englebright Dam Reach is invalid. There was no expectation that the first injection of transported gravel/cobble would yield substantial spawning habitat, but that such habitat would only exist if no flood redistributed the injected sediment within the reach. Had 2011 been a dry winter and spring, the material would have stayed as one riffle in the injection zone according to the Area A and B fills presented in the design in the GAIP. There was no problem with the material redistributing downstream within the reach, but that did affect the gravel efficiency outcome, with most of the material going into deep water, not shallow water. The outcome of the 2010-2011 pilot injection has thus far yielded the expected outcomes, especially given the lessons learned from the 2007 injection. The GAIP includes a long-term plan and until the gravel deficit of the reach is filled, there should be limited expectations of habitat, because spawning habitat is not a direct function of gravel volume, but instead a function of gravel surface area. It is necessary to stick with the GAIP's injection regime and conduct the GAIP's stated monitoring before any judgments about spawning habitat value should be made.

BO STATEMENT (Pages 177)

"The proposed gravel augmentation would be a short-term increase in the ability of the proposed action to enhance the reproductive fitness of Central spring-run Chinook salmon and Central Valley steelhead, because, as the gravel moves through the system, the level of spawning habitat available will diminish, eventually returning to baseline conditions."

COMMENT

This statement is false. Gravel augmentation is to occur in perpetuity. This is a small price to pay compared to the tremendous environmental and societal benefits of Englebright Dam, which is promoting passive river rehabilitation in the LYR and holding back a vast anthropogenically created hazard that could devastate the ~100 miles of lowlands downstream of the Dam.

According to the long-term plan articulated in the GAIP, once the gravel deficit in the Englebright Dam Reach is eliminated, then the USACE will monitor to determine annual losses and will add gravel to maintain the required gravel volume in the reach. If this plan is followed, there will never be a return to baseline post-dam conditions. Several reports including Pasternack (2008) and the GAIP itself state that flood will not evacuate sediment from EDR, because downstream in the vicinity of Sinoro Bar and the confluence with Deer Creek the canyon widens substantially and gravel/cobble naturally deposits on the inside of the bend. Deer Creek floods also present a hydraulic jet barrier to sediment transport in the mainstem Yuba at the confluence.

Pasternack (2008) showed that sediment has been present in this location for over 100 years and has persisted there for the entire duration since gravel/cobble supply was cut off, even with many floods >50,000 cfs. Pasternack (2010b) analyzed the history of sediment in the Narrows Reach and reported that sediment has also persisted in the wide upper half of that reach as well for the whole duration since supply was cut off. Further, although the mean water temperature at this landscape position in the watershed is naturally warm in the late summer when groundwater flow drops, this is an area that the USGS has mapped as having a lot of local springs that could have provided sufficiently cold conditions for spring-run salmon to hold and then spawn when it cooled off in the fall. Spring-fed holding microhabitats are known to be utilized for this purpose in California.

In conclusion, the BO statement is wrong, because sediment natural holds in the two bedrock reaches regardless of flows and continuity of sediment supply and because the GAIP calls for gravel augmentation in perpetuity.

BO STATEMENT (Pages 177)

"Daguerre Point Dam does not appreciably affect gravel transport, because the pool is full of gravel and dredging is needed to keep the ladders and diversions clear; however, ladder maintenance and dredging that does not return gravel to the Yuba River downstream of Daguerre Point Dam would affect gravel transport. Spawning gravels downstream of Daguerre Point Dam are not a consideration, because the gradient of the river allows for gravel retention."

COMMENT

A run-of-the-river dam is one with no water storage capacity. Daguerre Point Dam is a run-of-the-river dam. The primary geomorphic function of DPD not to provide a reservoir to store sediment, but rather to hold together the longitudinal profile of the river by establishing and maintaining a base-level elevation. In light of this information, the concept in the BO statement that "the pool is full" does not make much sense geomorphically. It is feasible to clear a pool in the immediate vicinity of the dam, but the rest of the river upstream of DPD is either adjusted to or adjusting to the base level set by DPD (Pasternack, 2008), so there should not be a large pool there. Rather than thinking of DPD has having a little water reservoir that fills in with sediment, one should think of DPD as holding back the volume of the entire longitudinal profile of coarse sediment upstream of the dam down to the elevation that the river would grade to in the absence of the dam. This is the purpose and function of DPD. How sediment pulses are naturally responding to the presence of DPD appears to be somewhat complex, as reported by Carley et al. (submitted), and requires further study.

The BO claim that the failure to return the sediment dredged out of the ladders and in the pool immediately upstream of the dam affects gravel transport is predominantly not true. According to the RMT's data used in Carley et al. (submitted), the river upstream of DPD sends an average of ~80,000 m^3 of sediment per year past DPD. A few hundred to a few thousand m^3 are moved around in operations at the dam itself every few years, which is below ~1-10% of the annual flux. When floods are moving sediment past DPD, there is virtually nothing that could be done with the dredged material that would affect sediment transport or geomorphic processes. Also, the amount of material is too small to affect the sediment budget appreciably. The overall LYR sediment budget consists of ~2.52 million m^3 of scour and 2.46 million m^3 of fill, so relative to that, DPD gravel/cobble operations are inconsequential.

Not only does the lower gradient of the river downstream of DPD promote retention, but so too do the higher reach-scale bankfull and floodway widths.

BO STATEMENT (Page 233)

"GAP 3. The Corps shall place a minimum of 15,000 short tons of graded and washed gravel and cobble into the Englebright Dam Reach annually. This will continue until the gravel/cobble deficit (estimated at 63,077 to 100,923 short tons in the GAIP) for the Englebright Dam Reach is eliminated. Thereafter, gravel placement will be made to replace gravel that has moved downstream out of the placement areas. Gravel deposits will be placed at a time and manner each year as approved by NMFS."

COMMENT

Much of this statement is consistent with the GAIP, except the initial annual injection volume and the constraint on timing and manner of injection. I appreciate the intent to push gravel augmentation at the highest rate conceivable and with more NMFS control, but there are problems with these specifications. First, the gravel sluicing method piloted in 2010-2011 took 2 months to inject 5,000 tons, and that was facilitated by (a) flood flows during injection that cleared additional space for gravel addition at the single injection point and (b) the use of a gravel mixture specified by USFWS that was significantly undersized for the LYR, which made it easier to sluice. On the basis of that pilot effort, many lessons were learned and the system will be improved to be faster. However, the sediment mixture will also likely change to reflect the advancement in knowledge of spawning substrates for the Yuba since the original mixture was specified and it is very unlikely that floods will occur at the times NMFS chooses to allow injection to occur (i.e. late summer). I have not calculated it out yet, but I am concerned about the appropriateness of injecting a plug of 15,000 short tons into the upper EDR in one short period each year. I have raised these concerns with NMFS and others already.

Overall, there needs to be flexibility in volume, timing, and manner of injection to enable safe and effective implementation, and the BO statement confounds that. Incremental technological and scientific improvements are coming with each new effort and these are being documented in reports. On the basis of each new report, a team of those involved should collaborate with NMFS to review best practices for the volume, timing, and manner of injection for subsequent years. A multidisciplinary, team-based approach involving NMFS, those performing the work, and those having the expertise about the LYR is the best management approach over having some one who has never been to the site or used any of these methods dictate what should happen.

BO STATEMENT (Page 234)

"The operations and maintenance of Englebright Dam perpetuates the interruption of the movement of gravel in the Yuba River. The Corps have identified that the deficit of gravel in the reach downstream of Englebright Dam (Englebright Dam to Deer Creek) is between 63,077 to 100,923 short tons. It is expected that high flows will cause gravel to move downstream of the Englebright Dam reach, and it will be necessary to replenish the gravel that leaves the Englebright Dam reach. NMFS believes placement of gravel in the reach downstream of Englebright Dam will improve the viability of spring-run Chinook salmon, steelhead, and possibly green sturgeon. Similarly, the area in the Yuba River around the confluence of Deer Creek provides some opportunities to improve habitat and through those habitat improvements, improve spring-run Chinook salmon and steelhead viability."

COMMENT

In pointing out that Englebright Dam blocks gravel transport, the BO statement should recognize that (a) the present volume of sediment supplied to Englebright Lake from the watershed, including the gravel fraction, is unnaturally excessive due to the degraded state of the watershed associated with the cumulative impacts of historic and modern anthropogenic activities and (b) the gravel entering the lake is mixed in with all the other sediment sizes stored behind the Dam and would not be transmitted to the LYR or stored there in the absence of the vast abundance of finer sediment. As of 2003 data, Englebright Dam actually holds back a total volume of ~21.9 million m^3 (~25.6 million metric tons or ~28.2 million short tons) of mixed sediment sizes. Given the 61 year history of the dam (1942-2003), the average annual flux of sediment is ~359,000 m^3 (~462,000 short tons). These are daunting abundances that remind us of the importance of having Englebright Dam in light of the persistence of a degraded watershed upstream of it. The BO should not use the modern annual supply of any sediment fraction into Englebright Lake as representative of what the supply for the LYR should be or what it was prior to the gold mining era.

As already explained, since Englebright Dam was built, notable deposits of gravel/cobble substrates have stayed in the Englebright Dam and Narrows Reaches where the canyon is wider and where there are flow obstructions. Therefore, gravel/cobble can and does persist. Nevertheless, more alluvial landforms are possible than just those; creating and sustaining many potential areas of fish spawning habitat will require a perpetual gravel augmentation program.

LARGE WOODY MATERIAL

BO STATEMENT (Page 138)

"Few pieces of large wood are found within the reach of the lower Yuba River extending from Parks Bar to Hammon Bar, largely due to upstream dams disrupting downstream transport from the upper watershed and the overall lack of supply and available inventory along the riparian corridor of the river downstream of Englebright Dam (cbec et al. 2010)."

COMMENT

This BO statement is false. CBEC et al. (2010) provided planning-level conjecture, not evidence-based data and analysis. Figure 8 above shows 31 examples of locations where there are pieces of large wood. As explained earlier, LWM is ubiquitous in the LYR river corridor and there is an abundant supply of LWM to the LYR. In addition, downstream of DPD in the Hallwood and Marysville Reaches, the riparian corridor contributes LWM to the channel.

Scientific studies are needed to quantify the LWM budget, composition, and processes in the Yuba watershed, including the LYR.

BO STATEMENT (Page 144)

"The lower Yuba River has an outstanding deficiency of LWM, with only a handful of large pieces of LWM known to occur at Hammond Bar. The rest of the lower Yuba River is devoid of LWM.

…little instream woody material occurs in the lower Yuba River because upstream dams reduces the downstream transport of woody material, and because of the general paucity of riparian vegetation throughout much of the lower Yuba River.

During uncontrolled spill events, accumulated woody material spills over the Englebright Dam. These are typically small in diameter and pass through the system rapidly, because there is lack of riparian vegetation to capture or anchor woody material and a lack connectivity of the lower Yuba River with its floodplain where woody material can strand or anchor."

COMMENT

This BO statement is false. Figure 8 above shows 31 examples of locations where there are pieces of large wood. As explained earlier, LWM is ubiquitous in the LYR river corridor and there is an abundant supply of LWM to the LYR. In addition, downstream of DPD, the riparian corridor contributes LWM to the channel. The floodplain is not disconnected from the channel and there is a large amount of LWM on the floodplain. In terms of large-diameter pieces, I have observed many such tree trunks throughout the LYR.

This BO statement claims that there is a “lack of riparian vegetation”. There is no evidence or citations in the BO statement to substantiate this. In 2008 the RMT did a LiDAR survey of the LYR from highway 20 to the confluence and by 2011 the RMT had both a topographic map of the land surface as well as a canopy height map. In addition, the RMT digitized the patches of vegetation in recent aerial imagery of Timbuctoo Bend and EDR. These data and maps could have been analyzed by NMFS alone as well as together with other data, such as the RMT’s 2D model results to actually characterize the riparian zone. I have gone ahead and done that full analysis to yield the real evidence characterizing the conditions on the river. Based on the RMT’s vegetation map, there exists 23.2 million square feet of vegetation within the 42,200 cfs inundation zone, which covers 25% of the surface. The Daguerre Reach beginning at DPD has the highest vegetated abundance at the reach scale, with 33 % vegetation coverage. Of the alluvial reaches, Timbuctoo Bend has the least vegetation (9%), but it is also naturally valley-constricted and still systemically downcutting relative to the DPD base level (Pasternack, 2008), so there is no reason why it should be heavily vegetated on its floodplain. Overall, both data and observations demonstrate that the BO statement is false and there is significantly more vegetation in the floodway that just a “general paucity”.

In terms of having sufficient riparian vegetation to provide ecological functionality (to address the “lack” statement in the BO), there are two lines of evidence suggesting that the coverage is significant and functional. First, the RMT has conducted paired hydrodynamic modeling of the LYR in which one set of models lacks vegetation and the other represents the actual LYR vegetation pattern and height as best as possible. As shown at the 2011 LYR Symposium and in presentations at RMT meetings, vegetation was found to significantly affect the hydraulics of the river, and thus may be deemed present in a significant quantity relative to that functionality. Second, there are accounts of LYR observations that LWM is abundantly trapped in the vegetated patches lining the bankfull channel and scattered out on the floodway, especially in the vegetated patches. I have performed a recon of the river to verify this and in the effort I made a photo database showing many examples demonstrating this to be the case. Formal LWM mapping is being undertaken in relicensing, so more data is yet to come.

I appreciate that the BO aims to explain controls and impacts on LWM for the LYR, but the explanation is wrong. Scientific studies are needed to quantify the LWM budget, composition, and processes in the Yuba watershed, including the LYR. In my preliminary professional judgment regarding this matter, here is what I offer so as to not just be critical, but to offer a better explanation: Far and away, the #1 predominant control on the geomorphology of the LYR, including LWM patterns and processes, is the vast deposit of unconsolidated hydraulic mining sediment that filled the LYR valley. This deposit has strongly influenced every reach-scale hydraulic variable from the onset of Timbuctoo Bend to the confluence with the Feather River, such as reach-average slope, bankfull and floodway width, channel width/depth ratio, and strong connectivity between floodplain and channel. Every aspect of channel pattern is influenced by what this pile of unconsolidated alluvium can hold together. On top of that and contrary to statements in the BO, the LYR's flood regime is highly dynamic with the frequency of overbank floods exceeding the natural expectation for a semi-arid climate. This flow regime has been found to be capable of reworking the mining fill and is moving it downstream over time. With respect to LWM, no matter how big the tree trunks are that wash over Englebright Dam, the fact that the floodway is so wide means that on the falling limb of the flood the wood gets scattered over a vast area, with disproportionate concentrations racked behind flow obstructions, racked throughout vegetation patches, and lining the water's edge demarking peak flood stages. I have walked the line of the 1997 flood stage in Timbuctoo Bend and there is a lot of large streamwood tree trunks at that line. There is ample roughness along the fringe to catch very large wood pieces, but the situation is that the river is so wide and deep in flood that the wood cannot produce jams relative to the scale of the system. I can think of ways to change the functionality of the river, but the fact is that none of this has anything to do with the USACE's operation and maintenance of Englebright and Daguerre Point Dams and Englebright Reservoir on the Yuba River. I am not sure what the baseline or reference functionality is or ought to be for the LYR-simply aiming for "complexity" everywhere is naïve application of theoretical dogma; it is mindless of the true diversity of rivers, which includes many types of homogeneous reaches as well as heterogeneous ones. The LYR should not be compared to a lowland coastal river or a low-slope, sand-bedded river with miles of wood jams. Neither NMFS nor any one else has performed a comprehensive comparative analysis of the LYR to develop a meaningful and appropriate baseline for what the river's unimpaired baseline ought to be.

BO STATEMENT (Page 145)

"In the lower Yuba River, mature riparian vegetation is scattered intermittently, leaving much of the banks devoid of LWM and unshaded. This lack of cover affects components that are essential to the health and survival of the freshwater lifestages of salmonids and their prey.

COMMENT

This BO statement is wrong. There are two issues here, (1) height and maturity of LYR vegetation and (2) abundance and distribution. First, the canopy height map of the LYR easily provides the data regarding the actual heights from SR20 to the terminus of the river to analyze where tall trees occur and in what abundance. The data shows that the height of the vegetation in the 42,200 cfs inundation area varies by reach, but is not insignificant, with reach-scale averages between 17.5 to 33.6 feet and individual tree heights up to a maximum of ~150 feet. The literature states that mature sandbar willows (*Salix exigua*) range in height from ~12-25', and in my experience using the LYR canopy height map and incorporating vegetation into 2D models of the LYR, willow patches of that height are widespread on the LYR. Also, tall cottonwoods and oaks are present in backwater areas, especially when there are recently abandoned channels or floodrunners at the outer margin of the floodway as well as in the lower section of Daguerre Alley. Figure 9 illustrates what happens to tall trees in the naturally valley-constricted Timbuctoo Bend during even a small flood with just a ~2.5-3 year recurrence interval. Given the aggressive flood regime in the LYR, there is no reason to expect anything other than r-type rapid colonizers, such as willows, to persist as a population along the bankfull channel. The recovery time for mature willow patches is less than the recurrence interval of the floods that disturb them, whereas the recovery times for cottonwood and oak patches are too long.

In terms of streambank vegetation, in the 1,000 to 5,000 cfs inundation band, the river has 3.54 million square feet of vegetation, comprising 28% of the bank area along the whole LYR (excluding the Narrows Reach). The Daguerre and Hallwood Reaches below DPD have the highest abundances, with >33 % vegetation coverage in the streambank area. Even Timbuctoo Bend manages to have 20% of its streambank area vegetated. Because these are areal estimates and not linear bank length estimates, let's consider some individual sites to further evaluate the presence and height of vegetation along the banks. Figure 10 below illustrates (a) dense vegetation lining the bankfull channel in Timbuctoo Bend, (b) effective floodplain-channel connectivity, and (c) the entire length of channel-adjacent vegetation is producing shading against the rising sun. Figure 3 shows a juvenile fish using exactly this kind of cover in Timbuctoo Bend. Figure 11 shows the same situation in the Marysville Reach, and it visually evident in that photo that the riparian vegetation lining the Marysville reach is quite tall. In terms of the data, the average tree height in the Marysville Reach within the 1,000 cfs inundation zone is 34.7', while in Timbuctoo Bend it is 11.9'. A simple effort of viewing the LYR in Google Earth is enough for any person to visually confirm that long sections of the LYR has significant riparian vegetation providing shading and cover.

In conclusion, there is far more riparian vegetation in the LYR corridor than the "general paucity" cited in the BO and the vegetation is providing hydraulic (e.g. flow deflection, flow-focusing, and turbulence generation), geomorphic (sediment trapping), and ecological (streamwood trapping) functions. In addition, there is a preponderance of vegetated riverbanks in the LYR and this vegetation does provide shading and cover. Since 1942, the abundance of vegetation in the LYR has increased, but the nature and abundance of the hydraulic mining sediment in the river corridor asserts a primary control on riparian vegetation and LWM.

Figure 9. Photo of Timbuctoo Bend apex at ~26,000 cfs during the May 2005 flood showing a tree on a submerged medial bar near the center of the photo. After the flood the tree was gone, but the island was actually bigger (Sawyer et al., 2010). Meanwhile, the sandbar willows shown in the upper left of the photo returned in the years after this flood and the subsequent larger New Years 2006 flood.

Figure 10. Aerial image of part of Timbuctoo Bend on 6/26/2011 when mean daily discharge was 9027 cfs and the water is clearly overbank with a lot of inundated vegetation. Vegetation lines all alluvial banks in the photo. There is also a sizable backwater area at top center. All along the channel bank on the bottom of the photo (east side), the rising sunlight is hitting the vegetation lining the channel and producing visible shading in the water.

Figure 11. Aerial image of part of the Marysville Reach on 6/26/2011 when mean daily discharge was 9027 cfs and the water is overbank with a lot of inundated vegetation. All along the channel bank on the bottom of the photo (east side), the rising sunlight is hitting the vegetation lining the channel and producing visible shading in the water.

BO STATEMENT (Page 145)

The Yuba Goldfields section near Daguerre Point Dam is largely devoid of streamside vegetation (CALFED and YCWA 2005).

COMMENT

This statement is wrong. According to the LiDAR data, the reach below DPD has the greatest areal abundance of vegetation within the 42,200 cfs inundation zone among reaches on the LYR. Meanwhile, the Dry Creek Reach just upstream of DPD has the second highest areal abundance. Figure 12 shows the upper half of the area in question, just above DPD. Nearly the entire length of water's edge on either river bank as well as much of the water's edge on the medial bar is covered with vegetation. Anyone who looks at this photo would conclude that there is an abundance of streamwide vegetation, not a deficit of it. Although not shown, the matching area just downstream of DPD also has streamside vegetation, with the first bar and floodplain on the south bank ~50% vegetated and the north bank >50% vegetated. Figure 13 shows the abundance of vegetation a little further downstream of DPD in the Goldfields area. It is not largely devoid of streamside vegetation.

Figure 12. Aerial image of the upper Goldfields section of the LYR just upstream of DPD on 6/27/2012 showing abundant streamside vegetation and overbank inundation.

Figure 13. Aerial image of part of the lower Goldfields section of the LYR downstream of DPD on 6/27/2012 showing abundant streamside vegetation and overbank inundation.

BO STATEMENT (Page 145)

Englebright Dam continues to inhibit regeneration of riparian vegetation by preventing the transport of any new fine sediment, woody debris, and nutrients from upstream sources to the lower river.

Subsequently, mature riparian vegetation is sparse and intermittent along the lower Yuba River, leaving much of the bank areas unshaded and lacking in LWM. This loss of riparian cover has greatly diminished the value of the habitat in this area.

COMMENT

Taking the second sentence first, that BO statement has already been refuted in the text above.

Addressing the first sentence, Englebright Dam is not a barrier for fine sediment carried as washload and is only a partial barrier for suspended load. This is evidenced by high turbidity during floods that overtop the dam. The dam is not a barrier for LWM, as evidenced by the 31 photos of LWM presented in Figure 8. The dam is not a barrier to dissolved nutrients or particulate organic carbon. According to the literature, a river's washload is rich with nutrients, metal, and organic carbon. Also, for the supply of useful materials that are actually blocked, the fact is that if the barrier was not there, the consequences would be environmental and economic devastation for the ~100 miles of downstream lowlands as well as for the estuary beyond. The question is how to quantify, characterize, and mitigate the negative effects, while still obtaining the positive ones.

The conjecture that a supply of fine sediment, woody debris, and nutrients would promote regeneration of riparian vegetation is wrong. First, it has already been stated that since 1942 the abundance of vegetation in the LYR has been increasing. A historical characterization of vegetation growth is needed prior to making a biological opinion about what the actual regeneration rates are with the dams and operations present and what they otherwise might or should be. Second, availability of these materials, which is not as limited as stated anyway, is not the primary stressor on riparian vegetation growth. This BO statement does not account for the fact that the LYR is systematically lowering as part of its recovery to a devastating historical disturbance in the form of hydraulic mining sediment smothering. Against the power of the flood regime driving the downward trajectory of river corridor, establishing a completely forested floodplain with stable soils on an artificially elevated platform is a misguided and inappropriate reference. The LYR has a moderately high slope and strong floodplain-channel connectivity, so it behaves as an active pioneer setting across its whole floodway. This setting is not unique, but does exist worldwide, and in such place one finds that the ecology is commonly dominated by r-type rapid colonizers, as previously mentioned. The BO should provide an appropriate and transparent baseline as to what the target is for the LYR to be. The idea that it should be a highly sinuous, extremely complex, completely forested river sounds more like a low-slope, sand-bedded, single-threaded river like the lower Mississippi River, Athafalaya River delta or perhaps the lowermost Cosumnes River at the confluence with the Mokelumne River in the Sacramento-San Joaquin Delta. There ought to be a semi-arid, moderate slope, gravel/cobble bed, valley-confined, active flood regime reference used, but that is lacking.

BO STATEMENT (Page 192)

"Loss of LWM in the Yuba River directly affects the ability of the river to retain spawning gravels and indirectly affects the ability of the river to establish a riparian overstory.

COMMENT

Based on the information provided above, this BO statement is not true. The LYR has nearly ubiquitous spawning gravels and is not exporting much at all. LWM is not "lost" by the upstream facilities, except New Bullard Bar, but passes to the LYR where there is an abundance of LWM.

BO STATEMENT (Page 247)

"In addition, Englebright Dam impedes and reduces the frequency of LWM delivered and deposited in the reach, which further decreases gravel retention and channel complexity."

COMMENT

There is no evidence or literature cited to support this false claim. In a previous response above I explained what is known about this topic and why this statement is false. Further, USACE plans to conduct a LWM study to reduce the uncertainty in what is known.

TRAINING WALLS

BO STATEMENT (Page 136)

"The training walls channelize the lower Yuba River and may have been the primary driver for the river downcutting and separating the Yuba River from its floodplain."

COMMENT

The facts provided earlier in this report demonstrate that the channel and floodplain and not only not disconnected, but are actually strongly connected. Floods that spill overbank and inundate the floodplain occur at a higher frequency on the LYR than anticipated for pristine semi-arid rivers.

The training walls do not channelize the river in the sense of defining and controlling the geometric shape of the bankfull channel. The north flank of the river is mostly up against the valley wall, so the training berms on that side are not very consequential. On the south side the berms do temporarily block the river's ability to move to the south, but the bankfull channel is migrating through the training walls very quickly; left to its own progress, the river will move into the Yuba Goldfields, which adds no environmental benefits and grave environmental and societal hazards. The idea from the BO statement that if the training walls were removed, the river would be better off is not correct. The training walls are not there in support of Englebright and Daguerre Dams. They are there as a lowland flood control measure and to save the river ecosystem from that wasteland.

BO STATEMENT (Page 181)

"Rearing habitat is adversely impacted by water diversions associated with the project and by the training walls disconnecting the Yuba River from its floodplain and disrupting hydrogeomorphic function. The interrelated and interdependent conjunctive uses of water delivery and energy production prevent or reduce the types of releases from Englebright Dam that would stimulate natural hydrogeomorphic processes and reconnect the Yuba River with its the floodplain. River channelization and downcutting exacerbate this problem."

COMMENT

These claims are all wrong. Throughout the Yuba Goldfields region, the training walls do not separate the active river corridor from a floodplain, they separate it from a hazardous wasteland. Removal of the training berms would be disastrous. Meanwhile, within the available river corridor, the river has a strong connection between channel and floodplain. River downcutting is not exacerbating any problem, but is the natural, beneficial process of ecological recovery that is being facilitated by Englebright Dam.

As previous explained, the LYR is well known to have natural fluvial landforms and the evidence thus far in several publications and presentations is that the natural organization of landforms in the LYR exists because the river has an active flood regime, dynamic channel changes, and a whole suite of self-driven geomorphic processes.

Controlled releases from Englebright Dam cannot exceed 4,500 cfs and do not need to, because the river naturally floods right over the dam when the watershed generates sufficient flow, which occurs more frequently than is common for pristine semi-arid rivers. Although it is not possible to provide a tightly controlled recession from 10,000 cfs down to 4,500 cfs, even if there was such a control, a hydrological analysis of water availability raises the question as to whether there is sufficient water in the spring snowmelt recession to facilitate cottonwood recruitment without otherwise using up the supply needed for other ecological functions later in summer and fall. More studies are needed to assess stressors on riparian recruitment on the LYR, especially given that vegetation abundance has been increasing on the LYR over time.

BO STATEMENT (Page 184)

"The proposed action and interrelated and interdependent actions perpetuate the flow conditions that result in lack of connectivity with the floodplain, perpetuate the existence of the training walls that separate the Yuba River from its flood plain and cause further down-cutting of the river, and hold back LWM contributions that would relieve the stressor of lack of food resources.

The training walls upstream of Daguerre Point Dam prevent juvenile spring-run Chinook and Central Valley steelhead from being sheltered from fast currents and is likely to expose them to *increased predation. The river confinement caused by the training walls adjacent to the Yuba Goldfields decreases riverine habitat complexity and results in a decrease in the quantity and quality of juvenile rearing habitat. The channel will continue to incise some areas on the lower Yuba River, increasing the severity of this stressor."*

COMMENT

All of these statements have already been refuted above. The most important thing to restate is the river's overall downcutting is not a stressor, but a natural method of ecological recovery to a terrible unnatural disturbance. As illustrated by Pasternack (2008), White et al. (2010), Sawyer et al. (2010), and Wyrick and Pasternack (2011), despite systemic downcutting, the river maintains a natural suite of organized fluvial landforms by way of a suite of natural geomorphic processes. These geomorphic dynamics support ecological functions, such as salmonid rearing.

BO STATEMENT (Page 243)

"The Corps' training walls affect natural riverine processes through constriction of the river channel and limiting the areas in which riparian vegetation can become established."

COMMENT

Based on the evidence provided above, this BO statement has already been refuted.

CHANNEL RESTORATION

BO STATEMENT (Page 235)

"CR 1. The Corp shall develop a Channel Restoration Plan for the Englebright Dam Reach, and upper portions of the Narrows Reach (extending from Deer Creek confluence to 1,000 ft downstream) of the Lower Yuba River, CA by December 2012. Specific areas to be included in the Channel Restoration Plan include Sinoro Bar, the mid-channel bar adjacent to the downstream end of Sinoro Bar at the Deer Creek confluence, and potentially other suitable depositions areas or surfaces that no longer function properly due to armoring or deposition of shot-rock. The Channel Restoration Plan will include conceptual level plans for design that identify areas where shot-rock needs to be removed, where channel recontouring should occur, locations for installment of potential flow obstructions, identify areas where local/site specific gravel additions are warranted, and identify sources of shot-rock in the vicinity of Englebright Dam that can be stabilized. At a minimum the Channel Restoration Plan will include shot-rock removal at Sinoro Bar and the mid-channel bar at the entrance to Narrows Gateway, recontouring of these bars, addition of at least eight flow obstruction structures that may potentially be part of the large wood augmentation program, and stabilization of shot-rock sources in the vicinity of Englebright Dam. Localized gravel augmentation at the recontoured bars and hydraulic structures will also be included, specific amounts will be determined as part

of the design process and potentially partially accounted for with the annual gravel augmentation supplied at the top if the EDR. An implementation schedule will also be part of this plan. The Channel Restoration Plan shall be submitted to NMFS for approval by December 2012.”

COMMENT

Pasternack (2008), Pasternack (2010c), and Pasternack et al. (2010) reported that the primary cause of river degradation in the lower half of the Englebright Dam Reach and upper section of the Narrows Reach was mechanized gold mining. In addition to that activity that started ~1960, I have learned and gathered evidence that government regulators have required the local landowners to re-channelize portions of that area from time to time since 1970. Therefore, this proposed action has nothing to do with mitigating the effects of USACE facilities. I strongly support the goal of having this rehabilitation done, but I have no professional opinion as to who ought to do it, as that is ultimately not a scientific question, but a political one. If the rehabilitation was tied to causative responsibility, then the Bo does not make sense, but my understanding from NMFS is that there is no intended causative link in terms of responsibility by the Corps for how the channel got degraded.

References:

Pasternack, G.B. 2010c. Estimate Of The Number Of SpringRun Chinook Salmon That Could Be Supported By Spawning Habitat Rehabilitation At Sinoro Bar On The Lower Yuba River. Prepared for the PG&E and DWR Habitat Evaluation Agreement Steering Committee.

Pasternack, G. B., Fulton, A. A., and Morford, S. L. 2010. Yuba River analysis aims to aid spring-run Chinook salmon habitat rehabilitation. California Agriculture 64:2:69-77.

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APPENDIX C

Protective Conservation Measures Incorporated into the Proposed Action

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This Appendix Includes:

- ❑ Daguerre Point Dam Fish Passage Sediment/Gravel Management Plan
- ❑ Flashboard Management Plan
- ❑ Debris Monitoring and Maintenance Plan for Daguerre Point Dam, Lower Yuba River, California

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DAGUERRE POINT DAM
FISH PASSAGE SEDIMENT/GRAVEL MANAGEMENT PLAN

Purpose: The purpose of this plan is to describe the methods used to manage the sediment/gravel that accumulates upstream of Daguerre Point Dam. The sediment/gravel could impede upstream fish passage. This plan was developed by the US Army Corps of Engineers (Corps) with cooperation and advice from the National Marine Fisheries Service (NMFS), the California Department of Fish and Game (CDFG) and the US Fish and Wildlife Service (FWS).

Goal: The goal is to maintain an adequate water depth across the face of the dam to allow unimpeded fish passage from the ladders to the main channel upstream from Daguerre Point Dam. An adequate water depth is defined as a “channel” at least 30 feet wide when measured from the face of the dam upstream and 3 feet deep when measured from the crest of the dam to the riverbed. The process to determine the adequacy of the water depth is described in the Criteria section of this plan.

Criteria: In June of each year, water depth measurements will be taken across the face of the dam to determine the depth of the channel. The goal is to keep an area 30 feet wide by 3 feet deep upstream from the face of the dam cleared of sediment/gravel in order to facilitate fish passage. If the flows are too high in June to take the measurements, they will be taken as soon as conditions are safe.

If the water depth measurements show that the channel is still at least 30 feet wide by 3 feet deep, no sediment removal is required for that year.

If the water depth measurements show that sediment/gravel has encroached and the channel has filled in to less than 30 feet wide by 3 feet deep, sediment/gravel removal will be conducted during the first 2 weeks in August (01-15). The channel will be widened to 45 feet and deepened to 5 feet.

High Flow Events: In addition to the annual inspections described above, the Corps shall also inspect the channel as soon as practicable following a “high flow event”. A “high flow event” is defined as a storm “that generates Yuba River flow exceeding 20,000 cubic feet per second as measured at the Marysville flow gauge or flow that is sufficient to move sediment loads into the bed of the river.” If the “high flow event” inspection reveals significant sediment buildup that risks impairing fish passage, the Corps shall dredge the channel in a manner that minimizes adverse impact risks to the fish. The Corps will reconsider the need for "high flow event" inspections upon issuance by NMFS of a Biological Opinion for the continued operation and maintenance of Daguerre Point Dam and Englebright Dam.

Equipment: A tracked excavator will be used to remove the sediment/gravel. The excavator will be cleaned of all oils and greases, and will be inspected and re-cleaned daily as necessary to insure no contaminants are released into the water. All hydraulic hoses and fittings will be inspected to insure there are no leaks in the hydraulic system.

Management: Sediment/gravel removed shall be managed in one of two ways. The preferred method is to deposit this material downstream from the dam on either bank above the ordinary high water mark to augment downstream spawning gravels. With this method, natural river flows during the spring run-off will naturally recruit the gravel. If conditions do not allow the downstream placement, then the material will be removed and disposed of above the ordinary high water mark.

Monitoring/Coordination: Management of the sediment/gravel at Daguerre Point Dam will be monitored and coordination will be made with NMFS, CDFG and FWS to ensure the methods used are beneficial to the fishery. Any recommended changes to the procedures will be discussed and coordinated with these agencies.

FLASHBOARD MANAGEMENT PLAN

The long-term flashboard operations plan developed by the Corps includes the following.

- ☐ Conditions of Placement. Flashboards will be used in periods of low flow to direct water toward the fish ladders to provide optimal flow conditions. Because there is no recorded flow information at this time to set a flow-based trigger, the flashboards will be set in place when the flows recede to a point that only part of the dam has water flowing over it. Flows will be recorded at the time of placement to determine the flow rate trigger for future placement.
- ☐ Period of Placement. Flashboards and brackets will be installed as described above, but only after April 15 and will be removed before November 1 of each year. Further, flashboards will be removed within 24 hours, if directed by the Corps, NMFS or CDFW.
- ☐ Flashboard Adjustments. Flashboards will be closely monitored in accordance with monitoring and inspection activities (see below) to ensure they have been placed in a manner that leads to actual improvement in fish passage and will be adjusted accordingly based on such monitoring. All adjustments will be coordinated with NMFS and CDFW. Any recommended adjustments will be made within 24 hours of notification unless flow conditions prohibit them. In that case, the adjustments will be made as soon as conditions allow.
- ☐ Method of Placement. Flashboards will be installed using metal brackets that are attached to the dam with anchor bolts. The brackets will be fabricated of material that is light enough that it will break away if the flows increase too rapidly before the brackets can be removed.
- ☐ Location of Placement. When flashboard placement is required, they will be placed in the center portion of the dam in such a way that the flows are directed toward both fish ladders. This will ensure adequate flows through the fish ladders to promote optimal flow conditions and attraction flows to the fish ladders. The number of boards placed and the exact location will be determined based upon flow conditions and channel position. Adjustments will be made as necessary to provide optimal fish attraction and passage. All adjustments will be coordinated with NMFS and CDFW.
- ☐ Flashboard Material. Flashboard material will be 2” x 10” Douglas Fir or equal material. Material will be free of preservatives and other contaminants – no pressure treated material will be used.

- ☐ Monitoring and Inspection. Once the flashboards have been placed, fish passage will be closely monitored for the first week after placement to confirm that the flashboard installation improves fish passage. This monitoring will be conducted via the VAKI in coordination with the RMT. Additionally, during the period that flashboards are installed in accordance with this plan, the flashboards will be monitored at least once per week to make sure that the flashboards have not collected debris that might contribute to juvenile fish mortality. The flashboards will be cleared within 24 hours of finding a blockage, or as soon as it is safe to clear them.
- ☐ Updates. The Corps will update and adjust this plan as required based upon new information generated through monitoring efforts.

As part of future Cordua Irrigation District license renewal and approval processes after 2016, the Corps will refine the description of specific operations addressing the placement, timing and configuration of the flashboards at Daguerre Point Dam and incorporate changes to the Flashboard Management Plan into the terms and conditions for the Corps license to be re-issued to Cordua Irrigation District (Grothe 2011a), and Cordua Irrigation District will remain responsible for implementing the flashboard operations.

If the Corps does not renew the license to Cordua Irrigation District or another entity when it expires in 2016, then the Corps will assume responsibility for implementing the operations and maintenance activities addressing the placement, timing and configuration of the flashboards at Daguerre Point Dam that are described in the Flashboard Management Plan on a long-term basis.

DEBRIS MONITORING AND MAINTENANCE PLAN FOR DAGUERRE POINT DAM

LOWER YUBA RIVER, CALIFORNIA

US Army Corps
of Engineers ®
Sacramento District

Purpose: The purpose of this plan is to describe the methods used for clearing accumulated debris and blockages in the fish ladders at Daguerre Point Dam. This plan was developed by the US Army Corps of Engineers (Corps) with cooperation and advice from the National Marine Fisheries Service (NMFS) and the California Department of Fish and Wildlife (CDFW).

Goal: The goal is to clear any accumulated debris and blockages in the fish ladders at Daguerre Point Dam.

History: In 2003, the Corps installed a log boom at the north ladder exit to divert debris away from the ladder. In September 2011, as a result of an order issued by Judge Karlton in *South River Citizens League, et al. v. National Marine Fisheries Servce et al (SYRCL 1),* Case No. S-06-2845 LKK-JFM (ECF Doc. 402), the Corps installed locking grates over most of the fish ladder bays. To date, these grates have helped to keep debris from collecting in the fish ladders.

Monitoring/Coordination: Through coordination with CDFW and NMFS, the Corps will implement the Debris Monitoring and Maintenance Plan. This plan specifies that CDFW is responsible for inspecting and clearing the portion of the ladders containing the VAKI device, and that the Corps is responsible for all other parts of the ladders.

Inspection Criteria: Inspections will include sub-surface inspections of the ladders. The Corps will conduct weekly inspections of the Daguerre Point Dam fish ladders for surface and subsurface debris. The Corps also will routinely inspect the fish ladder gates to ensure that no third parties close them. Routine inspections shall occur at least weekly, and may be conducted under agreement with CDFW.

This plan also specifies that routine inspection and clearing of debris from the two fish ladders at Daguerre Point Dam may be conducted by CDFW pursuant to agreement with the Corps, or by other parties (e.g., PSMFC) under CDFW direction. Routine inspections and debris clearing will occur weekly, although more frequent inspections and debris clearing activities may be conducted by CDFW, or other parties (e.g., PSMFC) under CDFW direction.

High Flow Events: When river flows are 4,200 cfs or greater, the Corps or other designated parties as described above, will conduct daily manual inspections of the Daguerre Point Dam fish ladders. Upon discovering debris in the ladders, the debris will be removed within twelve hours, even if the Corps or CDFW determines that flow levels are adequate for fish passage.

If conditions do not allow for safe immediate removal of the debris, the debris will be removed within twelve hours after flows have returned to safe levels.

APPENDIX D
Voluntary Conservation Measures

This Appendix Includes:

- ☐ Gravel/Cobble Augmentation Implementation Plan (GAIP) for the Englebright Dam Reach of the Lower Yuba River, CA
- ☐ Lower Yuba River Large Woody Material Management Plan

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Gravel/Cobble Augmentation Implementation Plan (GAIP) for the Englebright Dam Reach of the Lower Yuba River, CA

(photo of proposed gravel augmentation location)

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September 30, 2010

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OVERVIEW

The purpose of this report is to thoroughly document a plan for implementing a gravel/cobble augmentation program below Englebright Dam and to address its biogeomorphic impact on the lower Yuba River. As described below, Englebright Dam plays a crucial role in protecting the downstream region from being overwhelmed by sedimentary mining waste debris still being eroded off hillsides and stored in long sections of the channel network upstream. Most of the active lower Yuba River also still has tens of millions of cubic yards of sedimentary mining waste debris in it that pre-date Englebright Dam and are still being re-worked as part of a highly dynamic, meandering gravel-bed river. However, the reach between Englebright Dam and the confluence with Deer Creek is now almost devoid of river-rounded gravel and cobble necessary for salmon spawning. In particular, spring-run Chinook salmon that historically went far upstream would substantially benefit from a gravel/cobble augmentation program below Englebright Dam. Yet the critical reach is in a narrow canyon that is difficult to access and manage, let alone place thousands of tons of coarse sediment into. Numerous issues have to be considered and addressed. That effort is facilitated by the existence of many studies of the river in recent years that form the basis for understanding the status and challenges ahead for the river.

This report covers topics related to preliminary planning efforts, pre-project characterization of the reach in question, design development for the specific 2010 next-phase pilot project, and long-term planning. Section 1 is an overview of the literature that describes what is already known about the river leading to a geomorphic and biological nexus for the action necessary to rehabilitate the river with respect to the impact of Englebright Dam. Section 2 explains what gravel/cobble augmentation is and how it may be implemented. Specific constraints and opportunities associated with the possible use of each method below Englebright Dam are described, including how specific methods affect site selection and project goals. Section 3 presents the pre-project characterization of the Englebright Dam Reach. That includes a summary of available data and information, a new estimation of the gravel/cobble deficit for the reach, 2D hydrodynamic modeling and analysis of results, and a conception of how the reach works in its baseline condition. Section 4 presents the details of the concept for how to get gravel to the river bed in the remote canyon. The recommended method involves sluicing gravel and cobble to the river. Section 5 explains and tests design concepts, objectives, and methods for the opportunity to place gravel in 2010 to yield immediate, preferred salmon spawning physical habitat. Section 6 describes a long-term plan for monitoring the outcome of the 2010 pilot project and then what actions should be taken thereafter to continue to rehabilitate gravel/cobble storage and enhance salmonid spawning habitat in the reach with additional augmentations over time.

1. LOWER YUBA RIVER BACKGROUND

The 3,490-km^2 Yuba River basin has hot, dry summers and cool, wet winters. Relative to other Sierra basins, the Yuba has among the highest mean annual precipitation (>1,500 mm), so it has been used for hydropower, water supply, flood regulation, gold mining and sediment control (James 2005). During the Gold Rush (mid- to late 1800's), hillsides were hydraulically mined until several court decisions first outlawed the practice, then reinstated it with restrictions and taxes instituted to construct and pay for dams such as Daguerre Point Dam and Englebright Dam. These dams were designed to prevent the transport of hydraulic mining debris to the valley, thus lowering the risk of flooding. However, hydraulic mining never returned to the levels of the 1800's (Gilbert, 1917). Englebright Dam is located at 39°14'23.37"N, 121°16'8.75"W (Yuba River mile 23.9 upstream from confluence with the Feather River) in a narrow bedrock canyon on the Yuba River in northern California. Streamflow is recorded at the United States Geological Survey Smartville gage (#11418000) 0.5 km downstream of Englebright Dam. The gage's statistical bankful discharge 1971-2004 was 5620 cfs (159.2 $m^3 s^{-1}$), which matches field indicators (tops of active medial bars and positioning of bank vegetation) for the bankful discharge in Timbuctoo Bend. Given that the Middle and South Yuba tributaries lack large reservoirs, winter storms and spring snowmelt produce floods that overtop Englebright Dam. The Lower Yuba River (LYR) is ~38 km (24 mi) long from Englebright to the junction with the Feather. The Englebright Dam Reach (EDR) extends from Englebright down to the confluence with Deer Creek (Fig. 1.1).

1.1. LYR Geomorphic History

No records are known to exist describing river conditions in the canyon that Englebright sits in prior to placer gold mining in the mid-Nineteenth century. During the era of placer gold mining, Malay Camp on the northern bank of the Yuba close to the confluence of Deer Creek served as a base of operations for miners working Landers Bar, an alluvial deposit in the canyon nearby. The historical records of the existence of this camp and placer-mining site proves that coarse sediment was stored in the canyon prior to hydraulic mining in a large enough quantity to produce emergent alluvial bars.

During the period of hydraulic gold mining, vast quantities of sand, gravel, and cobble entered the Yuba River (Gilbert, 1917) and deposited throughout the system (Fig. 1.2). This human impact completely transformed the river. Historical photos from 1909 and 1937 document that the canyon was filled with alluvial sediment with an assemblage of river features including riffles (Pasternack et al., 2010). Conditions downstream of the canyon during that period were described by James et al., (2009). Even though Daguerre Point Dam was built on the valley floor in 1906 (at Yuba River mile 11.4 upstream from confluence with the Feather River) to prevent the transport of hydraulic mining debris, it is too small to block sediment migration during floods.

Englebright Dam (capacity of just 82.6 million m^3) was constructed in 1941 to serve as an additional, highly effective barrier to the hydraulic-mining waste material continuing to move down to the Central Valley. Thereafter, photos show that the amount of alluvium in the entire lower Yuba River, including the canyon, decreased (Pasternack et al., 2010). At the Marysville gaging station, the river incised ~20’ from 1905-1979, while 0.5 mi downstream of the Highway 20 bridge it incised ~35’ over the same period (Beak Consultants, Inc., 1989). These landform adjustments are still on-going. For example, Pasternack (2008) estimated that ~605,000 yds^3 of sediment (primarily gravel and cobble) were exported out of Timbuctoo Bend from 1999 to 2006. Further investigations of landform and sediment-storage changes are on-going, and the early indications are that they will show significant dynamism well beyond what was presumed by Beak Consultants, Inc (1989).

The reported changes conform with the expected, natural response of a river to blockage of downstream sediment passage (e.g. Williams and Wolman, 1984). For most rivers, such geomorphic changes represent a harmful human impact on a river, but in this case of pre-existing, unnatural snuffing of the river corridor by mining debris, the dam is actually *restoring* the river toward its historical geomorphic condition, in the truest meaning of the term- to go back to the pre-existing state prior to hydraulic gold mining. Hydraulic mining is the primary disturbance to the Yuba River. Going back in this case means evacuating much of the waste debris associated with that historic practice. Abatement of the downstream effects of sediment derived from uplands through the use of dams is an accepted practice for watershed rehabilitation (Shields, in press). On the LYR, there is strong evidence that Englebright Dam has helped to evacuate sediment without hurting important channel processes. For example, despite the evidence that Timbuctoo Bend is undergoing significant sediment export and river-corridor incision, White et al. (2010) reported that eight riffles persisted in the same locations over the last 26 years (likely back much further). Most of these persistent riffles are positioned in the locally wide areas in the valley, while intervening pools are located at valley constrictions. Thus, incision and sediment export do not necessary translate into harmful degradation of fluvial landforms. In Timbuctoo Bend, the existence of undular valley walls preserves riffle-pool morphology in the face of on-going geomorphic change. Given the vast quantity of waste material still present in the upper system and the ability of many unhealed hillsides to generate more, Englebright Dam continues to serve as an important protection for the environment of the LYR.

Confounding the natural response of the river to the restorative impact of Englebright, the Yuba River has been subjected to harmful in-channel human activities that further altered it. The greatest impact came from dredgers processing and re-processing most of the alluvium in the river valley in the search for residual gold and to control the river (James et al., 2009). First, there was the formation of the ~10,000 acre Yuba Goldfields in the ancestral migration belt. Then there was the relocation of the river to the valley's northern edge and its isolation from the Goldfields by large "training berms" of piled-up dredger spoils. Dredger-spoil training berms also exist further upstream in Timbuctoo Bend away from the Goldfields (Fig. 1.3); these berms provide no flood-control benefit.

Although no training berms exist in the canyon downstream of Englebright Dam, mechanized gold mining facilitated by a bulldozer beginning ~1960 (Fig. 1.4) completely reworked the alluvial deposits in the vicinity of the confluence with Deer Creek, changing the river's form there (Pasternack et al., 2010). Prior to mechanized mining, glide-riffle transitions were gradual, enabling fish to select among a diverse range of local hydraulic conditions. Bulldozer debris constricted the channel significantly, induced abrupt hydraulic transitioning, and caused the main riffle at the apex of the bar to degrade into a chute. In addition, mining operations evacuated the majority of alluvium at the mouth of Deer Creek. On top of these impacts, the 1997 flood caused angular hillside rocks and "shot rock" debris from the canyon bottom to be deposited on top of the hydraulic-mining alluvium in the canyon.

At present, the Yuba River downstream of Englebright Dam continues to change in response to the complex assemblage of natural processes and human impacts. The legacy of hydraulic mining is the first and foremost impact to the system, relative to the pre-existing condition. Englebright Dam blocks further impacts from upstream mining waste and is directing the river on a trajectory toward restoration of the pre-existing landform. Daguerre Point Dam serves as a stabilizer in the system, providing a base level for how far incision can go between it and Englebright Dam. Mechanized re-working of alluvium and associated channelization have dictated the lateral bounds of what the river can do now and also impact the diversity and distribution of river-corridor landforms.

In summary, the fluvial geomorphology of the Yuba River is so unique that it is crucial to evaluate it on its own terms and not apply simple generations and concepts from other rivers with dams. Hydraulic mining, dredger re-processing of the valley floor, mechanized in-channel mining, upstream watershed management choices, and dams all combine to yield a system that requires careful investigation before making conclusions about how the fluvial geomorphology works and what restoration opportunities exist. Recent studies have helped clarify the current status of the river and more investigations are on-going.

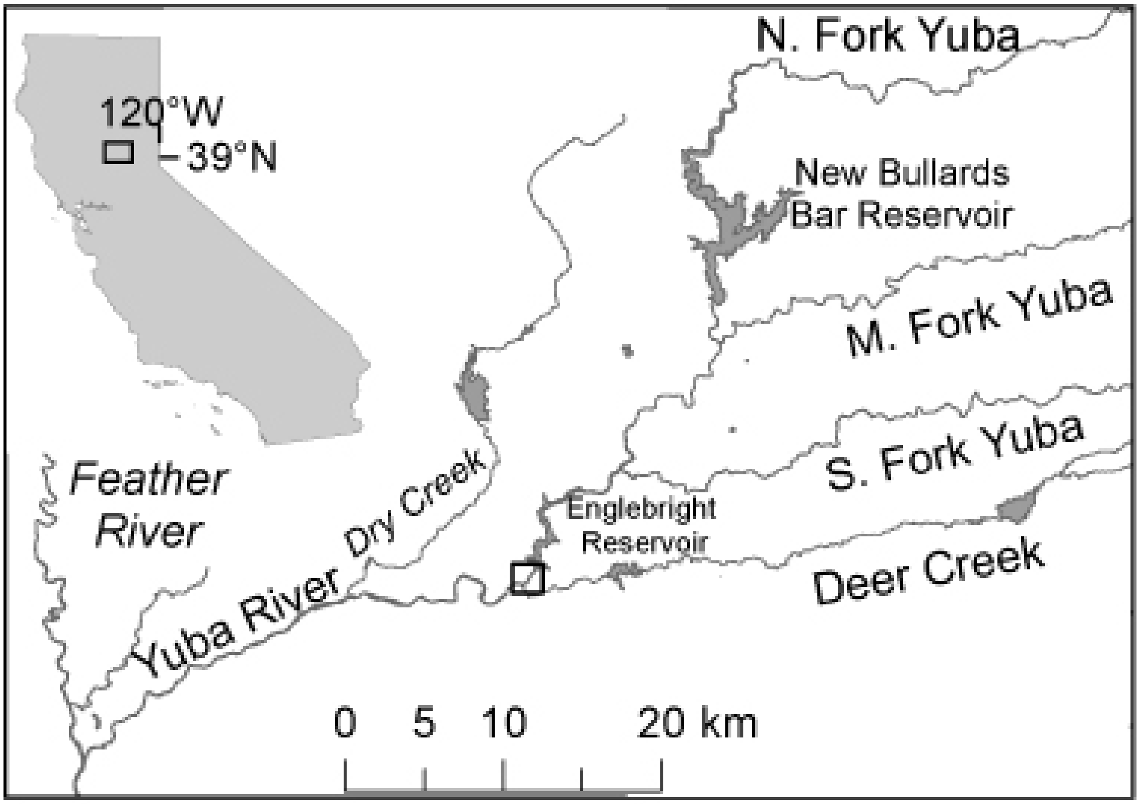


Figure 1.1. Location map of the Englebright Dam Reach (black box) in the Yuba catchment.

Figure 1.2. 1905 photo of the LYR near Parks Bar taken by G.K. Bilbert (http://libraryphoto.cr.usgs.gov/photo_all.htm).

Figure 1.3. Dredger forming high tailings berm out of a mining-waste point bar at Rose Bar on 10/21/1937. (Photo from the California Transportation State Archive).

Figure 1.4. Photo of a gold mining operation on Sinoro Bar circa 1960. (Photo courtest of Ralph Mullican).

1.2. LYR Salmonids History

1.2.1. Historical Population Accounts

The spring run of Chinook salmon (SRCS) is a federally threatened species that is differentiated by the time at which adults migrate from the ocean to freshwater systems (Yoshiyama et al. 1996). There are no quantitative estimates for pristine, historic salmonid populations on the Yuba River prior to hydraulic gold mining, let alone isolating just SRCS, but Yoshiyama et al. (1996) reported historic accounts suggesting a large population, possibly in the hundreds of thousands. For example, they cite Chamberlain and Wells (1879) as stating that the Yuba was so full of salmon that Indians speared them “by the hundred”. However, during hydraulic gold mining much water was diverted away and the river valley was allowed to fill 20-80’ high with mine tailings. A first-hand account of a miner at Long Bar in the valley stated that the miner’s diet primarily consisted of pancakes and there is no mention of fish at all (Lecouvreur, 1906). Yoshiyama et al. (1996) reported accounts of the construction of Bullards Bar Dam in 1921-1924 in which it was stated that so many salmon were blocked at the construction location that their carcasses had to be burned. SRCS and steelhead both were known to migrate far up into the North and Middle Yuba Rivers and several miles up into the South Yuba before reaching potentially impassable waterfalls. However, much of the spawning habitat in the upper watershed was badly degraded by mining debris, sand, and turbidity. If the SRCS population was in the hundreds of thousands of fish, then the riffles in the canyon where Englebright Dam is located would likely have been used by part of that large population during the mining era and early 20th century. However, relative to the total abundance, this number of fish spawning in the canyon may not have drawn the attention of naturalists at the time, especially given the difficulty of getting to that area.

During the latter half of the 20th century, Yuba River salmonid populations were estimated quantitatively (Fig. 1.5), but it is still difficult to isolate SRCS numbers. Yoshiyama et al. (1996) cite several estimates of the fall-run Chinook salmon population, but provide no enumeration of SRCS. They cite John Nelson as reporting that fall- and spring-run populations are mixed and that these mixed fish are now present in “minimal numbers”. CDFG (1991) enumerates the annual estimate of fall-run Chinook salmon, with a range of 1000 in 1957 to 39,000 in 1982. For SRCS, CDFG (1991) states that a remnant population exists and that it is composed of some in-river natural reproduction, strays from the Feather River, and restocked, hatchery-reared fish. Restocking of fingerlings and yearlings was done in 1980. CDFG (1991) reported that 20 pairs of Chinook salmon were observed to spawn at the Narrows powerhouse in autumn 1986 and due to passage barriers in the autumn, it was decided that these were SRCS that migrated during high spring flows. CDFG stopped conducting annual escapement surveys in 1989. No survey was done in 1990. The Yuba County Water Agency (YCWA) sponsored Jones and Stokes, Inc. to perform escapement surveys using the CDFG methodology for 1991-2004.

For 2005-2007 CDFG took over the effort again, but beginning in 2008 the responsibility shifted to the Yuba Accord River Management Team (RMT) as part of its new Monitoring and Evaluation Plan. The RMT's 2008 escapement and redd reports used temporal modalities associated with fresh carcass observations and frequencies of redd observations to try to differentiate spring- and fall-run Chinook salmon. However, it was not possible to obtain a clear distinction and all data were analyzed together. In all of these modern enumerations, abundance estimates did not isolate SRCS or the subpopulation of all Chinook in the EDR; carcass counts were not made in the EDR due to challenging accessibility.

For March 2007 through February 2008, the RMT operated a Vaki RiverWatcher video monitoring system on both fish ladders at Daguerre Point Dam (~12 miles downstream of the EDR). This system scans the side-view projected area of each fish and takes a color photo of each fish. From these data, staff counts the number of fish that pass and use characteristic morphometrics to identify the species of each fish (for ~70% of individuals). Of the 1,324 Chinook that were observed, 336 (25%) passed in March-August, which is the period that SRCS likely migrate.

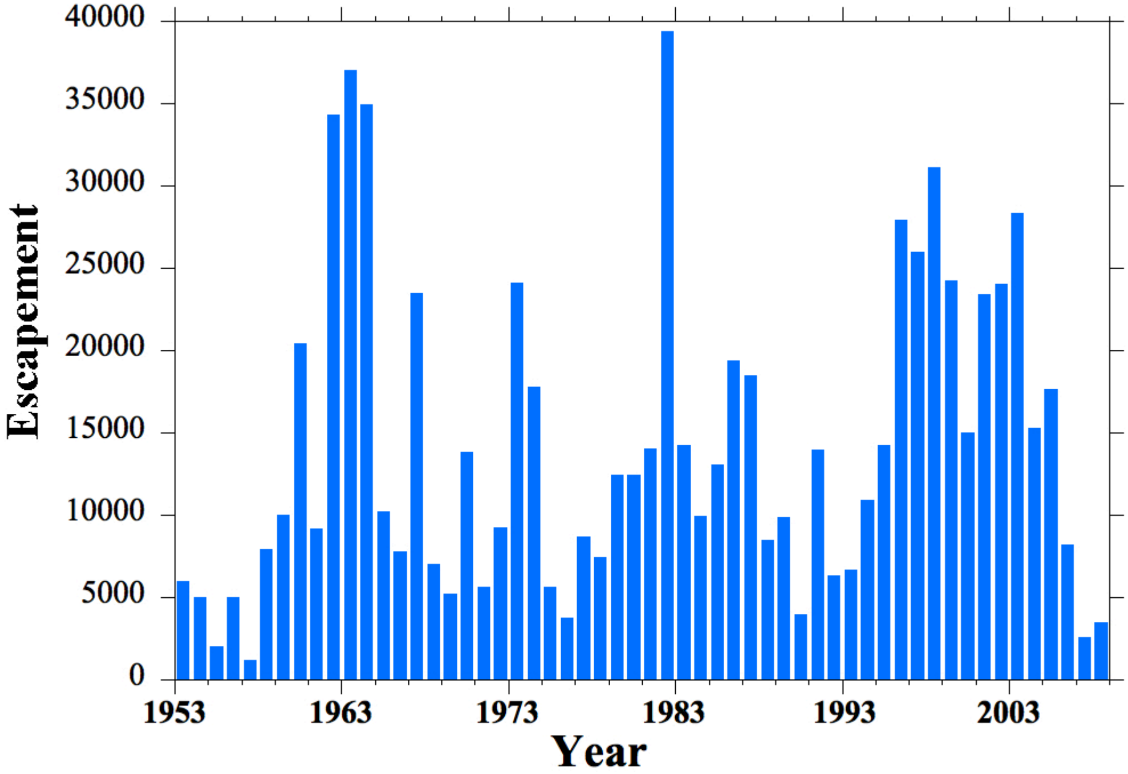


Figure 1.5. Adult Chinook salmon abundance for the LYR based on carcass surveys and coded-wire tagging.

1.2.2. Physical Habitat Conditions

Physical habitat units in rivers are defined as zones with characteristic attributes where organisms perform ecological functions, which are the ways in which organisms interact with each other and their surroundings. Common attributes of physical habitat include substrate type, water depth, water velocity, water temperature, cover objects, and shading. The quantity and quality of physical habitat are critical factors that can limit the size of fish populations. The assemblage of these attributes stem from the interaction among hydrologic, hydraulic, and geomorphic processes. As a result, when processes are altered or degraded by human intervention, then physical habitat will likely be degraded too. In turn, that decreases the size of fish populations.

Physical habitat conditions related to salmonids downstream of Englebright Dam have been studied over the years. With respect to the spawning life stage, Fulton (2008) investigated salmon spawning habitat conditions in the canyon below Englebright Dam and found the conditions to be very poor to nonexistent. No rounded river gravels/cobbles are present in the canyon between Englebright Dam and Sinoro Bar by the confluence with Deer Creek other than a small amount injected artificially in November 2007. For the whole lower Yuba River, Beak Consultants, Inc (1989) states:

> "The spawning gravel resources in the river are considered to be excellent based on the abundance of suitable gravels, particularly in the Garcia Gravel Pit and Daguerre Point Dam reaches. The tremendous volumes of gravel remaining in the river as a result of hydraulic mining make it unlikely that spawning gravel will be in short supply in the foreseeable future. Armoring of the channel bed is possible, but has not developed to date, probably due to periodic flushing by floods comparable to the 1986 event."

Similarly, Pasternack (2008) reported that:

> In Timbuctoo Bend "…there is adequate physical habitat to support spawning of Chinook salmon and steelhead trout in their present population size. Furthermore, all of the preferred morphological units in the *[Timbuctoo Bend Reach]* TBR have a lot of unutilized area and adequate substrates to serve larger populations."

With respect to rearing life stages, Beak Consultants, Inc (1989) states that:

> "The Daguerre Point Dam and Garcia Gravel Pit reaches contribute most of the *[Weighted Usable Area]* WUA, and substantially more than the Simpson Lane Reach; The Narrows Reach contributes little fry habitat… Total WUA for juveniles is highest in the Daguerre Point Darn and Garcia Gravel Pit reaches… The Simpson Lane Reach contributes a small amount of WUA, while The Narrows Reach provides virtually no juvenile habitat."

Adult migration is presently under study by the RMT, but there are some pre-existing observations. Adult SRCS are commonly observed holding in pools in the canyon below Englebright Dam, in the pools in Timbuctoo Bend, and in the pool below Daguerre Point Dam. In September 2007, UC Davis graduate student Aaron Fulton observed SRCS attempting to dig redds and spawn on bedrock covered with a thin veneer of angular gravel, causing them injury. Acoustic tracking of adult SRCS in 2009 by the RMT showed that some individuals migrate into and out of the canyon until September at which point they stop migrating and attempt to spawn between Englebright Dam and the highway 20 bridge.

1.3. LYR Geomorphology-Salmonids Nexus

Two key conclusions from this review of previous knowledge are that most of the lower Yuba River is still geomorphically dynamic and that the river possesses a diversity of in-channel physical habitats, even if some types are not as abundant as would be optimal for restoring the size of fish populations that likely existed in the Yuba River prior to the onset of hydraulic gold mining. Hydraulic mining snuffed the river and its floodplain with a vast, homogenous mix of mining waste. Since Englebright Dam blocked that, channel complexity and habitat diversity has been re-emerging, and that process continues. The extent to which it can continue is impacted by the role of the training berms and the degraded state of the entire Yuba Goldfields, both of which are beyond the scope of actions related specifically to the impact of Englebright Dam, which is the focus of this report. The glaring problem in the system associated with this dam is the status of SRCS spawning in the EDR.

The dramatic decline in SRCS in California has been attributed to dams, as they block up to ~80% of historic spawning habitat. Based on life history, impassable high dams have hurt the spawning life stage of adult SRCS the most, because spawning is the purpose behind the migration of SRCS to Sierran headwaters. Under a regulated flow regime, SRCS migrate to bedrock reaches at the base of large dams and hold in pools supplied with cold sub-thermocline water releases. On the Yuba holding occurs below Daguerre Point Dam and to a lesser extent below Englebright Dam (Fig. 1.6), but once it is time to spawn, SRCS move upstream into the canyon. Therefore, whether they provided historically preferred physical spawning habitat or not (and for the Yuba the evidence is that they did), bedrock reaches at the base of large dams play a key role in SRCS viability under the current regime of impassable dams.

If SRCS cannot spawn in sufficient numbers, then physical habitats supporting their subsequent life stages downstream are irrelevant. There is no question that Englebright Dam is a complete barrier to fish migration upstream and gravel/cobble transport downstream. Any effort to reinstate SRCS presence upstream of Englebright Dam would take significant time to figure out, implement, and evaluate its effectiveness. If such an effort were undertaken, it would still be critical to sustain existing populations below the dam using well-proven methods until passage efforts were equally well demonstrated in the watershed. To achieve usable, preferred SRCS spawning habitat in the canyon, it is necessary to resolve the lack of river-rounded gravels/cobbles there. At this time and for the foreseeable future, only the canyon is in need of a gravel/cobble supply to offset the impact of Englebright Dam.

Figure 1.6. Photo of SRCS holding in bedrock/boulder section of the LYR near the mouth of Deer Creek (photo courtesy of Ralph Mullican).

2. GRAVEL/COBBLE AUGMENTATION

The key negative impact of Englebright Dam on the lower Yuba River is the loss of a mixture of gravel- and cobble-sized river-rounded rocks in the canyon between Englebright Dam and the confluence with Deer Creek, which is necessary to support SRCS spawning there. This reach is known as the Englebright Dam Reach (EDR). Fulton (2008) investigated physical habitat in the uppermost third of the EDR and found that suitable hydraulics for salmon spawning were present there, but needed substrates were absent (Fig. 2.1). Subsequent modeling of the entire EDR showed that the same holds true for the entire reach- there are areas of good hydraulics, but they lack the needed river-rounded gravel and cobble mixture (Pasternack, 2008a). Thus, the solution to this problem is to implement a procedure known as gravel/cobble augmentation (Wheaton et al. 2004a; Pasternack, 2008b).

Figure 2.1. Photo of the EDR below Narrows 1 showing the dominance of shot rock on the banks. The wetted channel is devoid of river-rounded gravel and cobble in this area.

2.1. Gravel/Cobble Augmentation Defined

Gravel/cobble augmentation (aka gravel/cobble injection) is defined as the piling up of coarse sediment (usually a mixture of gravel and cobble ranging in size from 0.3-4 inches (8-100 mm) in diameter) within or along a river (Wheaton et al., 2004a).

The ***geomorphic goal*** *of gravel/cobble augmentation is to reinstate interdecadal, sustainable sediment transport downstream of a dam during floods, which is necessary to support and maintain diverse morphological units, such as riffles, pools, point bars, and backwaters* (Pasternack, 2008b).

The ***ecological goal*** *of gravel/cobble augmentation that yields self-sustainable morphological units is to have the associated assemblages of physical attributes that are preferred for each of the freshwater life stages of salmonids* (Pasternack, 2008b).

Pasternack (2008b) explains the pros and cons of gravel/cobble augmentation relative to other methods of river rehabilitation in support of salmon spawning. It is important to understand that achieving the geomorphic goal does not mean that the ecological goal will be achieved too. It has frequently been observed that when gravel is injected into a river, it just settles into the bottom of a deep in-channel pit or pool, never to be re-entrained. Unless a reach is investigated for its hydrogeomorphic mechanisms of fluvial landform maintenance, then there is no basis to an assumption that ecological benefits will necessary be achieved from successful redistribution of injected coarse sediment. This is the concept of “process-based” river restoration (Beechie et al., 2010). Any action may or may not work, depending on whether its usage has been placed into the context of the fluvial mechanisms at work in the system. Augmentation of flow or gravel/cobble in the absence of an understanding of processes and impacts is a gamble of unknown value or harm (Pasternack, 2008b).

When performing gravel/cobble augmentation it is often possible to place the material into the wetted channel according a specific design capable of yielding immediate salmon spawning habitat (Wheaton et al., 2004b; Elkins et al., 2007). It can be beneficial to add large wood and boulders during construction to form hydraulic structures in symphony with the gravel/cobble placement (Wheaton et al., 2004c). Together, these diverse elements are shaped (but not hard-wired) to provide adult holding habitat proximal to high-quality spawning habitat, further enhance spawning habitat with complex gravel oxygenation and shading conditions, and furnish early rearing habitat before fish migrate or are flushed downstream. Depending on site history and the specific goals and methods of such efforts, this approach of blending gravel/cobble placement and hydraulic structure construction can dramatically enhance or rehabilitate morphological units and sub-unit hydraulic complexity for a reach below a dam (Elkins et al., 2007). By coupling that with a long-term gravel/cobble injection program at the base of a dam and evaluation of the flow regime, a comprehensive framework for rehabilitating and managing a regulated river can be achieved (Pasternack 2008b). Such a framework for river rehabilitation is hierarchical, because it incorporates a) microhabitat diversity to provide preferred local conditions to support different life stages of existing populations, b) geomorphically sound mesohabitats that provides more and larger organized areas to grow populations, and c) flow variability and injections of gravel to provide the physical inputs necessary for geomorphic dynamics that renew and sustain a gravel-bed river.

2.2. LYR Pilot Gravel/Cobble Augmentation

The United States Army Corps of Engineers (The Corps), UC Davis, and USFWS collaborated on an experimental gravel/cobble injection below Englebright Dam (in the pool below the Narrows II powerhouse) in November 2007. The purpose of this experiment was to find out if and where gravel/cobble would deposit in the EDR and thus gain insight into the efficacy of gravel/cobble injection as a habitat enhancement tool for spring-run Chinook salmon in the EDR. The basic study design involved injecting gravel/cobble during low flow in autumn of 2007 and then waiting for high flows in subsequent water years to move it. Then it would be possible to track where those materials went.

Five hundred short tons of triple washed river gravel/cobble was purchased from a nearby quarry downstream. Based on bucket tests in a quarry, Merz et al. (2006) reported a dry bulk density of gravel/cobble to be ~0.722 yds^3 per short ton for a Mokelumne River quarry. Using this estimate, a total of 361 yds^3 of gravel/cobble was available to be injected in the EDR. The material was trucked in ahead of time and piled on top of the gravel parking lot at the Narrows II powerhouse (Fig. 2.2). Gravel/cobble injection took place on November 29, 2007 beginning at 9:30 am and finishing by 3:00 pm (Fig. 2.3). A TB 135 truck-mounted gravel conveyor was used to reach out over the river and inject gravel into the Narrows II pool. A single small loader was used to transfer piled gravel/cobble into the hopper, but it turned out that not all the gravel/cobble could be fully injected during the single allotted day using that one loader. Consequently, a small amount ended up being incorporated into the parking lot, instead of going into the river (Fig. 2.4). Using a tape measure, the volume of gravel/cobble left behind on the parking lot, in between boulders on the edge of the lot, and spilled over the side was estimated to be ~34 yds^3. Thus, ~327 yds^3 of gravel and cobble was placed into the river.

As the material was being placed into the river, ~400 painted, magnetized tracer stones were put into the hopper with the gravel/cobble to facilitate tracking. Those tracers are thus integrated all throughout the in-river gravel/cobble pile. Those stones are traceable using a magnetic locator, but any rounded gravel that is found downstream in the EDR must be coming from this source, because there is virtually no other such material in this reach.

Pasternack (2009) investigated the status of the injected gravel/cobble after two winters, and some interesting lessons were evident. Although the two intervening winters were relatively dry (Fig. 2.5), some transport did take place. Of the 327 yds^3 that was successfully injected to the river, only ~3 yds^3 moved during the period when flow was ≤ 8014 cfs. After a flood with a peak flow of 15381 cfs, a total of ~75 yds^3 moved. That amount includes the ~3 yds^3 that was moved prior to that, so that means that ~252 yds^3 remained in the gravel/cobble injection pile in the Narrows II pool as of July 1, 2009. For the 2010 water year, the peak discharge occurred in June 5, 2010 and it was only 6928 cfs.

Preliminary observations of Chinook salmon redds in 2009-2010 by the RMT found that 120 redds were located in the EDR between September 7, 2009 and February

22, 2010. This response to limited gravel injection indicates that if more gravel was present, a population of SRCS could be accommodated.

Figure 2.2. 500 short tons of gravel/cobble prior to injection into the Narrows II pool.

Figure 2.3. Gravel injection on November 29, 2007. Gravel pile is located in zone of aeration downstream of the Narrows II powerhouse.

Figure 2.4. Photo of stockpiled gravel/cobble left on the parking area and hillside after the 2007 pilot injection.

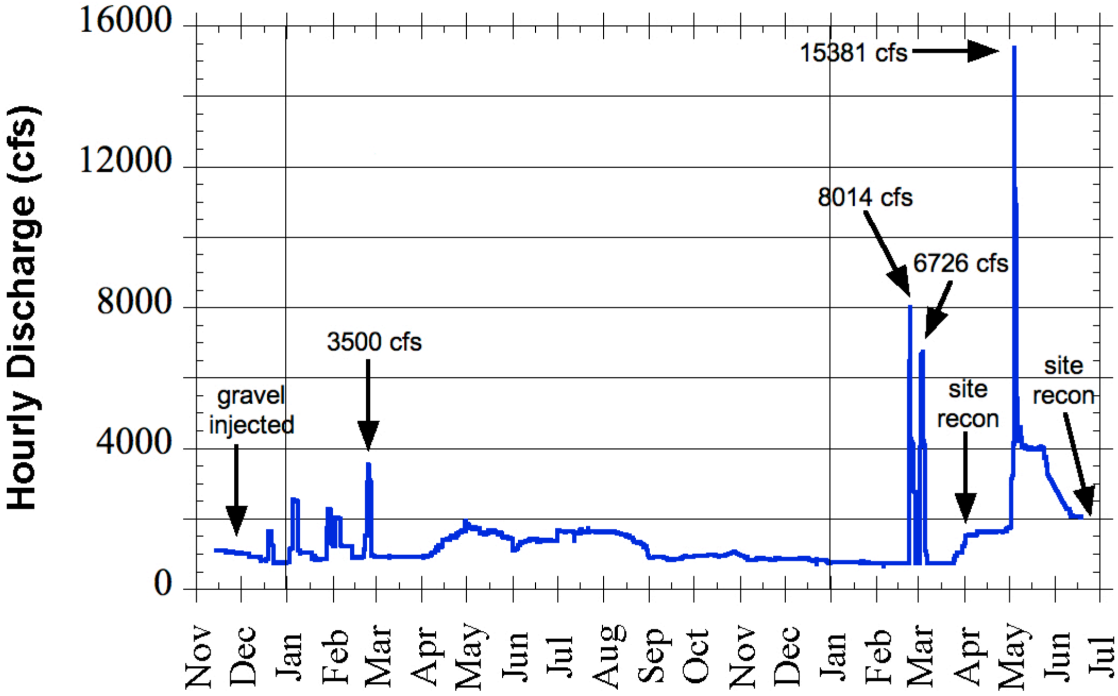


Figure 2.5. EDR Hydrograph of 2008-2009 water years showing flow peaks and the timing of key activities.

2.3. Methods for Gravel/Cobble Augmentation

Once a decision is made to perform gravel/cobble augmentation relative to other possible actions (Pasternack, 2008b), then it is necessary to determine how to implement it. Several reports have analyzed different methods for implementing gravel/cobble augmentation downstream of dams on rivers. Kimball (2003) described methods, limitations, horizontal placement distance, discharge rate, and the price per ton for 1,000 tons of gravel/cobble placed using helicopters, cable ways, and various conveyor belt systems (portable, truck-mounted, crane mounted and attached to dump truck). Bunte (2004) took a different approach and focused on the diverse river forms made with gravel/cobble-augmentation deposits through active construction and "passive" injection. Those included hydraulic structures, big flat plateaus of gravel, supplementation and lengthening of existing riffles (either upstream or downstream of crest), long riffles with 1-3 crests, artificial spawning channels, complex river patterns, filling of pools, bar shaping, spot fixing. She also covered placement of emergent deposits for future flood redistribution, including dumping along the streambank and construction of ephemeral wing dams directing flow into irrigation diversion canals (Bunte, 2004). Sawyer et al. (2009) reported a thorough analysis of the opportunities and constraints of using front loaders to place gravel/cobble according to a detailed design.

The environmental assessment report for the 2007 pilot gravel/cobble injection analyzed three methods of gravel/cobble augmentation (USACE, 2007). For the remote canyon downstream of Englebright Dam, there is a tremendous challenge to get down to the water's edge in the section where gravel is needed most. The alternatives considered were road construction, helicopter, and truck-mounted conveyor belt.

2.3.1. Road Construction and Gravel Placement

The first method assessed by USACE (2007) was gravel/cobble placement by hauling material in 10-ton and 20-ton trucks down to the river's edge, pouring it along the edge, and distributing it with front loaders. However, the EDR has not had a road down to the water's edge since the 1997 flood destroyed the previous one there. The elevation of the river's water surface at 855 cfs is ~292' (NAVD88 datum), whereas the elevation of the end of the existing road at the Narrows II facility is ~353'. The vertical drop of 61' takes place over a horizontal distance of just ~100', so the slope is 0.5 (50%). As a result, the road would have to be steep with switchbacks. It would be unlikely for 20-ton trucks to negotiate the switchbacks, so delivery would be limited to 10-ton trucks or front loaders. Moreover, to construct a new road would require importing a large quantity of road fill materials. USACE (2007) raised a serious concern about the risk of these materials eroding by rain, landslide, or flood, which would cause harmful mud, sand, and angular crushed rock to enter the river and integrate into the bed material. USACE (2007) also indicated that it would be extremely costly and environmentally harmful to remove a temporary road after gravel/cobble augmentation. It is not possible to remove a road off a steep rocky hillside without causing debris to be left behind risking water quality and river-substrate problems. Further considerations in 2010 raised the concern over possibly having to excavate the end of the road in the channel, which could cause water quality problems. Also, the permitting process for road construction would take a long time, precluding gravel/cobble augmentation in 2010 and possibly 2011.

Assuming that a road was constructed and gravel/cobble were to be placed by front loaders, then a suite of concerns related to these machines come into consideration (Sawyer et al., 2009). Extra care would be necessary to avoid oil or gas leaks out of the machinery (a problem known from other efforts). There is also a limitation in matching grading plans in that front loaders cannot go into water deeper than ~2-2.5' or else the transmission can be flooded, ruining the machine (another problem known to have happened in the past on another river). Finally, front loaders cause a high level of turbidity as they drive over the river bed, which can be a water quality problem. For all the above reasons, the method of direct gravel/cobble placement commonly used on the American, Mokelumne, and Trinity Rivers in California is not preferable.

2.3.2. Helicopter Delivery

The second method assessed by USACE (2007) was helicopter delivery. This can be the only means possible for extremely remote locations. However, this approach is the most expensive method, it has a slow delivery rate (depending on how far the stockpile is from the placement site), and it involves highly risky helicopter flying in the presence of power lines and in a narrow canyon with variable winds.

2.3.3. Truck-Mounted Conveyor Belt

The third method assessed by USACE (2007), which was ultimately used in the 2007 pilot project, was a truck-mounted conveyor belt. For this approach, a 135’ long conveyor belt mounted onto a truck is fully extended and rotated perpendicular to the truck so that its end is over the river. With a ~100-120’ bank width, this length is just sufficient to get material into the Narrows II pool. Material is fed into a hopper using a small 0.5- to 1-ton front loader, and then a feeder with a conveyor belt lifts the material up and onto the truck-mounted belt that delivers it out over the water. By pouring the gravel/cobble into a deep pool, particle breakage is avoided. The experience with using this method in 2007 was highly positive. The only lesson learned from the 2007 pilot project that would enhance future usage of this method was that gravel/cobble injection would have been faster if two loaders had been used instead of one.

Unfortunately, there are two serious problems with using the truck-mounted conveyor belt approach in 2010 and beyond below Englebright Dam. First, given the geometry of the road, hillside, channel, and Narrows II powerhouse, the area of the wetted channel suitable for injection that is within the 135’ length of the conveyor belt is very limited. Gravel/cobble is not permitted to be injected up against the powerhouse and any pile cannot interfere with the immediate outflow jet issuing from the powerhouse. The Narrows II pool is ~15’ deep, but much of it is not reachable with the conveyor belt. Based on visual appearance at the end of the injection in 2007, the gravel/cobble pile was ~ 11’ high off the bed. Given some more rotation capability and making the water even shallower, it looked like a total amount of <1000 tons could be stored in the pool by this method. The gravel/cobble deficit for the EDR (to be enumerated below in section 3) is one to two orders of magnitude higher than that, making this approach inadequate for the need.

Second, there is a proven concern of gravel/cobble injected into the Narrow II pool depositing into the shallow area between the Narrows II and Narrows I powerhouses (Pasternack, 2009). The gravel/cobble injected in 2007 fractionated by size during transport in 2008-2010, such that coarser material deposited on the first bedrock plateau and finer material deposited further downstream. Spawning has been observed on the shallow coarser material on the bedrock plateau. A potential exists in emergency situations where gravel may be de-watered.

When Fulton (2008) and Pasternack (2008a) evaluated the scour potential in the Narrows II pool for different sized floods, they assumed that the gravel/cobble would be in a blanket at the bottom of the pool, not standing ~11’ high in a loose conical pile. They had no knowledge at the time of their efforts in 2005-2006 how gravel/cobble augmentation might be done at remote Englebright Dam, so they made a basic assumption about it. As a result, they studied a very different situation from what ended up happening. For the case of a blanket fill on the bed, they predicted that any flood capable of scouring the bottom of this deep pool would easily transport the material beyond the Narrows I powerhouse. The reason is that the intervening channel area consists of a bedrock plateau that is narrower and shallower over the whole flow range, so that focuses flow into the fastest, most scouring jet of water possible for the EDR. Based on 2D modeling, it was demonstrated that any flow that could scour gravel/cobble off the bed of the deep pool would definitely be able to transport it beyond the Narrows I facility.

In fact, the actual conditions associated with the 2007 pilot (and any such gravel/cobble augmentation using the truck-mounted conveyor belt) as well as the flow regime that occurred in 2009 were quite different from what had been investigated. Not only was the gravel/cobble piled high unlike in the model simulations, but another important factor not considered was that the Narrows I powerhouse was releasing 500 cfs perpendicular to the channel during the 2009 peak flow overtopping Englebright Dam. Fulton (2008) did not have a topographic map all the way down to Narrows I for his model study and did not investigate the impact of a flow jetting across the riverbed at that location. Conceptually, such a jet would be expected to dramatically reduce bedload transport past that location.

Thanks to the use of a real-world pilot experiment, Pasternack (2009) observed that the 2009 flood of 15381 cfs scoured off the top ~23% of the 2007 pile. None of the eroded material made it past the Narrows I powerhouse. Instead, it deposited in the nooks in bedrock fractures and behind boulders and bedrock outcrops in a narrow band down the length of the area between the two powerhouses. In autumn 2009 Chinook salmonids were observed by RMT staff to be spawning on that material.

Pasternack (2009) provides a thorough evaluation of what happened and the consequence is that injection of a large amount of gravel/cobble into the Narrows II pool would certainly yield deposits in the area between the powerhouses that is at risk for annual dewatering in September-November. Given that the entire EDR is lacking in gravel/cobble, there are other areas where gravel could be introduced downstream of Narrows I, thereby avoiding the problem if channel dewatering. At a later time it might be worthwhile to revisit the issues related to gravel augmentation upstream of the Narrows I powerhouse to determine any conditions under which gravel/cobble could be added there to expand total habitat capacity and gravel/cobble storage in the reach.

2.3.4. Dumping Gravel/Cobble off Roadside

Although not discussed in USACE (2007), another option is that gravel/cobble may be added to a stream by dumping it off a truck down a hillside to the stream bank or into a stream (Bunte, 2004). This approach has been used on Clear Creek, Trinity River, and the upper Sacramento River. It is very inexpensive and fast. However, this approach only serves geomorphic and ecologic goals if the material avoids breakage and actually becomes entrained into the river. Normally that requires a flood to achieve, which could be years to decades before it happens, precluding ecological benefits. For the hillside below Englebright Dam, the only section accessible by truck is between Narrows I and II powerhouses raising the potential problem of material depositing on the bed at risk of dewatering. Also, the hillside is composed of large boulders, shot rock, and bedrock, so dumping material there would cause a lot of breakage. Angular gravel/cobble harms adult spawners. Finally, there are so many nooks in the material on the hillside that it is most likely that the material would be absorbed into those recesses and locked away. Dramatically more material would have to be placed to offset that problem, and even then it is unclear that the material would ever deposit where desired. A thorough, process-based analysis would be required, but the technical challenges of such an assessment yield high uncertainty.

2.3.5. Cableway Delivery

For steep canyons it is possible to build a cableway high across the canyon and drop gravel down into the river. By having one end of the cableway at a higher elevation than the other, it is possible for the weight of gravel/cobble to carry the load down over the river. After dumping to out, then one winches the container back up. Kimball (2003) reported details and costs. For the canyon below Englebright Dam, the problem is that the only place to stockpile gravel and install/operate a cable way would be in the area between Narrows I and II facilities. As discussed before, this area has a risk of gravel/cobble dewatering in September and October making it unsuitable for gravel/cobble augmentation at this time. Also, gravel/cobble placement is limited to a single cross-section, and for that cross-section there is little control over how and where gravel is place in the river. These factors make this method unsuitable for the EDR for 2010 and likely beyond.

2.3.6. Gravel/Cobble Sluicing

According to Pittman and Matthews (2007) and Kimball (2003), gravel/cobble sluicing involves drawing water up from a source and into an 8” diameter “Yelomine” flexible pipe where gravel/cobble is added from the top to produce a water-sediment slurry that is then piped down to a site for directed placement by 1-2 operators. The amount of water used to do the sluicing depends on the pipe and pump configuration, and is typically 1000-1500 gallons per minutes, which is 2.23-3.34 cfs. The best way to get the water is to locate the water pump(s) at the source-water’s edge and then push the water uphill in a 6-8” pipe. The pump cannot draw water vertically up to it more than 30’, but if the pump is placed at the water’s edge it can push the water vertically much farther as needed to get to the top of the a hill where the gravel/cobble is added.

Normally, it takes five people to operate the system- one person operating the water pump at the water source, one person in a loader bringing gravel to the feeder, one person operating the feeder to prevent clogs and coordinate communications, and two people at the nozzle directing gravel placement and adding pipe as needed to move downstream periodically. This approach is particularly notable for its minimal construction footprint. The main cost is in the upfront purchase of expensive piping, so it largely depends on how far water and the water/sediment slurry has to be pumped. Once the pipes are purchased, they may be used for several years, and the more sediment that is injected, the lower the cost per ton. Also, it may be possible to permanently fix the pipes for annual injections, thereby reducing the labor cost of setting up and taking down the system each year.

Using the sluicing method, the rate of gravel/cobble injection is ~100-300 tons per day, all depending on how frequently the system clogs. This is slow relative to gravel placement by truck-mounted conveyor (~500 tons per day) or truck/front loaders (~1000 tons per day). Indeed, clogs at pipe joints are a likely occurrence and are factored into operations. The primary factors that cause them are 1) low local head, 2) dense packing of 4-6” clasts, and 3) long, flat “finger” shaped rocks that fit through 5-6” sieve openings, but are much longer than that. Once in the pipe finger rocks can turn perpendicular and jam in a coupling. When a jam happens, operations stop, the location of the jam is determined (usually in a coupling), the coupling is broken to release the jam, a new coupling installed, and then operations continue. The steeper the descent (speeding flux), the more continuous the slurry flow (preventing deposition in the pipe), and the finer the sediment mixture (reducing the size of finger rocks), the less clogging will occur. Grain breakage in the pipe has not been evident in any noticeable amount, but the sediment does abrade the pipe, especially at bends. The typical lifetime of a pipe section at a bend has not been reported. Having extra pipe segments on hand is important for long-duration sluicing operations.

In terms of the gravel/cobble placement into the river, the approach with sluicing is to start at the water’s edge, build across the river, and then work downstream. At the outlet of the system, gravel/cobble goes into a rigid pipe supported by floating, air-filled barrels. The outlet is manually directed to the placement spot with the aid of ropes as needed. Using this approach, it is possible to place gravel/cobble according to a sophisticated design with a few constraints. As the operators work their way out into the channel, they must add additional pipe to reach new areas. Pipe in the river lies on the bed. Given the weight of the pipe sections and the need to manually couple them, the pipes have to be placed in shallow water. That limits the depth of water that pipes may be placed into to depths of < ~2-2.5'. As a result, front slopes up to the riffle crest have to be relatively steep. Back slopes can be lower, because ambient river velocity aids distribution of the sediment slurry in a blanket downstream. This approach has been used on the lower Stanislaus River and Clear Creek, with favorable reports in both cases. Given its remoteness and steepness, the canyon below Englebright Dam is a strong candidate for gravel/cobble sluicing.

3. PRE-PROJECT CHARACTERIZATION OF THE EDR

The spatial focus of this gravel/cobble augmentation implementation plan is the Englebright Dam Reach (EDR) of the lower Yuba River, which has been identified to be the area of the river below Englebright Dam that has been impacted by the dam requiring action (Beak Consultants, 1989; Pasternack, 2008a; Pasternack et al., 2010). The next step is to perform a pre-project characterization that documents the baseline conditions of the EDR. This involves reviewing the available data and information for the reach to yield a conceptual model that captures the processes playing central roles in shaping fluvial landforms in the EDR. Broad based information related to the entire watershed helps guide an understanding of the processes relevant to the focal reach, but ultimately what is needed is an understanding of the mechanistic physical process active in the reach today and potentially active through rehabilitation actions. Thus, the effort involves a process-based approach to the problem by nesting different spatial and temporal scales of investigation.

3.1. EDR Literature Summary

Because the EDR is remote, it has not been nearly as well studied as the rest of the lower Yuba River, but it has received some investigation. As described earlier, Beak Consultants, Inc (1989) performed studies in the EDR, including fish habitat mapping, fish community characterization, and implementation of the Instream Flow Incremental Methodology (IFIM) for evaluating stage-dependent physical habitat (using 6 cross-sections in “The Narrows”, which includes the EDR and the subsequent 1.8-km long gorge). In 1999, the terrestrial land in the EDR was topographically mapped by contractors working for The Corps by aerial photogrammetry, but the river’s bathymetry in the reach was not mapped. From 2003-2008 the U.S. Fish and Wildlife Service collaborated with the Watershed Hydrology and Geomorphology Lab at UC Davis to compare and contrast conditions in the EDR and those in Timbuctoo Bend. The reports that presented data and information on EDR were Fulton (2008), Pasternack (2008a), and Pasternack et al. (2010).

3.2. EDR Existing Data and Analyses

There does exist some data for the EDR. Key data include a bathymetric survey and digital elevation model of the reach (Fig. 3.1), substrate pebble counts, water surface elevation observations for flows ranging from 800-91400 cfs, georeferenced historical aerial photos, and observations of Chinook salmon attempting to spawn on bedrock. At the time that Fulton (2008) performed his 2D modeling analysis in 2005-2006 to assess flow-habitat relations, sediment entrainment, and geomorphic processes, available data were limited to just the reach between the Narrows II pool and the Narrows I powerhouse. Subsequently, Pasternack (2008a) did do a few 2D model simulations of the EDR using a newer software program suitable for that length of canyon. Pasternack et al. (2010) reported a detailed historical aerial photo analysis of the EDR focusing on the history and status of Sinoro Bar in the vicinity of the confluence with Deer Creek. Finally, Pasternack (2009) did reconnaissance of the EDR to map the movement of injected gravel and cobble out of the Narrows II pool and quantify a sediment budget for that material.

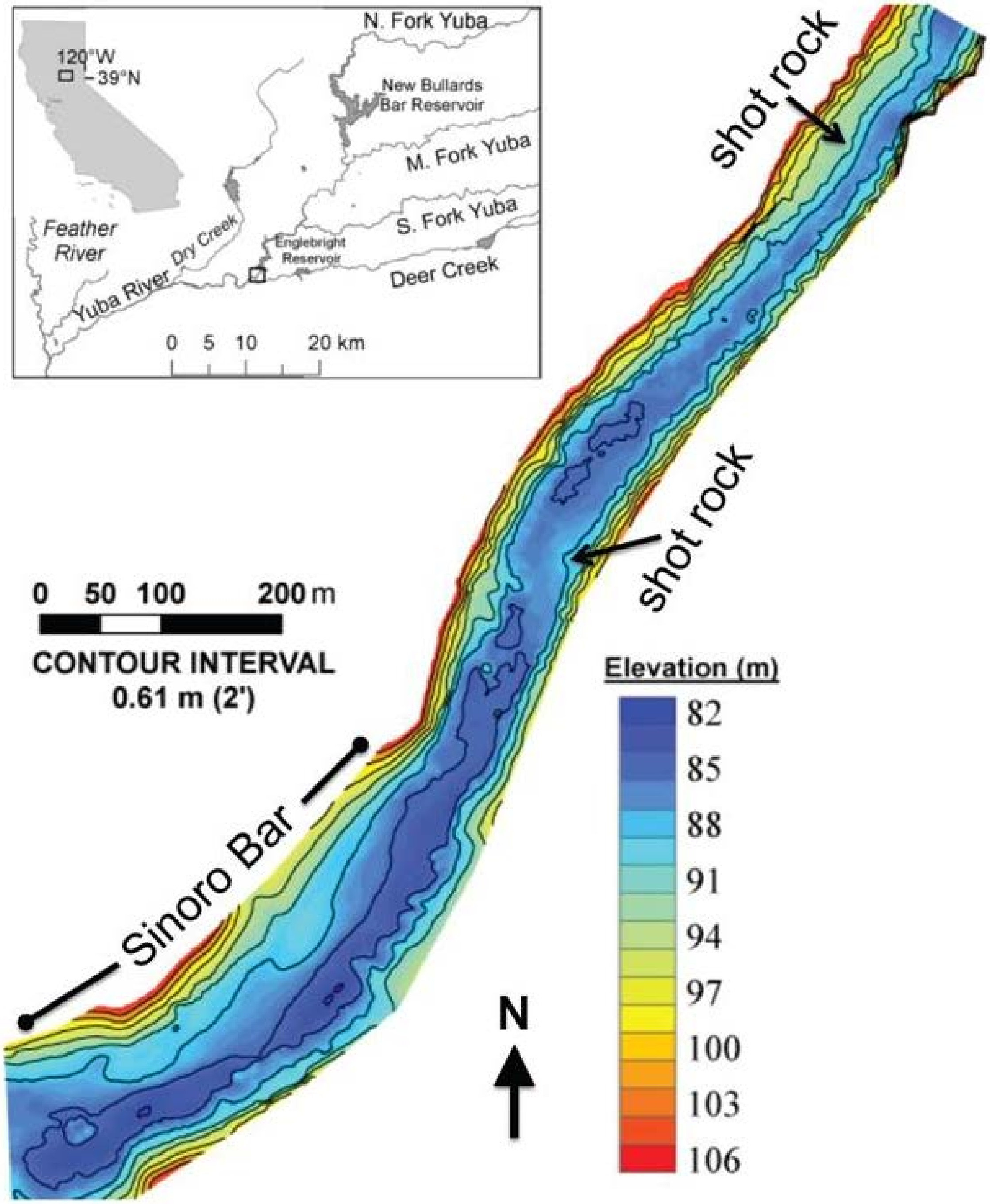


Figure 3.1. EDR topographic map showing locations of existing shot rock deposits. Inset map shows location of study site within the Yuba River basin and within California.

3.3. EDR Gravel/Cobble Deficit

The EDR is mostly devoid of any river-rounded gravel/cobble. This material is the basic building block of alluvial morphological units for the LYR. It is the necessary substrate for SRCS spawning. That leads to the following question:

How much gravel/cobble is needed in the EDR to rehabilitate ecological functionality?

To answer this question it needs to be recognized that different volumes of material would be required to achieve different combinations of geomorphic and ecologic functions. Let us define a placement volume (PV) as

$$PV = \alpha \bullet A \bullet D$$

where A is the plan-view wetted channel area (m^2), D is average depth (m) at spawning flow, and α is a non-dimensional depth scaling factor. A simple approach would be to fill in the entire wetted channel for a typical low autumnal spawning discharge to form one large, flat spawning riffle. Completely filling in the wetted channel in this way would involve assigning $\alpha=1$, so $PV=A \bullet D$. This amount would displace the water up, making it shallower and faster, due to a significant decrease in cross-sectional area. However, past studies have all concluded that large, flat spawning riffles do not work. Adult SRCS spawners need deep holding habitat for over-summer holding, local holding refugia proximal to red locations for rest during spawning activity, and locations with hydraulic complexity (presumably because it promotes better hyporheic flow).

Based on many years of experience with designing diverse spawning habitat rehabilitation projects, Pasternack (2008b) reported that for rehabilitating a small riffle of ~50-500' length, a value of $\alpha=0.8$ is appropriate. At this scale the focus is just on a single riffle crest and the presumption is that morphological unit diversity exists at a larger scale outside of this one riffle site. For a long reach for which a diversity of morphological units would need to be created, a value of $\alpha=0.5$ is more appropriate. This value is lower, because riffle crests are the highest points by definition, so constructing a reach with other morphological unit types involves using less volume than that for a riffle crest. As a result, for an intermediate length scale between a site and a reach, an intermediate value of $0.5<\alpha<0.8$ would be appropriate. Although there is no formal scientific proof of these values, they provide a simple, low-cost method of estimating gravel/cobble needs. This provides a reasonable starting point for thorough analysis and design development.

To apply the above method for use in the EDR, the variables A and D were estimated using the SRH-2D model simulation for 855 cfs for three separate sub-reaches and the amount was totaled (Table 3.1). The volume-to-tonnage conversion of Merz et al. (2006) was applied (see section 2.2 above). The total amount of material to eliminate the deficit for the EDR is estimated to be 63,077 short tons (45,510 yds^3). To account for uncertainty, a higher estimate using $\alpha = 0.8$ was also generated, which yielded an estimate of 100,923 short tons (72,816 yds^3). These numbers bound the likely intermediate amount of storage that would be appropriate for the EDR.

Because the reach widens downstream, the largest component is associated with the area downstream of the gaging station rapid. However, that area has been heavily impacted by mechanized gold mining and would greatly benefit from an independent river rehabilitation effort to take advantage of the opportunity to fix Sinoro Bar, which is beyond the scope of the gravel/cobble augmentation plan required to account for the impacts of Englebright Dam. Also, material placed upstream in the narrower part of the canyon is expected to migrate downstream anyway, addressing the gravel deficit in the vicinity of Sinoro Bar over time. Recognizing that the section between the Narrows II and Narrows I facilities has other uncertainties with operations, the relevant area of gravel addition is therefore the area between the Narrows I facility and the top of the rapid downstream of the gaging station.

The recommended long-term gravel storage volume for the section between the Narrows I powerhouse and the rapid downstream of the gaging station is 15,949 to 25,518 short tons.

The exact value may be determined in future design development and evaluation. The idea would be to augment gravel into the appropriate area of the EDR until this amount of gravel storage is achieved. Then, as floods transport material out of the area, more additions would return the storage amount to the total level.

Table 3.1. Estimated gravel/cobble deficit for the EDR to have a diverse assemblage of morphological units (excludes any independent action related to rehabilitating Sinoro Bar). Assumes $\alpha = 0.5$.

subreach	A (ft^2)	D (ft)	volume (ft^3)	volume (yds^3)	short tons
Narrows II to I	61107	4.313	131777	4881	6765
Narrows I to top of rapid	117373	5.294	310686	11507	**15949**
bottom of rapid to end	306193	5.136	786304	29122	40364
total			1228767	45510	63077

Table 3.2. Maximum estimated gravel/cobble fill associated with $\alpha = 0.8$.

subreach	A (ft^2)	D (ft)	volume (ft^3)	volume (yds^3)	short tons
Narrows II to I	61107	4.313	210844	7809	10823
Narrows I to top of rapid	117373	5.294	497098	18411	**25518**
bottom of rapid to end	306193	5.136	1258086	46596	64582

3.4. EDR SRH 2D Model

Two-dimensional (depth-averaged) hydrodynamic models have existed for decades and are used to study a variety of hydrogeomorphic processes. Recently, their use in regulated river rehabilitation emphasizing spawning habitat rehabilitation by gravel placement has been evaluated (Pasternack et al., 2004, 2006; Wheaton et al., 2004a; Elkins et al., 2007). Two-dimensional models have also been applied to better understand the relative benefits of active river rehabilitation versus flow regime modification on regulated rivers.

The U.S. Bureau of Reclamation created and maintains a 2D model called Sedimentation and River Hydraulics 2D (SRH) that is freely available to the public. SRH is highly efficient in its computations and is also highly stable in performing wetting and drying, which is a common problem of other 2D models. The way it has been programmed, it is highly automated. Thus, it is now possible to make 2D models of dramatically larger river segments than before, while retaining the same high resolution desired for characterizing microhabitat.

Apart from characterizing the spatial pattern of hydraulics in the EDR, SRH 2D was to answer two specific questions:

1) *what the spatial pattern of hydraulic habitat for Chinook spawning at 855 and 4500 cfs?*
2) *what is the spatial pattern of gravel/cobble erosion potential for flows ranging from 855 to 96100 cfs?*

The former question addresses the need to determine the extent to which the inadequacy of spawning habitat is due solely to the lack of spawning substrate or whether it is a combination of more microhabitat factors. The latter question seeks to understand the stage-dependent hydrogeomorphic processes responsible for scour and deposition in the EDR, given its unique pattern of channel nonuniformity.

3.4.1. EDR 2D Model Setup

As part of this planning effort, the SRH 2D model of the EDR reported by Pasternack (2008a) was updated to the latest software version and used again. To maintain computational efficiency, three different computational meshes were used, each with an intermodal spacing of ~3’ in the wetted area. For low-flow conditions, the original mesh from Pasternack (2008a) was used for flows <5000 cfs. This mesh covered the whole canyon width with ~3’ internodal spacing in the channel and up to 6’ internodal spacing along the edge. The wetted area for the low flow runs were all within the mesh elements with ~3’ internodal spacing. A mid-flow mesh was made for flows 5000-30000 cfs. A high-flow mesh was made for flows 30000-96100 cfs. A higher flow mesh may always be used to run a lower flow, but it takes longer to run than using the appropriate lower flow mesh. Creating a new EDR mesh takes only ~1-2 hours compared with models running for 3-7 days, so making a mesh that is optimal for a given flow is worth the small time and effort.

Table 3.1 reports the stage-discharge relation estimated for the exit cross-section of the model reach as well as the constant Manning’s n roughness parameter used and the constant eddy viscosity coefficient used for turbulence closure. For all simulations, 500 cfs was pushed into the river from the bank at the location of Narrows I and all remaining flow came from the upstream boundary in the Narrows II pool. Unfortunately, the stage-discharge relation for the end of the reach was not directly observed, but was estimated by linear slope interpolation based on the water surface elevation (WSE) values at the exit and at the Smartville gaging station observed at 855 cfs. The one test of the accuracy of this approach was obtained by surveying the photo-based evidence of the water line for the 88600 cfs flow occurring on 12/31/2005 (photo and land access for surveying graciously donated by local landowner Ralph Mullican). The two observed WSE’s for that flood were 309.71’ and 310.77’, so the predicted value of 309.58’ is reasonable, given the uncertainty in the field observations (especially the higher value, which was measured at a spot up on the side of a large boulder). Ideally, a water level recorder ought to be installed and maintained at the confluence with Deer Creek in support of future investigations.

The chosen constant Manning’s n value is more certain as it was based on 2D model calibrations performed by Fulton (2008) for the same wide range of flows. Manning’s n does not decrease with increasing stage in the EDR or Timbuctoo Bend, which is consistent with the concept that as flow increases, large roughness elements become active and maintain the overall roughness of the reach, even as grain-scale roughness and riffle-undulation form roughness become less important.

No velocity validation data exists for the EDR at this time, but WSE data is available over the full range of flows from Fulton (2008). Analysis of model performance with WSE indicated that it was within the normal range typical of 2D models. Extensive velocity validation has been performed for this model for the LYR between Hammon Grove Park and Hallwood Road, with the resulting metrics equaling or exceeding the performance of 2D models of other rivers (Barker et al., 2010). Velocity validation has also been done for Timbuctoo Bend (Moir and Pasternack, 2008; Pasternack, 2008) as well as for bedrock and boulder/cobble reaches of the upper South Yuba between Spaulding Dam and Washington, CA (Pasternack, unpublished data). All evidence indicates that the model is suitable and valid for the EDR.

Table 3.3. SRH 2D model inputs and parameters for the discharges simulated.

Q (cfs)	exit WSE	Manning's n	eddy viscosity coefficient
855	283.65	0.032	0.6
1590	284.86	0.032	0.6
4500	287.80	0.032	0.6
10000	291.16	0.032	0.6
15400	293.58	0.032	0.6
30000	298.38	0.032	0.6
50500	303.14	0.032	0.6
88600	309.58	0.032	0.6
96100	310.65	0.032	0.6

3.4.2. Microhabitat Prediction Method

Hydraulic habitat quality predictions for Chinook spawning were made by extrapolating 2D model depth and velocity results through independent habitat suitability curves. No bioverified habitat suitability curves (HSC) for depth, velocity, substrate, or cover for salmonid life stages are accepted by stakeholders on the LYR. Beak Consultants, Inc (1989) collected observations of depths and velocities for a typically small number of redds for that era and generated "utilization-based" curves. They compared their curves to those for the lower Mokelumne River available at that time and found a lot of similarities. CDFG (1991) published utilization-based curves for the lower Mokelumne River and in recent years these curves have been shown to perform very well at predicting Chinook spawning preference and avoidance for baseline and post-rehabilitation conditions (Pasternack, 2008b; Elkins et al., 2007). These Mokelumne curves were tested for use in Timbuctoo Bend on the LYR by Pasternack (2008a) and found to pass all bioverification tests. Other curves based on logistic regression proposed by the USFWS in recent years have not passed the same rigorous tests and remain controversial. Consequently, the bioverified curves used by Pasternack (2008a) were applied in this study.

A global habitat suitability index (GHSI) was calculated as the geometric mean of the depth and velocity indices (Pasternack et al., 2004). To account for uncertainty SRH-2D model predictions, GHSI values were lumped into broad classes, with GHSI = 0 as non-habitat, 0 < GHSI < 0.2 as very poor quality, 0.2 < GHSI < 0.4 as low quality, 0.4 < GHSI < 0.6 as medium quality, and 0.6 < GHSI < 1.0 as high quality hydraulic habitat (pasternack, 2008a). In bioverificaiton, it turned out that only the medium and high quality habitat classes proved to be preferred in terms of being utilized by spawners more than their percent availability, while the remaining classes were all avoided. Therefore, an even further simplification may be made by lumping GHSI into classes of 0-0.4 and 0.4-1.0. This reduces the possibility of error down to just misclassifications across this threshold.

3.4.3. Sediment Transport Regime Prediction Method

To evaluate gravel/cobble sediment scour risk across the widest possible range of flows, nondimensional Shields stress was calculated at each node in the model as described in Pasternack et al. [2006]. The reference grain size used to characterize the mixture of a gravel/cobble bed was 64 mm, which is close to the median size reported for Timbuctoo Bend (Pasternack, 2008a) and is in the range of common values used for assessing spawning habitat rehabilitation materials. Shields-stress values were categorized based on sediment transport regimes defined by Lisle et al. [2000] where values of $\tau^*<0.01$ correspond to no transport, $0.01< \tau^*<0.03$ correspond to intermittent entrainment, $0.03< \tau^*<0.06$ corresponds to "partial transport", and $\tau^*>0.06$ corresponds to full transport.

3.4.4. EDR 2D Model Results

Depth and velocity results are depicted in Figures 3.2-3.5 below. For flows <5000 cfs there are distinct areas of high and low velocity longitudinally down the river. As discharge increases, the longitudinal variation in velocity decreases and lateral variation increases. This is a common pattern previously reported for other constricted reaches (Brown and Pasternack, 2008). It is characteristic of the stage-dependent role of multiple scales of channel nonuniformity in controlling flow-habitat relations and fluvial geomorphology.

The GHSI pattern for Chinook spawning hydraulic habitat (Fig. 3.6) shows that regardless of gravel/cobble presence, the canyon presently has almost no suitable microhabitat (GHSI>0.4) capability to support SRCS spawning. At 855 cfs there is a small area of suitable hydraulics on the bedrock plateau just downstream of the Narrows II pool, a little upstream of the rapid by the gaging station, and a little habitat on the edge of the Sinoro Bar point bar. At 4500 cfs there is significantly less hydraulic habitat present.

The pattern of the sediment transport regime for the EDR (Fig. 3.7-3.8) is highly stage dependent. For flows below 15,400 cfs, the primary area of scour risk is in the narrowest part of the canyon between narrows I and II powerhouses, which is the area studied by Fulton (2007). The only other area of high scour potential is in the rapid below the gaging station. At 30,000 cfs, large area experience full bedload mobility, but there is a small area of lower Shield stress in the pool adjacent to the gaging station. Also, the widest part of the canyon around Sinoro Bar does not experience full mobility at this flow, so it is highly unlikely that a gravel/cobble mixture would move past that area. Note that the model does not include the perpendicular influx from Deer Creek, which would further reduce velocities and block transport. At 50,500 cfs there is full mobility through the upper 2/3 of the reach, but still no full mobility around Sinoro Bar. At 96,100 cfs, there is full mobility through the reach; again, not considering any influx from Deer Creek to block that.

In summary, detailed 2D hydraulic modeling of the EDR found that the river is too deep to provide Chinook spawning habitat right now, necessitating gravel augmentation to fill in the channel and provide opportunities for creating morphological unit complexity. Geomorphically, the river does not exhibit stage-dependent flow convergence, with routing of sediment through pools and deposition on high “riffles” at high discharges. Instead, as discharge increases, depth and velocity simply increase almost everywhere, so the area of scour increases down the river. The widest part of the canyon would be the ideal location for a diverse assemblage of morphological units, but it was degraded by mechanized mining in the 1960s. In terms of a gravel augmentation program, the indication is that the area in the upper half of the EDR where gravel might be augmented into the river is susceptible to full mobility at 10,000 cfs (except for the Narrows II pool, which is deep enough to require much higher discharge to scour the bottom of it). Meanwhile, augmented gravel would be unlikely to move out of the EDR until a flood of >95,000 cfs associated with minimal flow out of Deer Creek, such as during a snowmelt period or the later stages of a rain-on-snow event. The reason Deer Creek flow needs to be minimal (not maximal), is that at high flow the tributary enters the Yuba nearly perpendicular to it. This creates a barrier to sediment transport. Maximum export of sediment out of the EDR is thus expected to occur during the lowest Deer Creek outflow. The timing of flows out of the Yuba and Deer Creek catchments differs, based on their differing watershed hydrology.

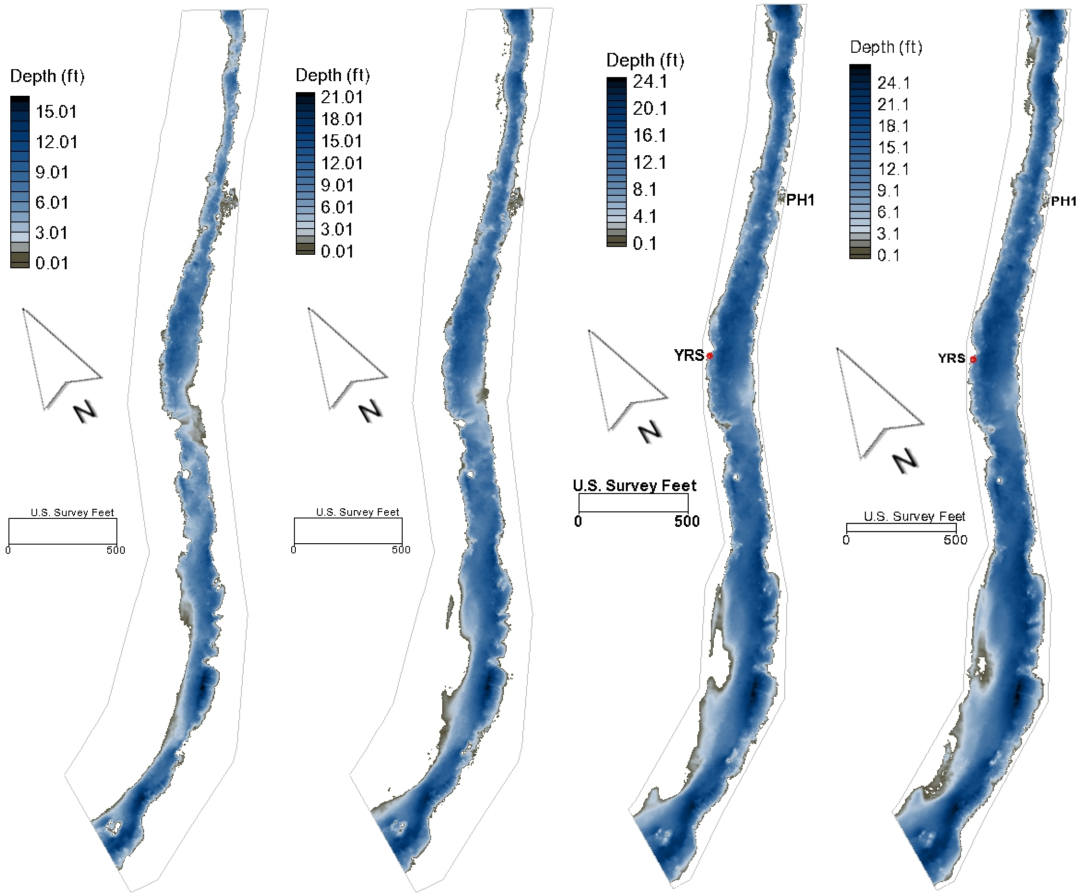


Figure 3.2. EDR water depth for increasing discharge from left to right (855, 4500, 10000, 15400 cfs). Color scale is different for each image.

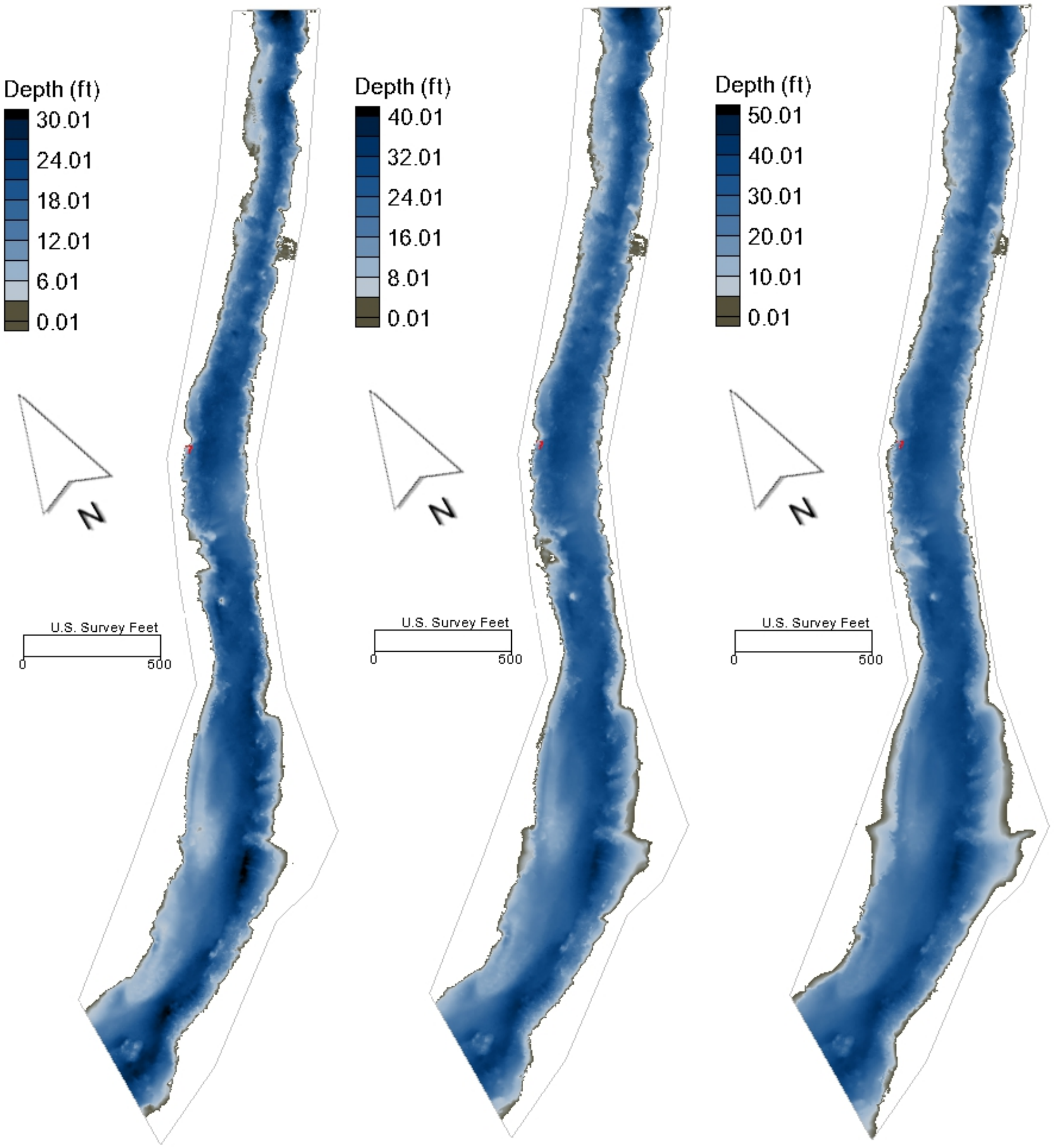


Figure 3.3. EDR water depth for increasing discharge from left to right (30000, 50500, 96100 cfs). Color scale is different for each image.

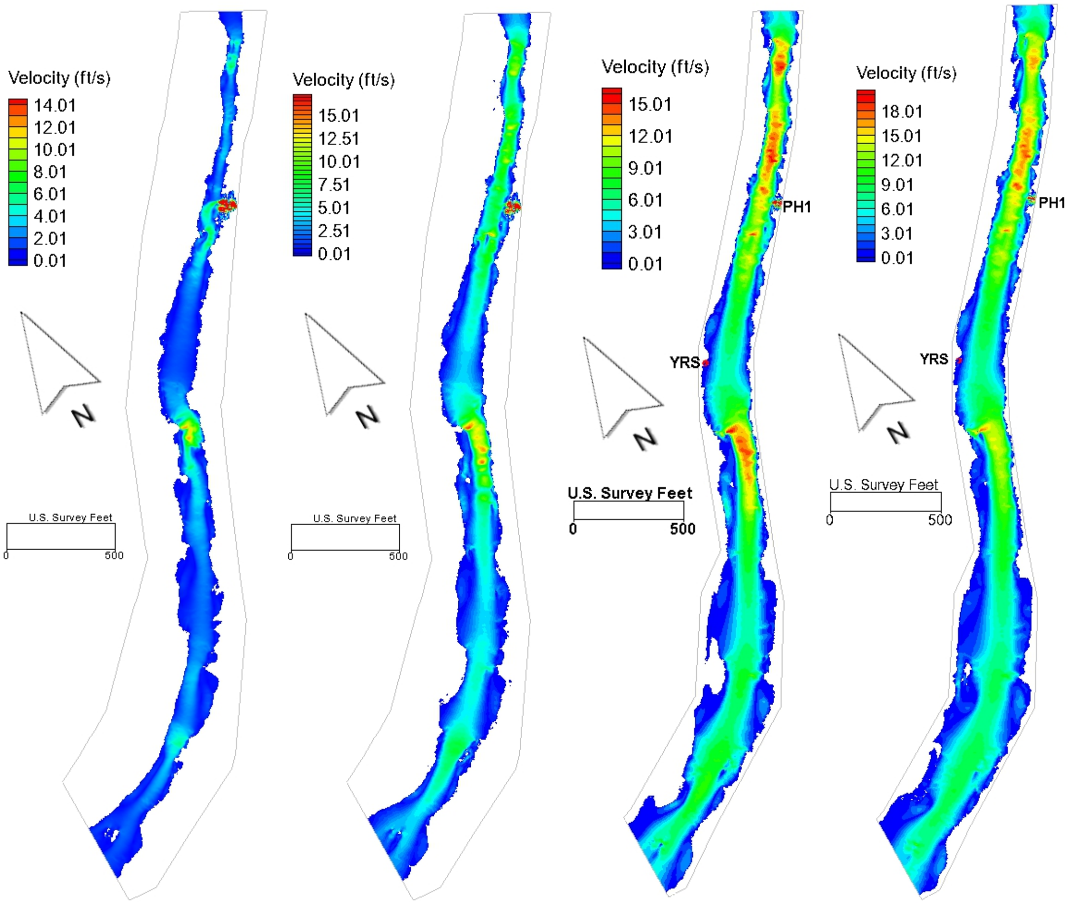


Figure 3.4. EDR water velocity for increasing discharge from left to right (855, 4500, 10000, 15400 cfs). Color scale is different for each image.

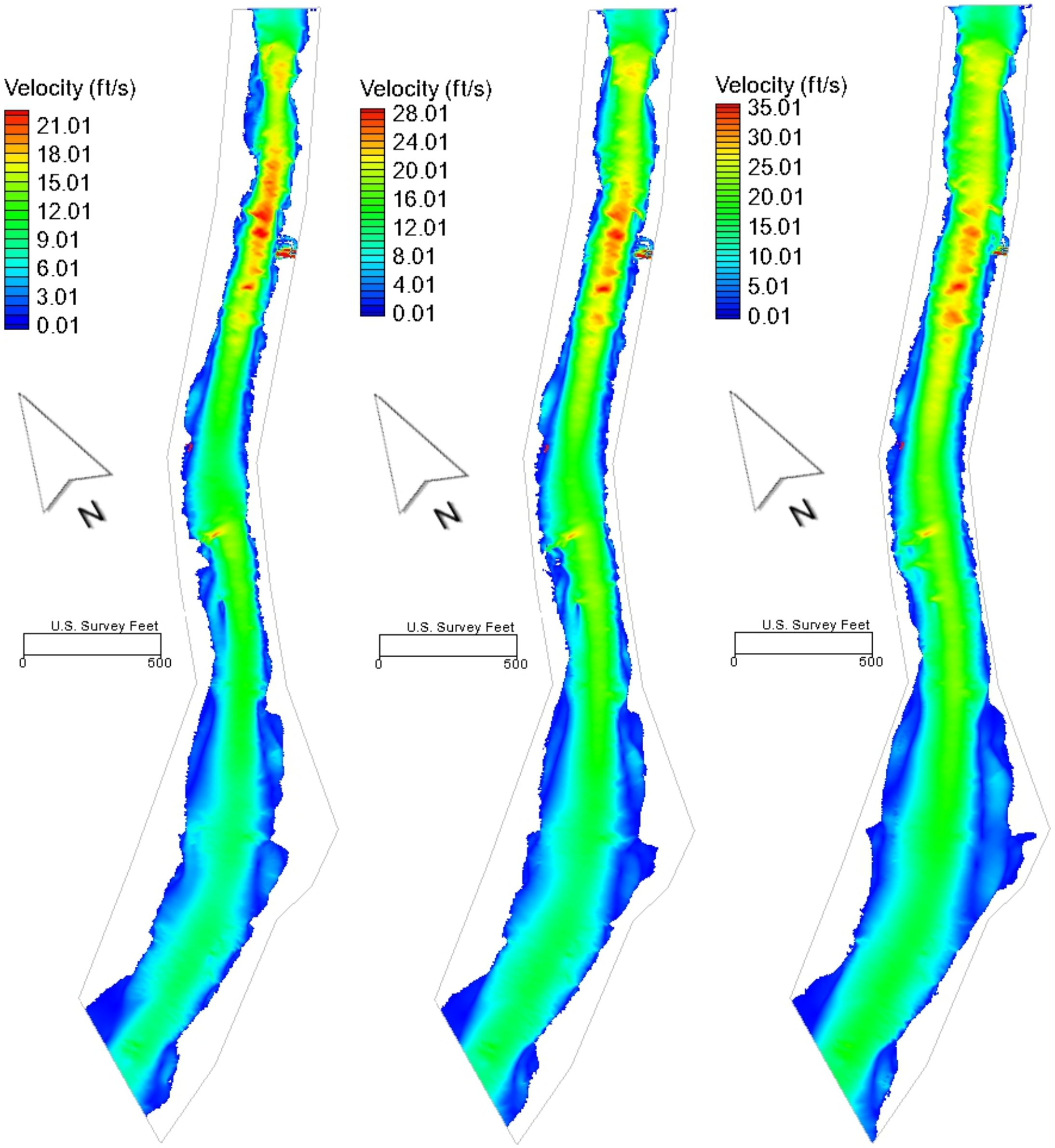


Figure 3.5. EDR water velocity for increasing discharge from left to right (30000, 50500, 96100 cfs). Color scale is different for each image.

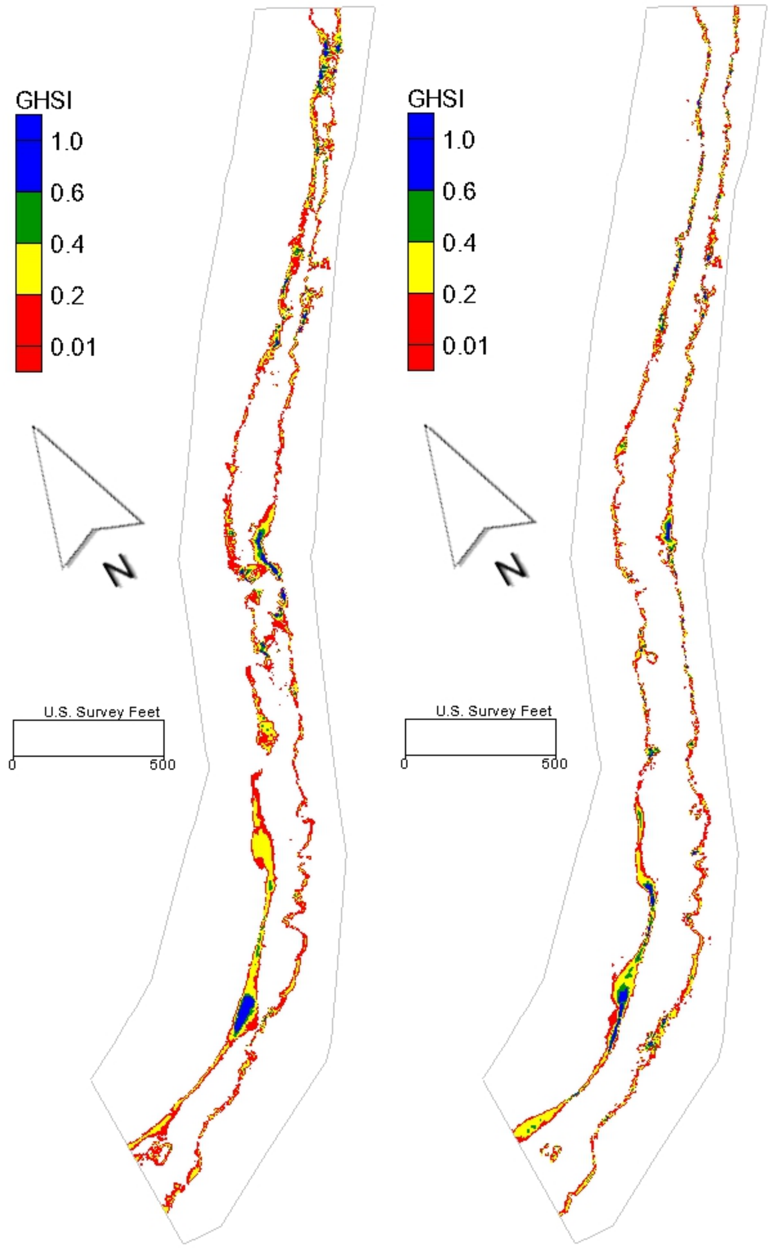


Figure 3.6. EDR Chinook spawning hydraulic habitat quality (GHSI) for 855 (left) and 4500 cfs (right). Color scale is identical for both images

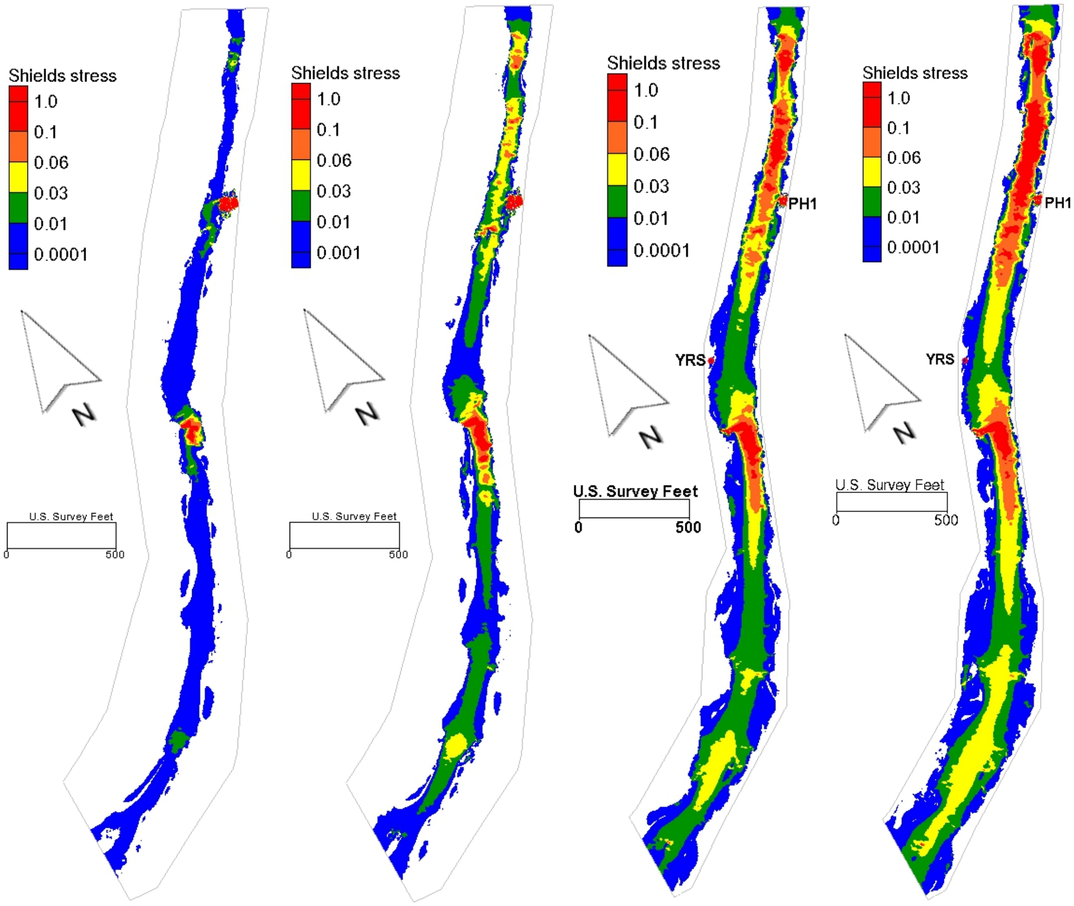


Figure 3.7. EDR Shields stress for increasing discharge from left to right (855, 4500, 10000, 15400 cfs). Color scale is identical for each image.

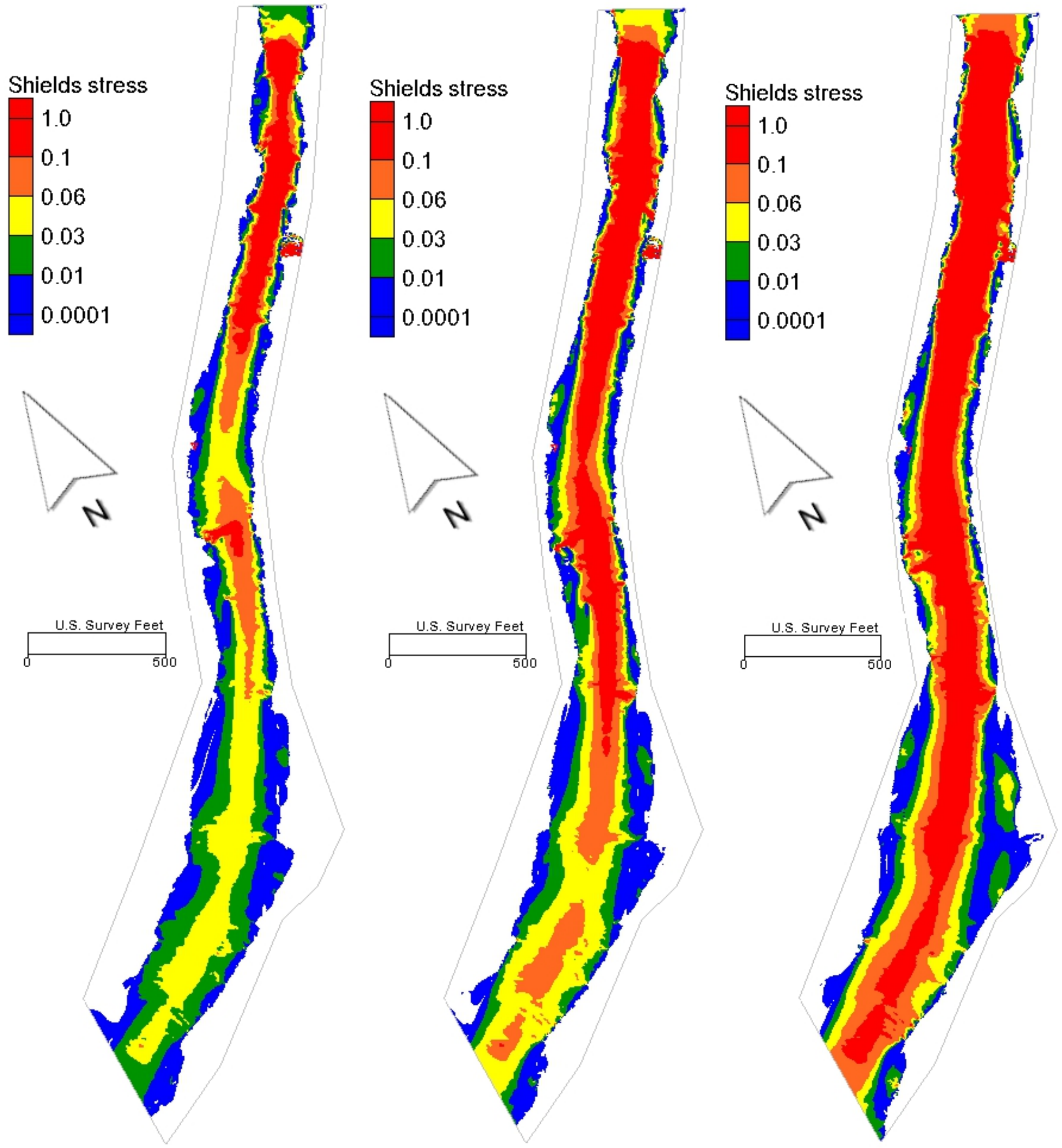


Figure 3.8. EDR Shields stress for increasing discharge from left to right (30000, 50500, 96100 cfs). Color scale is identical for each image.

4. RECOMMENDED METHOD FOR GRAVEL/COBBLE AUGMENTATION

Discussion of how to implement gravel/cobble augmentation below Englebright Dam has been on-going for years. Every idea that has been thought up by diverse stakeholders has been thoroughly discussed and vetted. The Lower Yuba River Technical Working Group and the Yuba Accord River Management Team have provided forums for discussion about this topic over the years. The 2007 pilot gravel injection with a truck-mounted conveyor belt demonstrated that gravel/cobble augmentation is not only technically feasible, but institutionally and politically possible. Observations of Chinook spawning in 2009 prove that salmon will use what is injected.

4.1. Elimination of Inadequate Methods

For the canyon below Englebright Dam, gravel is needed throughout the reach, but most especially in the longer and wider sections downstream of the Narrows I facility, as reflected in the estimates provided in Tables 3.1 and 3.2. This is a key constraint on augmentation methods. The truck-mounted conveyor belt method, roadside-dumping method, and (short of heroic measures) cableway delivery method are simply unable to get gravel into the river downstream of the Narrows I facility. A helicopter theoretically could dump gravel into the river, but the U.S. civil helicopter accident rate per 100,000 flight hours is 8.09 (IHSS, 2005), which is high. Operating in a narrow canyon with uncertain winds is even riskier than normal. Taking such a risk with human life is not necessary. That leaves road construction with front-loader placement and gravel/cobble sluicing.

Part of the reason why there is so much undesirable debris down at Sinoro Bar at the confluence of the Yuba and Deer Creek is that the pre-existing road down to the river at Englebright Dam washed away and deposited down there. Building a road requires a large amount of crushed aggregate, and in this case it has to be placed on a landslide-prone hillside where it will be attacked by large floods (Fig. 4.1). The 1997 flood was not a fluke. Floods of close to the same size or bigger occurred in 1955, 1963, 1964, and 1997 (Pasternack et al., 2010). That is four times in the last 55 years, or roughly once every ~14 years (foregoing detailed flood frequency analysis). If the road went all the way to the baseflow channel, then the lower part of the road would be submerged almost annually and seriously scoured every 3-5 years. The potential environmental harm from this is serious. Together with the long duration for permitting, the difficulty of getting big trucks down the steep road with switchbacks, and water quality impacts, the risk of aggregate entering the river makes road construction an unsatisfactory alternative.

Figure 4.1. Photo of the New Year's 2006 flood drowning the area where a road would have to be built to use trucks and front loaders as the delivery method for gravel/cobble augmentation. Aggressive velocities were evident all along the north bank.

4.2. Best Method for The EDR

By the process of elimination, the only remaining option is gravel/cobble sluicing. To my knowledge, no one has ever attempted to do gravel/cobble augmentation by as long of a sluice pipe as would be necessary for this plan. The long distance that water has to be pumped up and then slurry pumped down make the method much more expensive than for past projects using this method. Also, this method is relatively slow and potentially subjected to regular clogs. At an average rate of 150 tons per day, it would take 33 days to inject 5,000 tons. Front loaders typically place that much into a roadside river in ~4-6 days. On the other hand, the elevation drop for the EDR is so great that clogs may be relatively infrequent; a record speed of injection is possible. Once pipes are purchased in the first year, they can be stockpiled and used again in future years, reducing the overall cost of the system to a normal level. After thorough scrutiny, discussion, and on-site visit with the inventor of the method, no major impediment to the approach is evident at this time.

4.3. Detailed Concept for Sluicing Gravel Mix Down to EDR

Despite the fact that sluicing will have to be done over a long distance, the EDR has excellent attributes that promote the idea of attempting this method. The overall schematic for the application of sluicing to get gravel/cobble into the EDR is shown in Figure 4.2. Prior to the start of sluicing operations, 2000 short tons of gravel would be stockpiled in the three parking/turnaround areas at the overlook on the north side of the dam. This location is behind a locked gate and is inaccessible to the public. Englebright Reservoir is close by and easily accessible. Only ~2.3 cfs is needed for the sluicing operation, in comparison to the typical autumnal release of ~750 cfs- that's just 0.3%. A gravel road on the north side of the reservoir close to the dam (Fig. 4.3, right) goes right to the water's edge (Fig. 4.3, left), so that the water intake pump system (including fish screening custom built by Morrill Industries) can be safely positioned and easily operated. From there, water would be pumped in one or two 6-8" diameter pipes ~1070' up the side of the road (Fig. 4.3, right) to the crest. Where needed, the pipe would cross 1-2 roads in Rain-For-Rent Entrance/Exit Ramps, enabling vehicles to pass over the pipe with no interference to anyone's normal activities. The water pipe(s) would go over the crest of the hill and down the side of the paved road ~300' toward the Narrows II powerhouse until a point at which there is a noticeable slope break especially favorable to beginning gravel/cobble addition to the pipe. At that location a screened hopper on the north side of the road would receive sediment from a front loader bringing the material the short distance from the stockpile. The loader operator would gently bounce the bucket to trickle the sediment into the hopper as the primary control on the flow rate. A hopper operator would be standing there to ensure no blockages, clean out finger rocks as needed, and communicate conditions with other operations participants by radio. Under the hopper the gravel and water would join in a metal pipe that would then connect to the beginning of the 8" diameter, semi-flexible "Yelomine" pipe. This pipe would then go ~1270' down the ditch on the north side of the road to the switchback. From that point, the best option would be to go 264' straight down the grassy hillside (Fig. 4.4, left) to a terrace level where an old roadbed and foot trail is located. From there, the pipe would make a straight line 130' down to the water's edge near the upstream end of the gravel placement area for 2010 (Fig. 4.4, right). Overall, this approach would use roughly 2000' of Yelomine pipe to drop a vertical height of roughly 360', yielding an overall slope of 0.18 (18%).

Figure 4.2. Schematic of the gravel/cobble delivery system using a sluice method.

Figure 4.3. Landing area at the water's edge of Englebright reservoir (left) and gravel road leading up to the hillcrest (right).

Figure 4.4. Hillslope from road down to low terrace (left) and view from low terrace down to the Area A gravel placement location (right).

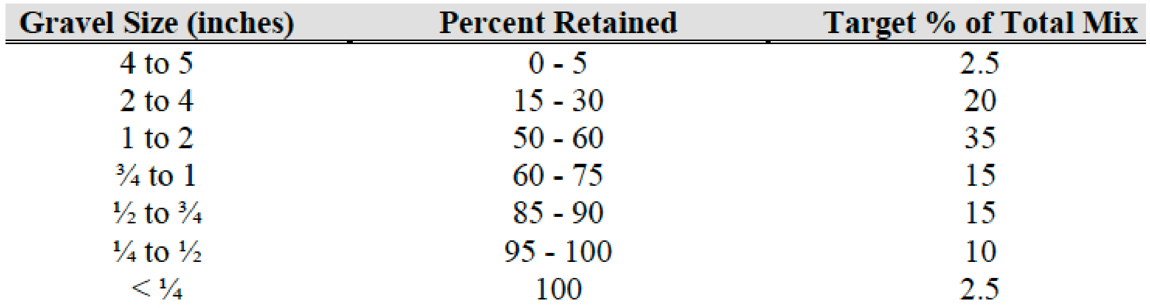
4.4. Gravel/Cobble Placement Location

The selection of the specific location within the EDR for focusing gravel/cobble placement was guided by constraints in powerhouse operations, potential benefits to the river, and feasible delivery methods. Powerhouse operations presently make gravel/cobble augmentation between Englebright Dam and the Narrows I powerhouse uncertain for the reasons described in section 2.3.3. To get the most benefit and longevity from adding gravel to the river, the further upstream it is introduced, the better. Thus, gravel/cobble augmentation could begin in the scour pool adjacent to the Narrows I facility. This pool is up to 8' deep at 855 cfs. To avoid having to fill in that scour hole and yield riffle habitat for immediate spawning use with the least amount of initial gravel injection during a pilot gravel sluicing operation, it would be advantageous to begin placement ~115' downstream of the end of the Narrows 1 powerhouse where the maximum depth is under 5' at 855 cfs. If the sluicing operation is successful, the Narrows 1 pool could be partially filled in a future year. Accessing this placement location with the gravel/cobble sluicing method is highly feasible according to the pipe pathway described in section 4.3. From this point, additional sluice pipe could be added to reach across the river or shift placement downstream in future years.

4.5. Gravel Cobble Mixture Design

Table 4.1 below provides the design of the gravel mixture to be used at the site. This mixture is consistent with the scientific literature on what is preferred for salmon spawning, embryo incubation, and fry emergence. Because the mix only specifies 2.5% of the material to be 4-5" in its B-axis dimension, that helps reduce the likelihood of having large finger rocks that can clog the sluice pipe.

Table 4.1. EDR gravel and cobble specifications (from USACE, 2007).



Gravel Size (inches)	Percent Retained	Target % of Total Mix
4 to 5	0 - 5	2.5
2 to 4	15 - 30	20
1 to 2	50 - 60	35
¾ to 1	60 - 75	15
½ to ¾	85 - 90	15
¼ to ½	95 - 100	10
< ¼	100	2.5

5. 2010 EDR SPAWNING RIFFLE DESIGN DEVELOPMENT

The Watershed Hydrology and Geomorphology Lab at UC Davis has been designing spawning habitat rehabilitation projects since 1999 using the Spawning Habitat Integrated Rehabilitation Approach (SHIRA) (Fig. 5.1). Over the years, testing of numerous gravel-contouring schemes in 2D models and in actual construction has yielded a conceptual understanding of expected hydraulic attributes, geomorphic processes, and ecologic benefits. Numerous specific design examples are illustrated on the SHIRA website at http://shira.lawr.ucdavis.edu/casestudies.htm.

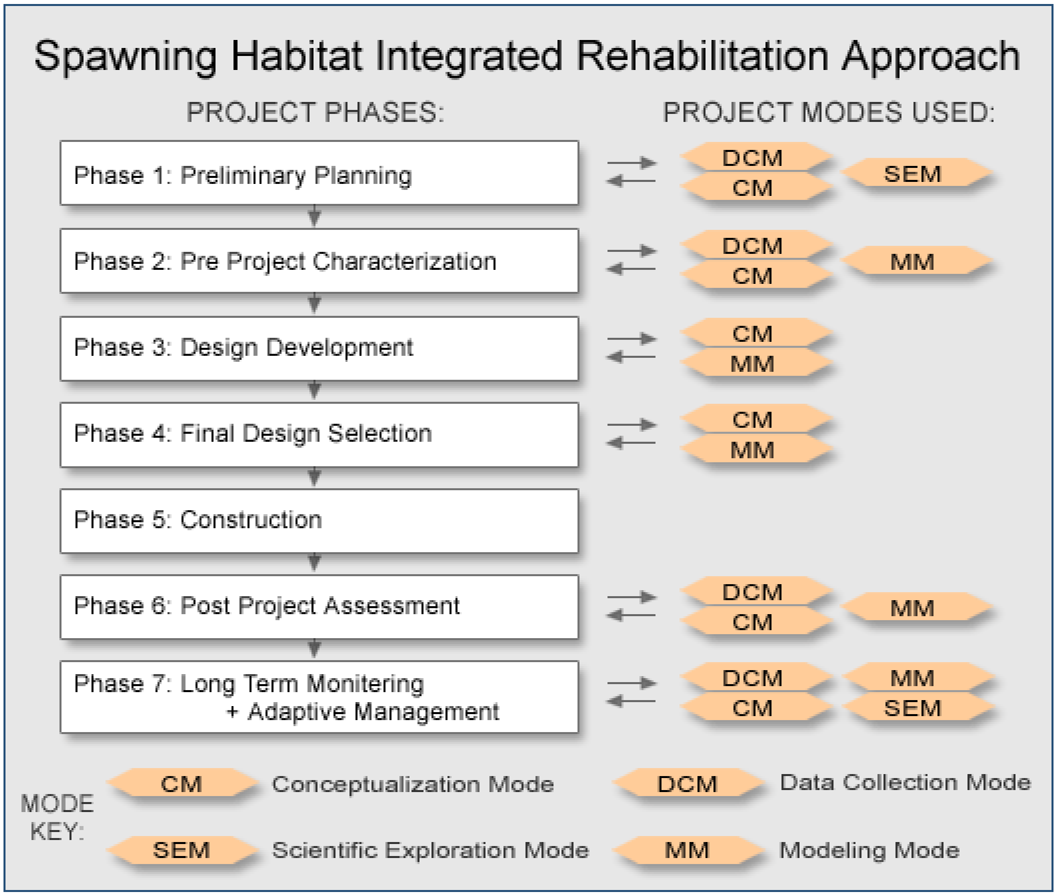


Figure 5.1. General schematic illustrating what is involved in the SHIRA framework.

5.1. Project Constraints

Based on past experience and site-specific constraints, it is possible to reduce the number of possible alternatives down considerably. An enumeration of key constraints helps put the options into focus. First, the amount of gravel to be added in the 2010 pilot trial of the gravel/cobble sluicing method has to be relatively small compared to the total deficit in the EDR given the uncertainty over how the method will work out. A lot of lessons may be learned from this trial in support of improvement to facilitate larger placements in future years. The consequence of placing a small amount of gravel is that there may not be enough material to form a resilient landform at the injection location in the face of a range of flow releases. Second, even at the typical low discharge of ~500-950 cfs in the EDR in September and October, baseline 2D modeling shows that the flow in the placement area is deep and fast (Figs. 3.1-3.4). This location is in a narrow part of the canyon that focuses flow over a range of discharges (Figs. 3.3-3.4). Several placement configurations (e.g. diagonal bar and chevron) would be at risk to scour away quickly under such focused scour. Third, the rate of gravel sluicing may be to low relative to the ambient velocity to control placement pattern at all. As sediment settles out of the water column, it will be pushed downstream in a way that is not easy to control.

One element excluded from consideration for this plan was the addition of large wood to the wetted channel in support of habitat heterogeneity, refugia, and cover. Presently there is large wood stored in the EDR (Fig. 5.2), which is ultimately derived from the small tributaries of the Middle and South Yuba Rivers. These two high-order tributaries have long stretches of unblocked channel network leading into Englebright Dam. The dam itself passes streamwood over its top during floods (wood floats, gravel/cobble does not), as evidenced by the available large wood stored in the EDR and the debris clogging Daguerre Point Dam and its fish ladders during and after floods. Historical photos 1909-2006 do not show wood jams or smaller wood accumulations in the wetted channel of the EDR. Given the width of the channel in the EDR and the power of the flow during floods, there is no reason to expect that large wood was ever stored in the channel there, in contrast to gravel/cobble, which was stored there and is now absent. Finally, because wood floats, any placement of large wood as part of the gravel/cobble augmentation plan would be highly likely to wash downstream. Use of engineered cables and fasteners to force wood to stay in place is problematic, because the underlying sediment is not expected to stay in place. Hard-wiring objects in place is also inconsistent with the approach of rehabilitating naturalized dynamic processes.

Figure 5.2. Example of large wood stored in the EDR.

5.2. Project Goals

Regardless of these constraints, the primary project goal of injecting river-rounded gravel/cobble is not at risk in the choice of placement design. If the sluice method gets the sediment into the wetted channel, then it is a success with regard to the primary goal of the project. *Creating a placement design is a bonus opportunity enabled by the ability of the sluicing method to have moderate control over where gravel is laid down on the river bed.* The extent to which the bonus can be achieved hinges on the amount of gravel added and ambient flow conditions. It is impossible to predict in advance how that will turn out. Nevertheless, it is sensible to be prepared for a successful outcome in which it is possible to control gravel placement on the bed. In that case the extra effort of controlling placement can yield physical habitat immediately available for Chinook salmon spawners to use (Elkins et al., 2007).

5.3. Design Objectives And Hypotheses

A design objective is a specific goal that is aimed for when a project plan is implemented. To achieve the objective, it has to be translated into a design hypothesis. According to Wheaton et al. (2004b), a design hypothesis is a mechanistic inference, formulated on the basis of scientific literature review and available site-specific data, and thus is assumed true as a general scientific principle. Once a design hypothesis is stated, then specific morphological features are designed to work with the flow regime to yield the mechanism in the design hypothesis. Finally, a test is formulated to determine after implementation whether the design hypothesis was appropriate for the project and the degree to which the design objective was achieved. Through this sequence, a process-oriented rehabilitation is achieved. From the mathematics of differential equations, it is evident that processes derive from the physics of motion, input conditions, and boundary conditions. Changes to either of input or boundary conditions impact processes, so it is possible and appropriate to design the shape of the river bed to yield specific fluvial mechanism associated with desired ecological functions.

The design objectives and associated information for the EDR gravel/cobble augmentation plan are enumerated in Table 5.1. This table provides a transparent accounting of the objectives, hypotheses, approaches, and tests for the gravel/cobble augmentation effort.

The last column in the table lists specific measures for monitoring the success of gravel/cobble augmentation.

Table 5.1. Design objectives and hypothesis for EDR gravel/cobble augmentation.

Design objective	Design hypothesis	Approach	Test
1. Restore gravel/cobble storage	1A. Total sediment storage should be at least half of the volume of the wetted channel at a typical base flow under a heavily degraded state (Pasternack, 2008b).	Inject gravel into the river to fill up recommended volume of sediment storage space.	Use DEM differencing of bed topography over time to track changes in storage
2. Provide higher quantity of preferred-quality Chinook spawning habitat	2A. SRCS require deep, loose, river-rounded gravel/cobble for spawning (Kondolf, 2000).	Add river-rounded gravel/cobble.	Perform Wolman pebble counts of the delivered sediment stockpile and in the river after each gravel injection to insure that the mixture's distribution is in the required range.
	2B. Spawning habitat should be provided that is as close to GHSI-defined high-quality habitat as possible (Wheaton et al., 2004b)	Place and contour gravel to yield depths and velocities consistent with salmon spawning microhabitat suitability curves.	Measure and/or simulate the spatial pattern of GHSI after project construction to determine quantity of preferred-quality (GHSI>0.4) habitat present.
3. Provide adult and juvenile refugia in close proximity to spawning habitat.	3A. Structural refugia in close proximity to spawning habitat should provide resting zones for adult spawners and protection from predation and holding areas for juveniles.	Create spawning habitat in close (<10 m) proximity to pools, overhanging cover, bedrock outcrops, boulder complexes, and/or streamwood.	Measure distance from medium and high GHSI quality habitats to structural refugia and check to see that most spawning habitat is within reasonable proximity.
4. Provide morphological diversity to support ecological diversity, including behavoral choice by individuals.	4A. Designs should promote habitat heterogeneity to provide a mix of habitat patches that serve multiple species and lifestages.	Avoid GHSI optimization of excessively large contiguous areas of habitat; design for functional mosaic of geomorphic forms and habitat.	Large (>2 channel widths) patches of homogenized flow conditions in hydrodynamic model and homogenized habitat quality in GHSI model results should not be present at spawning flows.
5. Allow gravel/cobble to wash downstream	5A.Suitable mechanisms of riffle-pool maintenance are not present or realistically achievable in the upper section of the EDR	no specific action required	Conduct annual recon of EDR to track where injected gravel/cobble goes.
	5B. Flows that overtop Englebright Dam erode sediment off the placement area	no specific action required	Measure and/or simulate the spatial pattern of Shields stress and identify areas with values >0.06

5.4. Design Concept

Given the array of site and project constraints described earlier, there is a limited range of concepts possible for implementing spawning habitat rehabilitation. To facilitate a larger, longer term vision, a staged design concept was developed that can be aimed for over time. The design concept for the plan is illustrated in Figure 5.3. Area A is the focus of the effort for 2010. The design for Area A involves filling in the channel to a depth of ~2’ for the primary spawning area at 855 cfs and then having a 3’ deep thalweg going up to the crest. The thalweg is in the 2D model-predicted location of the pre-existing thalweg for 855 cfs. A deeper thalweg is required to cope with the total volume of flow focusing through the gravel-placement site. The thalweg ends at the riffle crest allowing water to diverge laterally across the crest. By design the thalweg does not go all the way through riffle, because that would increase the rate and likelihood of the flow cutting the gravel deposit into two lateral benches, which is not desirable (Pasternack et al., 2004). However, given the strength of the flow, it may be unavoidable, even without the thalweg going through the whole riffle by design. If fully built, Area A would use up an estimated 4673 short tons of gravel. The conversion of gravel amount from a design volume to a tonnage is based on the density measurements of Merz et al. (2006) reported earlier in section 2.2, noting that with the sluicing method there is no heavy machinery to compact the bed, in contrast to the effect of front loaders reported by Sawyer et al. (2009). A key reason to aim for 2’ water depth at 855 cfs is that flows can drop to 700 cfs in a schedule A year and 500 cfs in a schedule B year. This depth provides a hydrologic buffer so that the riffle does not dewater. This is consistent with design objective #4. Another factor is that the design has to be constructible using the gravel sluicing method, and this simple design meets construction criteria based on past experience.

Figure 5.3 also illustrates design concepts for adding coarse sediment in future years to continue to meet the design objectives (Areas B and C). Because the channel deepens downstream, Area B uses more gravel than Area A, but is about half as long. Area B divides the flow and refocuses it into two 3’-deep thalwegs. Between them is a medial bar. This channel pattern is known to promote habitat diversity as well as resiliency against interannual flow differences during the spawning season. Area B requires an estimated 4870 short tons. Area C terminates the medial bar and joins the two thalwegs along the right bank, before beginning to shift it back toward the center. Area C requires an estimated 3192 short tons. Thus, the overall design concept would use 12735 short tons of gravel if it were possible to build it out over a period of a few years. This accounts for 56% of the estimated gravel/cobble storage deficit for the area from Narrows II to the rapid below the gaging station (Table 3.1). For the sake of comparison, a "blanket fill" design that would involve filling half of the pre-existing mean water depth at 855 cfs with coarse sediment between Narrows I and the rapid downstream of the gaging station would require an estimated 15850 short tons. Such a blanket installation is not feasible by gravel sluicing as it is currently practiced. Nevertheless, this value is helpful to appreciate that the creation of a heterogeneous spawning riffle in a relatively small area can achieve the same gravel/cobble storage goal, while also yielding the benefit of providing preferred SRCS spawning habitat.

If the gravel introduced in the first year washes downstream consistent with design objective #5, then that is fine, as the eroded material would still be serving the primary plan goal (design objective 1). Future injections would use the next amount of material purchased to rebuild as much of Area A, then Area B, and then Area C as possible. It is possible that frequent floods could preclude the complete design concept from ever being achieved, and that is an acceptable outcome consistent with the overall goals of the plan and the specific design objectives.

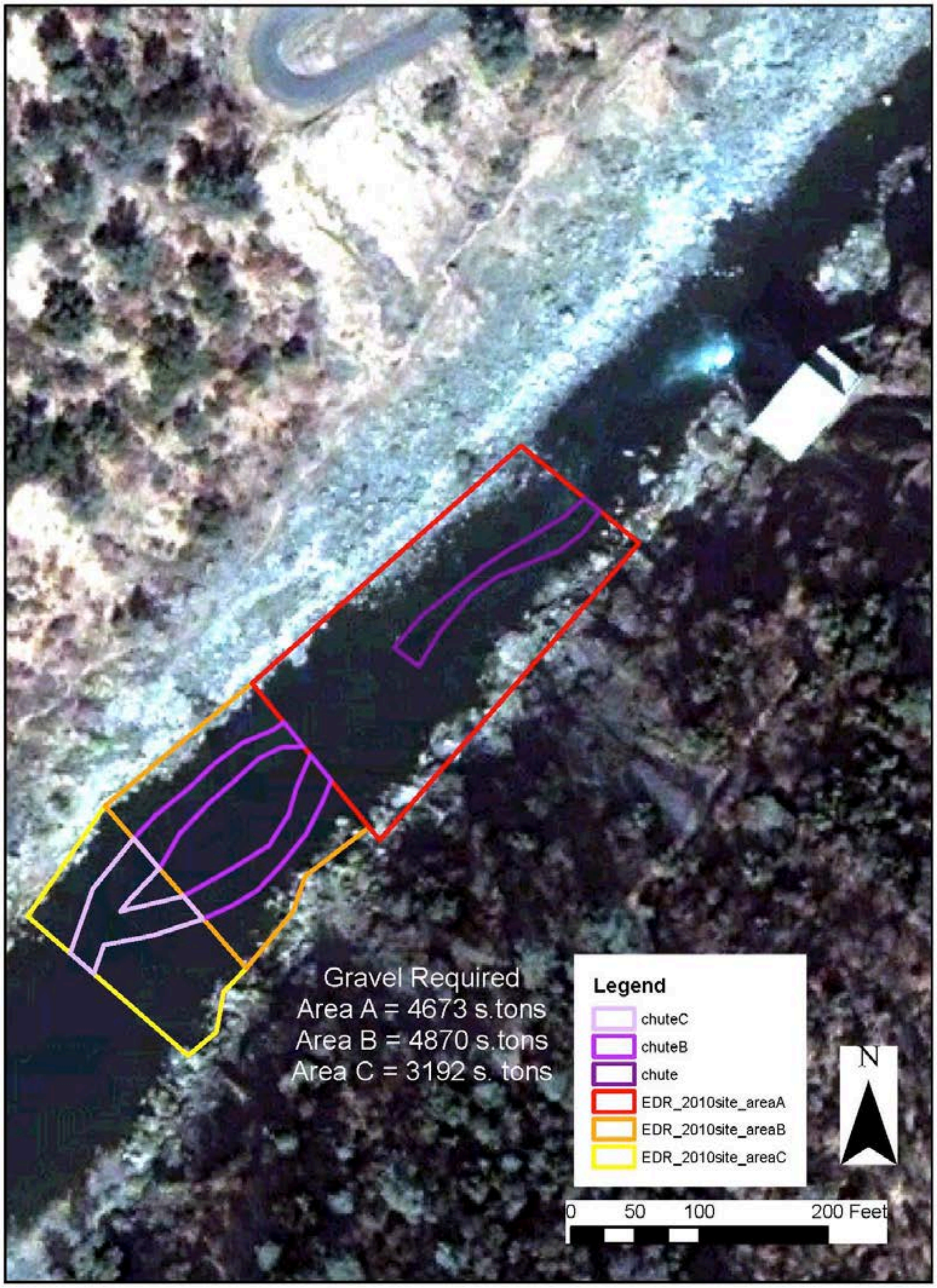


Figure 5.3. Design concept for using gravel augmentation in the EDR to possibly obtain a salmon-spawning riffle with diverse microhabitat features.

5.5. 2D Model Testing of Design Hypotheses

The likely ability of the design concept to achieve design objectives 2 and 5 is testable by performing spatially distributed, mechanistic numerical modeling of the design. Objective 2 and hypothesis 2B require that the design yield areas with GHSI>0.4 at a typical autumnal discharge of ~500-950 cfs. Objective 5 and hypothesis 5B require that the design yield areas with Shield stress values > 0.06 at flows overtopping Englebright Dam, which is Q>4500 cfs. The abilities of the design for Area A, Areas A+B, and Areas A+B+C to achieve these requirements were tested by incorporating their respective topographic features into SRH-2D models of the EDR and putting these models through the same paces as the models reported in section 3. The computational meshes used were the same as for the baseline simulations, with only the bed topography changed.

The SRH-2D model simulation for 855 cfs revealed that the design concept for Area A successfully achieves substantial area of spawning habitat with GHSI>0.4 (Fig. 5.4). Because excessive depth appears to be the limiting variable, lower discharges would have lower depths, higher GHSI values, and thus a larger total area of preferred Chinook spawning habitat.

The SRH-2D model simulation for 855 cfs revealed that the design concept for Area A yields a stable bed with a Shields stress of 0.01-0.03 during this spawning discharge (Fig. 5.5). Depending on how loosely the gravel/cobble settles onto the bed and whether any grain size fractionation occurs during settling, it is unclear whether this range of Shields stress values would be associated with partial transport. However, if that happened, the bed can be expected to adjust very quickly to yield a stable configuration prior to the autumn 2011 spawning season.

The SRH-2D model simulation for 10,000 and 15,400 cfs revealed that the design concept for Area A successfully provides a condition of full bedload mobility over the majority of the project area at these discharges (Fig. 5.6). That means that at these high discharges and any higher ones, the project site will scour significantly. Beginning with the 1991 water year, flows of >10,000 cfs have occurred in 12 out of 20 years, or once every 1.67 years. Therefore, there is a high likelihood that the placed grave/cobble will transport downstream in accordance with design objective #5. Results shown in Figures 3.6-3.7 indicate that the placed material is unlikely to leave the EDR. Considering that those analyses do not account for the impeding effects of flow out of Deer Creek, then the likelihood is even stronger that the material will stay in the EDR.

One other consideration related to any riffle design is the fact that a riffle is a partial barrier to flow. Water backs up behind a riffle and accelerated over it. When a riffle is added artificially or degraded riffle-pool relief is rehabilitated, then an increased backwater effect will result (Wheaton et al., 2004a). The Area A 2D model simulations show that effect for that design. In the EDR, there is no negative environmental impact of this upstream backwater effect, because it serves to decrease velocity and increase depth in an area that is already mostly devoid of spawning habitat anyway. In terms of powerhouse operations, both powerhouses operate normally with a wide range of tailwater depths, so an increase in water surface elevation in the Narrow I pool and Narrows II pool should not impact their operations.

Overall, there do not appear to be any impediments for the use of the Area A design. The design uses a reasonable amount of gravel to pilot the gravel sluicing method in 2010. If the material survives in its placement location through winter and spring 2011, the design is predicted to yield preferred Chinook spawning habitat and is predicted to yield a stable riffle during spawning and embryo incubation in 2011 prior to winter storms in 2012. The designed riffle is predicted to be erodible during floods overtopping Englebright Dam roughly every other year, but when moved the material is expected to stay within the EDR. This means that the tonnage still counts toward achieving the geomorphic goal of eliminating the gravel/cobble deficit for the reach over the long term. Further gravel additions to re-build Area A in future years would yield short-term habitat benefits and add up toward the longer term geomorphic goal. The last column of Table 5.1 lists specific measures than can be used to test the efficacy of gravel augmentation toward meeting each specific design objective.

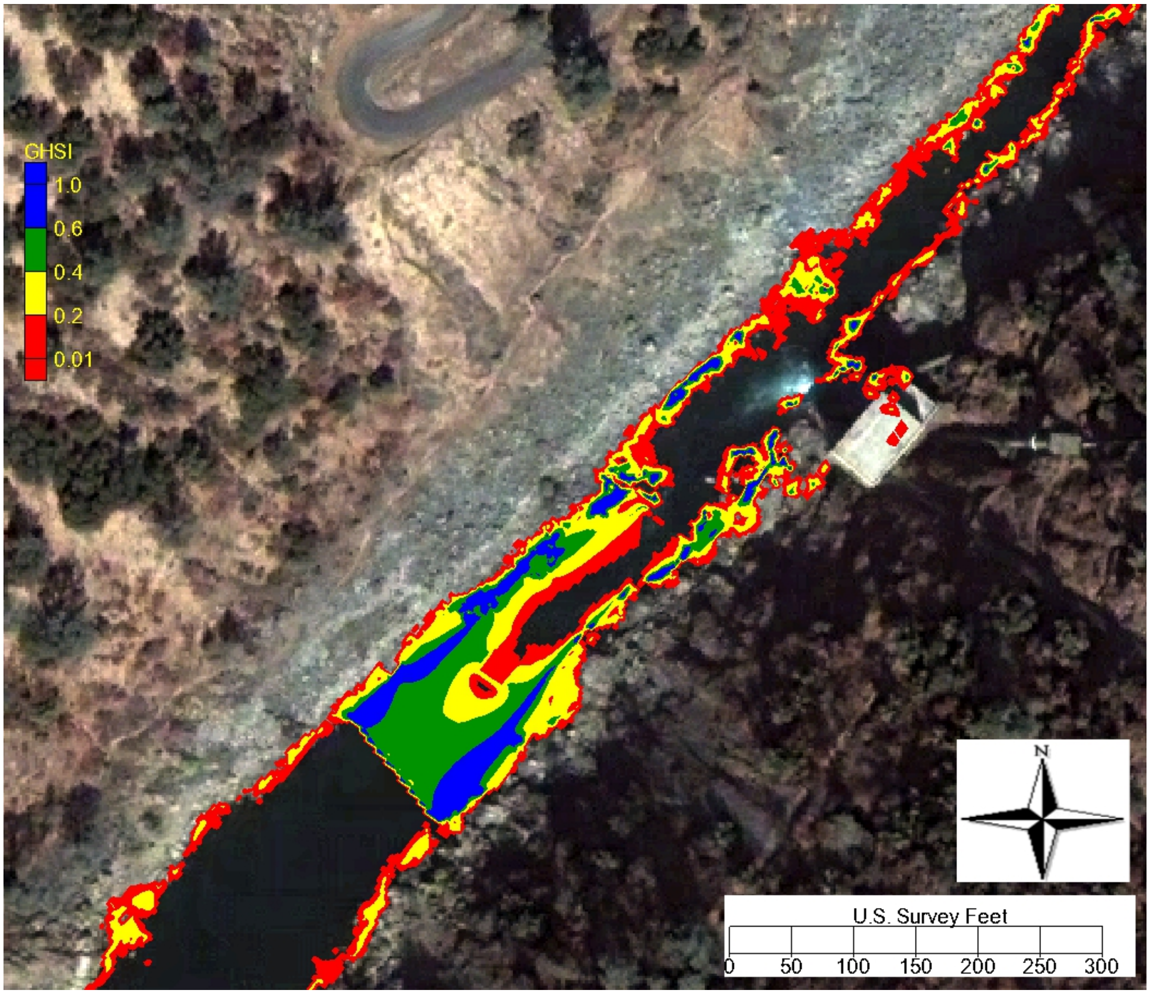


Figure 5.4. GHSI prediction for Area A at 855 cfs. Areas of green and blue are predicted to be preferred Chinook spawning habitat.

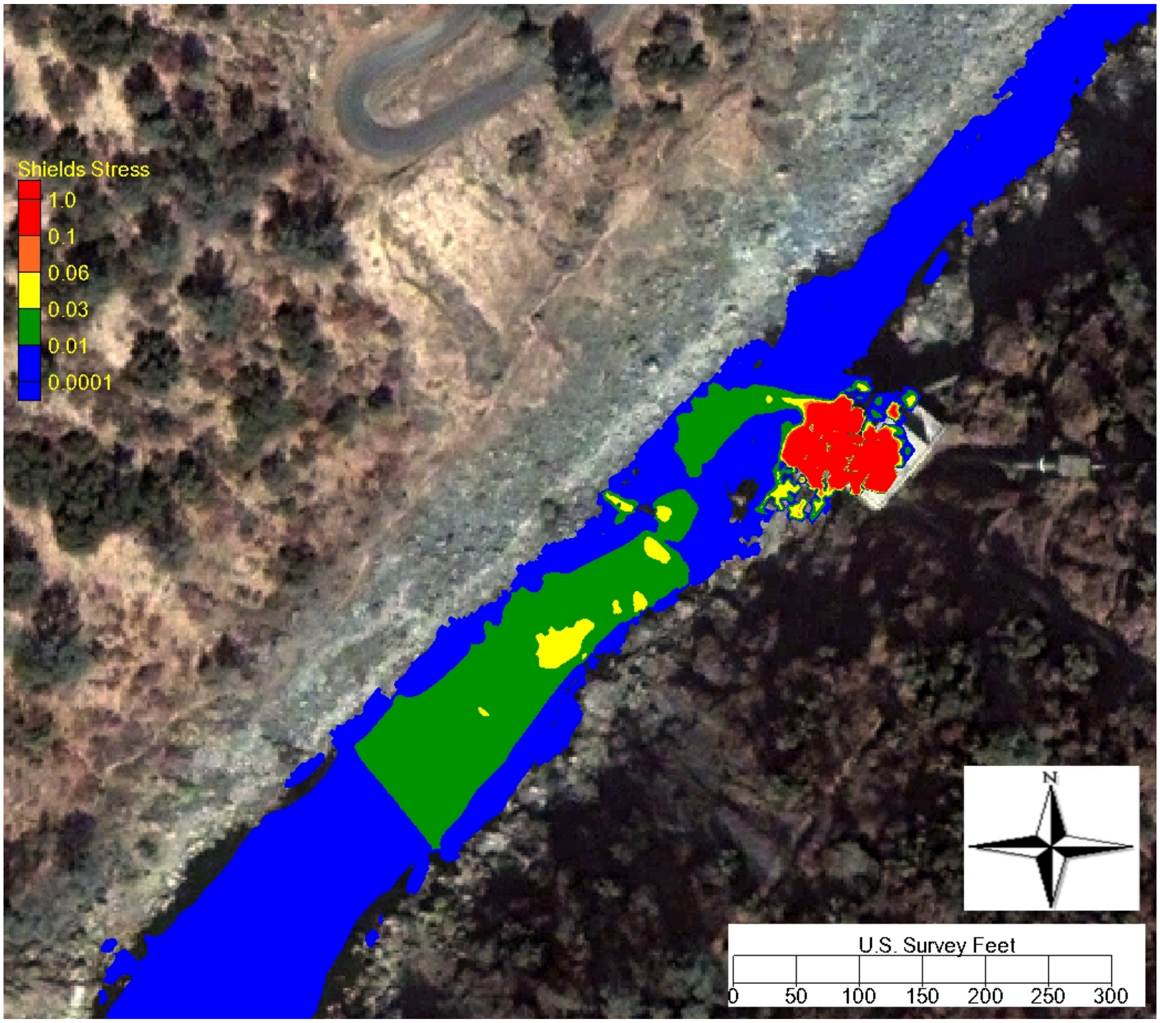


Figure 5.5. Shields stress prediction for Area A at 855 cfs.

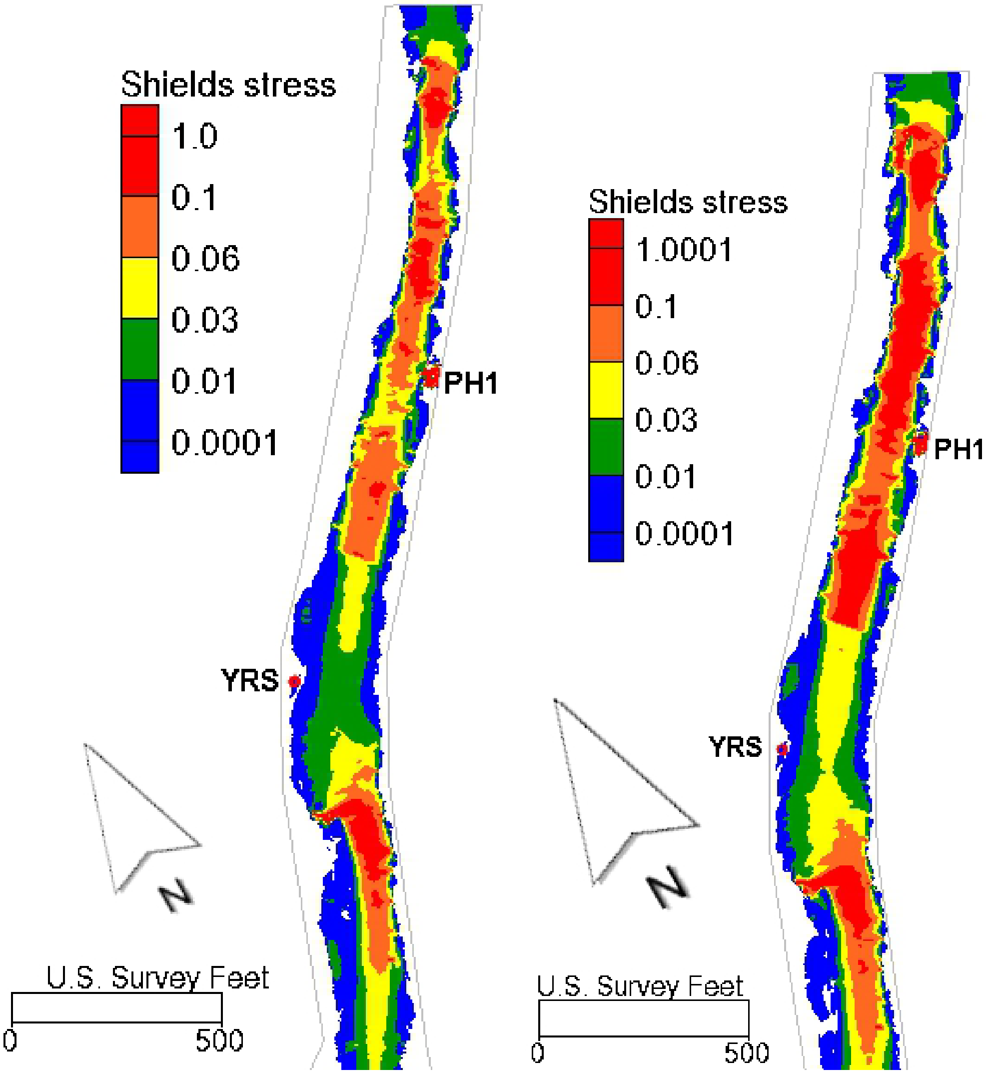


Figure 5.6. 2D model predictions of Shields stress for flows of 10,000 cfs (left) and 15,400 cfs (right), focusing on the location of gravel placement below the Narrows I powerhouse (PH1). In both scenarios, Shields stress > 0.06 over the majority of Area A.

6. LONG-TERM GRAVEL AUGMENTATION PLAN

The estimated gravel/cobble deficit for the EDR is 63,077 to 100,923 in the current condition. Considering just the area from the Narrows I powerhouse to the rapid downstream of the gaging station, the amount is 15,949 to 25,518 short tons. The lower value for each domain is consistent with the idea of having a diversity of complex morphological units in the reach, while the higher value for each domain is consistent with the idea of having a fully alluvial reach with a lot of riffle area and low morphological diversity. The former conception involving a balanced role of alluvial and bedrock influences is interpreted to be the best match for what was likely present prior to hydraulic mining. The latter conception of a fully alluvial river within the canyon would more resemble the state of the river during severe alluviation with hydraulic mining debris, and therefore is deemed less appropriate.

Strategically, different approaches are feasible for the sequencing of placing gravel and cobble. It is not feasible to erase the entire gravel/cobble deficit in one year. It is very important to use an incremental approach in this type of project, because it yields a more resilient and better-tested outcome (Elkins et al., 2007). The area of the river that is presently appropriate for gravel augmentation is the domain from the Narrows I pool to the top of the rapid downstream of the gaging station. The recommendation for the 2010 pilot project is to use the sluicing method to place 2000 to 5000 short tons of gravel/cobble to build up an Area A riffle. This project is a “pilot”, because the gravel/cobble sluicing method has never been attempted for salmon habitat rehabilitation over such a long distance and with such a high height drop.

During and after the 2010 pilot gravel/cobble placement, a monitoring program should be instituted to evaluate what happened. Baseline data exists for the pre-project characterization (see section 3). Observation, description, and photo-documentation of the gravel/cobble sluicing operation would help assess its logistical effectiveness to get gravel/cobble into the river. After construction, an as-built topographic survey should be performed to enable 2D hydrodynamic modeling for mapping of physical habitat and sediment transport potential for the site. The as-built survey is also required for DEM differencing to track volumetric change over time. Thereafter, the seven tests listed in

Table 5.1 should be carried out. These tests will ascertain the veracity of the design hypotheses and the suitability of the design objectives. Based on the outcome of a thorough evaluation, future projects may be designed differently to yield improved outcomes.

Assuming the gravel-sluicing method of doing gravel/cobble augmentation is judged successful after evaluation of the 2010 pilot project, then a long-term plan that continues to use this approach would be recommended. The concept would be to add gravel and cobble to Areas A, B, and C until the EDR deficit is erased. Building out the design concept for Areas A, B, and C would come close to achieving the total deficit for this section, and it would be easy to add an Area D to finish it off when and if that is needed. Thereafter, as floods relocate the sediment into the lowermost section of the EDR, further additions would be made to the placement area to keep up with the flux into the lowermost section plus any outflux leaving the EDR. Eventually, the gravel deficit for the whole reach would be erased. Once the overall deficit is erased, then further additions would only be appropriate after material is observed leaving the EDR, and then the amount would match the estimated loss.

For the section between the Narrows II and I powerhouses, it may or may not be feasible to ever erase the gravel/cobble deficit. Further evaluation of options in light of existing and possible future powerhouse operations is required.

Overall, the evidence shows that the EDR has the potential to accommodate thousands of Chinook spawners. Erasing the gravel/cobble deficit for the reach would be beneficial toward achieving that potential. Gravel sluicing is the recommended method for augmenting gravel into the EDR. Going further to build diverse morphological units in the reach would yield a sufficient amount of preferred holding, spawning, and embryo-incubation habitat for the population. Such actions would account for the most significant and evident geomorphic impacts of Englebright Dam on the lower Yuba River.

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Lower Yuba River Large Woody Material Management Plan

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1.0 Introduction

Instream large woody material (LWM) provides escape cover and relief from high current velocities for juvenile salmonids and other fishes (**Figure 1**). Snorkeling observations in the lower Yuba River have indicated that juvenile Chinook salmon had a strong preference for near-shore habitats with instream woody material (JSA 1992). As part of the Central Valley Project Improvement Act Anadromous Fish Restoration Program, the United States Fish and Wildlife Service (USFWS) (1995) identified the need for increasing the amount of instream woody material to improve juvenile salmonid rearing habitat in the lower Yuba River. Beak (1996, as cited in CALFED and YCWA 2005) recommended the addition of instream woody material as a habitat enhancement action to increase annual salmonid smolt production in the lower Yuba River.

Figure 1. Juvenile salmonids associated with LWM.

It has been reported by the lower Yuba River Fisheries Technical Working Group (CALFED and YCWA 2005) that little instream woody material occurs in the lower Yuba River, because upstream dams block some downstream transport of woody material, and because of the lack of riparian vegetation throughout much of the lower Yuba River. However, the CALFED and YCWA (2005) report did not indicate that any surveys or studies were conducted to support these statements. Some woody material may not reach the lower Yuba River due to collecting on the shoreline and sinking in Englebright Reservoir. However, Englebright Dam does not substantively block woody material from reaching the lower Yuba River because there is no woody material removal program implemented for Englebright Reservoir, and accumulated woody material therefore spills over the dam during uncontrolled flood events (R. Olsen, Corps, pers. comm. 2011). Nonetheless, few pieces of large wood reportedly are found within the reach of the lower Yuba River extending from Parks Bar to Hammon Bar, presumably due to upstream dams disrupting downstream transport from the upper watershed and the overall lack of supply and available inventory along the riparian corridor of the river downstream of Englebright Dam (USFWS 2010).

On November 21, 2007, National Marine Fisheries Service (NMFS) issued a long-term biological opinion (BiOp) regarding the U.S. Army Corps of Engineers' (Corps) operation and maintenance of Daguerre Point and Englebright dams. The BiOp included an incidental take statement (ITS) with several terms and conditions. Term and condition D.2. requires the Corps to "*develop and implement a long term program to replenish large woody materials in the lower Yuba River*." In accordance with this term and condition, the Corps must "*determine an effective method of* *replenishing the supply of large woody material ... back into the lower Yuba River, in a manner that provides instream cover, invertebrate flood sources, and micro-habitat complexity…*"

In October of 2011, the Corps submitted a Biological Assessment (BA) to NMFS assessing the effects of ongoing operations and maintenance of Englebright and Daguerre Point dams in the lower Yuba River. The BA included a conservation measure addressing LWM. The conservation measure in the BA stated that the Corps will: (1) develop a plan or policy for management of LWM, consistent with recreation safety needs; (2) conduct a pilot program to identify suitable locations and evaluate the efficacy of placing large instream woody material to modify local flow dynamics to increase cover and diversity of instream habitat for the primary purpose of benefitting juvenile salmonid rearing; and (3) based upon the outcomes of the pilot program, develop and implement a long-term Large Woody Material Management Plan (LWMMP) for the lower Yuba River, anticipated to occur within one year following completion of the pilot program.

This LWMMP has been prepared consistent with term and condition D.2. in the BiOp and the conservation measure presented in the BA, with technical assistance provided by HDR Engineering, Inc. It includes the following key elements.

- ☐ Metrics for assessing LWM value and selection criteria
- ☐ Design considerations including LWM sources, collection location(s), collection methods, transportation methods, and stockpiling location(s).
- ☐ Description of a LWMMP Pilot Program

1.1 Goals of the LWMMP

The overall goal of this plan is to provide and manage LWM in the lower Yuba River downstream of Englebright Dam to improve habitat for juvenile salmonids and other non-listed fish species, by improving cover and diversity of instream habitat for rearing juvenile anadromous salmonids, and provide increased cover, invertebrate food sources, and micro-habitat complexity. The Corps recognizes that the accomplishment of this goal has to occur while maintaining recreation and public safety values.

2.0 LWMMP Design Considerations

The application of LWM to improve habitat for juvenile salmonids and other non-listed fish species in the lower Yuba River considers several design characteristics including the source of LWM, collection methods, size and type criteria for selection, access and transportation of LWM, and placement techniques for optimal benefit of LWM.

LWM is a naturally occurring feature in stream channels. LWM may alter existing hydrodynamics, habitat availability and use, and a redistribution of species (Saldi-Caromile et al. 2004). The deliberate placement of wood in streams and floodplains to form discrete structures at specific locations may create habitat immediately, or may take years to develop (Saldi-Caromile et al. 2004). Wood can be a naturally occurring feature anywhere in a stream system where trees are present in the adjacent riparian zone or upstream watershed. However, there is risk associated with adding mobile wood to certain stream types. For example, as the velocity and depth of flow increases, so do the buoyant and drag forces acting to transport LWM. And as the width and depth of the stream increases, the likelihood of wood getting wedged between banks, or held up on bank and channel obstructions decreases. Consequently, the risk of wood transport (though not necessarily project failure) increases with channel gradient, channel depth, and channel width (Saldi-Caromile et al. 2004). Ideal locations for wood replenishment include less developed watersheds where infrastructure is not located within or immediately adjacent to the stream (Saldi-Caromile et al. 2004).

2.1 LWM Availability and Collection

Within the Yuba River Basin, several dams have altered the downstream movement of large wood into the lower Yuba River. New Bullards Bar Dam and Reservoir is located relatively low in the watershed and functions as the dominant flood control and water supply reservoir in the Yuba River Basin (CALFED and YCWA 2005). The drainage area of the North Yuba Basin is approximately 489 square miles (mi^2), which is the largest drainage area of the three Yuba River sub-basins (i.e., North Yuba River Basin, South Yuba River Basin, and Middle Yuba River Basin). Since completion of New Bullards Bar Dam in 1969, the movement of LWM from the North Yuba River Basin into the Yuba River has been reduced. A cable-and-buoy line (floating boom) spans New Bullards Bar Reservoir just upstream of the dam, which captures woody material that has entered and traveled downstream on the reservoir's surface.

The woody debris that accumulates on New Bullards Bar Reservoir consists of various materials, including leaves, twigs, branches, logs, root-wads, and trees. However, the quantity, size, and type of LWM entering New Bullards Bar Reservoir on an annual basis are not well known. In general, the most commonly available floating wood is generally small diameter material, with large diameter trees occurring less frequently and usually associated with flood events.

A flood event that occurred December 31, 2005 reportedly resulted in approximately 6,300 cubic yards (yd^3) of floating woody material on the surface of New Bullards Bar Reservoir (**Figure 2**). The Yuba County Water Agency (YCWA) obtained a Federal Emergency Management Agency (FEMA) grant to gather up and remove the woody material, and about 4,800,000 pounds of wood was chipped and hauled to Oroville to be used as fuel for a biomass generation unit.

Because the availability of LWM is related to magnitude, duration and frequency of large floods (City of Tacoma 2004), it is likely that the quantity and quality of LWM entering New Bullards Bar Reservoir from the North Yuba River vary inter-annually. Research quantifying the large wood loading in the Yuba River Basin is presently underway by Anne Senter, a UC Davis student advised by Dr. Pasternack (USFWS 2010). Preliminary estimates have quantified the volume of wood stored in New Bullards Bar Reservoir at two times - 1998 and 2006.

Figure 2. Large Woody Material in New Bullards Bar Reservoir (YCWA 2006).

Aerial photography examinations resulted in an estimated 34,400 yd^3 of wood accumulated on New Bullards Bar Reservoir during 1998, and an estimated 110,000 yd^3 accumulated on New Bullards Bar Reservoir during 2006 (A. Senter unpublished data, as cited in USFWS 2010).

YCWA presently manages the LWM that is washed into New Bullards Bar Reservoir from the North Yuba River Basin upstream. Although no formal LWM Management Plan has been established, YCWA methods currently involve pushing the floating LWM into shallow coves of New Bullards Bar Reservoir using tug boats, and subsequently gathering and removing the dry LWM from the reservoir using a boom (G. Rabone, YCWA, pers. comm.). USFWS (2010) reports that accumulated wood from New Bullards Bar Reservoir is burned every 1 to 3 years.

Consistent with past LWM removal efforts on New Bullards Bar Reservoir, YCWA will continue to manage LWM on New Bullards Bar Reservoir by pushing the floating LWM using tug boats into shallow coves that have landside access along New Bullards Bar Reservoir, and subsequently stockpiling the LWM on the shoreline using a boom. The Corps will coordinate with YCWA to gather some of the stockpiled LWM along New Bullards Bar Reservoir and place it onto transport trucks for relocation downstream in the lower Yuba River. It is anticipated that LWM that is not selected for enhancement downstream will be burned on the shoreline of New Bullards Bar Reservoir.

For the Pilot Program (see Section 4.0, below), the Corps will use LWM available from the stockpiles located along New Bullards Bar Reservoir, which is anticipated to be dominated by coniferous species. However, if the amount, type and size of available LWM from the stockpiled sources along New Bullards Bar Reservoir are insufficient to meet the needs of the Pilot Program, then the LWMMP will consider augmentation of LWM from New Bullards Bar Reservoir with LWM from orchard trees, if a suitable source and quantity can be identified.

2.1.1 LWM Selection Criteria

LWM is highly variable in size, texture, plant species, and degree of decomposition (SAFCA 1999). Not all the woody material entering New Bullards Bar Reservoir is expected to be suitable for meeting the goal of this LWMMP. In general, some LWM that enters reservoirs may not be removed from a reservoir such as wood that is habitat for snag and log dependent species and provide greater ecological benefit by remaining in place rather than being removed and stockpiled (Puget Sound Energy 2011). For example, large trees along a reservoir shoreline riparian zone that fall into the reservoir are not necessarily removed if their rootwad rests more than a couple of feet above the full pool surface elevation and prevents the wood from floating away. For the LWMMP, LWM selected for removal from the stockpiles located along the shoreline of New Bullards Bar Reservoir will be based on the size and type criteria identified below.

Size

A review of available literature indicates that LWM size criteria is highly variable, although two general size criteria methods were identified: (1) specific length and diameter dimensions of LWM irrespective of channel width; and (2) length and diameter criteria that are scaled to the width of the channel under consideration (PG&E 2008). Several studies that specify a minimum length and diameter define LWM as being wood with a diameter of at least 10 centimeters (cm) along 2 meters (m) of their length, or rootwads less than 2 m long with a minimum bole diameter of 20 cm, and may include whole trees with rootwad and limbs attached, pieces of trees with or without rootwads and limbs, and cut logs (Saldi-Caromile et al. 2004). USFWS (2010) identified large wood (conifers or hardwoods) as greater than or equal to 16 inches (in) in diameter and greater than or equal to 15 feet (ft) in length. Fox (2004, as cited in CRH 2007) specifies a mid-point diameter of 10 cm or greater, a length of 2 m or greater, and protruding into the bankfull channel is required for designation as LWM (CRH 2007). Additionally, a log with a rootwad is considered a “key piece” because it is likely to be stable during bankfull flows and influences many of the physical and ecological characteristics (CRH 2007). Similarly, the 1998 CDFG Stream Habitat Restoration Manual (Flosi et al. 1998) identifies a single piece of large wood greater than 12 inches in diameter and 6 ft long as LWM, and small woody material as any amount of small wood that is less than 12 in diameter. Other studies are less specific and focus on LWM that ranges between 10-20 cm in diameter, 1-3 m in length, or both (e.g., Robison and Beschta 1990; Bilby and Ward 1991; Fausch and Northcote 1992; Crispin et al. 1993; Beechie and Sibley 1997, as cited in SAFCA 1999).

Other management plans suggest that the length of LWM selected for placement must be shorter than the bankfull width of the river, due to transport considerations and the potential for log jams to occur downstream following mobilizing flood events (Flanagan 2004 and Wohl 2000, as cited in Energy Northwest 2005). However, this LWM size criterion may not be relevant to the lower Yuba River in consideration that the river generally is much wider (e.g., 300-600 ft) than the rivers addressed in these other plans. LWM is defined in the USFS Region 5 Stream Condition Inventory (SCI) protocol as all pieces of wood lying within the bankfull width of the channel that measures one half bankfull width or longer (SMUD undated). Cramer et al. (2002) suggests size of trees and rootwads have a minimum trunk diameter 0.5 × bankfull discharge depth, and minimum tree length 0.25 × bankfull discharge width. Again, however, these types of criteria and considerations are generally most relevant to smaller streams.

Size criteria in this LWMMP are more inclusive to provide a greater range of options for future monitoring, and to facilitate comparison with other existing data sets on LWM load in streams. Therefore, based on a review of the literature, this LWMMP defines LWM as pieces of wood that are minimally 12 inches in diameter, and 6 ft long. The maximum length of LWM pieces will correspond to that length with is capable of being transported by truck.

Type

In addition to size of the LWM, the type influences stability of the LWM and is defined as the species, geometry, and presence versus absence of rootwad (Saldi-Caromile et al. 2004). Decay rates are climate dependent, due to the requirements of the fungi responsible for aerobic decomposition of wood. Differences in the durability between coniferous and hardwood species can be quite dramatic when not fully submerged. Several studies conducted in the northern hemisphere recommend coniferous species be used for all key pieces of wood that are critical to structure stability and function and may not be continuously submerged. Lacking tannins that slow decay, deciduous wood decays much more rapidly and may lose structural integrity within a decade, depending on its size and the degree of wetting and drying that occurs (Saldi-Caromile et al. 2004).

Widely spreading or multiple-stemmed hardwoods are more prone to forming snags than the more cylindrical conifers which are more readily transported and accumulate as racked members, and may beneficially enhance recruitment of other woody material (CRH 2007). Complex woody material structures that feature numerous branches and high stem density locally decrease flow velocity, inducing sediment deposition. Accordingly, materials should be selected that have numerous branches, being careful not to break or remove branches during wood placement (Corps 2007).

Hilderbrand et al. (1997) suggest using trees with branches or rootwads left intact because they are less likely to move when flow is high (SAFCA 1997). Root tissue is more resistant to decomposition and provides increased stability than trunks and stems (SAFCA 1999). The

Sacramento River Bank Protection Project (SAFCA et al. 2011) states that selected trees for LWM placement should have a structurally complex canopy and/or root mass containing many branches and roots of various sizes. Trees that provide optimal LWM have many fine- and medium-sized branches or roots. A dense network of smaller roots and branches provides optimal cover for target fish species. Emphasis should be placed on selecting those trees with the greatest volume, density, and complexity of branches or roots. For example, SAFCA et al. (2011) state that trees to be imported to the Sacramento River Bank Protection Project sites should have a minimum trunk diameter of 10 in diameter at breast height (DBH) and a minimum total length of 25 ft (including trunk, canopy, and/or root wad) (DBH is a standard measurement of trunk diameter as measured 4 ft above the ground). Therefore, for the LWMMP, pieces with rootwads will be preferentially selected from the materials stockpiled along the shoreline of New Bullards Bar Reservoir.

Quantity

Several different methods of identifying the appropriate loading levels of LWM have been used in various localities, including proportion of adjacent riparian, volume per stream channel area, emulation of natural loading, and pieces per length. Classifying and inventorying LWM within a stream is a key step in a LWM management plan. A LWM assessment provides a baseline on the amount and type of LWM and the locations along a stream. The assessment also helps to quantify the impact of LWM on the designated uses of the stream. Following a LWM assessment, management options should be evaluated. Any management action needs to fit within what is expected of the stream through its designated uses and what is feasible based on a stream's characteristics. Other key factors that determine management options include cost and the experience of the responsible parties designing and/or implementing management activities (CRH 2007).

As a part of the Corps' compliance with term and condition D.2. of the BiOp and as part of a conservation measure identified in the BA, the Corps will: (1) develop a plan or policy for management of LWM, consistent with recreation safety needs; (2) conduct a pilot program to identify suitable locations and evaluate the efficacy of placing large in-stream woody material to modify local flow dynamics to increase cover and diversity of instream habitat for the primary purpose of benefitting juvenile salmonid rearing, anticipated to occur no later than one year of NMFS issuance of a new biological opinion for this project; and (3) based upon the outcomes of the pilot program, develop and implement a long-term large woody material management plan for the lower Yuba River, anticipated to occur within one year following completion of the pilot program.

Under Agreement No. W912HZ-11-2-0004, the Corps is a federal agency partner in the University of California's Office of Research Cooperative Ecosystem Studies Unit (CESU). Through the CESU, the Corps coordinated with Dr. Greg Pasternack at UC Davis in the spring of 2011 regarding the potential development of a multi-disciplinary research study that would investigate ecologic, hydrologic, and geomorphologic considerations associated with large woody material adaptive management actions. In September 2011, a one-year study was approved. A contract will be awarded and the study implemented in spring 2012. It is anticipated that the results of this study will provide the following information: (1) a streamwood budget for the Yuba River watershed above Englebright Dam; (2) a detailed accounting of large woody material distribution and abundance; and (3) potential design concepts for instream hydraulic structure placement in the Englebright Dam Reach of the lower Yuba River. The technical information provided by this research would be used to facilitate the development and implementation of a large woody material adaptive management plan for the lower Yuba River, including identifying the appropriate quantities of LWM to be placed in the lower Yuba River.

2.2 New Bullards Bar Reservoir Access Site

The Corps will coordinate with YCWA regarding access to, and availability of LWM at accessible shoreline sites around New Bullards Bar Reservoir prior to LWM collection activities. In their determination of suitable access locations related to the collection of LWM, the Corps and YCWA will consider equipment size, available space, as well as minimizing impacts to recreational facilities. Recreational facilities located along New Bullards Bar Reservoir include Emerald Cove Marina, Hornswoggle Group Camp, Schoolhouse Family Camp, Dark Day Campground, Dark Day Boat Ramp, Garden Point Campground, Madrone Cove Campground, and Cottage Creek Boat Ramp.

2.3 LWM Transportation Methods

LWM collected from the surface of New Bullards Bar Reservoir and placed in stockpiles along the shoreline that meets the suitable criteria stated above (see Section 2.1.1) will be transported downstream to placement sites identified below in Section 2.4. The equipment needed to move the LWM can include self-loading log trucks, excavators, end dumps, skidders and dump trucks (Saldi-Caromile et al. 2004). The LWM will be transported to downstream areas along the lower Yuba River via truck.

The Corps will identify a Licensed Timber Operator, who is licensed under the Forest Practice Act law and is authorized to conduct forest tree cutting and removal operations, for the loading, transporting and unloading of LWM collected from New Bullards Bar Reservoir.

2.4 LWM Placement

Placement of LWM in the lower Yuba River is anticipated to temporarily improve habitat for juvenile salmonids and other non-listed fish species in the lower Yuba River directly at the placement site, in addition to areas downstream as transport of LWM occurs during high flow conditions. The following factors will be considered in identifying potentially suitable LWM placement sites: (1) within the boundaries of the lower Yuba River frequently occurring inundation zone (approximately 880 to 5,000 cfs); (2) located at the downstream end of a meander bend, the head of a side channel, the apex of a bar, in backwatered reaches, pools, or relatively low energy sites, consistent with LWM stability guidelines presented in Saldi-Caromile et al. (2004); (3) consistent with potential habitat rehabilitation sites identified in the *Rehabilitation Concepts for the Parks Bar to Hammon Bar Reach of the Lower Yuba River* by USFWS (2010) and *Potential Juvenile Rearing Habitat Expansion Actions in the Lower Yuba River, Appendix L to the Final Habitat Expansion Plan* by PG&E (2010); (4) provide access for heavy equipment; and (5) sites under federal land management or where the Corps can obtain necessary real estate rights. The Corps will conduct a real estate assessment for each of the potential sites as part of the Pilot Program (see Section 4.0).

Additionally, it is preferable to place appropriate LWM at bank locations where juvenile salmonids are most likely to occur so that they will benefit most from the LWM. The LWM placement sites identified in this LWMMP are approximate locations for improving juvenile salmonid rearing habitat on the lower Yuba River. Implementation ultimately relies on the experience and judgment of the equipment operators or supervisor to select the specific location and orientation of each individual log and the methods for placing LWM.

Factors influencing the structural stability of LWM clusters include magnitude, duration, and frequency of flooding, as well as natural geomorphic processes in the channel. Hydrologic assessment methods are useful in identifying the most appropriate bank position for placement of LWM (SAFCA 1999). According to Pasternack (2009), the lower Yuba River experiences floods capable of inducing geomorphic changes to the mainstem, which potentially would influence downstream transport of placed LWM complexes. Additionally, a review of 2D-hydrologic modeling developed by the Yuba Accord River Management Team (RMT) indicates that the frequently occurring inundation zone is defined by the inundated channel between the low flow (e.g., 880 cfs) and nearly annual high flow (e.g., 5,000 cfs) boundaries.

LWM stability guidelines presented in Saldi-Caromile et al. (2004) suggest that optimal placement locations for LWM include the downstream end of a meander bend, the head of a side channel, at the apex of a bar, in backwatered reaches, pools, or relatively low energy sites. The upper portions of the bars or inlets where LWM placement sites are identified would remain undisturbed in order to preserve natural hydrologic and geomorphic structure. LWM will be placed and allowed to potentially move under high flow conditions. In some locations, large wood would promote the geomorphic processes of scour and deposition, further enhancing a heterogeneous mosaic of aquatic habitat types. This LWMMP identifies suitable LWM placement sites, consistent with optimal placement locations identified by Saldi-Caromile et al. (2004) and within the boundaries of the lower Yuba River frequently occurring inundation zone (e.g., the floodplain between 880-5,000 cfs).

Two studies were primarily referenced in the identification of approximate LWM placement sites in this LWMMP, including *Rehabilitation Concepts for the Parks Bar to Hammon Bar Reach of the Lower Yuba River* by USFWS (2010) and *Potential Juvenile Rearing Habitat Expansion Actions in the Lower Yuba River, Appendix L to the Final Habitat Expansion Plan* by PG&E (2010). USFWS (2010) reports that the approximate 4-mile reach of the lower Yuba River downstream of the

Highway 20 Bridge, often referred to as the Parks Bar to Hammon Bar reach, is relatively dynamic because of the availability of sediment and the potential for the alignment of this sediment to be altered during large magnitude floods in the reach. Further, USFWS (2010) states that the entire reach between Parks Bar and Hammon Bar could be suitable for placing large wood along the margins of the active main channel, side channels and backwaters. The Parks Bar to Hammon Bar reach (**Figure 3**) is considered a focal reach for restoration because of its proximity to the primary spring-run Chinook salmon and steelhead spawning reaches, favorable rearing temperatures, and the limited current extent of off-channel habitat (PG&E 2010). Pending the results of the five factors considered in identifying potentially suitable LWM placement sites, additional sites upstream of the Highway 20 Bridge also may be considered.

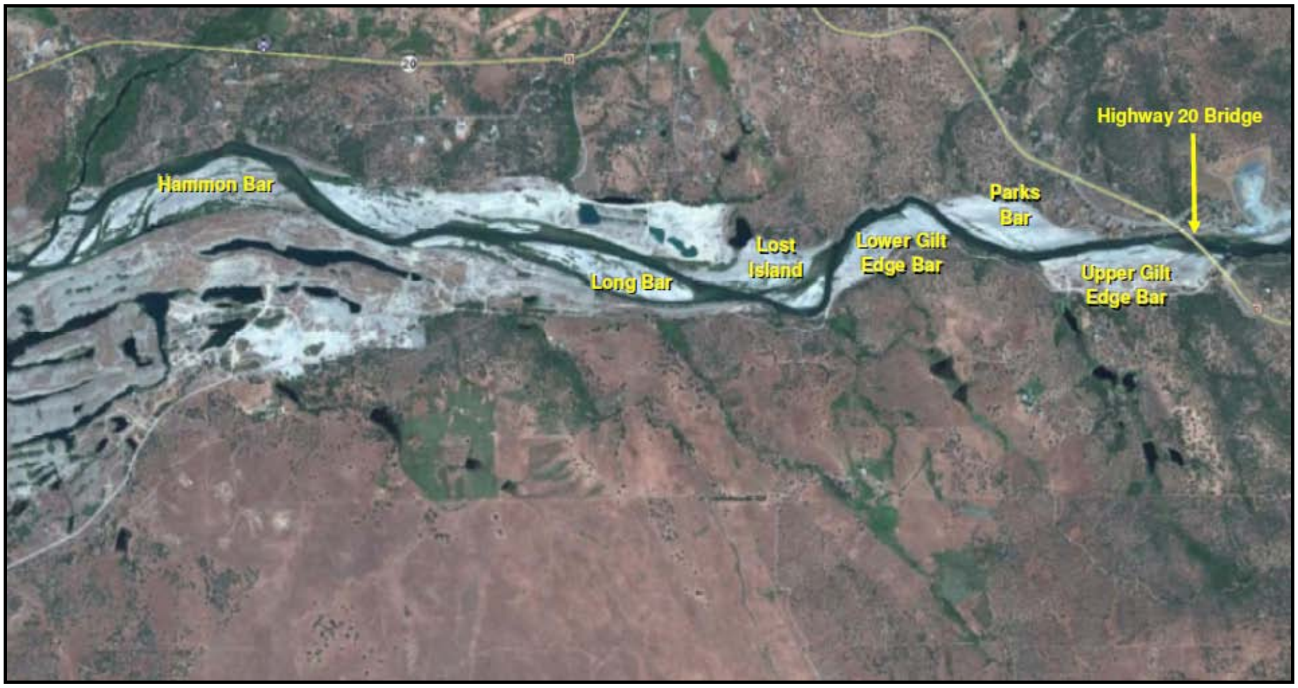

Figure 3. Proposed LWM placement areas within the Parks Bar to Hammon Bar reach of the lower Yuba River (Modified from PG&E 2010).

At the upstream portion of the Parks Bar to Hammon Bar reach, the river is laterally confined by bedrock canyon walls; however, in the downstream portion of the reach, the river is laterally confined to approximately the same width by the remnant sediment (i.e., training walls) of historic gold dredging activities (USFWS 2010). The functional valley width in the reach ranges between approximately 310 ft to 1,420 ft, with a mean width of approximately 980 ft and a mean gradient of 0.19% (G. Pasternack unpublished data). LWM placement guidelines presented in Saldi-Caromile et al. (2004) indicates that constructed log jams work well in alluvial channels having less than a 2% slope and may not be appropriate in alluvial channels with high sediment loads that can cause frequent channel avulsions and lateral migrations that can abandon log jams shortly after construction. In consideration of these criteria, the Parks Bar to Hammon Bar reach is identified in this LWMMP as suitable for placing LWM to improve the availability of juvenile salmonid rearing habitat.

Potential habitat enhancement actions proposed in PG&E (2010) include large wood placement. The general design concept for the rearing habitat enhancement actions proposed by PG&E (2010) were informed by aerial photography and extensive field surveys of off-channel habitats reportedly conducted beginning in 2007. PG&E (2010) reports that many of the surveyed floodplain habitats support fry for variable periods of time following winter flows, but do not provide suitable rearing habitat after flows recede because they become too shallow, too warm, or lack sufficient cover to protect fry from piscivorous birds and other predators. Locations identified by PG&E (2010) as suitable for juvenile salmonid rearing habitat expansion projects include Upper Gilt Edge Bar, Lower Gilt Edge Bar, Lost Island, and Hammon Bar (Figure 3). These habitat expansion projects generally consisted of provision of currently unavailable side-channel and/or backwater habitat areas, and not LWM placement *per se*. However, these locations may be appropriate as LWM placement sites in consideration of the selection criteria, particularly heavy equipment access and proximity to salmonid spawning and rearing areas.

Although USFWS (2010) stated that the entire stream margin along this 4-mile reach of the lower Yuba River is potentially suitable for LWM placement, specific locations have been identified for LWM placement, corresponding to sites identified in *Rehabilitation Concepts for the Parks Bar to Hammon Bar Reach of the Lower Yuba River (*USFWS 2010) and *Potential Juvenile Rearing Habitat Expansion Actions in the Lower Yuba River, Appendix L to the Final Habitat Expansion Plan* (PG&E 2010). Within the 4-mile reach of the lower Yuba River that has been identified for LWM placement, vehicular access to the river is limited, and the transport of LWM would require the Corps to use roads that traverse privately owned lands. Therefore, site selection, LWM stockpiling and placement within the frequently inundated floodplain will be dependent on whether or not the Corps is able to obtain permission from private landowners for an easement or right-of-way access.

Lower Gilt Edge Bar

Potential LWM placement sites are located along the southern edge of Lower Gilt Edge Bar, which is a stable point bar that starts near the low water elevation at the top of the bar and extends well above the low water elevation at the downstream end of the bar (USFWS 2010). Based on assessment of aerial photography, this location has been stable in recent years, and may be a suitable candidate for LWM placement, as long as there are no real estate constraints with this location.

Hidden Island (also referred to as Lost Island)

Hidden Island, which is also referred to as Lost Island, is located on the northern side of the lower Yuba River downstream of Lower Gilt Edge Bar, where a high flow side channel is present

(USFWS 2010). Inspection of historic aerial photography indicates that the side channel used to remain inundated and longitudinally connected at lower river discharges and has presumably become disconnected at lower discharges (USFWS 2010). Field observation indicates that at present the high flow side channel becomes longitudinally connected at mainstem flows >3,300 cfs (USFWS 2010). LWM would be placed along the banks and within the side channel, predominantly in the most upstream and downstream region where the side channel joins the lower Yuba River and backwater habitat may occur at lower flows. USFWS (2010) hypothesize that the historic side channel has converted into a high flow channel due to incision of the mainstem and/or deposition on the bar. It is uncertain how long this side channel will be maintained at this location, if the main channel is indeed incising in this area or a future flood deposits on the bar. In addition, access and cooperation the north bank land owner is unknown and will need to be pursued.

Hammon Bar

LWM placement could occur within and along the existing backwater on the southern edge of Hammon Bar. Along the upper portion and some edges of the existing backwater, woody riparian vegetation is well established. LWM would be placed throughout the length of Hammon Bar, along existing backwater and riparian vegetation, as well as along vegetation planted during recent riparian restoration activities. Additionally, the western end of Hammon Bar is characterized by a series of remnant channels that intersect the bar and lead to a large side channel sustained by groundwater flows from the river and the Yuba Goldfields. This side channel supports high densities of juvenile Chinook salmon, steelhead, and other native fishes during spring and summer. LWM placement could occur in the large side channel to provide additional cover. It should be noted that potential placement of LWM on Hammon Bar would need to avoid disruption of the recently implemented riparian vegetation enhancement pilot project being undertaken by USFWS.

2.4.1 Placement Configuration

Large wood in interaction with channel margins has been shown to create a variety of microhabitats and affect geomorphic processes in a way that supports natural riparian recruitment and diversity (Gerhard and Reich 2000 in USFWS 2010). Juvenile salmonids are known to show preference for habitats with cover and velocity refugia associated with large wood (Roni and Quinn 2001). Large wood has been found to locally improve spawning conditions (Merz 2001; Senter and Pasternack 2010).

LWM is found in many natural configurations. In general, placement of in-channel structures has had mixed results in providing sustained habitat improvement and one factor influencing the persistence or risk of such projects is the dynamics or flood potential of the stream. Placement of LWM should allow for potential transport under high flow conditions. LWM placement also can be configured to provide specific habitat benefit, such as provision of low velocity refuges during high flow conditions (**Figure 4**).

Figure 4. Example of large wood placed on the floodplain will provide low velocity refuge during high flows (Finney Creek in Skagit County, Washington, as shown in Saldi-Caromile et al. 2004).

Corps (2007) suggests that combinations of woody materials with stone and living plant materials are common. Rootwads may be placed at spaced intervals or in an interlocking fashion so they may be considered either intermittent or continuous types. Intermittent structures provide greater aquatic habitat diversity than continuous protection. The configuration of LWM structures should consider the dominant erosion processes operating on the site (Shields and Aziz 1992 in Corps 2007), as well as key habitat deficiencies such a lack of pools, cover, and woody substrate. Intermittent structures could be built by stacking whole trees and logs in crisscross arrangements that emulate natural formations, creates diverse physical conditions, and traps additional debris. Alternatively, LWM may be placed as single logs and angled upstream. Large accumulations are frequently the result of a key log that is transported or falls into the stream at a low energy point, becomes anchored in that location, and collects additional debris that is transported from upstream (Saldi-Caromile et al. 2004; CRH 2007).

The specific influence of woody debris on velocity and habitat formation is determined by LWD type and orientation within the channel. For example, a log with a root-wad in a stream will create a scour pool on the upstream end of the root-wad and a sediment bar on the downstream end (Saldi-Caromile et al. 2004). In larger streams, LWM creates scour pools, controls floodplain construction and side channel development (Saldi-Caromile et al. 2004; CRH 2007).

The stability of LWM once it enters a stream is determined by the interaction of the forces resisting its transport downstream and the forces driving its transport downstream. Examples of resisting forces would be the LWM's weight and friction on the streambed and channel banks. Driving forces would be the drag from the flowing water on the LWM and the buoyancy of the wood (Saldi-Caromile et al. 2004). Large wood debris is stable when the resistive forces are greater than the driving forces (CRH 2007). Often, the most stable LWM structure in a stream is a log with an attached rootwad (Fox 2001, as cited in CRH 2007). Channel constrictions and bends, or locations where the channel depth is less than the buoyant depth, tend to be the locations where mobilized LWM becomes trapped (Braudrick and Grant 2001, as cited in Energy Northwest 2005).

Moving a log that is perpendicular to the stream channel to a forty-degree angle to the bank, away from the flow will increase the capacity of the channel and maintain the local habitat (Rutherford et al. 2002 in CRH 2007). It is important to determine after changing the orientation of a LWM structure whether or not the structure will require anchoring, which should be done by estimating the net buoyancy force and drag force on the LWM (Shields et.al. 2004 in CRH 2007).

LWM can be anchored to the stream channel or bed by one of four basic techniques (Saldi-Caromile et al. 2004; Washington State Aquatic Habitat Guidelines Program 2003): (1) No anchors - existing and newly recruited wood is mobile and finds stable locations based on stream characteristics; (2) Passive - the weight and shape of the LWM structure provides resistance to downstream transport; (3) Flexible - LWM is tethered in by at least one point into the bank or bed, but allowed to float and rotate during high flows; (4) Rigid - LWM is tethered by two or more connection points to anchors such as standing trees, duckbill or deadman anchors or keyed into a bank and not allowed to move (CRH 2007). Not anchoring any existing or newly recruited LWM, but rather allowing LWM to find stable locations based on the stream characteristics, provides the greatest benefits to stream function (CRH 2007).

For this LWMMP, the LWM will be placed in the functional inundated floodplain, or deposited directly within the low flow channel, as access allows. The low flow channel is defined by the edge of the wetted channel top width which is generally occurs at about a 880 cfs baseflow. The upper extent of the frequently inundated floodplain is defined by 5,000 cfs. Because high flows have been reported to import LWM into the channel and recruit it downstream (Keller and Swanson 1979 in CRH 2007), it is anticipated that for this LWMMP, placement of LWM within the functional inundated floodplain will result in the transport and distribution of LWM to downstream reaches in the lower Yuba River and the creation of new habitat for aquatic species downstream.

2.4.2 Placement Equipment

Sites for stockpiling of LWM along the lower Yuba River need to provide sufficient space for operation of equipment used to transport LWM to and from the site. Equipment used to place individual LWM elements and/or complexes includes an excavator with a hydraulic thumb and/or a track log loader (Saldi-Caromile et al. 2004). A “spyder” excavator (**Figure 5**) is preferred because it is relatively low-impact, requires minimal disruption of the surrounding environment to maneuver, can operate on steep slopes, and can work in water up to 1.7 m depth. However, “spyder” excavators are relatively slow which can be a time/cost issue if they are used to transport materials very far. Dual fuel tanks allow the excavator to work for 4 days between refueling, which is important when working on remote, steep or environmentally sensitive sites. The telescopic extending boom provides long reach which reduces the number of times

Figure 5. “Spyder” excavator (Source: ArcRidge LTD Environmentally Responsible Forest Services 2011).

the machine must move thereby reducing ground disturbance. Panolin biodegradable hydraulic fluid is used to protect the environment in the event of a hose failure (ArcRidge LTD Environmentally Responsible Forest Services 2011). A loader, however, does not have the ability to dig or move rocks if required. Regardless of the specific equipment used, heavy machinery that is operated in the floodplain of the lower Yuba River will use biodegradable hydraulic fluid and will be steam cleaned of residual hydraulic fluid and oil prior to operating.

2.5 Timing and Frequency

Natural LWM recruitment is generally considered to be episodic due to variable frequency and magnitude of storm events which may result in few LWM pieces entering New Bullards Bar Reservoir in some years and large amounts of LWM entering in other years. Therefore, LWM collection and downstream placement activities are anticipated to be variable in the frequency of activity in response to the episodic nature of LWM recruitment. The long-term frequency of LWM collection in New Bullards Bar Reservoir, stockpiling and placement along the lower Yuba River will be informed by the results of the previously described CESU woody material investigations, particularly the large woody material adaptive management plan.

Collection will generally occur during early summer months (e.g., June and July) following the spring snow melt and rain events when LWM is most likely to be mobilized from the North Yuba River Basin, and transported to New Bullards Bar Reservoir. It is further anticipated that stockpiling along the reservoir will continue through the summer, and LWM will be transported to the lower Yuba River during fall. Stockpiling at the enhancement sites in the lower Yuba River will occur when river stage is low to ensure placement of LWM is within the boundaries of the active floodplain. The Corps will conduct the initial collection, transporting, and placement of LWM within one year upon acceptance of this LWMMP, pending funding and fulfillment of all regulatory compliance requirements.

Prior to implementation of the LWMMP Pilot Program (see Section 4.0, below), it is anticipated that the Corps would need to comply with applicable environmental and regulatory requirements such as National Environmental Policy Act (NEPA) and the Clean Water Act (CWA). As part of compliance with the CWA, it is anticipated that the Corps will coordinate with the Regional Water Quality Control Board. As part of the NEPA process, it is also anticipated that the Corps would coordinate with NMFS, as well as USFWS and CDFG regarding potential effects to botanical and terrestrial species that may be present in areas selected for LWM stockpiling and placement along the lower Yuba River.

3.0 Recreation and Public Safety Considerations

Safety issues for recreational use and public safety on New Bullards Bar Reservoir and on the lower Yuba River are important considerations in this LWMMP. Floating debris or LWM located near the water surface of New Bullards Bar Reservoir represents a hazard to other forms of water-based recreation such as water skiing and tubing. While associated with boating, these activities require participants to be outside of the boat. Participants travel at relatively high speeds without anything to protect them should an impact with any object occur. Generally, these activities are conducted away from areas with potential hazards; however, due to the transient nature of floating debris, hazards could be present in areas where they had previously been absent. It is important to note that potential boating hazards, including debris, exist in all waterways. It is impossible to identify or remove all potential boating hazards. However, removal of LWM from New Bullards Bar Reservoir is anticipated to reduce public risk posed by floating material.

Structures that protrude into a river channel, block the channel, or are designed to trap floating materials can be hazardous to recreational users and boaters (Saldi-Caromile et al. 2004). For this LWMMP, LWM will be placed along the shoreline of the frequently inundated channel and not transversing a significant portion of the cross-sectional length of the channel at any location, to minimize impediments to flow or navigation. Some concerns regarding LWM structures stem from the fact that materials used in anchoring often persist long beyond the functional life of the structure. Cables can pose significant public safety concerns as they can form traps for recreational users, and often have sharp ends (Saldi-Caromile et al. 2004). Thus, this threat will be avoided by placing LWM without the use of cables or anchoring structures. Potential safety hazards may be reduced by placing warning signs at public access points and upstream from the LWM placement reach to alert the public.

4.0 LWMMP Pilot Program

Upon acceptance of this LWMMP, the Corps in consultation with NMFS and CDFG will conduct field reconnaissance investigations of road access, site stockpiling and LWM placement locations for the LWMMP Pilot Program. For the Pilot Program, the Corps will use LWM available from the stockpiles located along New Bullards Bar Reservoir, which is anticipated to be dominated by coniferous species. However, the long-term LWMMP will consider augmentation of LWM from New Bullards Bar Reservoir with LWM from orchard trees, if a suitable source and quantity can be identified. According to SAFCA et al. (2011), trees appropriate for use as imported LWM include orchard trees being removed for urban development or agricultural conversion, native and non-native trees designated to be removed at project sites, and other native and non-native trees designated for removal from unrelated projects. Preferred species of trees to use as LWM include almond (*Prunus dulcis*), because of the hardness, flexibility of limbs, durability of branches, and their resistance to decay. If almond trees are not available, other dense hardwood trees such as walnut (*Juglans regia*), pistachio (*Pistacia vera*), orange (*Citrus sp.*), lemon (*Citrus sp.*), olive trees (*Olea europaea*), and durable ornamental species such as redwood, cedar, other resinous trees can be used. Trees such as eucalyptus, pine species and trees of the pome fruit family (e.g., cherry, apricot, pear and apple) should be avoided (SAFCA et al. 2011).

For the LWMPP Pilot Program, wood will be placed in either LWM complexes, defined as being comprised of 10 or more pieces of LWM, or as individual pieces. The specific quantity and arrangement of LWM placement during the LWMPP Pilot Program will be determined through site-specific accessibility, and through Corps consultation with NMFS and CDFG. Preliminary considerations regarding the quantity of LWM included in the LWMMP Pilot Program include log truck capacity, end dump truck capacity, distance from New Bullards Bar Reservoir to sites identified along the lower Yuba River, individual LWM pieces or pieces with rootwads and multiple branches. These considerations indicate that, depending on the nature and availability of the LWM, quantities of LWM for the LWMMP Pilot Program could range from approximately 500 – 1,000 logs (1-2 ft in diameter) and from 1,000 – 3,000 yd^3 of rootwad material.

The Corps will take advantage of studies currently being undertaken by YCWA as part of the FERC Relicensing study plan process and by the Yuba Accord RMT to establish a baseline of LWM presence, location and abundance in the lower Yuba River. Field mapping efforts of LWM in select locations within the lower Yuba River was performed by the RMT, but the extensive amount of material present made the ground surveys unrealistically time consuming. RMT field methods were revised to largely substitute aerial photograph analyses.

Aerial photography and other remote sensing techniques can be used to obtain inventory data and can be valuable tools for making management decisions (USDOI 2001). Aerial photos have proven especially useful in the management of riparian-wetland areas. Aerial photography can also assist in assessing functionality, determining classification, and improving management planning processes. Aerial photos also link data geographically, allowing detailed vegetation maps to be transferred to a Geographic Information System (GIS) for spatial modeling purposes (USDOI 2001). Aerial photo baseline data, when carefully selected prior to a project, allows analysis of a large area of interest, at a minimum cost, in less time per hectare than conventional on-the-ground methods (Keating 1993 in USDOI 2001). Certainly tree canopy, herbaceous cover, and to some extent, age distribution of woody dominant species can also be identified using aerial photos at an adequate scale.

As part of the YCWA FERC Relicensing process and the RMT process, an analysis of historic aerial photographs and maps of the lower Yuba River dating from 1906 through 1998 will be undertaken as a joint project between YCWA and the RMT. This effort is anticipated to be completed prior to summer 2012. In addition, YCWA will conduct field measurement of LWM along study sites in the lower Yuba River during spring/summer of 2012. According to YCWA, LWM occurring within study sites will be counted as follows: all LWM greater than 3 ft in length within the active channel within four diameter classes (4-12 in, 12-24 in, 24-36 in, and greater than 36 in) and four length classes (3-25 ft, 25-50 ft, 50-75 ft, and greater than 75 ft).

More detailed measurements will be taken for key pieces located within riparian habitat study sites. Key pieces of LWM are defined as pieces either longer than 1/2 times the bankfull width, or of sufficient size and/or are deposited in a manner that alters channel morphology and aquatic habitat (e.g., trapping sediment or altering flow patterns). Key piece characteristics to be recorded will include:

- ☐ Piece location, either mapped onto aerial photos or documented with GPS
- ☐ Piece length
- ☐ Piece diameter
- ☐ Piece orientation
- ☐ Position relative to the channel
- ☐ Whether the piece has a rootwad
- ☐ Tree species or type (e.g., conifer or hardwood)
- ☐ Whether the LWM piece is associated with a jam or not (number of LWM pieces in the jam) recruitment source and mechanism function in the channel

These same key piece characteristics will be recorded for all LWM placed in the lower Yuba River as part of the LWMMP Pilot Program, in addition to photographs taken of all placed LWM. In addition to key pieces, measurements will be taken and data recorded for all LWM greater than 3 ft in length within the active channel within four diameter classes (4-12 in, 12-24 in, 24-36 in, and greater than 36 in) and four length classes (3-25 ft, 25-50 ft, 50-75 ft, and greater than 75 ft).

Because fish habitat creation is usually identified as one of the primary goals of an in-stream project utilizing LWM, project monitoring generally focuses on the physical expressions of this goal (Larson et al. 2001). However, structural habitat may be only one of numerous conditions that are a limiting factor for fish survival, as well as survival of other aquatic species (such as benthic invertebrates) that are critical links in the aquatic food web (Larson et al. 2001). Studies have shown that macroinvertebrate community structure changes and diversity increases when structures are added (Hilderbrand et al. 1997; Gortz 1998).

Effectiveness monitoring of LWM placed in the lower Yuba River is anticipated to be conducted by using: (1) aerial photography to visually detect wood movement into downstream reaches; and (2) field-based reconnaissance/verification using GPS tracking to detect and record wood movement.

The resultant effects of the Corps’ LWMMP Pilot Program will be evaluated to assess the effectiveness of LWM placement in the lower Yuba River, including whether LWM placement at the locations selected has resulted in improved habitat conditions for anadromous salmonids. It is anticipated that a performance evaluation will be conducted, which will use the performance criteria described below. Performance evaluation considerations will include the size and quantities of LWM collected from New Bullards Bar Reservoir, and the spatial and temporal distribution of

LWM in the lower Yuba River. Components of the performance evaluation to be conducted include the following.

- ☐ Estimate the quantity of LWM collected that met the size, type, and density suitability criteria
- ☐ Evaluate the spatial and temporal distribution of LWM in the placement reaches and the downstream reaches of the lower Yuba River
- ☐ Estimate the proportion of LWM contributed to the lower Yuba River by introduction, relative to LWM contributed to the lower Yuba River by natural recruitment
- ☐ Evaluate the physical, geomorphic characteristics where LWM was deposited (e.g., landform, water velocity, geomorphologic unit)
- ☐ Characterize the extent and substrate size of spawning gravel recruitment in areas directly downstream of LWM
- ☐ Assess the potential for public safety to be affected given the distribution of LWM in the placement reaches and in the downstream reaches of the lower Yuba River

The effectiveness monitoring is anticipated to be conducted during the first low flow period (i.e., fall) occurring after initial placement of the LWM as part of the LWMMP Pilot Program. Thus: (1) baseline monitoring will be complete by end of September 2012; (2) initial LWM placement under the Pilot Program will occur during September 2012; and (3) Pilot Program monitoring will be conducted during September 2013. During winter 2012/2013, the Corps will prepare an interim report describing the results of the monitoring and analyses conducted as part of the LWMMP Pilot Program performance evaluation. The interim report will include:

- ☐ Summary description of the existing LWMMP, and proposed plan modifications (if any)
- ☐ Summary of efforts completed in the previous year relating to the plan requirements, including a tally of the LWM collected from the stockpiles along the shoreline of New Bullards Bar Reservoir and transported to the lower Yuba River
- ☐ Inventory of the number and size of LWM along the lower Yuba River
- ☐ Information regarding: (1) the sizes, types and locations of LWM mobilized during higher flow conditions; and (2) LWM movement patterns in the lower Yuba River, as observed via aerial photography and field reconnaissance efforts
- ☐ Description of any problems encountered and associated remedies

The interim report also may identify provisions addressing future LWM needs and the frequency of subsequent LWM reintroductions into the lower Yuba River, as well as recommended considerations for the integration of the LWMMP with other future or ongoing plans (e.g., Riparian Restoration Plan).

The Corps will submit a copy of the interim report to NMFS and CDFG for review, comment and identification of other potential LWMMP recommendations. During the performance evaluation, lower Yuba River site conditions or study findings also may warrant modifications to the approach that will be used in the long-term LWMMP, which will be described in the report.

If necessary, following completion of the performance evaluation and report review by NMFS and CDFG, recommended modifications to the LWMMP would be considered and incorporated into the Long-term Adaptive Monitoring and Evaluation Plan. LWM placement under the long-term LWMMP is anticipated to occur during September 2014.

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APPENDIX E

Attachment 1 to the March 2011 Yuba County Water Agency Yuba River Development Project FERC Project No. 2246 ESA/CESA-Listed Salmonids Downstream of Englebright Dam Study Proposal

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ATTACHMENT 1
TO THE
MARCH 2011 YUBA COUNTY WATER AGENCY
YUBA RIVER DEVELOPMENT PROJECT
FERC PROJECT NO. 2246
ESA/CESA-LISTED SALMONIDS DOWNSTREAM OF ENGLEBRIGHT DAM
STUDY PROPOSAL

AVAILABLE FIELD STUDIES AND DATA COLLECTION REPORTS

CDFG. 1978. *Yuba River Steelhead, Yuba County*. Technical Memorandum, prepared by R. Rogers, CDFG Region 2, Rancho Cordova, California.

> During the winter of 1975-76, records of steelhead caught, size, and angling effort in the lower Yuba River were acquired through angler survey questionnaires. All *O. mykiss* 14 in. total length (TL) or longer were considered steelhead, and *O. mykiss* less than 14 in. were considered resident rainbow trout. Monthly catch rates estimates were divided by various assumed harvest rates to devise population estimates. This technical memorandum suggested a reasonable population estimate of 2,000 steelhead, given the methods and assumptions utilized. This technical memorandum also suggested that a good fall-run and winter-run of steelhead occurred, indicating the stocking program of *O. mykiss* during the 1970s had been successful and Yuba River steelhead habitat had improved since completion of New Bullards Bar Dam.

CDFG. 1984. *Yuba River Steelhead Run During Winter of 1976-77*. Technical Memorandum, prepared by R. Rogers, CDFG Region 2, Rancho Cordova, California.

> During the winter of 1976-77, CDFG and USFWS conducted trapping for marking and tagging and a creel survey to estimate size and timing of the steelhead spawning run, origin of spawners (wild vs. hatchery), harvest rate and catch rate by anglers. Upstream migrant steelhead were trapped at a weir located on the lower Yuba River 6 miles upstream from the

confluence with the Feather River that was fished continuously from September 23, 1976 to March 6, 1977. Each morning and evening steelhead in the trap were marked or tagged, checked for sex, length, general condition, amount of dorsal fin wear, and scale samples were taken before being released upstream. All *O. mykiss* observed were equal to or greater than 16 in. fork length (FL), and were therefore considered to be steelhead rather than resident rainbow trout.

Population estimates based on the Peterson tag-recapture method resulted in an estimate of 494 steelhead in the annual run, although this technical memorandum acknowledged that much of the annual run was not sampled, that sampling was conducted during an extreme drought year, and that an estimate of the normal steelhead run as about 2,000 fish seems reasonable.

Two migration peaks of steelhead was observed, one in October and one in February. Average fork length of 69 males measured was 24.8 in. with a range of 16 to 33 in. Average fork length of 77 females measured was 23.6 in. with a range of 16 to 30 in. From dorsal fin wear, 49% of the steelhead observed were judged to be of hatchery origin, although this technical memorandum stated that designating origin of steelhead according to fin wear is not entirely reliable. From scale analysis, 50% of the fish were judged to be of wild origin, although this technical memorandum also acknowledged that information on the origin of fish (wild vs. hatchery) is inconclusive.

This technical memorandum stated that fishing for steelhead trout on the lower Yuba River has improved considerably since New Bullards Bar Reservoir filled in 1970.

CDFG. 1991. *The Lower Yuba River Fisheries Management Plan Final Report*. The Resources Agency, CDFG, Stream Evaluation Report No. 91-1. February 1991.

Between 1986 and 1988, the California Department of Fish and Game (CDFG) and its contractor (Beak Consultants Inc. 1989) conducted a comprehensive series of detailed studies addressing fish community structure, fish populations, fish passage, flow-habitat relationships, water temperature, water quality, riparian habitat, and diversion impacts. These studies were conducted in four reaches of the lower Yuba River: (1) Narrows Reach extending approximately 2.2 miles below Englebright Dam and downstream of the Narrows 1 and Narrows 2 powerhouses; (2) Garcia Gravel Pit Reach beginning downstream of the Narrows Reach and extending to the DPD located 12.5 miles downstream of Englebright Dam; the (3) DPD Reach extending 7.8 miles to the downstream terminus of the Yuba Goldfield; and (4) the remaining 3.5 miles below the Simpson bridge to the confluence with the Feather River in the town of Marysville. The results of these studies led to the development of CDFG's *The Lower Yuba River Fisheries Management Plan Final Report* in 1991.

Assessment of the fish community structure within the lower Yuba River included the estimation of fish species composition, relative abundance, and distribution parameters using electrofishing and snorkel survey techniques. Both methods were used because of their utility in addressing different informational needs of the study. Snorkeling surveys allowed for the characterization of juvenile salmonid habitat during spring months that were otherwise inaccessible to boat electrofishing, such as shallow near-shore and riffle areas. Electrofishing was conducted primarily to assess those species that were underrepresented in snorkel surveys.

Combined results from the electrofishing and snorkeling surveys resulted in the documentation of 15 fish species in the lower Yuba River. Chinook salmon and steelhead were observed in all river reaches downstream of the Englebright Dam, and were the only fish species observed in the Narrows Reach. Chinook salmon were the most abundant of all fish species in the lower Yuba River representing 49% of total number of fish observed, followed by steelhead/rainbow trout representing 22% of the total number of fish observed.

A total of 1,707 fish were collected by electrofishing with increasing species diversity in the downstream direction. Only Chinook salmon and two other fish species were captured in the Narrows Reach. Diversity was greater in the Garcia Gravel Pit Reach including Chinook salmon, steelhead/rainbow trout, and seven other species. Chinook salmon also were collected in the DPD Reach, although steelhead/rainbow trout were not. Relative abundance estimates from electrofishing indicated Chinook salmon and Sacramento sucker were the most abundant species, comprising 49% and 32% of total electrofishing efforts, respectively. Steelhead/rainbow trout represented less than 1% of lower Yuba River abundance.

A total of 8,815 fish were observed during snorkeling surveys. Chinook salmon and steelhead/rainbow trout were present in all four reaches and were the only fish observed just below Englebright Dam in the Narrows Reach. Snorkel survey abundance estimates suggested that Chinook salmon were the most abundant fish species in the lower Yuba River representing 49% of all fish observed, and steelhead/rainbow trout comprised 22% of total observations.

CDFG (1991) reported that a small spring-run Chinook salmon population historically occurred in the Yuba River but the run virtually disappeared by 1959. As of 1991, a remnant spring-run Chinook salmon population reportedly persisted in the lower Yuba River maintained by fish produced in the lower Yuba river, fish straying from the Feather River, or fish previously and infrequently stocked from the Feather River Hatchery. CDFG (1991) reported that adult spring-run Chinook salmon migrate into the lower Yuba River beginning in March extending into July, spend the summer in deep pools in the Narrows Reach, and spawn from early to mid-September into November. Spring-run Chinook salmon juvenile rearing reportedly occurred in off-channel areas, and emigration occurred as fry within a few weeks of emergence or as larger juveniles as late as June.

CDFG (1991) reported that approximately 200 steelhead/rainbow trout spawned in the lower Yuba River annually prior to 1970. During the 1970s, CDFG annually stocked hatchery steelhead from the Coleman National Fish Hatchery into the lower Yuba River, and by 1975 estimated a run size of about 2,000 fish (CDFG 1991). CDFG stopped stocking steelhead into the lower Yuba River in 1979. CDFG (1991) reported that steelhead enter the lower Yuba River as early as August, migration peaks in October through February, and may extend through March. A run of “half-pounder” steelhead reported occurred from late-June through the winter months. Spawning reportedly occurred from January through April with egg incubation occurring from January through May, with fry emerging between February and June. CDFG (1991) reported that juvenile steelhead reared throughout the year but, unlike Chinook salmon in the lower Yuba River, may spend from one to three years in freshwater before emigrating primarily from March to June. CDFG (1991) indicated that most juvenile steelhead rearing occurred above DPD in the Garcia Gravel Pit Reach.

CDFG (1991) reported that adult Chinook salmon densities were greatest in riffle and deep pool habitats, whereas juvenile Chinook salmon and steelhead/rainbow trout were highest in the fast flowing riffle and run/glide habitats.

Microhabitat use criteria were developed to address habitat-flow relationships in the lower Yuba River for the Chinook salmon spawning, fry, and juvenile rearing lifestages. Substrate criteria used frequency of observation of dominant substrate particle size, whereas water depth and velocity criteria were developed by applying the non-parametric tolerance limits method to the frequency-of-use distribution measurements taken on the lower Yuba River. CDFG (1991) considered spawning gravel resources in Garcia Gravel Pit and DPD reaches of the lower Yuba River to be excellent, and also recommended future habitat improvement including construction of shallow rearing areas and off-channel habitat to increase survival of fry and juveniles.

CDFG (1991) also conducted riparian vegetation mapping of lower Yuba River plant communities within the study area. Three plant communities (blue oak/digger pine woodland, riparian forest, and grassland/agriculture), one topographic feature (hydraulic mine tailings), and one urban region were mapped. Riparian vegetation accounted for 56% of the total lineal shoreline coverage downstream of Englebright Dam.

SWRI, JSA, and BE. 2000. *Hearing Exhibit S-YCWA-19. Expert Testimony on Yuba River Fisheries Issues.* Prepared for the California State Water Resources Control Board Water Rights Hearing on Lower Yuba River February 22-25 and March 6-9, 2000.

The SWRI et al. (2000) document summarized data collection in the lower Yuba River obtained from 1992 through 2000. Since 1992, Jones and Stokes Associates (JSA) biologists conducted fish population surveys in the lower Yuba River used snorkel surveys to determine annual and seasonal patterns of abundance and distribution of juvenile Chinook salmon and steelhead during the spring and summer rearing periods. The SWRI et al. (2000) report stated that in general, juvenile Chinook salmon were observed by snorkeling throughout the river but with higher abundances above DPD. This report suggested that higher abundances above DPD may have been due to larger numbers of spawners, greater amounts of more complex, high quality cover, and lower densities of predators such as striped bass and American shad, which reportedly were restricted to areas below the dam.

Chinook Salmon

The SWRI et al. (2000) report stated that in 1992, beach seining surveys were conducted to measure lengths and weights of juvenile Chinook salmon at several locations in the lower Yuba River upstream and downstream of DPD. Beach seining was conducted at four sites (two upstream and two downstream of DPD) at weekly intervals from April 30, 1992 to June 5, 1992. Weekly measurements of lengths and weights were also taken from emigrating juvenile Chinook salmon at the Hallwood-Cordua fish screen during this period. Major findings of the 1992 surveys were summarized in SWRI et al. (2000) as follows.

- ❑ Juvenile salmon in the lower Yuba River exhibited significant growth in 1992. The average fork length at the Parks Bar site increased from 51.0 mm on May 1 to 69.1 mm on May 29, for an average growth rate of approximately 0.65 mm per day. Although accurate estimates of growth were not possible at other sites because of small sample sizes, the average sizes of juvenile on specific sampling dates both upstream and downstream of DPD were consistent with relatively rapid growth based on generalized growth curves for Chinook salmon.
- ❑ The seining data indicated a general increase in the size of juvenile Chinook salmon with distance downstream on any given date, possibly reflecting downstream movement of larger fish.
- ❑ Emigrating Chinook salmon salvaged at the Hallwood-Cordua fish screen were larger on any given date and encompassed a narrower size range (64.6 mm on April 30 to 77.5 mm on June 4) than Chinook salmon sampled above DPD. Although differences in efficiency existed between beach seining and the fish screen, the larger, more consistent size of emigrating juveniles compared to juveniles sampled in the river is consistent with the general knowledge that smolt migrations begin after the fish reach a certain size.

The SWRI et al. (2000) report stated that in 1993, high flows precluded the use of beach seines, although direct observations of juvenile Chinook salmon during monthly snorkel surveys (March 2, 1993 through August 10, 1993) revealed increases in the average size of juvenile salmon from 30-40 mm in early March, to approximately 60-70 mm by mid-June. Significant numbers of juvenile Chinook salmon continued to rear in the lower Yuba River through August, attaining average sizes of 70-80 mm and maximum sizes up to 120 mm. The apparent slower growth rates, longer residence periods, and later emigration timing in 1993 compared to 1992 were consistent with the hypothesis that emigration readiness is determined, at least in part, by the effects of water temperature of growth and development of young Chinook salmon during the spring rearing period. SWRI et al. (2000) reported that beach seine surveys were again conducted in 1994 at several locations upstream and downstream of DPD. The growth rates and body sizes of juvenile Chinook salmon on specific dates appeared to be similar to those observed in 1992.

SWRI et al. (2000) reported that individual lengths and weights of juvenile Chinook salmon in 1992 and 1994 were used to calculate condition factors. During the 1992 and 1994 surveys, fish were also examined for the presence of outward signs of stress (i.e., physical abnormalities, lesions, parasites). In 1992, juvenile Chinook salmon exhibited good condition factors at all locations throughout the sampling period (average condition factor ranged from 1.01 to 1.21 among all sampling sites and dates). SWRI et al. (2000) suggested that growth conditions were better in 1992 than in 1994. In 1994, average condition factors among all sampling sites and dates ranged from 0.95 to 1.05. No outward signs of stress were observed either in 1992 and 1994.

The SWRI et al. (2000) report stated that based on daily records of the number of Chinook salmon salvaged at the Hallwood-Cordua canal fish screen, the spring emigration period of juvenile salmon can begin as early as mid-April and continue until mid-June. However, it was noted that CDFG had not initiated salvage operations early enough in the season to sufficiently address the overall outmigration period. For the sampling that had been conducted, SWRI et al. (2000) reported that most juvenile Chinook salmon emigrated past DPD in April and May with peak numbers in early to late May. However, of all fish sampled, the median date of emigration past the dam (date when 50% of the total number of fish were collected at the Hallwood-Cordua fish screen) varied from late April to early June and was positively related to average April-May flow measured at the Smartsville gage. The report also stated that, in general, the median date of outmigration was delayed approximately 7-8 days with each 1,000-cfs increase for flows ranging from 400 cfs to 4,000 cfs, and that emigration timing during 1992-1994 continued to follow that relationship.

SWRI et al. (2000) suggested that the relationship between flow and emigration timing may reflect the effect of spring water temperatures on salmon growth rates and readiness to migrate; low water temperatures associated with high flows during the spring rearing period result in slower growth rates and later emigration. Conversely, higher water temperatures associated with lower flows result in higher growth rates and earlier emigration. SWRI et al. (2000) also suggested that observations of extended rearing of juvenile Chinook salmon into the summer months in high-flow years and the consistent size of emigrating juvenile Chinook salmon at the Hallwood-Cordua fish screen also support that relationship.

Steelhead/Rainbow Trout

The SWRI et al. (2000) report stated that since 1992, snorkeling, electrofishing, and angling surveys revealed the presence of large numbers of juvenile steelhead/rainbow trout in the lower Yuba River. This report suggested that the presence of a highly-acclaimed sport fishery, the lack of direct hatchery influence, and the presence of juveniles represented by a number of age classes confirmed that significant natural spawning and rearing of steelhead/rainbow trout occurred in the lower Yuba River. The physical appearance of adults and the presence of seasonal runs and year-round residents suggested that both sea-run (steelhead) and resident rainbow trout existed in the lower Yuba River, although no definitive characteristics had been identified to distinguish young steelhead from resident trout. Therefore, observations presented in the SWRI et al. (2000) report may apply to juveniles of either or both steelhead and resident rainbow trout, as summarized below.

- ☐ The primary spawning and rearing habitat for juvenile steelhead/rainbow trout is upstream of DPD. In 1993 and 1994, snorkeling surveys indicated that the population densities and overall abundance of juvenile trout (age 0 and 1+) were substantially higher upstream of DPD, with decreasing abundance downstream of DPD. In 1992, a general increase in the average size of juvenile trout in seine catches from the uppermost to the lowermost monitoring sites suggested a similar distribution pattern.

- Since 1992, a broad range of trout size classes have been observed in the lower Yuba River during spring and summer snorkeling, electrofishing, and angling surveys. Juvenile trout ranging in size from 40-150 mm were commonly observed upstream of DPD. Numerous larger juveniles and resident trout up to 18 inches long were also commonly observed in the mainstem upstream and downstream of DPD.

- The 1999 results of the juvenile steelhead study suggested that the highest abundance of young-of-the-year steelhead occurred above DPD despite suitable flow and water temperatures below the dam. Age 0 (young-of-the-year) trout were clearly shown by the distinct mode in lengths of fish caught by electrofishing (40-100 mm fork length). A preliminary examination of scales indicated that most yearling (age 1+) and older trout were represented by fish greater than 110 mm long, including most if not all of the fish caught by hook and line. The sizes of age 0 and 1+ trout indicated substantial annual growth of steelhead/rainbow trout in the lower Yuba River. Seasonal growth of age 0 trout was evident from repeated sampling of trout in 1992 and 1999, but actual growth rates could not be estimated because of continued recruitment of fry (newly-emerged juveniles) or insufficient sample sizes.

- Approximately 200 juvenile trout in 1992 and 1,100 trout in 1999 were measured, weighed, and examined to determine their general health and condition. All trout appeared healthy and in good physical condition. Like salmon, condition factors for juvenile trout increased with increasing size. In spring 1992, average condition factors for age 0 trout (48-82 mm average fork length) ranged from 1.07 -1.34. In summer 1999, average condition factors for age 0 trout (43-60 mm average fork length) ranged from 0.89-1.03, while those of age 1+ and older trout (156-420 mm fork length) averaged 1.13.

The SWRI et al. (2000) document also developed proposed minimum instream flow requirements which built upon additional information developed since 1992, including fish habitat utilization and detailed analyses of fish habitat-flow relationships and water availability. Development of the proposed instream flow requirements was based primarily on: (1) updated information characterizing Yuba River Basin hydrology and water year type classification; (2) water availability assessments for lower Yuba River instream flows, based on five water year types; (3) updated and additional lower Yuba River fishery information; (4) improved flow-temperature relationships for the lower Yuba River; and (5) a definition of maintaining lower Yuba River fish resources in “good condition.”

CDFG. 2002. *Sacramento River Spring-run Chinook Salmon. 2001 Annual Report.* Prepared for the Fish and Game Commission. Habitat Conservation Division, Native Anadromous Fish and Watershed Branch. October 2002.

CDFG (2002) summarized information from limited upstream migration surveys conducted during 2001, reconnaissance-level redd surveys conducted during 2001 and 2002, and rotary screw trapping during 2001-2002. CDFG (2002) reported that despite limited information on the population size of spring-run Chinook salmon in the lower Yuba River, data at that time indicated that adult escapement of spring-run Chinook salmon was relatively low and had been greatly reduced from historical levels. Prior to 2001, when CDFG conducted a study to estimate the number of adult spring-run Chinook salmon immigrating into the Yuba River by trapping fish in the fish ladder at DPD, there was almost no specific information on the run timing and size of the population in the lower Yuba River (CDFG 2002). In the 2001 CDFG study, which involved limited sampling of fish ascending the north ladder at DPD, a total of 108 adult Chinook salmon were estimated to have passed the dam between March 1, 2001, and July 31, 2001 (CDFG 2002).

Based upon reconnaissance-level redd surveys conducted by CDFG on the lower Yuba River from the Narrows pool downstream to DPD from August 31 to September 28, 2001, CDFG (2002) reported that the first redd was observed on September 7, 2001, and a total of 288 redds were observed. They also reported that 205 redds were observed in the lower Yuba River during the same time period in 2000. CDFG (2002) suggested that spring- and fall-run Chinook salmon were restricted to spawning in the same reach of the lower Yuba River.

Rotary screw trap operations were conducted during the 2001-2002 season to document the outmigration patterns of juvenile salmonids in the lower Yuba River. Data collected included timing, duration, and size of all Chinook salmon at the time of emigration. Although spring- and fall-run spawning occurred in the same physical location, initial length-frequency data from juveniles captured in the rotary screw trap indicated the presence of both a dominant fall-run and a smaller population of spring-run Chinook salmon CDFG 2002). Spring-run Chinook salmon were determined by size-at-date differences through the operation of the rotary screw trap. A total of 6,719 juveniles classified as spring-run Chinook salmon were captured between November 10, 2001 and May 8, 2002. These juvenile Chinook salmon sized ranged from 26mm FL to 108mm FL.

Lower Yuba River Water Transfer Monitoring Reports 2001 – 2004

The summaries below regarding recent water transfer studies conducted on the lower Yuba River were derived from the following sources:

YCWA and SWRCB. 2001. *Environmental Assessment: Proposed Temporary Transfer of Water From Yuba County Water Agency to DWR, Year 2001*. Prepared for Yuba County Water Agency and the State Water Resources Control Board by EDAW.

YCWA. 2003. *Draft Evaluation of 2002 Yuba River Water Transfers.* Prepared for Yuba County Water Agency by Surface Water Resources, Inc. January 28, 2003.

YCWA. 2005. *Evaluation of the 2004 Yuba River Water Transfers, Draft.* Prepared for Yuba County Water Agency by Surface Water Resources, Inc.

Water transfers and related monitoring studies and evaluations were performed in the lower Yuba River during 2001, 2002, and 2004. The primary fisheries issues evaluated by these studies included: (1) juvenile steelhead downstream movement; (2) adult Chinook salmon immigration and the potential for increased straying of non-native fish into the lower Yuba River; and (3) water temperatures in the lower Yuba River and Feather River.

The 2001 water transfers (172,000 acre-feet) occurred between approximately July 1, 2001 and October 14, 2001. Over a few days, flows increased by about 1,200 cubic feet per second (cfs) and were generally sustained in the lower Yuba River through late August when ramp-down began.

The 2002 water transfers (157,050 acre-feet) occurred from mid-June through mid-September and did not have a definitive ramp-up period. Instead, the relatively high flows that occurred during spring were sustained until initiation of the water transfers. Relatively stable flows of approximately 1,200 to 1,400 cfs at the Marysville gage were maintained through August 16, 2002. The ramp-down period associated with the water transfers began on August 17, 2002 and ended on September 16, 2002.

The 2004 water transfers (100,487 acre-feet) lacked a definitive ramp-up period. The relatively stable high June flows averaged 946 cfs at Marysville and were sustained through the initiation of the transfers (July 1) to the cessation of transfers on August 28, when flows were approximately 970 cfs at Marysville. Although the water transfers continued through September, a short ramp-down period occurred from August 28, 2004 through September 1, 2004, when flows at the Marysville gage were reduced to 531 cfs. Flows remained low and stable during the rest of September, averaging approximately 513 cfs.

Juvenile Steelhead/Rainbow Trout Non-Volitional Downstream Movement

Previous reporting of the water transfer studies used the term steelhead when referring to *O. mykiss* juveniles. However, it is recognized that both anadromous and resident lifehistory strategies of *O. mykiss* have been and continue to be present in the lower Yuba River, and that definitive distinction of juveniles between these lifehistory strategies were not previously conducted. Therefore, the following summaries use the term “steelhead/rainbow trout” when referring to *O. mykiss.*

The 2001 water transfer was characterized by a relatively large, rapid ramp-up period. A week subsequent to the start of the 2001 water transfers, the daily catch at the CDFG Hallwood Boulevard (RM 7) RST increased from less than 10 young-of-the-year (YOY) steelhead/rainbow trout juveniles per day, to more than 450 YOY per day (CDFG unpublished data). The next week, daily catches decreased to about 190 YOY per day and continued to further decrease during the following weeks while the transfers were continuing, but still surpassed catches prior to the water transfers, suggesting that juvenile steelhead/rainbow trout moved from the upstream reaches of the lower Yuba River to areas downstream of Hallwood Boulevard.

In response to these observations, an instream flow release schedule for the water transfers was created by YCWA, NMFS, USFWS, and CDFG to avoid a rapid increase in flow when the transfers begin, and to minimize or avoid potential impacts on anadromous fish in the lower Yuba River associated with non-volitional downstream movement. During the 2002 and 2004 water transfers, YCWA maintained instream flows in the lower Yuba River at a relatively stable rate in the late spring, with gradual changes in flow rates through initiation of the water transfer. Monitoring data (RST catch data) indicated that the large peak in downstream movement of juvenile steelhead/rainbow trout observed in 2001 did not occur in 2002 or 2004.

Water transfer monitoring in 2001, 2002, and 2004 indicated that the character of the initiation of the water transfers could potentially affect juvenile steelhead/rainbow trout downstream movement. Based upon the substantial differences in juvenile steelhead/rainbow trout downstream movements (RST catch data) noted between the 2001 study, and the 2002 and 2004 studies, it was apparent that the increases in juvenile steelhead/rainbow trout downstream movement associated with the initiation of the 2001 water transfers were avoided due to a more gradual ramping-up of flows that occurred in 2002 and 2004.

Attraction of Non-natal Adult Chinook Salmon in the Lower Yuba River

Water transfer monitoring efforts also studied the potential for the Yuba River water transfers to affect the straying of Feather River hatchery Chinook salmon into the lower Yuba River via decreased water temperatures and increased flow relative to the Feather River. YCWA and CDFG monitoring efforts in 2001, 2002, and 2004 water transfer years indicated that Chinook salmon of hatchery origin ascended the fish ladders at DPD in the lower Yuba River during both the water transfer and non-transfer periods. Chinook salmon of hatchery origin also have been observed ascending the Yuba River in non-transfer years (CDFG unpublished data).

Sampling of adult Chinook salmon via ladder trapping at DPD during 2001 was not sufficient to provide a dataset that could be statistically analyzed, and although 2002 data were statistically analyzed, a number of unexpected procedural difficulties were encountered resulting in low reliability of 2001 and 2002 abundance estimates. However, observations made during these water transfer studies led to the June 2003 installation of a VAKIRiverwatcher system, an infrared detection device, as well as a photographic recorder at DPD.

The use of the VAKI Riverwatcher as a counting device enabled more efficient and reliable monitoring of adipose fin-clipped and non-adipose fin-clipped adult Chinook salmon that immigrated into the lower Yuba River before, during, and after the 2004 water transfer. Estimates were conducted of immigration rates (fish/day), abundance of adipose fin-clipped and non-adipose fin-clipped adult Chinook salmon, and proportions of adipose fin-clipped adult Chinook salmon. The findings of these analyses led to the following general conclusions:

- The temporal distributions of the daily counts of adipose fin-clipped and non-adipose fin-clipped adult Chinook salmon likely were reflections of Chinook salmon adult immigration life stage periodicity, with the relatively abundant fall-run Chinook salmon mostly migrating during the post-transfer period.

- The estimates of the proportions of clipped adult Chinook salmon to the total number of adult Chinook salmon immigrating into the lower Yuba River did not suggest the attraction of non-natal adult Chinook salmon during the 2004 transfer period, because the proportion calculated for the transfer period was not greater than the proportions for the pre-transfer and post-transfer periods.

- Multivariate time series analyses indicated that the immigration rates of non-adipose fin clipped and adipose-fin clipped Chinook salmon in 2004 were not significantly associated with: (1) attraction flows, defined as the difference between lower Yuba River and Feather River flows; or (2) attraction water temperatures, defined as the difference between lower Yuba River and Feather River water temperatures.

JSA. 2003, 2007, and 2008. *Lower Yuba River Redd Dewatering and Fry Stranding Monitoring and Evaluation Plan.* November 2003. *Lower Yuba River Redd Dewatering and Fry Stranding Study 2007 Annual Report* (JSA 2007) and *Lower Yuba River Redd Dewatering and Fry Stranding Study 2008 Annual Report* (JSA 2008).

In D-1644, the SWRCB in 2001 directed YCWA to submit a plan, in consultation with USFWS, NMFS, and CDFG that describes the scope and duration of future flow fluctuation studies to verify that Chinook salmon and steelhead redds are being adequately protected from dewatering with implementation of D-1644 criteria (JSA 1992). In RD-1644, the SWRCB in 2003 readopted this requirement. After various comments and revisions, the March 2002 Plan (Plan) was approved by the SWRCB on April 17, 2002. Phase I of the Plan was undertaken in 2002, and implementation of Phase II of the Plan continues.

These studies combine habitat mapping, field surveys, and information on the timing and distribution of fry rearing in the lower Yuba River to evaluate the effectiveness of D-1644 flow fluctuation and reduction criteria in protecting Chinook salmon and steelhead/rainbow trout fry. Two studies were conducted and summarized in the 2007 and 2008 *Lower Yuba River Redd Dewatering and Fry Stranding Annual Reports* (JSA 2007, 2008) to the SWRCB.

The first *Lower Yuba River Redd Dewatering and Fry Stranding Study* was conducted in April 2007 to evaluate bar and off-channel stranding of juvenile salmonids associated with a flow reduction of 1,300-900 cfs (at Smartsville) at a ramping rate of 100 cfs per hour. Bar stranding was again evaluated in June with a temporary flow reduction of 1,600-1,300 cfs at a rate of 100 cfs per hour. Snorkel surveys were conducted between Rose Bar and the Highway 20 Bridge in the lower Yuba River. During the April 5, 2007 drawdown, field crews observed 8 stranded salmon fry in the interstitial spaces of substrates on bar slopes (perpendicular to shoreline) ranging from 0.5 to 5.5%. No stranded fish were observed during surveys conducted on June 18, 2007. The presence of both juvenile Chinook salmon and steelhead/rainbow trout were confirmed in shallow, near-shore areas adjacent to the study sites, suggesting that the risk of bar stranding is greatly reduced by June. Following April 5, 2007 flow reductions, a total of 11,100 juvenile Chinook salmon were found in 20 isolated off-channel habitats. Most (93%) of the isolated juveniles were newly emerged and exhibited a length ranging from 30 to 50 mm.

An update *Lower Yuba River Redd Dewatering and Fry Stranding Study* was subsequently conducted from May 29, 2008 through June 4, 2008 with a scheduled flow reduction on June 1, 2008. Two of the three potential stranding locations had changed since the 2007 study. A total of 7 stranded trout fry (ranging between 30-35mm) were observed in the interstitial spaces of substrates on bar slopes (perpendicular to shoreline) ranging from 2.0 to 5.7%. Following the June 1, 2008 flow reductions, 266 juvenile salmonids were isolated in 6 off-channel sites. JSA (2008) suggested that the preliminary findings indicated that juvenile steelhead/rainbow trout fry may be less vulnerable to off-channel stranding than juvenile Chinook salmon because of their more restricted distribution and inability to access off-channel areas under late spring flow conditions. Long-term monitoring of several isolated off-channel sites confirmed that some sites can support juvenile salmonids for long periods and even produce favorable summer rearing conditions.

In accordance with the *Lower Yuba River Redd Dewatering and Fry Stranding Monitoring and Evaluation Plan* (2003), YCWA and JSA will continue to monitor and evaluate stranding risk and flow-habitat relationships for off-channel stranding. Future actions will include the following : (1) continued evaluation of the effects of time of day (night versus day) on stranding risk of juveniles; (2) inspection of interstitial habitats along the river margins to determine the presence of young fry before bar stranding evaluations; (3) evaluation of the effects of higher ramping rates (>100 cfs per hour) on stranding risk of larger fry and juveniles; (4) continued evaluation of the relationship between flow range and the number, area, and distribution of off-channel sites that become disconnected from the main river; (5) evaluation of the effect of peak winter and spring flows on the incidence of off-channel stranding; and (6) continued monitoring of habitat conditions and survival of Chinook salmon and steelhead/rainbow trout in selected off-channel monitoring sites where stranding is frequently observed.

Massa, D. 2004. *Yuba River Juvenile Chinook Salmon (Oncorhynchus tshawytscha), and Juvenile Central Valley Steelhead Trout (Oncorhynchus mykiss), Life History Survey: Annual Data Report 2003-2004.* California Department of Fish and Game Annual Report, Sacramento Valley & Central Sierra Region, Rancho Cordova, CA.

This study was conducted to continue development of baseline information for the Central Valley Project Improvements Act's (CVPIA), Anadromous Fish Restoration Program (AFRP) for juvenile Chinook salmon and steelhead/rainbow trout life history strategies on the lower Yuba River. Data were collected to determine the timing and duration of downstream emigration, abundance and/or relative abundance, and to monitor the condition and size of outmigrating juvenile Chinook salmon and steelhead/rainbow trout. Emigrating juvenile Chinook salmon were coded-wire tagged (CWT) in an effort to enumerate and determine the relative contribution to adult escapement on the lower Yuba River.

Juvenile Chinook salmon and steelhead trout were captured using a rotary screw trap (RST) with an eight-foot diameter cone placed in the lower Yuba River located approximately 6 miles east of the city of Marysville, adjacent to the south end of Hallwood Boulevard. Except during extraordinarily high water flows or during periods of excessive debris, the trap was fished 24-hours-per-day, seven-days-a-week from October 15, 2003 through June 17, 2004 following its installation on October 1, 2003.

Twenty-one species of fish were captured in the RST including a total of 307,297 juvenile Chinook salmon. Steelhead/rainbow trout were captured less frequently and totaled 590 fish during the October – June trapping period. This study revealed that peak catches of juvenile Chinook salmon on the lower Yuba River occur between December and March, which is approximately one month earlier than observed during previous monitoring efforts. Over 67,000 juvenile Chinook salmon were captured during the first two weeks of December 2003, and captures remained high until mid-March 2004. A total of 21,396 captured fry for the month of March 2003 signified the conclusion of peak emigration for juvenile Chinook salmon. Massa (2004) suggested that three runs of Chinook salmon (spring-, fall-, and late-fall run) were identified by modal distributions of captures at the RST. Spring-run Chinook salmon were first observed on November 1, 2003, followed by fall-run observations in December 2003, and late-fall run during mid-April 2004. Fall-run Chinook represented the majority of juveniles captured in the lower Yuba River. Coded Wire Tagging (CWT) began November 26, 2003 and ended June 15, 2004 with the majority of tagging occurring during peak emigration between December 9, 2003 and March 18, 2004. Of the 307,397 total juvenile Chinook salmon captured in the RST, 185,305 juvenile Chinook salmon were successfully injected with a CWT and adipose-fin clipped prior to release.

Kozlowski, J.F. 2004. *Summer Distribution, Abundance, and Movements of Rainbow Trout (Oncorhynchus mykiss) and other Fishes in the Lower Yuba River, California*. UC Davis Thesis.

Kozlowski (2004) conducted electrofishing (early-July and late-August), two mid-channel snorkel surveys (late-July and early-September), and river margin surveys (mid-August) just prior to the second electrofishing period during 2000. In addition, he reviewed 1999-2000 salvage data for the Hallwood-Cordua canal, a diversion canal located at DPD, and 1999-2001 trapping data for the Hallwood rotary screw trap (RST) near Hallwood Boulevard. These surveys were conducted to assess the distribution, abundance, and movement of steelhead/rainbow trout and other species below Englebright Dam.

The study focused on the portion of the lower Yuba River between Marysville and the Narrows within the following four reaches: (1) the Simpson Lane Bridge (about RM 3.2) to the Yuba Goldfields (about RM 8.3); (2) the western boundary of the Yuba Goldfields (about RM 8.3) to DPD (about RM 11.5); (3) upstream from DPD (about RM 11.5) to the upstream side of Long Bar (about RM 16.2); and (4) Highway 20 (about RM 16.2) to the downstream side of the Narrows (about RM 22.2).

Backpack electrofishing and snorkel survey data collection methods were used to estimate distribution and abundance population parameters for various life stages of steelhead/rainbow trout, as well as assess the aquatic community composition in the lower Yuba River. Fish screen salvage at DPD and rotary screw trapping methods were used to assess fish movements within the lower Yuba River, including above and below DPD. Age-0, juvenile, and adult summer distribution, abundance and movements were investigated between 1999 and 2000.

During the study a total of at least 12 species were observed including Chinook salmon and steelhead/rainbow trout. Kozlowski (2004) found higher abundances of juvenile and adult steelhead/rainbow trout above DPD, relative to downstream of DPD. Chinook salmon occurrence and abundance increased throughout the summer.

Kozlowski (2004) observed age-0 and adult steelhead/rainbow trout throughout the entire study area, with highest densities in upstream habitats and declining densities with increasing distance from the Narrows. Total numbers of juvenile and adult steelhead/rainbow trout observed below DPD accounted for 18 to 26% of the total number of steelhead/rainbow trout observed in the study area. The distribution of age-0 steelhead/rainbow trout observed appeared to be related to the distribution of spawning adults. The majority of redds observed during snorkel surveying occurred in the upstream reach between Long Bar and the Narrows during winter and spring 2000.

Some age-0 steelhead/rainbow trout dispersed downstream soon after emerging, beginning in July and August, and continued throughout the year (Kozlowski 2004). Salvage data at the Hallwood-Cordua fish screen suggested that most juvenile fish initiated their downstream movements immediately preceding and following a new moon, indicating the presence of lunar periodicity in the timing or outmigration patterns in the lower Yuba River (Kozlowski 2004).

Kozlowski (2004) stated that flow and temperature did not appear to cause age-0 steelhead/rainbow trout to initiate these downstream movements since these factors varied little or not at all during the duration of the summer. Similarly, water temperatures remained within the range preferred by steelhead/rainbow trout throughout the study area and did not vary substantially among reaches. As a result, the distributional pattern of steelhead/rainbow trout in the study area could not be explained by differences in water temperatures in the lower Yuba River.

Kozlowski (2004) found that the density of age-0 steelhead/rainbow trout was positively correlated to median substrate size of the upstream reach suggesting suitable rearing habitat for this life stage in the lower Yuba River. Juvenile and adult steelhead/rainbow trout were observed in greater numbers in pool habitats, and identified more frequently downstream of the Narrows, than in run habitats. Kozlowski (2004) suggested that results of this study indicated a relatively higher degree of habitat complexity, suitable for various life stages, in the reaches just below the Narrows compared to farther downstream. This includes greater occurrence of pools-type microhabitat suitable for juvenile and adult steelhead/rainbow rearing and holding, as well as small boulders and cobbles preferred by the age-0 emerging life stage.

Growth of age-0 steelhead/rainbow trout in the lower Yuba River was relatively slow throughout the summer, averaging between 47.9 mm (July 3 2000 - July 14, 2000) and 56.5 mm (August 25, 2000 – September 11, 2000) during the summer (Kozlowski 2004). The mean size observed in the lower Yuba River during this study was reportedly smaller than the August mean fork length (70 mm) reported by Cavallo et al. (2003; as cited in Kozlowski 2004) for age-0 rainbow trout in the low flow channel of the lower Feather River, and the lower American River in July (82 mm) reported by Snider and Titus (1994) but may be due to the presence of sampling biases inherent to electrofishing and snorkeling or seining methods. In a comparison of sampling methodology for this study, Koslowski (2004) suggested that snorkeling methods underestimated age-0 steelhead/rainbow trout numbers at sites where electrofishing yielded relatively high catches, but appeared to be a better estimator of fish density at sites where electrofishing yielded low numbers and was attributed to steelhead/rainbow trout fleeing sampling sites rather than hiding in the substrate as the electrofishing crew sampled the river margin.

Massa, D. and C. McKibbin. 2005. *Yuba River Juvenile Chinook Salmon (Oncorhynchus tshawytscha), and Juvenile Central Valley Steelhead Trout (Oncorhynchus mykiss), Life History Survey: Annual Data Report 2004-2005.* California Department of Fish and Game Annual Report, Sacramento Valley & Central Sierra Region, Rancho Cordova, CA.

Massa and McKibbin (2005) is a continuation of the Life History Surveys for the annual period extending from 2004-2005. Juvenile Chinook salmon and steelhead/rainbow trout were captured using two rotary screw traps (RST) with an eight-foot diameter cone placed in the lower Yuba River approximately 6 miles east of the city of Marysville, adjacent to the south end of Hallwood Boulevard. Except during extraordinarily high water flows or during periods of excessive debris, the traps were fished 24 hours per day, 7 days a week from October 21, 2004 through June 27, 2005 (Trap 1) and from April 26, 2005 to June 20, 2005 (Trap 2).

Twenty-two species of fish were captured in the RST including a total of 285,034 juvenile Chinook salmon. Steelhead/rainbow trout were captured less frequently and totaled 614 fish during the trapping periods. Massa and McKibbin (2005) suggested that peak catches of juvenile Chinook salmon on the lower Yuba River were observed later in the calendar year than in the previous 2003-2004 season, but were consistent with observations from earlier monitoring efforts (1999-2002).

Massa and McKibbins (2005) suggested that three runs of juvenile Chinook salmon (spring-, fall-, and late-fall run) were identified by modal distributions of captures at the RST. Fall-run Chinook represented the majority of juveniles captured in the lower Yuba River. CWT began November 29, 2004 and ended June 7, 2005 with the majority of tagging occurring during peak emigration between early January 2005 and late February 2005. Of the 285,034 total juvenile Chinook salmon captured in the RST, 242,774 juvenile Chinook salmon were successfully injected with a CWT and adipose-fin clipped prior to release.

JSA. 2006. *2003 Fall-run Chinook salmon spawning escapement in the Yuba River*. Prepared for Yuba County Water Agency by Jones and Stokes Associates, Inc.

JSA (2006) reported that annual surveys of Chinook salmon carcasses have been conducted on the lower Yuba River since 1953 to estimate fall-run Chinook salmon (*Oncorhynchus tshawytscha*) spawning escapement (i.e., the number of salmon that return to spawn each year). They reported that CDFG has conducted annual surveys of Chinook salmon carcasses on the lower Yuba River from 1953 to 1989, but suspended its surveys because of budget cuts. In response, YCWA with the assistance of JSA in 1991, conducted subsequent escapement surveys through 2003. CDFG assisted JSA from 1992 through 1994. In 2002 and 2003, additional funding was provided by the California Department of Water Resources (CDWR) and the Pacific States Marine Fisheries Commission (PSMFC) to ensure a complete search for tagged hatchery strays. The main objective of the annual carcass surveys was to estimate annual spawning escapement of fall-run Chinook salmon in the lower Yuba River downstream of Englebright Dam.

JSA (2006) reported an estimate of 28,897 Chinook salmon spawned in the lower Yuba River based on surveys conducted during 2003. JSA (2006) reported that the average spawning escapement for 1996–2003 was estimated to be 24,563 fish, which was substantially higher than the average of 13,809 for the preceding period between 1972–1995 representing the post–New Bullards Bar Reservoir period. Overall, average spawning escapement for the pre- and post-reservoir periods (1953–1971 and 1972–2003) was 12,906 and 16,050 fish, respectively.

Grover, A. and B. Kormos. (undated). *The 2006 Central Valley Chinook Age Specific Run Size Estimates*. Scale Aging Program, California Department of Fish and Game 475 Aviation Blvd, Suite 130 Santa Rosa, CA 95403

Through scale aging, this study produced age-structured hatchery and natural escapement estimates for all principal reaches and runs of Chinook salmon (*Oncorhynchus tshawytscha*) in the Central Valley. Digital imaging and reading techniques were used, and a modified maximum likelihood estimator based on the work of Kimura and Chikuni (1987; as cited in Grover and Kormos undated) was utilized. This method uses known, aged CWT salmon scale samples in conjunction with those of unknown aged (non-CWT) fish to create bias-corrected age proportions from which age-specific run size estimates were made. Grover and Kormos (undated) reported that preliminary results showed that there are differences between the age structure of hatchery and natural escapement. In addition, they indicated that there are age structure differences among the Chinook lifehistory types present in the Central Valley. Results from this study indicated that in the lower Yuba River about 4.5% of the 2006 total escapement was comprised of 2 year old Chinook salmon, 16% were age 3, and 79.5% were age 4.

Grover, A. and B. Kormos. (undated). *The 2007 Central Valley Chinook Age Specific Run Size Estimates.* Scale Aging Program, California Department of Fish and Game 475 Aviation Blvd, Suite 130 Santa Rosa, CA 95403

Results from the 2007 evaluation utilized the same methods and procedures described for the 2006 evaluation (presented above). Grover and Kormos (undated) stated that there are differences between the age structure of hatchery and natural escapement, and among the Chinook life history types present in the Central Valley. Results from this study indicated that in the lower Yuba River about 3% of the 2007 total escapement was comprised of 2 year old Chinook salmon, 36% were age 3, 59% were age 4, and 1.6% were age 5.

NMFS. 2007. *Biological Opinion on the Operation of Englebright and Daguerre Point Dam on the Yuba River, California.* File Number 151422-SWR-2006-SA00071:MET (PCTS # 2007/01232). November 21, 2007.

In November 2007, NMFS issued a BO on the operation of USACE's facilities on the Yuba River, including DPD and Englebright Dam. Central Valley spring-run Chinook salmon and Central Valley steelhead passage at DPD was addressed in the BO, although NMFS (2007) stated that a final preferred alternative was not identified to alleviate passage impediment issues at DPD. The BO did not address project effects on the threatened southern-DPS of North American green sturgeon.

According to NMFS (2007), infrared and videographic sampling at ladders located at DPD since 2003 has provided more robust estimates of spring-run Chinook salmon numbers migrating into the lower Yuba River. NMFS (2007) reported preliminary estimates of adult spring-run Chinook salmon ascending DPD as 1,250 in 2003, 431 in 2004, 1,019 in 2005, 217 in 2006, and 242 in 2007. However, NMFS (2007) considered these numbers to be preliminary, minimum estimates, because periodic problems with the sampling equipment resulted in periods when fish ascending the ladders were not counted, so it is likely that the actual numbers are higher than those reported. NMFS (2007) observed that the detection of adipose fin clips on some of these fish indicated that they were hatchery strays, most likely from the Feather River Hatchery, and that the short time period in which this sampling has been conducted, coupled with the salmon's three to four year life cycle made it difficult to determine decisive trends in the spring-run Chinook salmon population. While the data from 2006 and 2007 indicate a reduction in total abundance, passage in May (the primary spring-run migration month) of 2007 was the highest detected in that month since the sampling has been conducted (NMFS 2007).

Based on infrared and videographic sampling at both DPD fish ladders since 2003, NMFS (2007) reported that minimum, preliminary estimates of the number of steelhead ascending DPD were 170 in 2003, 762 in 2004, 356 in 2005, 150 in 2006, and 511 in 2007. Additionally, because steelhead can be similar in size to many other species of fish in the Yuba River, only those inferred images that were backed up by photographic images clearly showing that the fish was a steelhead were included in the counts (NMFS 2007). Therefore, NMFS (2007) stated that it is likely that the actual numbers of steelhead passing DPD were higher than those reported. The data indicated that through the first half of the month of July 2007, upstream adult steelhead passage at DPD was the highest since the device was installed in 2003, although determination of decisive trends in the Yuba River steelhead population was difficult at that time (NMFS 2007).

Massa, D. 2008. *Lower Yuba River Chinook Salmon Escapement Survey: October 2007 – January 2008.* California Department of Fish and Game Annual Report, North Central Region, Chico, CA.

This report presents results of Chinook salmon spawning escapement surveys during 2007 to 2008, as well as summary information from preceding years. Massa (2008) reported that although escapement surveys were conducted on the lower Yuba River to estimate the number of returning adult Chinook salmon since 1953, previous estimates were infrequent and unlike more recent surveys (1994, 1996-2006), because methods were not consistent from year to year. Survey duration and area of sampling varied, resulting in data that were statistically inappropriate for trend analysis.

Massa (2008) estimated 2,604 Chinook salmon (2,423 adult and 81 grilse) spawned in the lower Yuba River survey area during the period of October 2, 2007 to January 3, 2008. This estimate was the lowest observed in twelve consecutive years, and was less than a third of the escapement estimate reported for 2006 (8,231 fish).

Separate estimates could not be created for each of the six survey reaches due to low sample size, although previous surveys have suggested that the majority of spawning occurs above DPD (JSA 2006; Massa 2006; Massa 2007). Approximately 70% of the returning escapement in 2006 utilized the area between the Narrows pool and DPD (Massa 2007). Massa (2008) stated that although it is difficult to accurately determine time of spawning from carcass recovery dates, spring-run carcasses, as identified through CWT recovery, were recovered between October 3, 2007 and October 16, 2007. As observed in 2005, all spring-run Chinook salmon recoveries were from the Feather River Hatchery. A single fall-run recovery also originated from the Feather River Hatchery. No recoveries were observed from the CDFG's wild-tagging operation (*Lower Yuba River Life History Investigation*) during this survey. As observed in 2005 and 2006, the majority of Feather River Hatchery strays were from plants transported far from their natal hatchery, mostly to San Pablo Bay via the Wickland Oil net pens (Massa 2008).

Beginning in 2005, the Feather River Hatchery began tagging early arriving (May/June) spring-run Chinook salmon with floy tags and releasing these fish to the river. Incidentally, two of these floy-tagged Feather River spring-run Chinook salmon have been collected during escapement surveys on the lower Yuba River - one in 2006 and one in 2007 (Massa 2008).

Scale samples were collected at random from October 2, 2007 through January 3, 2008. As a result of low overall sample numbers, an attempt was made to collect scales from all fresh carcasses encountered. A total of 346 samples were collected.

Annual population abundance estimates of Chinook salmon for the Sacramento-San Joaquin River system, including the lower Yuba River, have been complied by the CDFG Fisheries Branch Anadromous Resource Assessment Unit and presented as an independent dataset in GrandTab. The GrandTab report is a compilation of sources estimating the late-fall, winter, spring, and fall-run Chinook salmon populations for all streams surveyed in the Central Valley and are based on counts of fish entering hatcheries, migrating past dams, annual carcass surveys, live fish counts, and ground and aerial redd surveys. Population estimate sources for GrandTab include: (1) CDFG; (2) USFWS; (3) CDWR; (4) the East Bay Municipal Utilities District; (5) PG&E; and (6) the Fisheries Foundation of California. Fall-run Chinook salmon have been monitored since 1952, spring-run Chinook salmon since 1960, and late-fall and winter Chinook salmon runs since 1970.

Zimmerman, C., G. Edwards, and K. Perry. 2009. *Maternal origin and Migratory History of Steelhead and Rainbow Trout Captured in Rivers of the Central Valley, California.* Trans. of the Amer. Fish. Soc. 138:280-291. February 23, 2009.

Zimmerman et al. (2009) stated that the treatment of sympatric life history forms as single populations exhibiting polyphenism or as reproductively isolated populations has profound implications in decisions related to protection and recovery of species (Zimmerman and Reeves 2000; McEwan 2001; as cited in Zimmerman et al. 2009). Zimmerman et al. (2009) analyzed otolith strontium:calcium (Sr:Ca) ratios to determine maternal origin (anadromous vs. non-anadromous) and migratory history (anadromous vs. non-anadromous) of *O. mykiss* collected in Central Valley rivers between 2001 and 2007, including the lower Yuba River.

Fish were captured by various sampling techniques including beach seining, rotary screw trapping, electrofishing, carcass surveying, and hook and line.

A total of 964 otoliths were examined to determine age, maternal origin, and migratory history. Age-0 fish were collected from only three sites: Deer Creek, lower Yuba River, and Calaveras River. Zimmerman et al. (2009) found that age and length composition of samples varied among locations, and that mean length-at-age varied among locations. They determined mean fork length of steelhead and rainbow trout collected from the lower Yuba River as age-0 (68mm ± 24mm), age-1 (228mm ± 2mm), age-2 (271mm ± 24mm), age-3 (348mm ± 25mm), and age-4 (424mm ± 29mm).

Of the 964 otoliths examined from Central Valley streams, 224 were classified as steelhead progeny and 740 were classified as progeny of rainbow trout females. The proportion of steelhead progeny in the lower Yuba River (about 13%) was intermediate to the other rivers examined (Sacramento, Deer Creek, Calaveras, Stanislaus, Tuolumne, and Merced), which ranged from 4% in the Merced River to 74% in Deer Creek (Zimmerman et al. 2009).

Mitchell, W.T. 2010. *Age, Growth, and Life History of Steelhead Rainbow Trout (Oncorhynchus mykiss) in the Lower Yuba River, California.* ICF International. March 2010.

Steelhead/rainbow trout age structure, life history, stock composition, origin, and growth in the lower Yuba River were analyzed using scales, which is an effective method for determining these life history characteristics, as well as the relationships between growth, life history variation, and recruitment (Mitchell 2010). Scales from 787 juvenile and adult steelhead/rainbow trout were collected in the lower Yuba River from 1998 to 2007. Most fish were collected by trapping, angling, and electrofishing. Upstream migrants were captured at DPD between November 11, 2000 and March 12, 2001. The remainder of sampling was conducted opportunistically via hook-and-line angling from 2004 to 2007.

Scales were taken from 142 age 0+ and age 1+ steelhead/rainbow trout collected by electrofishing during July to September 1999 and July to August 2000. Sampled fish averaged 107 mm FL and ranged from 68 to 198 mm FL. Of 467 juvenile and adult steelhead rainbow trout collected by angling between September 1998 and June 2007, only four fish were identified as steelhead and ranged in length from 438 to 559 mm FL. Scales taken from 71 juvenile and adult steelhead/rainbow trout trapped in the fish ladder at DPD from November 1, 2000 through March 28, 2001averaged 401 mm FL and ranged from 220 to 720 mm FL, with ten fish identified as steelhead and ranging in length from 453 to 720 mm FL (Mitchell 2010).

Scale analysis indicates the presence of at least four age categories for steelhead/rainbow trout in the lower Yuba River that spent 1, 2, or 3 years in freshwater and 1 year at sea before spawning. Mitchell (2010) does not report any steelhead/rainbow trout spending more than 1 year at sea before returning to spawn. Two of the 14 steelhead sampled were returning to spawn for a second time. A relatively higher proportion of age-3/1 were reported.

Results from Mitchell (2010) indicate steelhead/rainbow trout in the lower Yuba River are exhibiting a predominately residential life history pattern. He found that only 14% of samples gathered from DPD, and 1% from angling were anadromous steelhead adults. Based on scale analysis, nearly all fish had spent 1 to 4 winters in freshwater with no evidence of ocean residence (Mitchell 2010).

Mitchell (2010) reported that back-calculation of fork length (FL) showed substantial variability in size and growth for steelhead/rainbow trout juvenile age classes (0+ and 1+ fry). Late summer emerging 0+fry were smaller (<70mm FL) than average (108mm FL) by the end of their first winter, while early spring emergers were generally larger than average by the end of winter. Age 1+ juveniles grew 146mm in length following their first winter, reaching an average FL of approximately 265mm by the end of their second winter. Analysis of scale growth patterns indicate a period of accelerated growth during the spring peaking in the summer months, and followed by decelerated growth in the fall and winter. Following the second winter, steelhead/rainbow trout in the lower Yuba River exhibit reduced annual growth in length with continued growth in mass until reaching reproductive age. Additionally, more rapid juvenile and adult steelhead/rainbow trout growth occurred in the lower Yuba River compared to the lower Sacramento River and Klamath River steelhead/rainbow trout, with comparable growth rates to steelhead/rainbow trout in the upper Sacramento River (Mitchell 2010).

Garza, J.C., and D.E. Pearse. (undated). *Population Genetic Structure of Oncorhynchus mykiss in the California Central Valley.* Final report for California Department of Fish and Game Contract # PO485303. University of California, Santa Cruz and NOAA Southwest Fisheries Science Center.

Garza and Pearse (undated) reported that genotype data was collected from 18 highly variable microsatellite molecular markers in more than 1,600 fish from the Central Valley region sampled by CDFG biologists, as well as a sample of adult steelhead from Battle Creek sampled by the USFWS. Analyses of these data examined population structure within the region, relationships between populations above and below barriers to anadromy, relationships of Central Valley populations with coastal steelhead populations, and population genetic diversity.

The analysis in Garza and Pearse (undated) focused on 17 initial “population” samples, comprised of fish sampled from the Kings, Tuolumne, Stanislaus, Calaveras, American, Yuba, Feather, Butte, Deer, Battle, and McCloud river sub-basins. Additional analyses were conducted with data from the same microsatellite markers in rainbow trout hatchery stocks and steelhead from coastal and California Central Valley populations. These analyses examined whether specific fish are, or are descended, from hatchery strains used in local stocking efforts, as well as providing biogeographic context for the Central Valley regional results. Garza and Pearse (undated) reported that in general, all naturally-spawned populations within the Central Valley basin were closely related, regardless of whether they were sampled above or below a known barrier to anadromy. This is due to some combination of pre-impoundment historic shared ancestry, downstream migration and, possibly, limited, anthropogenic, upstream migration. However, lower genetic diversity in above-barrier populations indicates a lack of substantial genetic input upstream and highlights lower effective population sizes for above-barrier populations. In contrast to coastal steelhead, close relationships were not found between populations above and below barriers within the same sub-basin. Instead, above-barrier populations clustered with one another and below-barrier populations clustered with one another in all tree analyses. The consistent clustering of the above-barrier populations with one another, and their position in the California-wide trees, indicate that they are likely to most accurately represent the ancestral population genetic structure of steelhead in the Central Valley (Garza and Pearse undated).

Garza and Pearse (undated) also identified possible heterogeneity between samples from different tributaries of the upper Yuba and Feather rivers, although Linkage (gametic phase) Disequilibrium (LD) was lower in these populations. Other than in the Nimbus Hatchery sample, only one other fish, in the lower Yuba River population, was identified as a hatchery fish with high confidence. In fact, the salient characteristic of population structure for Central Valley *O. mykiss* inferred from this study is that the populations of naturally-spawning fish sampled here are all closely related, regardless of whether they are currently above or below barriers to anadromy. This indicates that hatchery rainbow trout planted above dams in the region have not replaced *O. mykiss* populations trapped upstream of dam construction, fish commonly referred to as residualized steelhead (Garza and Pearse undated).

Garza and Pearse (undated) stated that these results indicate smaller effective size in above-barrier populations, which is consistent with the expectation of decreased upstream migration and the lost influx of new genes through migration. This situation will lead to gradual genetic erosion, which can contribute to eventual population extirpation (Srikwan and Woodruff 2000 as cited in Garza and Pearse undated). Facilitating upstream migration might help to alleviate such eventual genetic effects, but may also counteract the potential adaptation of above-barrier populations that is expected because of the strong selection against downstream migration in such populations (Garza and Pearse undated).

Garza and Pearse (undated) stated that efforts to integrate above-barrier populations with those below dams to increase overall effective size of steelhead populations and reestablish historical connectivity should also proceed with great caution, as these fish have been under very strong selection against anadromy since dam construction. The consequences of such integration are not known, but could range from beneficial increases in genetic diversity and effective size, to decreased fitness of hybrids and various ecological interactions such as competition or direct predation (Garza and Pearse undated).

OTHER RELEVANT DOCUMENTS

CDFG. 1993. *Restoring Central Valley streams: A plan for action*. The Resources Agency, CDFG, Sacramento, California. November 1993.

The CDFG (1993) report assessed the condition of Central Valley anadromous fish habitat and associated riparian wetlands, and set priorities for taking actions to restore and protect aquatic ecosystems that support fish and wildlife and to protect threatened and endangered species. Priorities were identified to guide future efforts toward restoration. On the lower Yuba River, priority actions included installing fish screens on lower Yuba River diversions, improving spawning and rearing habitat, and protecting and managing riparian habitat. Recommendations for administrative actions to improve anadromous fish habitat in the lower Yuba River also included specific stream flow recommendations which were consistent with the CDFG (1991) report titled *The Lower Yuba River Fisheries Management Plan Final Report*. The recommendations also included target water temperatures, although no specific water temperature studies, flow-temperature relationships, or water temperature availability studies were presented.

Busby, P.J., T.C. Wainwright & G.J. Bryant. 1996. *Status review of West Coast steelhead from Washington, Idaho, Oregon, and California*. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-27. 261 pp.

The NMFS Biological Review Team (BRT) prepared a Status review of West Coast steelhead from Washington, Idaho, Oregon, and California which presented environmental and biological information concerning steelhead populations in Washington, Idaho, Oregon, and California. The BRT identified 15 steelhead ESUs throughout the region of evaluation,

> 12 of which include coastal forms including the Central Valley, and 3 of which include inland forms.
>
> Within the Central Valley, the Yuba Rivers and others (i.e., the American, Feather, and possibly the upper Sacramento and Mokelumne rivers), were identified as have naturally spawning populations (CDFG 1995 as cited in Busby et al. 1996), but have had substantial hatchery influence and their ancestry was not clearly known. Genetic data was the primary evidence considered for the reproductive isolation criterion, supplemented by inferences about barriers to migration created by natural geographic features.
>
> This document reported conclusions reached by the BRT for determining whether the listing of west coast steelhead under the ESA would be warranted. The BRT reported that few detailed studies existed on the relationship between resident and anadromous O. mykiss in the same location, but that each of the ESUs included multiple spawning and resident populations of O. mykiss. Additionally, genetic studies generally show that rainbow trout and steelhead from the same area may share a common gene pool. The BRT reports that progeny of nonanadromous O. mykiss can be anadromous, and that anadromous O. mykiss can produce nonanadromous progeny, however, evidence exists to suggest substantial genetic divergence between resident and anadromous fish in areas where resident populations have been isolated by long-standing natural barriers.
>
> The BRT reported the status of native natural steelhead in the Yuba River as unknown, although the population appeared to be stable and supporting a fishery (McEwan and Jackson 1996 as cited in Busby et al. 1996) likely due to influence by Feather River Hatchery fish. The BRT also concluded that the Central Valley steelhead ESU was in danger of extinction, and that introgression from hatchery fish may be a concern in the Yuba River and throughout the Central Valley.

Biologists familiar with the stock of the Yuba River steelhead suggest that almost no natural production of steelhead occurs on the Yuba River (Hallock 1989 as cited in Busby et al. 1996). However, Busby et al. 1996 also identified two areas of scientific uncertainty regarding natural reproducing including as deficiency of recent run-size estimates for natural steelhead stocks, and uncertainty in determining which populations to include in the ESU considering that there was substantial question regarding the genetic heritage of natural populations in the Central Valley.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 1996. *Historical and present distribution of Chinook salmon in the Central Valley Drainage of California.* In: Sierra Nevada Ecosystem Project, Final Report to Congress, vol. 111, Assessments, Commissioned Reports, and Background Information (University of California, Davis, Centers for Water and Wildland Resources, 1996).

> This report summarized historical accounts of spring-run Chinook salmon populations, including the Yuba River. Yoshiyama et al. (1996) reported that prior to the impacts associated with gold mining, dam construction, and water diversions, large numbers of spring-run Chinook salmon were taken by miners and Native Americans as far upstream as Downieville on the North Yuba River. During the construction of the original Bullards Bar Dam (1921 - 1924), numerous Chinook salmon congregated and died below the dam. Due to their presence high in the watershed, Yoshiyama et al. (1996) concluded that these fish were spring-run Chinook salmon. In addition, this report indicated that prior to the construction of Englebright Dam, CDFG fisheries biologists observed large numbers of steelhead spawning in the uppermost reaches of the Yuba River and its tributaries.

CDFG. 1996. *Steelhead Restoration and Management Plan for California.* Prepared by D. McEwan and T. Jackson. Inland Fisheries Division, Sacramento, CA.

> CDFG developed the *Steelhead Restoration and Management Plan for California* (Steelhead Plan) in 1996 as a component of the SB 2261 program. As mandated by *The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 (SB 2261),* a policy of the State of California is to significantly increase the natural production of salmon and steelhead, and directed CDFG to develop a program that strives to double naturally spawning anadromous fish populations by the year 2000.
>
> CDFG (1996) reported that the Yuba River historically supported the largest, naturally-reproducing, persistent population of steelhead in the Central Valley, and that wild stocks in the Sacramento River system are mostly confined to upper Sacramento River tributaries such

as Antelope, Deer, and Mill creeks and the Yuba River. This report, referencing CDFG (1991), stated that the lower Yuba River maintained natural production, and was managed by CDFG as a naturally sustained population. CDFG (1996) reported that the run size for the Yuba River in 1984 was estimated to be about 2,000 steelhead (CDFG 1984 as cited in CDFG 1996).

This report stated that as of 1996, the status of the Yuba River steelhead population was unknown, although it appeared to be stable and continued to support a steelhead fishery, and that the Yuba River was essentially the only wild steelhead fishery remaining in the Central Valley. This report, referencing CDFG (1991), reported that the lower Yuba River was annually stocked with 27,270 to 217,378 yearling steelhead from the Coleman National Fish Hatchery between 1970 to 1979, and that as of 1996 it was unknown whether the steelhead stock was of native origin or was derived from the planting of Coleman National Fish Hatchery fish. Although no specific water temperature studies, flow-temperature relationship evaluations, or water temperature availability studies were presented, CDFG (1996) suggested that low flows and elevated water temperatures resulting from water diversions had affected the anadromous populations of the lower Yuba River.

The CDFG (1996) report recommended that efforts should continue to seek adequate flows and temperatures, and implement restoration actions for the lower Yuba River. This report also stated that CDFG should continue to manage the lower Yuba River as a wild steelhead fishery, and recommended that hatchery steelhead not be planted in the lower Yuba River.

NMFS. 1997. *Status review update for West Coast steelhead from Washington, Idaho, Oregon, and California.* Memorandum date 7 July 1997 from the Biological Review Team to the National Marine Fisheries Service Northwest Regional Office. Online at http://www.nwr.noaa.gov/1salmon/salmesa/pubs/sru970707.pdf

This report summarizes conclusions of the NMFS Biological Review Team (BRT) regarding the Central California Coast, South-Central California Coast, Southern California, Central Valley, Upper Columbia River, and the Snake River Basin ESUs. The west coast steelhead biological review team (BRT), convened by NMFS, reviewed comments and new data received from federal, state, and tribal agencies, nine west coast fisheries scientists, and the public solicited in response to the proposed rule, Busby et al. 1996 Status Review for West Coast Steelhead from Washington, Idaho, Oregon, and California August 1996.

The BRT notes new information from CDFG, including some additional counts of juvenile steelhead in the mainstem San Joaquin River and the Stanislaus River, and noted additional information on the distribution of steelhead in the San Joaquin System (Yoshiyama et al. 1996 as cited in NMFS 1997). However, the BRT determined that for the Central Valley ESU, no new information was provided that was sufficient to estimate population trends. No changes were made to the geographic delineation of the Central Valley steelhead ESU, ESU distribution, population-trends, or to the assessment of Central Valley steelhead ESU risk of extinction. Additionally, the BRT concluded that any ESU identified in geographic region of California's Central Valley would almost certainly be considered at risk of extinction. The BRT recognized that native steelhead may no longer exist in many streams in the Central Valley and that under some ESU configurations, identification of any native, naturally-spawning fish of ESA concern may be difficult.

CDFG. 1998. *A Status Review of the Spring-Run Chinook Salmon (Oncorhynchus tshawytscha) in the Sacramento River Drainage***.** Candidate Species Status Report 98-01. CDFG, Sacramento, CA.

This status report was prepared in response to a petition to list Sacramento River spring-run Chinook salmon as an endangered species pursuant to the California Endangered Species Act (Fish and Game Code Sections 2050 *et seq*.). Based on information available to CDFG at that time, and in consideration of existing and future proposed actions affecting spring-run Chinook salmon, CDFG (1998) concluded spring-run Chinook salmon to be threatened.

Regarding the lower Yuba River, this report suggested that spring-run Chinook salmon populations may be hybridized to some degree with fall-run Chinook salmon due to lack of spatial separation of spawning habitat. CDFG (1998) suggested measures to improve habitat and survival of spring-run Chinook salmon in the lower Yuba River, including: (1) supplement flows with water acquired from willing sellers; (2) reduce flow fluctuations; (3) maintain adequate instream flows for temperature control; (4) screen all diversions to meet CDFG and National Marine Fisheries Services (NMFS) criteria; (5) improve fish bypass at water diversions; (6) improve adult and juvenile passage at DPD; (7) maintain and improve riparian habitat; (8) operate reservoirs to provide adequate water temperatures; (9) evaluation of the feasibility of removal of Englebright Dam to re-introduce spring-run Chinook salmon to their historic range; and (10) changing CDFG fishing regulations to prevent take of adult spring-run Chinook salmon during upstream migration.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grand, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. *Status review of Chinook salmon from Washington, Idaho, Oregon, and California*. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 p.

This document reports results of the comprehensive ESA status review of Chinook salmon from Washington, Oregon, California, and Idaho. To provide a context for evaluating these populations of Chinook salmon, biological and ecological information for Chinook salmon in British Columbia, Alaska, and Asia were also considered. NMFS formed a team of scientists with diverse backgrounds in salmon biology to conduct this review. This Biological Review Team (BRT) for Chinook salmon included fisheries scientists, and federal and state agencies.

The BRT addressed issues related to the definition of Distinct Population Segments, population abundance, and causes of decline for Chinook salmon. Ecoregions delineated in this report include those geographic areas throughout the broad distribution of Chinook salmon, including California's Central Valley. The BRT analyzed regional variations in life-history, ecology, and genetic information as part of the assessment regarding California Central Valley Chinook salmon. The report includes discussion and conclusions specific to Central Valley spring-run and fall-run ESU's found in the Sacramento, Feather, and Yuba rivers.

NMFS (2007) reports that historically, spring-run Chinook salmon were predominant throughout the Central Valley, occupying the upper and middle reaches (450-1,600 m in elevation) of several rivers including Yuba, Feather, and Sacramento rivers, with smaller populations in most other tributaries with sufficient cold-water flow to maintain spring-run adults through the summer prior to spawning (Stone 1874, Rutter 1904, and Clark 1929 as cited in NMFS 2007). CDFG (1965) as cited in NMFS (2007), reported spring-run Chinook salmon to be extinct in the Yuba, American, Mokelumne, Stanislaus, Tuolumne, Merced, and San Joaquin Rivers. However, populations of spring-run Chinook salmon in the Sacramento and Yuba rivers were identified as being at a moderate risk of extinction (Nehlsen et al. 1991 as cited in NMFS 2007).

Calkins et al. (1940) estimated abundance at 55,595 fish in the Sacramento River Basin during the period 1931-39 (NMFS 2007). In the early 1960s, adult escapement was estimated to be 327,000, predominantly in the mainstem Sacramento River (187,000), but with substantial populations in the Feather (50,000), American (36,000), and Yuba (22,000) Rivers and in Battle Creek (21,000); remaining escapement was scattered among numerous tributaries (CDFG 1965 as cited in NMFS 2007).

NMFS. 1998. *Endangered and threatened species: Threatened status for two ESUs of steelhead in Washington, Oregon, and California*. Federal Register [Docket No. 980225046-8060-02, 19 March 1998] 63(53):13347.

NMFS filed a final rule, notice of determination regarding the listing of two *O. mykiss* ESUs as threatened under the Endangered Species Act (ESA) located in Washington, Oregon, and California (Lower Columbia River) and including the Central Valley. The Central Valley, California steelhead ESU occupies the Sacramento and San Joaquin Rivers and their tributaries. NMFS (1998) has identified only naturally spawned populations of steelhead (and their progeny) residing below naturally and man-made impassable barriers (e.g., impassable waterfalls and dams) as threatened.

The BRT identified long-term declines in abundance, small population sizes in the Sacramento River, and the high risk of interbreeding between hatchery and naturally spawned steelhead as major concerns for steelhead in this ESU. Addition, the BRT emphasized the significant loss of historic habitat, degradation of remaining habitat from water diversions, reduction in water quality and other factors, and the lack of monitoring data on abundance as other important risk factors for this ESU. During the examination of the relationship between hatchery and natural populations of steelhead assessed whether any hatchery populations are essential for their recovery. At this time, no hatchery populations are deemed essential for recovery (and hence listed) in either of the two listed ESUs. At this time, NMFS is listing only anadromous life forms of *O. mykiss*. NMFS(1998) concluded that Central Valley steelhead warrant listing as a threatened species at this time but may be reconsidered if new information indicates a substantial change in the biological status of this ESU or the direction of restoration efforts in the Central Valley.

YCWA. 2000. *Draft Environmental Evaluation Report, Yuba County Water Agency, Yuba River Development Project* (FERC No. 2246). Prepared by Yuba County Water Agency, Surface Water Resources Inc., and Jones and Stokes Associates. December 2000.

An Environmental Evaluation Report was prepared to address potential effects of the operation of Yuba River Development Project (YRDP) on anadromous salmonids in the lower Yuba River below Englebright Dam. The report was prepared in response to the listing of steelhead as threatened in March 1998, the listing of spring-run Chinook salmon in September 1999, and designation of critical habitat in February 2000. The report evaluated potential flow and water temperature related effects, and compared instream conditions prior to the completion of New Bullards Bar Dam in 1970, and since that time. In addition, the report listed several conservation measures being undertaken as part of YRDP operations in the lower Yuba River.

Yoshiyama, R., E. Gerstung, F. Fisher, and P. Moyle. 2001. *Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California*. In Contributions to the Biology of Central Valley Salmonids, California Fish and Game, Bulletin 179, Volume 1. Salmonid Symposium, Bodega Bay, California. October 22-24, 1997, Randall Brown, editor.

This report characterized historic distributions of Chinook salmon throughout the Central Valley of California and states that both spring- and fall-run Chinook salmon historically occurred in the Yuba River watershed.

Yoshiyama et al. (2001) reported that salmon were caught in the North Fork Yuba River by PG&E workers in the Bullards Bar area during the 1898–1911 period of operation of the Yuba Powerhouse Project, and that salmon ascended in “considerable numbers” up to Bullards Bar Dam during its period of construction (1921–1924). This report stated that there were no natural barriers above the Bullards Bar Dam site, so Chinook salmon and steelhead presumably had been able to ascend a considerable distance up the North Fork Yuba River, potentially as far as Downieville at the mouth of the Downie River (CDFG file records as cited in Yoshiyama et al. 2001). This report further suggested that: (1) there were no natural obstructions from Downieville upstream to Sierra City, where Salmon Creek enters, spring-run Chinook salmon and steelhead most likely were able to traverse that distance; (2) spring-run Chinook salmon and steelhead probably ascended the higher-gradient reaches up to about two miles above the juncture of Salmon Creek; and (3) the absolute upstream limit on the North Fork Yuba River would have been Loves Falls for spring-run Chinook salmon and steelhead.

This report stated that in the Middle Fork Yuba River, there were no significant natural obstructions except for a 10-foot falls in the lower reach, and Chinook salmon possibly had access to a considerable portion of the Middle Fork Yuba River. Both Chinook salmon and steelhead were observed in the lower part of the Middle Fork Yuba River, near where the North Fork Yuba River joins, during a CDFG survey in 1938 (CDFG unpublished data as cited in Yoshiyama et al. 2001). Steelhead were found as far upstream as the mouth of Bloody Run Creek (CDFG unpublished data as cited in Yoshiyama et al. 2001). Whether Chinook salmon also reached that far remains conjectural. Yoshiyama et al. (2001) concluded that direct information was lacking and it was uncertain if many salmon were able to surmount the 10-foot falls on the lower river, and they conservatively considered the falls located 1.5 mi. above the mouth as the effective upstream limit of salmon in the Middle Fork Yuba River.

Yoshiyama et al. (2001) reported that little is known of the original distribution of salmon in the South Fork Yuba River where the Chinook salmon population was severely depressed and upstream access was obstructed by dams when CDFG began surveys in the 1930s. There were records of salmon occurring within one to two miles upstream of the mouth of the South Fork Yuba River (DFG unpublished data as cited in Yoshiyama et al. 2001). A substantial cascade with at least a 12-foot drop, located one-half mile below the juncture of Humbug Creek (CRA 1972; Stanley and Holbek 1984; as cited in Yoshiyama et al. 2001), may have posed a significant obstruction to salmon migration, but it was not necessarily a complete barrier. However, Yoshiyama et al. (2001) categorized the cascade below Humbug

Creek as essentially the historical upstream limit of salmon during most years of natural streamflows. They also stated that steelhead were known to have ascended the South Fork Yuba River as far as the juncture of Poorman Creek near the present town of Washington (CDFG unpublished data as cited in Yoshiyama et al. 2001), and perhaps some spring-run Chinook salmon historically also reached that point.

CDWR and USACE. 2003a. *Daguerre Point Dam Fish Passage Improvement Project 2002 Fisheries Studies – Analysis of Potential Benefits to Salmon and Steelhead from Improved Fish Passage at Daguerre Point Dam*. Prepared for CDWR and USACE by ENTRIX, Inc. and J. Monroe. March 2003.

The purpose of this report was to examine available data on habitat conditions, flow, passage, and spawning above and below DPD to assist in the analysis of potential benefits or impacts of improved passage at the dam prior to selection of an alternative concept(s) for consideration in the environmental review process. The report included a review of available data from CDFG, USFWS, JSA, and other sources. It also incorporated field observations of river habitat conditions made by ENTRIX, Inc. (ENTRIX) in September of 2002 (ENTRIX and J. Munroe 2003 as cited in CDWR and USACE 2003). The report described channel morphology, spawning habitat suitability, historical and potential habitat use by species, water temperature, hydrology, as well as discussions regarding conceptual benefits and impacts for different fish passage alternatives.

CDWR and USACE. 2003b. *Daguerre Point dam fish passage improvement project 2002 water resources studies.* Prepared for CDWR and USACE by ENTRIX, Inc. June 2003.

The purpose of this report was to summarize and analyze the available hydrologic (including groundwater and flooding), hydraulic, and sediment data for the lower Yuba River. This report characterized the conditions on the river, including hydrology (groundwater and surface water), flow hydraulics, sediment transport, and flooding as part of the DPD Fish Passage Improvement Project.

USACE. 2003. *Daguerre Point Dam Fish Passage Improvement Project – Alternative Concepts Evaluation.* Prepared for ENTRIX, Inc. by W. Rodgers, Inc. September 2003.

USACE (2003) focused conceptually on improving fish passage for native anadromous fish species at DPD while maintaining water interests and flood management. Project alternative feasibility was assessed with consideration given to fisheries benefits and limitations, environmental impacts, sediment/mercury containment, water supply impacts, operation and maintenance requirements, engineering and construction demands, and economics.

YCWA. 2003. *Initial Study/Proposed Mitigated Negative Declaration for the Narrows 2 Powerplant Flow Bypass System Project*. November 2003.

The Initial Study (YCWA 2003) addressed the environmental impacts of construction and operation of a synchronous full-flow bypass at YCWA's Narrows 2 Powerplant. Prior to implementation of the Narrows 2 Powerplant Full-flow Bypass System, the Narrows 2 Powerplant did not allow the full-flow capacity to be bypassed during non-operation. Even a brief loss of power resulted in a substantial loss of river flow. YCWA (2003) suggested that any facility shutdowns, particularly those occurring during the warm and dry summer months, could result in flow and temperature conditions in the lower Yuba River potentially detrimental to fish by increasing water temperatures in the river above physiologically suitable levels, or reducing flow magnitude to levels that could result in redd dewatering or juvenile stranding.

The primary objectives of the Narrows 2 Powerplant Full-flow Bypass System Project were to: (1) maintain more stable releases from the Narrows 2 Powerplant during emergency and maintenance shutdowns at the same flow rate as was being discharged before the shutdown occurred; and (2) make the flow fluctuation and reduction criteria stated in YCWA's FERC License No. 2246 more protective of downstream fish species than the criteria that were previously stated in that license. Detailed information on the population status, lifestages, general population trends, and critical habitat for Central Valley spring-run Chinook salmon and Central Valley steelhead in the lower Yuba was provided in Appendix B to the IS/MND.

Since the issuance of the SWRCB Yuba Accord Water Rights Decision (D-1644) in March 2008, a full-flow bypass structure has been installed on the Narrows 2 hydropower facility which will essentially eliminate the potential for detrimental flow and temperature

fluctuations to occur in the lower Yuba River associated with maintenance and operation of the Narrows 2 Powerplant.

YCWA, FERC, and NMFS. 2003. *Biological Assessment, Yuba River Development Project* (FERC No. 2246) Proposed License Amendment. Prepared for Yuba County Water Agency, Federal Energy Regulatory Commission, and National Marine Fisheries Services by Surface Water Resources, Inc.

This Biological Assessment addressed a proposed amendment to the Federal Power Act (FPA) license for Project No. 2246 issued to the YCWA by the Federal Power Commission (FPC). Pursuant to 50 CFR 402.11, YCWA filed with the Federal Energy Regulatory Commission (FERC), a definitive proposal to amend the license to: (1) authorize YCWA to construct and operate a synchronous full-flow bypass (bypass) at YCWA's Narrows II Powerhouse; and (2) revise the license's flow reduction and fluctuation criteria.

This Biological Assessment concluded that the Proposed Action generally will improve conditions for Central Valley spring-run Chinook salmon and steelhead in the lower Yuba River by largely eliminating adverse effects on those species resulting from unplanned outages at the Narrows 2 Powerhouse; the primary element of the Proposed Action that will have this effect is the installation of a synchronous full-flow bypass at the Narrows II Powerhouse. Biological effects of short-term outages were expected to be eliminated by providing essentially simultaneous restoration of flows. Biological effects of long-term outages on spring-run Chinook salmon and steelhead were expected to be eliminated by allowing YCWA to bypass almost the entire river flow without generating electricity.

CALFED and YCWA. 2005. *Draft Implementation Plan for the 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.* Prepared by Lower Yuba River Fisheries Technical Working Group. Funded by CALFED and Yuba County Water Agency. October 2005.

The purpose and goal of the CALFED and YCWA (2005) report was to facilitate the implementation of prioritized actions and studies that intended to 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.

The report described abiotic (geomorphology, water flow, and water temperature) and biotic (habitat, species-specific profile and population status) conditions in the lower Yuba River watershed to provide a technical basis for the development of species-specific conceptual models to assess how physical conditions may be affecting the anadromous fish species of primary management concern (i.e., spring- and fall-run Chinook salmon, steelhead, green sturgeon, American shad and striped bass). The conceptual models prioritized potential life-stage specific stressors that may negatively affect fish survival, growth or other critical lifecycle processes.

CALFED and YCWA (2005) identified major factors (directly flow-related) influencing the status of naturally-spawning spring-run Chinook salmon and steelhead in the lower Yuba River including: (1) restricted flow-dependent habitat availability; (2) limited habitat complexity and diversity; (3) elevated water temperatures; and (4) flow fluctuations. Major factors (not directly flow-related) influencing the status of naturally-spawning spring-run Chinook salmon and steelhead in the Yuba River were identified as: (1) blockage of historic spawning habitat resulting from the construction of the Englebright Dam in 1941, which has implications for the spatial structure of the populations; (2) impaired adult upstream passage at DPD; (3) unsuitable spawning substrate in the uppermost area (i.e., Englebright Dam to the Narrows) of the lower Yuba River; (4) limited riparian habitats, riverine aquatic habitats for salmonid rearing, and natural river function and morphology; and (5) impaired juvenile downstream passage at DPD.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. *Updated status of federally listed ESUs of West Coast salmon and steelhead.* U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-66, 598 p.

This report summarizes biological information updated from the 1999 status review for the 26 ESUs of listed salmon and steelhead, and one candidate ESU (lower Columbia coho salmon), and presents the team's conclusions regarding the current risk status of the these ESUs. The status of the Central Valley spring-run Chinook salmon ESU, which includes populations found on the Yuba River, was formally assessed during a coastwide status review (Myers et al. 1998). In June 1999, a BRT convened to update the status of this ESU by summarizing information and comments received since the 1997 status review and presenting BRT conclusions concerning four deferred Central Valley Chinook salmon ESUs (NMFS 1999). The Good et al. (2005) Biological Review Team (BRT) consisted of scientists from the NMFS Northwest and Southwest Fisheries Science Centers, and supplemented by experts on particular species from NMFS and other federal agencies

Good et al. (2005) suggests that previous status reviews were focused primarily on risk assessments, and (apart from the discussion of resident fish in steelhead ESUs) did not consider issues associated with the geographic boundaries, artificial propagation, or non-anadromous resident forms of ESUs. These issues, as well as hatchery information from the Salmon and Steelhead Hatchery Assessment Group (SSHAG), and updated stock histories and biological information for every hatchery population, were further reviewed by Good et al. (2005) to obtain a better understanding of the nature and role of hatcheries associated with each listed ESU and to facilitate conclusions about the ESU/DPS status of resident fish.

Good et al. (2005) reports that of the numerous populations of Central Valley spring-run Chinook salmon once inhabiting Sierra Nevada streams, only the Feather River and Yuba River populations remain. The BRT indicates that little is known about the status of the spring-run Chinook salmon population on the Yuba River, other than that it appears to be small (Good et al. 2005).

The Feather and Yuba rivers contain populations that are thought to be significantly influenced by the Feather River Hatchery spring-run Chinook salmon stock. The Feather River Hatchery spring-run Chinook salmon program releases its production far downstream of the hatchery, causing high rates of straying (CDFG 2001a). The BRT suggests there is concern that Central Valley fall-run and spring-run Chinook salmon have hybridized, and that the Feather River Central Valley spring-run Chinook salmon population is depends on Feather River Hatchery production (Good et al. 2005). The BRT reports the Feather River Hatchery stocks as a major threat to the genetic integrity of the remaining wild, spring-run Chinook salmon populations.

Good et al. (2005) indicates that Yuba River spring-run Chinook salmon, Feather River Hatchery spring-run Chinook salmon, and putative Feather River natural spring-run Chinook salmon, were categorized into a large cluster composed mostly of natural- and hatchery-origin fall-run Chinook salmon. In the original Chinook salmon status review conducted by Myers et al. (1998), a majority of the BRT members concluded that the Central Valley spring-run Chinook salmon ESU was in danger of extinction (Good et al. 2005). Listing of this ESU was deferred, and in the status review update conducted by NMFS (1999), the BRT majority shifted to the view that this ESU was not in danger of extinction, but was likely to become endangered in the foreseeable future (Good et al. 2005). A major reason for this shift was data indicating that a large run of spring-run Chinook salmon on Butte Creek in 1998 was naturally produced, rather than strays from Feather River Hatchery. Naturally spawning spring-run Chinook salmon in the Feather River were included in the listing, but the Feather River Hatchery stock of spring-run Chinook salmon was excluded. Little is known about the status of the spring-run Chinook salmon population on the Yuba River, other than that it appears to be small.

NMFS. 2005. *Preliminary Biological Opinion Based on Review of the Proposed Yuba River Development Project License Amendment for Federal Energy Regulatory Commission License No. 2246, Located on the Yuba River in Yuba County, California, and Its Effects on Threatened Central Valley Spring-Run Chinook Salmon (Oncorhynchus Tshawytscha) and Central Valley Steelhead (O. Mykiss), in Accordance With Section 7 of the Endangered Species Act of 1973, As Amended.* November 4, 2005.

NMFS issued a preliminary biological opinion (BO) to FERC which analyzed the potential effects of the proposed Yuba River Development Plan License Amendment (FERC License No. 2246) on threatened Central Valley spring-run Chinook salmon and Central Valley steelhead. Subsequent to the completion of this BO, the action area was proposed for designation as critical habitat for these two fish species, as well as for the southern-DPS of North America green sturgeon. A final rule designating critical habitat was published September 2, 2005 (70 FR 52488) and became effective January 2, 2006. Therefore the NMFS (2005) Preliminary BO as a final BO considering effects of the Yuba River Development Plan on Central Valley spring-run Chinook salmon and Central Valley steelhead, and as a conference opinion considering project effects on the Southern-DPS of North American green sturgeon.

NMFS (2005) provided a review of available information that generally described life history characteristics for lower Yuba River threatened species. NMFS (2005) reported that a loss of habitat and altered instream flow conditions were the primary factors affecting the status of critical habitat for spring-run Chinook salmon. Additionally, NMFS (2005) reported that predation by striped bass and largemouth bass may be exacerbated by the alteration of natural flow regimes and structures.

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

This draft report presented flow-habitat relationships for spring- and fall-run Chinook salmon and steelhead/rainbow trout spawning in the lower Yuba River. This draft report used the 2-dimensional hydraulic model River2D and habitat suitability criteria (HSC) developed for the lower Yuba River from data collected during 2000 – 2004. Representatives of YCWA, PG&E, and UC Davis submitted comments on this draft report, requesting necessary revisions to the hydraulic model, and particularly to the HSC development. Although the report was revised in March 2008, The issues raised in the comments remain unresolved.

Lindley, S., R. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2007. *Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin.* San Francisco Estuary & Watershed Science Volume 5: California Bay-Delta Authority Science Program and the John Muir Institute of the Environment.

This report provided a framework to assess the viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin basin, and included some information regarding the Yuba River. Lindley et al. (2007) reported that adult Chinook salmon expressing the phenotypic timing of adult immigration associated with spring-run Chinook salmon persisted and spawned in the lower Yuba River below the Englebright Dam, and that the lower Yuba River is among the last Central Valley floor tributaries supporting populations of naturally-spawning spring-run Chinook salmon and steelhead. They reported that in the long-term, the Yuba River has high potential for maintaining suitable anadromous salmonid habitat, despite the expected long-term climate warming, and that under the expected climate warming scenario of about 5°C by the year 2100, substantial salmonid habitat would be lost in the Central Valley, with the Yuba River being one of the only Central Valley tributaries with significant amounts of habitat remaining.

YCWA. 2007. *Draft Environmental Impact Report/Environmental Impact Statement for the Proposed Lower Yuba River Accord.* Prepared for the Department of Water Resources, Bureau of Reclamation and Yuba County Water Agency by HDR|SWRI. June 2007.

The Draft EIR/EIS for the Proposed Lower Yuba River Accord provided a comprehensive compilation of existing information regarding the aquatic resources of the lower Yuba River, as well as descriptions of the development of the Yuba Accord flow schedules and impact evaluation. The Fisheries Chapter of the Draft EIR/EIS consisted of 411 pages, with over 15,000 pages of related model output in the Appendices. Provided below is a brief summary of the most relevant information presented in YCWA (2007) regarding population characteristics of spring-run Chinook salmon and steelhead, and development of the Yuba Accord flow schedules.

Population Characteristics

The spring-run Chinook salmon spawning period extends from September through November, while the embryo incubation life stage generally extends from September to March. Limited redd surveys during late-August and September conducted by CDFG have detected spawning activities beginning during the first or second week of September. They have not detected a bimodal distribution of spawning activities (i.e., a distinct spring-run spawning period followed by a distinct fall-run Chinook salmon spawning period) but instead have detected a slow build-up of spawning activities starting in early September and transitioning into the main fall-run spawning period.

Spring-run Chinook salmon juveniles are believed to rear in the lower Yuba River year-round. In general, juvenile Chinook salmon have been observed throughout the lower Yuba River, but with higher abundances above DPD. This may be due to larger numbers of spawners, greater amounts of more complex, high-quality cover, and lower densities of predators such as striped bass and American shad, which reportedly are restricted to areas below DPD (YCWA 2007).

The spring-run Chinook salmon smolt emigration period is believed to extend from November through June, although based on CDFG's run-specific determinations, the vast majority (approximately 94 percent) of spring-run Chinook salmon were captured as post-emergent fry during November and December, with a relatively small percentage (nearly 6 percent) of individuals remaining in the lower Yuba River and captured as YOY from January through March. Only 0.6 percent of the juvenile Chinook salmon identified as spring-run were captured during April, 0.1 percent during May, and none were captured during June (YCWA 2007).

Steelhead adult immigration and holding in the lower Yuba River extends from August through March (YCWA 2007). Spawning generally extends from January through April, primarily occurring in reaches upstream of DPD. The embryo incubation life stage generally extends from January through May. Juvenile steelhead/rainbow trout are believed to rear in the lower Yuba River year-round.

Steelhead/rainbow trout juveniles have been observed moving downstream past the lower portion of the lower Yuba River during spring and summer months. However, at least some of this downstream movement may be associated with the pattern of flows in the river. Based upon the substantial differences in juvenile steelhead/rainbow trout downstream movements (RST catch data) noted between the 2001 study, and the 2002 and 2004 studies, it is apparent that the increases in juvenile steelhead downstream movement associated with the initiation of the 2001 water transfers were avoided due to a more gradual ramping-up of flows that occurred in 2002 and 2004. The steelhead smolt emigration period is believed to extend from October through May (YCWA 2007).

Yuba Accord Flow Schedules

Development of the flow schedules and the three agreements that comprise the Yuba Accord was a collaborative process that took place over a period of approximately two and a half years. The flow schedules were developed by a Technical Team of biologists representing YCWA, the NGOs, CDFG, NMFS, and USFWS with the express goal of optimizing fisheries conditions in the lower Yuba River. During development of the flow regime for the Yuba Accord, extensive stressor analyses were undertaken which principally considered steelhead, spring-run Chinook salmon, and fall-run Chinook salmon.

A suite of six flow schedules, plus Conference Year rules for 1-in-100 critically dry years, were developed and are based on water availability, including inflow into New Bullards Bar Reservoir and reservoir carry-over storage. In addition to the biological and other science-based considerations, 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). Based on computer simulation model results, the estimated predicted probabilities of occurrence over the 78-year period of hydrologic record indicate that the two most optimum flow schedules (1 and 2) would be achieved nearly 80 percent of the time.

To support the impact analyses conducted for the Yuba Accord EIR/EIS, hydrologic modeling was used to simulate potential changes in flows and water temperatures in the lower Yuba River that would be expected to occur as a result of implementing the Yuba Accord. The fisheries analyses utilized several methodologies to evaluate project-related impacts, including: (1) a flow-duration assessment; (2) evaluation of flow dependent spawning habitat availability expressed as weighted usable area; and (3) utilization of available data on flow and water temperature relationships to determine the cumulative probabilistic distribution of water temperatures for each month at a given river location.

A statistical water temperature model was developed to evaluate the potential impacts of the alternatives considered in the Yuba Accord EIR/EIS. The statistical model was used to estimate the effects of various New Bullards Bar Reservoir storage regimes, flow releases, and diversions at DPD on water temperatures in the lower Yuba River.

Water temperature evaluations conducted for the Yuba Accord EIR/EIS indicated that Yuba River water temperatures generally remain suitable for all life stages of spring-run Chinook salmon and steelhead with implementation of the Yuba Accord flow schedules. Water temperatures generally remained below 58°F year-round (including summer months) at Smartsville, and generally remain below 60°F year-round at DPD. At Marysville, water temperatures generally remain below 60°F from October through May, and generally remain below 65°F from June through September.

Gard, M. 2008a. *Flow-Habitat Relationships for Juvenile Spring/Fall-Run Chinook Salmon and Steelhead/Rainbow Trout Rearing in the Yuba River.* Draft report prepared by the Energy Planning and Instream Flow Branch of the USFWS, Sacramento, CA.

This draft report presented flow-habitat relationships for spring- and fall-run Chinook salmon and steelhead/rainbow trout juvenile rearing in the lower Yuba River. This draft report used the 2-Dimensional hydraulic model River2D and habitat suitability criteria (HSC) developed for the lower Yuba River from data collected during 2003 – 2005. Representatives of YCWA, PG&E, and UC Davis submitted comments on the draft report requesting necessary revisions to the hydraulic model and HSC development. These comments have not been addressed to date.

Gard, M. 2008b. *Sensitivity Analysis for Flow-Habitat Relationships for Steelhead/Rainbow Trout Spawning in the Yuba River.* Draft report prepared by the Energy Planning and Instream Flow Branch of the USFWS, Sacramento, CA.

This draft report presented a sensitivity analysis that was conducted to examine the effects of alternative criteria on flow-habitat relationships and biological validation for steelhead/rainbow trout spawning in the lower Yuba River. This draft report did not resolve the comments made by representatives of YCWA, PG&E and UC Davis on the Gard 2007 draft report.

Gard, M. 2008c. *Relationships Between Flow Fluctuations and Redd Dewatering and Juvenile Stranding for Chinook Salmon and Steelhead/Rainbow Trout in the Yuba River.* Draft report prepared by the Energy Planning and Instream Flow Branch of the USFWS, Sacramento, CA.

This draft report presented potential relationships between lower Yuba River flow fluctuations and Chinook salmon and steelhead/rainbow trout redd dewatering and juvenile entrapment stranding. These relationships were presented as the percentages of spawning habitat dewatered and area stranded with different flow reductions. The draft report assumed that juvenile salmon would be stranded if the depth at the stranding point is less than the minimum depth at which Gard (2008a) found juvenile salmon during juvenile habitat suitability data collection, and that there would be insufficient intra-gravel flow through a redd if the mean water column velocity at the redd was less than the lowest velocity at which Gard (2007) found a salmonid redd in the lower Yuba River. YCWA has provided comments on this draft report.

NMFS. 2009. *Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon, and the Distinct Population Segment of Central Valley Steelhead.* National Marine Fisheries Service, Southwest Regional Office, Sacramento, California. October 2009.

The NMFS (2009) Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon, and the Distinct Population Segment of Central Valley Steelhead ("Draft Recovery Plan") recognizes the importance and potential to increase spring-run Chinook salmon and steelhead populations in the lower Yuba River. The Draft Recovery Plan (NMFS 2009) established three priority levels to help guide recovery efforts for watersheds that are currently occupied, and are referred to as Core 1, 2, and 3 populations. Core 1 Populations are highest priority, have a known ability or potential to support viable populations, and have the capacity to respond to recovery actions. Spring-run Chinook salmon and steelhead in the lower Yuba River are Core 1 populations. Core 1 populations form the foundation of the recovery strategy, and should be the first focus of an overall recovery effort (NMFS 2009).

The Draft Recovery Plan (NMFS 2009) states that "*…many of the processes and conditions that are necessary to support a viable independent population of spring-run Chinook salmon can be improved with provision of appropriate instream flow regimes, water temperatures, and habitat availability. Continued implementation of the Yuba Accord is expected to address these factors and considerably improve conditions in the lower Yuba River*".

The lower Yuba River, downstream of Englebright Dam, was characterized as having a high potential to support viable populations of spring-run Chinook salmon and steelhead, primarily because: (1) the river supports persistent populations of spring-run Chinook salmon and steelhead; (2) flow and water temperature conditions are generally suitable to support all life stage requirements; (3) the river does not have a hatchery on it; (4) spawning habitat availability does not appear to be limiting; and (5) there is high habitat restoration potential (NMFS 2009).

The Draft Plan (NMFS 2009) states, that in order to secure a viable independent population of spring-run Chinook salmon, and to secure the extant population and promote a viable population of steelhead in the lower Yuba River, several key near-term and long-term habitat restoration actions were identified, including the following:

- Continued implementation of the Yuba Accord flow schedules to provide suitable habitat (flow and water temperature) conditions for all life stages
- Improvements to adult salmonid upstream passage at DPD
- Improvements to juvenile salmonid downstream passage at DPD
- Implementation of a spawning gravel augmentation program in the uppermost reach (i.e., Englebright Dam to the Narrows) of the lower Yuba River
- Improvements to riparian habitats for juvenile salmonid rearing
- Creation and restoration of side-channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas
- Implementation of projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing

The Draft Plan (NMFS 2009) identified the following Priority 1 recovery actions for the Yuba River: (1) develop and implement a phased approach to salmon reintroduction planning to recolonize historic habitats above Englebright Dam; and (2) improve spawning habitat in the lower Yuba River by gravel restoration program below Englebright Dam and improve rearing habitat by increasing floodplain habitat availability.

Comments on the Draft Recovery Plan (NMFS 2009), including issues specific to the lower Yuba River and the Yuba River Watershed, have been provided to NMFS. FR (51553-51555) states that all comments received by the due date will be considered before NMFS' decision whether to adopt a final recovery plan. NMFS (74 FR 51553) specifically states that it will consider and address all substantive comments received during the comment period. A Final Recovery Plan has not yet been issued.

CDFG and PG&E. 2009. *Draft Habitat Expansion Agreement for Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead.* November 2009.

PG&E and CDWR entered into the *Habitat Expansion Agreement for Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead* (HEA) effective November 20, 2007, with multiple government and non-government entities including American Rivers, Arthur G. Baggett, Jr., CDFG, U.S. Department of Agriculture Forest Service, NMFS, USFWS, and the State Water Contractors. The overall goal of the HEA is to expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon (and steelhead) in the Sacramento River Basin. Specifically, the Habitat Expansion Threshold (HET) is to expand spawning, rearing and adult habitat sufficiently to accommodate an annual estimated net increase of 2,000 to 3,000 spring-run Chinook salmon for spawning in the Sacramento River Basin. The HET is focused on spring-run Chinook salmon as the priority species, because expansion of habitat for spring-run Chinook salmon typically accommodates steelhead as well (CDFG and PG&E 2009). The intent of the HEA is to create "permanent" solutions to problems which provide benefits through the term duration of a typical FERC license (i.e., up to 50 years).

Substantial efforts have been undertaken to identify, develop and consider the relative merits of habitat restoration actions in the lower Yuba River. The need for, identification of, and relative merits of the actions to expand habitat and accomplish the goals of the Oroville FERC Relicensing HEA regarding biological, physical and operational considerations pertinent to the lower Yuba River were presented in a report as Appendix G to the Draft

HEA during early November 2009. The lower Yuba River has been designated as having a high potential to meet the HEA goals and thresholds. A Final HEA has not yet been adopted.

ONGOING DATA COLLECTION, MONITORING AND EVALUATION ACTIVITIES

LOWER YUBA RIVER ACCORD MONITORING AND EVALUATION PROGRAM

The Yuba Accord River Management Team (RMT) is comprised of representatives of YCWA, NMFS, USFWS, CDFG, PG&E, CDWR, and the non-governmental organizations (NGOs) that are parties to the Fisheries Agreement of the Yuba Accord (South Yuba River Citizens League, Trout Unlimited, Friends of the River, The Bay Institute). The RMT, in collaboration with representatives from University of California at Davis and the Pacific States Marine Fisheries Commission, has developed a Monitoring and Evaluation Program (M&E Program) to guide the efficient expenditure of approximately $6 million to evaluate the effects of implementation of the Yuba Accord on the aquatic resources of the lower Yuba River over the period extending from 2008 to 2016. Monitoring and data from implementation of the M&E Program will be complied into annual reports and available at the RMT website www.yubaaccordrmt.com. The M&E Program embraces a monitoring-based adaptive management approach to increase the effectiveness of, and to address the scientific uncertainty associated with, specific monitoring and study activities, and restoration actions. Within the framework of this M&E Program, the RMT retains the flexibility to revise monitoring actions to address specific issues or obtain additional information. In addition, the parties to the Fisheries Agreement of the Yuba Accord intended that the monitoring and data collection activities implemented via the M&E Program will produce a useful database for the proceedings of the Federal Energy Regulatory Commission (FERC) regarding the relicensing of YCWA's Yuba River Development Project.

In addition to monitoring and evaluation of the fish community, the fisheries evaluations in this M&E Program focus on steelhead/rainbow trout and the two principal Chinook salmon runs that are known to use the lower Yuba River (i.e., fall-run and spring-run[1,2] Chinook salmon), although evaluations of Chinook salmon exhibiting the phenotypic characterization of lifestage

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[1] Federally listed as threatened.
[2] State listed as threatened.

periodicities associated with late fall-run Chinook salmon also are included[3]. Regarding steelhead/rainbow trout, the physical appearance of adults and the presence of seasonal runs and year-round residents indicate that both sea-run (steelhead[1]) and resident rainbow trout exist in the lower Yuba River. Thus, it is recognized that both anadromous and resident lifehistory strategies of *O. mykiss* have been and continue to be present in the lower Yuba River, resulting in the use of the term "steelhead/rainbow trout" when referring to *O. mykiss* in this document.

The primary purpose of the M&E Program is to provide the monitoring data necessary to evaluate whether implementation of the Yuba Accord will maintain fish resources (i.e., the fish community including native fish and non-native fish) of the lower Yuba River in good condition, and will maintain viable anadromous salmonid populations. The "Viable Salmonid Population" (VSP) concept was developed by McElhany et al. (2000; as cited in the M&E Program) in order to facilitate establishment of Evolutionarily Significant Unit (ESU)-level delisting goals and to assist in recovery planning by identifying key parameters related to population viability. Four key parameters were identified by McElhaney et al. (2000; as cited in the M&E Program) as the key to evaluating population viability status, including: (1) abundance; (2) productivity; (3) diversity; and (4) spatial structure. McElhaney et al. (2000; as cited in the M&E Program) interchangeably use the term population growth rate (i.e., productivity over the entire life cycle) and productivity. Good et al. (2007; as cited in the M&E Program) used the term productivity when describing this VSP parameter, which also is the term used for this parameter in the Yuba Accord M&E Program.

Abundance is an important determinant of risk, both by itself and in relationship to other factors (McElhaney et al. 2000 as cited in the M&E Program). Small populations are at a greater risk for extinction than larger populations because risks that affect the population dynamics operate differently on small populations than in large populations. A variety of risks are associated with the dynamics of small populations, including directional effects (i.e., density dependence - compensatory and depensatory), and random effects (i.e., demographic stochasticity, environmental stochasticity, and catastrophic events).

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[3] Although late fall-run Chinook salmon populations occur primarily in the Sacramento River (CDFG Website 2007), use of the lower Yuba River by late fall-run Chinook salmon has been reported to occur (D. Massa, CDFG, pers. comm.; M. Tucker, NMFS, pers. comm.). When the various studies addressing steelhead and spring-run and fall-run Chinook salmon are conducted, the collected data will be analyzed to examine Chinook salmon exhibiting phenotypic characterizations of late fall-run Chinook salmon.

The parameter of productivity and factors that affect productivity provide information on how well a population is "performing" in the habitats it occupies during the life cycle (McElhaney et al. 2000 as cited in the M&E Program). Productivity and related attributes are indicators of a population's performance in response to its environment and environmental change and variability. Intrinsic productivity (the maximum production expected for a population sufficiently small relative to its resource supply not to experience density dependence), the intensity of density dependence, and stage-specific productivity (productivity realized over a particular part of the life cycle) are useful in assessing productivity of a population.

Diversity refers to the distribution of traits within and among populations, and these traits range in scale from DNA sequence variation at single genes to complex life-history traits (McElhaney et al. 2000 as cited in the M&E Program). Traits can be completely genetic or vary do to a combination of genetics and environmental factors. Diversity in traits is an important parameter because: (1) diversity allows a species to use a wide array of environments; (2) diversity protects a species against short-term spatial and temporal changes in its environment; and (3) genetic diversity provides the raw material for surviving long-term environmental changes (McElhaney et al. 2000 as cited in the M&E Program). Some of the varying traits include run timing, spawning timing, age structure, outmigration timing, etc. Straying and gene flow strongly influence patterns of diversity within and among populations (McElhaney et al. 2000 as cited in the M&E Program).

Spatial structure reflects how abundance is distributed among available or potentially available habitats, and how it can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change. A population's spatial structure encompasses the geographic distribution of that population, as well as the processes that generate or affect that distribution (McElhaney et al. 2000 as cited in the M&E Program). A population's spatial structure depends fundamentally on habitat quality, spatial configuration, and dynamics as well as the dispersal characteristics of individuals in the population. Potentially suitable but unused habitat is an indication of the potential for population growth.

In the Yuba Accord M&E Program, performance indicators associated with each of the VSP parameters (Abundance, Productivity, Diversity and Spatial Structure) and analytical steps ("analytics") to address each of these performance indicators are provided separately for the adult and juvenile lifestages of the anadromous salmonids (including spring-run Chinook salmon and steelhead) in the lower Yuba River. In addition, each section includes examinations of potential relationships between measures of VSP parameters, and flows and water temperatures resulting from implementation of the Yuba Accord. Data for the analytics associated with the performance indicators for the VSP parameters, and for examination of potential relationships between measures of VSP parameters and flows and water temperatures are obtained from the specific sampling protocols and procedures. The RMT has developed the following Protocols and Procedures in accordance with the Yuba Accord M&E Program:

1) Flow and Water Temperature Monitoring
2) Topographic Mapping (Digital Elevation Model) – *physical habitat assessment*
3) Substrate and Cover Mapping – *spawning/juvenile rearing habitat characterization*
4) 2-D Hydrodynamic Modeling – *physical habitat dynamics and availability*
5) Mesohabitat Classification – *physical habitat characterization*
6) Riparian Vegetation Mapping – *juvenile rearing habitat characterization*
7) Acoustic Tagging and Tracking – *Chinook salmon immigration and holding*
8) VAKI Riverwatcher Monitoring – *adult immigration, temporal distribution*
9) Redd Surveys – *spawning spatial and temporal distribution, habitat utilization*
10) Carcass Surveys – *spawning stock escapement estimation*
11) Snorkel Surveys – *juvenile rearing, spatial/temporal distribution, habitat utilization*
12) Rotary Screw Trapping – *juvenile emigration, temporal distribution*
13) Genetic Sampling and Characterization – *Chinook salmon run differentiation*
14) Otolith Sampling and Characterization – *natal stream origin, growth, age, and size*

Each of the Yuba Accord M&E Program Protocols and Procedures prepared by the Yuba Accord RMT are summarized below. Detailed descriptions of each of the Protocols and Procedures may be referenced at www.yubaaccordrmt.com.

1) Flow and Water Temperature Monitoring

The lower Yuba River Accord consists of a Fisheries Agreement that requires YCWA to comply with the Yuba Accord flow schedules. In addition to simply documenting the flows and water temperatures in the lower Yuba River associated with implementation of the Yuba Accord, the overarching goal of the flow and water temperature monitoring is to provide the data to identify and evaluate potential relationships between flows and water temperatures with fish population/community responses, measures of Viable Salmonid Population parameters, and aquatic habitat attributes.

Flow and water temperature monitoring is considered to be a long-term effort to track in-river water temperature conditions over time with the implementation of the Yuba Accord. Water temperature monitoring is anticipated to be conducted annually for at least five years, from 2008/2009 through 2013/2014. The RMT will review the data and reports on an annual basis, and determine whether the overall duration of the water temperature monitoring study plan should be modified.

In the lower Yuba River, water temperature data loggers are deployed in the main channel at the following stations: (1) at Simpson Lane (RM 3); (2) at Marysville (RM 6); (3) at Walnut Avenue (RM 8.1); (4) at DPD (RM 11.4); (5) upstream of DPD (RM 13.2); (6) downstream of Dry Creek (RM 13.3); (7) at Long Bar (RM 16.0); (8) at Parks Bar (RM 17.4); (9) downstream of Deer Creek (RM 22.7); (10) downstream of Narrows 2 Powerhouse at Smartsville (RM 23.6); and (11)in Narrows 2 Powerhouse Penstock (RM 23.9)

In the Feather River, thermographs are deployed at the following stations: (1) one mile upstream of the Yuba River confluence (RM +1); (2) the left (east) bank at the Yuba River confluence (RM 0); and (3) the right (west) bank at the Yuba River confluence (RM 0).

Streamflow gages in the lower Yuba River are located at the following locations: (1) Smartsville downstream of Narrows 2 (USGS 11419000; PG&E NY28); and (2) Marysville (USGS 11421000).

Stream water temperatures in the Feather and lower Yuba rivers are monitored using StowAway Tidbits (Onset Computer Corporation) water temperature recorders that have 12-bit resolution with a minimum accuracy of +/- 0.2° C. All temperature data loggers are programmed to record water temperatures at 15 minute intervals. Redundant water temperature loggers are installed at each site as close as possible to the primary recorders.

Water temperature recorders are secured in the channel by a cable to a root mass, tree trunk, or man-made structure, or secured using embedded rebar where necessary. A GPS coordinate is taken and recorded at each installation point, along with other points that may be useful for retrieving the recorder (i.e., point lacks a distinct trail for access). Photographs are taken of each site, including recorder installation configuration.

The loggers are retrieved at approximately monthly intervals to check their status and download new data. During each visit, water temperature data are downloaded into an optic shuttle or directly to a personal computer. Prior to each download of the water temperature data, a National Institute of Standards and Technology (NIST) traceable digital thermometer is used to measure the water temperature at the recorder, and compared to the last logger reading to check for accuracy drift of the recorder. Only after the raw water temperature data is downloaded and safely backed-up is the optic shuttle cleared or data used. Data recorded for each site visit includes: (1) date; (2) time; (3) station ID; (4) field team; (5) air temperature; (6) water temperature (NIST); (7) current weather; (8) site notes (i.e., vandalism, logger replacement, etc); (9) download file name; (10) backup file name; (11) GPS coordinates (first visit); and (12) photo numbers (first visit or when appropriate).

Concurrent with in-river data retrieval activities each month, electronic records of flow data recorded at Smartsville and Marysville is obtained from the California Data Exchange (http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=YRS) and/or from YCWA. These data are saved into the flow and water temperature monitoring database for use during preparation of the annual reports.

2) Topographic Mapping (Digital Elevation Model)

The overarching goal of the Topographic Mapping and Digital Elevation Model (DEM) Protocol and Procedure is to provide a highly detailed dataset to be used in the assessments of physical habitat, and in the identification and evaluation of potential relationships between flows and water temperatures with fish population/community responses and aquatic habitat attributes. Methods to obtain the data necessary to develop a detailed topographic map of the lower Yuba River include both airborne Light Detection And Ranging (LIDAR) mapping of the terrestrial river corridor and boat-based echo-sounding of the submerged river channel.

Lower Yuba River LIDAR data was acquired on September 21, 2008. On that day, the Yuba River discharge at Smartsville was constant at 860 cfs, Deer Creek was at 3 cfs, and Marysville was at 622 cfs. Bathymetric data was acquired on multiple dates: August 19, 20, 22, 25, and 26, 2008; September 16, 17, 18, and 19, 2008; March 4-6, 2009; May 6, 15, 20, 2009.

The topographic map of the lower Yuba River was completed during April 2010.

The study area for this protocol and procedure is the river corridor of the lower Yuba River extending from Englebright Dam to the confluence of the Yuba and Feather rivers (near Marysville, California).

After the flight, data was directly processed and reduced to obtain a detailed “bare earth” only dataset with a vertical accuracy of approximately 0.15-m, which is the level of resolution prescribed by the rigorous Class 1 standard. The spatial resolution for this protocol is 1 point every 0.738-m (1 pt per ~2 ft). The LIDAR survey also yielded the intensity of the LIDAR return signal at each point, rasterized to yield a black and white image of the river corridor, which serves as a base map for GIS and was used to construct a polygon shapefile of the water’s edge. Data points from the LIDAR survey were imported into ArcGIS to create a DEM of the terrestrial land around the river using a standard TIN-based approach with breaklines and additional quality assurance measures.

The 2008-2009 mapping used multiple echo-sounders deployed simultaneously across the bow of the boat. A customized aluminum jet-boat was outfitted with up to five Odom Hydrotrack survey-grade fathometers (each with a 3,200-kHz transducer) and a TSS 335B motion sensor that adjusted for roll/pitch of the vessel. Position data for the fathometers was collected using real-time kinematic (RTK) GPS receiving corrections by radio from an on-site base station located on one of the pre-established benchmarks. These benchmarks were established by long-duration static surveys with an RTK GPS and then waiting to obtain "ultra precise" solutions through NOAA's Online Positioning User Service (OPUS).

Where depth permitted, the boat made cross sections on a approximate 3-m interval and performed six longitudinal transects approximately evenly spaced across the channel. To account for the water surface slope and its changes through time, Mini Troll 400 vented pressure transducers (In-situ, Inc., Fort Collins, CO) were placed in the river along the survey area and their elevations were surveyed using RTK GPS. An algorithm was used to interpolate water surface slopes based on the distance between the pressure transducers.

Position data was recorded every 1-s, and a radial filter was applied in post-processing to the boat-based data to obtain 0.6-m spacing between points, achieving the goal of obtaining bathymetric data at a resolution of 1 point per m^2 along the boat tracks.

To create the topographic map, the following items were obtained through data collection: LIDAR flight and data file tiling scheme polygon shapefile, LIDAR data coverage polygon shapefile, LIDAR intensity images (all returns), LIDAR ground-return point file (ASCII format), boat-based echo-sounder/RTKGPS point file filtered to 2-foot spacing, total station point data.

3) Substrate and Cover Mapping

Fluvial processes that are important for the lower Yuba River are influenced by a suite of hydrogeomorphic variables including channel topography, flows, substrate, and cover. A restricted amount of substrate and cover information exists for some sites on the lower Yuba River since the floods of 2006.

The objectives of the Substrate and Cover Mapping Protocol and Procedure are to: (1) produce a substrate map of the lower Yuba River; and (2) produce a cover map of the lower Yuba River. Each of these maps will then be used for a number of specific analytics in the M&E Program which includes activities such as characterization of microhabitat and mesohabitat conditions (including their spatial diversity) as well as assessment of dynamic fluvial processes and design of habitat rehabilitation projects.

Substrate and cover mapping is planned to occur during September 2010 because relatively low flows and high visibility conditions are expected to occur at that time.

The Substrate and Cover mapping Protocol and Procedure study area extends from Englebright Dam to the confluence with the lower Feather River. 2D hydrodynamic modeling of the lower Yuba River has yielded a wetted area boundary for a flow of 4,000 cfs at Smartsville, which will be converted to an ArcGIS polygon shapefile and uploaded into GPS units used by the mapping team. Substrate and cover will only be mapped in this domain. Because flow at the time of mapping will be <4,000 cfs, some of the mapping area will be on land and some underwater.

Regardless of whether the crew is on land or in water, the crew will start at Englebright Dam and work downstream one section at a time. In each section, the crew will map the substrate and cover by making three passes of the wetted channel and three passes of the terrestrial land. Each pass will consist of the following activities: (1) an initial pass to get an overview of the conditions in the section; (2) going back to the top and then mapping substrate polygons on the way down; and (3) going back to the top and then mapping all cover as points, lines, or polygons according to cover classification.

Crew members will create point, line, or polygon features of all substrates and cover features of interest using handheld differential GPS units (sub-meter accuracy) by plotting GPS coordinates while walking, driving, or boating around the perimeter of a feature. The procedure for mapping on land involves doing the three passes by walking or using an ATV, depending on accessibility for an ATV in each section and how rough the surface is for moving faster than walking speed on an ATV.

Substrate

A pre-established method for performing observational reconnaissance of the lower Yuba River substrate already exists for the salmonid redd surveys. Crew members have been trained to cover the whole submerged domain by scanning the river from the shore to the middle of the river, working downstream in a kayak. Side channels in the survey area are observed by walking. This method will be used for mapping substrate and cover. Surveyors will wear polarized sunglasses during walking or driving surveys, and use transparent bottom buckets while boating in shallow water areas. Deepwater surveys will be conducted via underwater video, snorkel, SCUBA, or other methods pending results of field-tested techniques during the spring through summer 2010.

Handheld GPS units require that each substrate polygon be larger than 5x5 m^2 to be accurately mapped, so that will be the minimum size of a substrate or cover patch recorded. However, if a substrate polygon has more than one substrate size class present in it with an area >10%, then the minimum polygon size will be 10x10 m^2. This constraint represents the consensus for balancing effort and cost relative to the needs of the dataset for analytic application.

Regardless of whether the crew is on land or in water, substrate classification categories will be used to make a “facies” map of the surficial pattern of substrate, with each area of a homogeneous substrate type mapped as a polygon. For each substrate polygon, the observer will estimate the percent of area composed of each substrate size class to the nearest 10% value, only recording those with >10% contribution. For a substrate polygon, a GPS data dictionary file accompanying the coordinates will identify the substrate classes present and the percent of each substrate class to the nearest 10%. Substrate classification categories include: (1) bedrock (no alluvium); (2) boulder field (D>256); (3) large cobble (128<D<256); (4) cobble (90<D< 128); (5) medium gravel/small cobble (32<D<90); (6) fine gravel (2<D<32); (7) sand (0.0625<D<2); and (8) silt/clay (D<0.0625).

Cover

For individual wood elements, length and mid-point diameter will be obtained using a tape measure and tree caliper, with recorded accuracies of ±5 cm and ±2 cm, respectively. Origins should be identified as bank erosion when roots are present, as cut or placed when evident by visual inspection, as limb breakage when the large wood piece could be matched up with a nearby scar on a riparian tree, and as unknown in all other cases.

For boulders, diameter should be measured with a tape measure and the angularity designated as angular (i.e., having sharp edges), well-rounded, or unknown. The following classification will be used to characterize cover on the lower Yuba River: (1) wood log (≥3 m long by ≥10 cm diameter); (2) wood jam (≥3 m); (3) boulder (>3 m); (4) boulder cluster (>3 m); (5) undercut bank (>3 m); (6) submerged aquatic (>3 m); (7) wetted channel woody vegetation (> 3 m long by >1 m above substrate); (8) overhanging riparian vegetation (> 3 m in longest dimension and >1 m above substrate); and (9) human detritus by name (car, cement block, refrigerator, and other items. ≥3-m long by ≥10-cm diameter).

4) 2-D Hydrodynamic Modeling

Two-dimensional (2D) numerical models solve vertically integrated conservation of momentum and mass equations using a finite element, finite difference, or finite volume computation method to acquire local water depth and depth-averaged 2D velocity vectors at each node in a computational mesh. These models further add the ability to consider full lateral and longitudinal variability down to the sub-meter scale, including effects of alternate bars, transverse bars, islands, and boulder complexes, but require highly detailed topographic maps of channels and floodplains. Four different 2D numerical models have been used on the lower Yuba River, including FLO-2D, RIVER2D, FESWMS, and SRH-2D. SRH-2D is a relatively new model that spans many of the capabilities of FLO-2D, RIVER2D and FESWMS, but it is more computationally efficient and numerically stable, so it can be used to simulate long river segments in very high resolution.

Presently, the Yuba Accord RMT is using SRH-2D to simulate hydraulics for the entire lower Yuba River downstream of the Highway 20 Bridge with 1-m intermodal spacing. To achieve this more efficiently, the lower Yuba River has been divided into three reaches: (1) Highway 20 Bridge to DPD; (2) DPD to the USGS Marysville gaging station; and (3) USGS Marysville gaging station to the confluence of the Yuba and Feather rivers. SRH-2D models of each reach are being run concurrently. Presently, the model is being run at variable discharges to test the model against available data. Subsequently, 4 flows between 700 and 4,500 cfs (at the Smartsville gage) will be simulated.

SRH-2D uses a flexible mesh that may contain arbitrarily shaped cells. A hybrid mesh may achieve the best compromise between solution accuracy and computing demand. SRH-2D adopts very robust and stable numerical schemes with a seamless wetting-drying algorithm. The resultant outcome is that few tuning parameters are needed to obtain the final solution.

SRH-2D was evolved from SRH-W which had the additional capability of watershed runoff modeling. Many features are improved from SRH-W. As described by the USBR Technical Service Center, Sedimentation and River Hydraulics Group website (http://www.usbr.gov/pmts/sediment/model/srh2d/index.html), SRH-2D features include: (1) 2D depth-averaged dynamic wave equations (standard St. Venant equations) are solved with the finite-volume numerical method; (2) steady state (with constant discharge) or unsteady flows (with flow hydrograph) may be simulated; (3) an implicit scheme is used for time integration to achieve solution robustness and efficiency; (4) an unstructured, arbitrarily-shaped mesh is used which includes the structured quadrilateral mesh, the purely triangular mesh, a combination of the two, or a Cartesian or raster mesh; (5) all flow regimes (i.e., subcritical, transcritical, and supercritical flows) may be simulated simultaneously without the need for special treatments; (6) robust and seamless wetting-drying algorithm; and (7) solved variables include water surface elevation, water depth, and depth-averaged velocity.

5) Mesohabitat Classification

The M&E Program recognizes that the processes creating microhabitat are dynamic and spatially diverse, and management of a river that undergoes periodic planform changes requires more than a static depiction of microhabitat conditions. Consequently, “mesohabitat” is defined as the interdependent set of microhabitat variables (depth, velocity, substrate, cover, and hyporheic parameters) over a discernible landform known as a morphological unit (i.e., scour pool, riffle, and lateral bar) associated with a specific magnitude of flow. Mesohabitats typically occur at a spatial scale of approximately 0.5 to 10 times the length scale of channel width. This spatial scale directly ties to the fluvial processes responsible for channel dynamics and thus enables a mechanistic understanding of how fluvial dynamics drives spatial structure.

Morphological units evaluated at a meso-scale can be used to explain fluvial-ecological relations and may therefore be good indicators of fish utilization patterns. The goals of the Mesohabitat Classification Protocol and Procedure are to: (1) identify mesohabitat units throughout the lower Yuba River; (2) evaluate the quality, number, size and distribution of mesohabitats for various lifestages of adult and juvenile anadromous salmonids; and (3) evaluate the maintenance of watershed processes in the lower Yuba River.

Mesohabitat characterization is planned to begin during summer of 2010 and be completed the same year.

The proposed study area for this project is the lower Yuba River from Englebright Dam to the confluence of the Yuba and Feather rivers (near Marysville, California).

This Protocol and Procedure emphasizes a GIS-based analysis of existing data layers for developing the classification, and then uses field-based reconnaissance for QA/QC and ground truthing of the classification. The key data layers required to perform GIS-based characterization of morphological units are: (1) a DEM of the river corridor; (2) a water's edge shapefile and associated digital water surface elevation model for each discharge at which mesohabitats will be characterized (the model may be obtained by overlaying the edge shapefile onto the DEM and extracting the ground elevations along the water's edge); (3) a derived water depth map made by subtracting the DEM from the water surface elevation model; and (4) aerial photography of the river at each discharge of interest.

Descriptions of the objective and numeric criteria used to delineate morphologic units incorporate concepts provided by Montgomery and Buffington (1997) and Thomson et al. (2001) (see www.yubaaccordrmt.com. for additional descriptions). Morphological units to be identified in the lower Yuba River may include the following: (1) forced pool; (2) pool; (3) chute; (4) run; (5) glide; (6) riffle entrance; (7) riffle; (8) recirculation; (9) backwater; and (10) medial bar.

Once the morphological unit classification and map is complete, a site reconnaissance will be performed by a team of two people to check the quality of the map in delineating the in-channel units. Upon arriving at a site by truck or boat, the crew will start at one end and systematically work along the river, wading or boating into each morphological unit and confirm that the depth and velocity criteria used to delineate the unit are met. Field-based delineation confirmation will consist of making 10 depth measurements using a graduated pole, and 10 water velocity measurements, using a velocity meter, at points randomly scattered around the unit. Resultant values will be compared to the criteria.

If field observations reveal a systematic error in the delineation of a specific unit, then the handheld GPS will be used to re-map the individual polygon by walking or boating around the perimeter and tracing the correct extent. Revised polygons will be imported into GIS to replace the faulty ones and boundaries of surrounding polygons will be amended to mesh with the revised boundary lines.

The definitions of the mesohabitats will be taken from the correspondingly named morphological units. Mesohabitat maps will be developed for forced pools, pools, secondary channels, backwaters, recirculations, chutes, riffles, riffle entrances, runs, and glides, using the appropriate shoreline shapefile and depth raster map.

6) Riparian Vegetation Mapping

The RMT is undertaking, collaborating or observing several riparian mapping and analysis efforts on the Yuba River below Englebright.

The California Department of Fish and Game (CDFG) mapped all riparian habitats of the Central Valley starting in the 1977. This mapping effort used large categories of vegetation type (e.g., forest, shrub, herbaceous and bare gravel bar), and would be useful to assess large changes of riparian habitat over the last 20-30 years. Known as the Katibah maps after the principal investigator, these resources are reported to exist in CDFG archives as scanned images of variable quality spatial rectification. Licensee has not been able to obtain these.

CDFG is currently mapping riparian habitats throughout the Central Valley at a similar scale as the Katibah maps, but following the National Vegetation Classification Standard and the California Vegetation Manual. A GIS layer of these maps for the lower Yuba River up to Highway 20 is expected to be available in 2011 (Diana Hixon, pers comm.).

A riparian mapping project has been initiated by the RMT. The RMT has used Light Detection and Ranging (LiDAR) data for the entire riparian corridor up to Highway 20 to yield a map of riparian structure (i.e., height and density). The RMT plans to use ground data from CDFG with the LiDAR data to develop stand classifications following the California Vegetation Manual, yet one scale finer than that being produced by CDFG. This effort is targeted for completion in late 2010.

In addition, the RMT in conjunction with University of California at Davis and YCWA have developed a topographic map and two-dimensional hydrodynamic model of the Yuba River downstream of Englebright Dam as a basis for integrating and understanding riparian trends.

Also, an analysis of historic aerial photographs and maps of the lower Yuba dating from 1906 through 1998 will be undertaken as a joint project between the Yuba County Water Agency and the RMT. That effort should be completed by summer 2011.

Depending on the products that result from these various ongoing study efforts, the RMT may undertake additional riparian data collection effort for the Yuba River downstream of Englebright Dam.

7) Acoustic Tagging and Tracking Surveys

The Acoustic Tagging and Tracking Protocol and Procedure consists of acoustic-tagging immigrating adult Chinook salmon and monitoring their distribution and movement in the lower Yuba River. Chinook salmon acoustic tagging will be conducted in conjunction with the Genetic Sampling and Characterization Protocol and Procedure.

Goals of the Acoustic Tagging and Tracking Protocol and Procedure include: (1) examination of habitat utilization of upstream migrating and spawning Chinook salmon exhibiting the run timing characteristics of spring-run Chinook salmon; (2) examination of the spatial and temporal distributions of holding spring-run Chinook salmon from spring through fall, and potential relationships with variable flow and water temperature regimes; (3) comparison of differential spatial and temporal distributions of immigrating and holding spring-run and fall-run Chinook salmon, and potential relationships with variable flow and water temperature regimes; and (4) examination of differential spatial and temporal distributions of spring- and fall-run Chinook salmon spawning (in conjunction with Chinook salmon redd surveys) and potential relationships with flow and water temperature regimes.

The adult spring-run Chinook salmon Acoustic Tagging and Tracking Survey is anticipated to be a multi-year effort. Acoustic tagging and tracking of 30 immigrating adult spring-run Chinook salmon occurred in the lower Yuba River from Englebright Dam downstream to the Yuba River and Feather River confluence from May to November 2009. During 2010, attempts will be made to tag 30 adult spring-run Chinook salmon during May and possibly into June, and for comparative purposes 30 adult fall-run Chinook salmon will be tagged during fall (October 2010). The RMT will review the data and reports annually, and will determine the overall duration of the acoustic tagging study.

Acoustic tagging of immigrating adult Chinook salmon will occur in the lower Yuba River downstream of DPD to the Yuba River and Feather River confluence. Adult Chinook salmon will be captured using hook-and-line sampling. Therefore, the exact location(s) for acoustic tagging will vary depending upon the specific locations of individual captures.

If an adult Chinook salmon is deemed to be sufficiently healthy for tagging, the fish will be placed in a CO_2 solution for anesthetization, and the following measurements and data will be recorded: (1) fork length (mm); (2) total length (mm); (3) body depth (mm); (4) sex (male or female); (5) adipose fin presence (Yes or No); (6) description and photograph of any visible parasites, fungi, lesions, or other signs of disease or injury, including potential hooking injuries; and (7) acoustic tag ID (serial) number of the tag that will be implanted into the fish.

After data collection, VEMCO V13-1L acoustic tags, programmed to have a “kill switch” and turn off after a pre-determined amount of time (i.e., 7 months) so that the tags do not interfere with other acoustic tagging studies after the tagged fishes have died, will be inserted into the fish. The esophageal insertion method will be used, where acoustic tags are inserted into the stomachs of spring-run Chinook salmon. Esophageal insertion will be used because surgery is not required, results in reduced tag loss and reduced changes in swimming behavior (due to the tag being placed near the center of the fish’s gravity) compared to external tagging, and a relatively short recovery time is required prior to releasing the fish (Demco et al. 2003 as cited in the M&E Program).

After tagging, a caudal fin-clip will be taken for genetic sampling (refer to Genetic Sampling and Characterization Protocol and Procedure for more information). A floy tag will be implanted in the subdural region near the dorsal fin of the fish for identification during carcass surveys. After the fish is measured, acoustic-tagged, sampled for genetics, and floy-tagged, the fish will be immediately released back into the river where the water is relatively calm and the fish can be observed.

Monitoring for acoustic-tagged spring-run Chinook salmon will occur on the lower Yuba River from Englebright Dam to the Yuba River and Feather River confluence through the use of acoustic hydrophones currently in place (J. Nelson, CDFG, 2008, pers. comm.). As of February 2009, there are 16 hydrophones located throughout the lower Yuba River, with an additional hydrophone planned to be installed at the downstream end of the Narrows. Monitoring for tag pings may also occur outside the lower Yuba River if tagged Chinook salmon move into other rivers such as the lower Feather River. Static receiver hydrophones will operate continuously year-round and data will be obtained at least every other month by CDFG (The Heritage and Wild Trout and the Steelhead Management and Recovery Programs). Data will be sent to the RMT's lead biologist from the RMT acoustic-tagged spring-run Chinook salmon every other month.

In addition to fixed-station hydrophones (i.e., static receivers), mobile tracking surveys will be conducted to monitor acoustic-tagged spring-run Chinook from Englebright Dam to the Yuba River and Feather River confluence via jet boat or walking and use of a hydrophone. A jet boat will be used to survey from the Yuba River and Feather River confluence to the bottom of the Narrows. Surveyors will track acoustic tagged Chinook salmon from the Narrows Pool to Deer Creek and from Englebright Dam to Deer Creek by walking. Surveyors will only survey reaches that they deem safe between Englebright Dam and Narrows Pool. One omni-directional and one directional hydrophone will be used in conjunction with an acoustic receiver for the mobile tracking surveys. When an acoustically tagged fish is detected, the location will be recorded using a GPS unit.

Mobile tracking surveys will begin during mid-May, or soon after tagged fish are released. From below the Narrows to the Yuba River and Feather River confluence, mobile tracking surveys will be conducted every week. Mobile tracking surveys from below Englebright Dam to the bottom of the Narrows Reach also will be completed weekly if possible.

Prior to initiation of the acoustic tagging survey, acoustic tags will be placed in various habitat types in the lower Yuba River, and mobile tracking surveys will be conducted to test the ability of detecting tag pings in the various habitat types. Mobile tracking techniques will be refined as necessary to maximize the detection of acoustic tags in all habitat types in the lower Yuba River.

8) VAKI Riverwatcher Monitoring

Fish passage monitoring on the lower Yuba River is conducted using two VAKI Riverwatcher systems, in conjunction with digital photography located in the north and south fish ladders at DPD. The data collected by the VAKI Riverwatcher systems for Chinook salmon and steelhead will be used in conjunction with data from redd surveys, carcass surveys, and angler surveys. The combined datasets will be used to generate abundance estimates, help evaluate habitat use, and examine trends in fish passage.

Goals of the VAKI Riverwatcher monitoring include: (1) estimate the abundance of spring-run, fall-run, and late fall-run Chinook salmon and steelhead above DPD; (2) examine the temporal distribution of immigration of the total run, and natural origin spring-run, fall-run, and late fall-run Chinook salmon and steelhead immigrating past DPD; (3) examine the size structure of salmonids using length-frequency distributions; (4) examine the age structure of salmonids by examining the modalities of length-frequency distributions; (5) examine the annual and multi-year trends in timing of immigrating salmonids past DPD; (6) examine the annual and multi-year trends in timing of different sizes of immigrating salmonids past DPD; (7) use VAKI Riverwatcher data in conjunction with redd survey data to estimate the abundance of steelhead below DPD; and (8) use VAKI Riverwatcher data in conjunction with water temperature and flow data to evaluate potential relationships between water temperatures and flows, and the timing of adult salmonid immigration.

Both of the VAKI Riverwatcher systems are operated year-round for monitoring fish migration in the lower Yuba River. The VAKI Riverwatcher system began operation during 2003, and is anticipated to be operated continuously at least through 2014.

The VAKI Riverwatcher system records both silhouettes and electronic images of each fish passage event. By capturing silhouettes and images, fish passage can be accurately monitored even in under turbid conditions. Data for each fish passage event is downloaded directly to an on-site PC for further analysis.

Data collection for individual fish passage events are automatically recorded by the VAKI Riverwatcher systems. Each data record is reviewed by personnel to: (1) identify the fish species; (2) examine if Chinook salmon have an adipose fin, and (3) identify non-fish passage events (i.e., debris). The VAKI Riverwatcher systems record the time/date of each fish passage event, the upstream or downstream direction of passage, the speed of the fish moving through the system (m/sec), the fish's body depth (mm), and logs water temperature every hour. The body depth of a fish is converted to a length measurement (cm) by the program software (Winari v. 4.16) utilizing a body length-to-depth ratio. The morphometric body ratios were obtained by measuring 36 fall-run Chinook salmon in 2003 and 119 fall-run Chinook salmon in 2005 from the Feather River Hatchery and 168 steelhead from the lower Yuba River (D. Massa, CDFG, pers. comm. 2009). To maximize the accuracy of passage estimates generated by the VAKI Riverwatcher systems, a full-time technician will be employed to monitor the systems and minimize system off-line events.

9) Redd Surveys

Redd counts have been used widely to estimate or provide indices of adult salmonid escapement or abundance, and examine the spatial and temporal distribution of spawning adult salmonids. In addition, data pertaining to redd location and size will be obtained to develop indices of redd superimposition using GIS analyses for the Chinook salmon runs and steelhead/rainbow trout in the lower Yuba River.

Goals of the redd surveys conducted in the lower Yuba River include: (1) evaluate and compare the spatial and temporal distribution of redds and redd superimposition over the spawning seasons for the Chinook salmon runs and steelhead/rainbow trout spawning in the lower Yuba River; (2) compare the magnitude (and seasonal trends) of lower Yuba River flows and water temperatures with the spatial and temporal distribution of redds (and rates of redd superimposition) for the Chinook salmon runs and steelhead/rainbow trout; (3) estimate the total annual abundance of adult fall-run Chinook salmon and steelhead/rainbow trout in conjunction with angler surveys and VAKI Riverwatcher data; and (4) establish a long-term data set to be used to evaluate habitat utilization by the Chinook salmon runs and steelhead/rainbow trout in the lower Yuba River under variable biotic and abiotic conditions.

Reconnaissance-level redd surveys will be conducted during August to document the initiation of spawning activity in the lower Yuba River. The 2008-2009 and 2009-2010 redd surveys were conducted weekly beginning the week after a redd was first observed during the reconnaissance-level redd survey through the portion of the season encompassing the majority of Chinook salmon spawning activity. Prior redd and carcass surveys indicate that the majority of Chinook salmon spawning activity occurs through December, with reduced amounts of Chinook salmon spawning continuing through late-March, and steelhead/rainbow trout spawning extending through April. From the 2008-2009 pilot redd survey data and a simulation approach, a weekly sampling frequency was found to result in the most precise and accurate (least biased) estimates of spawning activity. Therefore, weekly redd surveys will be conducted from the initiation of spawning activity until May each year beginning during the 2010-2011 redd survey and subsequent surveys.

Approximately 20.9 mi. of the 24 mi. of total length of the lower Yuba River will be surveyed during the redd surveys. About 0.7 mi. of the lower Yuba River located immediately below the first set of riffles downstream of Deer Creek to the top of Narrows Pool will not be surveyed due to rugged and dangerous conditions in the steep canyon known as the Narrows. Additionally, an approximate 2 mi. section of the lower Yuba River from Simpson Lane Bridge to the confluence with the Feather River will not be regularly surveyed because redds have not been observed during past surveys. This section of the river will be surveyed once during peak Chinook salmon spawning to ascertain that this section is, in fact, not being utilized for spawning.

Several species of fish exist in the lower Yuba River known to construct redds including Chinook salmon, steelhead/rainbow trout, Sacramento sucker (*Catostomus occidentallis*), and Pacific lamprey (*Lampetra tridentata*). Visual differentiation between steelhead/rainbow trout redds and Sacramento sucker, and Pacific lamprey spawning nests is of concern because these three species clean the gravel during spawning. Sacramento suckers do not typically spawn until late-March and April, and are generally visible during their spawning season.

Steelhead/rainbow trout redds are generally easy to distinguish, because they create a noticeable pit and tail spill in the gravel during redd construction. The Oregon Department of Fish and Wildlife (1999; as cited in the M&E Program) distinguish lamprey spawning nests and steelhead/rainbow trout redds using redd/nest dimension measurements. A steelhead/rainbow trout redd is distinguished by a longer length than width and the tailings are evenly distributed downstream by the current. Lamprey spawning nests generally have a neat and round appearance, with a conical bowl. The unique characteristic of a lamprey spawning nest is the placement of the tailings upstream from the nest. Lamprey excavate their spawning nests by sucking onto the gravel and then depositing it outside the nest.

Species-specific redd identification will be conducted by comparing the physical dimensions and locations for all known redds (i.e., redds which were positively identified with one species or another building or guarding them). During the redd surveys, each redd observed with an adult building or guarding them will be measured, and the species identified and recorded. Result from the 2008-2009 and 2009-2010 redd surveys in the lower Yuba River indicated that lamprey were observed spawning in late-March and early-April in the most downstream sampling reach of the lower Yuba River, where sand was the subdominant substrate.

The 2010-2011 redd surveys, and any subsequent surveys, will be conducted using two catarafts rather than the four kayaks used during the 2008-2009 and 2009-2010 redd surveys. Each surveyor, wearing polarized sunglasses, will scan the river from the shore to the middle of the river, working downstream. Side channels in the survey area may require walking. Visibility will be measured using a secchi disk at the top of the survey section.

Deep water surveys will be conducted during the 2010-2011 redd survey period in addition to the surveys conducted by cataraft. The specific methods employed for the deep-water surveys are being field tested during the winter and late-summer of 2010.

For each new redd observed throughout the sampling season, the following data will be recorded: (1) a GPS (Trimble GeoExplorer XT) location taken at the center of the redd's pit with a unique identifying number (i.e., Date + plus redd number; i.e. 082908-001); (2) total dimensional area (using a GPS) for areas appearing to contain multiple redds with no clear boundaries (i.e., mass aggregate spawning); (3) habitat type (i.e., pool, riffle, run, or glide); (4) substrate composition of ambient habitat based on substrate size immediately upstream of the pit; (5) redd species identification; (6) number of fish observed on the redd; (7) location information (i.e., side channel or main channel); (8) comments regarding observable redd superimposition (i.e., redd overlap); and (9) any additional comments.

The path undertaken by each surveyor down the river will be recorded using Garmin GPSMAP 60Cx GPS units to document specific locations of the river surveyed. The GPS (Trimble GeoExploerXT) and a data dictionary will be used to ensure redds counted during the previous survey weeks are not double-counted. In addition, surveyors will mark each redd at the pit with a painted rock. Redd area measurements will be conducted to examine redd superimposition throughout the lower Yuba River for the Chinook salmon runs and steelhead/rainbow trout.

At each fresh redd located, measurements of mean water column velocity, “nose velocity” (i.e., fish focal point water velocity, which is the water velocity at an observed fish’s position or, when a fish is not observed actively preparing a redd, at the predetermined distance of 0.5 ft above the undisturbed streambed), total water depth and visual estimates of substrate composition will be made to approximate habitat conditions prior to gravel disturbance caused during redd construction. All measurements will be made 0.5 ft upstream of the leading edge of the pit along the mid-line of the redd, unless field personnel determine that measurements adjacent to the mid-point of the pit are more representative of undisturbed conditions for that specific location. The specific location of the measurements will be recorded on the data sheet.

Redd substrate composition will be visually estimated as percentage composition (to the nearest 10 percent) of each of eight size categories. Prior to conducting the steelhead/rainbow trout redd surveys, the field survey crews will become familiar with visual substrate size estimation by having undergone training by visually estimating substrate size, then comparing those estimates to results obtained by passing those substrate elements through a gravel template. Visual estimation of substrate sizes will be along the B axis of the substrate elements.

10) Carcass Surveys

The carcass surveys use a mark and recapture technique to estimate the abundance of spawning adult Chinook salmon. The annual abundance estimates are essential for monitoring trends in population size. In addition, biological data is collected from observed Chinook salmon carcasses (i.e., length, sex, spawning status, genetic tissue samples, scales, otoliths, and coded wire-tags) to monitor the populations.

Goals of the annual carcass surveys in conjunction with data collected from the VAKI Riverwatcher, and acoustic tagging survey include: (1) use the genetic tissue samples collected during the carcass survey and the acoustic tagging survey to differentiate spring-run and fall-run Chinook salmon; (2) use the coded-wire tags and otoliths collected to determine the origin of Chinook salmon (i.e., hatchery-origin, natural-origin and river of origin); (3) estimate the total, weekly, monthly and seasonal abundances of spring-run and fall-run Chinook salmon; (4) estimate the abundance of natural-origin and hatchery-origin spring-run and fall-run adult Chinook salmon; (5) use length data to examine the size structure of the spring-run and fall-run Chinook salmon populations; (6) use scale samples to examine the age structure of the spring-run and fall-run Chinook salmon populations; and (7) examine multi-year trends in the annual run sizes of spring-run and fall-run Chinook salmon (i.e., total population, hatchery-origin and natural-origin).

The annual Chinook salmon carcass surveys will be a long-term monitoring effort of the lower Yuba River spring-run and fall-run adult Chinook salmon populations. A consistent carcass survey methodology has been employed in the lower Yuba River since the mid-1990s (Massa 2008). Annual Chinook salmon carcass surveys will occur from the beginning of the spawning season (September) through the end of the spawning season (late-January). Begin and end dates of the annual carcass survey will vary depending on when Chinook salmon redds are observed and when the recapture rate of tagged carcasses in January approaches zero. Field reconnaissance teams begin to monitor Chinook salmon spawning during August. The first carcass survey will begin about 10 to 14 days after the first Chinook salmon redds are observed.

The study area for the carcass survey is the lower Yuba River extending from the Englebright Dam downstream to the Simpson Lane Bridge. The study area is divided into three survey reaches: (1) Narrows Pool to Highway 20 Bridge; (2) Highway 20 Bridge to DPD; and (3) DPD to Simpson Lane Bridge. All survey reaches will be surveyed once a week.

The weekly carcass survey will be conducted by a crew of 4-6 people and will be executed via jet boat and walking. Two crews will be utilized to collect scale samples, tissue samples, otoliths and heads for coded-wire tag recovery (i.e., 2008/2009 through 2013/2014).

During the weekly carcass survey, personnel will collect, count, and record data for: (1) fresh carcasses (carcass with red or pink gills, or at least one clear eye); (2) non-fresh carcasses (no clear eyes and gills are not red or pink); and (3) tagged carcasses. All observed non-fresh carcasses and adipose fin-clipped carcasses will be counted and chopped in half to prevent recounting during subsequent surveys. Tagged carcasses (recaptures from previous surveys) will be counted and chopped. Fresh carcasses that have an adipose fin will be counted and tagged. All carcasses will be released into the river. Fresh adult carcass data will be used in the Schaefer mark-recapture model (Schaefer 1951 as cited in the M&E Program) with modifications referenced to Taylor (1974; as cited in the M&E Program) to estimate abundance. Abundance will be estimated weekly throughout the annual spawning period, and annually.

11) Snorkel Surveys

The overall goal of the Snorkel Surveys Protocol and Procedure is to study anadromous salmonid diversity and habitat occurrence, in addition to observing community composition in the lower Yuba River. This Protocol and Procedure evaluates abiotic variables affecting fish diversity and habitat occurrence including external forces (i.e., daily cycle, time of year, flow, and fluvial landform structure), and internal responses to specific combinations of the external forces (i.e., spatial pattern of water depth and mesohabitat pattern).

It is anticipated that 2 years of snorkel surveys will be conducted, beginning during winter of 2011. Sampling months will be selected so that all juvenile salmonid life stages will be present in the river during the course of snorkeling activities, however, it may be prudent to continue sampling through the duration of summer. The study area for the snorkel surveys is the lower Yuba River from Englebright Dam to the confluence of the Yuba and Feather rivers (near Marysville, California). This study length includes a diverse assemblage of mesohabitat types as indicated by observed riffle habitat spacing at approximately 4-7 bankful widths in most gravel-bed rivers. The rapids in the Narrows will not be sampled due to potential safety issues.

The specific sampling design continues to undergo refinement by the RMT. However, at this time, it is anticipated that a morphological unit (up to 9 in-channel types and 3-5 edge types) oriented sampling strategy, stratified by river reach (up to 8 reaches based on geomorphic principles) will be employed. The objective of the survey sampling design is to obtain a strong geographical distribution suitable for longitudinal analysis. Prior to each sampling survey, specific localities will be identified using GIS and uploaded to Trimble GPS units for easy field location.

Divers will evaluate visibility in the lower Yuba River by taking NTU measurements before sampling each day to determine if surveying is warranted. For each day of sampling, “effective visibility’ will be measured using a standard “4” lure and measured maximum distance for underwater identification of parr marks.

Surveys will be conducted with three people in the river and a fourth on the river bank. A second bank recorder may be necessary for units with high densities of fish. Channel units will be surveyed by divers daily beginning at the downstream end of the channel unit working towards the upstream end of the channel unit whenever possible. This includes working in an upstream direction along channel margins in swift areas. In deep, high velocity areas of the river where snorkelers are physically unable to snorkel upstream, they will survey the area by drifting downstream 3 abreast. In some areas of the river, it may be impossible to conduct snorkel surveys in either direction due to water velocity and in river hazards (i.e., rapids, rocks). In these non-sampled areas, probability statistics may need to be applied. Fish that are disturbed during the survey (i.e., swimming away and/or seeking refuge) will not be considered to be exhibiting normal behavior. When undisturbed fish are located, snorkelers will first take a still image using their mask-integrated digital camera.

Snorkeling effort will not be uniform in all channel units because the lower Yuba River ranges in width from 10-100 m. Snorkelers will maintain “lanes” during surveys, spaced so that they are 3 m apart. Snorkelers are responsible for surveying the area 1.5 m on either side of their path through the river. The snorkeler closest to the bank should maintain a distance 1.5 m from the bank and is responsible for surveying the area from the bank to an imaginary line 3 m from the bank. Backwater habitats and off-channel pools will be visually sampled by the nearest surveyor.

Snorkelers will identify species and life stage, estimate fish length, and measure water depth that the fish is observed in. Fish length will be estimated in 20-mm size increments (i.e., 30-50 mm, 50-70 mm, etc.), which is believed to be the smallest interval that trained divers can distinguish. When a group of fish is observed, and it is not possible to characterize them all individually, then counts of the number of fish in habitat “patches” (defined by the area of riverbed that can be effectively observed by a single diver) will be made. A colored weight (large washers, fishing leads) with attached numbered tag will be placed on the bed to mark the location of either a single fish being observed or the central location of a group of fish too numerous to identify each one. Once the entire channel unit has been surveyed, two divers will walk or drift back downstream with a Trimble GPS to relocate and record the GPS location for all bed tags identified during the snorkel survey in order to be able to characterize water depth, water velocity, proximity to cover, and other geomorphic features. The area of non-sampled channel resulting from excessive water velocity will be quantified at a representative snorkeling discharge, or range of discharges, and subsequently classified as “swimmable” and “unswimmable” areas, as part of the M&E Program 2D Hydrodynamic Model of the lower Yuba River. The resulting two multi-feature GIS vector polygons will be intersected with the M&E Program Mesohabitat Map, as appropriate for that discharge, and used to determine the relative abundances of non-sampled mesohabitat at the lower Yuba River and study-site-only spatial scales.

12) Rotary Screw Trapping

Rotary Screw Traps (RSTs) are anchored at a fixed point in the stream channel and intercept a portion of the juveniles, smolts, or fry of juvenile salmonids migrating downstream, as well as other fishes, utilizing the force of moving water over baffles inside the cone to rotate. RSTs provide valuable information such as the presence/absence of migrating life-stages, determination of age and size at migration, condition, timing, species, and genetic characteristics (Volkhardt et al. 2007 as cited in the M&E Program).

Goals of the rotary screw trapping include: (1) document the (juvenile) fish community composition in the lower Yuba River; (2) estimate and examine trends in the weekly, monthly, seasonal and annual abundances of emigrating juvenile Chinook salmon and steelhead/rainbow trout from above DPD and the lower Yuba River; (3) estimate the number of juvenile spring-run Chinook salmon and steelhead/rainbow trout that rear during the summer and emigrate in the fall from DPD and the lower Yuba River; (4) examine the influence of lower Yuba River flows and water temperature on the timing of juvenile Chinook salmon and steelhead/rainbow trout emigration; (5) evaluate time-period specific size structure during juvenile Chinook salmon and steelhead/rainbow trout emigration; and (6) document the seasonal presence of developmental phases (i.e., yolk-sac fry, fry, parr, silvery parr, and smolt) of juvenile Chinook salmon and steelhead/rainbow trout.

RST sampling has been conducted seasonally on the lower Yuba River from 1999 to 2005 and year-round from 2006 to 2009. RST sampling has been temporarily suspended until the logistics associated with implementing a trapping device at or upstream of DPD have been resolved, in order to obtain comparable data between upstream and downstream locations for focused evaluations. It is anticipated that additional sampling will be conducted commencing in 2011, and may be conducted in subsequent years pending results, as evaluated by the RMT.

The RSTs are fished year-round, with the survey period defined as October 1 through September 31. Interruptions of sampling effort within a particular survey period due to, for example, excessive debris or high streamflow, is recorded and justified.

The M&E Program Rotary Screw Trapping activities have utilized a set of three RSTs near Hallwood Boulevard (approximately 0.5 mi. upstream of Hallwood Boulevard at RM 7.5). A fourth trap is intended for use upstream of DPD, although, the exact location has not been chosen. Two of the RSTs at the Hallwood Boulevard location are conically shaped with a cone diameter of 8 feet. The two 8-ft RSTs (RST 1 and RST 2) are fished in tandem and tethered to a rock anchor and set approximately 100 feet downstream of the 5-ft RST. The third RST at the Hallwood Boulevard location has a cone diameter of 5 feet, tethered by an earth anchor situated toward the downstream end of a large gravel bar.

A field crew of two to three technicians service the RSTs at least once per day to document their operational status, remove trapped fish from the live box, estimate rotation speed, remove debris, and record water temperature (°C), velocity (feet per second), and turbidity (NTUs). During periods of excessive algae growth (June-October), high debris loads, or high river flow events the RSTs will be serviced at least twice per day to keep them rotating continuously and reduce fish mortality.

Captured fish are processed on the bank of the river. Juvenile steelhead/rainbow trout and Chinook salmon are processed before other fish species and are kept in separate buckets for mark-recapture tests. Estimates of species abundance, weight (0.1 g), and fork length (mm) are made. Captured steelhead/rainbow trout and Chinook salmon are additionally assigned life-stage index values and run designation. Mark-recapture tests are performed approximately weekly for juvenile steelhead/rainbow trout and juvenile Chinook salmon once captured numbers equal or exceed the pre-specified target number (1000), or 5 days have elapsed, whichever comes first. A minimum of 300 juvenile Chinook salmon or steelhead/rainbow trout are needed for the efficiency tests. Fish are marked with Bismarck Brown powder on the day prior to release, held overnight, and released the next day. All recaptured fish in each of the RSTs are measured for fork length (mm), weighed (0.1 g), and assigned a life-stage index value. Trap efficiency is estimated using data collected during the seven days after a group of efficiency test fish is released. Marked fish are released 625 meters upstream from the trapping location and uniformly across the river for random dispersal. Capture efficiency tests will be performed throughout the year whenever catch of juvenile Chinook salmon or steelhead/rainbow trout in the RST is sufficient.

13) Genetic Sampling and Characterization

A genetic analysis of phenotypic spring-run Chinook salmon collected in the lower Yuba River will help identify the amount of introgression among spring-run and fall-run Chinook salmon, and source populations for phenotypic spring-run Chinook salmon that currently exist in the lower Yuba River. Additional monitoring such as Acoustic Tagging and Tracking and Carcass Surveying is ongoing, and will provide additional information regarding the current extent of reproductive isolation between spring-run and fall-run Chinook salmon in the lower Yuba River.

Goals of the Genetic Sampling and Characterization Protocol and Procedure are to use tissue samples to: (1) identify the genetic composition of lower Yuba River phenotypic fall-run and spring-run Chinook salmon; and (2) examine genetic differentiation between fall-run and spring-run Chinook salmon in the lower Yuba River.

Adult Chinook salmon genetic sampling began during May 2009, when 43 adult phenotypic spring-run Chinook salmon were sampled. Sampling also is being conducted during the May/June 2010 Acoustic Tagging and Tracking surveys, and during the 2010 fall Carcass Surveys (September through December). Additional sampling may be conducted during subsequent years, pending the RMT’s review of the results from previous and planned sampling.

Genetic sampling will occur during the acoustic tagging and tracking survey of immigrating adult spring-run Chinook salmon (May/June) and during Chinook salmon carcass surveys (September through December). Genetic sampling of Chinook salmon carcasses will occur throughout the carcass surveys, beginning in September (targeting spring-run Chinook salmon) and continuing through late December (targeting fall-run Chinook salmon).

For the purpose of genetic sampling of adult Chinook salmon, the study area extends from the downstream terminus of the Narrows to the confluence of the lower Yuba River and the Feather River near Marysville, California.

Genetic sampling of live adult phenotypic spring-run Chinook salmon will occur on the lower Yuba River downstream of DPD. Tissue samples will be obtained from adult phenotypic spring-run Chinook salmon during acoustic tagging and tracking surveys. Therefore, the exact location(s) for genetic sampling will vary depending upon the specific locations of individual captures. Genetic sampling also will be conducted during the

Chinook salmon carcass surveys, in survey reaches including: (1) Narrows pool to Highway 20 Bridge; (2) Highway 20 Bridge to DPD; and (3) DPD to Simpson Lane Bridge.

Guidelines for genetic sample collection provided by the NOAA Southwest Fisheries Science Center's Santa Cruz laboratory (refer to Attachment 2 of the M&E Program Genetic Sampling and Characterization Protocol and Procedure), as well as additional guidelines provided by the CDFG (refer to Attachment 3 of the M&E Program Genetic Sampling Protocol and Procedure), will be used to collect data and genetic samples from all live adult Chinook salmon and Fresh (i.e., pink or red gills or at least one clean eye) Chinook salmon carcasses. Genetic analyses are conducted by the NOAA Southwest Fisheries Science Center's Santa Cruz laboratory.

Scales are additionally collected as part of the M&E Programs Genetic Sampling and Characterization Protocol and Procedure for age assessment. If possible, all observed fresh Chinook salmon carcasses will have scale samples and associated data collected. For the CDFG Age Scale Program, a minimum goal of 550 scale samples is needed for each run of Chinook salmon being sampled (Kormos 2007 as cited in the M&E Program). In addition, scale samples are needed for all coded-wire tagged fish and all grilse. Scale samples are collected from a preferred scale area located on the left side of the fish. A diagonal section of 20-30 scales are taken from the posterior insertion of the dorsal fin and just slightly above the lateral line.

14) Otolith Sampling and Characterization

The Otolith Sampling and Characterization Protocol and Procedure will identify whether adults spawning on the Yuba River were originally born and reared in the lower Yuba River or whether they are strays to the lower Yuba River. The use of $^{87}Sr/^{86}Sr$ isotopic data permits the identification of whether individuals are of natural or hatchery origin, as well as their specific source of origin (e.g., Feather River Hatchery vs. Coleman National Fish Hatchery).

The Yuba River has an $^{87}Sr/^{86}Sr$ value of 0.7082 (Barnett-Johnson et al. 2008 as cited in the M&E Program). This relatively high ratio is distinct among other tributaries to the Sacramento River. Wild and hatchery-origin fish from the Feather River are likely sources of strays due to proximity to the lower Yuba River and are isotopically distinguishable from the lower Yuba River and each other, as are other potential sources of strays.

Goals of the Otolith Survey include: (1) determining the origin of Chinook salmon in the lower Yuba River (i.e., hatchery-origin, natural-origin and river of origin); and (2) evaluating the contribution of Chinook salmon naturally produced in the Yuba River to the returning spawning population.

Otolith sampling was conducted during 2009-2010 and will again be conducted during 2010-2011. The need for additional years of sampling will be determined pending the RMT's review of the results from previous and planned sampling. Otoliths are collected during the annual Chinook salmon carcass surveys as part of the long-term monitoring effort of the lower Yuba River spring-run and fall-run adult Chinook salmon populations. Annual Chinook salmon carcass surveys and otolith sampling occur from the beginning of the spawning season (September) through the end of the spawning season (late-January). Begin and end dates of the annual carcass survey will vary depending on when Chinook salmon redds are observed and when the recapture rate of tagged carcasses in January approaches zero.

In the field, otoliths are removed from all fresh non-adipose fin-clipped Chinook salmon carcasses. In addition, otoliths are removed from all of the heads collected from adipose fin-clipped carcasses in the laboratory unless a sub-sampling procedure (as described below) is required due to high carcass numbers. A "flip top" approach for removing otoliths is used so the fresh non-adipose fin-clipped fresh carcasses can be tagged for the mark-recapture study. A detailed description of this procedure is provided in the M&E Program Carcass Survey Protocol and Procedure.

The Otolith Sampling and Characterization Protocol and Procedure analyzes a minimum of 100 temporally stratified otoliths to reflect the distribution of spawners to the lower Yuba River and acquire a reasonable estimate of straying. Sample numbers may be increased to better constrain estimates as demonstrated during the 2009 Otolith Survey. Otolith survey results will be linked to the M&E Program Genetic Sampling analysis (spring- vs. fall-run Chinook salmon determination).

All fresh Chinook salmon carcasses were sampled during the 2009 carcass survey, with the exception of October 21, 2009 when sub-sampling methods were used because of a large sample size. Watershed-level composition estimate was attained by creating a 'Rand' variable in excel to assign a random number to each otolith sample. Samples were subsequently sorted in ascending order, and the first 120 samples used in analysis. The additional 20 samples were saved in case any of the initial 120 samples were compromised during the preparation process, or were required for later analysis.

Samples collected on October 21, 2009 were sub-sampled at a ratio 1:5 in the field. To ensure than these sub-samples were not underestimated in the watershed-level composition estimate, and to account for a greater representation of carcasses on that day that were not sampled, 4 “dummy” variables was created for each of samples collected, which represented the fish not sampled. The “dummy” variable was included in the original 'Rand' subsample. In the instance where a “dummy” variable was selected as part of the subsample, a collected otolith sampled from a carcass that day was substituted.

Otolith microchemistry analysis is performed via a contract with the Barnett-Johnson Fisheries and Otolith Laboratory at the University of California, Santa Cruz. Otolith microchemistry analyses conducted are expected to be similar to those used by Barnett-Johnson et al. (2007 and 2008; as cited in the M&E Program). The microchemistry analysis assessed the concentration of heavy and light Strontium isotopes, ^{87}Sr and ^{86}Sr respectively, because Sr substitutes for Ca in the otoliths carbonate matrix and can be extracted at daily growth increments. The technique analyses the ^{87}S /^{86}Sr isotopic ratios that identify natal freshwater habitat, small-scale movement patterns and timing of migration into freshwater from the ocean based on water chemistry or foodwebs disparities among habitats. In addition to otolith microchemistry analyses, efforts are underway to plan activities associated with otolith microstructure analyses to examine discrete daily growth increments deposited throughout the life of the fish.

OTHER DATA COLLECTION AND MONITORING PROGRAMS

CDFG Scale Aging Program

CDFG uses scales to estimate salmonid size at age, and obtain information on the age structure of the annual Chinook salmon runs in the Central Valley, including the lower Yuba River. Scale sampling occurs at hatcheries and on CDFG escapement surveys to reflect spatial and temporal differences in age structure among fish.

Goals of CDFG's Scale-Age Program include: (1) examining age structure and the variation in the age structure of the total (hatchery and natural origin) and of natural origin spring-run and fall-run Chinook salmon; and (2) estimating sex composition by age for the total (hatchery and natural origin) population and of natural origin adults, and determine the variability in sex composition of the adult population (by age) for spring-run and fall-run Chinook salmon.

Lower Yuba River Chinook salmon escapement surveys are conducted each year (see above). Scale samples are collected annually from October through January in the lower Yuba River. Results from the 2006-2007 and 2007-2008 are reported above (see Grover and Kormos undated).

Scale samples are collected from fresh Chinook salmon carcasses for age determination and cohort reconstruction through cooperation with the Ocean Salmon Project. The sample design was selected to achieve a non-biased estimate of age structure for the specific portion of the population where escapement estimates are made without respect to known or unknown age fish. Almost all of the adipose fin clipped fish from hatcheries are scale sampled to provide a reference collection of as many known age scales as possible. In hatcheries, samples are collected at a constant rate throughout the entire spawning period keeping track of the "random" age sample and the additional "non-random" known age samples. During carcass surveys, samples are collected at a constant rate as fish suitable for sampling are encountered. Because of the high sample rate for known age scales at hatcheries and the difficulty of sampling on spawning grounds, non-random samples are generally not taken from adipose fin clipped carcasses.

A skin patch containing between 20-30 scales is removed from the scale pocket located posterior of the last dorsal fin ray, and above the lateral line. Each skin patch is placed in an individual envelope containing: (1) unique sample code; (2) date; (3) location; (4) fork length; (5) sex; (6) ad-clip status; and (7) head tag number if available. Scale envelopes are placed in a dry storage area for later processing by the Ocean Salmon Project's scale aging team. State of the art mounting, digital imaging and digital reading techniques are currently used to examine age structures or patterns. Individual ages are determined from scales by counting winter annuli. Annuli can be identified as bands of closely spaced or broken circuli. Scale samples are read by an individual experienced reader and field biological data (sex and length) are taken into consideration only after the initial evaluation of age by the reader.

CDFG Angler Surveys

In 1998, the CDFG created the Central Valley Salmon and Steelhead Harvest Monitoring Project. The goal of this program is to estimate the number of adult Chinook salmon and steelhead resulting from natural production in Central Valley rivers and streams including: (1) determining annual estimates of the total in-river harvest of salmon and steelhead; and (2) provide limited harvest data on other anadromous and resident sport fish species. . According to CDFG's current Freshwater Sport Fishing Regulations, the lower Yuba River is closed to salmon fishing.

River sections for the lower Yuba River are surveyed year round (D. Massa, CDFG, pers. comm., 2009) Two river sections have been previously surveyed by the Central Valley Angler Survey on the Yuba River including: (1) Marysville to DPD; and (2) DPD to 1 mile upstream of the Highway 20 Bridge. All sample sections were surveyed eight randomly-selected days per month; four weekdays and four weekend days. Weekdays and weekend days were placed in separate strata due to the increase in angling effort commonly associated with weekend days.

The Yuba River is surveyed via kayak, so the angler count and interview data are collected in tandem as the surveyor travels downstream with the current. Start time and launch location are randomized using a random number generator. All data collected is linked to a unique number series assigned to the Central Valley tributaries of the Sacramento River that represent river miles.

Field data required to calculate angler use and catch estimates include hourly counts, angler counts, and angler interviews. During the angler count, time and location of anglers is collected, as well as parameters for angler effort such as the number of boats, the number of boat or shore anglers, and the start and finish times. An interview of all anglers observed during the angler count is preferable. However, if not feasible than every n^{th} angler is interviewed. Data collected during each interview includes: (1) angler location by river mile; (2) fishing method (boat or shore); (3) number of hours fished to the nearest quarter-hour; (4) number of anglers in group; (5) target species; (6) zip code; (7) whether the trip was completed; and (8) the number of fish kept and/or released by species.

Length is used to differentiate between steelhead and rainbow trout. All rainbow trout 16" or greater are considered to be steelhead. Rainbow trout less than 16" are recorded as rainbow trout. For, steelhead/rainbow trout, striped bass, and sturgeon, fish are measured to the nearest ½ centimeter and inspected for any marks or tags. All steelhead caught are inspected for the presence of an adipose fin. A steelhead missing an adipose fin indicated the fish was of possible hatchery origin.

YCWA Lower Yuba River Redd Dewatering and Fry Stranding Monitoring and Evaluation

In D-1644, the SWRCB in 2001 directed YCWA to submit a plan, in consultation with USFWS, NMFS, and CDFG that describes the scope and duration of future flow fluctuation studies to verify that Chinook salmon and steelhead redds are being adequately protected from dewatering with implementation of D-1644 criteria (JSA 1992). In RD-1644, the SWRCB in 2003 readopted this requirement. After various comments and revisions, the March 2002 Plan (Plan) was approved by the SWRCB on April 17, 2002. Phase I of the Plan was undertaken in 2002, and implementation of Phase II of the Plan continues.

Studies associated with the Plan combine habitat mapping, field surveys, and information on the timing and distribution of fry rearing in the lower Yuba River to evaluate the effectiveness of D-1644 flow fluctuation and reduction criteria in protecting Chinook salmon and steelhead/rainbow trout fry. Goals of YCWA Lower Yuba River Redd Dewatering and Fry Stranding Monitoring and Evaluation include: (1) determine the potential magnitude of redd dewatering in relation to the timing and magnitude of flow fluctuations and reductions; (2) determine the potential magnitude of fry stranding in relation to the timing, magnitude, and rate of flow fluctuations and reductions; (3) evaluate the effectiveness of flow fluctuation and reduction criteria in protecting redds and fry; and (4) recommend additional measures to protect redds and fry from flow fluctuations and reductions, if warranted.

Two studies were conducted and summarized in the 2007 and 2008 *Lower Yuba River Redd Dewatering and Fry Stranding Annual Reports* (JSA 2007, 2008) to the SWRCB (see the Available Field Studies and Data Collection Reports section of this document).

In accordance with the *Lower Yuba River Redd Dewatering and Fry Stranding Monitoring and Evaluation Plan* (2003), YCWA and JSA will continue to monitor and evaluate stranding risk and flow-habitat relationships for off-channel stranding. Future actions will include the following: (1) continued evaluation of the effects of time of day (night versus day) on stranding risk of juveniles; (2) inspection of interstitial habitats along the river margins to determine the presence of young fry before bar stranding evaluations; (3) evaluation of the effects of higher ramping rates (>100 cfs per hour) on stranding risk of larger fry and juveniles; (4) continued evaluation of the relationship between flow range and the number, area, and distribution of off-channel sites that become disconnected from the main river; (5) evaluation of the effect of peak winter and spring flows on the incidence of off-channel stranding; and (6) continued monitoring of habitat conditions and survival of Chinook salmon and steelhead/rainbow trout in selected off-channel monitoring sites where stranding is frequently observed.

CDFG Steelhead/Rainbow Trout Acoustic Tagging and Tracking Survey

This is a multi-year study to monitor the movement patterns of wild juvenile and adult steelhead/rainbow trout in the lower Yuba River by CDFG (The Heritage and Wild Trout and the Steelhead Management and Recovery Programs). Utilizing acoustical tags and instream hydrophones, this project will track tagged trout movements, habitat selection, and evaluate tracking techniques over multiple seasons and flow conditions. The goal of this program is to develop understanding regarding the movement of steelhead/rainbow trout to help agencies better manage the trout populations on the lower Yuba River, thus providing anglers with a continued sport fishing opportunity for wild resident/anadromous trout in the Central Valley.

Monitoring for acoustic-tagged spring-run Chinook salmon occurs on the lower Yuba River from Englebright Dam to the Yuba River and Feather River confluence through the use of acoustic hydrophones currently in place (J. Nelson, CDFG, 2008, pers. comm.). As of February 2009, there are 16 hydrophones located throughout the lower Yuba River. Static receiver hydrophones will operate continuously year-round and data will be obtained at least every other month by CDFG.

Wild juvenile and adult steelhead/rainbow trout are captured using hook-and-line sampling, and acoustic tags are inserted into the fish. The exact location(s) for acoustic tagging will vary depending upon the specific locations of individual captures.

In addition to fixed-station hydrophones (i.e., static receivers), mobile tracking surveys are conducted. When an acoustically tagged fish is detected, the location is recorded using a GPS unit.

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APPENDIX F

Simulation of Lower Yuba River
Flow and Temperatures for ESA Analysis
of Continued Operation of Daguerre Point Dam

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July 14, 2011

Simulation of Lower Yuba River Flow and Temperatures for ESA Analysis of Continued Operation of Daguerre Point Dam

Prepared by Stephen Grinnell, P.E.

The purpose of this memo is to provide modeling output data in support of the preparation of a Biological Assessment pertaining to continued operation of Daguerre Point Dam. Modeling of two scenarios was completed to provide monthly average flows and water temperatures on the lower Yuba River for two comparative conditions. The modeling was completed using two models, a water balance/operations model and a stochastic water temperature model. The water balance/operations model simulates the hydrology of the lower Yuba River and operations of the Yuba River Development Project, owned and operated by the Yuba County Water Agency (YCWA) on a monthly time step. The water temperature model predicts average monthly water temperatures at three locations on the lower Yuba River and uses statistically derived relationships between meteorology, flow, reservoir water storage levels and resulting water temperatures. Both of these models were used in the preparation of the lower Yuba River Accord EIR and are documented in a technical memorandum that was an appendix to the EIR, and which is provided as Appendix B to this memorandum.

For the water balance/operations model, Appendix B documents the significant attributes of the model. Three items were changed in the assumptions and modeling conditions from the model used for the Accord EIR and described in the documentation. These items are: 1) the maximum release capacity of Colgate Powerhouse, which is the primary release point for New Bullards Bar Reservoir, has been corrected to be 3,430 cfs where previously it was modeled as 3,700 cfs: 2) the hydrologic period of record used for the simulations has been extended and is now from water year 1922 to 2008, where previously it included water year 1922 through 2005 and 3) the irrigation diversion demands were changed as described in the following paragraphs.

Simulation Scenario Irrigation Demands

For the analysis of flows and water temperatures only one simulation element is varied between the two scenarios, which is the irrigation diversion demand at Daguerre Point Dam. The two scenarios are labeled “Environmental Baseline” and “Cumulative Condition”. For the Environmental Baseline, the irrigation demands are those of the seven Member Units of YCWA that receive water from the Yuba River in amounts and flow rates that represent current land use conditions as of 2005, which is the most recent land use survey data available. These Member Units are: Hallwood Irrigation Company, Cordua Irrigation District, Browns Valley Irrigation District, Ramirez Water District (these preceding Member Units divert water at or just upstream of Daguerre Point Dam to lands north of the Yuba River), Brophy Water District, South Yuba Water District and Dry Creek Mutual Water Company (these preceding Member Units divert water at Daguerre Point Dam to lands south of the Yuba River). The Cumulative Condition scenario includes the irrigation demands for the Member Units listed previously plus the irrigation demands of Wheatland Water District, which began receiving surface water through a new canal extension in 2010. The monthly amounts of irrigation demand for the Member Units were derived by taking the Department of Water Resources (DWR) 2005 land use data for irrigated lands within these Member Units, and multiplying the various land use areas by their respective crop type applied water rates as determined by DWR for Yuba County. The applied water rates for two different years are used, 1999 to represent a wet year condition and 2001 to represent a dry year condition. Wet year conditions are assumed to occur in Wet and Above Normal years, and dry conditions are assumed for Below Normal, Dry and Critical years, where the year types are defined by the Yuba River Index of SWRCB Decision 1644. Previously the Accord EIR irrigation demands were derived based on 1995 land use data and field adjusted applied water rates published in DWR's Bulletin 113-4. In the previous calculation the differentiation of wet and dry conditions was made by reducing the Bulletin 113 applied water rates for the spring months of wet years to represent the wetter soil conditions that occur in those years. Table 1 lists the monthly irrigation demands used in the new model simulations. Table 2 is the diversion amounts separated into the amounts diverted north and south of the Yuba River.

The total irrigation diversion demands used for this analysis differ only slightly from the amounts used in the Accord EIR. For example, the future irrigation demand used in the Accord EIR, which included the demands of Wheatland Water District, totaled 344,736 acre-ft for the dry condition, while the Cumulative Condition total annual irrigation dry year demand is 346,922 acre-ft, an increase of less than one percent.

Modeling Results

Appendix A of this document provides output results of the modeling. Resulting flows at two locations are provided in a summary table and as exceedance plots. The locations are: Smartsville gage, just below Englebright Dam that includes irrigation delivery flows, and Marysville Gage, 5.6 miles upstream from the mouth of the Yuba River which is the flow in the Yuba River below the diversions at Daguerre Point Dam. Average monthly water temperatures for three locations are provided in a summary table and as exceedance plots. The three locations are: Smartsville gage, just below Englebright Dam, Daguerre Point Dam at river mile 11.5, and Marysville Gage, 5.6 miles upstream from the mouth of the Yuba River.

Table 1: Monthly Irrigation Demands by Yuba River Index Year Type for the Environmental Baseline and Cumulative Condition scenarios

Environmental Baseline Scenario (acre-ft)

Year Type (YRI)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Wet	27,005	21,932	14,271	3,805	415	501	2,902	37,230	49,916	63,909	55,441	19,339	**296,666**
Above Normal	27,005	21,932	14,271	3,805	415	501	2,902	37,230	49,916	63,909	55,441	19,339	**296,666**
Below Normal	23,252	21,993	14,771	8,124	1,182	1,345	20,093	46,306	53,596	60,940	43,131	16,452	**311,185**
Dry	23,252	21,993	14,771	8,124	1,182	1,345	20,093	46,306	53,596	60,940	43,131	16,452	**311,185**
Critical	23,252	21,993	14,771	8,124	1,182	1,345	20,093	46,306	53,596	60,940	43,131	16,452	**311,185**

Cumulative Condition (acre-ft)

Year Type (YRI)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Wet	27,884	23,161	14,512	4,228	415	501	2,906	39,820	57,183	72,697	64,003	23,976	**331,286**
Above Normal	27,884	23,161	14,512	4,228	415	501	2,906	39,820	57,183	72,697	64,003	23,976	**331,286**
Below Normal	24,153	23,471	15,581	8,172	1,182	1,345	20,910	52,931	60,450	68,670	50,246	19,812	**346,922**
Dry	24,153	23,471	15,581	8,172	1,182	1,345	20,910	52,931	60,450	68,670	50,246	19,812	**346,922**
Critical	24,153	23,471	15,581	8,172	1,182	1,345	20,910	52,931	60,450	68,670	50,246	19,812	**346,922**

Note: The Yuba River Index (YRI) Year Type is defined in State Water Resource Control Board Decision 1644

Table 2: Monthly Irrigation Demands by Yuba River Index Year Type at the North and South Diversion Locations for the Environmental Baseline and Cumulative Condition scenarios

North Diversion Environmental Baseline Scenario (acre-ft)

Year Type (YRI)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Wet	18,992	13,641	9,193	1,644	139	103	628	21,913	28,064	34,480	30,474	9,296	**168,567**
Above Normal	18,992	13,641	9,193	1,644	139	103	628	21,913	28,064	34,480	30,474	9,296	**168,567**
Below Normal	15,973	13,317	8,474	5,214	126	372	11,753	26,918	29,912	33,302	22,536	9,057	**176,956**
Dry	15,973	13,317	8,474	5,214	126	372	11,753	26,918	29,912	33,302	22,536	9,057	**176,956**
Critical	15,973	13,317	8,474	5,214	126	372	11,753	26,918	29,912	33,302	22,536	9,057	**176,956**

South Diversion Environmental Baseline Scenario (acre-ft)

Year Type (YRI)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Wet	8,013	8,291	5,078	2,161	277	398	2,274	15,317	21,851	29,429	24,967	10,043	**128,099**
Above Normal	8,013	8,291	5,078	2,161	277	398	2,274	15,317	21,851	29,429	24,967	10,043	**128,099**
Below Normal	7,278	8,676	6,297	2,910	1,056	973	8,339	19,388	23,684	27,638	20,595	7,395	**134,229**
Dry	7,278	8,676	6,297	2,910	1,056	973	8,339	19,388	23,684	27,638	20,595	7,395	**134,229**
Critical	7,278	8,676	6,297	2,910	1,056	973	8,339	19,388	23,684	27,638	20,595	7,395	**134,229**

North Diversion Cumulative Condition Scenario (acre-ft)

Year Type (YRI)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Wet	18,992	13,641	9,193	1,644	139	103	628	21,913	28,064	34,480	30,474	9,296	**168,567**
Above Normal	18,992	13,641	9,193	1,644	139	103	628	21,913	28,064	34,480	30,474	9,296	**168,567**
Below Normal	15,973	13,317	8,474	5,214	126	372	11,753	26,918	29,912	33,302	22,536	9,057	**176,956**
Dry	15,973	13,317	8,474	5,214	126	372	11,753	26,918	29,912	33,302	22,536	9,057	**176,956**
Critical	15,973	13,317	8,474	5,214	126	372	11,753	26,918	29,912	33,302	22,536	9,057	**176,956**

South Diversion Cumulative Condition Scenario (acre-ft)

Year Type (YRI)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Wet	8,892	9,521	5,319	2,583	277	398	2,277	17,907	29,118	38,217	33,529	14,680	**162,719**
Above Normal	8,892	9,521	5,319	2,583	277	398	2,277	17,907	29,118	38,217	33,529	14,680	**162,719**
Below Normal	8,179	10,154	7,106	2,958	1,056	973	9,157	26,013	30,538	35,368	27,709	10,755	**169,966**
Dry	8,179	10,154	7,106	2,958	1,056	973	9,157	26,013	30,538	35,368	27,709	10,755	**169,966**
Critical	8,179	10,154	7,106	2,958	1,056	973	9,157	26,013	30,538	35,368	27,709	10,755	**169,966**

Note: North Diversion includes Cordua ID, Hallwood IC, Ramirez WD and BVID. South Diversion includes Brophy WD, South Yuba WD, Dry Creek MWC, and for the Cumulative Condition also includes Wheatland WD

Appendix A: Modeling Simulation Output

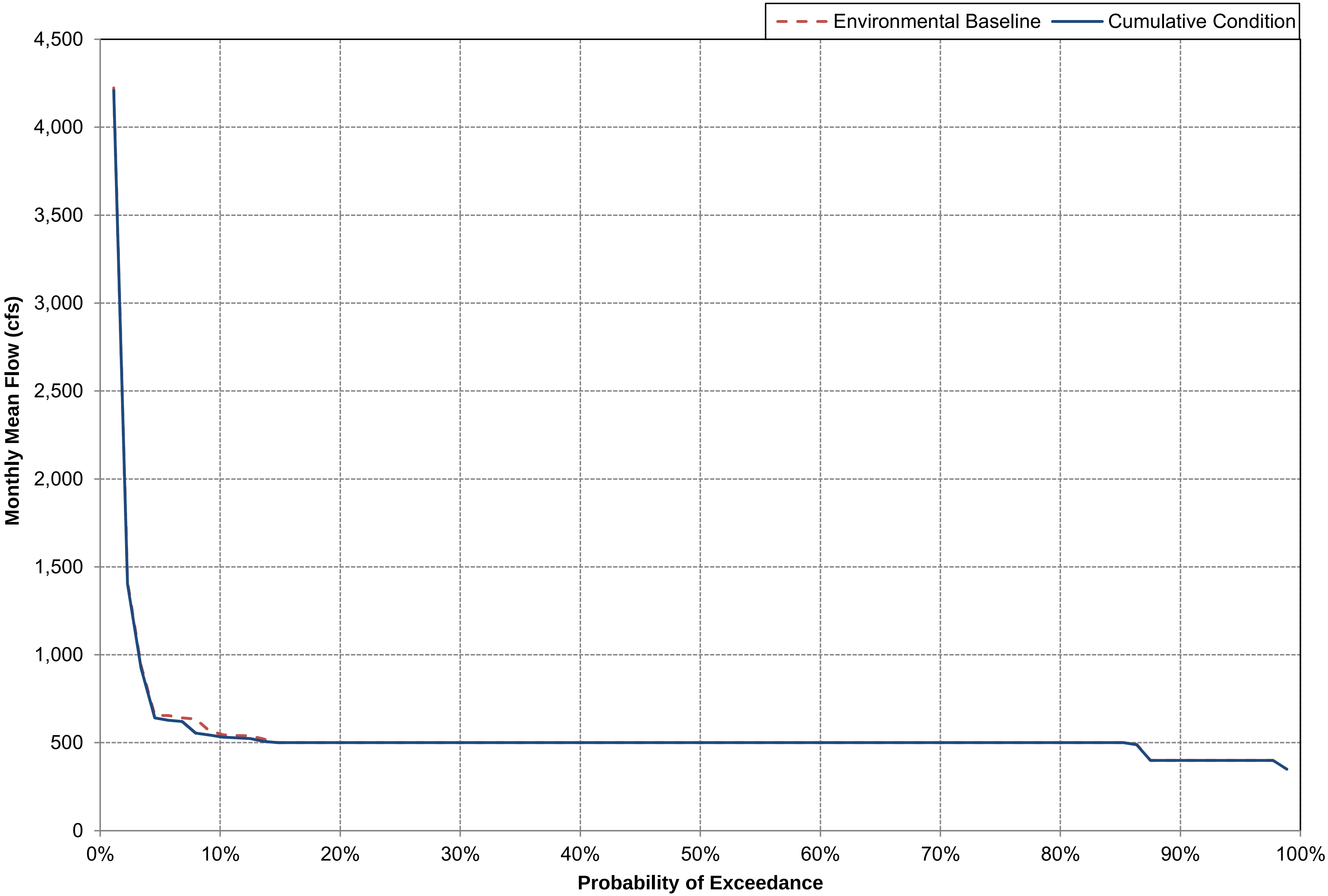
Long-term Average Flow, and Average Flow by Water Year Type in the Lower Yuba River at Marysville under the Environmental Baselin and Cumulative Conditions

	Average Flow (cfs)											
Analysis Period	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Long-term												
Full Simulation Period[1]												
Environmental Baseline	554	853	2,053	3,147	3,240	3,174	2,669	3,000	2,204	1,132	1,119	635
Cumulative Conditions	551	831	2,010	3,095	3,194	3,154	2,658	2,953	2,134	1,051	1,016	579
Difference	-3	-21	-43	-52	-46	-20	-11	-48	-70	-81	-103	-56
% Difference	-0.6%	-2.5%	-2.1%	-1.7%	-1.4%	-0.6%	-0.4%	-1.6%	-3.2%	-7.1%	-9.2%	-8.7%
Water Year Types[2]												
Wet												
Environmental Baseline	669	1,317	4,148	6,159	5,763	5,536	4,422	5,476	4,189	1,921	1,611	779
Cumulative Conditions	667	1,286	4,038	6,097	5,735	5,534	4,422	5,440	4,085	1,793	1,472	697
Difference	-3	-31	-110	-62	-28	-1	0	-37	-104	-127	-140	-82
% Difference	-0.4%	-2.4%	-2.6%	-1.0%	-0.5%	0.0%	0.0%	-0.7%	-2.5%	-6.6%	-8.7%	-10.5%
Above Normal												
Environmental Baseline	487	577	1,280	2,502	2,816	3,295	3,216	3,293	2,243	1,093	1,289	657
Cumulative Conditions	486	556	1,261	2,426	2,706	3,261	3,173	3,214	2,162	997	1,122	589
Difference	-1	-22	-19	-76	-110	-35	-43	-79	-82	-95	-168	-68
% Difference	-0.2%	-3.7%	-1.5%	-3.0%	-3.9%	-1.1%	-1.3%	-2.4%	-3.6%	-8.7%	-13.0%	-10.3%
Below Normal												
Environmental Baseline	484	666	864	1,287	2,093	1,827	1,661	1,295	965	714	992	616
Cumulative Conditions	482	653	860	1,240	2,030	1,760	1,647	1,201	877	628	900	566
Difference	-2	-13	-4	-47	-62	-67	-14	-93	-89	-87	-91	-50
% Difference	-0.4%	-1.9%	-0.5%	-3.6%	-3.0%	-3.7%	-0.8%	-7.2%	-9.2%	-12.2%	-9.2%	-8.1%
Dry												
Environmental Baseline	504	587	768	1,139	1,264	1,091	750	889	510	480	499	499
Cumulative Conditions	507	582	776	1,093	1,252	1,091	748	889	510	480	480	480
Difference	3	-5	8	-47	-12	0	-1	0	0	0	-19	-19
% Difference	0.6%	-0.9%	1.1%	-4.1%	-1.0%	0.0%	-0.2%	0.0%	0.0%	0.0%	-3.8%	-3.8%
Critical												
Environmental Baseline	507	596	739	926	937	815	583	606	399	379	379	398
Cumulative Conditions	494	576	733	917	935	815	587	594	391	371	371	387
Difference	-13	-20	-7	-9	-2	0	4	-12	-8	-8	-8	-12
% Difference	-2.6%	-3.4%	-0.9%	-1.0%	-0.2%	0.0%	0.7%	-2.0%	-1.9%	-2.0%	-2.0%	-2.9%

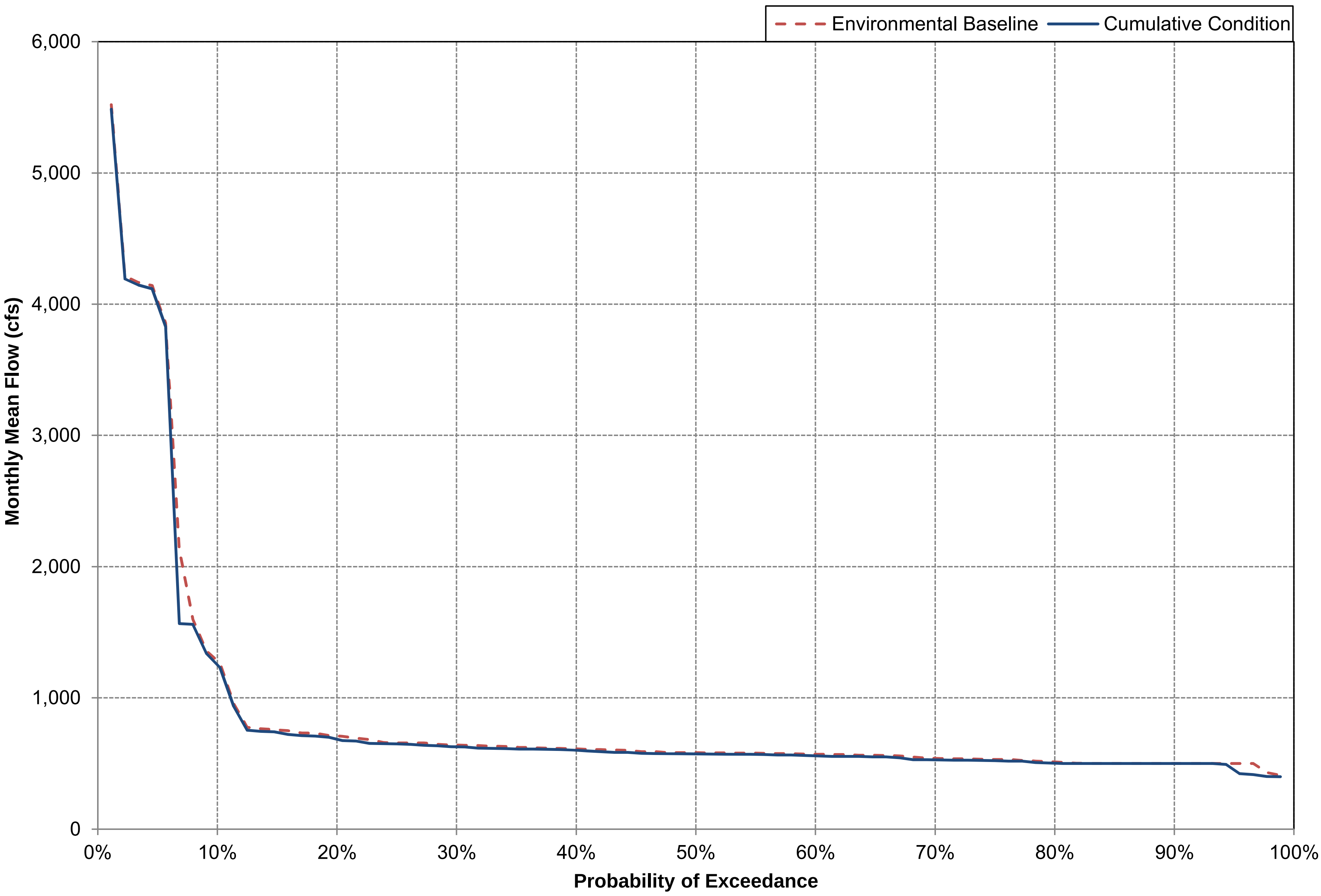
[1] Period of Record is Water Year 1922 - 2008

[2] As defined by the Yuba River Index described in SWRCB RD-1644

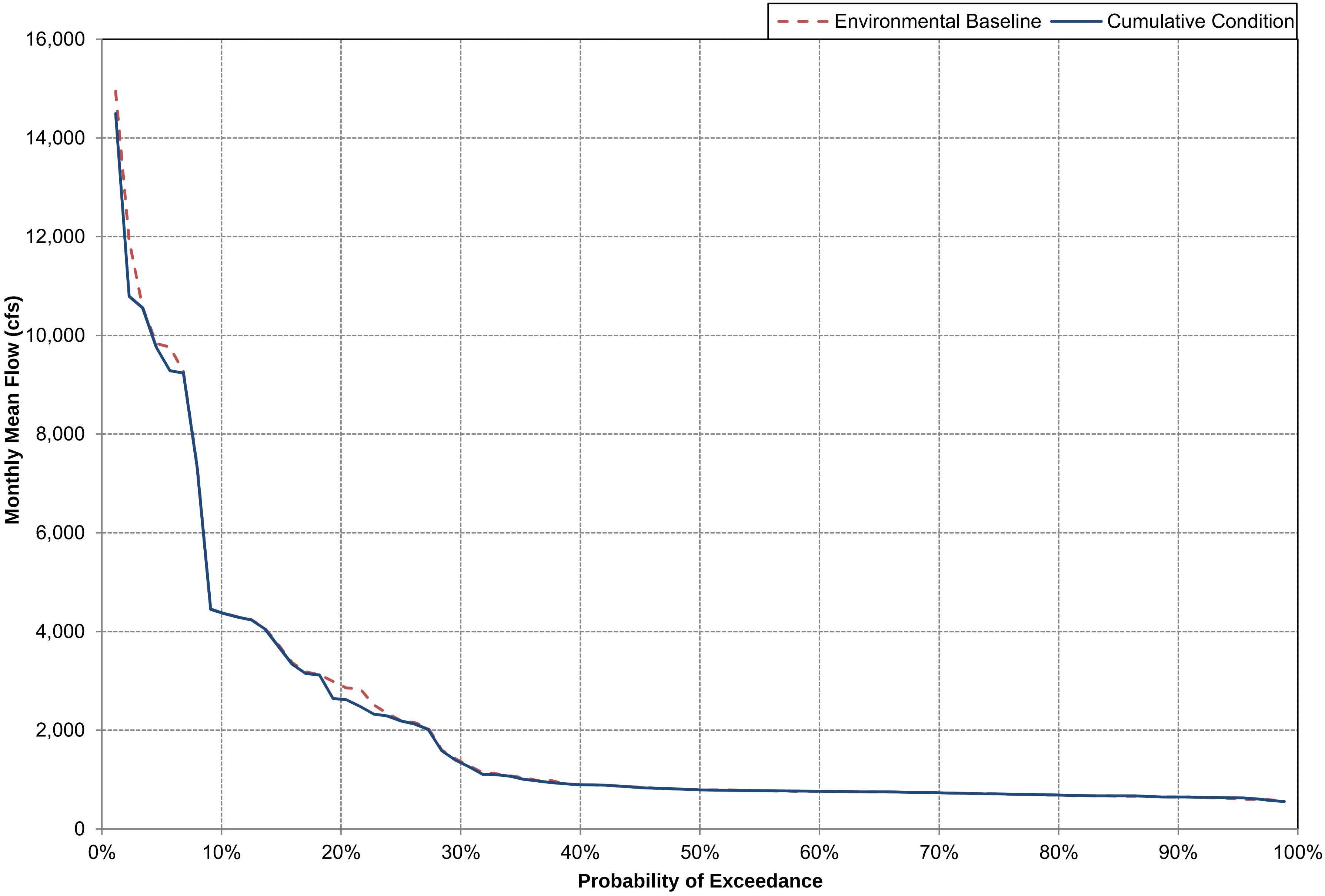
Lower Yuba River Flow at Marysville During October Under Environmental Baseline and Cumulative Conditions

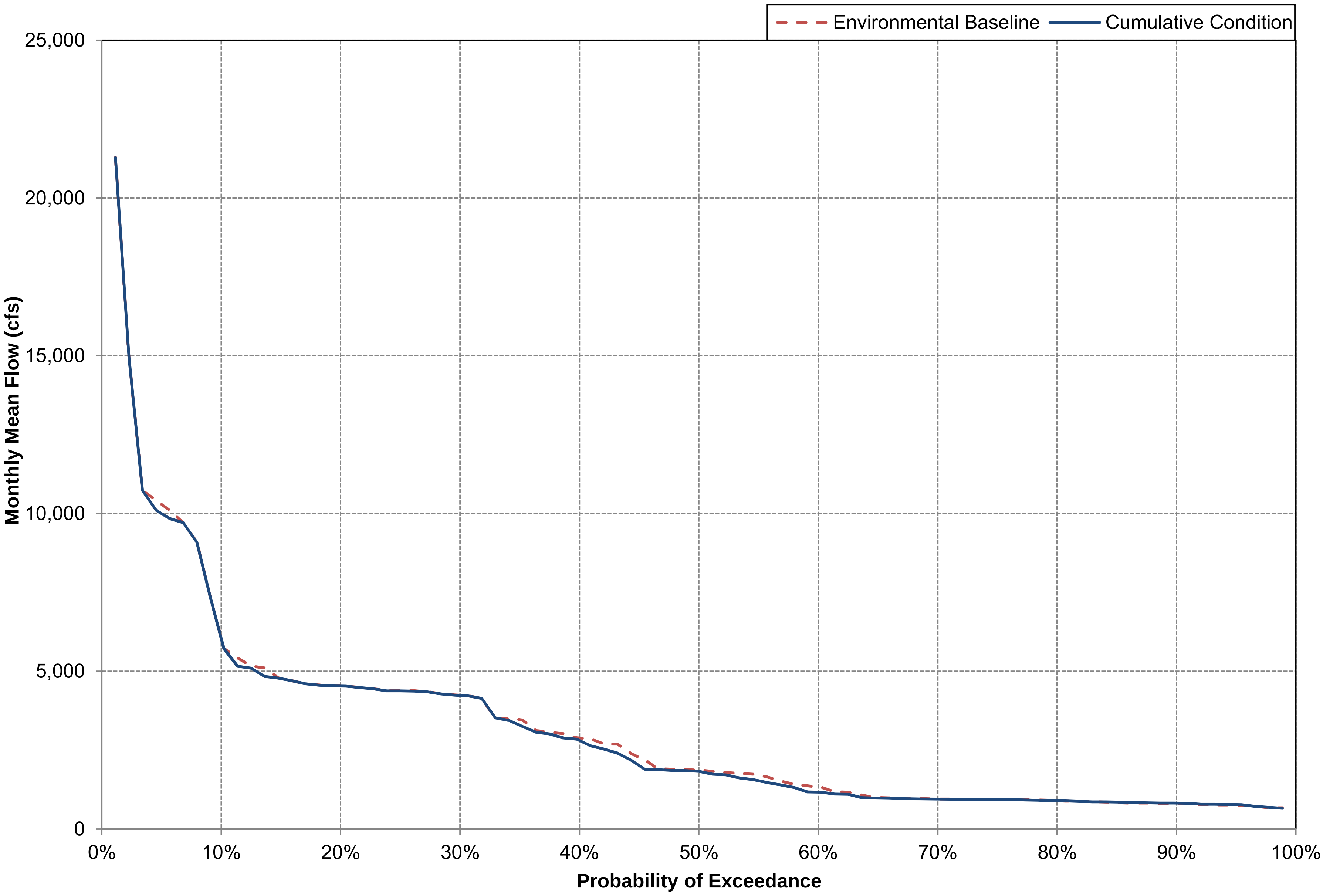


Lower Yuba River Flow at Marysville During November Under Environmental Baseline and Cumulative Conditions

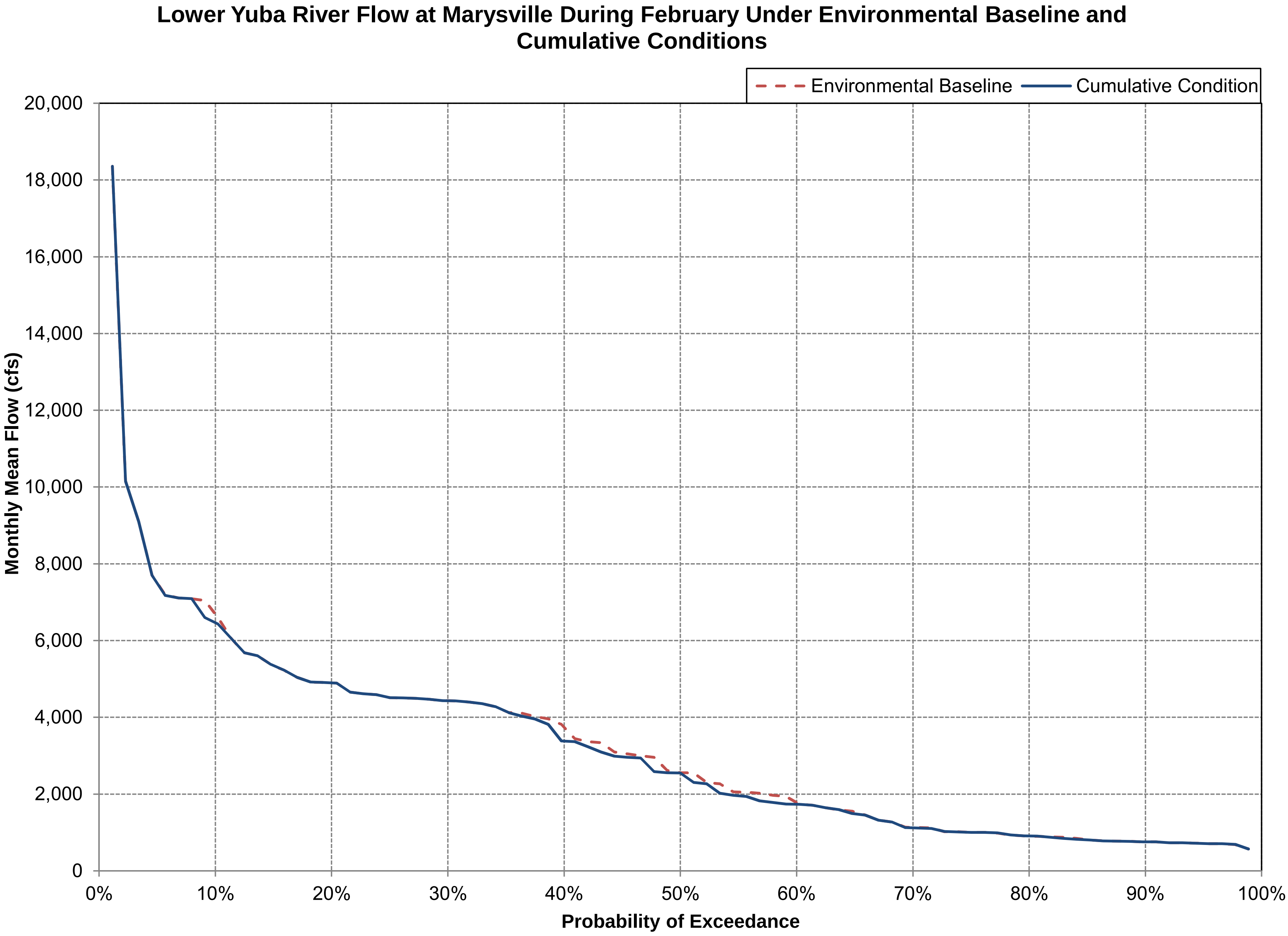


Lower Yuba River Flow at Marysville During December Under Environmental Baseline and Cumulative Conditions

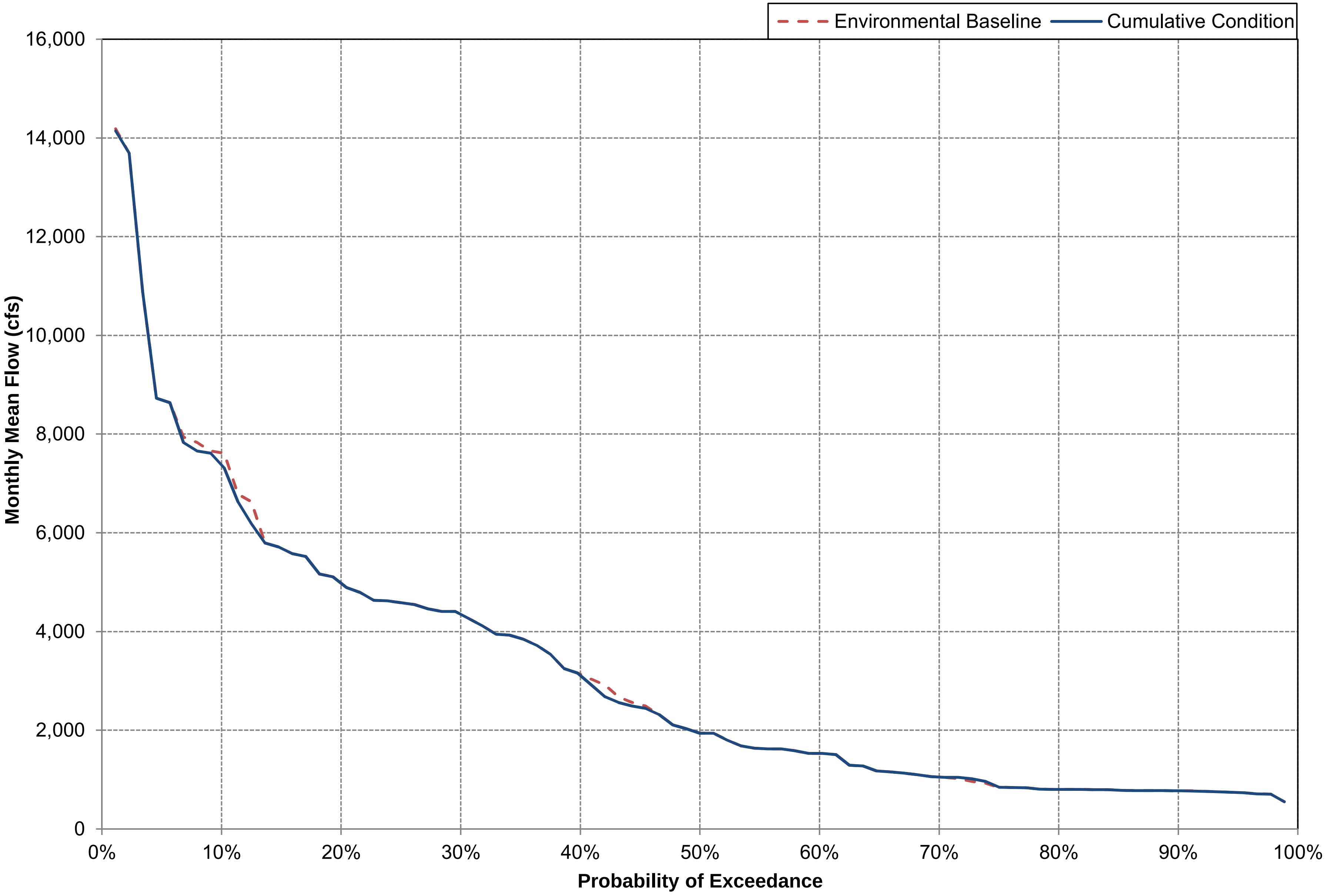


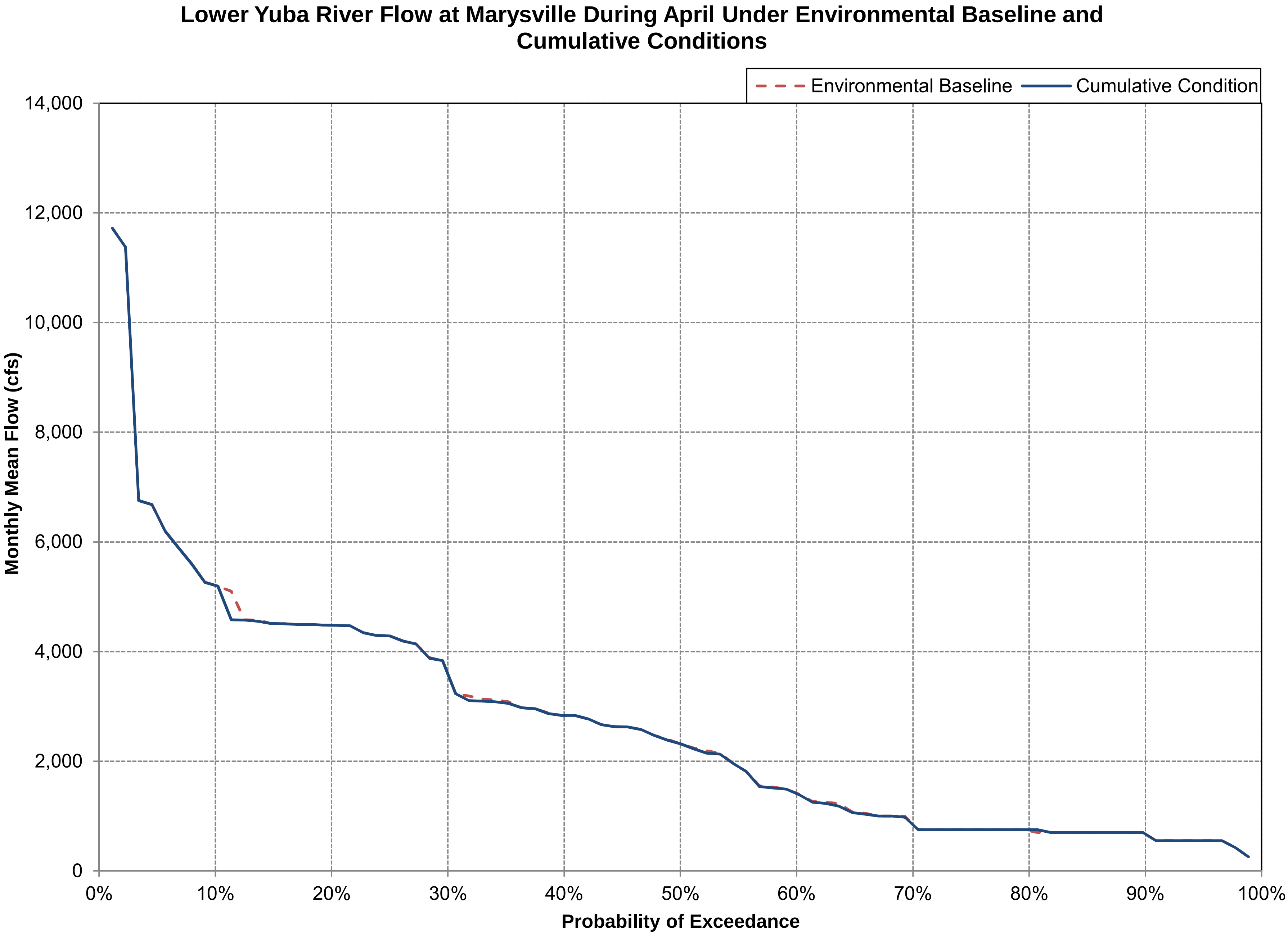


Lower Yuba River Flow at Marysville During January Under Environmental Baseline and Cumulative Conditions

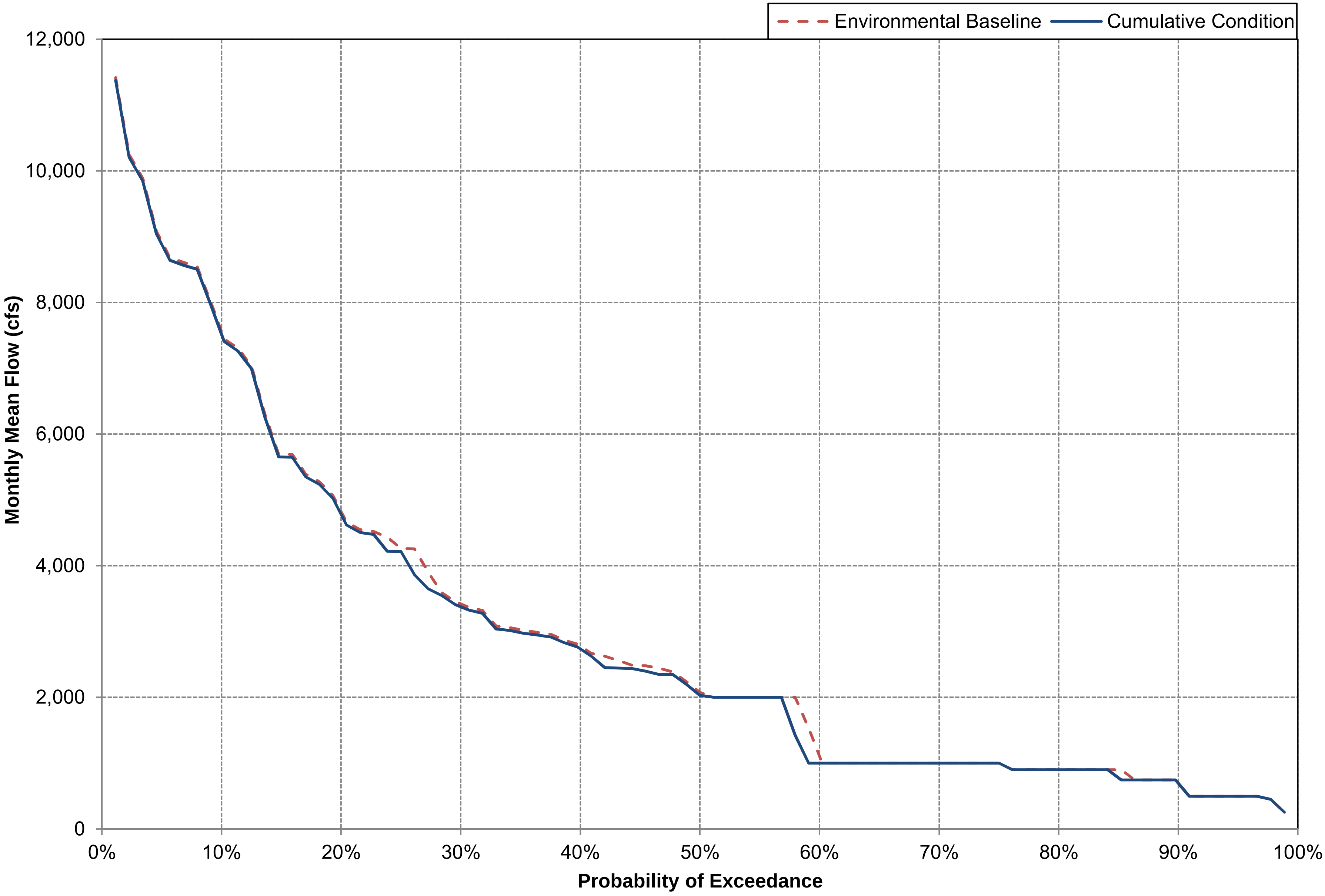

Lower Yuba River Flow at Marysville During February Under Environmental Baseline and Cumulative Conditions
Environmental Baseline
Cumulative Condition
Monthly Mean Flow (cfs)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Exceedance

Lower Yuba River Flow at Marysville During March Under Environmental Baseline and Cumulative Conditions

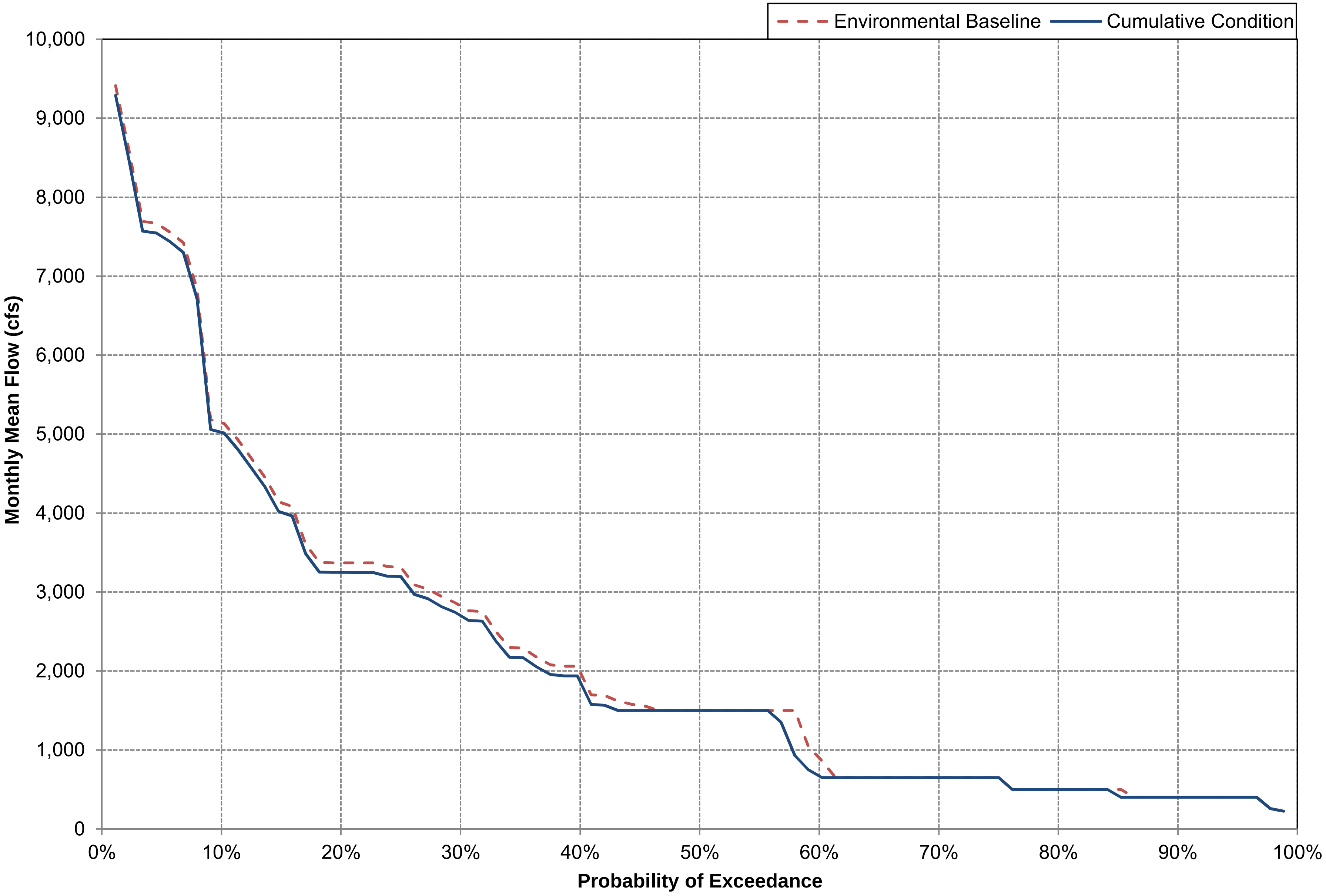



Lower Yuba River Flow at Marysville During April Under Environmental Baseline and Cumulative Conditions
Environmental Baseline
Cumulative Condition
Monthly Mean Flow (cfs)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Exceedance

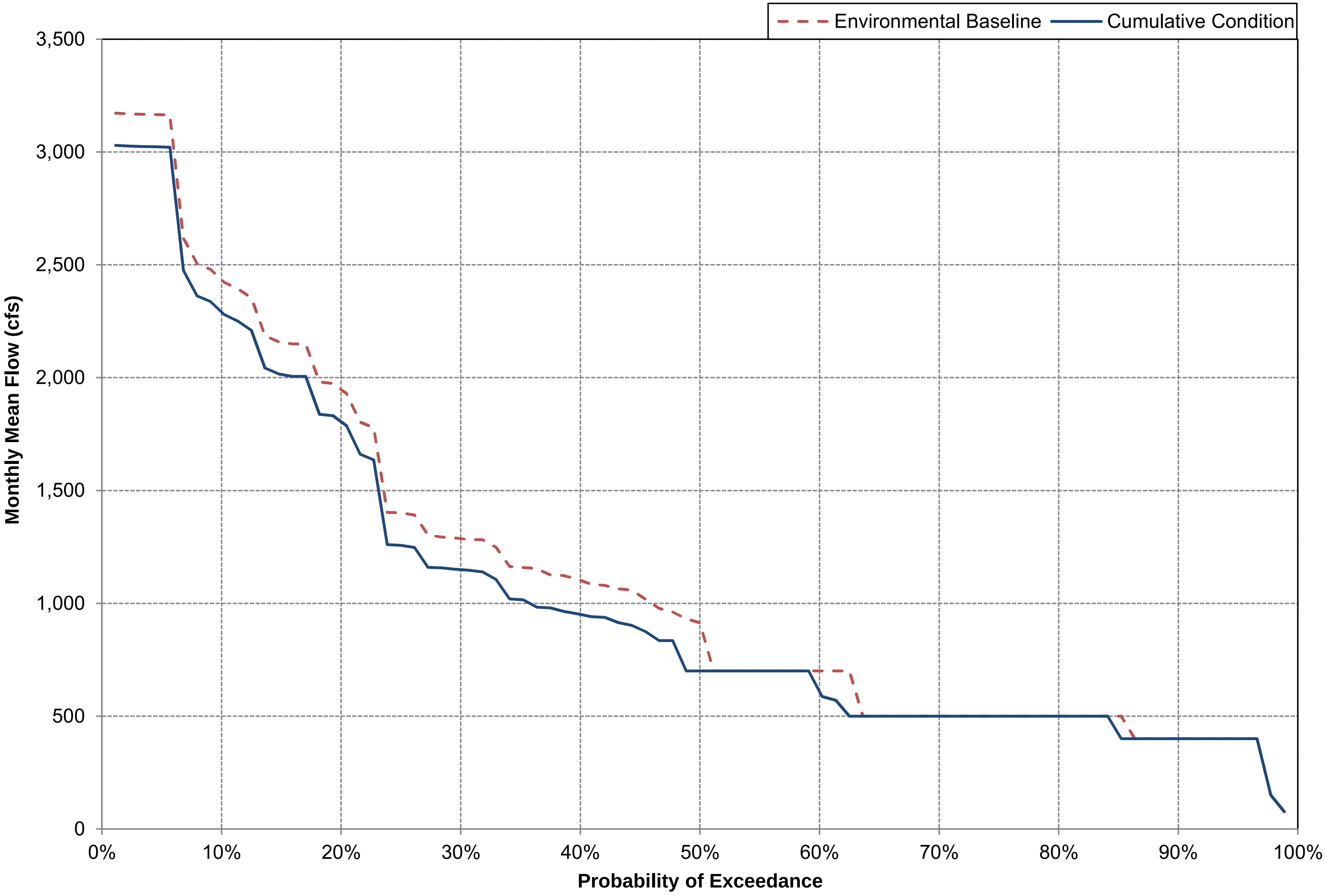
Lower Yuba River Flow at Marysville During May Under Environmental Baseline and Cumulative Conditions

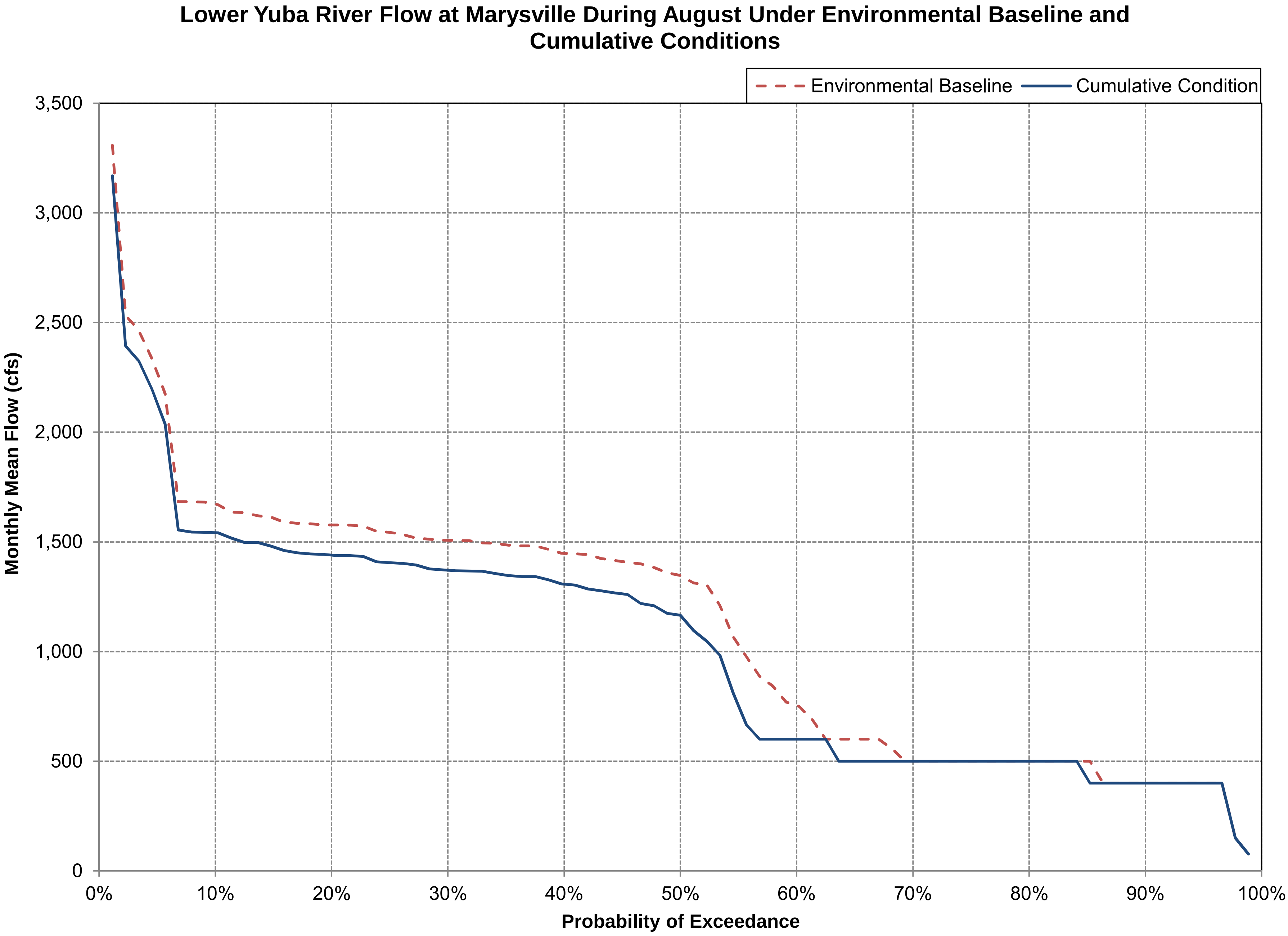


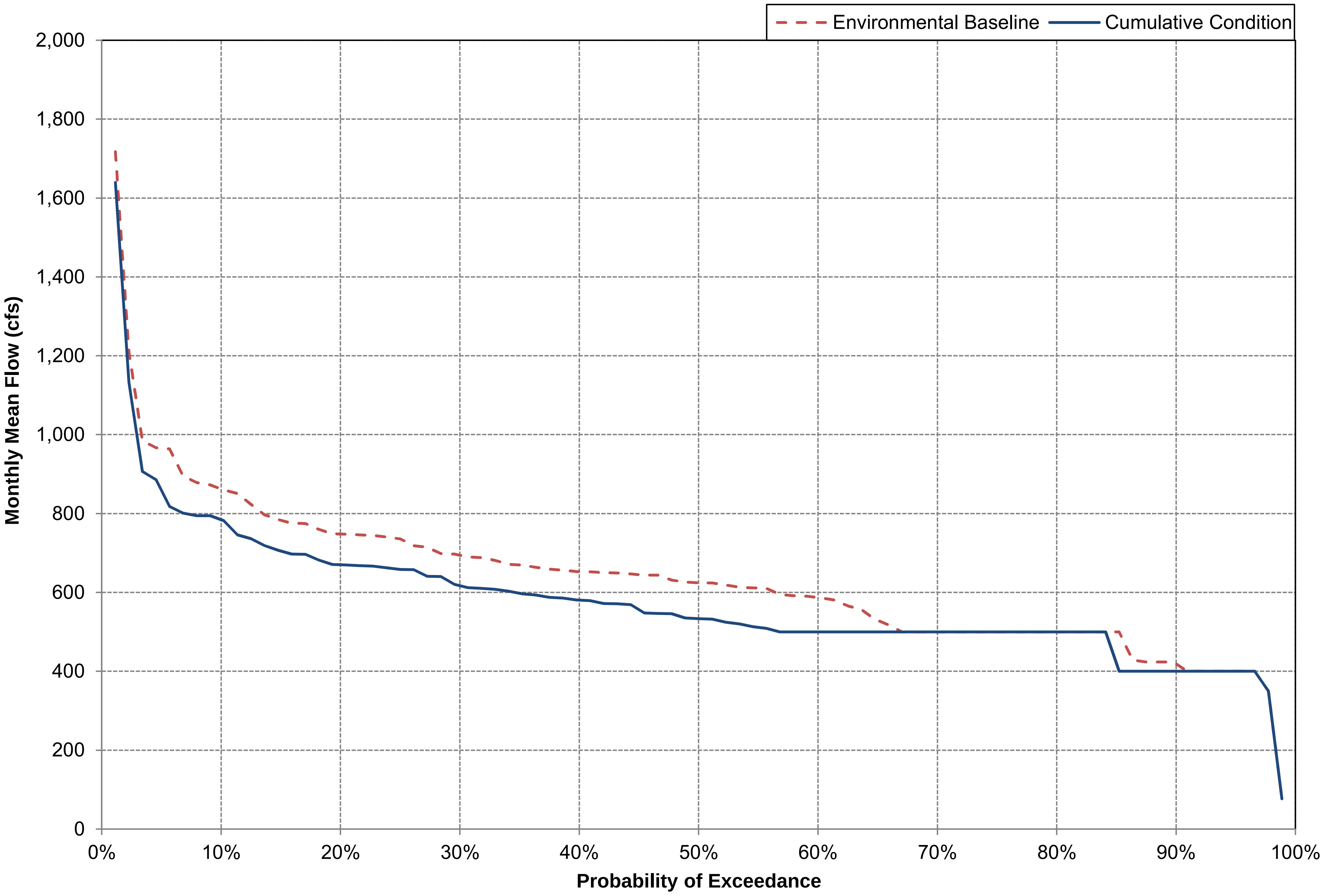
Lower Yuba River Flow at Marysville During June Under Environmental Baseline and Cumulative Conditions



Lower Yuba River Flow at Marysville During July Under Environmental Baseline and Cumulative Conditions




Lower Yuba River Flow at Marysville During August Under Environmental Baseline and Cumulative Conditions
Environmental Baseline
Cumulative Condition
Monthly Mean Flow (cfs)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Exceedance



Lower Yuba River Flow at Marysville During September Under Environmental Baseline and Cumulative Conditions

Long-term Average Flow, and Average Flow by Water Year Type in the Lower Yuba River at Smartsville under the Environmental Baselin and Cumulative Conditions

	Average Flow (cfs)											
Analysis Period	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Long-term												
Full Simulation Period[1]												
Environmental Baseline	942	1,148	2,131	2,990	2,938	2,895	2,663	3,595	3,042	2,126	1,912	929
Cumulative Conditions	952	1,148	2,095	2,942	2,893	2,875	2,657	3,616	3,088	2,176	1,934	940
Difference	10	0	-35	-48	-46	-20	-6	20	45	50	22	11
% Difference	1.1%	0.0%	-1.7%	-1.6%	-1.6%	-0.7%	-0.2%	0.6%	1.5%	2.4%	1.2%	1.2%
Water Year Types[2]												
Wet												
Environmental Baseline	1,059	1,564	4,079	5,775	5,263	5,069	4,141	5,957	5,004	2,942	2,494	1,090
Cumulative Conditions	1,071	1,554	3,976	5,718	5,235	5,067	4,141	5,962	5,023	2,958	2,493	1,085
Difference	12	-9	-103	-57	-28	-1	0	6	19	15	0	-4
% Difference	1.1%	-0.6%	-2.5%	-1.0%	-0.5%	0.0%	0.0%	0.1%	0.4%	0.5%	0.0%	-0.4%
Above Normal												
Environmental Baseline	855	879	1,402	2,360	2,522	3,020	3,072	3,824	3,060	2,116	2,176	978
Cumulative Conditions	867	879	1,391	2,287	2,413	2,985	3,028	3,788	3,101	2,164	2,148	988
Difference	13	-1	-11	-73	-110	-35	-43	-36	40	48	-29	10
% Difference	1.5%	-0.1%	-0.8%	-3.1%	-4.3%	-1.1%	-1.4%	-1.0%	1.3%	2.2%	-1.3%	1.0%
Below Normal												
Environmental Baseline	886	980	1,011	1,281	1,864	1,632	1,902	2,023	1,849	1,693	1,687	892
Cumulative Conditions	893	985	1,012	1,237	1,801	1,565	1,902	2,037	1,875	1,732	1,712	899
Difference	8	5	1	-44	-62	-67	0	14	26	39	24	6
% Difference	0.9%	0.5%	0.1%	-3.4%	-3.4%	-4.1%	0.0%	0.7%	1.4%	2.3%	1.4%	0.7%
Dry												
Environmental Baseline	912	925	941	1,138	1,162	982	1,039	1,610	1,398	1,470	1,199	774
Cumulative Conditions	929	942	956	1,096	1,150	982	1,051	1,718	1,513	1,596	1,296	812
Difference	17	17	15	-42	-12	0	12	108	115	126	97	37
% Difference	1.9%	1.8%	1.6%	-3.7%	-1.1%	0.0%	1.2%	6.7%	8.2%	8.6%	8.1%	4.8%
Critical												
Environmental Baseline	886	937	937	964	839	732	873	1,293	1,224	1,293	1,027	653
Cumulative Conditions	887	940	940	959	837	732	884	1,366	1,307	1,384	1,114	689
Difference	2	3	3	-6	-2	0	11	74	82	91	86	35
% Difference	0.2%	0.3%	0.3%	-0.6%	-0.2%	0.0%	1.2%	5.7%	6.7%	7.0%	8.4%	5.4%

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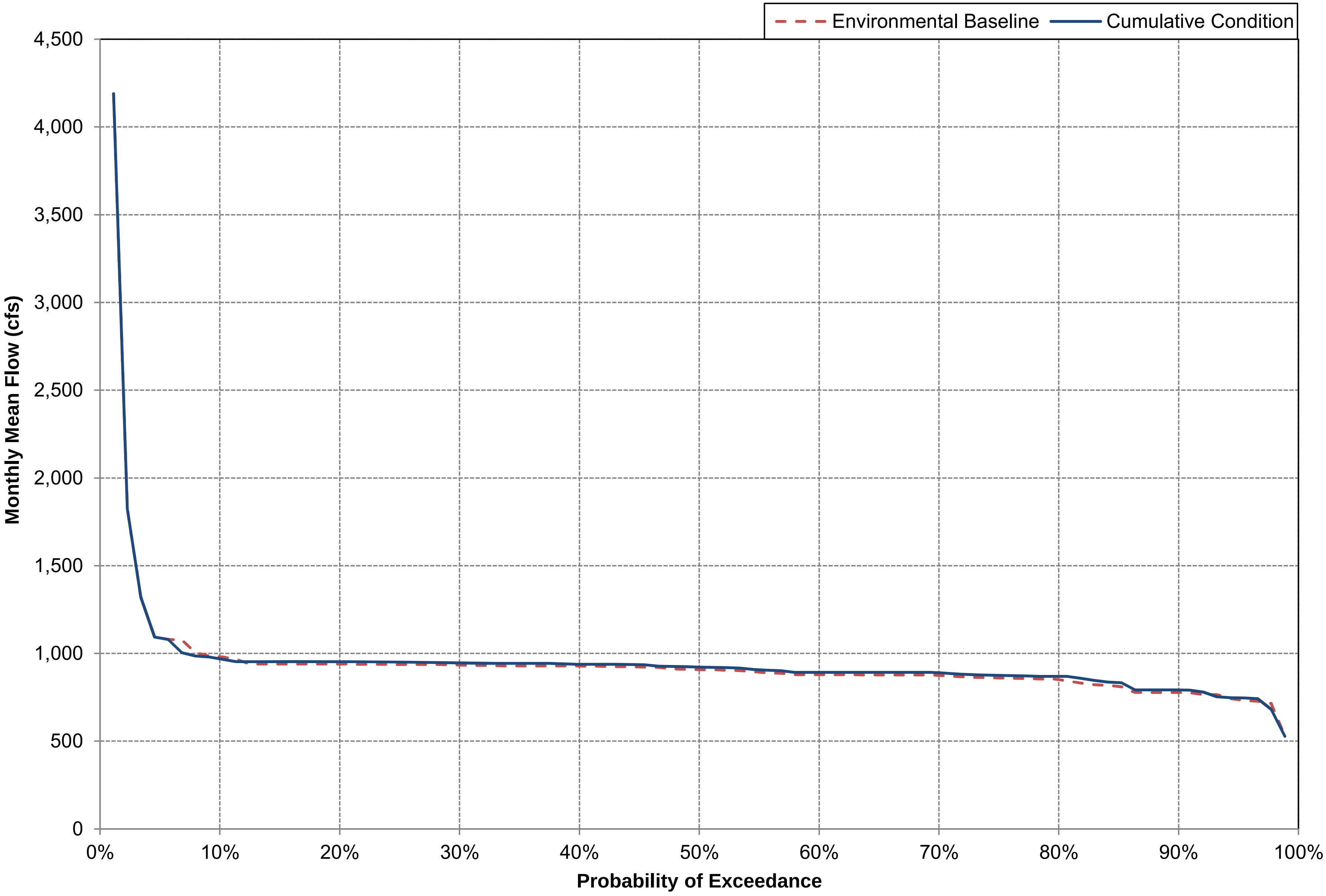
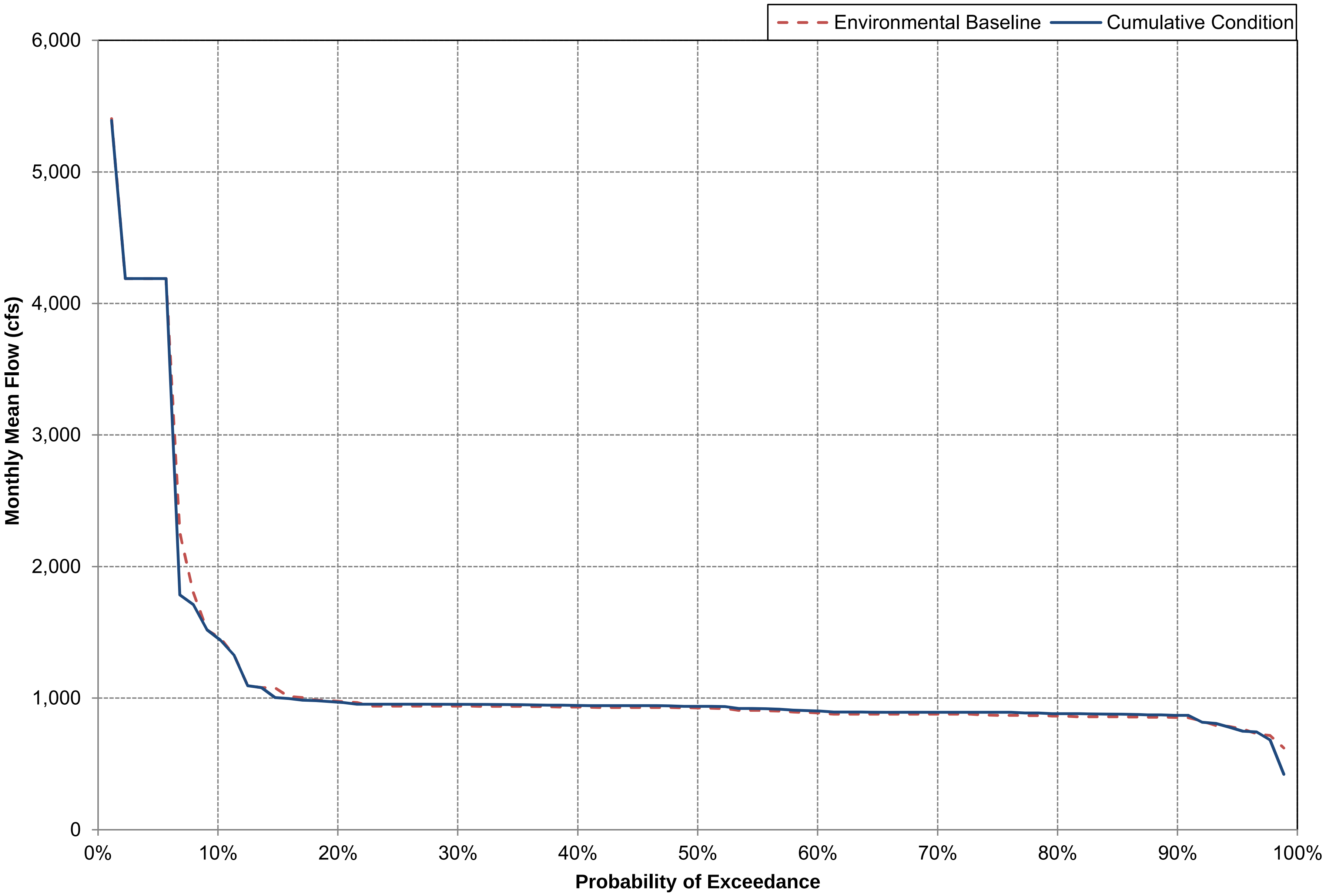
[1] Period of Record is Water Year 1922 - 2008

[2] As defined by the Yuba River Index described in SWRCB RD-1644

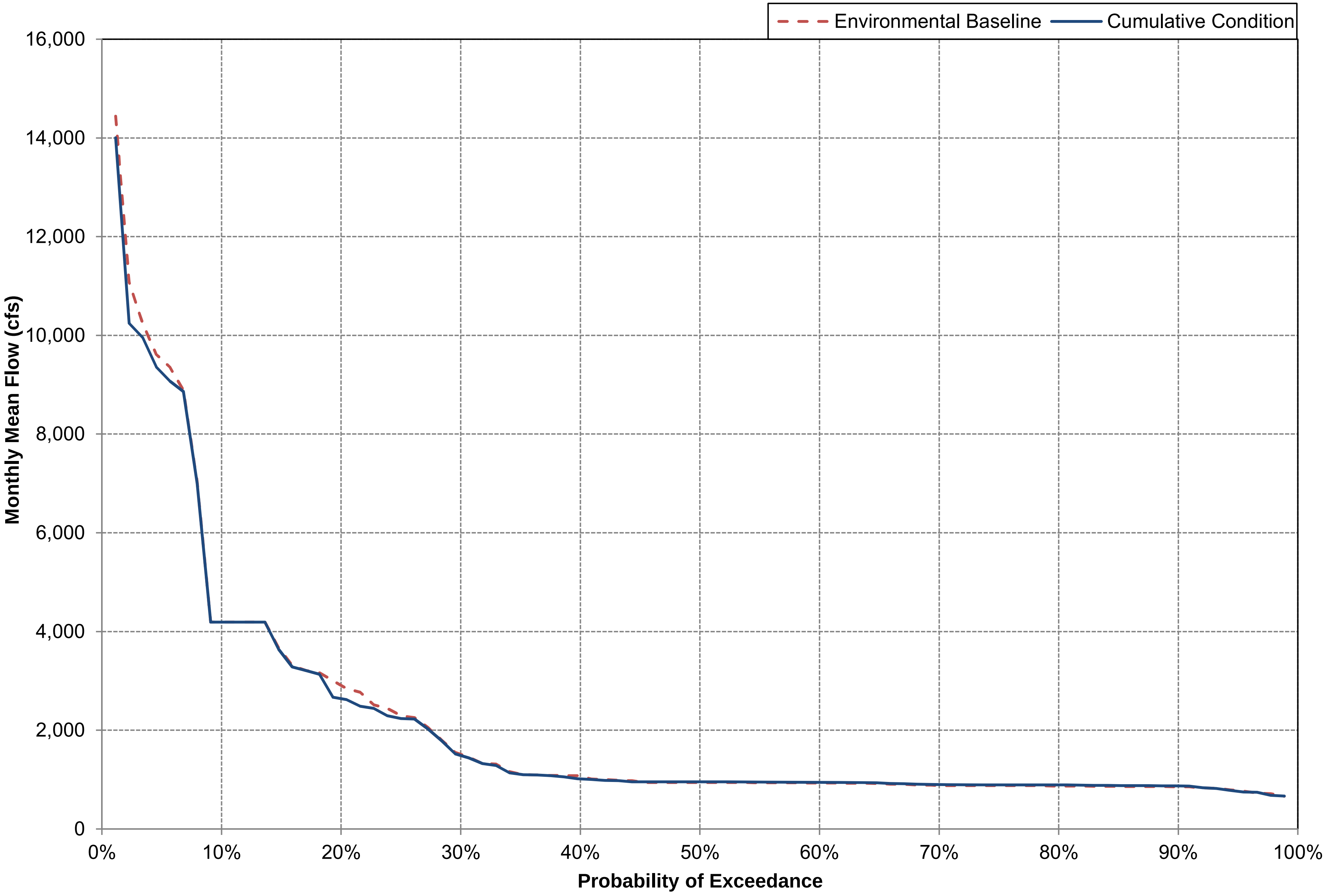
Lower Yuba River Flow at Smartsville During October Under Environmental Baseline and Cumulative Conditions



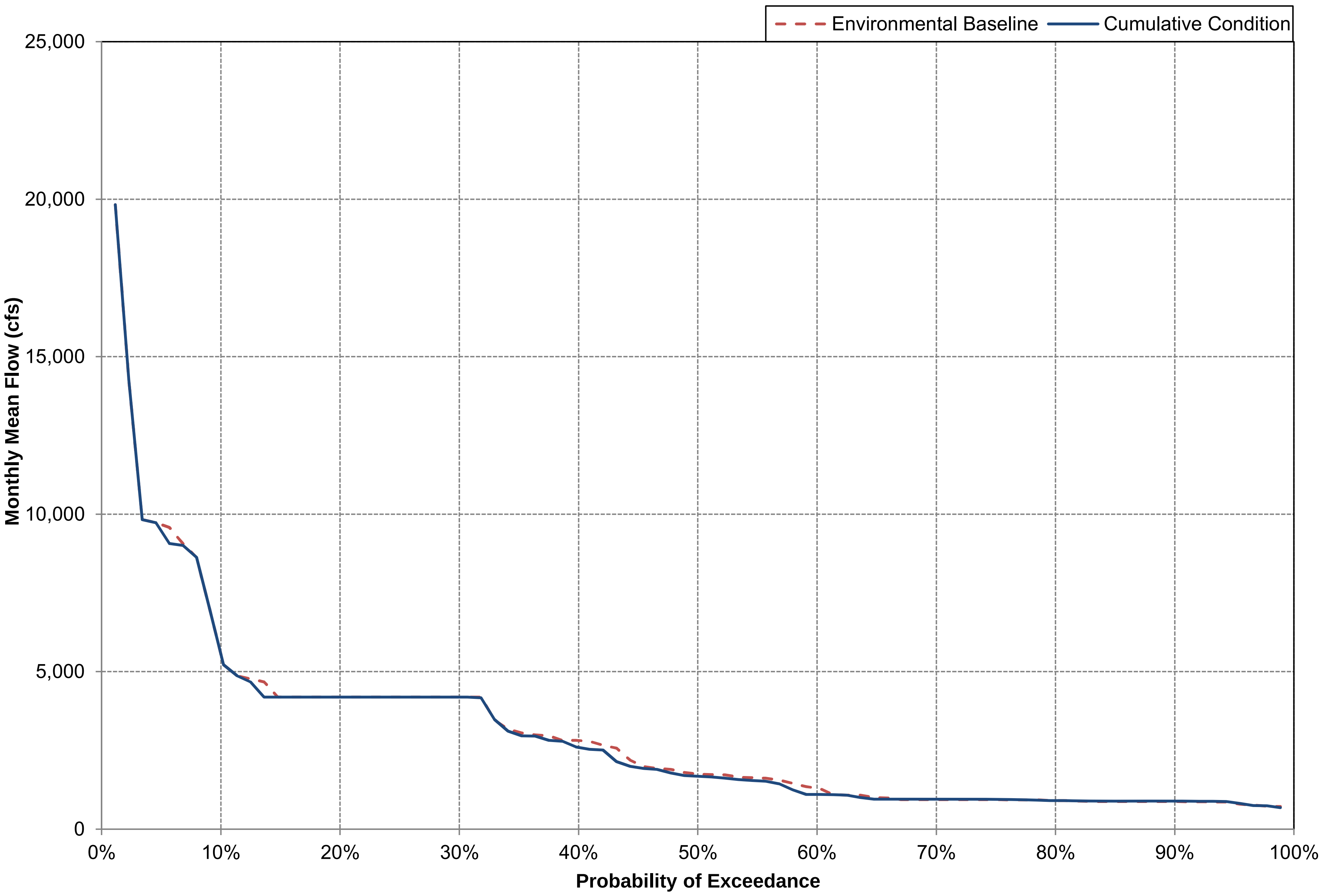
Lower Yuba River Flow at Smartsville During November Under Environmental Baseline and Cumulative Conditions



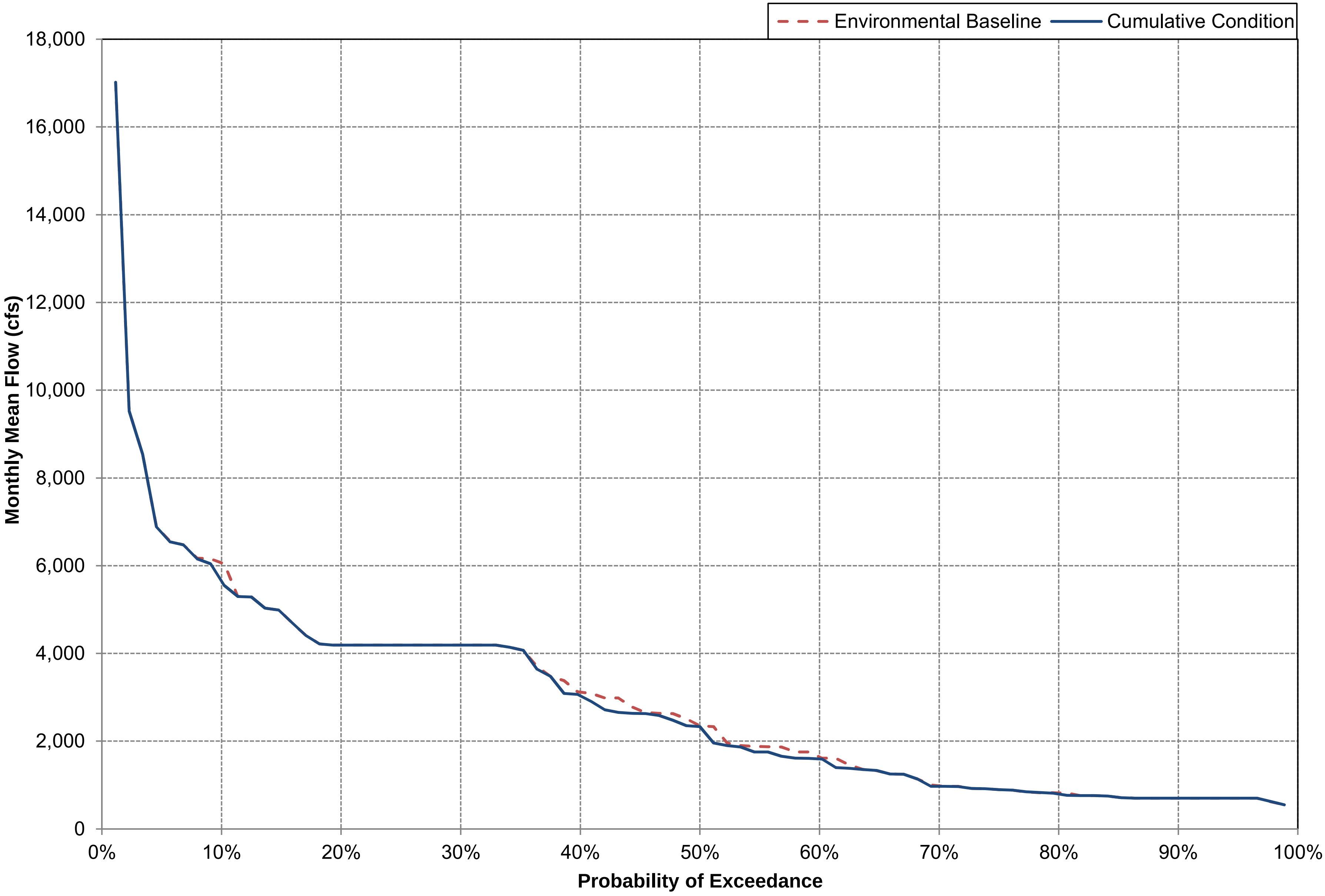
Lower Yuba River Flow at Smartsville During December Under Environmental Baseline and Cumulative Conditions

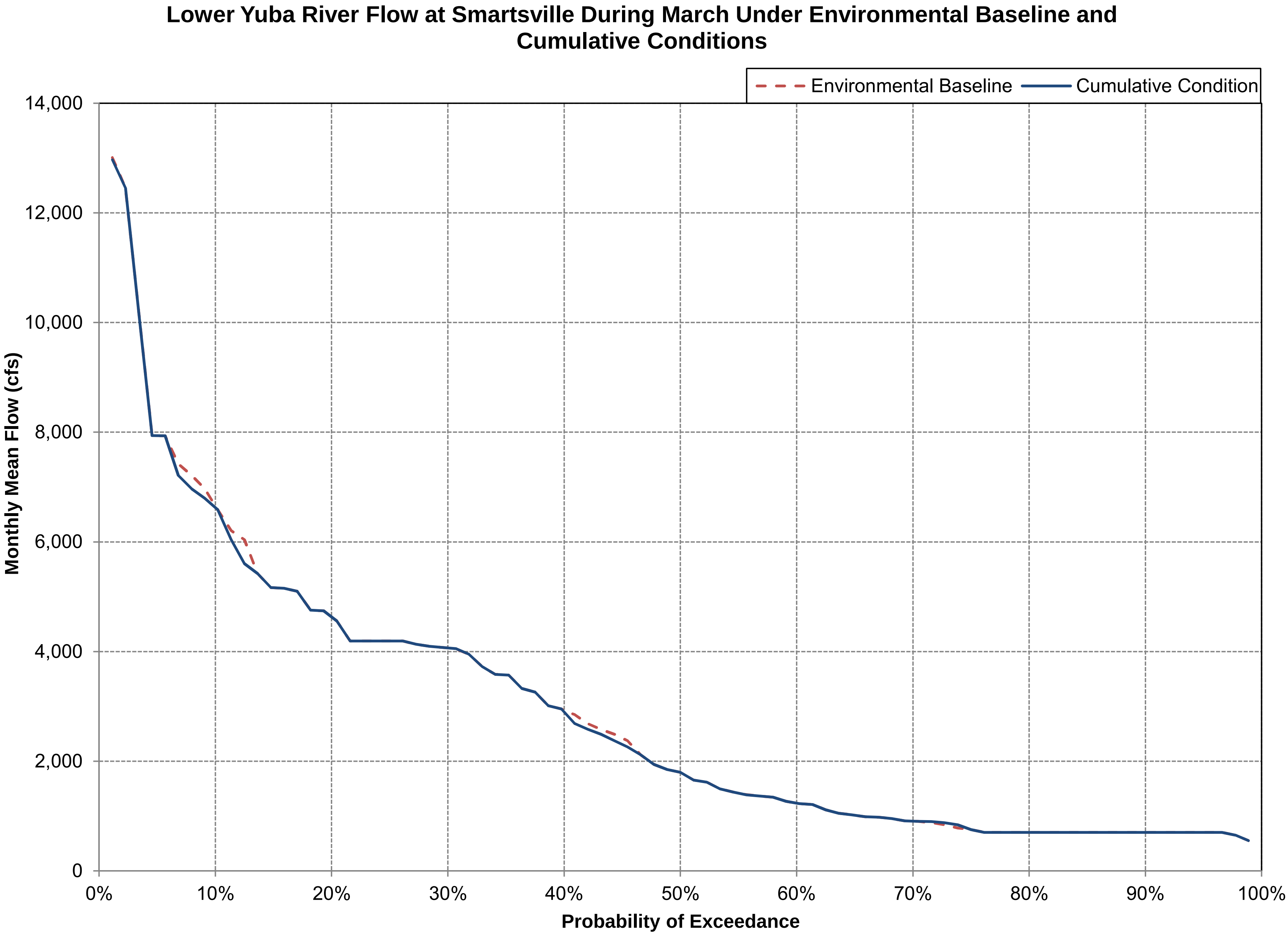


Lower Yuba River Flow at Smartsville During January Under Environmental Baseline and Cumulative Conditions



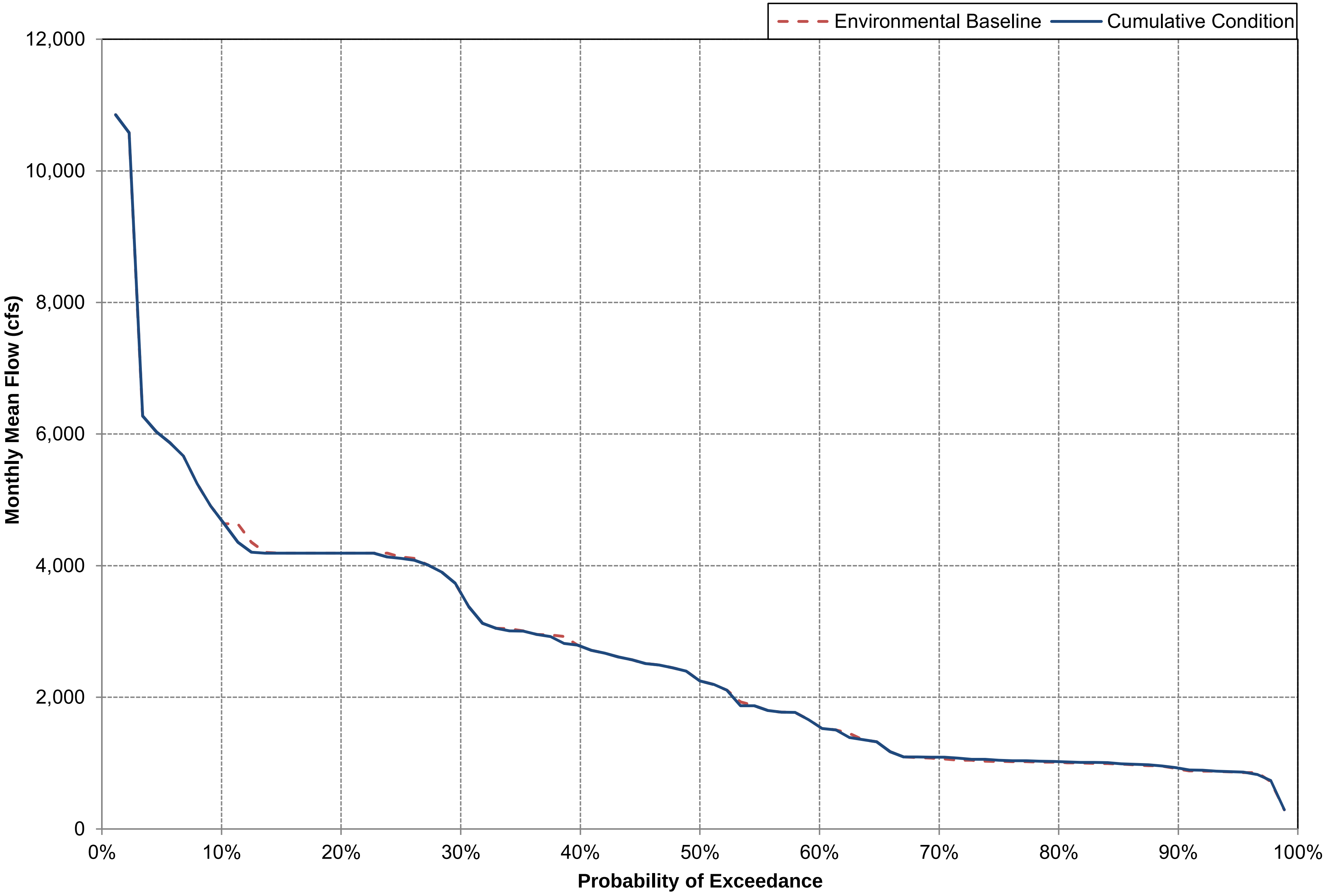
Lower Yuba River Flow at Smartsville During February Under Environmental Baseline and Cumulative Conditions



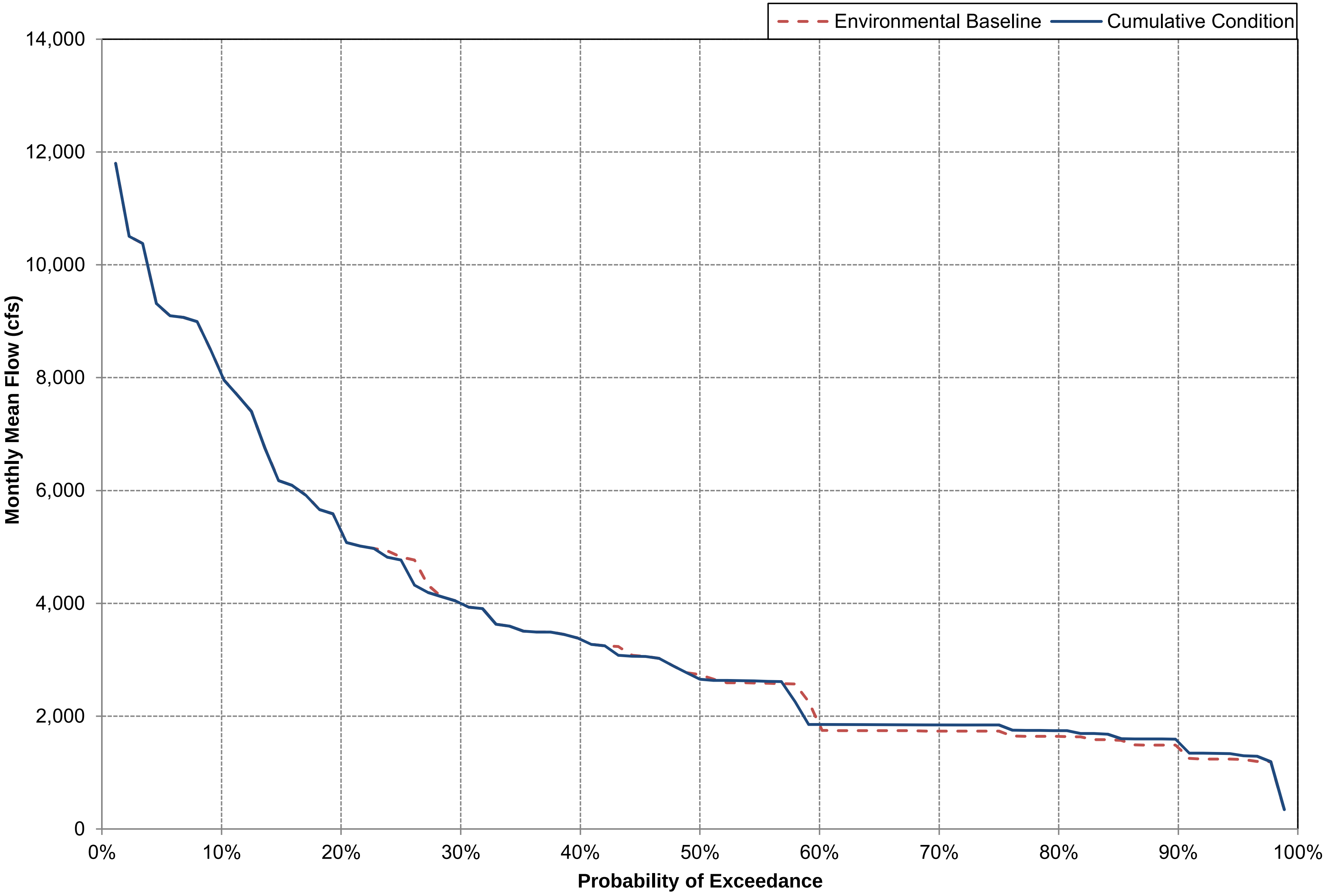


Lower Yuba River Flow at Smartsville During March Under Environmental Baseline and Cumulative Conditions
Environmental Baseline
Cumulative Condition
Monthly Mean Flow (cfs)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Exceedance

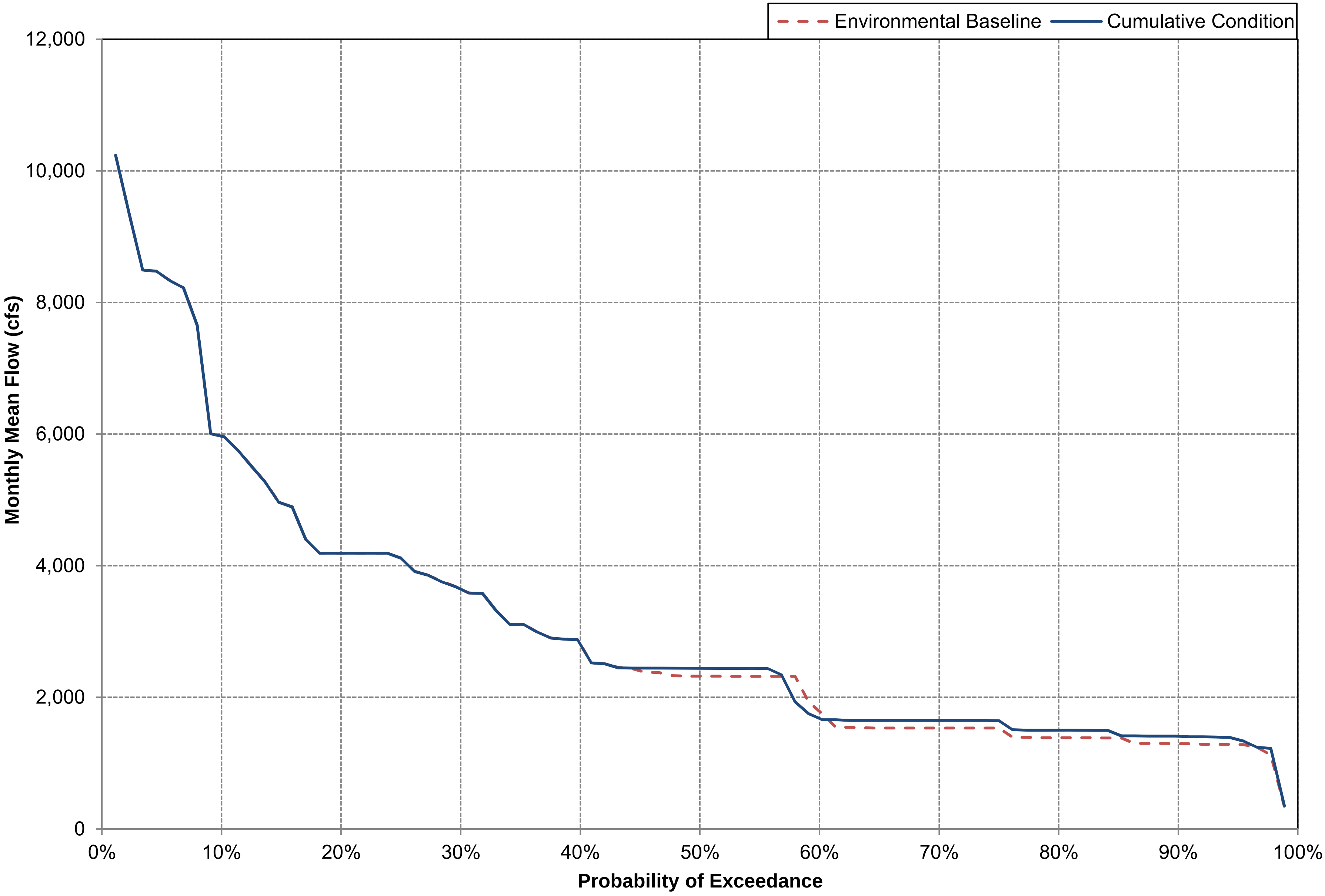
Lower Yuba River Flow at Smartsville During April Under Environmental Baseline and Cumulative Conditions



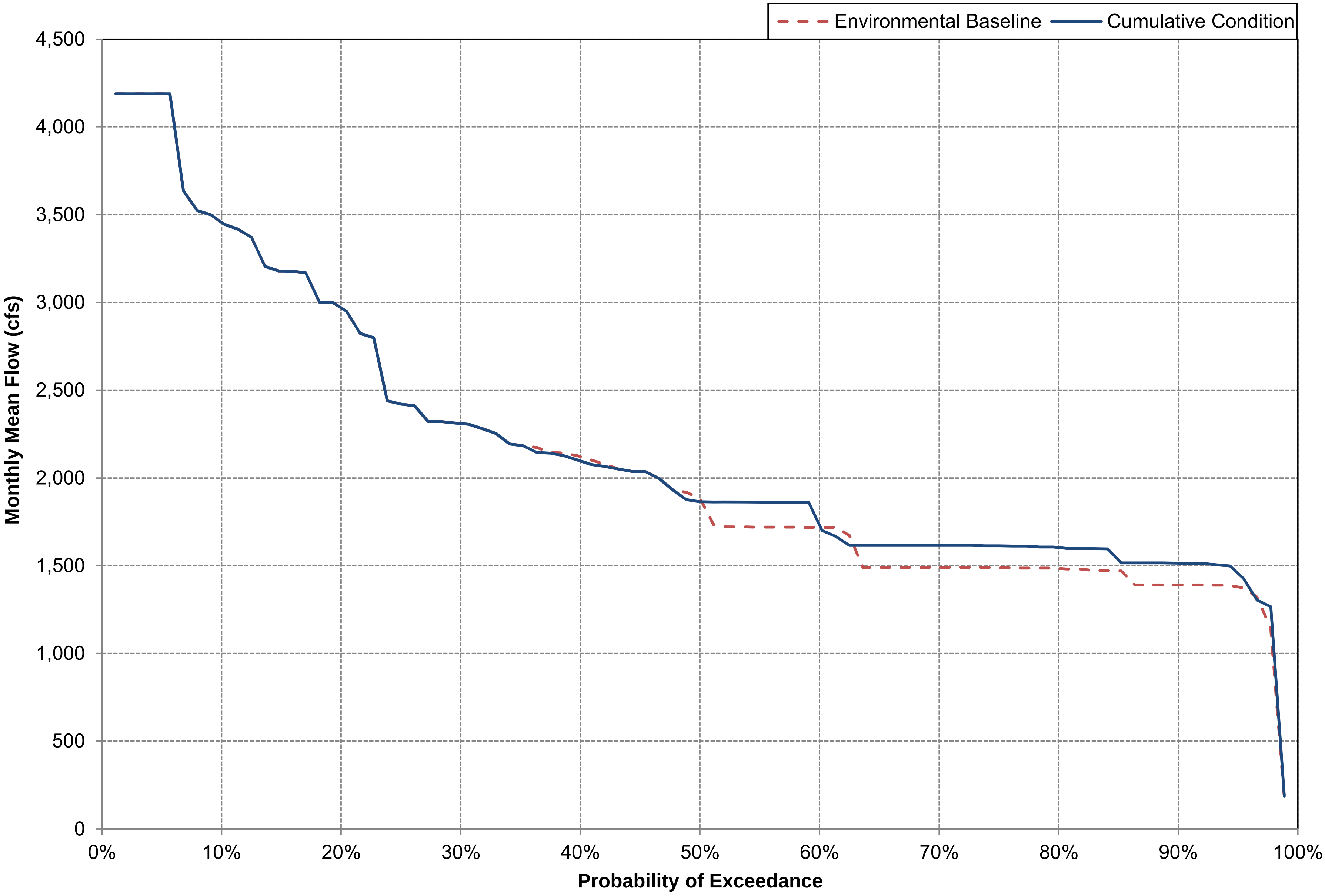
Lower Yuba River Flow at Smartsville During May Under Environmental Baseline and Cumulative Conditions



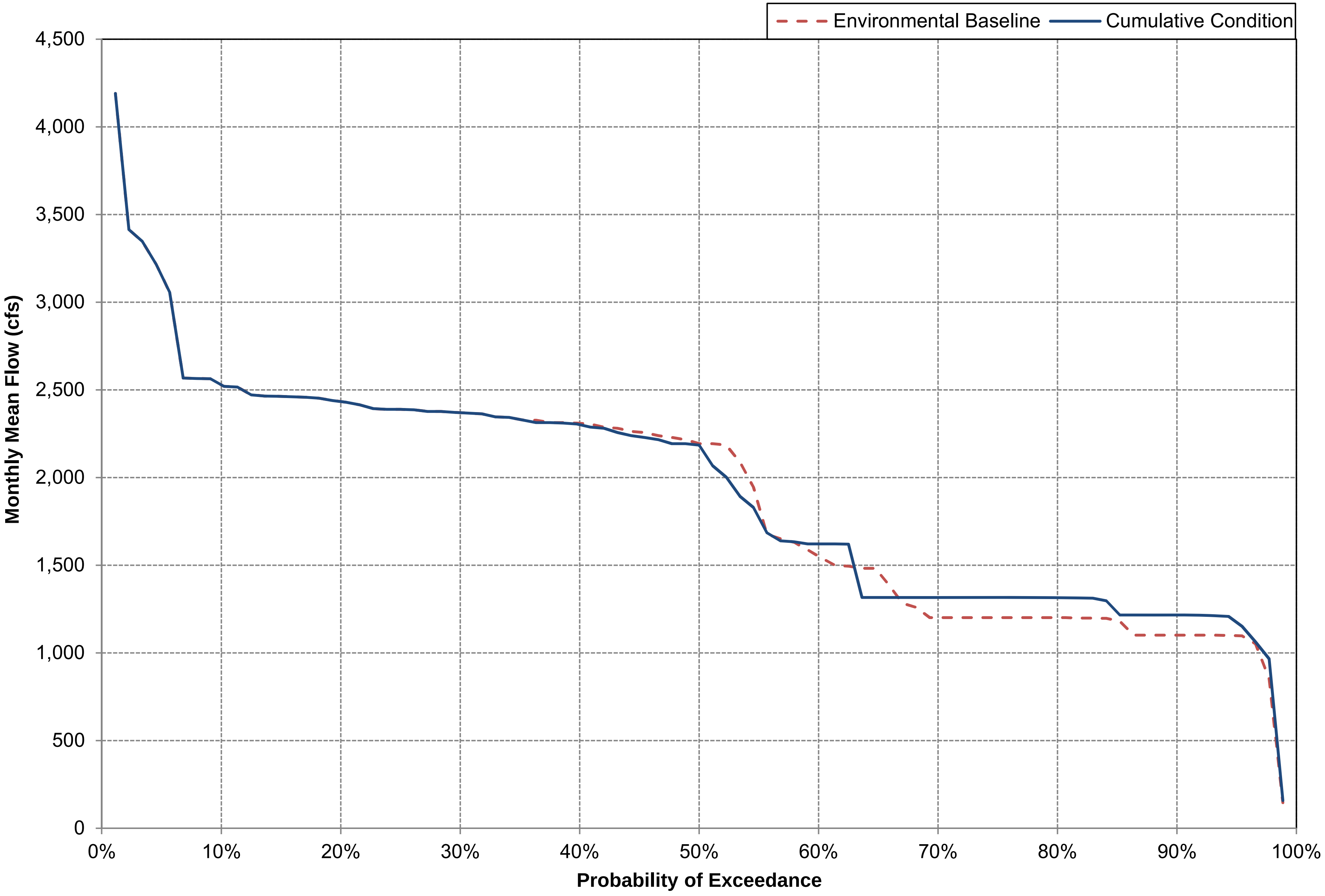
Lower Yuba River Flow at Smartsville During June Under Environmental Baseline and Cumulative Conditions



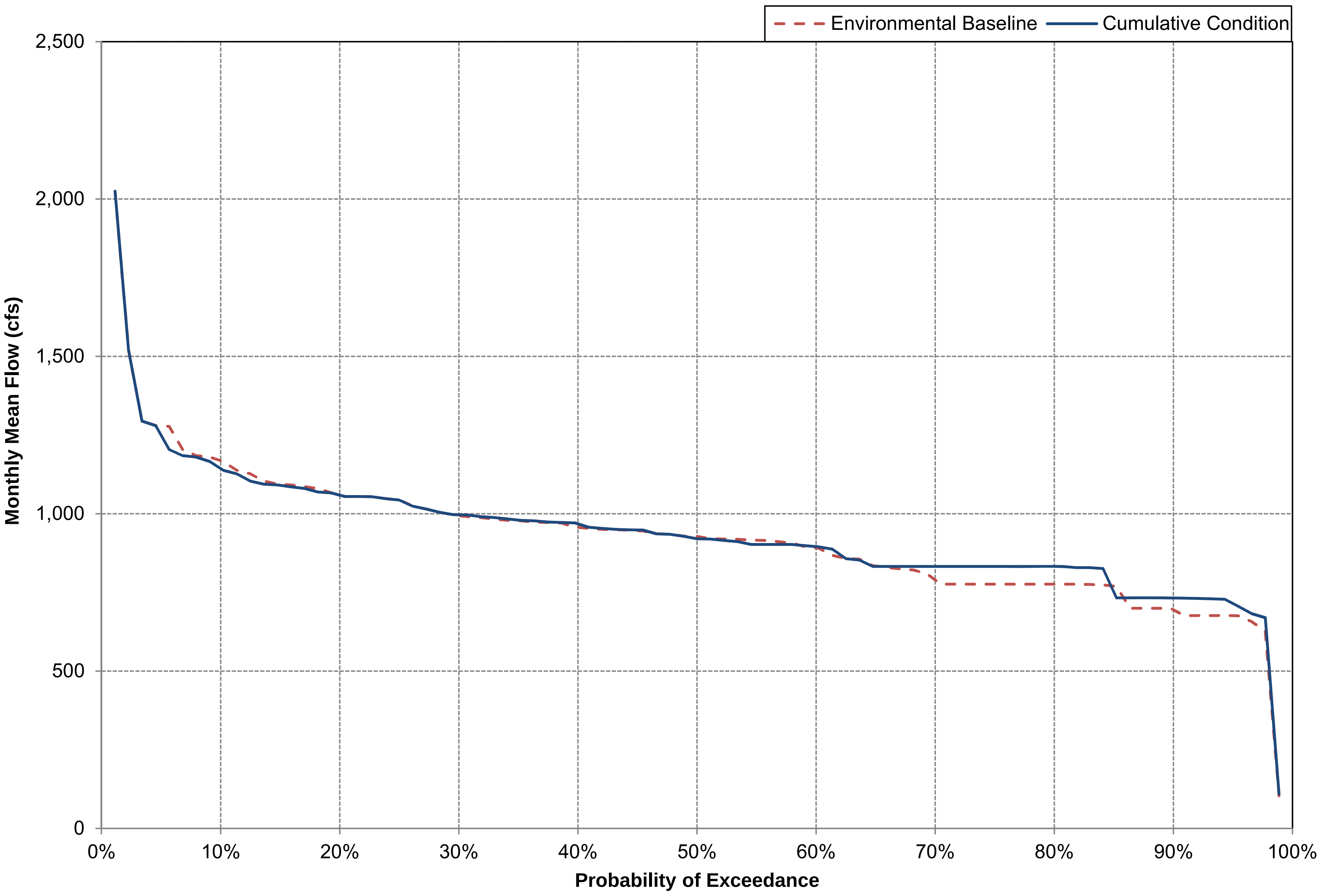
Lower Yuba River Flow at Smartsville During July Under Environmental Baseline and Cumulative Conditions



Lower Yuba River Flow at Smartsville During August Under Environmental Baseline and Cumulative Conditions



Lower Yuba River Flow at Smartsville During September Under Environmental Baseline and Cumulative Conditions



Long-term Average Water Temperature, and Average Water Temperature by Water Year Type in the Lower Yuba River at Marysville under the Environmental Baseline and Cumulative Conditions

	Average Temperature (°F)											
Analysis Period	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Long-term												
Full Simulation Period[1]												
Environmental Baseline	58.5	51.9	49.0	47.9	48.8	50.8	53.6	56.4	60.0	61.5	59.9	62.0
Cumulative Conditions	58.5	52.0	49.0	47.9	48.9	50.8	53.6	56.5	60.1	61.6	60.3	62.3
Difference	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.4	0.4
Water Year Types[2]												
Wet												
Environmental Baseline	58.1	51.5	48.7	47.3	46.5	48.3	54.1	54.1	56.1	57.6	57.6	60.9
Cumulative Conditions	58.1	51.5	48.8	47.4	46.5	48.3	54.1	54.1	56.2	57.8	58.1	61.4
Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.5
Above Normal												
Environmental Baseline	58.9	52.2	49.1	48.1	49.1	50.5	53.8	55.1	58.3	60.7	58.6	61.6
Cumulative Conditions	58.9	52.4	49.1	48.2	49.2	50.5	53.8	55.2	58.4	60.9	59.2	62.1
Difference	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.2	0.6	0.5
Below Normal												
Environmental Baseline	58.8	52.2	49.2	48.1	50.0	52.2	53.4	57.8	62.1	63.1	60.2	61.9
Cumulative Conditions	58.8	52.3	49.2	48.2	50.1	52.3	53.4	58.0	62.4	63.4	60.7	62.3
Difference	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.2	0.2	0.2	0.5	0.4
Dry												
Environmental Baseline	58.6	51.9	49.2	48.1	50.5	53.1	52.9	58.7	64.2	64.9	62.9	62.9
Cumulative Conditions	58.6	52.0	49.2	48.1	50.5	53.1	53.0	58.8	64.1	64.5	62.9	63.0
Difference	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	-0.4	0.1	0.1
Critical												
Environmental Baseline	58.7	52.1	49.2	48.2	51.1	53.5	52.8	60.0	65.3	67.0	64.5	64.3
Cumulative Conditions	58.7	52.2	49.2	48.2	51.1	53.5	52.8	60.1	65.3	66.7	64.5	64.3
Difference	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	-0.2	0.0	0.0

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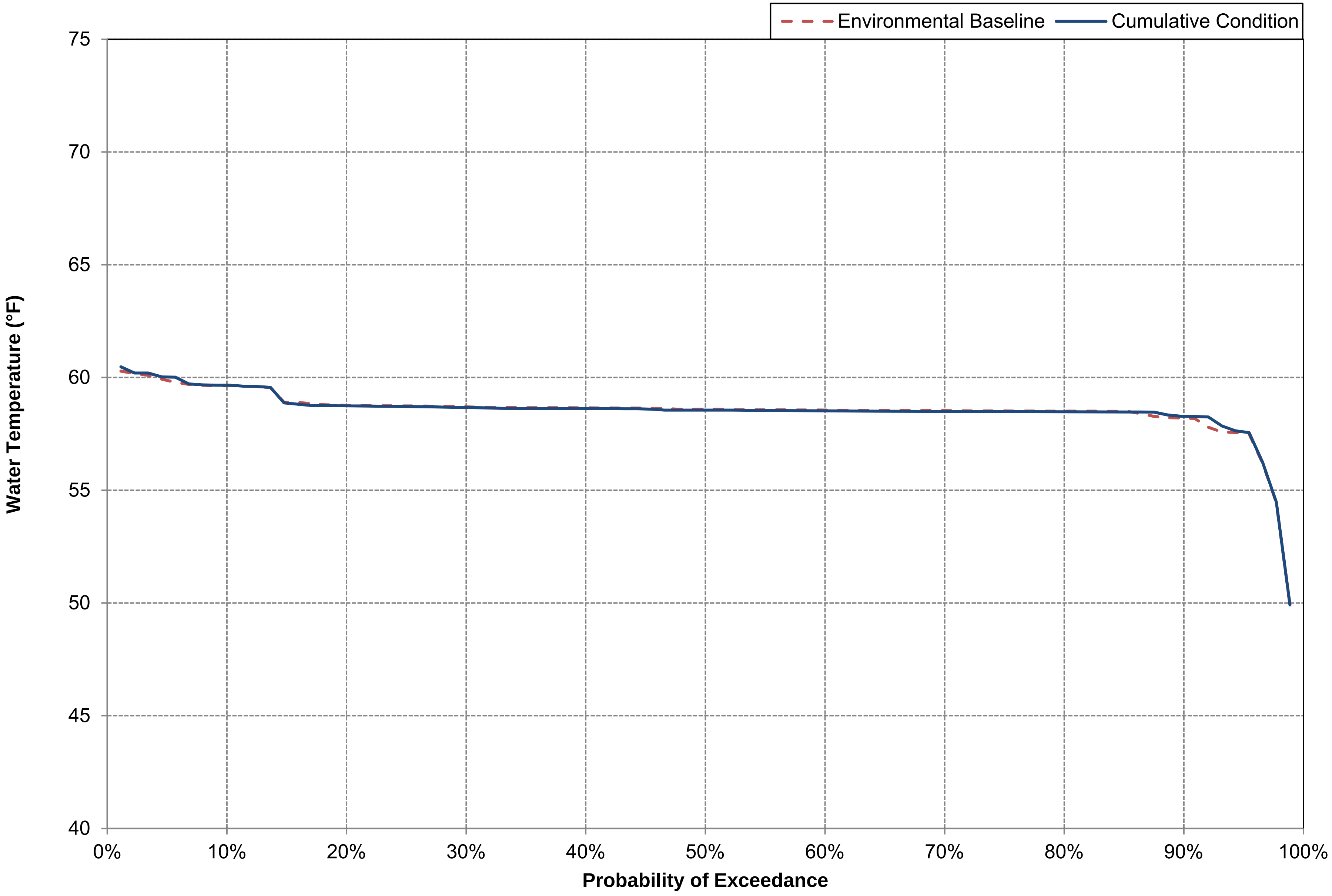
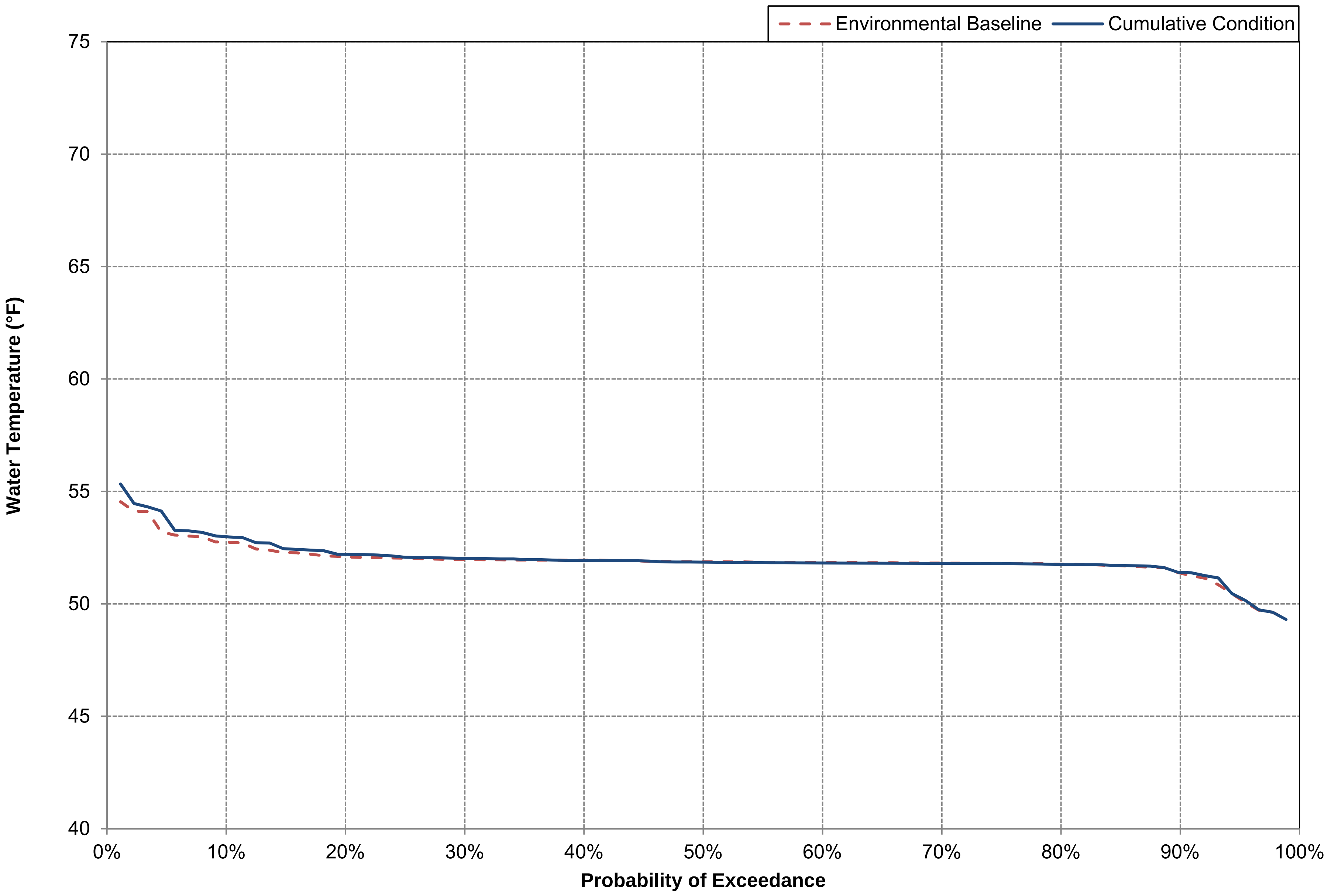
[1] Period of Record is Water Year 1922 - 2008

[2] As defined by the Yuba River Index described in SWRCB RD-1644

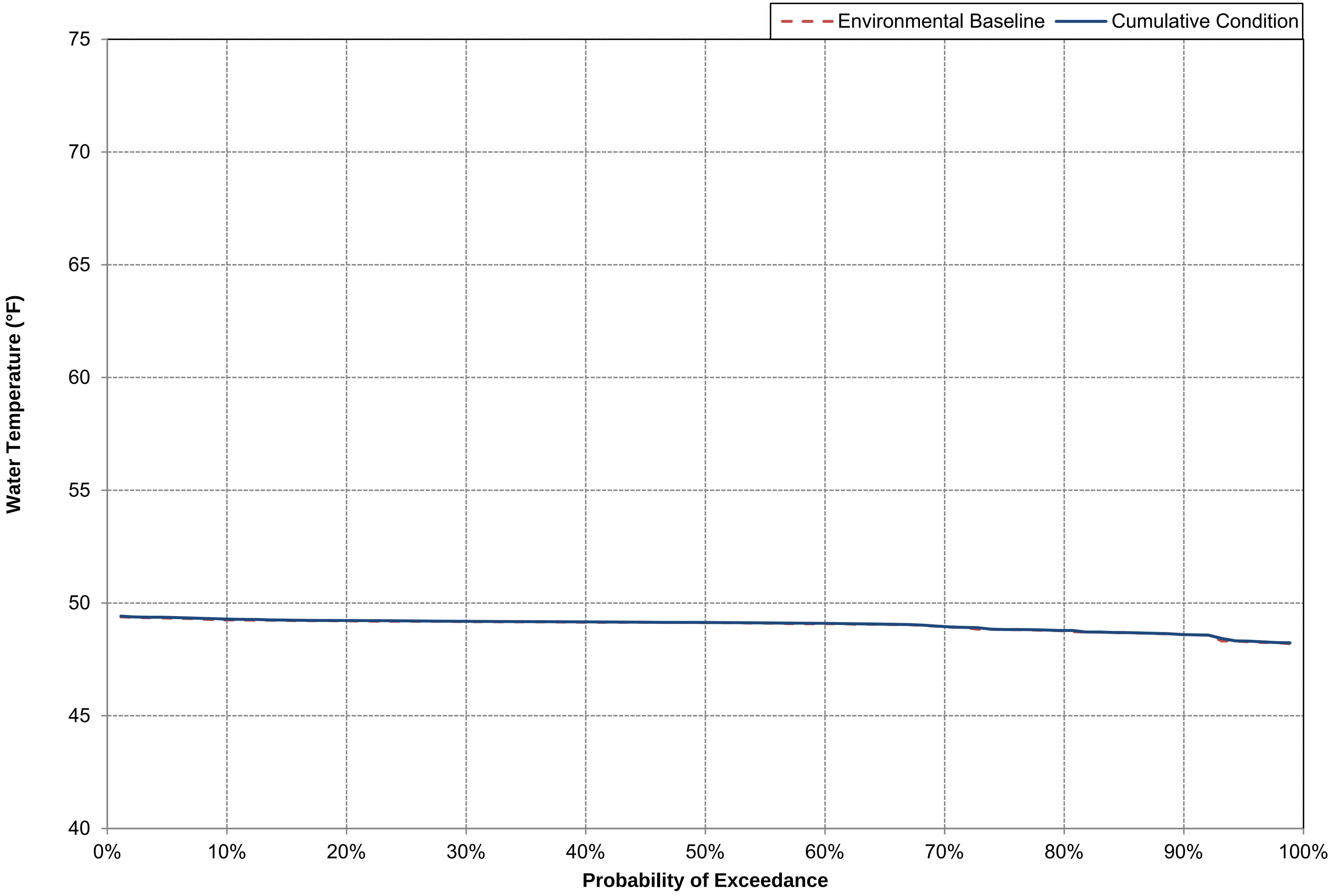
Water Temperature in the Lower Yuba River at Marysville During October Under Environmental Baseline and Cumulative Conditions



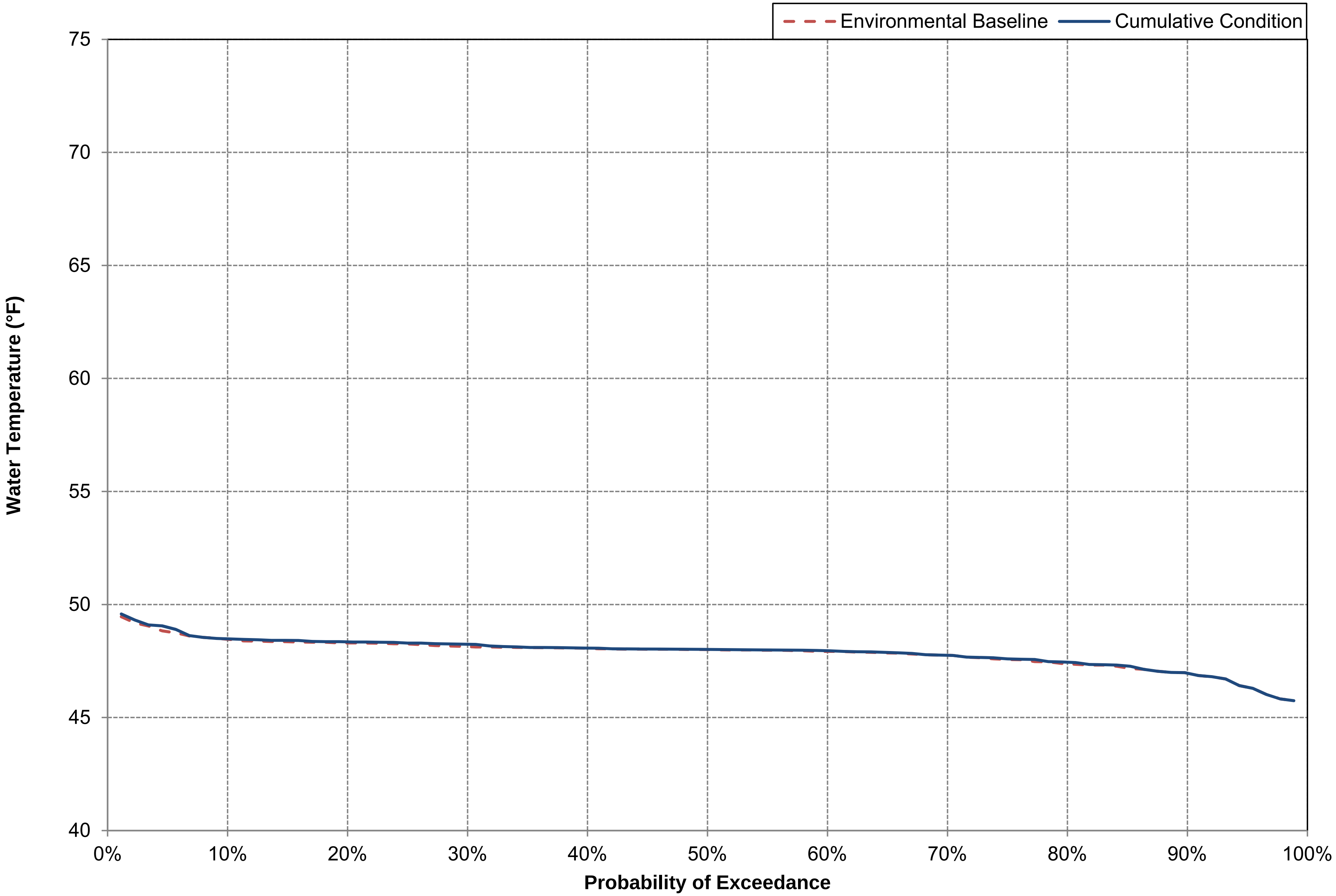
Water Temperature in the Lower Yuba River at Marysville During November Under Environmental Baseline and Cumulative Conditions



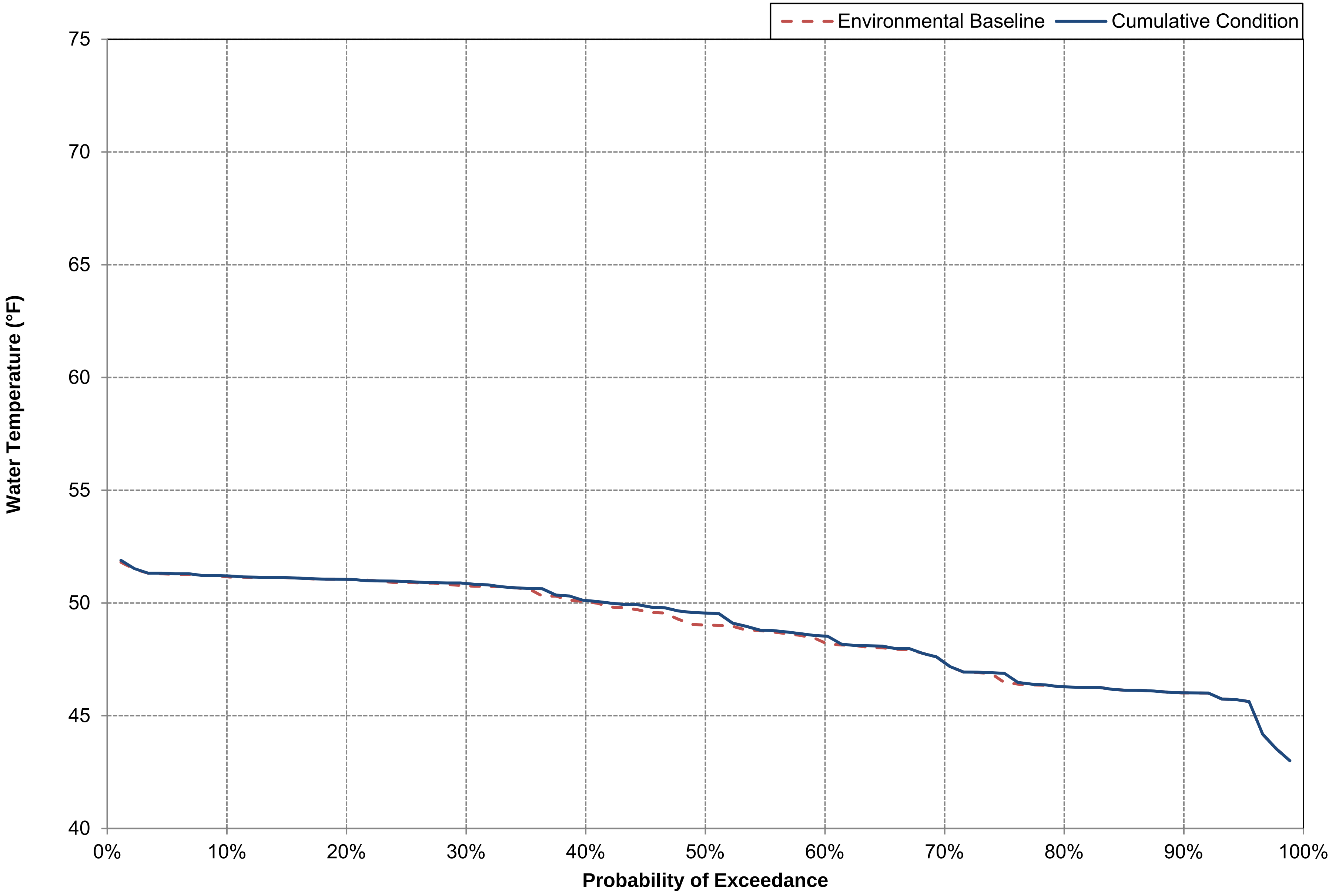
Water Temperature in the Lower Yuba River at Marysville During December Under Environmental Baseline and Cumulative Conditions



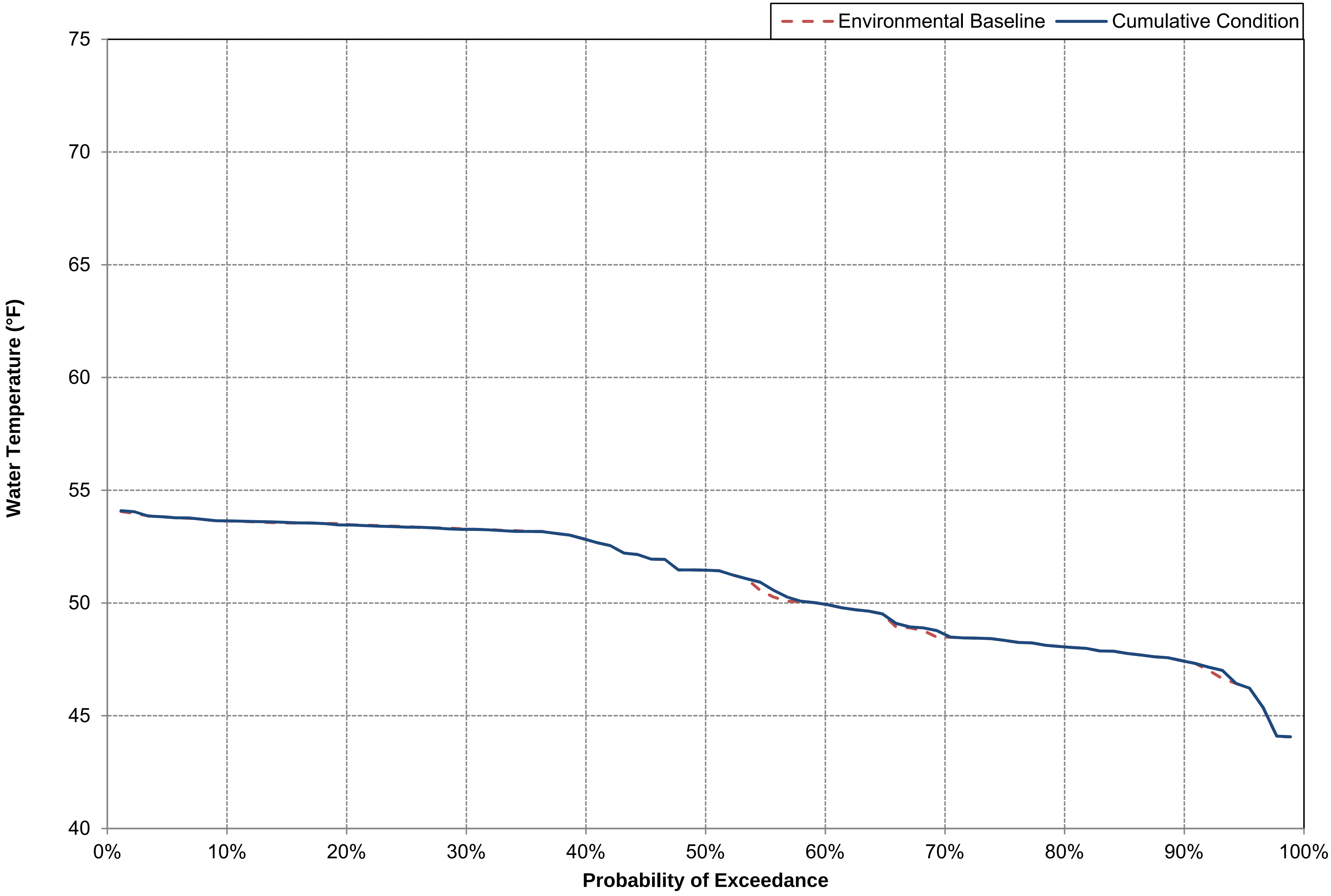
Water Temperature in the Lower Yuba River at Marysville During January Under Environmental Baseline and Cumulative Conditions



Water Temperature in the Lower Yuba River at Marysville During February Under Environmental Baseline and Cumulative Conditions



Water Temperature in the Lower Yuba River at Marysville During March Under Environmental Baseline and Cumulative Conditions



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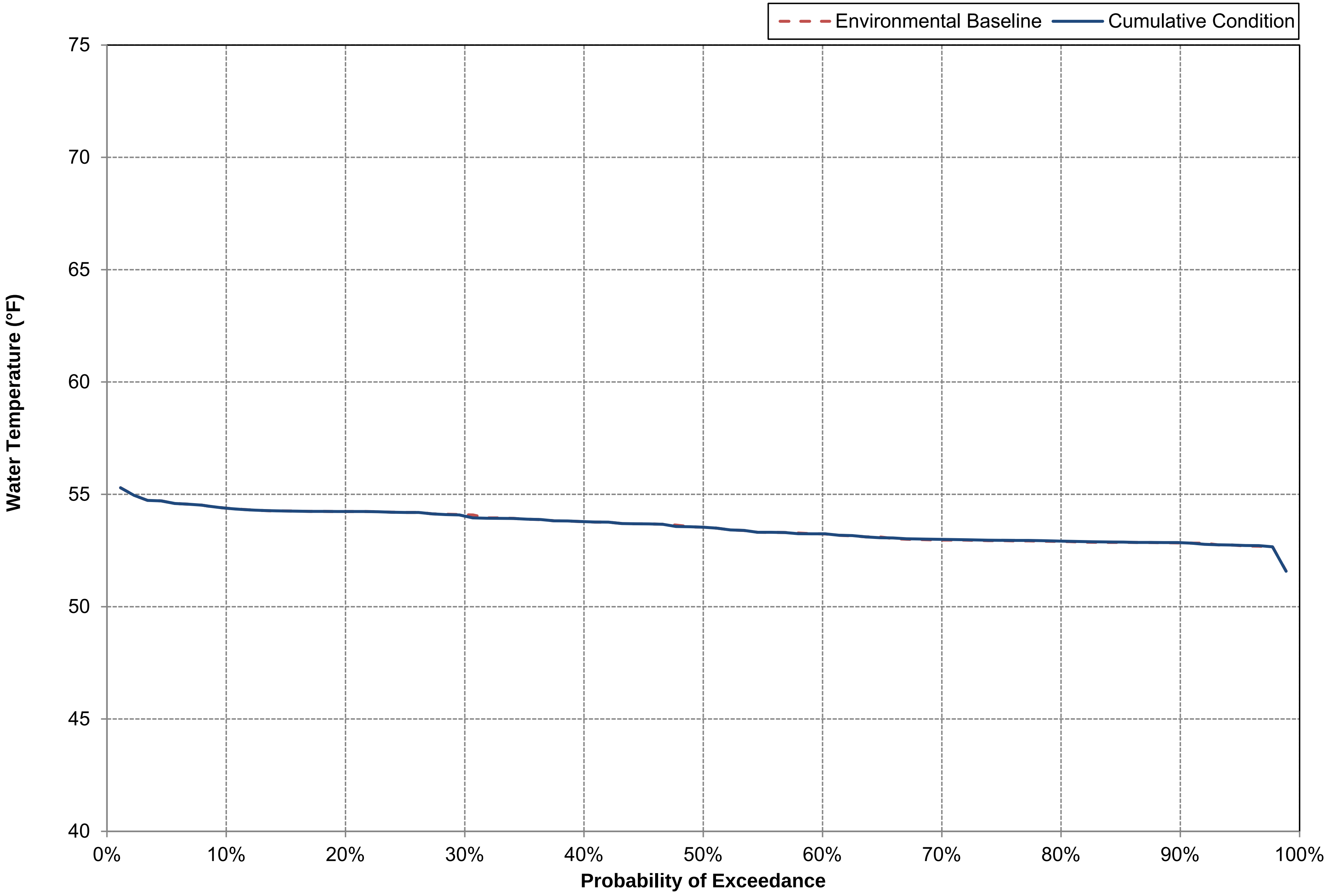
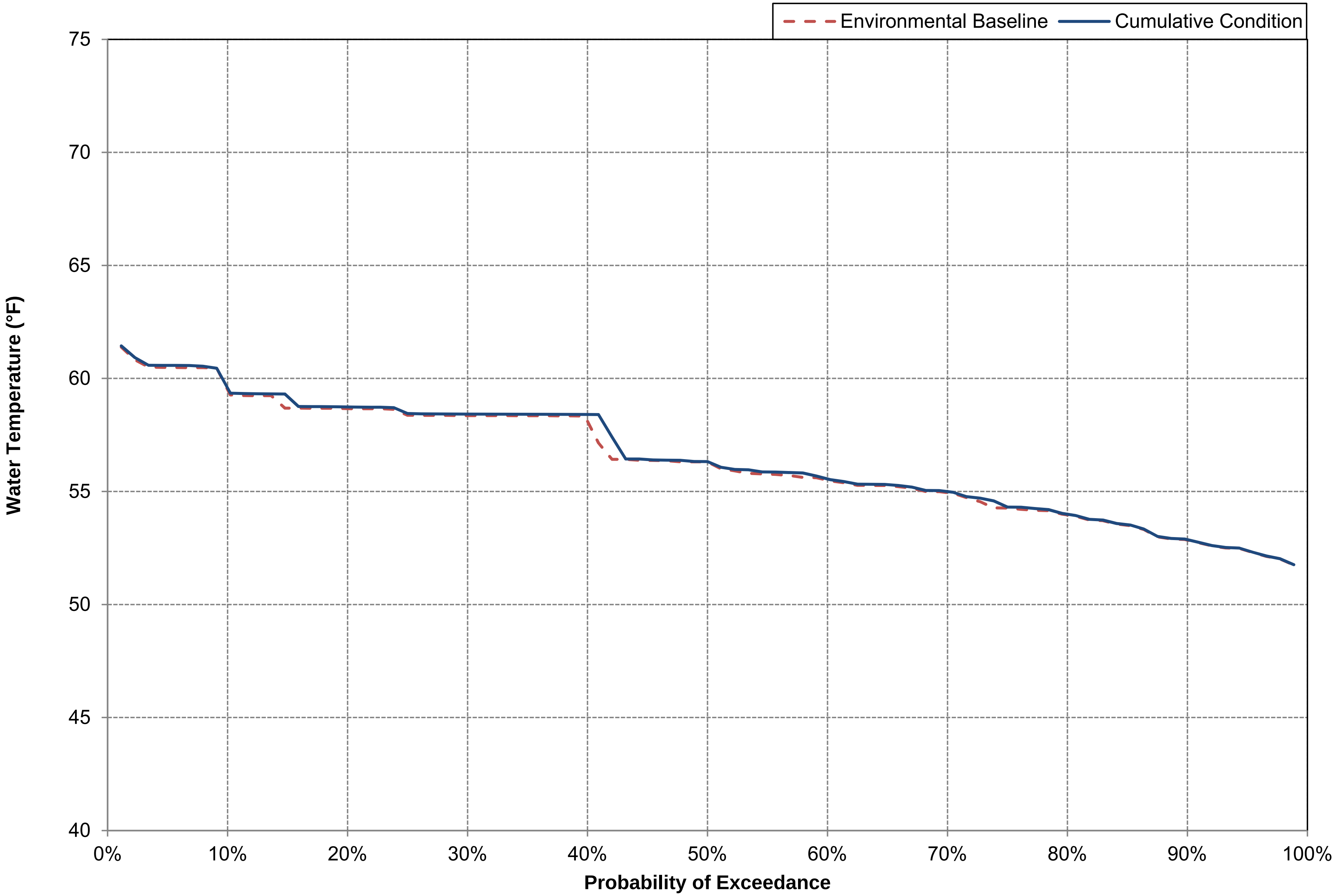
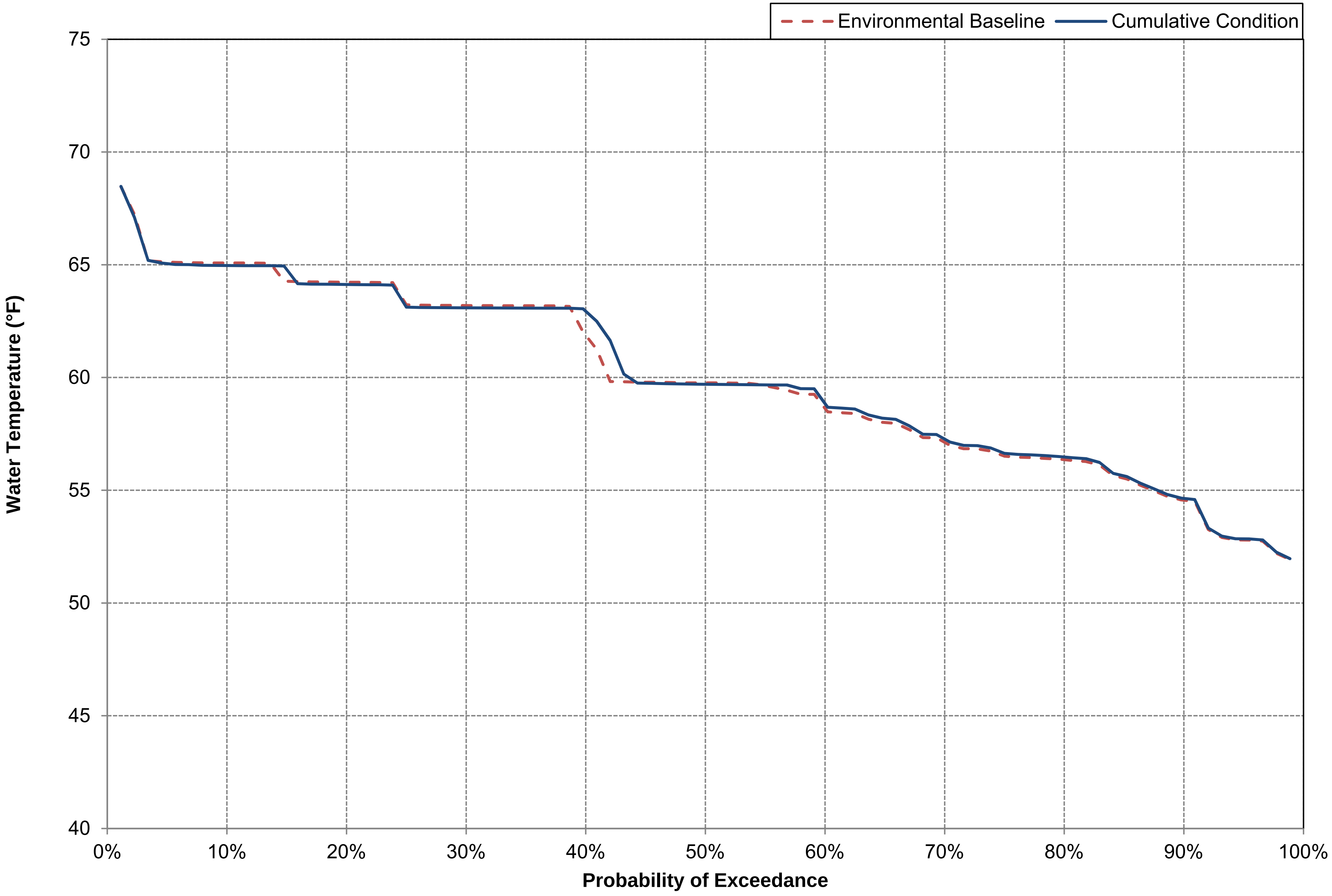


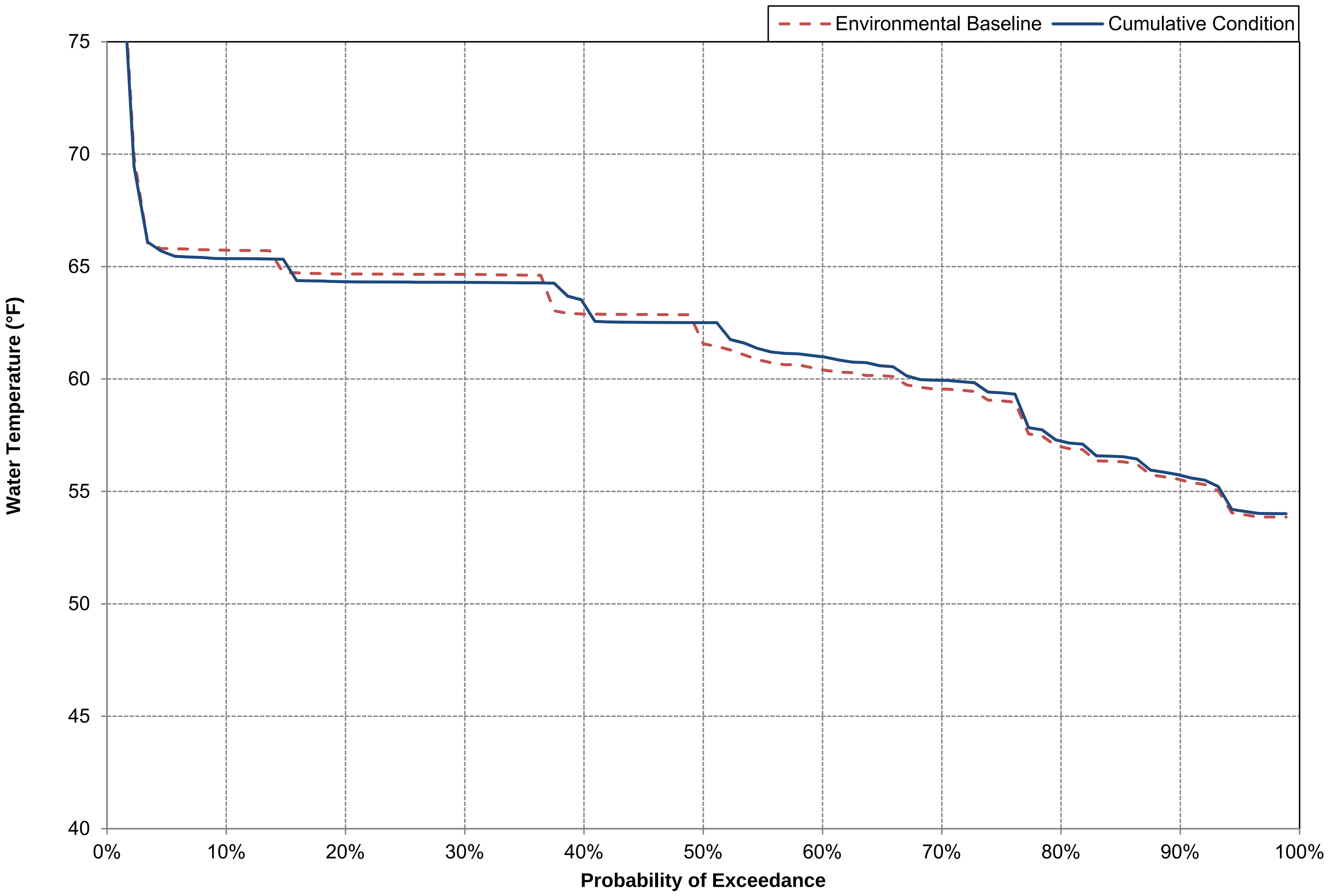
Water Temperature in the Lower Yuba River at Marysville During May Under Environmental Baseline and Cumulative Conditions



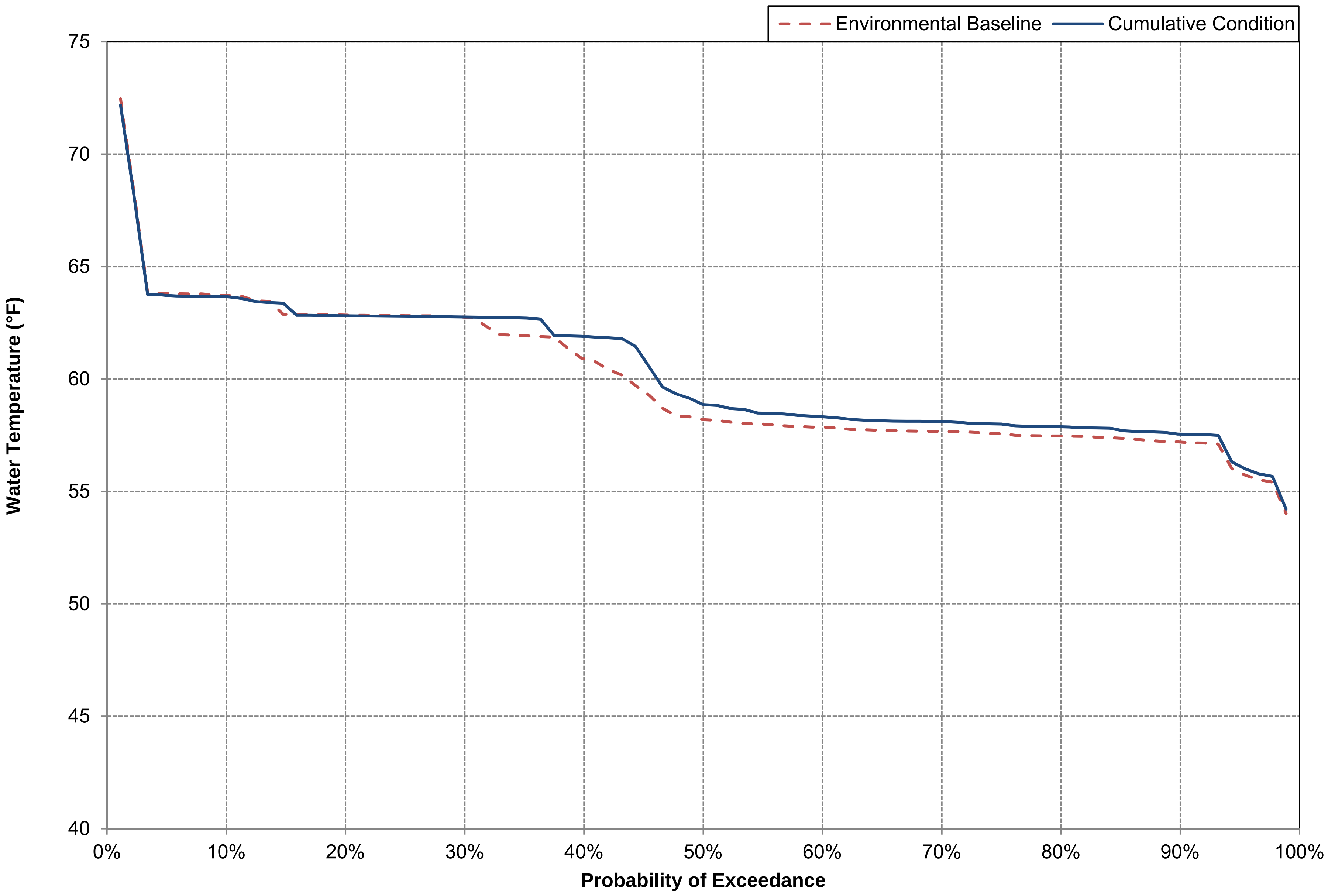
Water Temperature in the Lower Yuba River at Marysville During June Under Environmental Baseline and Cumulative Conditions



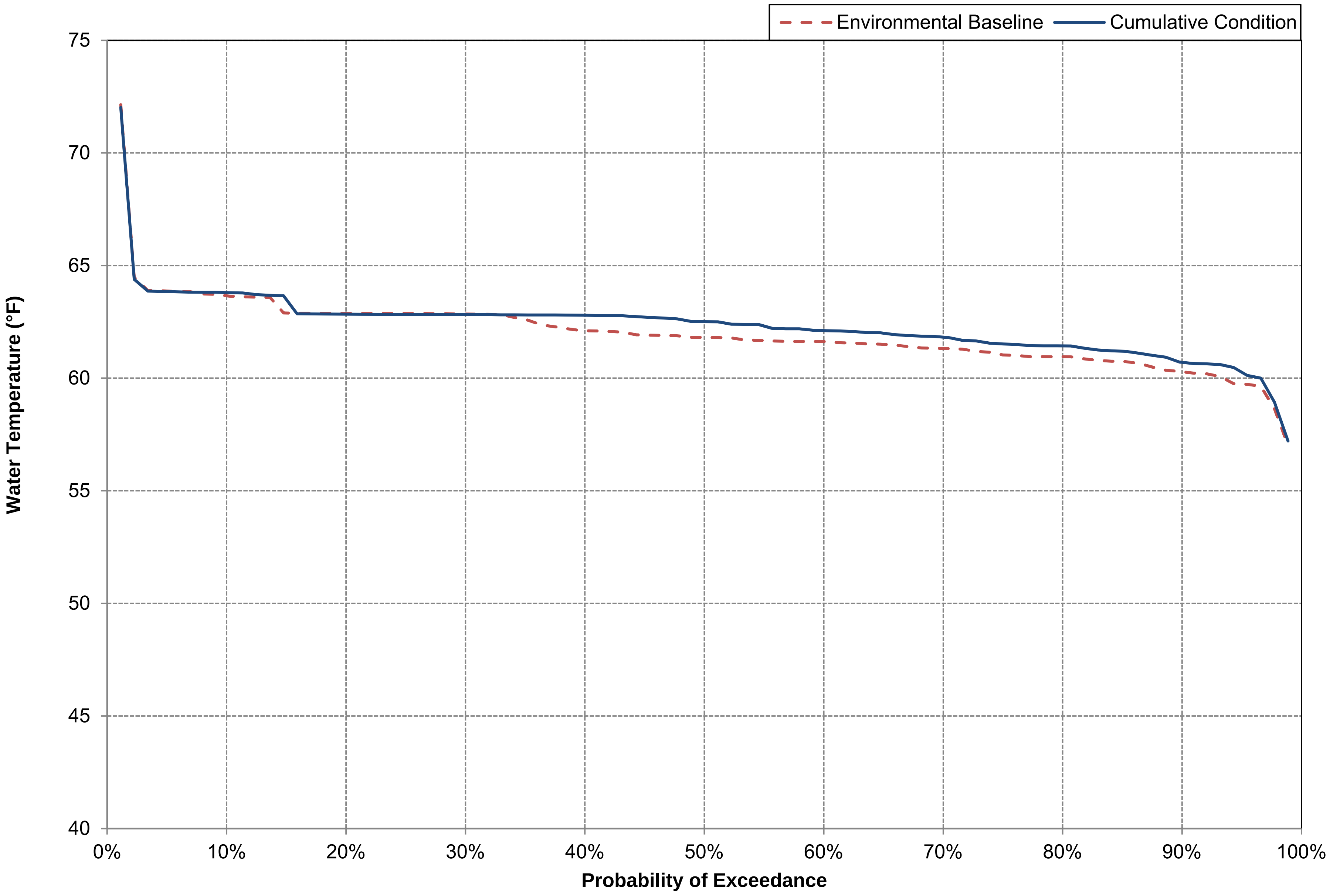
Water Temperature in the Lower Yuba River at Marysville During July Under Environmental Baseline and Cumulative Conditions



Water Temperature in the Lower Yuba River at Marysville During August Under Environmental Baseline and Cumulative Conditions



Water Temperature in the Lower Yuba River at Marysville During September Under Environmental Baseline and Cumulative Conditions



Long-term Average Water Temperature, and Average Water Temperature by Water Year Type in the Lower Yuba River at Daguerre Point Dam under the Environmental Baseline and Cumulative Conditions

	Average Temperature (°F)											
Analysis Period	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Long-term												
Full Simulation Period[1]												
Environmental Baseline	56.6	50.8	48.2	47.3	48.3	50.4	53.1	54.9	57.5	57.8	57.6	59.0
Cumulative Conditions	56.5	50.9	48.2	47.3	48.3	50.4	53.1	54.9	57.4	57.6	57.5	58.9
Difference	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.1	-0.1
Water Year Types[2]												
Wet												
Environmental Baseline	56.3	50.5	47.9	47.1	47.5	48.7	52.0	53.3	55.7	55.9	56.0	58.3
Cumulative Conditions	56.3	50.5	47.9	47.1	47.5	48.7	52.0	53.3	55.7	55.9	56.0	58.3
Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal												
Environmental Baseline	56.8	51.1	48.3	47.4	48.5	50.2	52.5	54.3	56.9	57.5	56.6	58.7
Cumulative Conditions	56.8	51.2	48.4	47.4	48.6	50.3	52.5	54.3	56.8	57.3	56.7	58.6
Difference	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0	-0.1	-0.1	0.1	0.0
Below Normal												
Environmental Baseline	56.7	51.1	48.4	47.4	48.8	51.4	53.4	55.8	58.5	58.6	58.0	59.1
Cumulative Conditions	56.7	51.2	48.5	47.4	48.9	51.5	53.4	55.8	58.4	58.5	57.9	59.0
Difference	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	-0.1	-0.1	-0.1	0.0
Dry												
Environmental Baseline	56.6	50.8	48.4	47.4	48.8	52.0	54.3	56.4	59.3	59.3	59.4	59.6
Cumulative Conditions	56.5	50.9	48.4	47.4	48.8	52.0	54.3	56.2	59.1	58.9	59.1	59.4
Difference	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.2	-0.4	-0.4	-0.2
Critical												
Environmental Baseline	56.7	51.0	48.4	47.4	48.9	52.2	54.7	57.1	59.9	60.4	60.6	60.7
Cumulative Conditions	56.7	51.1	48.5	47.4	49.0	52.3	54.7	57.0	59.7	60.0	60.2	60.4
Difference	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.3	-0.4	-0.2

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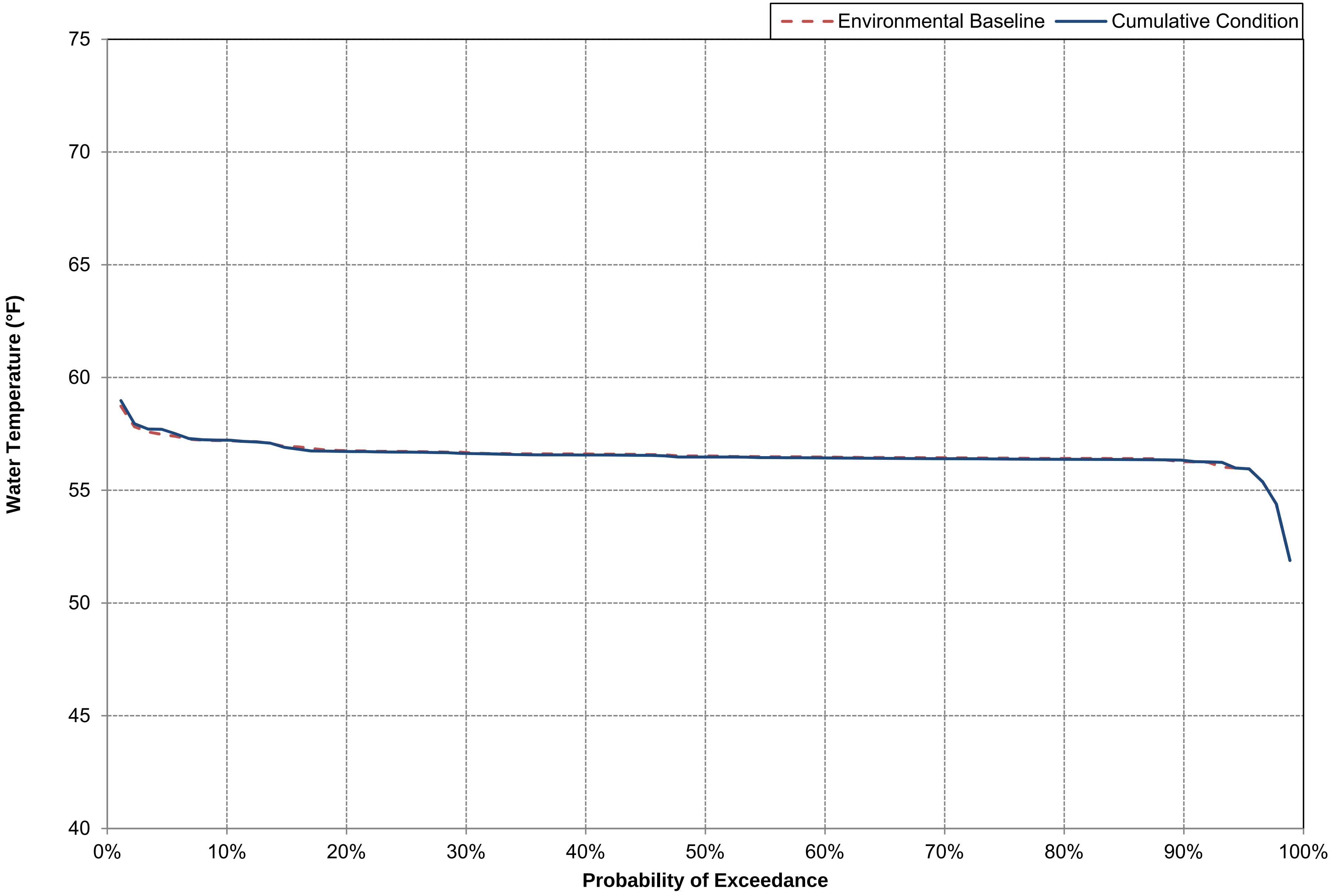
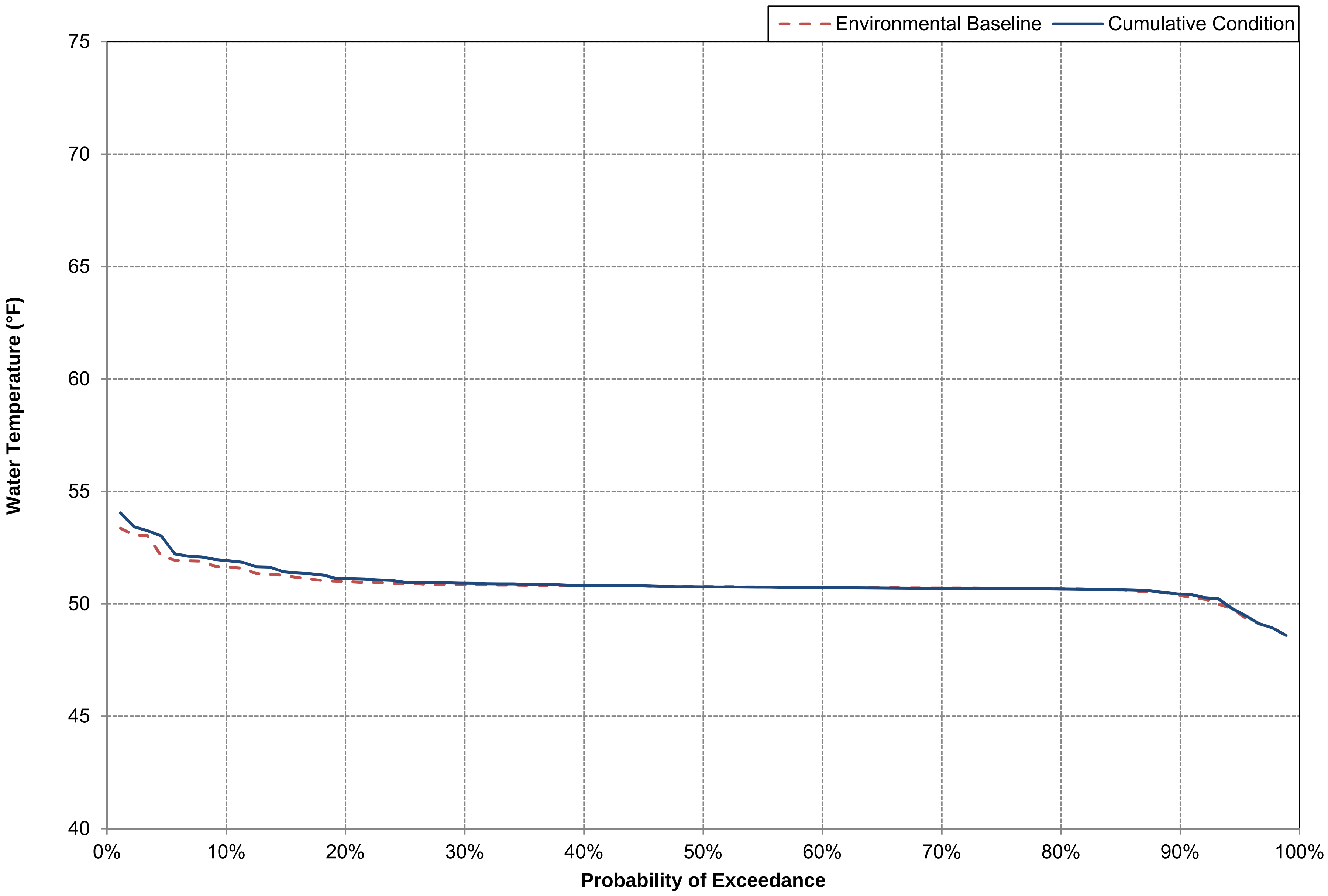
[1] Period of Record is Water Year 1922 - 2008

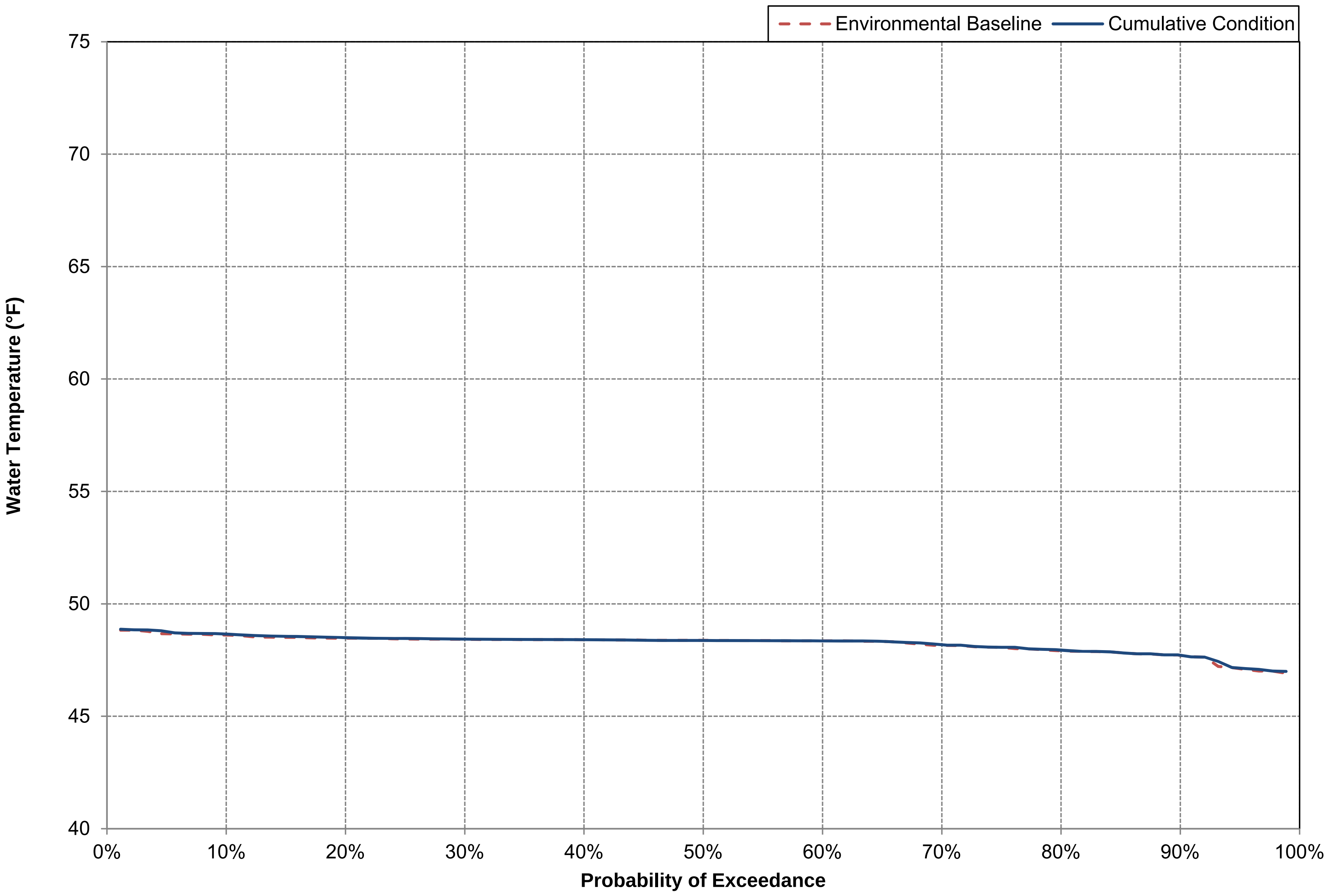
[2] As defined by the Yuba River Index described in SWRCB RD-1644

Water Temperature in the Lower Yuba River at Daguerre Point Dam During October Under Environmental Baseline and Cumulative Conditions



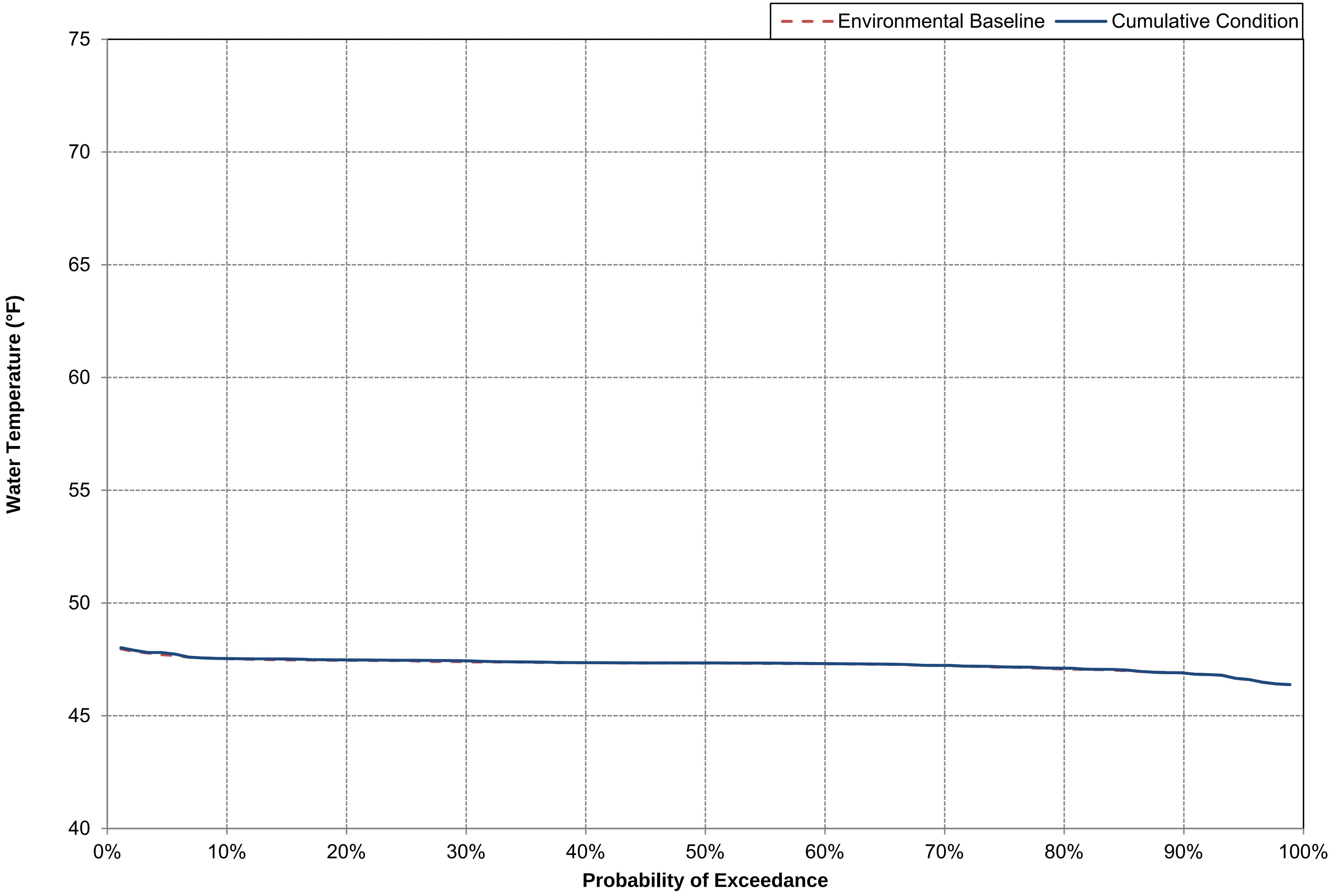
Water Temperature in the Lower Yuba River at Daguerre Point Dam During November Under Environmental Baseline and Cumulative Conditions



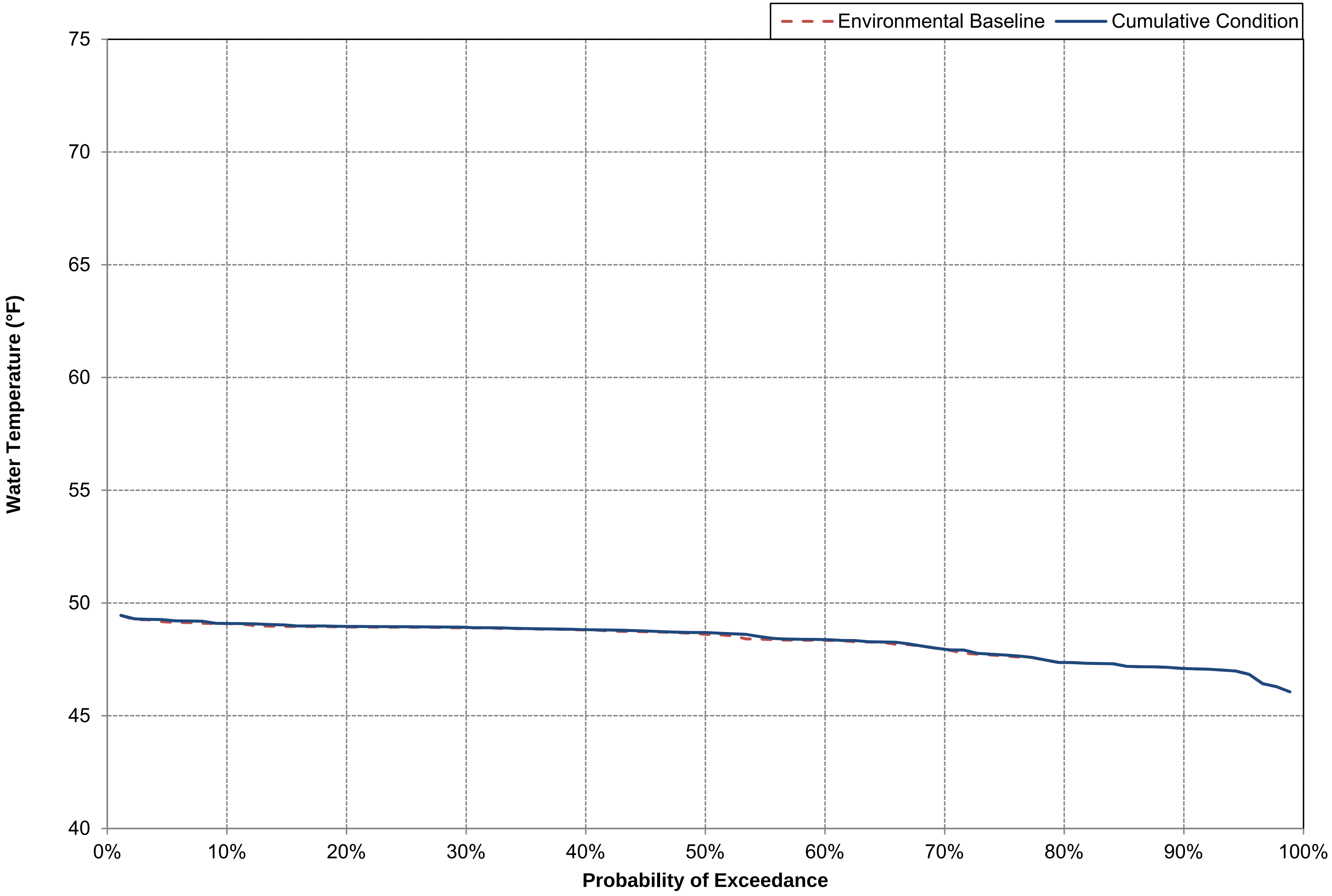


Water Temperature in the Lower Yuba River at Daguerre Point Dam During December Under Environmental Baseline and Cumulative Conditions

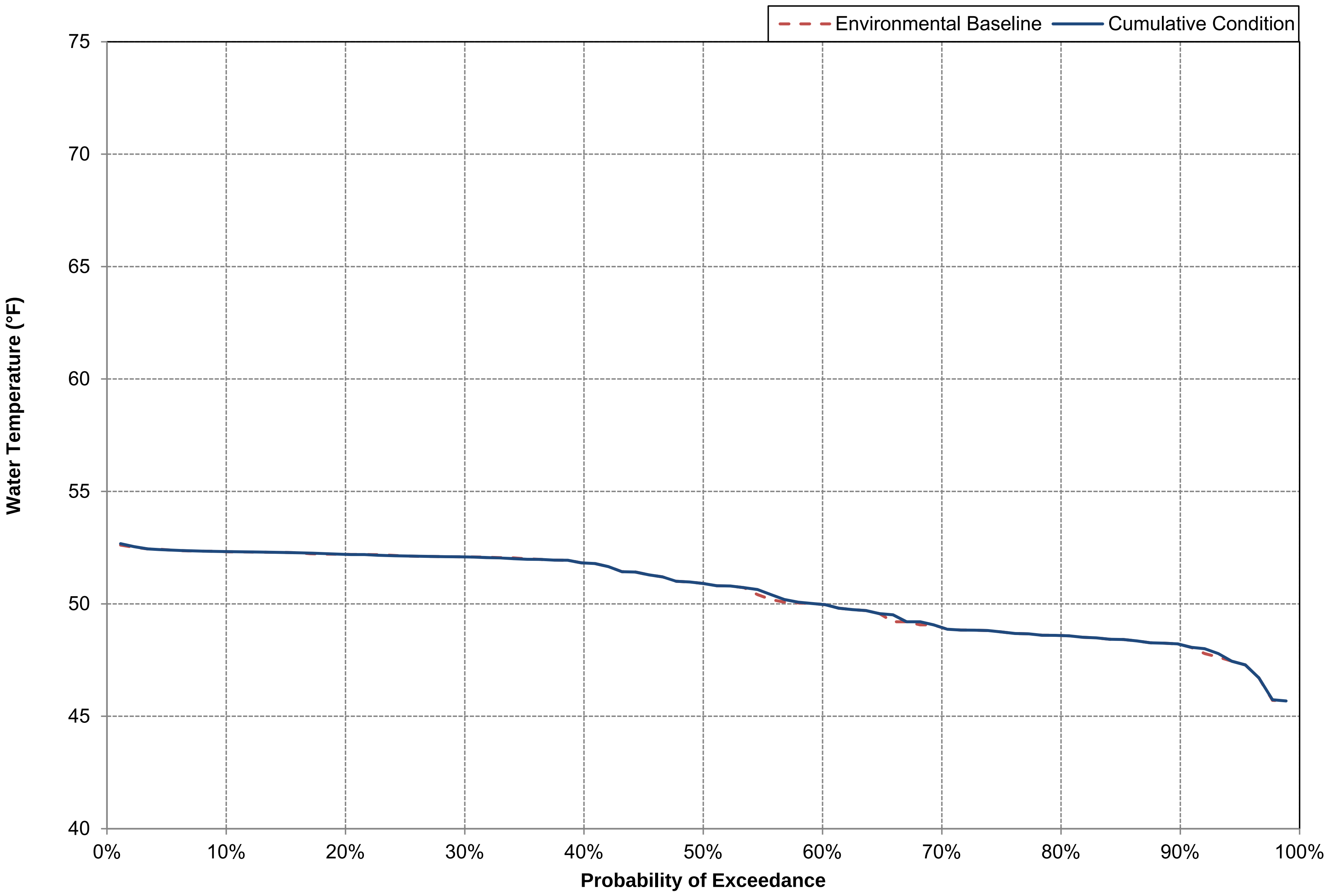
Water Temperature in the Lower Yuba River at Daguerre Point Dam During January Under Environmental Baseline and Cumulative Conditions



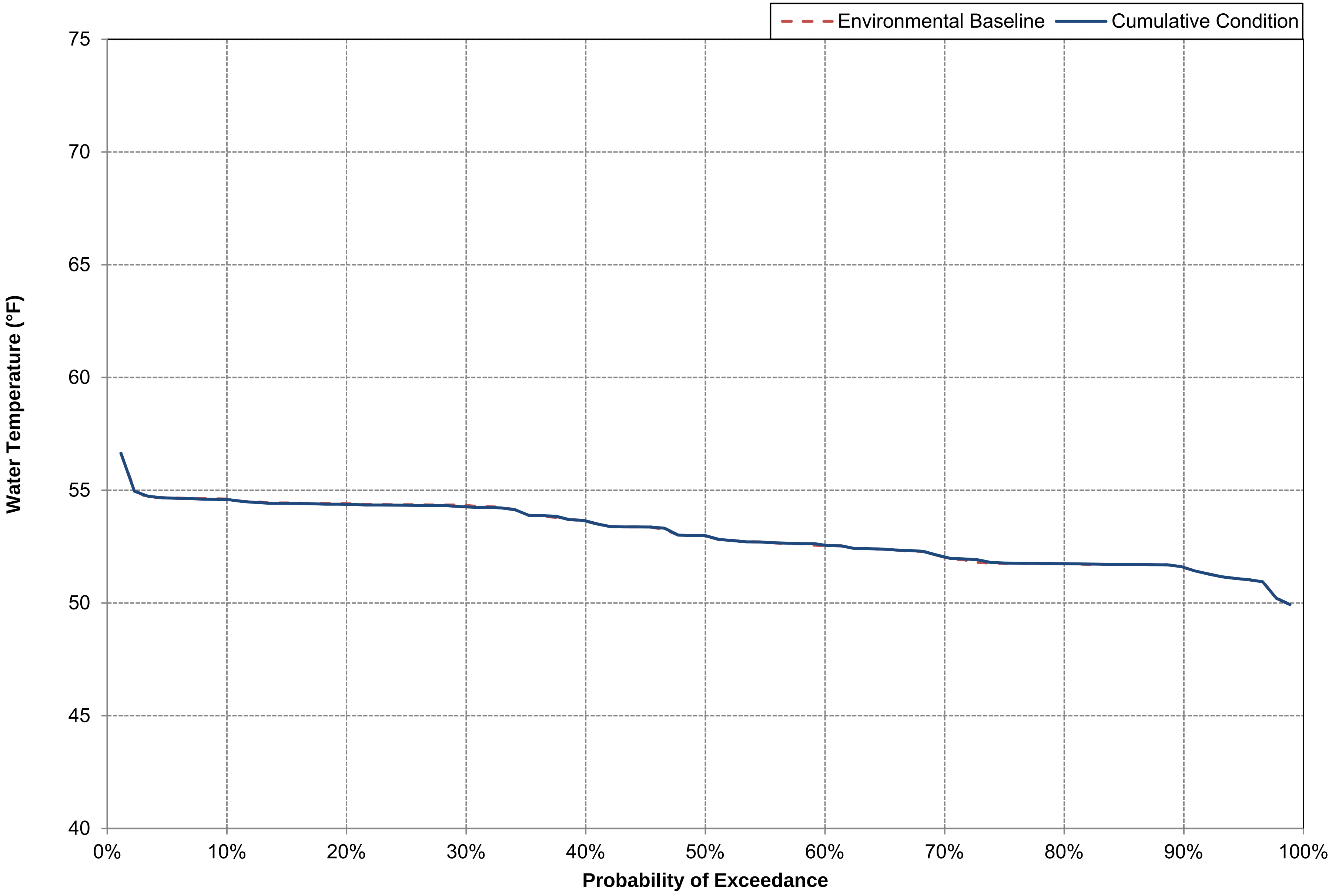
Water Temperature in the Lower Yuba River at Daguerre Point Dam During February Under Environmental Baseline and Cumulative Conditions



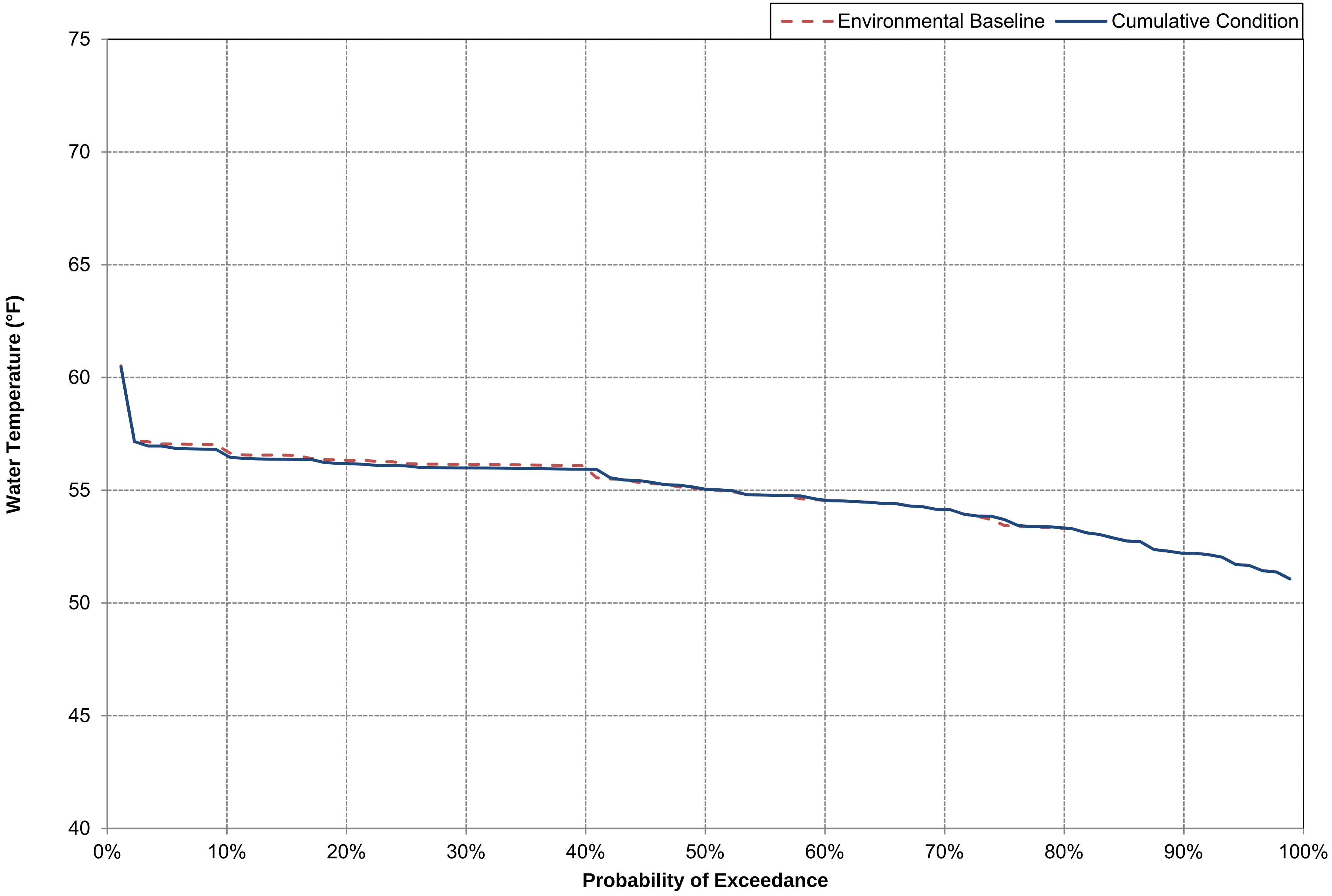
Water Temperature in the Lower Yuba River at Daguerre Point Dam During March Under Environmental Baseline and Cumulative Conditions

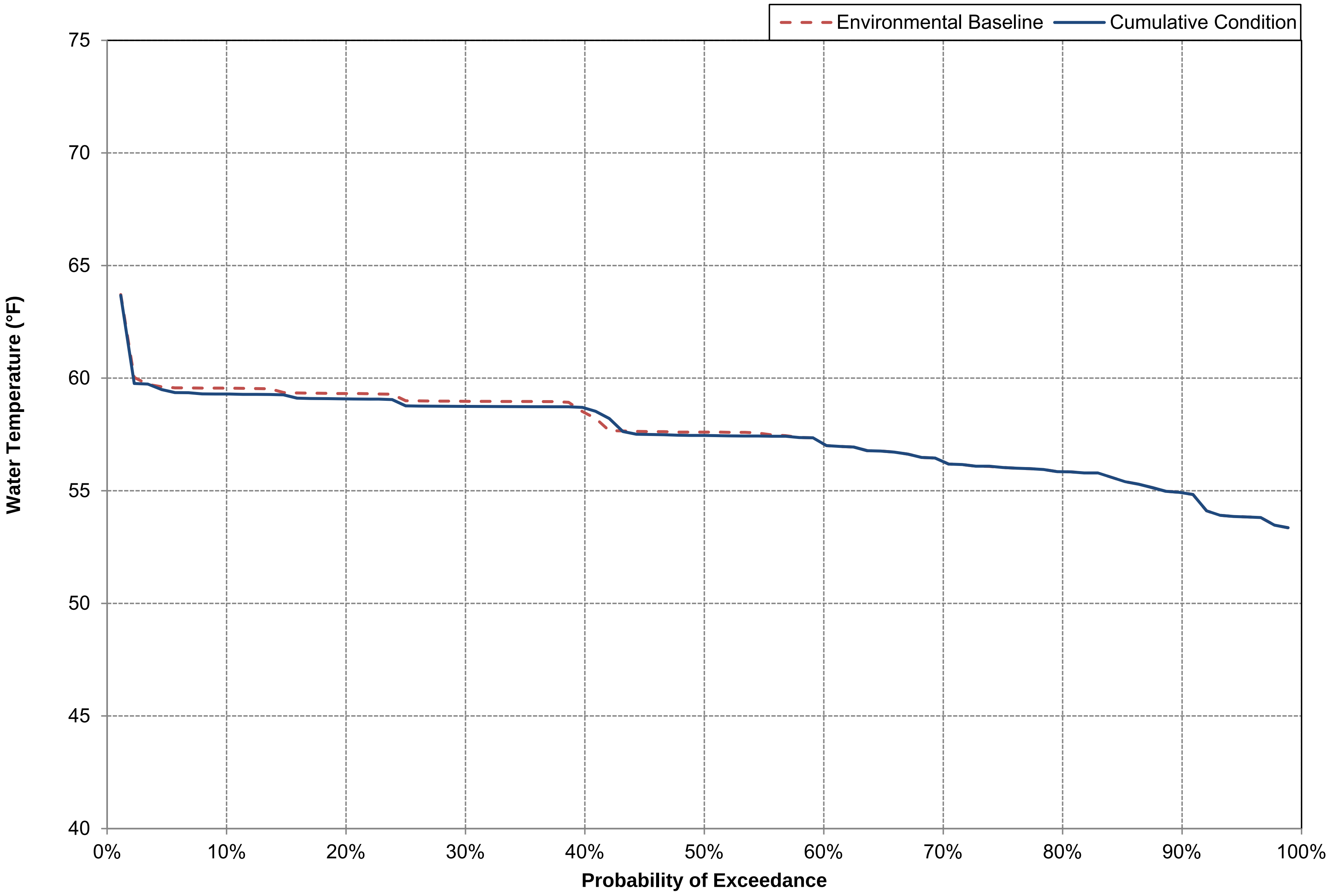


Water Temperature in the Lower Yuba River at Daguerre Point Dam During April Under Environmental Baseline and Cumulative Conditions



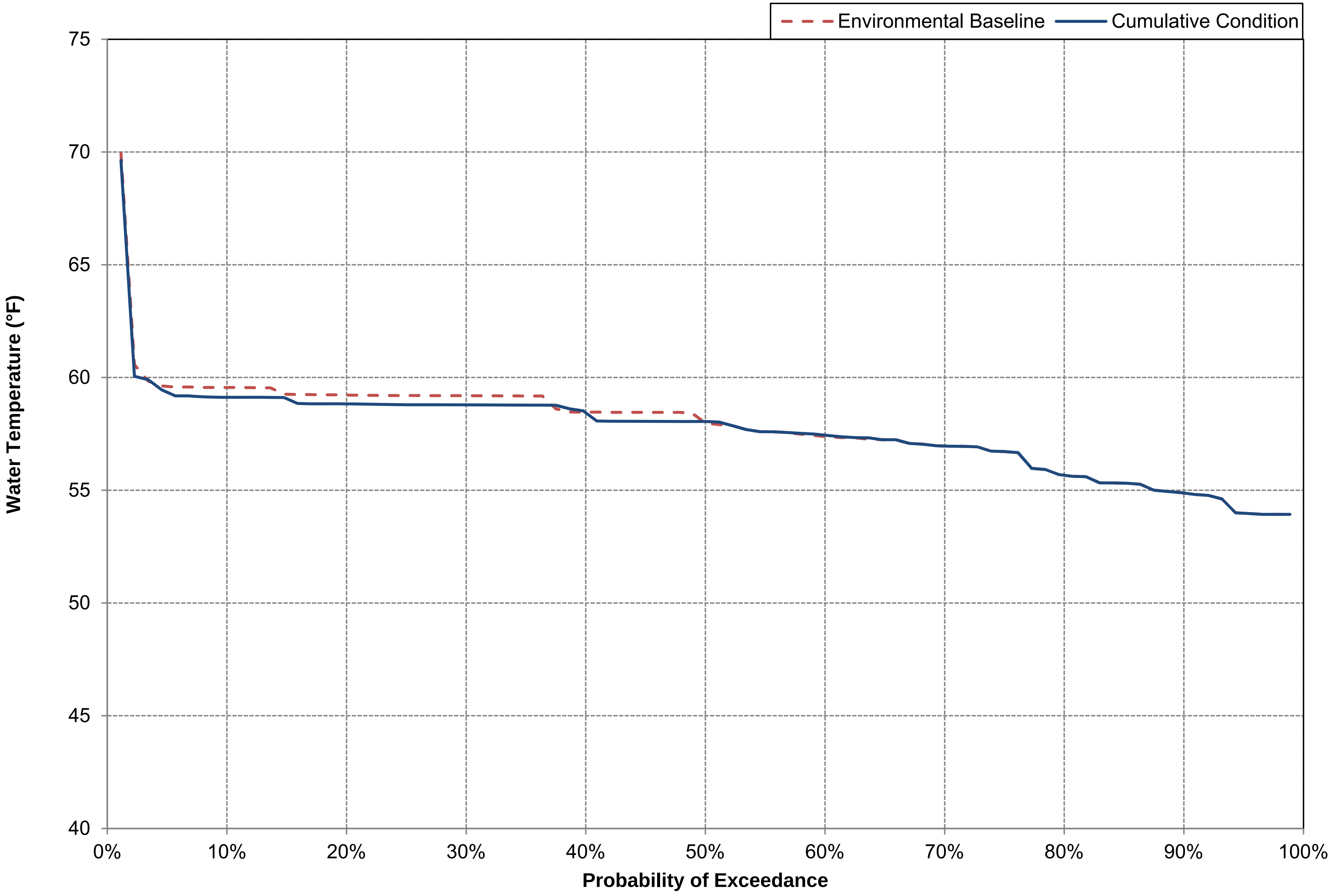
Water Temperature in the Lower Yuba River at Daguerre Point Dam During May Under Environmental Baseline and Cumulative Conditions



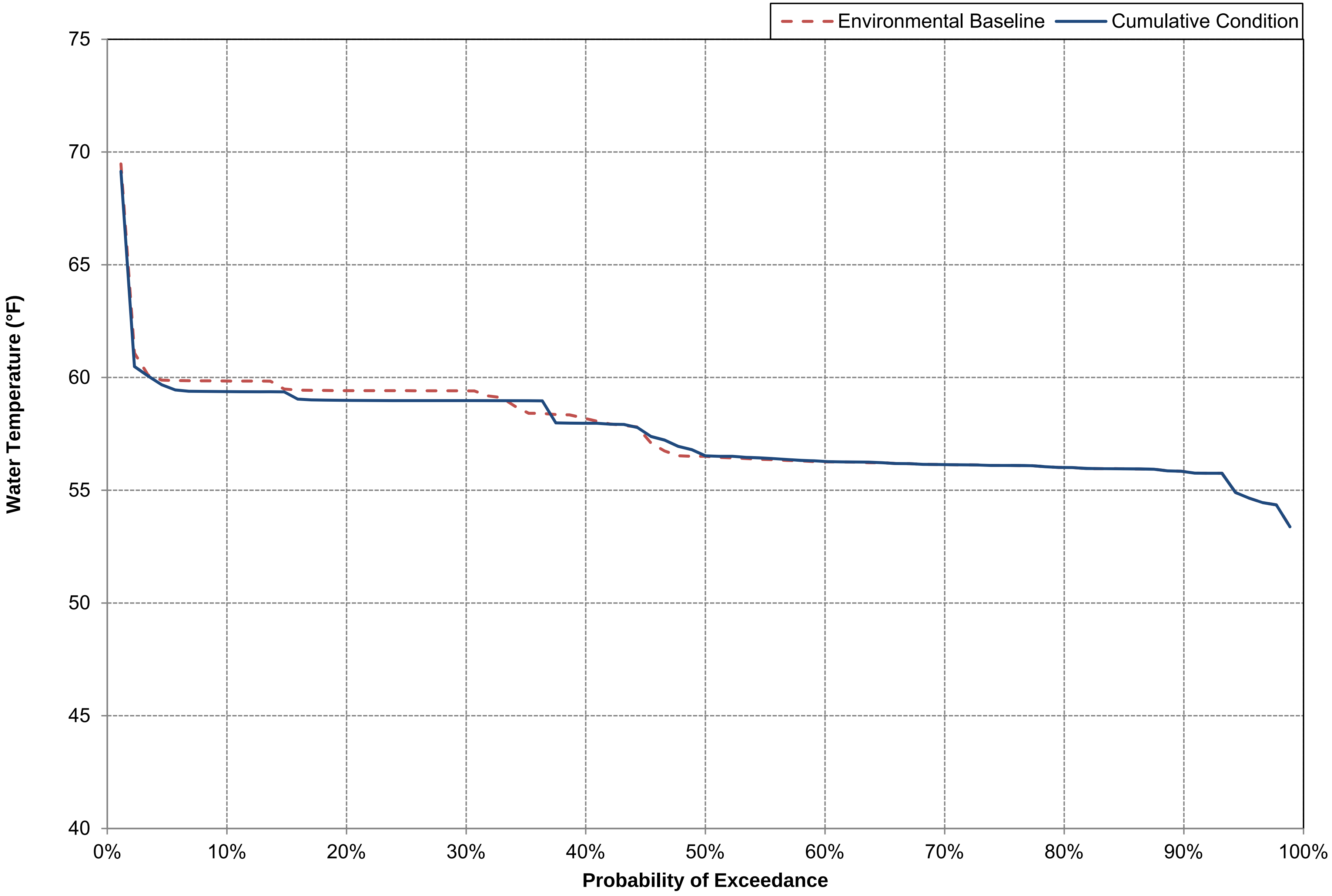


Water Temperature in the Lower Yuba River at Daguerre Point Dam During June Under Environmental Baseline and Cumulative Conditions

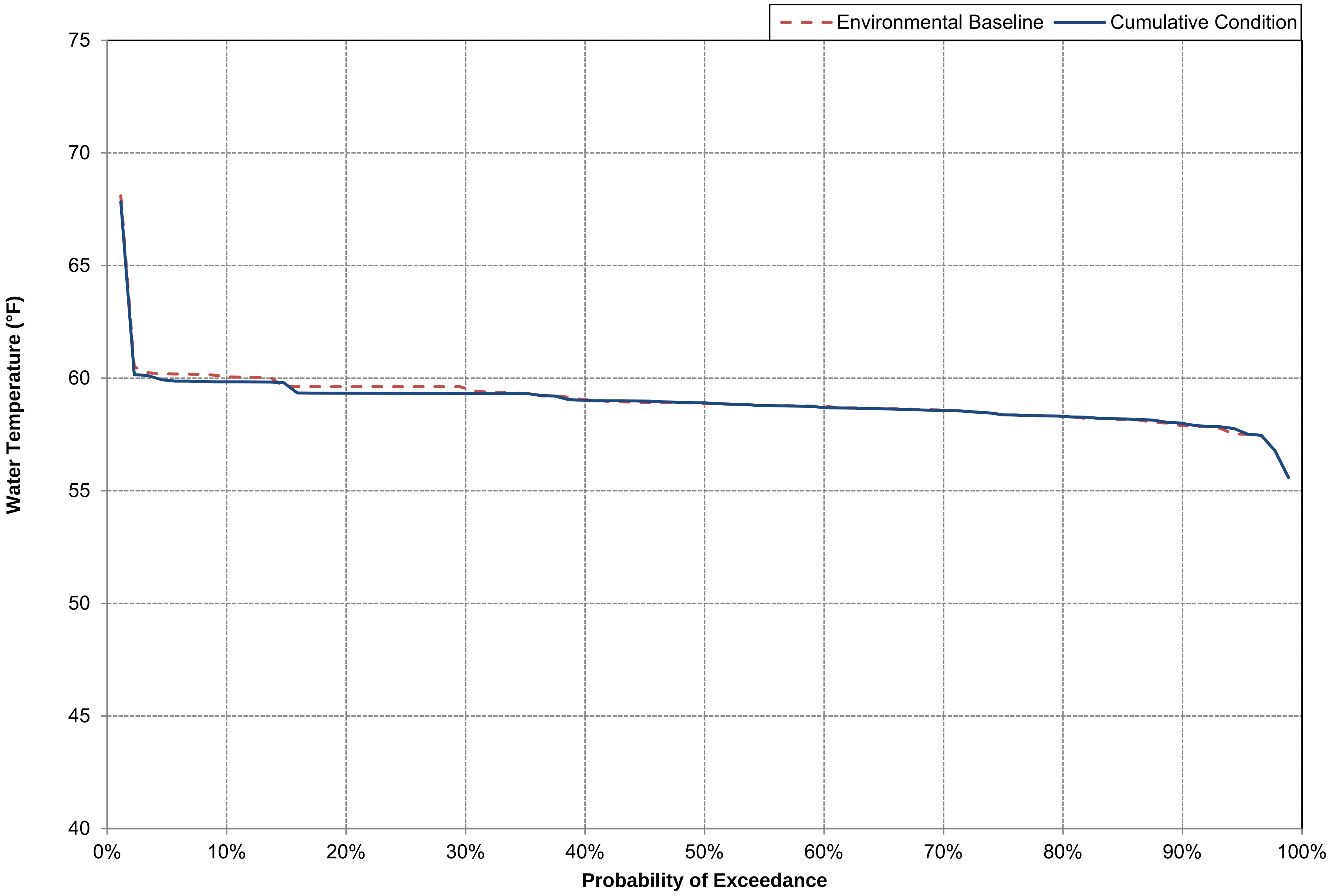
Water Temperature in the Lower Yuba River at Daguerre Point Dam During July Under Environmental Baseline and Cumulative Conditions



Water Temperature in the Lower Yuba River at Daguerre Point Dam During August Under Environmental Baseline and Cumulative Conditions



Water Temperature in the Lower Yuba River at Daguerre Point Dam During September Under Environmental Baseline and Cumulative Conditions



Long-term Average Water Temperature, and Average Water Temperature by Water Year Type in the Lower Yuba River at Smartsville under the Environmental Baseline and Cumulative Conditions

	Average Temperature (°F)											
Analysis Period	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Long-term												
Full Simulation Period[1]												
Environmental Baseline	53.1	50.6	48.7	47.6	48.6	49.3	50.6	52.0	53.5	54.8	54.7	54.8
Cumulative Conditions	53.2	50.7	48.8	47.7	48.6	49.3	50.6	52.0	53.5	54.7	54.7	54.9
Difference	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water Year Types[2]												
Wet												
Environmental Baseline	53.0	50.4	48.0	46.5	47.4	48.0	50.0	51.6	53.1	54.1	54.2	54.6
Cumulative Conditions	53.0	50.4	48.1	46.6	47.4	48.0	50.0	51.6	53.1	54.1	54.2	54.6
Difference	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal												
Environmental Baseline	53.2	50.8	49.0	47.9	48.9	49.2	50.3	51.9	53.2	54.6	54.4	54.7
Cumulative Conditions	53.4	51.0	49.1	48.0	49.0	49.3	50.3	51.9	53.1	54.6	54.5	54.7
Difference	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal												
Environmental Baseline	53.3	50.9	49.2	48.2	49.3	50.1	50.9	52.1	53.7	55.0	54.8	54.8
Cumulative Conditions	53.4	51.0	49.3	48.3	49.4	50.1	50.9	52.1	53.7	55.0	54.8	54.8
Difference	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Dry												
Environmental Baseline	53.1	50.6	49.0	48.2	49.2	50.3	51.3	52.4	54.2	55.3	55.3	55.0
Cumulative Conditions	53.1	50.6	49.1	48.3	49.2	50.3	51.3	52.3	54.1	55.2	55.3	55.0
Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.1
Critical												
Environmental Baseline	53.2	50.8	49.2	48.4	49.4	50.3	51.3	52.6	54.4	55.6	55.8	55.5
Cumulative Conditions	53.3	50.9	49.2	48.4	49.5	50.4	51.3	52.6	54.4	55.6	55.9	55.7
Difference	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2

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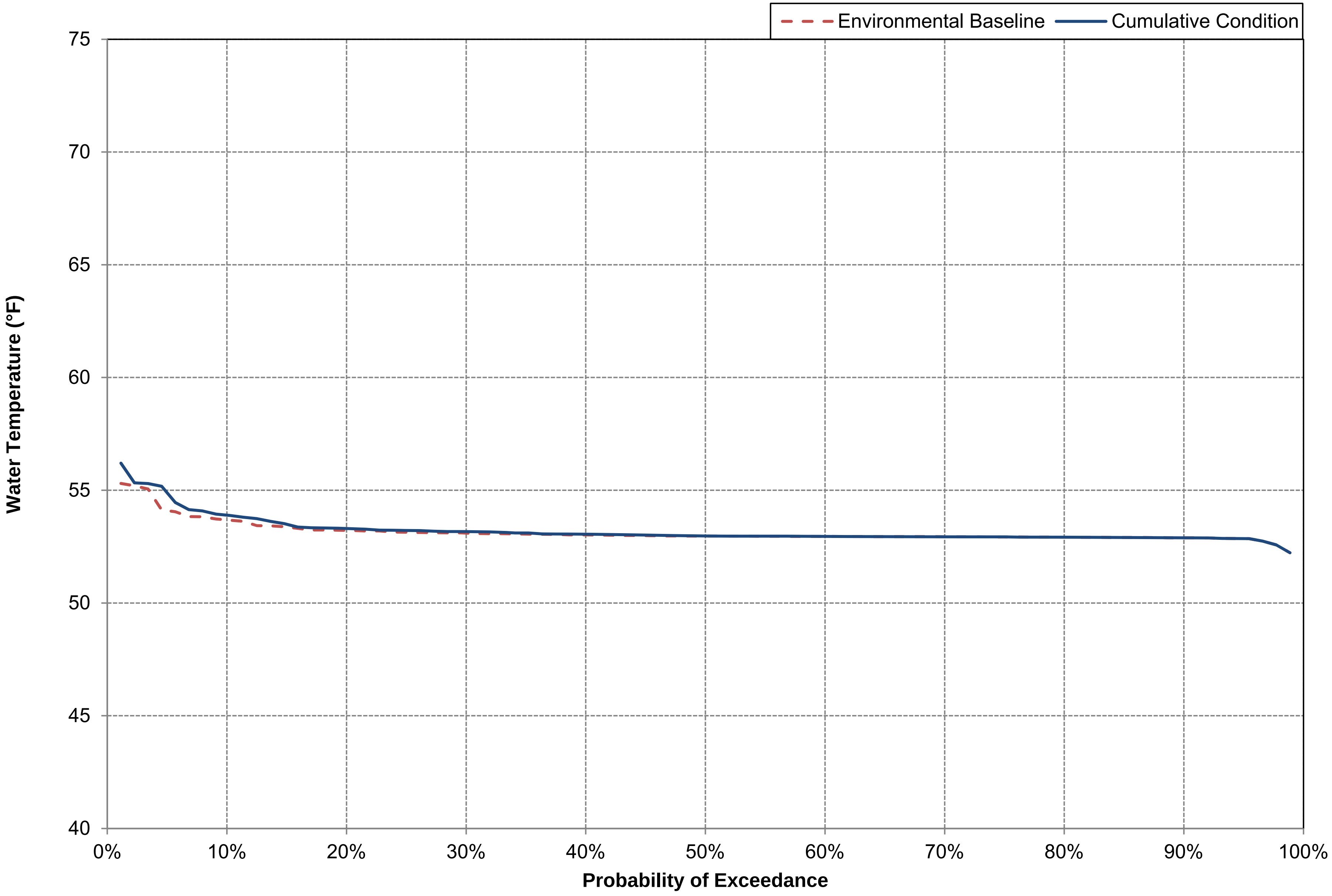
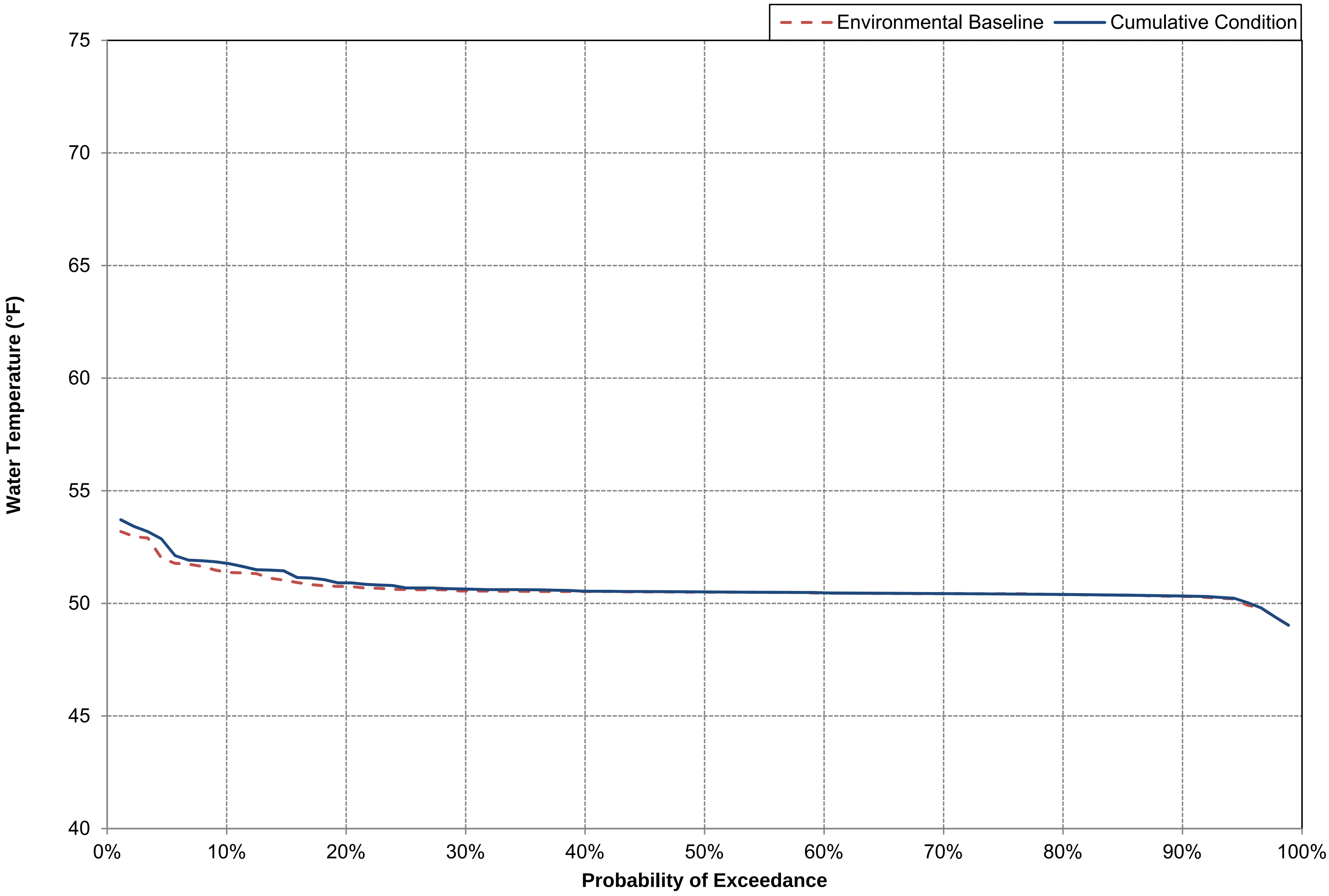
[1] Period of Record is Water Year 1922 - 2008

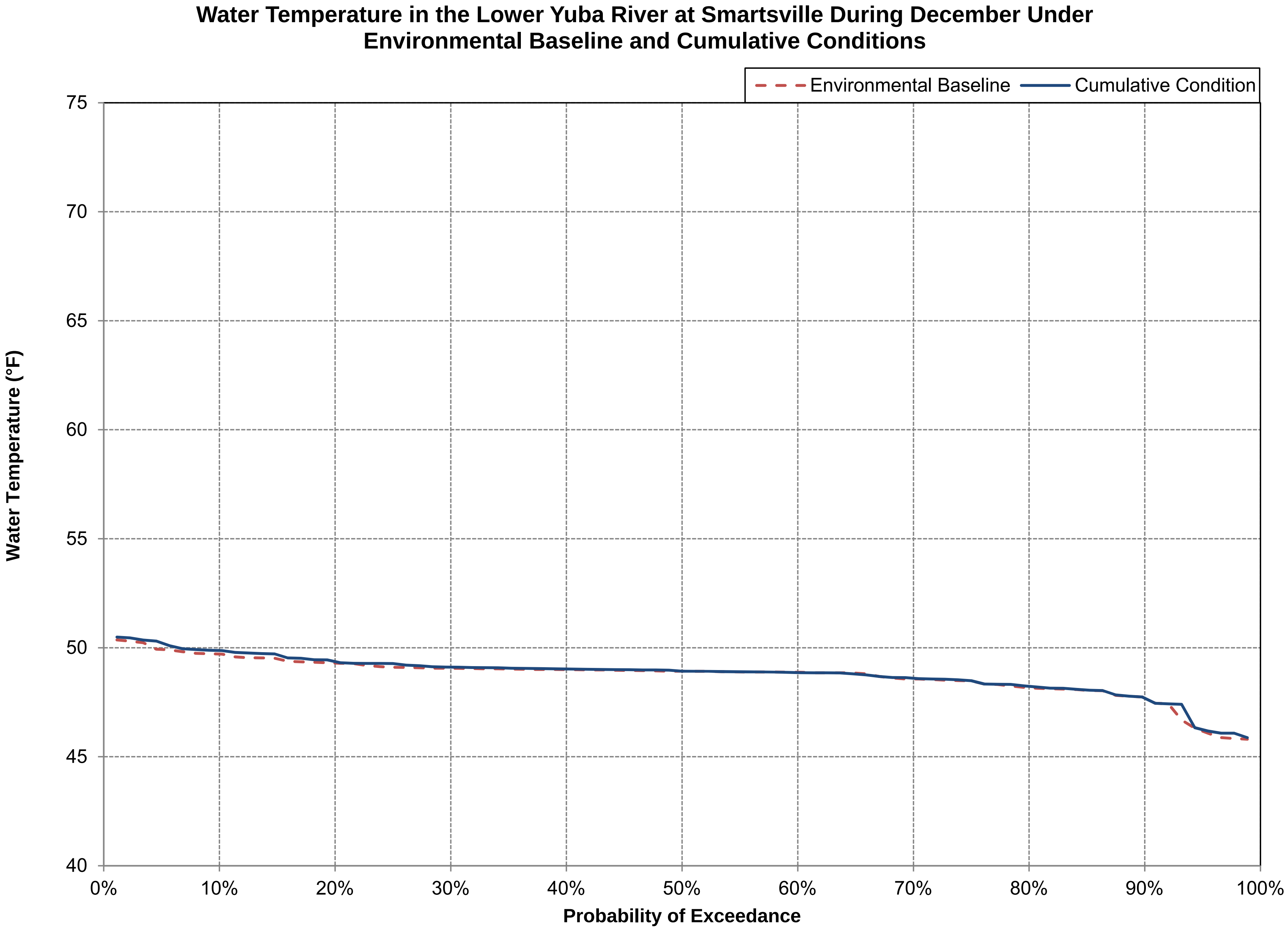
[2] As defined by the Yuba River Index described in SWRCB RD-1644

Water Temperature in the Lower Yuba River at Smartsville During October Under Environmental Baseline and Cumulative Conditions

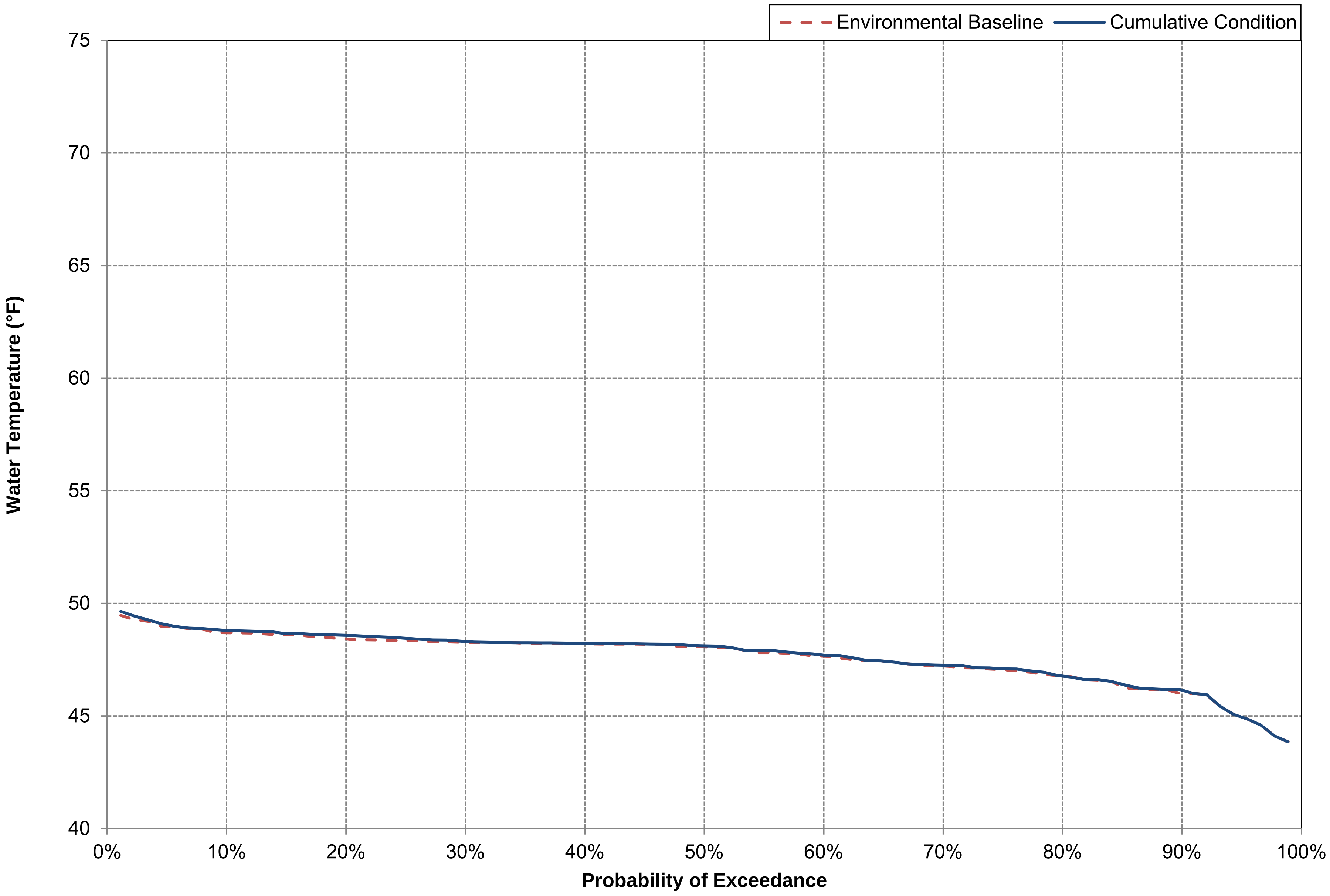


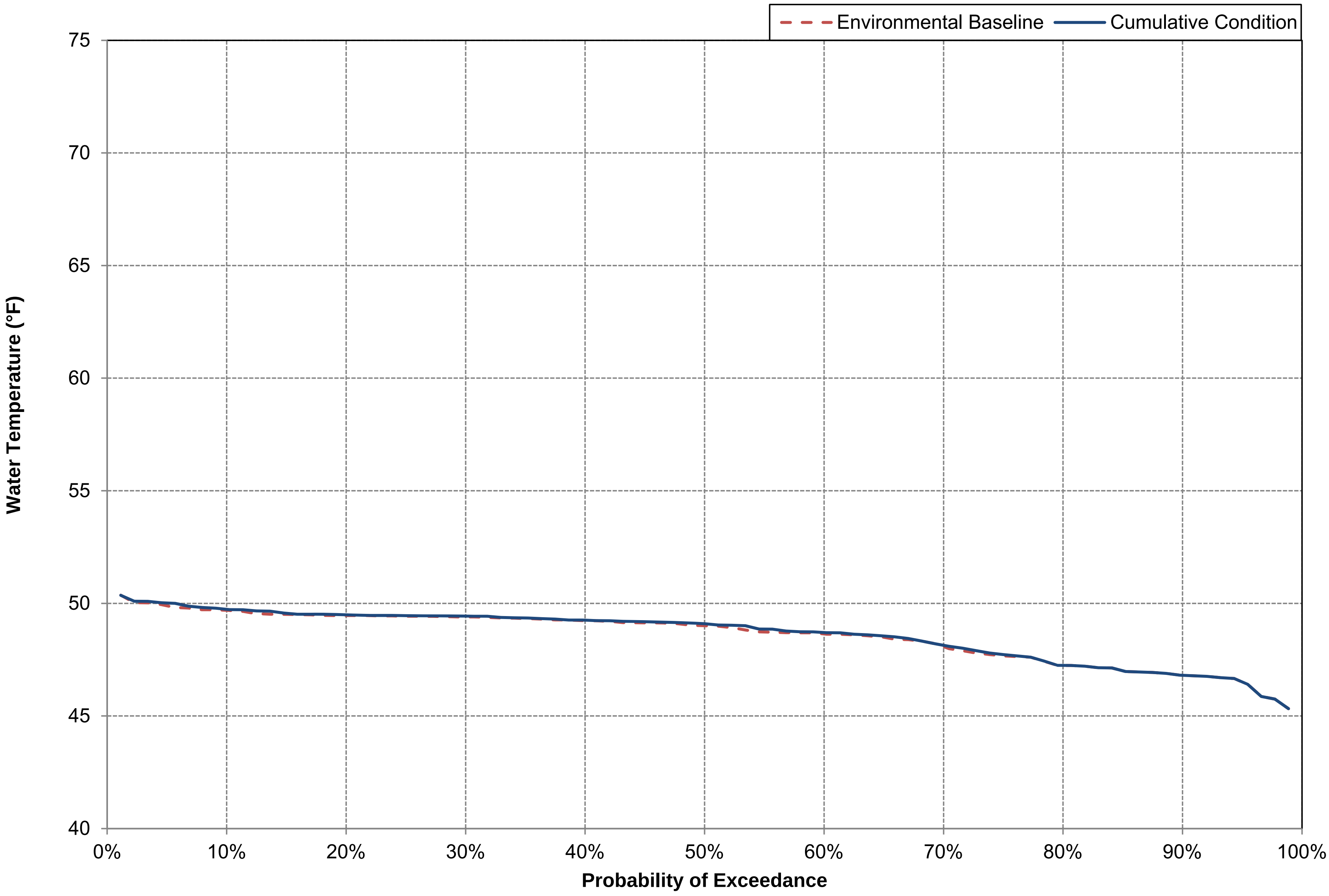


Water Temperature in the Lower Yuba River at Smartsville During November Under Environmental Baseline and Cumulative Conditions

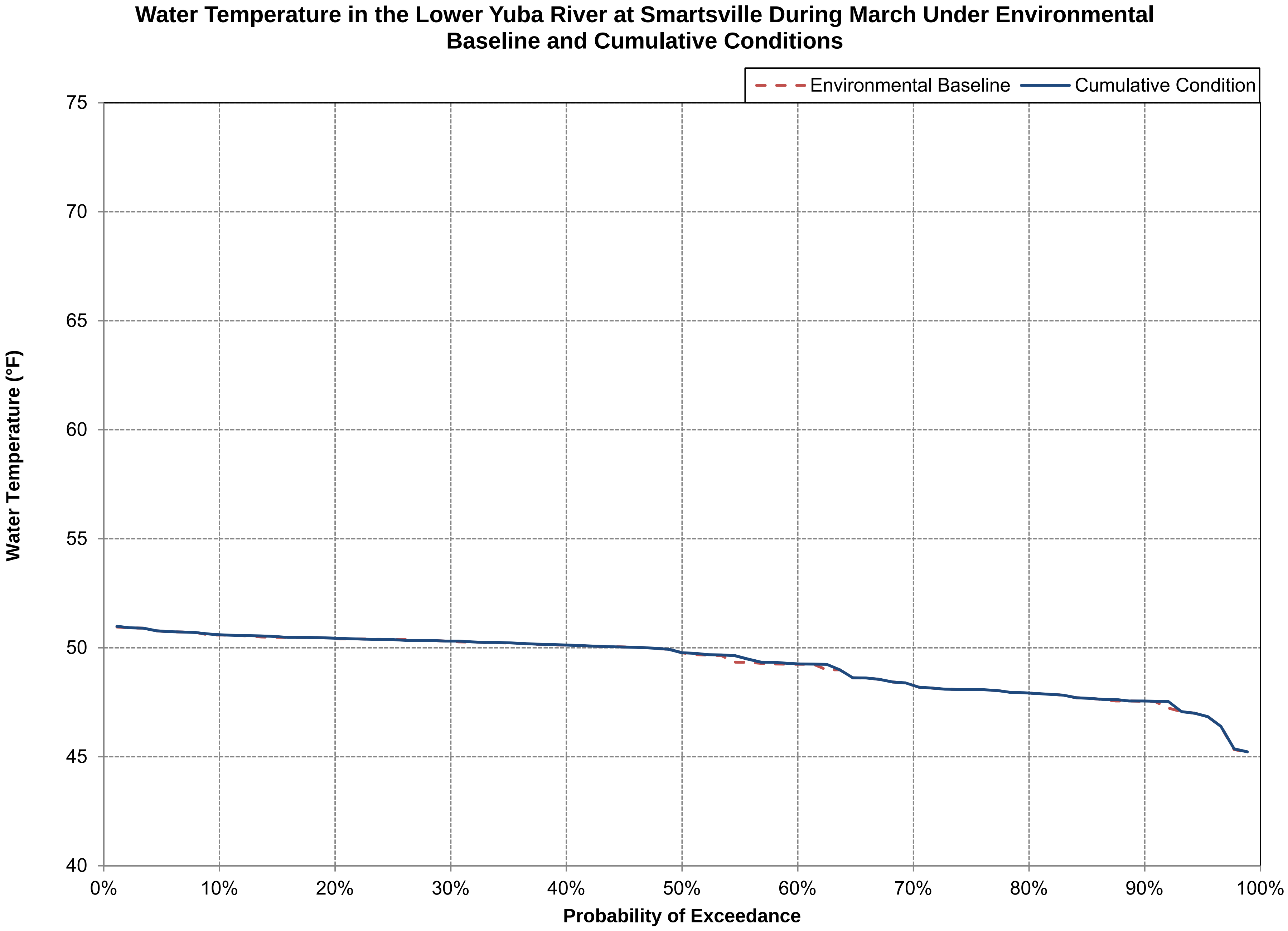

Water Temperature in the Lower Yuba River at Smartsville During December Under
Environmental Baseline and Cumulative Conditions
Environmental Baseline
Cumulative Condition
Water Temperature (°F)
75
70
65
60
55
50
45
40
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Exceedance

Water Temperature in the Lower Yuba River at Smartsville During January Under Environmental Baseline and Cumulative Conditions

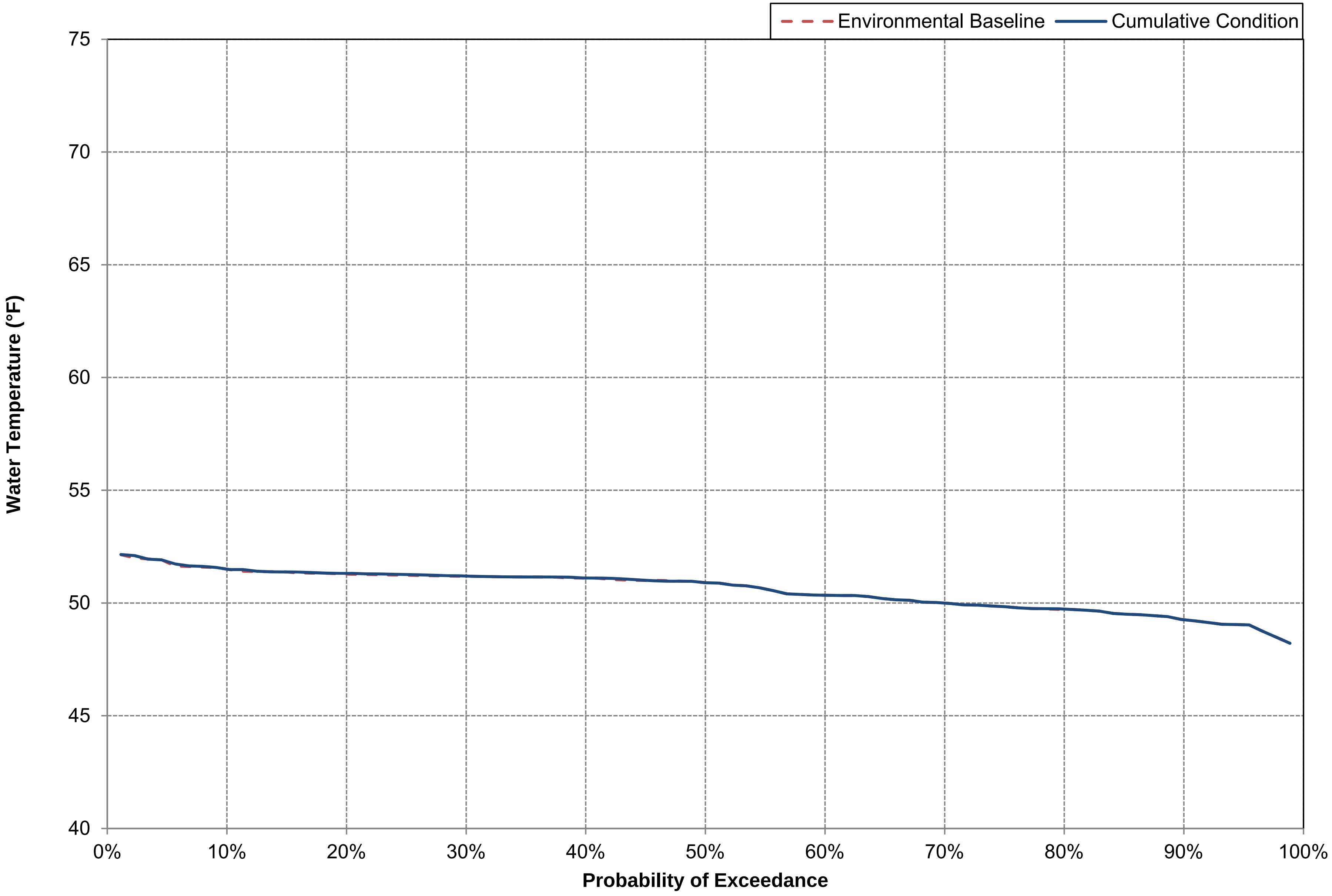




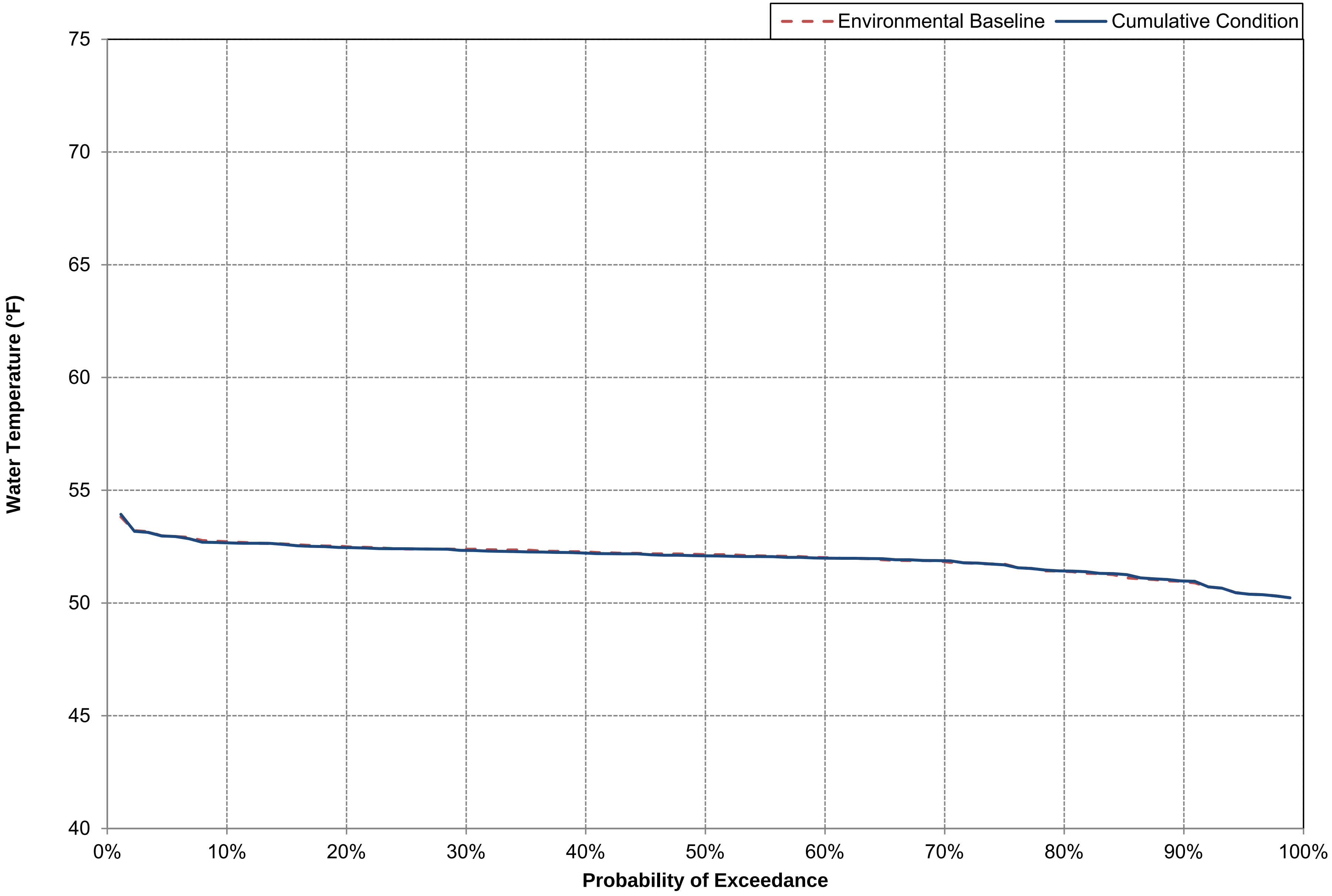
Water Temperature in the Lower Yuba River at Smartsville During February Under Environmental Baseline and Cumulative Conditions


Water Temperature in the Lower Yuba River at Smartsville During March Under Environmental Baseline and Cumulative Conditions
Environmental Baseline
Cumulative Condition
Water Temperature (°F)
75
70
65
60
55
50
45
40
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability of Exceedance

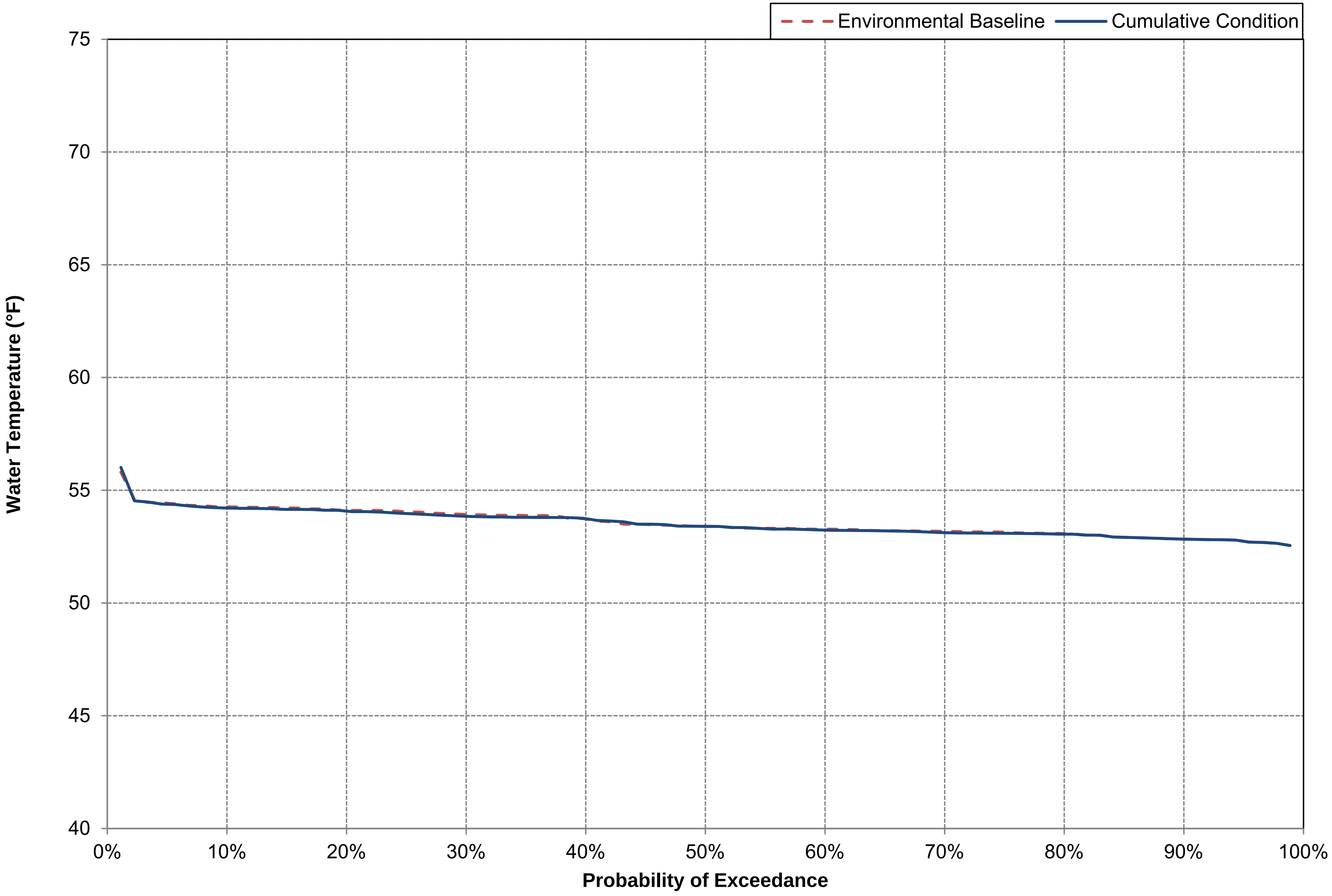
Water Temperature in the Lower Yuba River at Smartsville During April Under Environmental Baseline and Cumulative Conditions



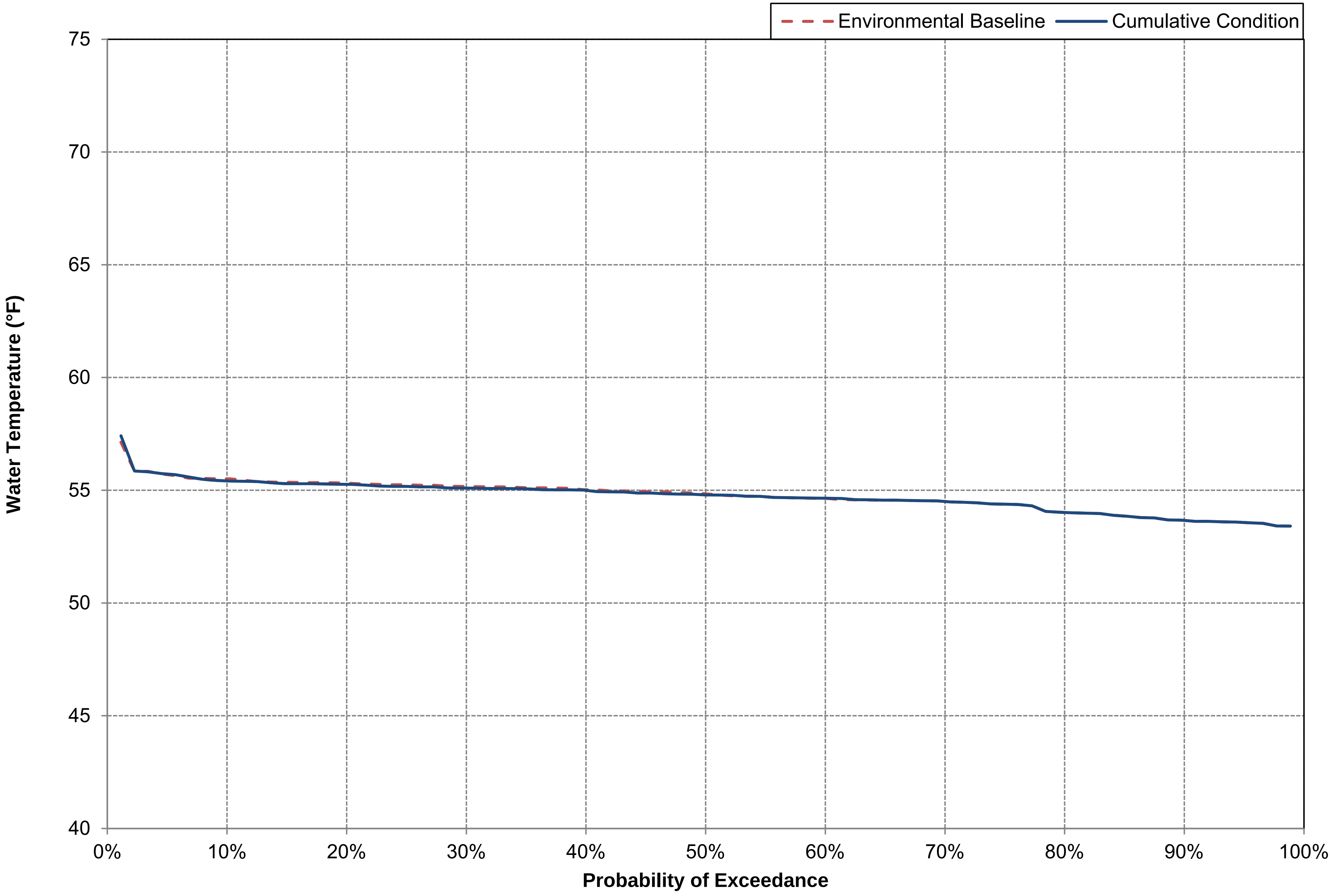
Water Temperature in the Lower Yuba River at Smartsville During May Under Environmental Baseline and Cumulative Conditions



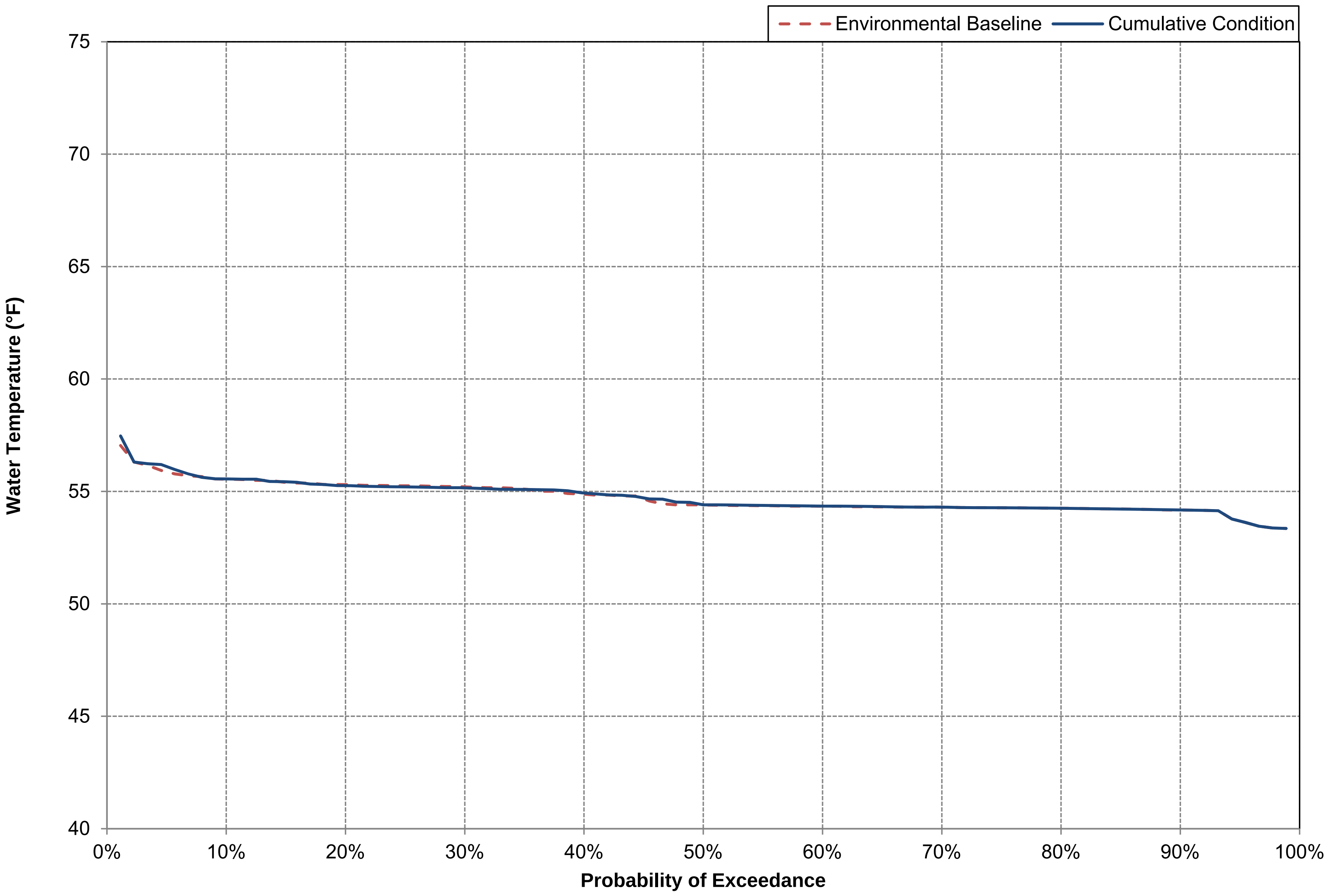
Water Temperature in the Lower Yuba River at Smartsville During June Under Environmental Baseline and Cumulative Conditions



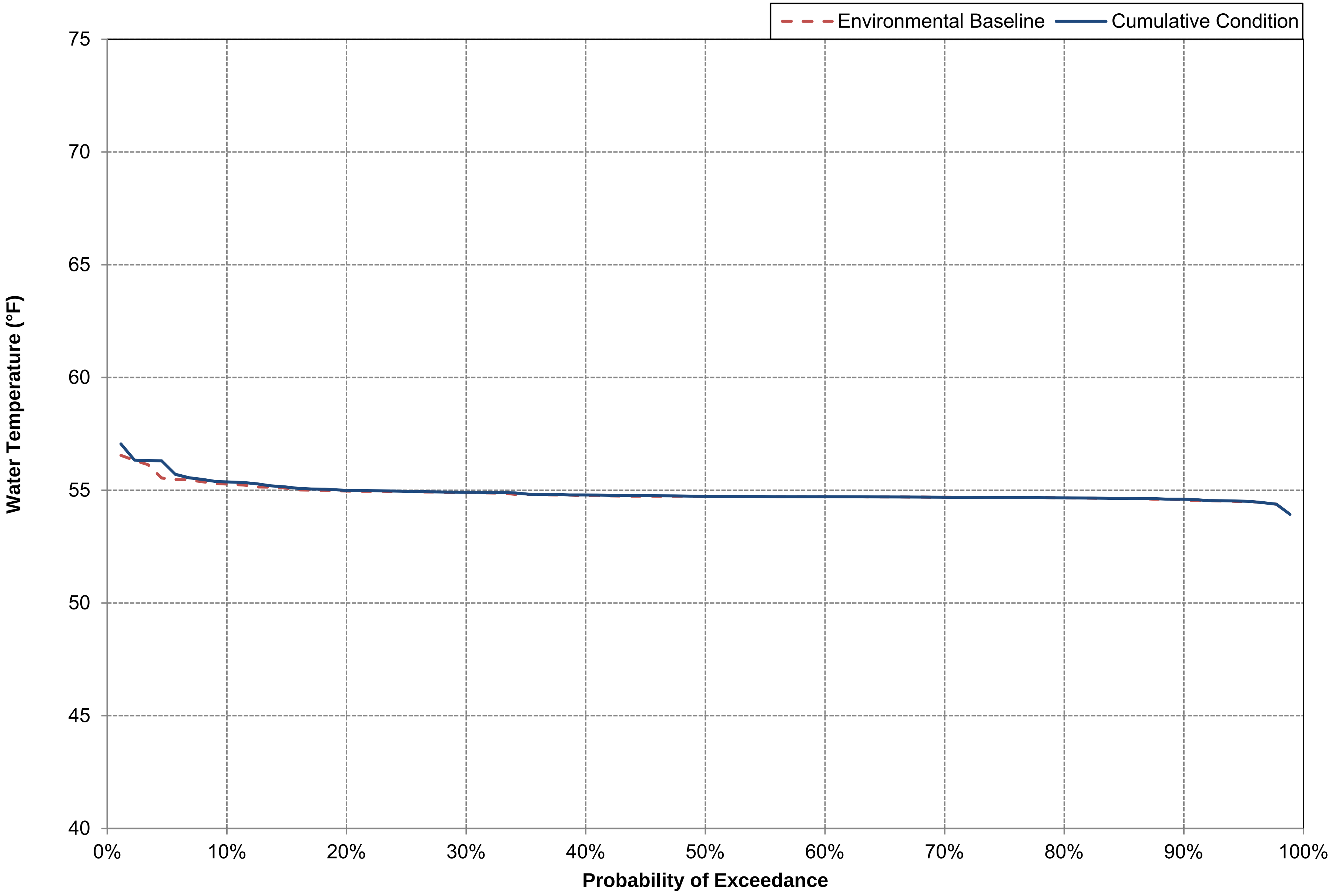
Water Temperature in the Lower Yuba River at Smartsville During July Under Environmental Baseline and Cumulative Conditions



Water Temperature in the Lower Yuba River at Smartsville During August Under Environmental Baseline and Cumulative Conditions



Water Temperature in the Lower Yuba River at Smartsville During September Under
Environmental Baseline and Cumulative Conditions



Appendix B: lower Yuba River Accord EIR Modeling Technical Memoranda

Proposed Lower Yuba River Accord

Modeling Technical Memorandum

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Proposed Lower Yuba River Accord
Modeling Technical Memorandum

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

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[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.

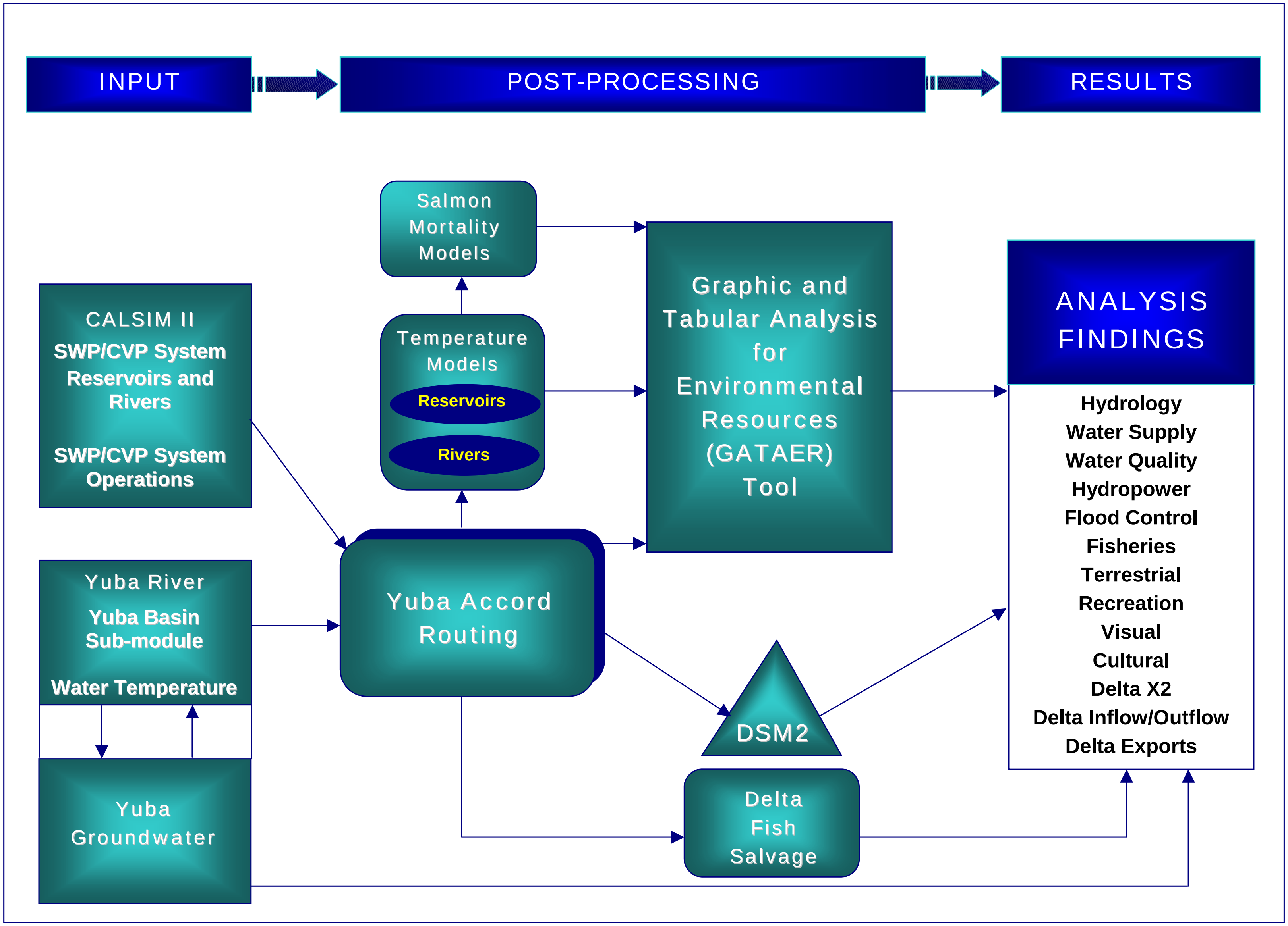

Figure 3-1. Modeling and Post-Processing Procedures

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.

New Bullards Bar
Inflow (as input)
Reservoir Storage
Reservoir Surface Area
Reservoir Evaporation
Reservoir Spill (flood release)
Colgate Release
Fishery Release (bottom outlet)
Power Generation
Englebright Reservoir
Inflow
Narrows Releases
Spill
Power Generation
Smartville Gage
Flow Requirement (as input)
Flow
Deer Creek
Inflow (as input)
Daguerre Point Dam
Diversion demand (as input)
Diversion
Diversion Shortage (TAF)
Diversion Deficiency (%)
Flow below Daguerre
Marysville Gage
Flow Requirement

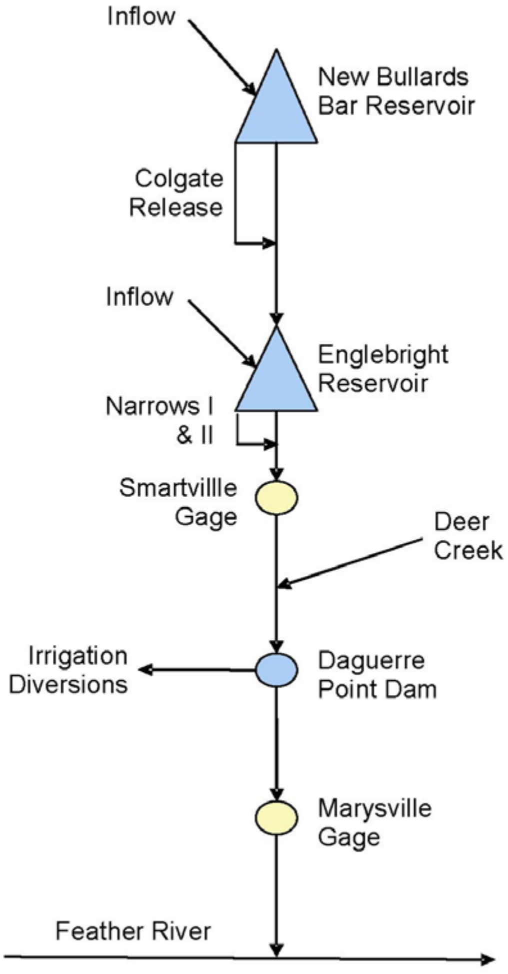

Figure 3-2. Lower Yuba River Model Network Schematic and Output

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

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[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].

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[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

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[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.

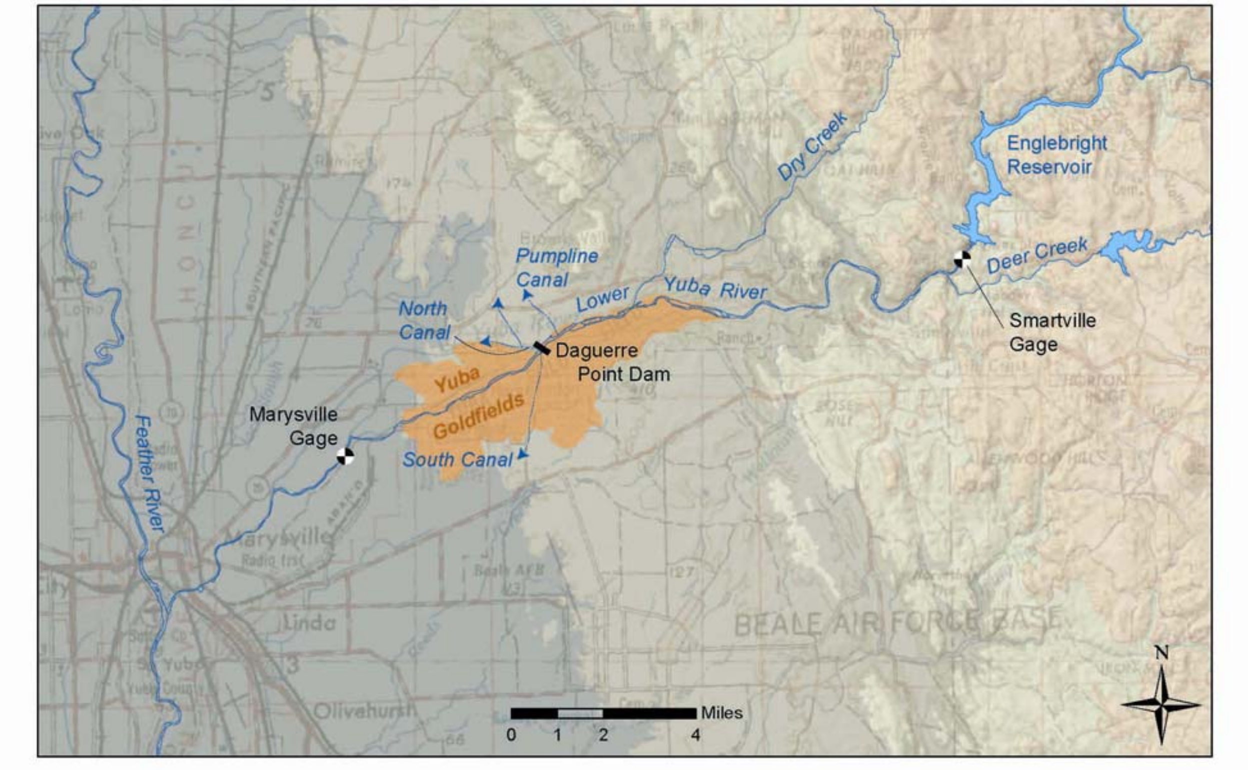

Figure A-2. Lower Yuba River

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.

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[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 1	70 170 1	70 170			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

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[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**.

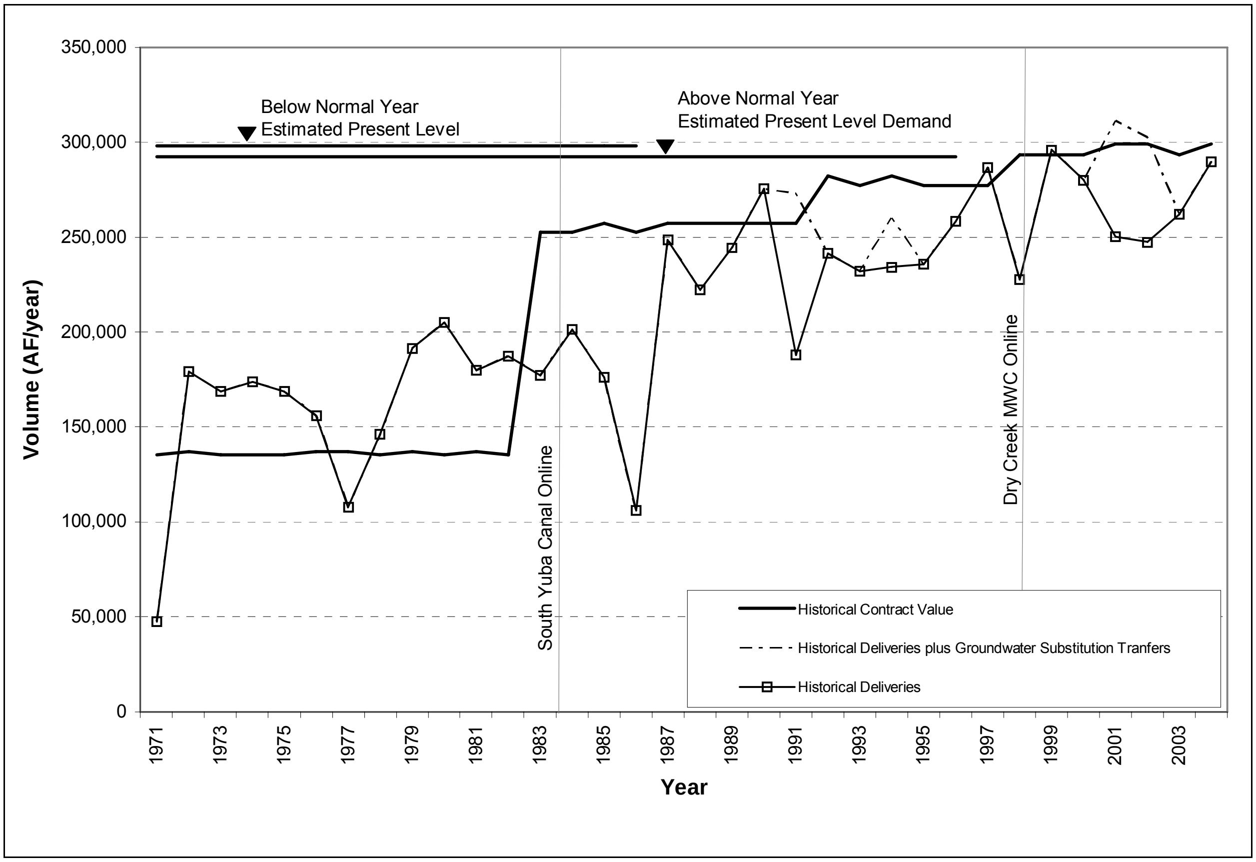

Figure A-3. Historical Deliveries to YCWA Member Units Compared to Estimated Present Level of Demands

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 Alternativ*e*
- ☐ 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.

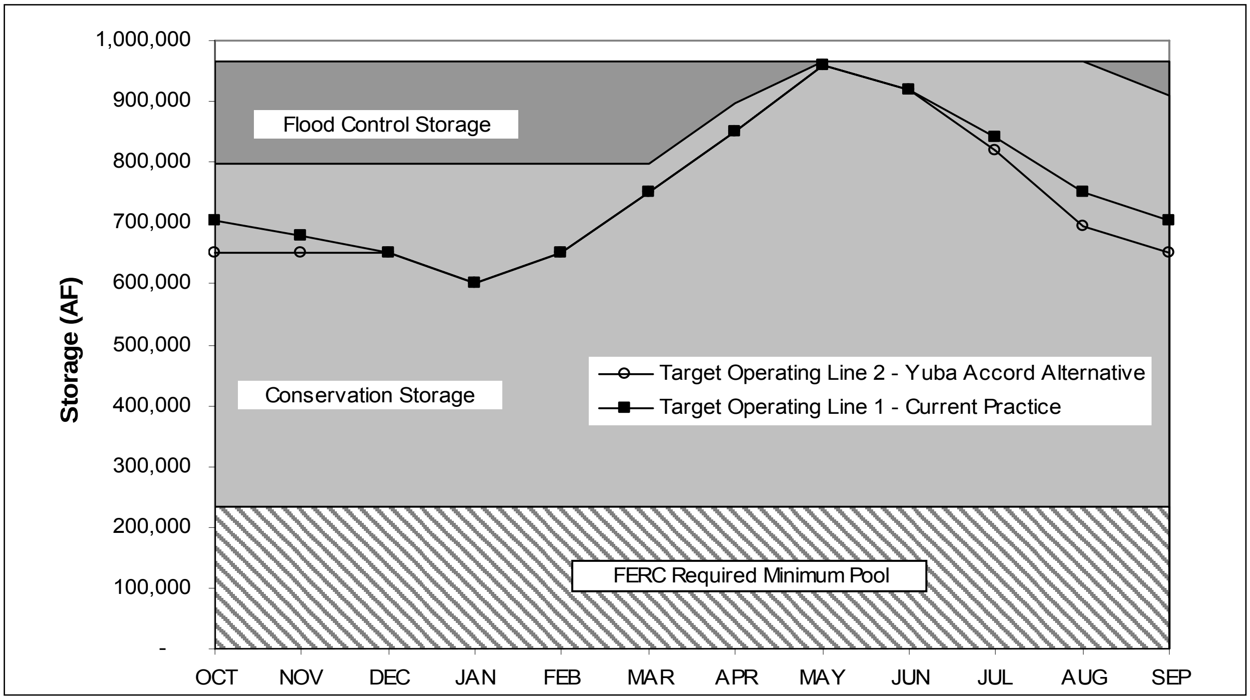

Figure A-4. New Bullards Bar Reservoir Target Operating Lines

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

1966 YCWA FERC License												
All Water Year Types [e]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	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

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[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

Attachment B

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.

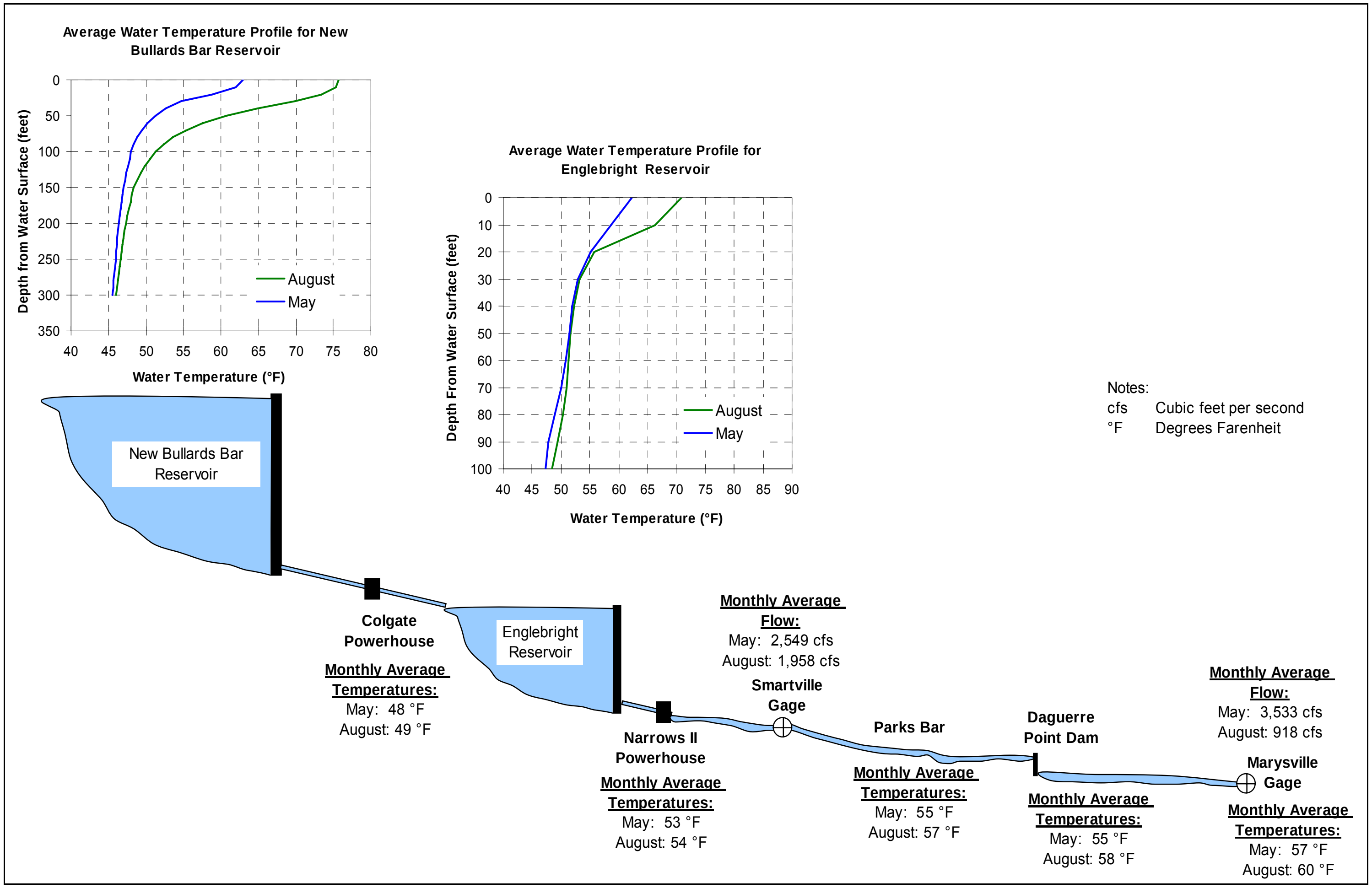

Figure B-1. Average Monthly Water Temperature Profile in the Lower Yuba River for May and August for the Period 1999 to 2004[1]

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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.

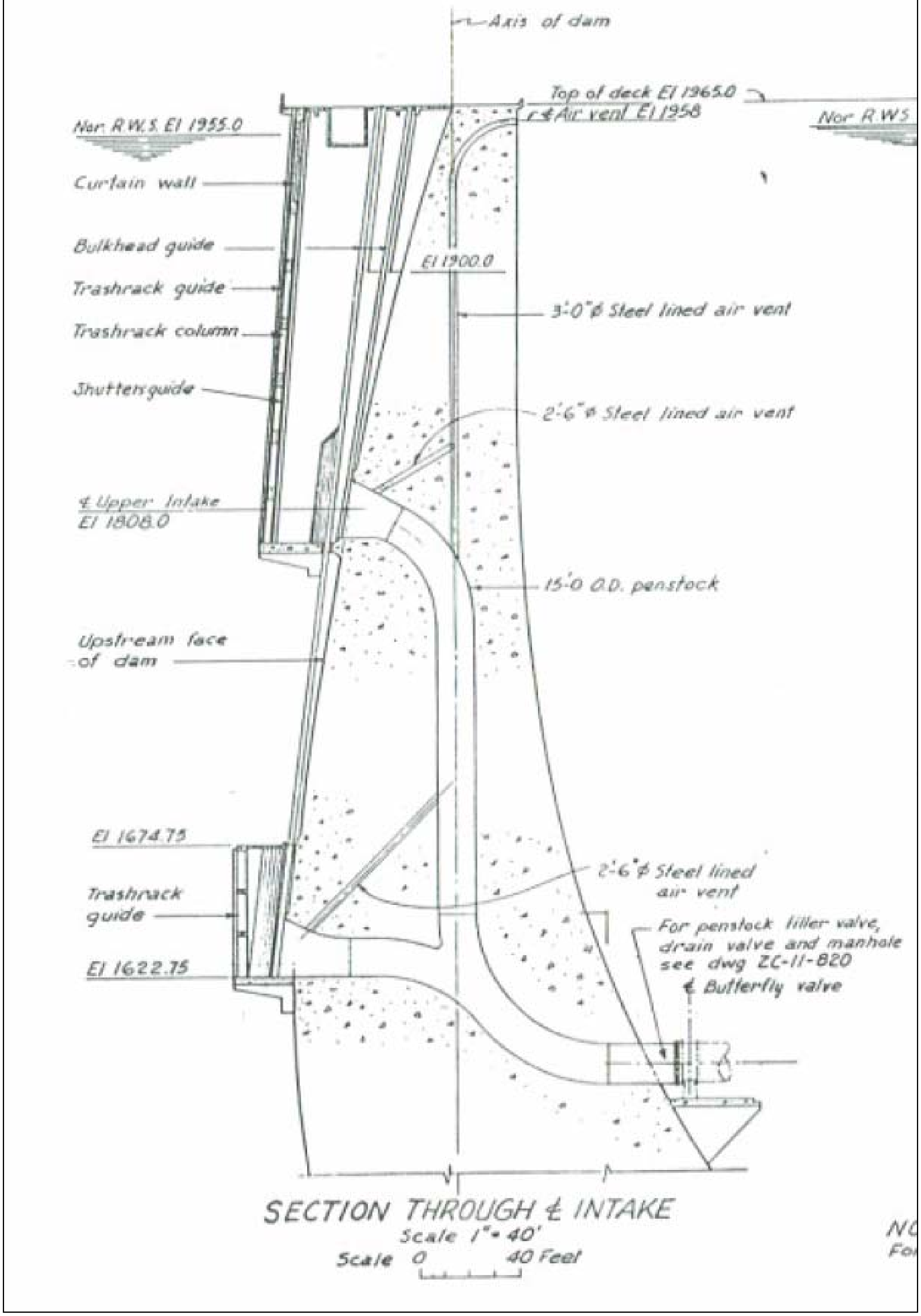


Figure B-2. Section Through New Bullards Bar Dam

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.**

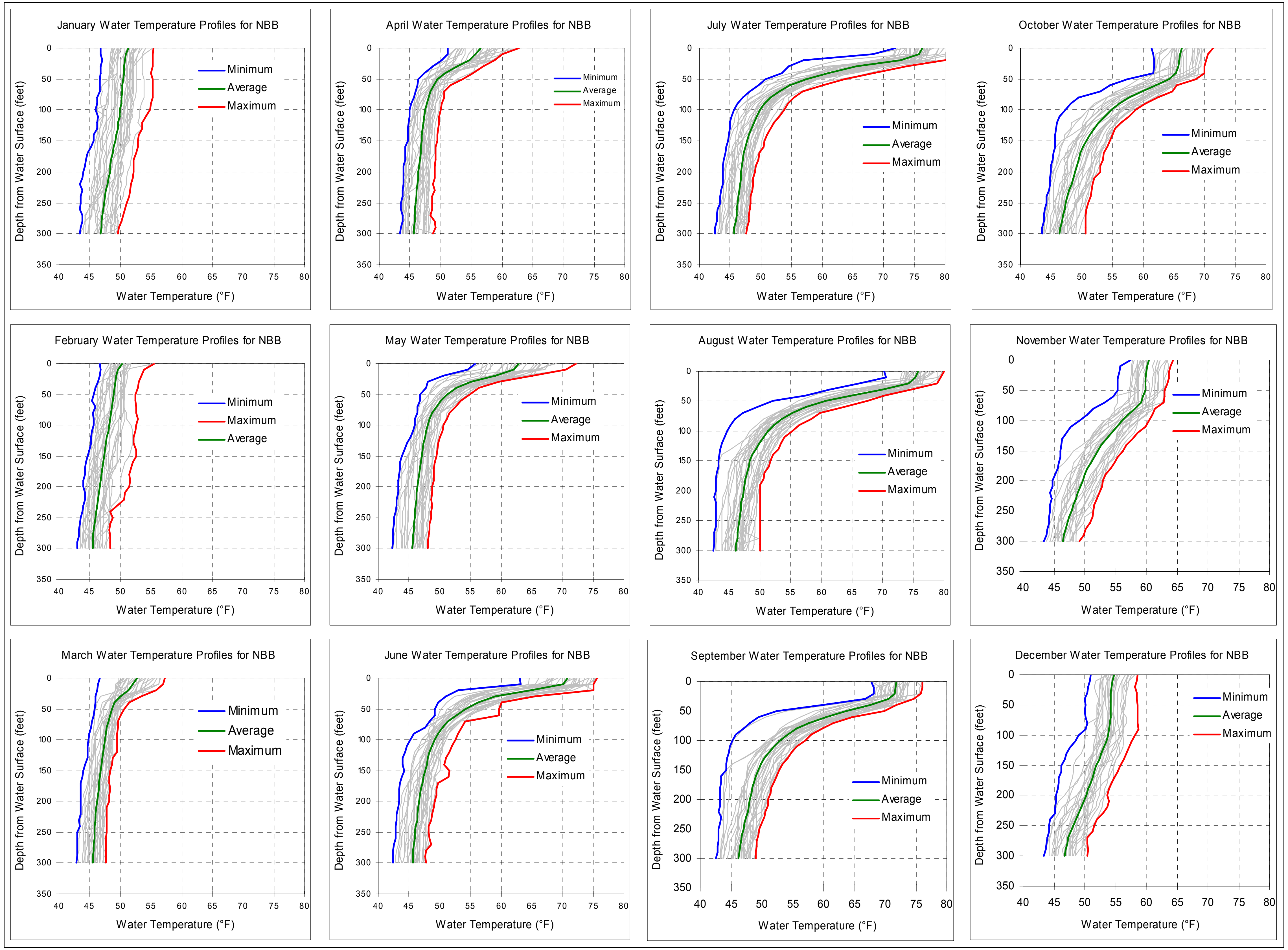


Figure B-3. Monthly Water Temperature Profiles of New Bullards Bar Reservoir

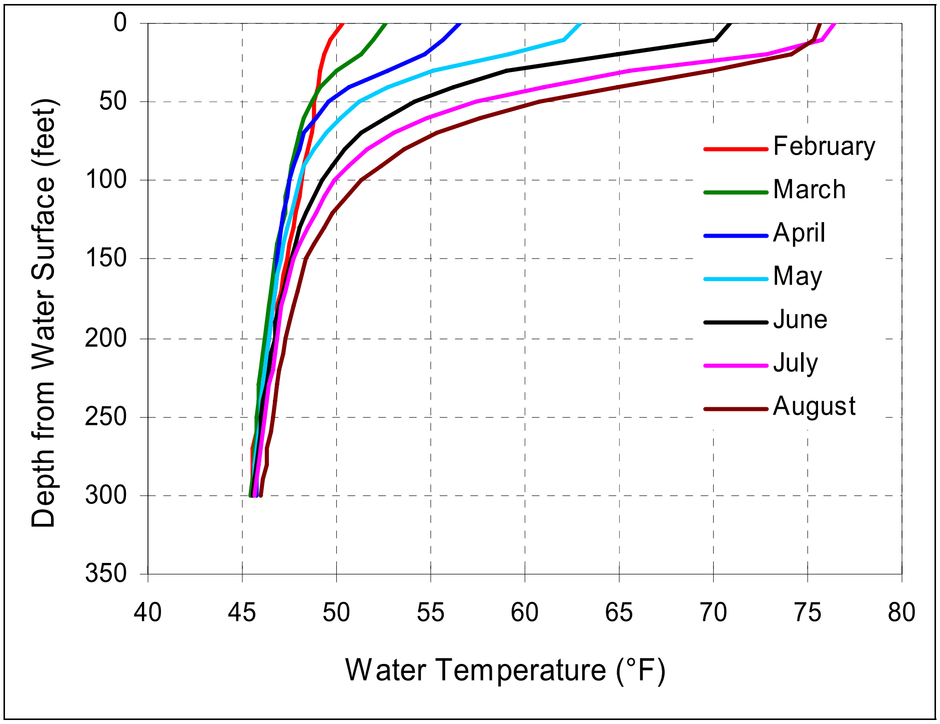


Figure B-4. New Bullards Bar Reservoir Average Monthly Water Temperature Profile, February to August Warming Cycle

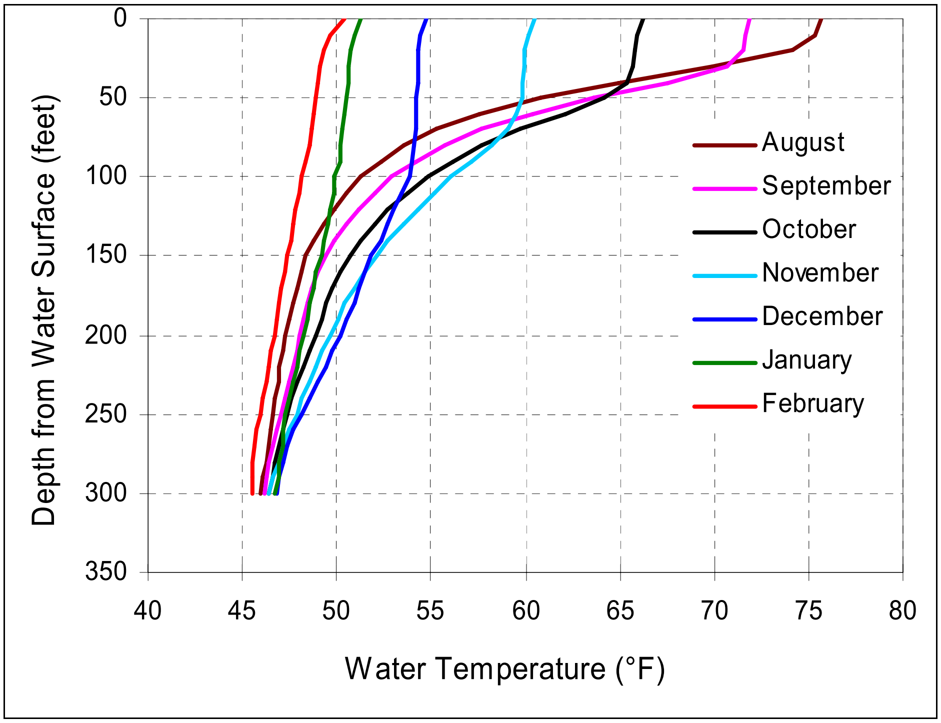
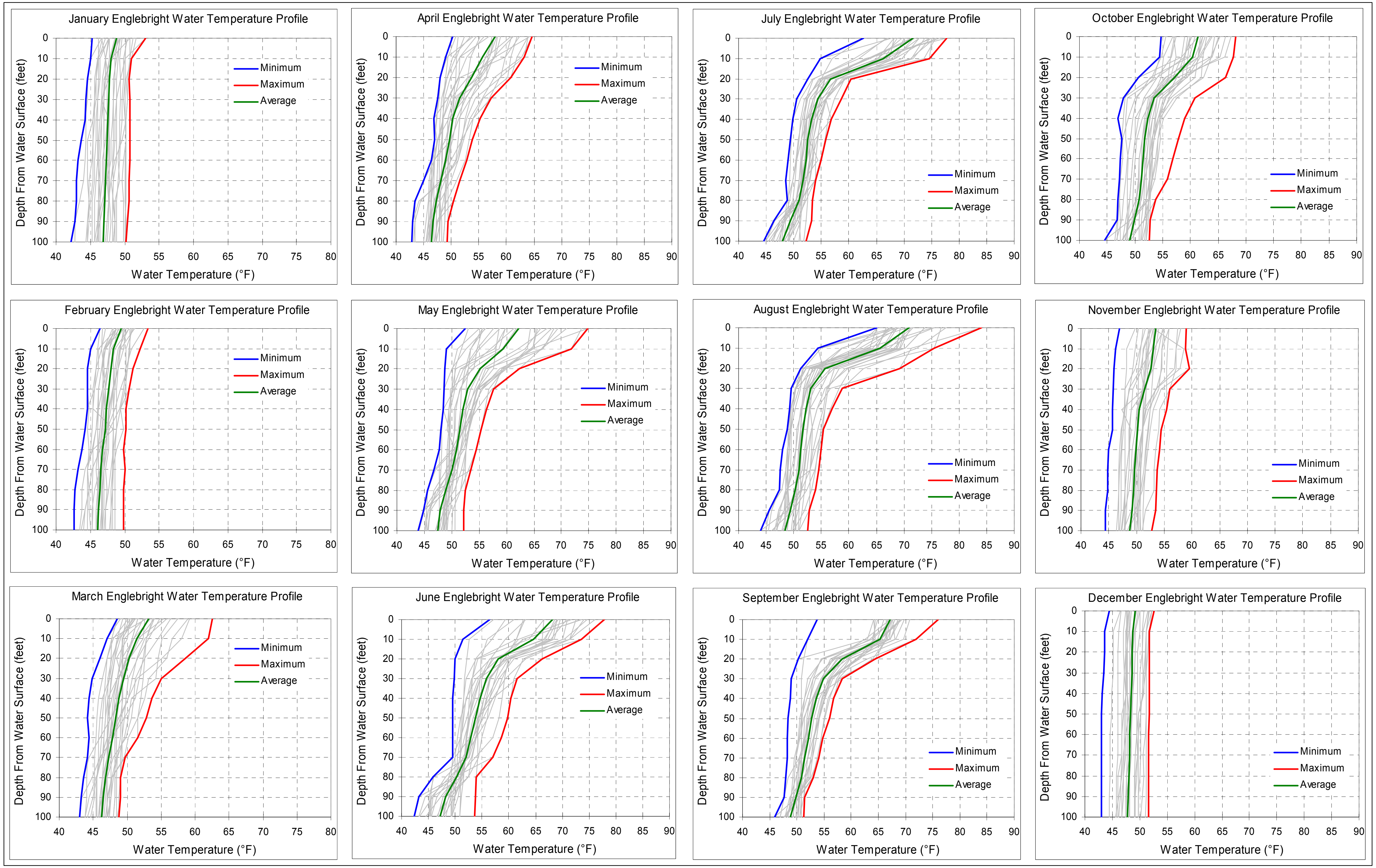


Figure B-5. New Bullards Bar Reservoir Average Monthly Water Temperature Profile, August to February Cooling Cycle



January Englebright Water Temperature Profile

April Englebright Water Temperature Profile

July Englebright Water Temperature Profile

October Englebright Water Temperature Profile

February Englebright Water Temperature Profile

May Englebright Water Temperature Profile

August Englebright Water Temperature Profile

November Englebright Water Temperature Profile

March Englebright Water Temperature Profile

June Englebright Water Temperature Profile

September Englebright Water Temperature Profile

December Englebright Water Temperature Profile

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

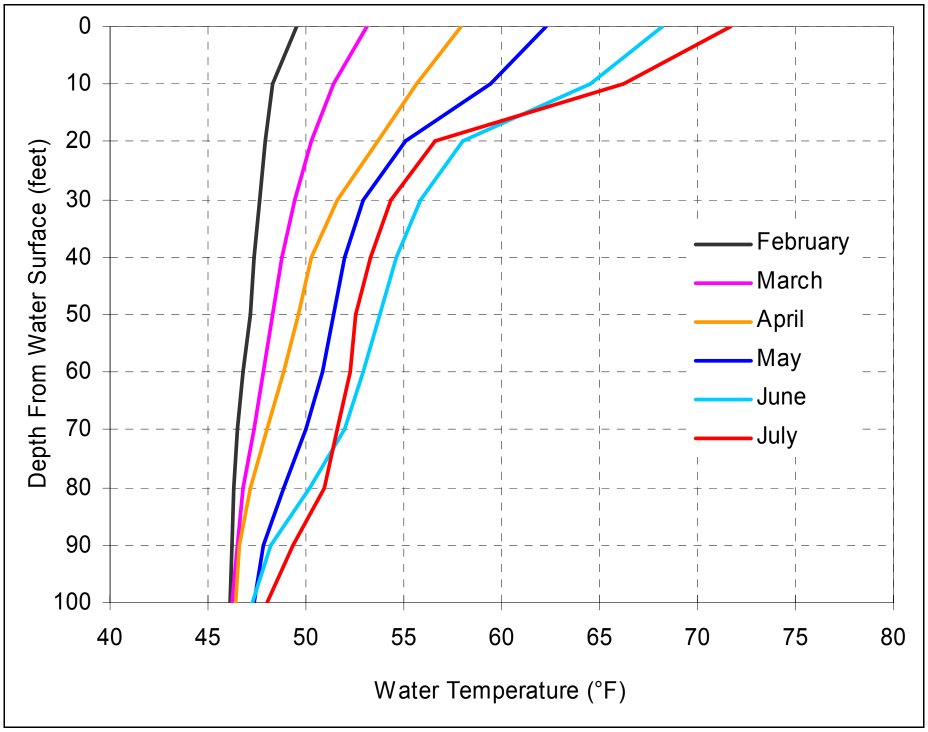


Figure B-7. Englebright Average Monthly Water Temperature Profile, February to August Warming Cycle

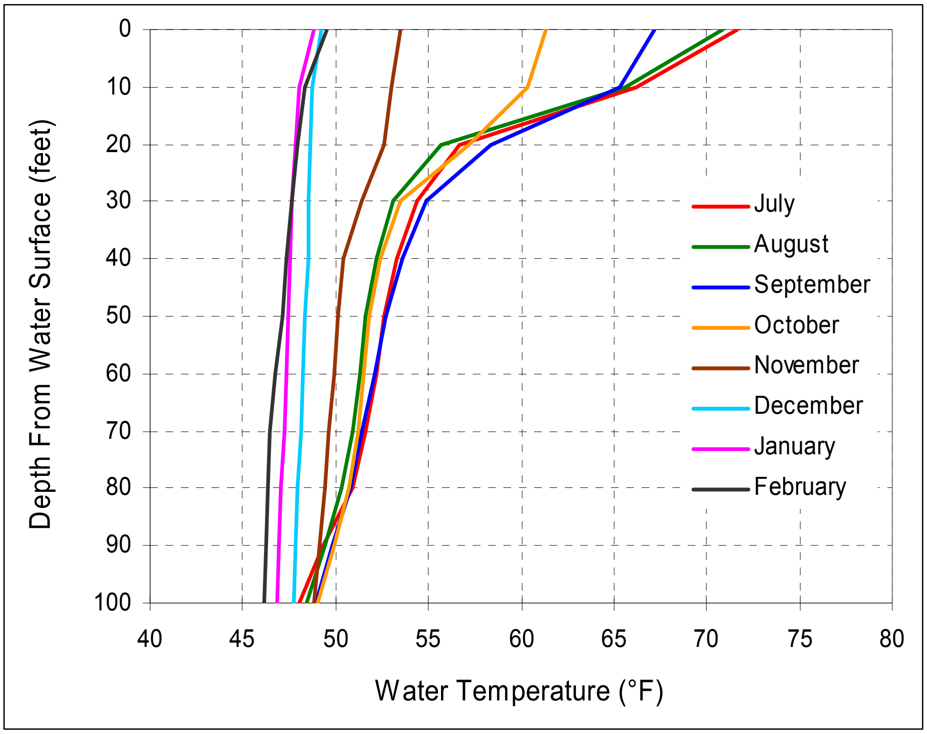


Figure B-8. Englebright Average Monthly Water Temperature Profile, August to February Cooling Cycle

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)

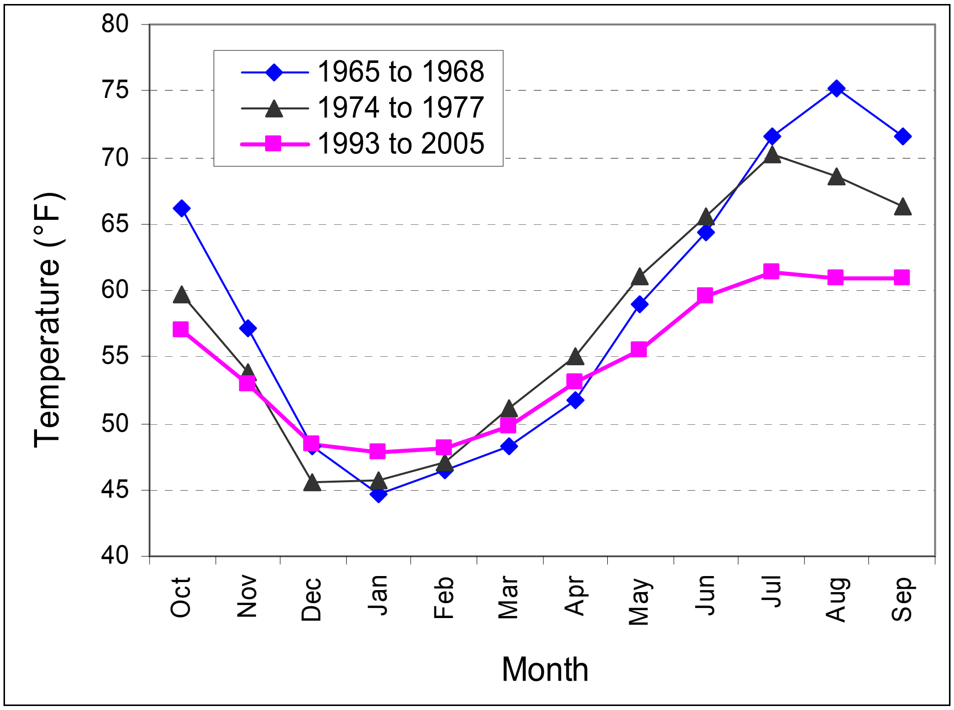


Figure B-9. Monthly Average of Daily Yuba River Water Temperatures at Marysville Gage for Periods of Pre- and Post-Yuba River Development Project

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

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[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.

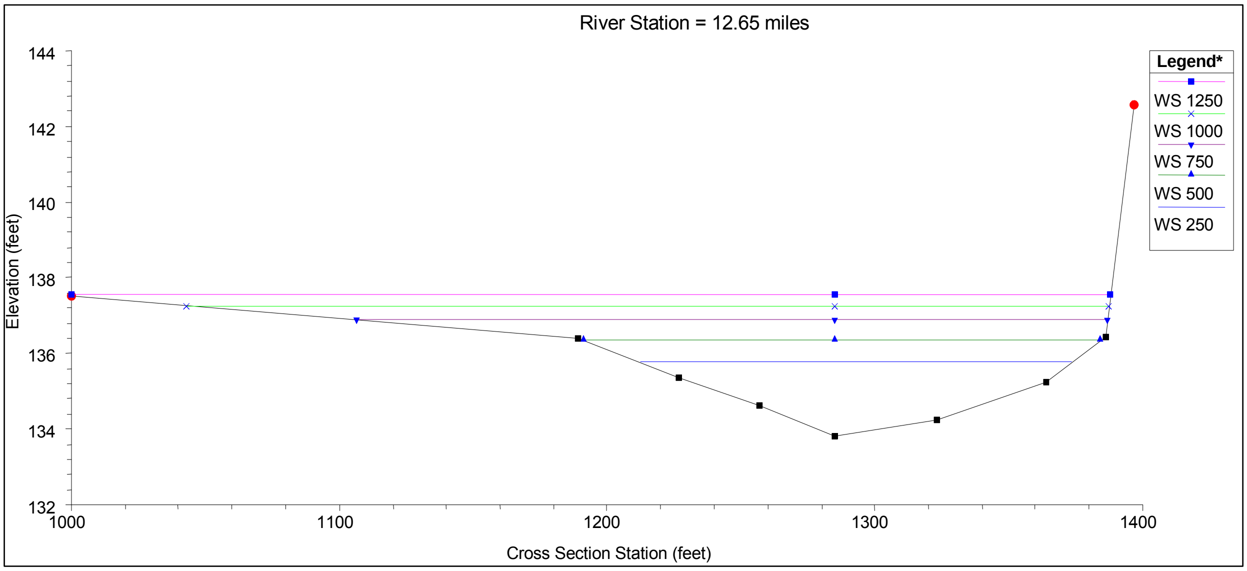

Figure B-11. Yuba River Cross Section at River Mile 12.65 with Flow Stages (e.g., WS 750: Water Surface Elevation at a Flow of 750 cfs)

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.

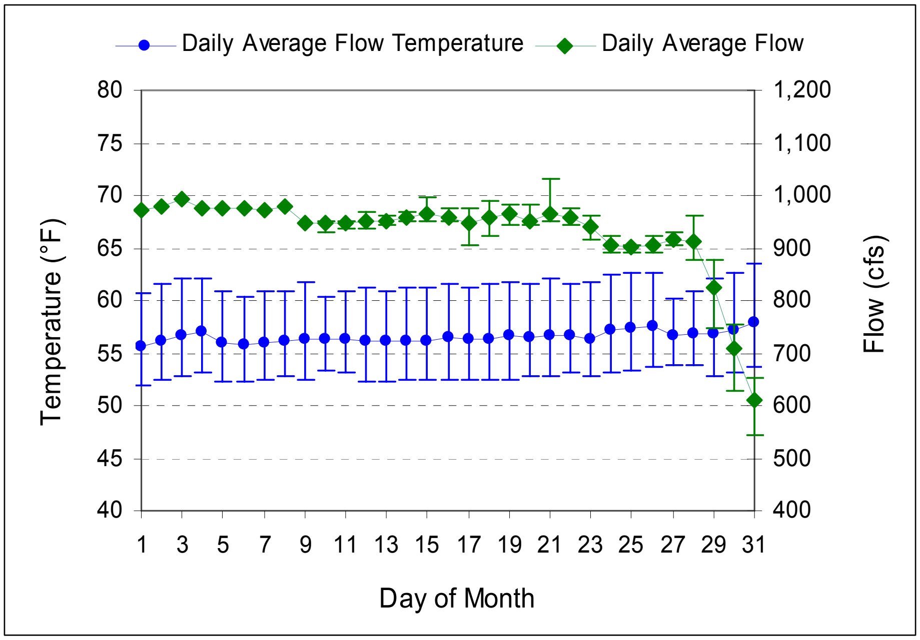

Figure B-12. Lower Yuba River Water Temperature at the Marysville Gage in August 2004

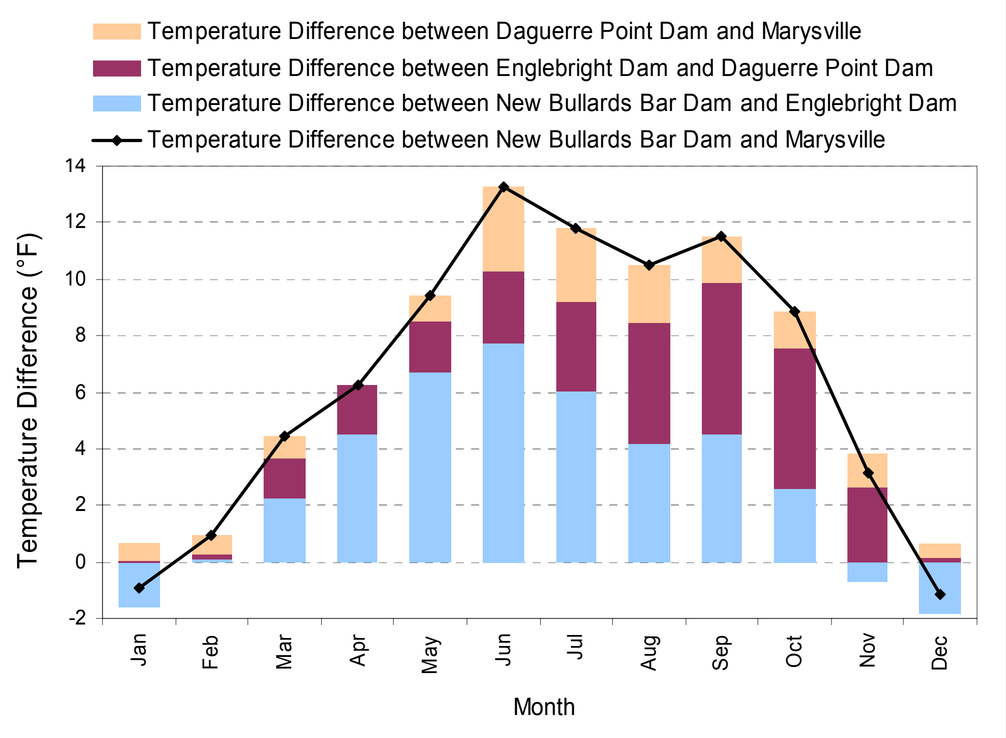

Figure B-13. Average Monthly Water Temperature Differences in the Lower Yuba River (1990 to 2005)

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

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[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

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[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.

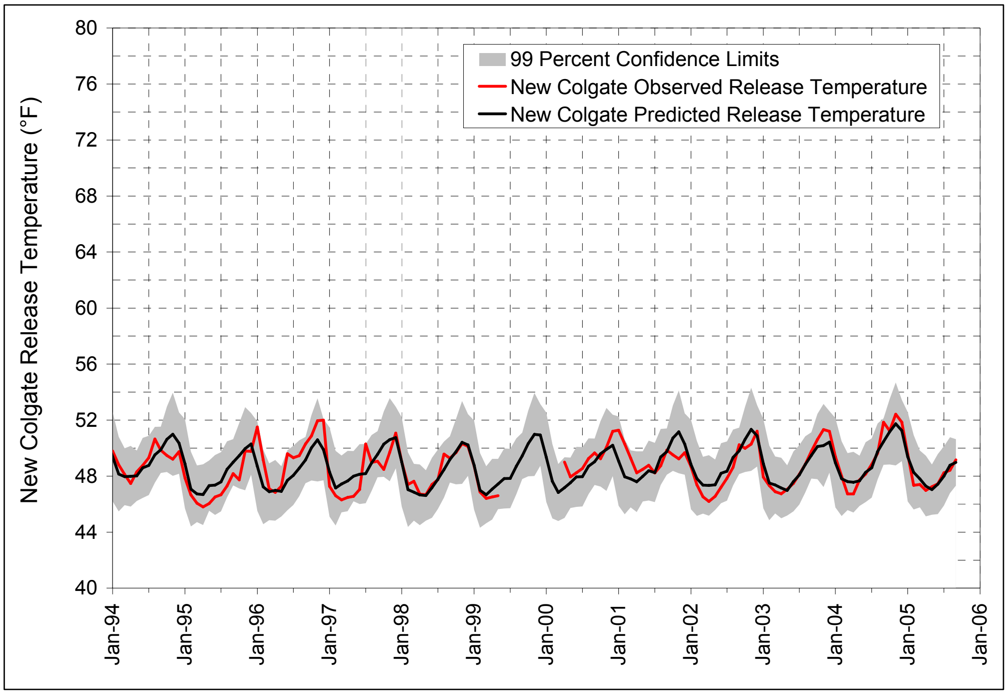

Figure B-14. Predicted and Observed Release Temperature at New Colgate Powerhouse for the Period 1994 to 2005

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.

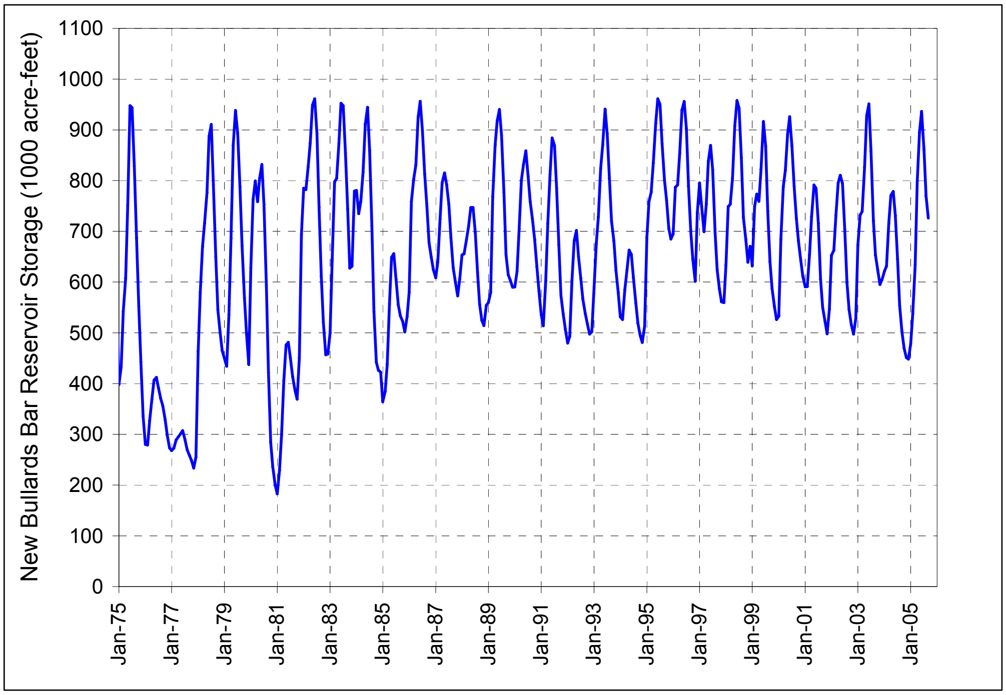

Figure B-15. New Bullards Bar Reservoir Monthly Storage Time Series

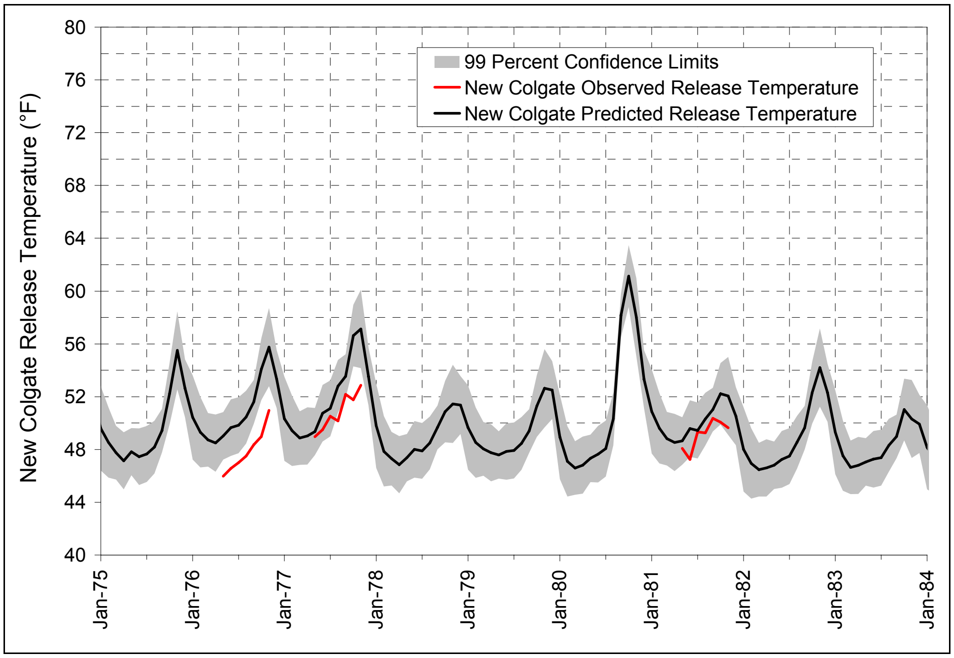

Figure B-16. Validation of New Colgate Release Temperature Model using Observed Release Temperature during 1976, 1977, and 1981[6]

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[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.

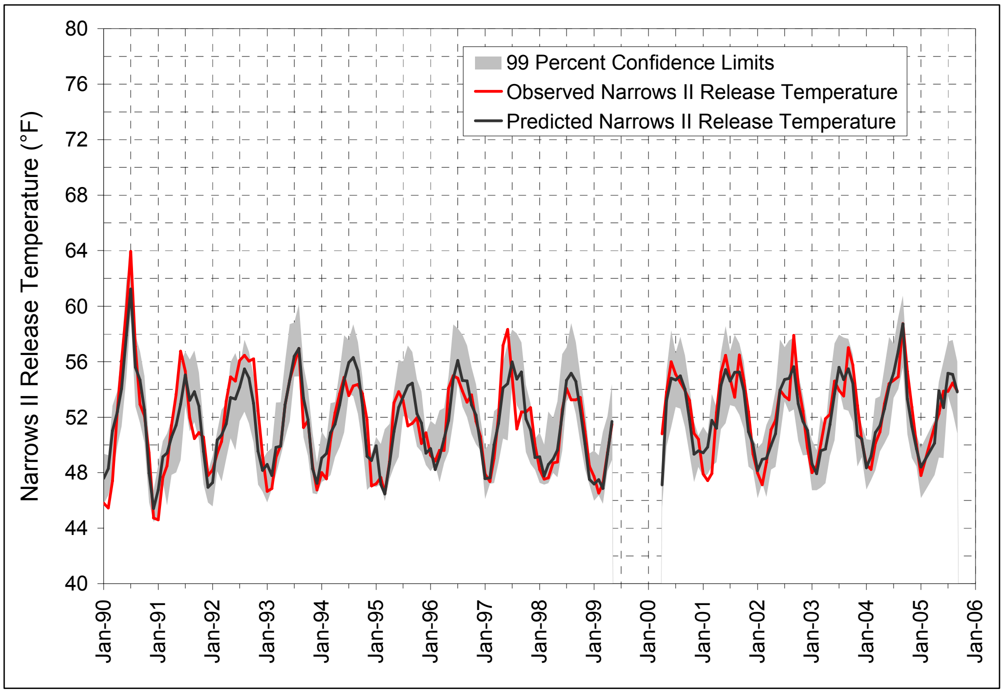

Figure B-17. Predicted and Observed Release Temperature at Narrows II Powerhouse for the period 1990 to 2005 (Calibration Results)

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.

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[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.

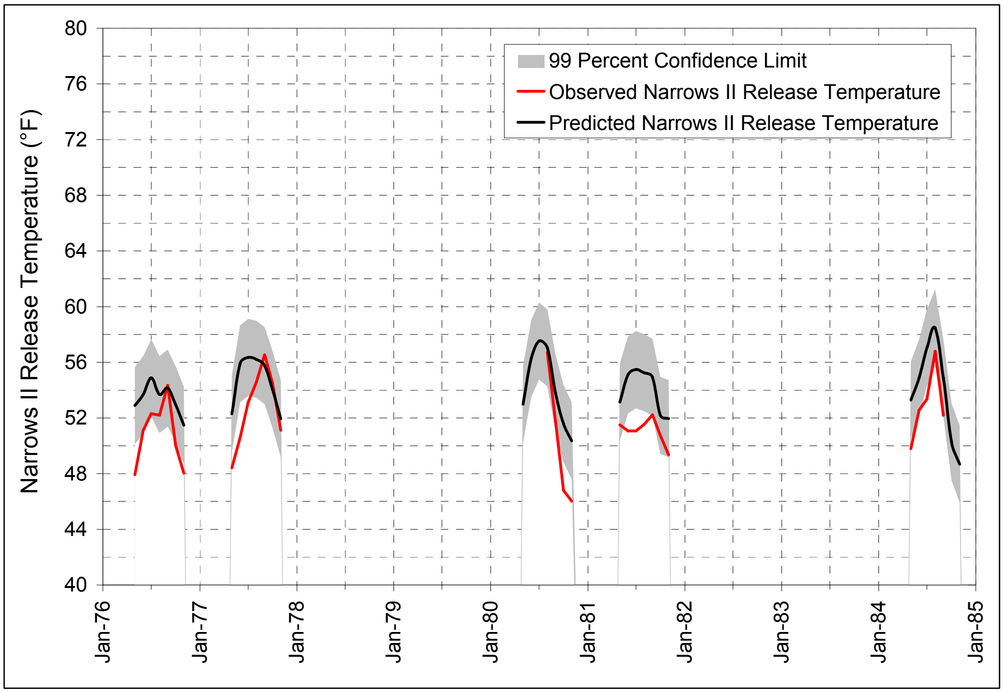

Figure B-18. Validation of Narrows II Release Temperature Model Using Observed Release Temperature at Narrows II Powerhouse for the Period 1976 to 1985

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

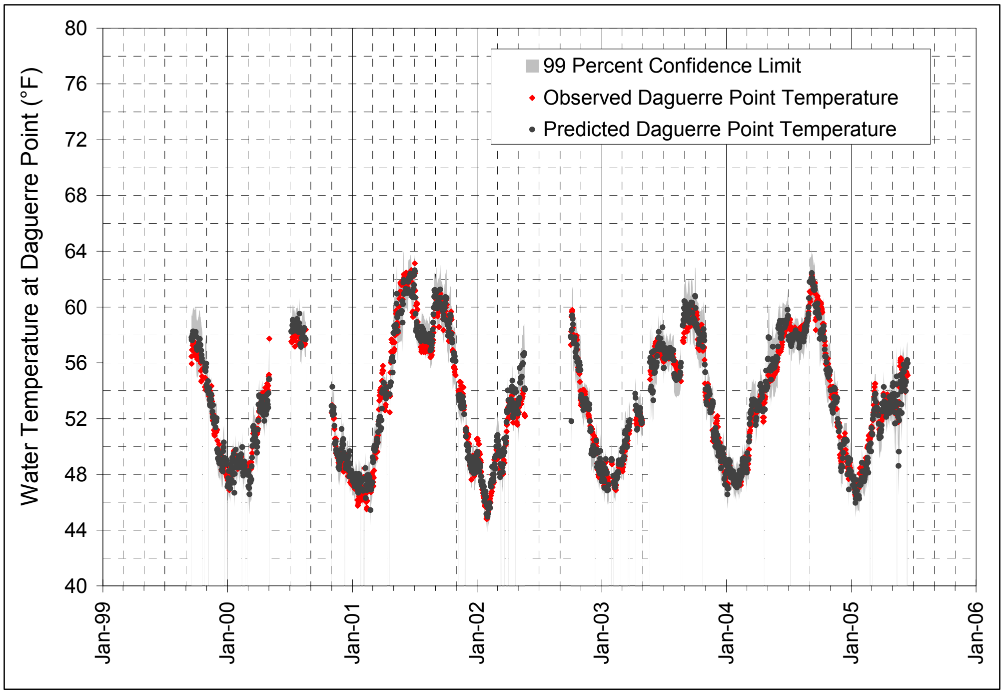

Figure B-19. Predicted and Observed Release Temperature at Daguerre Point Dam for the Period 1999 to 2005 (Calibration Results)

Note: Temperature Predictions are developed using the monthly-relations model.

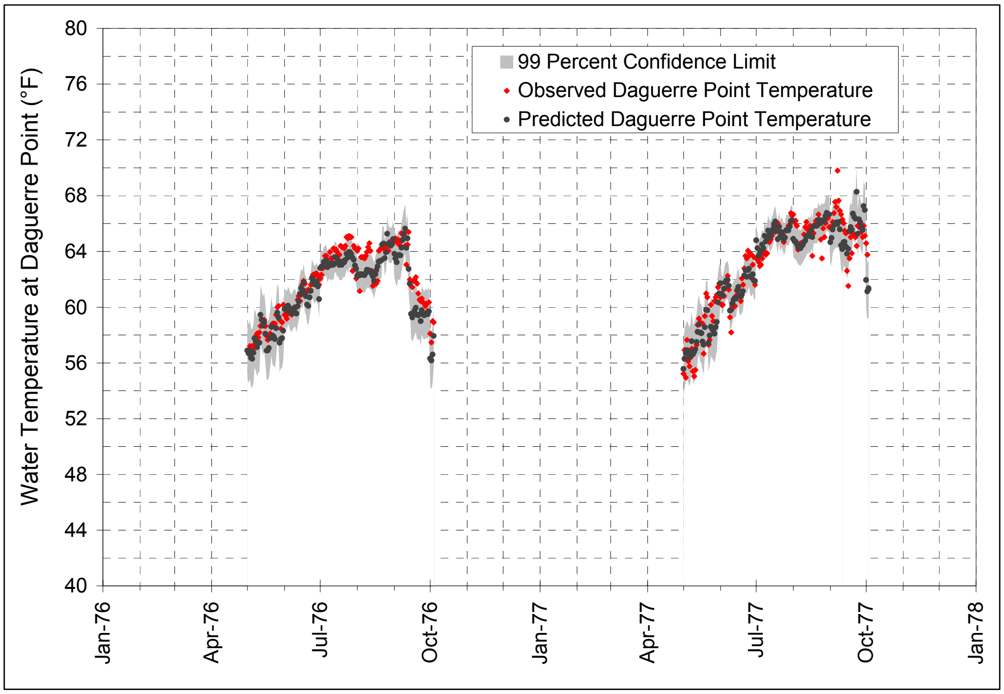

Figure B-20. Predicted and Observed Release Temperature at Daguerre Point Dam for the Period 1976 to 1977 (Calibration Results)

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.				

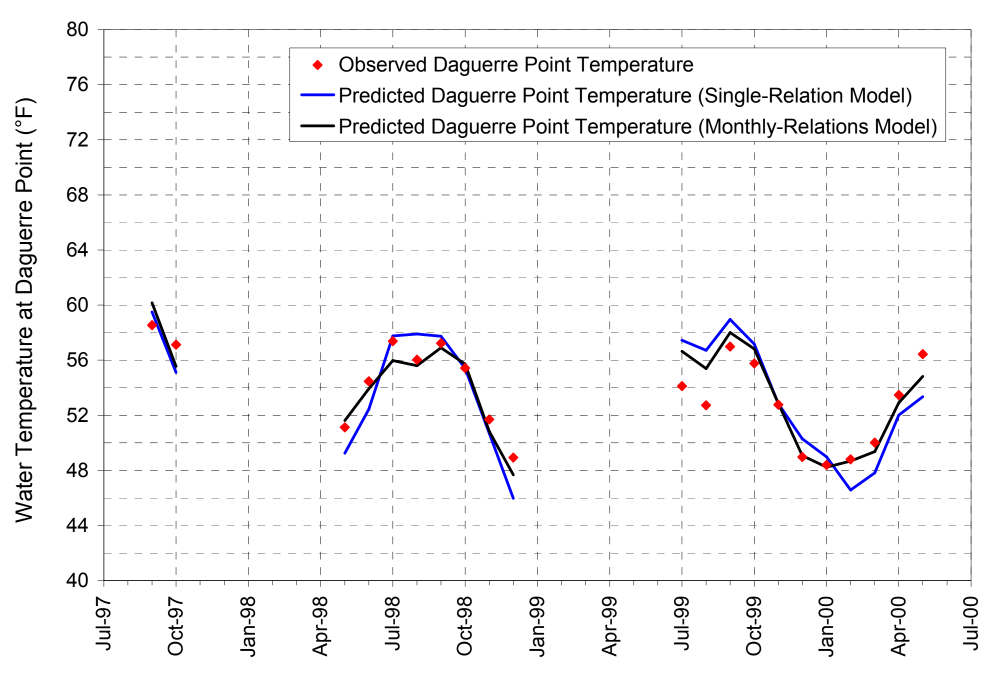

Figure B-21. Predicted and Observed Release Temperature at Daguerre Point Dam for the Period 1997 to 2000 (Validation Results)

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

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[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

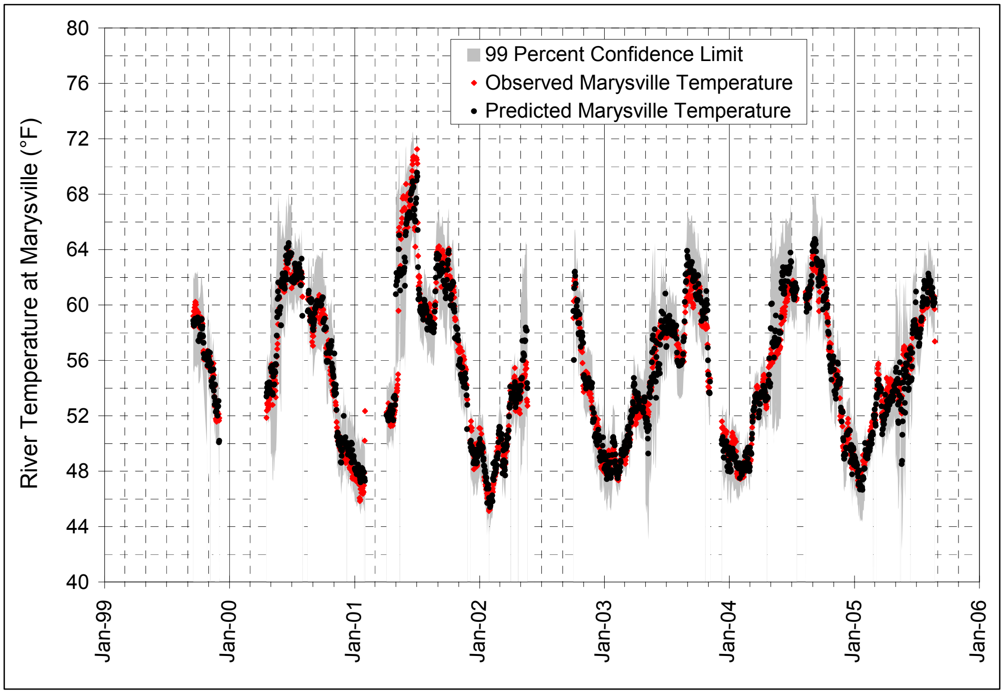

Figure B-22. Predicted and Observed Release Temperature at Marysville for the period 1999 to 2005 (Calibration Results)

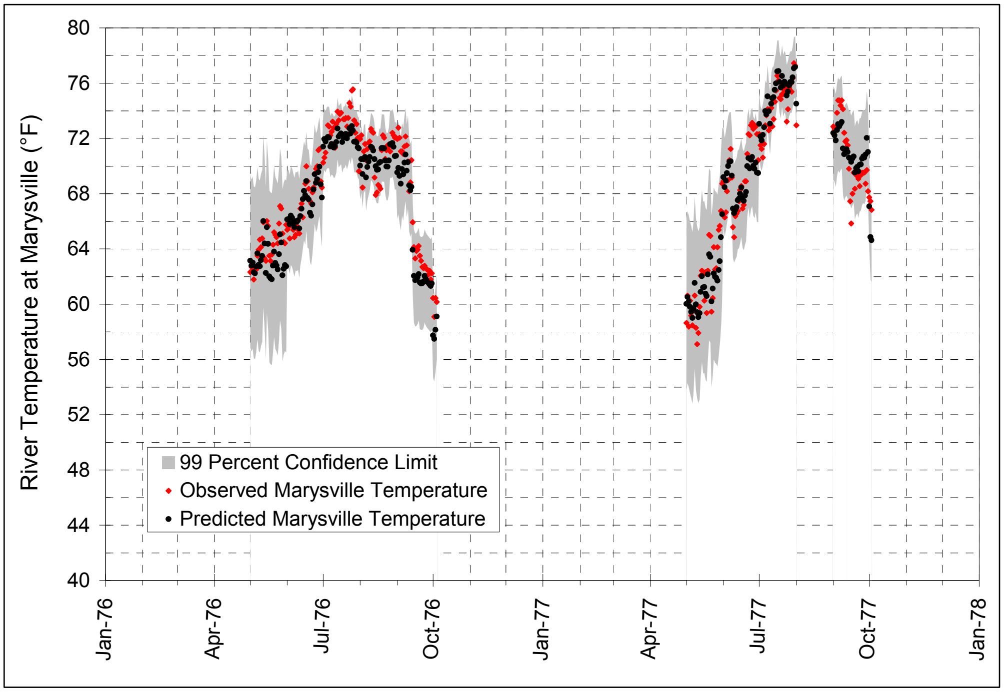

Figure B-23. Predicted and Observed Release Temperature at Marysville for the Period 1976 to 1977 (Calibration Results)

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					

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[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.

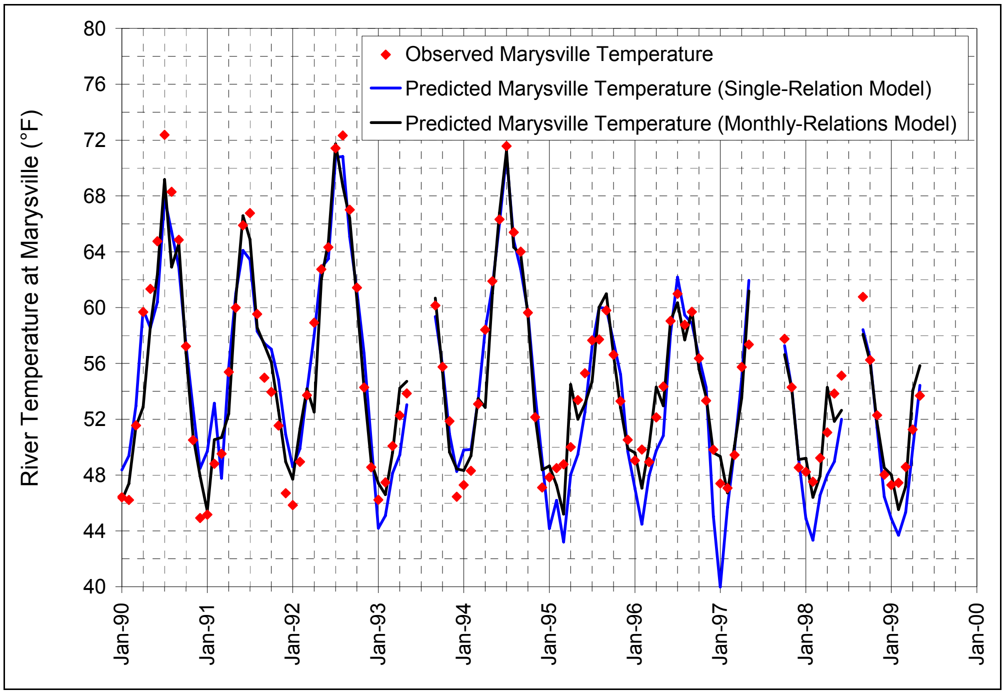

Figure B-24. Predicted and Observed Release Temperature at Marysville for the Period 1990 to 2000 (Calibration Results)

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:

$$\text{Error Margin} = \pm 2.56 * \text{STD}$$

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.

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APPENDIX G

Analytical Results Used to Support the Assessment of Potential Effects to Green Sturgeon in the Lower Yuba River

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ANALYTICAL RESULTS USED TO SUPPORT THE ASSESSMENT OF POTENTIAL EFFECTS TO GREEN STURGEON IN THE LOWER YUBA RIVER

Table G-1. Green sturgeon deepwater pool habitat availability metrics for the lower Yuba River downstream of Daguerre Point Dam.

Marysville Flow (cfs)	Minimum Depth (feet)	Maximum Depth (feet)	Mean Depth (feet)	Standard Deviation (feet)	Change in Depth Per Change in Flow (inch/100 cfs)	
					Maximum	Mean
530	10.0	23.1	12.2	2.0	n/a	n/a
600	10.0	23.2	12.2	2.0	1.1	0.1
622	10.0	23.2	12.2	2.0	0.5	0.2
700	10.0	23.2	12.2	2.0	1.3	0.3
800	10.0	23.3	12.2	2.0	1.0	0.2
880	10.0	23.4	12.3	2.0	1.1	0.3
930	10.0	23.4	12.3	2.0	1.0	0.2
1000	10.0	23.5	12.3	2.0	1.1	0.2
1300	10.0	23.8	12.3	2.0	1.1	0.3
1500	10.0	24.1	12.4	2.0	1.6	0.1
1700	10.0	24.2	12.4	2.1	1.1	0.1
2000	10.0	24.5	12.4	2.1	1.1	0.0
2500	10.0	25.0	12.4	2.2	1.1	0.0
3000	10.0	25.4	12.4	2.2	1.1	0.0
4,000	10.0	26.4	12.6	2.3	1.1	0.3
5,000	10.0	26.9	13.1	2.3	0.6	0.5
7,500	10.0	27.6	14.1	2.6	0.3	0.5
10,000	10.0	28.3	15.1	2.8	0.3	0.5
15,000	10.0	31.2	17.2	3.3	0.7	0.5
21,100	10.2	34.7	19.5	3.7	0.7	0.5
30,000	11.2	38.9	22.3	4.4	0.6	0.4
42,200	12.2	44.0	25.4	5.2	0.5	0.3

Table G-2. Long-term and water year type average pool depth in the lower Yuba River below Daguerre Point Dam under the Cumulative Condition and the Environmental Baseline.

Analysis Period	Average Pool Depth (ft)									
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Long-term										
Full Simulation Period²										
Environmental Baseline	12.8	12.8	12.6	12.7	12.5	12.1	12.1	12.1	12.2	12.2
Cumulative Condition	12.7	12.8	12.6	12.7	12.4	12.1	12.1	12.1	12.2	12.2
Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Difference³	-0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0
Water Year Types¹										
Wet										
Environmental Baseline	13.4	13.4	13.0	13.4	13.0	12.4	12.4	12.2	12.2	12.2
Cumulative Condition	13.4	13.4	13.0	13.4	12.9	12.4	12.3	12.2	12.2	12.2
Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Difference³	-0.1	0.0	0.0	-0.1	-0.2	-0.1	-0.1	-0.1	0.0	0.0
Above Normal										
Environmental Baseline	12.6	12.7	12.6	12.6	12.4	12.3	12.3	12.2	12.2	12.3
Cumulative Condition	12.5	12.7	12.5	12.5	12.4	12.3	12.3	12.2	12.2	12.3
Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Difference³	0.0	-0.1	-0.1	-0.2	-0.1	-0.1	-0.2	-0.1	0.0	0.0
Below Normal										
Environmental Baseline	12.4	12.4	12.3	12.3	12.3	12.2	12.3	12.2	12.2	12.2
Cumulative Condition	12.4	12.4	12.3	12.3	12.2	12.2	12.3	12.2	12.2	12.2
Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Difference³	-0.1	-0.1	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0
Dry										
Environmental Baseline	12.3	12.3	12.2	12.3	12.2	12.2	12.2	12.2	12.2	12.3
Cumulative Condition	12.3	12.3	12.2	12.3	12.2	12.2	12.2	12.2	12.2	12.3
Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Difference³	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Critical										
Environmental Baseline	12.3	12.3	12.1	12.3	11.8	10.9	10.9	11.4	12.2	12.2
Cumulative Condition	12.3	12.3	12.1	12.3	11.8	10.9	10.9	11.4	12.2	12.2
Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Difference³	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

1 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995)

2 Based on the WY 1922-2007 simulation period

3 Relative difference of the monthly average

Table G-3. Areal extent of green sturgeon deepwater pool habitat availability in the lower Yuba River downstream of Daguerre Point Dam.

Marysville Flow (cfs)	Wetted Pool Area (sq. ft.)	Areal Extent of Pools (% of wetted channel)
300	249,453	2.6%
350	261,441	2.6%
400	274,005	2.7%
450	284,508	2.8%
530	301,644	2.9%
600	316,044	3.0%
622	320,400	3.0%
700	335,484	3.1%
800	354,501	3.2%
880	370,296	3.3%
930	380,070	3.4%
1,000	395,181	3.5%
1,300	456,930	3.8%
1,500	499,626	4.0%
1,700	548,487	4.3%
2,000	634,266	4.8%
2,500	804,861	5.8%
3,000	1,000,071	6.8%
4,000	1,400,292	8.8%
5,000	1,579,815	10.3%
7,500	1,859,247	15.1%
10,000	1,920,357	18.7%
15,000	1,936,989	24.7%
21,100	1,938,600	29.5%
30,000	1,938,465	36.7%
42,200	1,938,600	44.8%

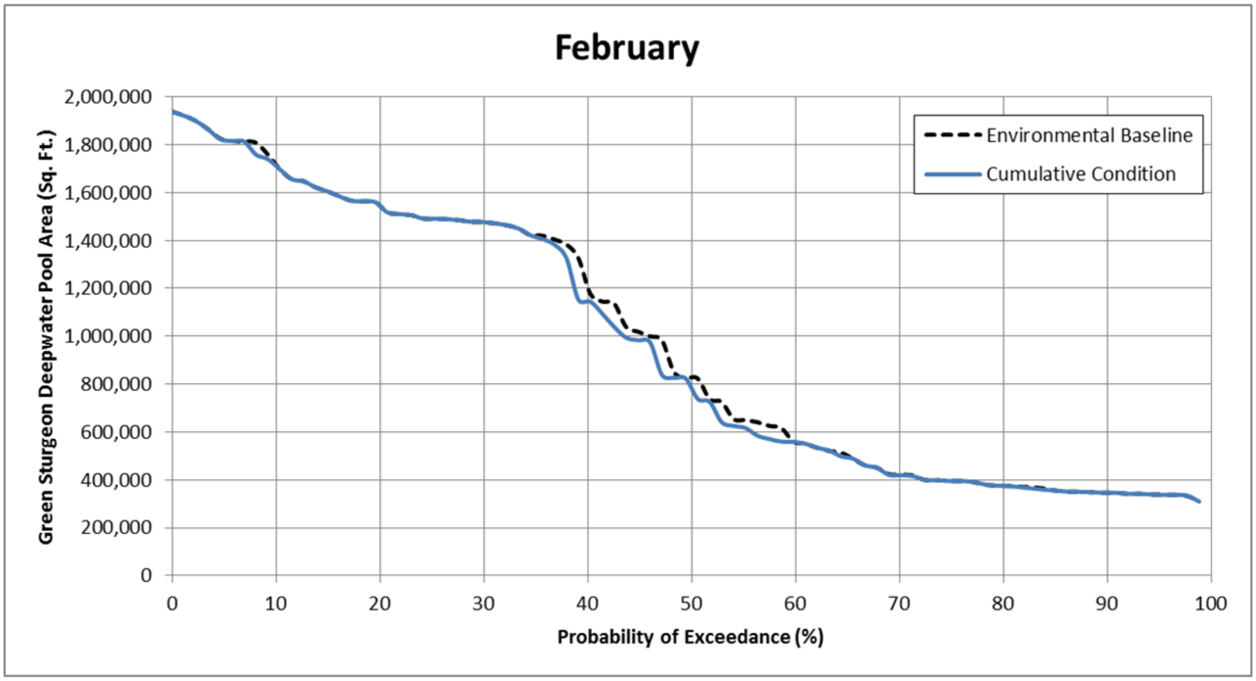

Figure G-1. Simulated adult green sturgeon deepwater holding habitat exceedance during February for 1922 through 2008.

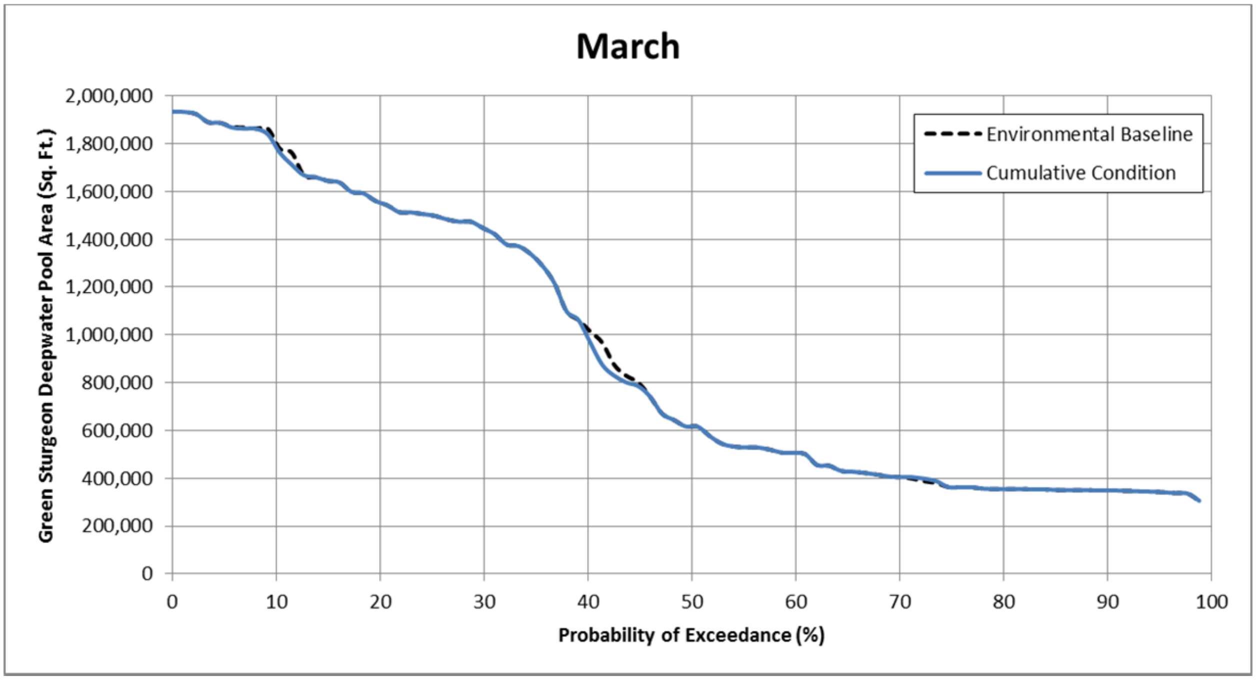

Figure G-2. Simulated adult green sturgeon deepwater holding habitat exceedance during March for 1922 through 2008.

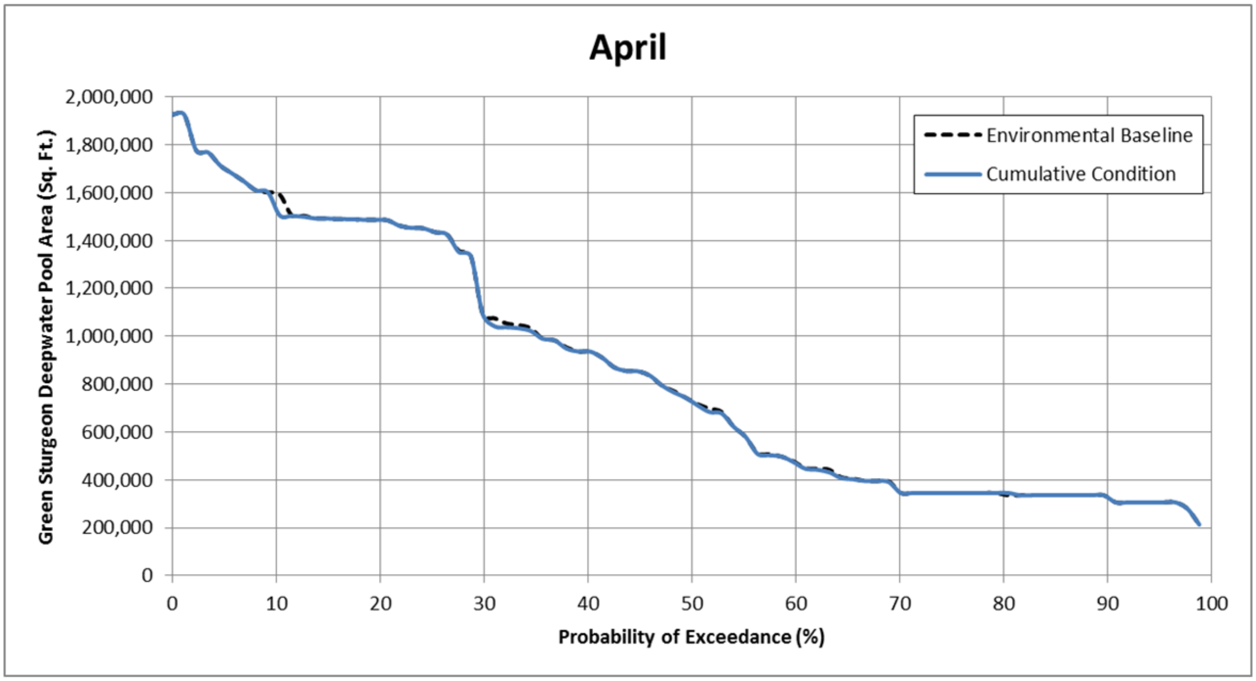

Figure G-3. Simulated adult green sturgeon deepwater holding habitat exceedance during April for 1922 through 2008.

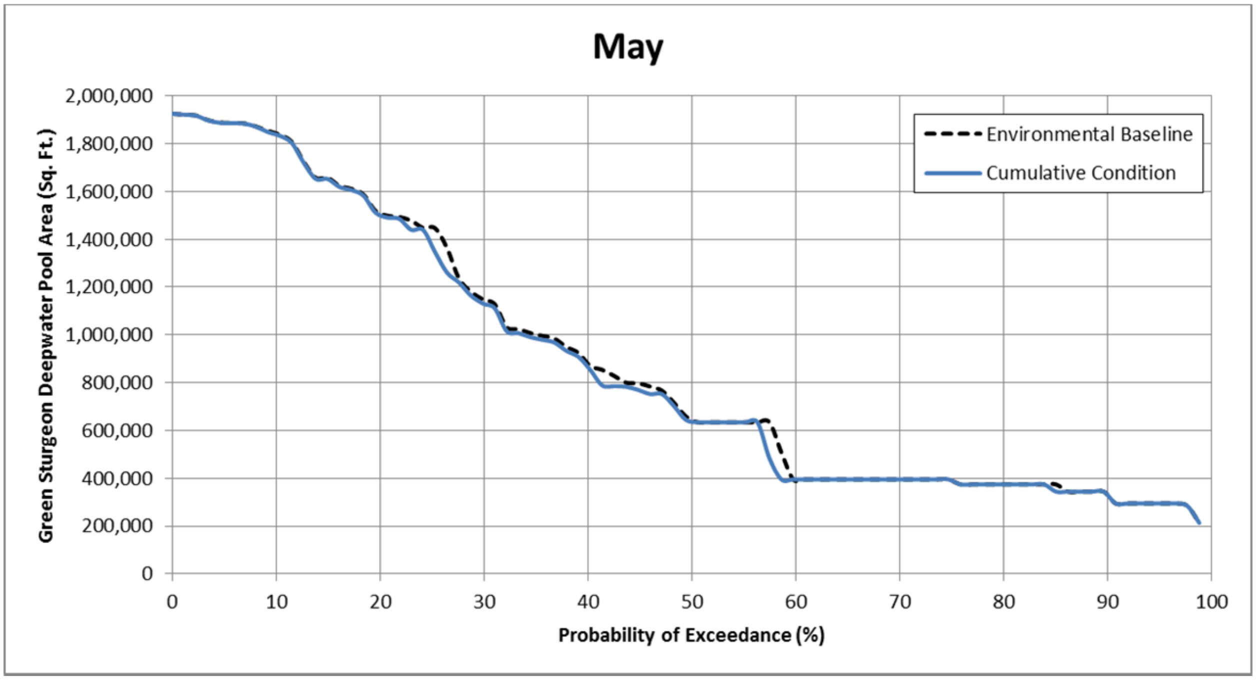

Figure G-4. Simulated adult green sturgeon deepwater holding habitat exceedance during May for 1922 through 2008.

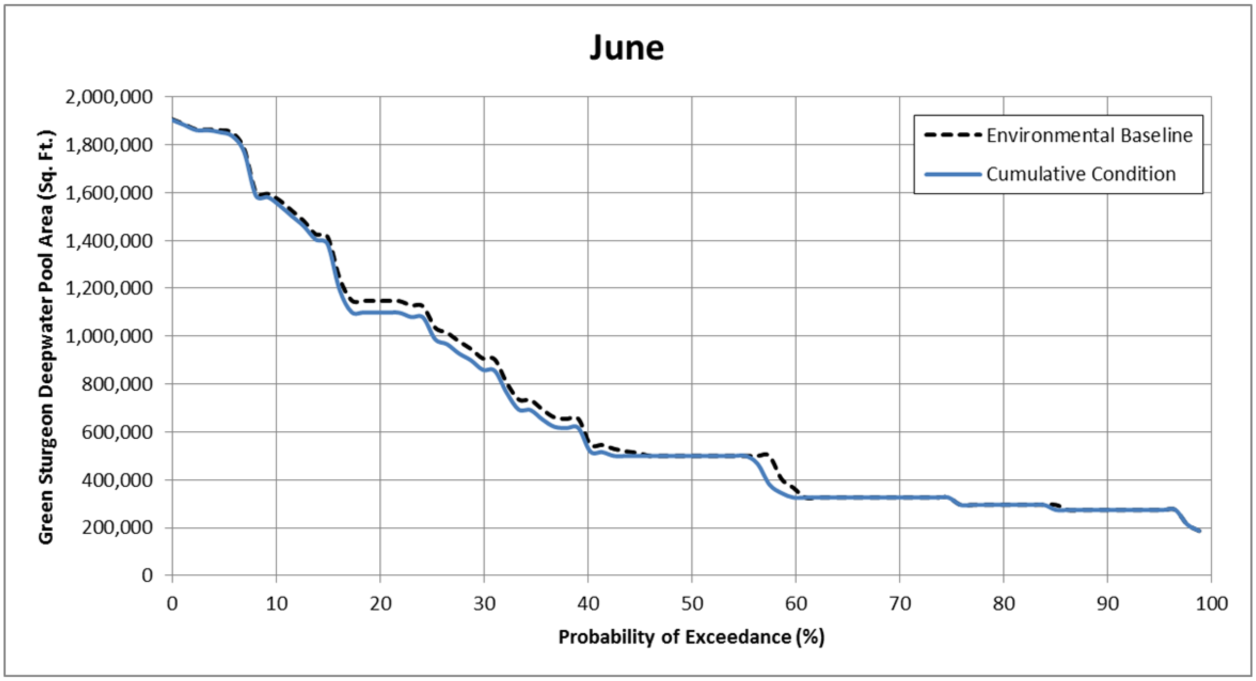

Figure G-5. Simulated adult green sturgeon deepwater holding habitat exceedance during June for 1922 through 2008.

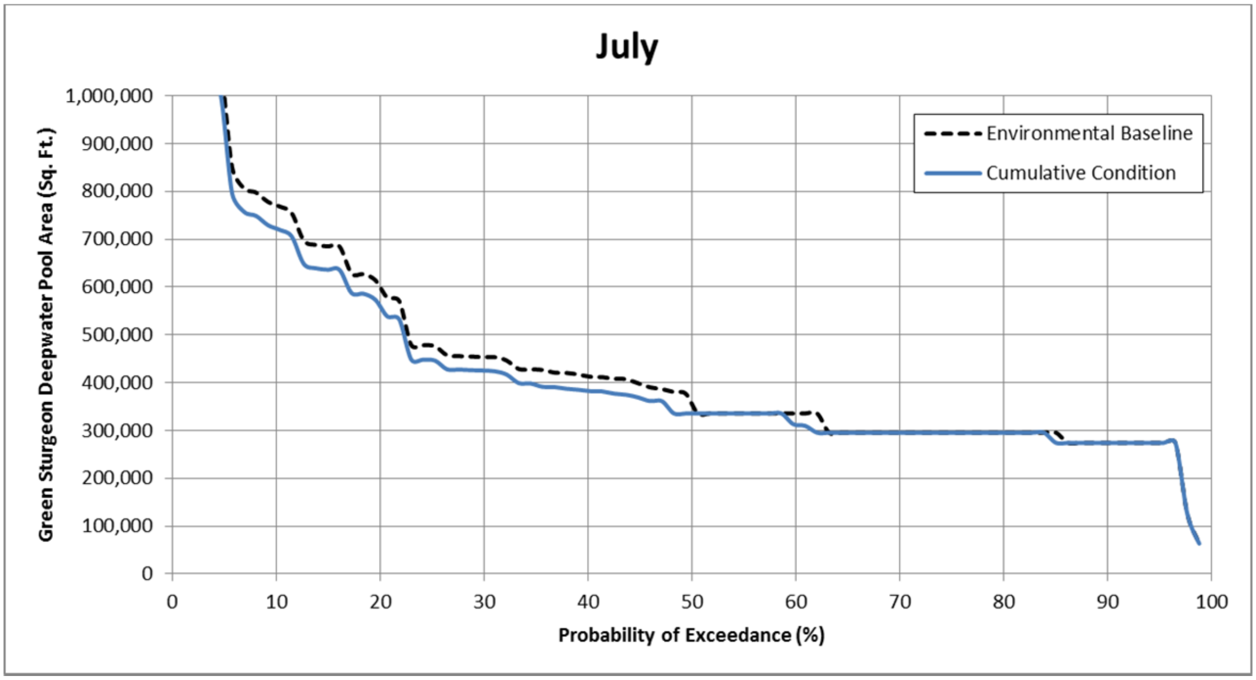

Figure G-6. Simulated adult green sturgeon deepwater holding habitat exceedance during July for 1922 through 2008.

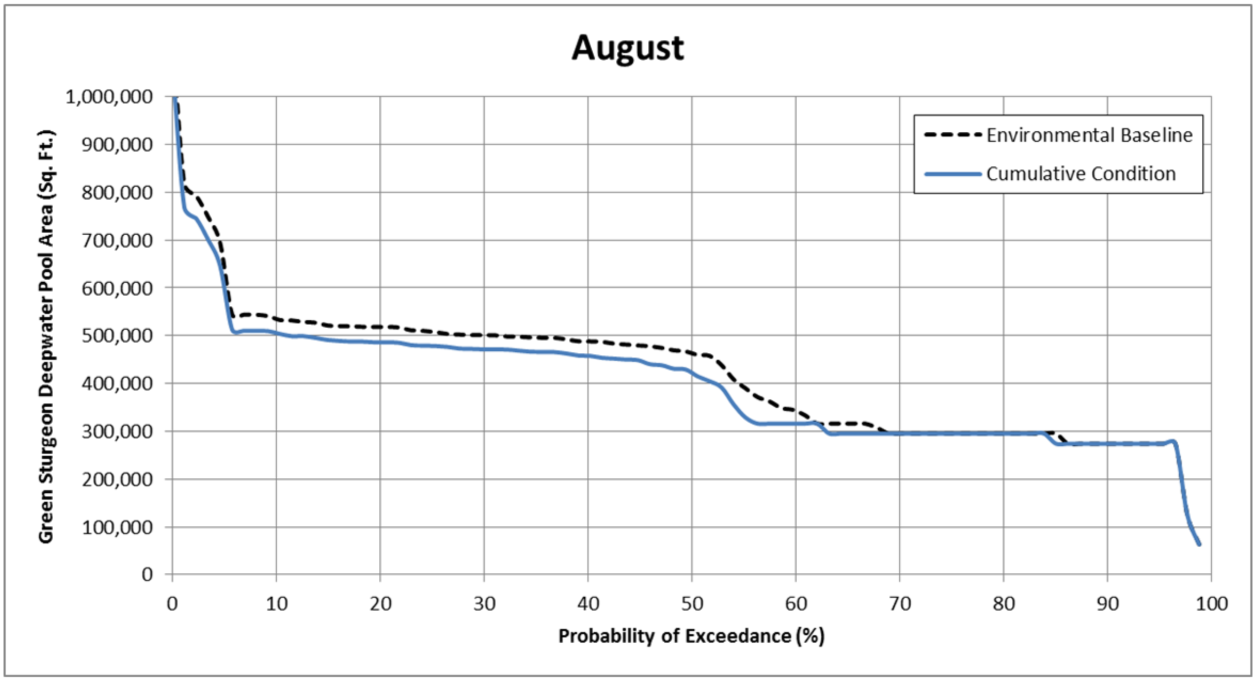

Figure G-7. Simulated adult green sturgeon deepwater holding habitat exceedance during August for 1922 through 2008.

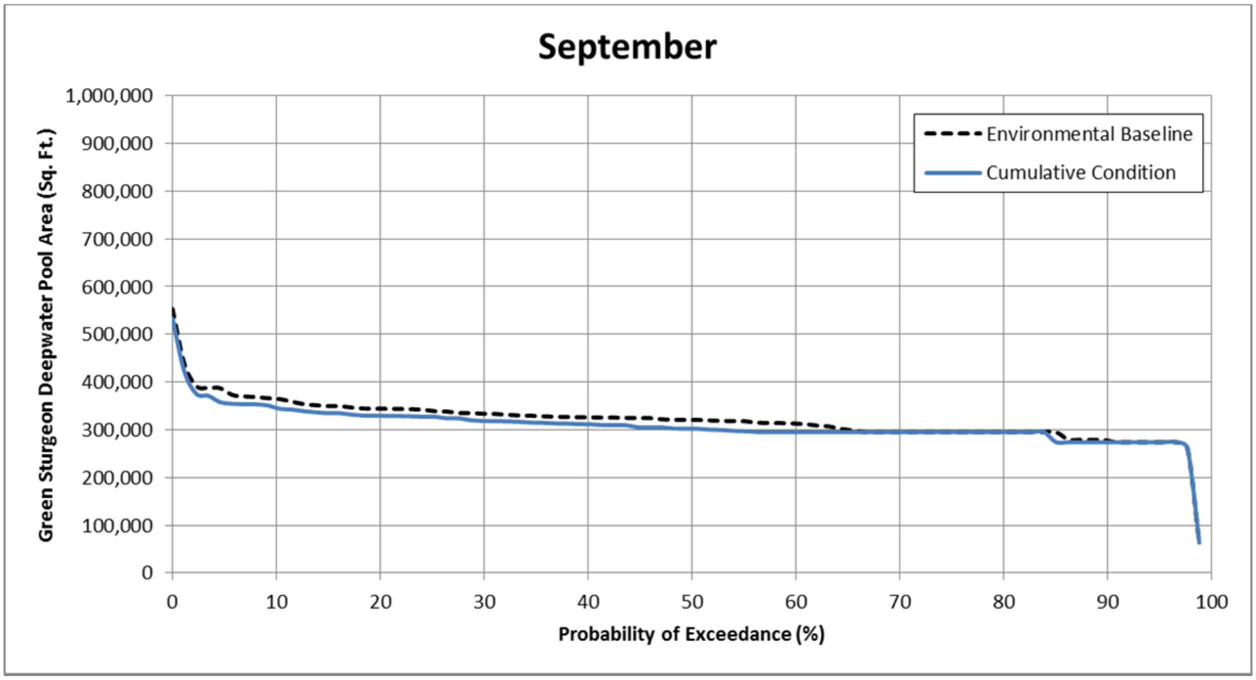

Figure G-8. Simulated adult green sturgeon deepwater holding habitat exceedance during September for 1922 through 2008.

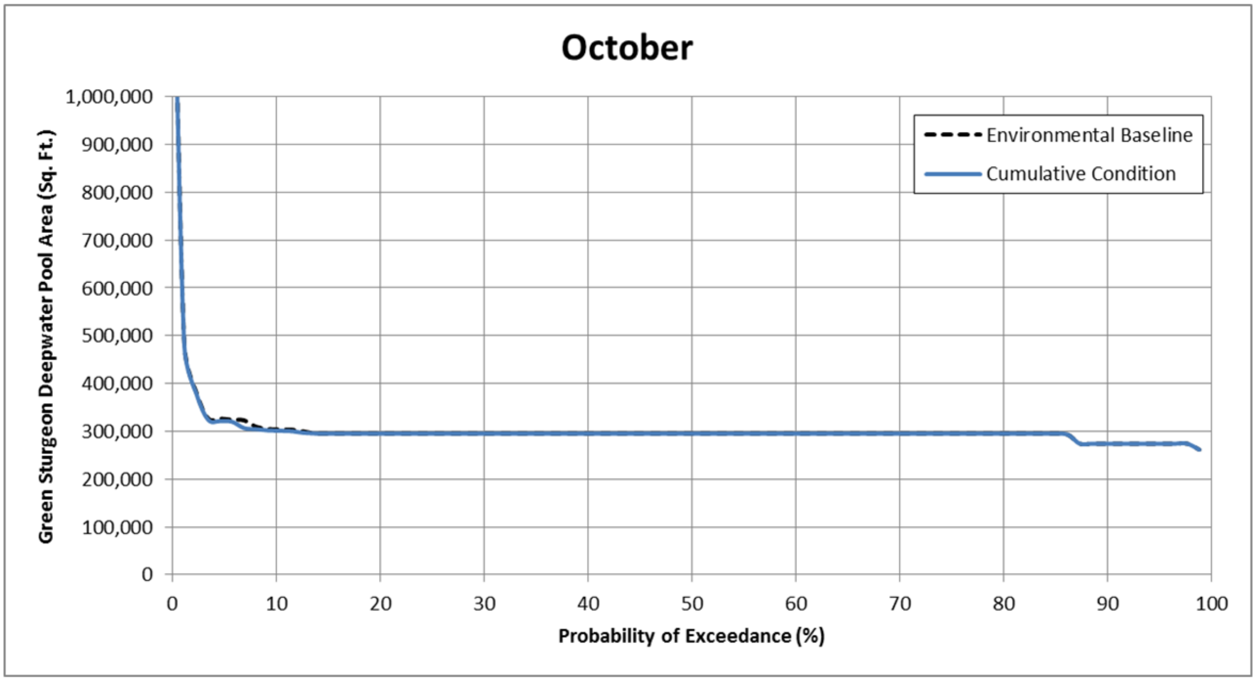

Figure G-9. Simulated adult green sturgeon deepwater holding habitat exceedance during October for 1922 through 2008.

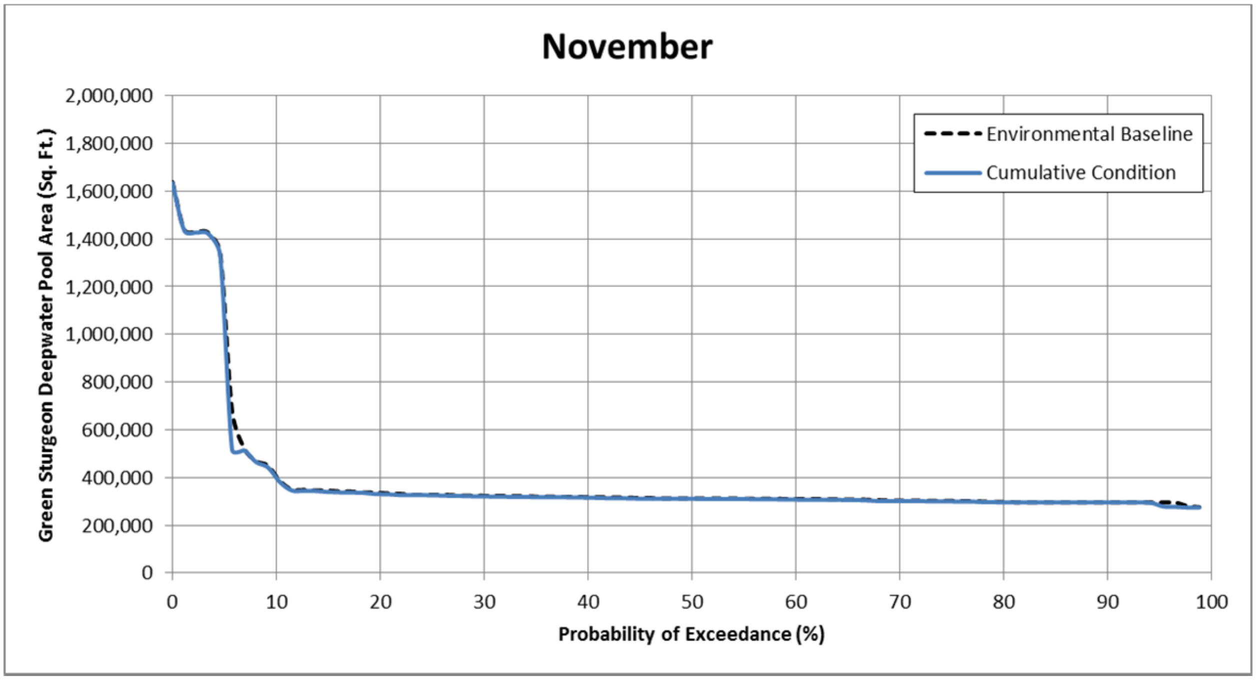

Figure G-10. Simulated adult green sturgeon deepwater holding habitat exceedance during November for 1922 through 2008.