UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

Refer to NMFS No: WCR-2018-10001

October 16, 2018

Mark Ziminske
Chief, Environmental Resources Branch
Sacramento District
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Brad Hubbard
Resources Management Division Chief
Central California Area Office
U.S. Bureau of Reclamation
7794 Folsom Dam Road
Folsom, California 95630

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response and Fish and Wildlife Coordination Act Recommendations for the Water Control Manual for Folsom Dam and Lake

Dear Mr. Ziminske and Mr. Hubbard:

Thank you for your letter of May 30, 2018, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the Water Control Manual for Folsom Dam and Lake.

Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 U.S.C. 1855(b)) for this action.

NMFS also reviewed the proposed action pursuant to the Fish and Wildlife Coordination Act for the proposed action.

This biological opinion is based on the best available scientific and commercial information, NMFS concludes in the enclosed biological opinion that the proposed action is not likely to adversely affect Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, the southern distinct population segment of North American green sturgeon, or their designated critical habitats, and not likely to jeopardize the continued existence of California Central Valley steelhead and not likely to destroy or adversely modify their designated critical habitat. However, NMFS anticipates that incidental take will occur in the form of death, injury, or changes to habitat associated with the proposed action. An incidental take statement with non-discretionary terms and conditions is included. This includes incorporating language into the updated Folsom Water Control Manual to consider measures to minimize impacts to spawning and incubating California Central Valley steelhead in the lower American River, to the extent possible without interfering with measures necessary to protect lives and property. The incidental take statement also includes measures for coordination to identify risks due to flood management operations to California Central Valley steelhead in the lower American River.

Please contact Gary Sprague, at our California Central Valley Office at (916) 930-3615 or via email at Gary.Sprague@NOAA.gov if you have any questions concerning this consultation, or if you require additional information.

for Maria Chen
Barry A. Thom
Regional Administrator

Enclosure

cc: To the file 151422-WCR2018-SA00431

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Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response and Fish and Wildlife Coordination Act Recommendations

Folsom Dam and Lake Water Control Manual

NMFS Consultation Number: 2018-10001

Action Agencies: United States Army Corps of Engineers, and
United States Bureau of Reclamation

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*)	Endangered	No	No	No	No
Central Valley spring-run Chinook salmon (*O. tshawytscha*)	Threatened	No	No	No	No
California Central Valley steelhead (*O. mykiss*)	Threatened	Yes	No	Yes	No
Southern distinct population segment of North American green sturgeon (*Acipenser medirostris*)	Threatened	No	No	No	No

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	Yes

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By: Maria C Rea for
Barry A. Thom
Regional Administrator

Date: **October 16, 2018**

TABLE OF CONTENTS

1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below.

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600.

Because the proposed action would modify a stream or other body of water, NMFS also provides recommendations and comments for the purpose of conserving fish and wildlife resources, and enabling the Federal agency to give equal consideration with other project purposes, as required under the Fish and Wildlife Coordination Act (FWCA, 16 U.S.C. 661 et seq.).

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Public Consultation Tracking System https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts. A complete record of this consultation is on file at the NMFS California Central Valley Office in Sacramento, California.

1.2 Consultation History

On June 29, 2011, NMFS met with the U.S. Army Corps of Engineers (Corps) and the U.S. Fish and Wildlife Service (USFWS) to discuss Folsom Dam Permanent Operations Study. The Corps and the U.S. Bureau of Reclamation (Reclamation) agreed to be joint action agencies for the project.

September 25, 2013, NMFS received an update from Corps on modeling methodology.

August 12, 2014, the Corps met with NMFS to provide an update on the status of Folsom Dam and Lake Water Control Manual (Folsom WCM). The existing Folsom WCM included operations at the "old" spillway. The update is to include operations at the new spillway.

November 18, 2014, the Corps convened a public workshop regarding the status of the update to the Folsom WCM.

November 19, 2014, NMFS provided comments to the Corps regarding the schedule for biological assessment, ESA consultation and the draft environmental impact statement.

July 23, 2015, NMFS met with the Corps regarding the status of the Folsom WCM update.

August 31, 2015, NMFS met with the Corps and USFWS regarding the status of the update for the Folsom WCM.

October 15, 2015, NMFS met with the Corps regarding preliminary model output.

May 18, 2016, NMFS met with the Corps regarding the Folsom WCM update.

January 5, 2017, NMFS met with the Corps and USFWS regarding preliminary model output.

January 19, 2018, the Corps requested consultation for the implementation of the Folsom WCM for the remainder of water year 2018 (through September 30, 2018).

February 13, 2018, NMFS sent to the Corps a letter concurring with the Corps' determination that the use of the Folsom WCM for the remainder of water year 2018 was not likely to adversely affect California Central Valley (CCV) steelhead, or their designated critical habitat.

March 20, 2018, NMFS received a letter and biological assessment from the Corps, requesting consultation on the long-term implementation of the updated Folsom WCM. Included with the request were a hard copy of the biological assessment, and a copy on a disk. The biological assessment identified the Corps as the lead agency for the proposed action, on behalf of the U.S. Bureau of Reclamation (Reclamation). The request for consultation identified that the proposed action may potentially adversely affect CCV steelhead (*Oncorhynchus mykiss*) and their designated critical habitat.

The request for consultation identified that the proposed action may affect but is not likely to adversely affect:

- Sacramento River (SR) winter-run Chinook salmon (*O. tshawytscha*) and their designated critical habitat,

- Central Valley (CV) spring-run Chinook salmon (*O. tshawytscha*) and their designated critical habitat,

- The southern distinct population segment (sDPS) of North American green sturgeon (*Acipenser medirostris*) and their designated critical habitat.

The request also included a request for consultation under the MSA.

March 26, 2018, NMFS sent an email to the Corps requesting additional information needed in order to initiate consultation.

April 3, 2018, the Corps provided a summary table of modeled releases that exceeded 30,000 cubic feet per second (cfs), and presented an offer from Sacramento Area Flood Control Agency (SAFCA) to provide sediment transport analysis.

April 9, 2018, NMFS sent an email stating that if complete information is not received within 45 days from March 26th, NMFS would close the consultation.

April 9, 2018, the Corps provided plots for the 82 years of modeled flows.

May 11, 2018, NMFS sent a letter to the Corps closing the consultation, due to insufficient information to initiate formal consultation.

The Corps requested consultation on May 30, 2018. The request was received by NMFS on June 4, 2018, and NMFS determined that the initiation package was complete and initiated consultation.

July 24, 2018, NMFS met with the Corps and SAFCA to obtain clarification regarding the American River gravel scour analysis.

September 5, 2018, the Corps concurred with NMFS' suggested language for inclusion in the updated Folsom WCM, in Section 7-01:

> "When conditions warrant, consideration will be given to protection of incubating steelhead eggs and alevins. When possible, releases above 30,000 cfs will be minimized to protect incubating steelhead eggs and alevins, and to reduce spawning gravel movement."

September 12, 2018, the Corps provide a letter updating the project description for the Folsom WCM update. The updates included:

1. SAFCA's annual supplementation of $20,000 for 15 years to augment the existing gravel augmentation program by approximately 300 short tons of spawning gravel.

2. SAFCA will establish or contribute (approximately $10,000/year for 15 years) to a monitoring program to evaluate movement of spawning gravel in the upper reach of the lower American River.

3. The Corps including language in the updated Folsom WCM to indicate releases between 30,000 cfs and 80,000 cfs should be minimized in order to reduce erosion of spawning gravel, when conditions warrant.

4. Folsom Dam operators (Corps and Reclamation) and SAFCA will hold an annual coordination meeting with representatives from NMFS, the USFWS, and the California Department of Fish and Wildlife at the start of the flood season to discuss the previous year's flows and their effects on spawning gravel movement as well as forecasted flows for the coming season.

1.3 Proposed Federal Action

"Action" for the purposes of the ESA means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02).

For purposes of EFH consultation under the MSA, a Federal action means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal agency (50 CFR 600.910).

Under the FWCA, except for circumstances that are not applicable under the proposed action, consultation is required "whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatever, including navigation and drainage, by any department or agency of the United States, or by any public or private agency under Federal permit or license" (16 U.S.C. 662(a)).

The purpose of the proposed action is to reduce flood risk in the Sacramento Metropolitan Area and improve dam safety at Folsom Dam. Folsom Dam is owned and operated by Reclamation. The Corps prescribes flood control operations through the Folsom WCM under Flood Control Regulations (33 CFR 208.11). Any deviations in operations from the Folsom WCM made by Reclamation must be approved by the Corps. The updated Folsom WCM incorporates operation of the new spillway into flood control operations, as well as river flow forecasts, and weather forecasts.

The proposed action would implement new flood risk management and dam safety operation rules into an updated Folsom WCM, which replaces the old Folsom WCM. The objectives of the updated Folsom WCM are:

1) Pass the probable maximum flood, while maintaining at least 3 feet of freeboard below the top of the dam.

2) Control a 1/100 year flood event to a release of 115,000 cfs (to support Federal Emergency Management Agency levee accreditation).

3) Control a 1/200 year flood event to a release of 160,000 cfs.

4) Reduce the variable space allocation from the baseline operating range of 400,000 to 670,000 acre feet (acft), to a range of 400,000 to 600,000 acft.

5) Incorporate improved forecasting capabilities from the National Weather Service.

The proposed action also includes:

6) SAFCA's annual supplementation of $20,000 for 15 years to augment the existing gravel augmentation program by approximately 300 short tons of spawning gravel.

7) SAFCA will establish or contribute (approximately $10,000/year for 15 years) to a monitoring program to evaluate movement of spawning gravel in the upper reach of the lower American River. The Corps including language in the updated Folsom WCM to state: "When conditions warrant, consideration will be given to protection of incubating steelhead eggs and alevins. When possible, releases above 30,000 cfs will be minimized to protect incubating steelhead eggs and alevins, and to reduce spawning gravel movement."

8) Folsom Dam operators (Corps and Reclamation) and SAFCA will hold an annual coordination meeting with representatives from NMFS, the USFWS, and the California Department of Fish and Wildlife at the start of the flood season to discuss the previous year's flows and their effects on spawning gravel movement as well as forecasted flows for the coming season.

The proposed action includes the utilization of the new spillway, which can release water from a lower elevation than the original spillway. The proposed action changes the amount of the flood reservation pool and does not incorporate upstream storage space. The proposed action also incorporates information from NOAA's National Weather Service's California-Nevada River Forecast Center regarding forecasted river flows. This includes forecasts of the conservation pool elevation. This allows forecasts of encroachment into the flood pool. Together this provides the information for computing water releases from Folsom Dam. This will allow drawdown of the reservoir in advance of major precipitation.

In addition to reducing peak flows in the lower American River, the updated Folsom WCM is expected to improve the ability of the reservoir to refill. This would provide more reliable water supply for agriculture, municipal water supply and for environmental flows downstream from Folsom Dam. The updated Folsom WCM is designed to address the variability in forecasts and inflow, to minimize effects to dam operations and downstream resources. Figure 1 shows the baseline and proposed water control diagrams.

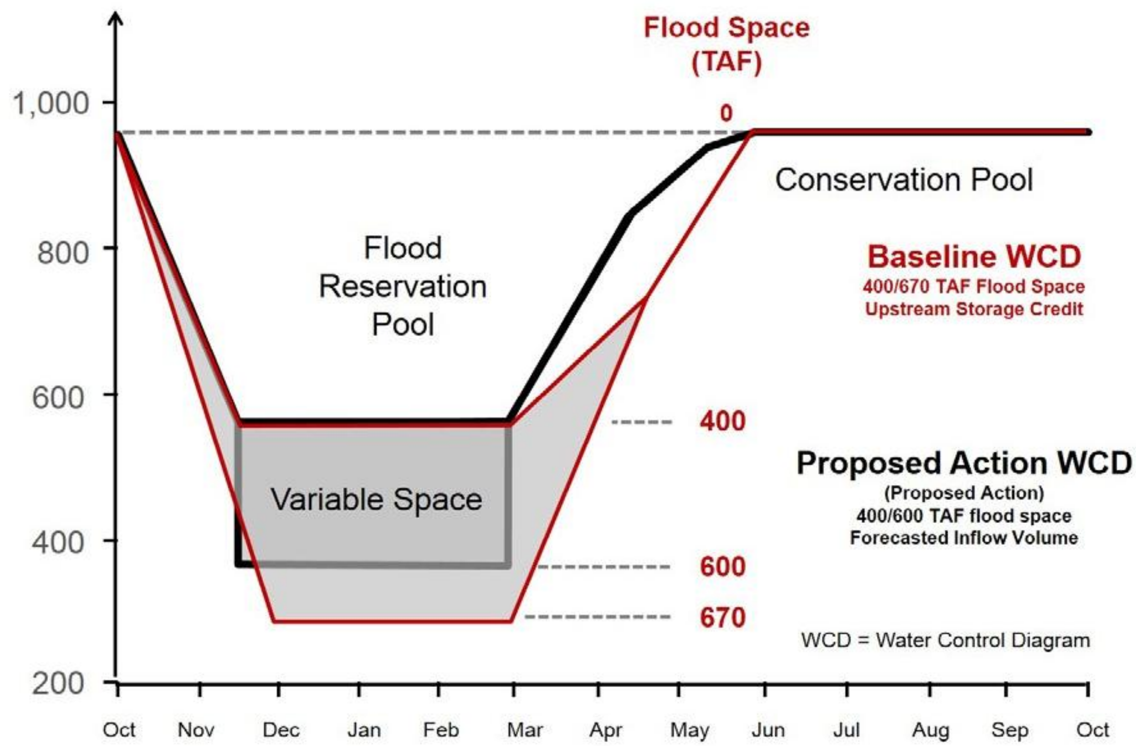

Figure 1. Baseline Condition Water Control Diagram and Proposed Action Water Control Diagram. Source: Corps (2018).

Conservation Measures

The proposed action includes the following measures to minimize potential impacts to fish and habitat.

Down ramping rates incorporated into the updated Folsom WCM in a release range of 8,000 cfs to 160,000 cfs, flows will not decrease by more than 10,000 cfs over any 2-hour period.

Minimum flows of the lower American River Flow Management Standard are incorporated into the updated Folsom WCM.

The Corps has included supplementation of the existing lower American River gravel augmentation program with $20,000/year for 15 years to compensate for the approximate loss of 300 short tons/year of spawning gravel resulting from the frequency of mid-range flows (30,000 cfs to 80,000 cfs) anticipated following implementation of the updated Folsom WCM.

SAFCA will establish or contribute (approximately $10,000/year for 15 years) to a monitoring program to evaluate the movement of spawning gravel in the upper reach of the American River (downstream of Nimbus Dam).

The Corps will include language in the updated Folsom WCM that identifies that releases between 30,000 cfs and 80,000 cfs should be minimized in order to reduce erosion of spawning gravels.

The Corps and Reclamation and SAFCA will hold an annual coordination meeting with NMFS, USFWS, and CDFW to discuss the previous year's flows and their effect on spawning gravel movement, and forecasted flows for the coming season.

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02).

Central Valley Project / State Water Project (CVP/SWP) operations occur at Folsom Dam and other Central Valley facilities. Because CVP/SWP operations and the proposed action can influence one another, NMFS carefully considered whether CVP/SWP operations are interrelated or interdependent actions with the proposed action. While the CVP/SWP operations may affect and be affected by flood control water operations associated with the implementation of the proposed action, CVP/SWP operations are not part of the proposed action, nor are CVP/SWP operations dependent on the proposed action for their justification. Furthermore, CVP/SWP operations have independent utility apart from the proposed action. Finally, CVP/SWP operations would occur but for the proposed action. Therefore, no interrelated or interdependent actions were identified.

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides a biological opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

The Corps and Reclamation determined the proposed action is not likely to adversely affect the following species or their designated critical habitats:

- SR winter-run Chinook salmon,
- CV spring-run Chinook salmon, and
- sDPS of North American green sturgeon.

Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations Section 2.12.

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that would 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 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This biological opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214, February 11, 2016).

The designations of critical habitat for species addressed in this biological opinion use the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414, February 11, 2016) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a reasonable and prudent alternative (RPA) to the proposed action.

2.1.1 Description of Models used for Effects Analysis

To analyze the effects of the proposed action, we used modeling for the existing Folsom Dam WCM to identify the conditions without the proposed action, and results from modeling of the proposed action. This was done for flows and water temperatures in the Sacramento River, Feather River, American River, and the Sacramento-San Joaquin Delta. In the American River, modeling was used to analyze the change in the magnitude of peak flow events to evaluate the scour of CCV steelhead redds and spawning gravel.

Modeling of water temperatures and flows in the biological assessment (Corps 2018) for the updated Folsom Dam WCM provided estimates of flows and temperatures for the baseline conditions with the future level of demand (J604 FLD) and for the conditions expected with the implementation of the updated Folsom Dam WCM with the future level of demand (J602F3 FLD). The physical models applied in the biological assessment and relied upon for this biological opinion are generalized and simplified representations of a complex water resources system. The models are not predictive models of actual operations and, therefore, the results cannot be considered as absolute and within a quantifiable confidence interval. For instance, CalSim II is a monthly planning model; it is not calibrated and cannot be used in a real-time predictive manner. CalSim II results are intended to be used in a comparative manner, which allows for assessing the changes in the CVP and SWP system operations and resulting incremental effects between two scenarios. This and any subsequent models that use CalSim II results require caution when used to characterize absolute conditions or conditions on a sub-monthly time step.

The modeling assumptions included implementation of the 2004 Folsom Dam water control diagram for the baseline conditions. This included a maximum rate of increase in flows of not more than 15,000 cfs every two hours, and a maximum rate of flow decrease of no more than 10,000 cfs every 2 hours. The baseline conditions reflect the measures being implemented by Reclamation and the California Department of Water Resources (CDWR) to meet the requirements of the biological opinion for the Long-Term Operations of the CVP/SWP (NMFS 2009). This includes balancing storages and releases from each of the CVP/SWP reservoirs. Coordination of reservoir releases is done to address water quality considerations (temperatures, salinity), minimum flow requirements, control flooding, and water deliveries. All analysis in the biological assessment (Corps 2018) assumed future level demand for both the proposed action and baseline conditions. In addition to the CalSim II model, the Reclamation Temperature Model, Flow-Habitat Relationships (PHABSIM), and the Reclamation Salmon Mortality Model were used for modeling the baseline conditions and future conditions with the updated Folsom WCM. These models should be viewed as having inherent uncertainty, due to the theoretical limitations of the models. Nonetheless, these models represent the best available information to evaluate the effects of the changes in operations due to the proposed action.

The change in flows between the baseline condition and the proposed action is an important factor in analyzing the effects of the project on anadromous fish listed under the ESA because changes in flow can change the amount of habitat available to rearing and migrating anadromous fish. Decreases in flow may also increase travel time for juvenile fish migrating downstream, and result in decreased survival.

Water temperature in Central Valley streams may be the most important environmental parameter influencing the status of anadromous fish (McCullough et al. 2001, Myrick and Cech 2001). Coldwater species such as Chinook salmon and CCV steelhead that are near the southernmost edge of their geographic distributional range (i.e., the California Central Valley) may be particularly constrained by elevated water temperatures, especially during the summer when instream conditions tend to exhibit increased warming due to ambient solar radiation. Water temperature is perhaps the physical factor with the greatest influence on CCV steelhead in the lower American River (NMFS 2009). Exposure to high water temperatures can result in negative effects on salmonids' biological functions, feeding activity, lifestage timing, growth, reproduction, competitive interactions, susceptibility to disease, growth and development, and ultimately probability of survival (McCullough 1999).

Monthly exceedance distributions of simulated water temperature from monthly water temperature model output (Sacramento River, Feather River, and Delta) and from daily water temperature model output (lower American River) were developed by the Corps for the entire simulation period. These distributions illustrate simulated water temperatures with the proposed action and the baseline condition. In general, water temperature exceedance distributions represent the probability, as a percentage of time, that modeled water temperature values would meet or exceed a specific temperature criteria, at a specific location during a certain time period. Monthly water temperatures and daily water temperatures were applied to CCV steelhead and lifestage-specific water temperature index values.

Impact indicators and evaluation guidelines have been developed as a means to assess the operations- related effects of the proposed action on aquatic resources. For the fisheries and aquatic habitat impact assessment, water temperature impact indicator values were used to evaluate whether the action would affect a species' habitat. Changes in water temperatures during certain periods of the year could affect all lifestages of fish species. Therefore, changes in water temperatures during the adult upstream migration and holding, spawning and embryo incubation, juvenile rearing, and outmigration lifestages of anadromous species were used by the Corps as impact indicators. Water temperature evaluation guidelines have been developed more extensively for Chinook salmon and steelhead than for other species because Chinook salmon and steelhead are native to the Pacific Coast and historically have been socially, recreationally, commercially, and economically important to the region (Bratovich et al. 2012, Yuba County Water Agency et al. 2007).

For the analysis (Corps 2018), water temperature index (WTI) values were used to analyze the baseline condition, and the condition under the proposed action. This information is presented in the following tables. Lifestage-specific WTI values were based on long-term (≥ 7 days) chronic temperature exposure rather than acute (< 7 days) temperature exposure. The boundary between the upper end of the chronic exposure range and the lower end of the acute exposure range is typically measured as the upper incipient lethal temperature (UILT) where 50-percent mortality occurs after 7 days (Elliott 1981).

In the Delta, in addition to temperature and flows, salinity is an important factor. This is represented by the X2 parameter. The term X2 is used to define the distance from the Golden Gate Bridge upstream to the location where salinity near the bottom of the water column is about 2 ppt. X2 reflects the physical response of the San Francisco Estuary to changes in flow and provides a geographic frame of reference for estuarine conditions (Kimmerer 2002b). Because the position of X2 relies on a number of physical parameters, including river flows, water diversions, and tides, its position shifts over many kilometers on a daily and seasonal cycle. Over the course of a year, the location of X2 can range from San Pablo Bay during high-river-flow periods up into the Delta during the summer.

According to the California Department of Fish and Game (CDFG (now CDFW) 2010), the available data and information indicate:

1. The abundances of many fish and aquatic species are related to water flow timing and quantity (or the placement of X2);

2. For many fish and aquatic species, more water flow translates into greater species production or abundance;

3. Fish and aquatic species are adapted to use the water resources of the Delta during all seasons of the year, but, for many species, important life history stages or processes consistently coincide with increased winter-spring flows; and

4. The source, quality, and timing of water flows through the estuary influences the production of Chinook salmon in both the San Joaquin River and Sacramento River Basins.

The CalSim II model was run for an 82-year period (water years 1922-2003). The modeling results of baseline conditions and conditions under the proposed action were then analyzed. The biological assessment (Corps 2018) provided both monthly graphical and tabular comparisons of flow exceedance plots for the baseline condition and the proposed action, and tabular differences of flows and temperatures by species and life stage at multiple locations in the Sacramento River, Feather River, Delta, and American River. Tables 3-5 summarize the analyses for the Sacramento River.

In tables 3 through 8, color shading helps elucidate more-suitable or less-suitable conditions. Blue shading indicates the potential change for more-suitable habitat conditions under the updated Folsom WCM. Red shading indicates the potential change for less-suitable habitat conditions. Net changes in exceedance are shaded in blue when the resulting difference values for the following parameters are positive and are shaded in red when they are negative for the following parameters: (1) riverine flow parameters; (2) Delta outflow; (3) water temperature ranges (i.e., frequency of occurring within the range); and (4) frequency of X2 occurring within a range or less than a specific criterion. Net changes in exceedance are shaded in red when the resulting difference values for the following parameters are less beneficial to species habitat conditions and are shaded in blue when they are more beneficial to species habitat conditions: (1) WTI values (i.e., exceedance of a specific WTI value); (2) general changes in X2. They are shaded this way because positive changes in WTI and X2 will result in less suitable habitat conditions and negative changes will improve habitat conditions.

Assumptions associated with the CalSim II modeling include:

- Planning horizon: 2033
- Simulation period: 1922-2003
- Land use development: 2030
- CVP: full build-out of contract amounts
- SWP: land-use based, limited by contract amounts, no rice decomposition water
- Federal refuges: Firm level 2 water needs
- American River basin water rights: 2025 full water rights
- American River basin CVP: 2025 full contracts including Freeport Regional Water Project
- American River minimum flows: as required by NMFS biological opinion (2009)

In addition to CalSim II and the other models used for the Sacramento River, Feather River, and Delta, the following models were used for assessing the effects in the American River: HEC ResSim, HEC -5Q, HEC -6T. Modeling of water temperature on the American River was conducted on monthly and daily time steps.

All of the assumptions used in modeling are identified in the biological assessment (Corps 2018).

2.2 Rangewide Status of the Species and Critical Habitat

This biological opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The biological opinion also examines the condition of critical habitat throughout the designated area, evaluates the value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential PBFs that help to form that value, for the conservation of the species.

Table 1 provides the federally listed species distinct population segment (DPS) and designated critical habitat that occur in the action area (described below) and are likely to be adversely affected by the proposed action.

Table 1. ESA Listing History

Species	DPS	Original Final FR Listing	Current Final Listing Status	Critical Habitat Designated
Steelhead (*Oncorhynchus mykiss*)	California Central Valley DPS	3/19/1998 63 FR 13347 Threatened	1/5/2006 71 FR 834 Threatened	9/2/2005 70 FR 52488

2.2.1 California Central Valley Steelhead

- Originally listed as threatened (March 19, 1998, 63 FR 13347); reaffirmed as threatened (January 5, 2006, 71 FR 834).

- Designated critical habitat (September 2, 2005, 70 FR 52488).

The federally listed CCV steelhead and its designated critical habitat occur in the action area and are likely to be adversely affected by the proposed action. Detailed information regarding DPS listing and critical habitat designation history, designated critical habitat, DPS life history, and VSP parameters can be found in the NMFS Final 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 California Central Valley Steelhead (NMFS 2014a).

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s the CCV steelhead run size had declined to about 40,000 adults (McEwan 2001). Current abundance data for CCV steelhead is limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data is the most reliable because redd surveys for steelhead are often made difficult by high flows and turbid water usually present during the winter-spring spawning period.

CCV steelhead returns to Coleman National Fish Hatchery (NFH) increased from 2011 to 2014. After hitting a low of only 790 fish in 2010, returns in 2013 and 2014 averaged 2,895 fish. Wild adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically 200–300 fish each year. Numbers of wild adults returning each year ranged from 252 to 610 from 2010 to 2014.

Redd counts are conducted in the American River and in Clear Creek (Shasta County). An average of 143 redds have been counted on the American River from 2002–2015 [data from Hannon *et al.* (2003), Hannon and Deason (2008), Chase (2010)]. An average of 178 redds have been counted in Clear Creek from 2001 to 2015 following the removal of Saeltzer Dam, which allowed steelhead access to additional spawning habitat. The Clear Creek redd count data ranges from 100-1,023 and indicates an upward trend in abundance since 2006 (USFWS 2015).

The returns of CCV steelhead to the Feather River Fish Hatchery (FRFH) experienced a sharp decrease from 2003 to 2010, with only 679, 312, and 86 fish returning in 2008, 2009 and 2010, respectively. However, returns have experienced an increase with 830, 1797, and 1505 fish returning in 2012, 2013 and 2014, respectively. Overall, steelhead returns to hatcheries have fluctuated so much from 2001 to 2015 that no clear trend is present (NMFS 2016a).

An estimated 100,000 to 300,000 naturally produced juvenile CCV steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good *et al.* 2005). Nobriga and Cadrett (2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (wild) CCV steelhead smolt catch ratios in the USFWS Chipps Island trawl from 1998 through 2000 to estimate that about 400,000 to 700,000 CCV steelhead smolts are produced naturally each year in the Central Valley. Trawl data indicate that the level of natural production of CCV steelhead has remained very low since the 2011 status review, suggesting a decline in natural production based on consistent hatchery releases (NMFS 2016a). Catches of CCV steelhead at the fish collection facilities in the southern Delta are another source of information on the production of wild CCV steelhead relative to hatchery CCV steelhead (CDFW data: ftp.delta.dfg.ca.gov/salvage). The overall catch of CCV steelhead has declined dramatically since the early 2000s, with an overall average of 2,705 in the last 10 years. The percentage of wild (unclipped) fish in salvage has fluctuated, but has leveled off to an average of 36 percent since a high of 93 percent in 1999.

About 80 percent of the historical spawning and rearing habitat once used by anadromous *O. mykiss* in the Central Valley is now upstream of impassible dams (Lindley *et al.* 2006). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. CCV steelhead are well-distributed throughout the Central Valley below the major rim dams (Good *et al.* 2005, NMFS 2016a). Most of the CCV steelhead populations in the Central Valley have a high hatchery component, including Battle Creek (adults intercepted at the Coleman NFH weir), the American River, Feather River, and Mokelumne River.

CCV steelhead abundance and growth rates continue to decline, largely the result of a significant reduction in the amount and diversity of habitats available to these populations (Lindley *et al.* 2006). Recent reductions in population size are supported by genetic analysis (Nielsen *et al.* 2003). Garza and Pearse (2008) analyzed the genetic relationships among CCV steelhead populations and found that unlike the situation in coastal California watersheds, fish below barriers in the Central Valley were often more closely related to below barrier fish from other watersheds than to *O. mykiss* above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers. The genetic diversity of CCV steelhead is also compromised by hatchery origin fish, placing the natural population at a high risk of extinction (Lindley *et al.* 2007). Steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms. Only winter-run (ocean maturing) steelhead currently are found in California Central Valley rivers and streams as summer-run have been extirpated (McEwan and Jackson 1996, Moyle 2002).

Although CCV steelhead will experience similar effects of climate change to Chinook salmon in the Central Valley, as they are also blocked from the vast majority of their historic spawning and rearing habitat, the effects may be even greater in some cases, as juvenile steelhead need to rear in the stream for one to two summers prior to emigrating as smolts. In the Central Valley, summer and fall temperatures below the dams in many streams already exceed the recommended temperatures for optimal growth of juvenile steelhead, which range from 14°C to 19°C (57°F to 66°F). Several studies have found that steelhead require colder water temperatures for spawning and embryo incubation than salmon (McCullough *et al.* 2001). In fact, McCullough *et al.* (2001) recommended an optimal incubation temperature at or below 11°C to 13°C (52°F to 55°F). Successful smoltification in steelhead may be impaired by temperatures above 12°C (54°F), as reported in Richter and Kolmes (2005). As stream temperatures warm due to climate change, the growth rates of juvenile steelhead could increase in some systems that are currently relatively cold, but potentially at the expense of decreased survival due to higher metabolic demands and greater presence and activity of predators. Stream temperatures that are currently marginal for spawning and rearing may become too warm to support wild steelhead populations.

2.2.1.1 Summary of California Central Valley Steelhead DPS viability

All indications are that natural CCV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (NMFS 2016a); the long-term trend remains negative. Hatchery production and returns are dominant. Most wild CCV populations are very small and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change. The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to wild fish.

The status of the CCV steelhead DPS appears to have remained unchanged since the 2011 status review, and the DPS is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (NMFS 2016a).

2.2.1.2 Critical Habitat and Physical or Biological Features for California Central Valley Steelhead

The critical habitat designation for CCV steelhead lists the PBFs (September 2, 2005; 70 FR 52488), which are described in NMFS (2014a). In summary, the PBFs include freshwater spawning sites; freshwater rearing sites; freshwater migration corridors; and estuarine areas. The geographical extent of designated critical habitat includes: the Sacramento, Feather, and Yuba rivers, and Deer, Mill, Battle and Antelope creeks in the Sacramento River basin; the San Joaquin River, including its tributaries but excluding the mainstem San Joaquin River above the Merced River confluence; and the waterways of the Delta.

One factor affecting the critical habitat of CCV steelhead is climate change. The world is about 1.3°F warmer today than a century ago and the latest computer models predict that, without drastic cutbacks in emissions of carbon dioxide and other gases released by the burning of fossil fuels, the average global surface temperature may rise by two or more degrees in the 21st century (IPCC 2007). Much of that increase likely will occur in the oceans, and evidence suggests that the most dramatic changes in ocean temperature are now occurring in the Pacific (Noakes *et al.* 1998). Using objectively analyzed data Liu and Huang (2000) estimated a warming of about 0.9°F per century in the Northern Pacific Ocean.

Sea levels are expected to rise by 0.5 to 1.0 meters in the northeastern Pacific coasts in the next century, mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding, and permanent inundation of low-lying natural ecosystems (*e.g*., salt marsh, riverine, mud flats) affecting listed salmonid PBFs. Increased winter precipitation, decreased snow pack, permafrost degradation, and glacier retreat due to warmer temperatures will cause landslides in unstable mountainous regions and destroy fish and wildlife habitat, including salmon-spawning streams. Glacier reduction could affect the flow and temperature of rivers and streams that depend on glacier water, with negative impacts on fish populations and the habitat that supports them.

Summer droughts along the South Coast and in the interior of the northwest Pacific coastlines will mean decreased stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global warming may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water may decline, while pollution, acidity, and salinity levels may increase. This will allow for more invasive species to overtake native fish species and impact predator-prey relationships (Petersen and Kitchell 2001, Stachowicz *et al.* 2002).

In light of the predicted impacts of global warming, the Central Valley has been modeled to have an increase of between 2 and 7°C by 2100, with a drier hydrology predominated by rainfall rather than snowfall (Dettinger *et al.* 2004, Hayhoe *et al.* 2004, VanRheenen 2004, Stewart *et al.* 2005). This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring and summer snowmelt dominated system to a winter rain dominated system. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This will truncate the period of time that suitable cold-water conditions exist downstream of existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures downstream of reservoirs, such as Lake

Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids that must hold and/or rear downstream of the dam over the summer and fall periods.

2.2.1.3 Summary of the Value of California Central Valley Steelhead Critical Habitat for the Conservation of the species

Across the DPS range, much of the PBFs of CCV steelhead critical habitat are currently degraded and provide limited high quality habitat. Passage to historical spawning and juvenile rearing habitat PBFs has been largely reduced due to construction of dams throughout the Central Valley. Levee construction has also degraded the value of rearing, migratory corridor, and estuarine PBFs for the conservation of the species. Riparian vegetation has been removed, reducing habitat complexity, food resources, and increasing predator habitat, in addition to other ecological effects. Contaminant loading and poor water quality in Central California waterways poses threats to lotic fish, their habitat and food resources.

Although the current conditions of CCV steelhead critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain in the Sacramento/San Joaquin River watersheds and the Delta are considered to have high intrinsic value for the conservation of the species as they are critical to maintain strongholds, and to contribute to ongoing recovery efforts.

2.3 Action Area

"Action area" means 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 action area includes the American River downstream of Nimbus Dam, the Feather River downstream of the Feather River Fish Barrier Dam, the Sacramento River downstream of Keswick Dam, and the Sacramento-San Joaquin Delta. Because the Central Valley Project and State Water Project operations are integrated, changes due to the proposed action may result in changes in operations in other parts of the system, outside the American River, and may result in adverse effects to CCV steelhead throughout the identified action area.

2.4 Environmental Baseline

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 (50 CFR 402.02).

Climate Change & Drought

Based on information discussed in Section 2.2, increases of air temperatures will result in increases of water temperatures in the Sacramento River, Feather River, and American River. Increases in the frequency and duration of droughts will also increase water temperatures in these rivers. Due to water temperature increases associated with climate change, water temperatures in the action area are expected to be less favorable for CCV steelhead.

One major factor affecting the rangewide status of CCV steelhead in the Central Valley, and aquatic habitat at large, is climate change. In summary, warmer temperatures associated with climate change reduce snowpack and alter the seasonality and volume of seasonal hydrograph patterns (Cohen *et al*. 2000). Central California has shown trends toward warmer winters since the 1940s (Dettinger and Cayan 1995). An altered seasonality results in runoff events occurring earlier in the year due to a shift in precipitation falling as rain rather than snow (Roos 1991, Dettinger *et al.* 2004). Specifically, the Sacramento River basin annual runoff amount for April-July has been decreasing since about 1950 (Roos 1987, Roos 1991). Increased temperatures influence the timing and magnitude patterns of the hydrograph.

The magnitude of snowpack reductions is subject to annual variability in precipitation and air temperature. The large spring snow water equivalent (SWE) percentage changes, late in the snow season, are due to a variety of factors including reduction in winter precipitation and temperature increases that rapidly melt spring snowpack (Vanrheenen *et al.* 2004). Factors modeled by Vanrheenen *et al.* (2004) show that the melt season shifts to earlier in the year, leading to a large percent reduction of spring SWE (up to 100 percent in shallow snowpack areas). Additionally, an air temperature increase of 2.1°C (3.8°F) is expected to result in a loss of about half of the average April snowpack storage (Vanrheenen *et al.* 2004). The decrease in spring SWE (as a percentage) would be greatest in the region of the Sacramento River watershed, at the north end of the Central Valley, where snowpack is shallower than in the San Joaquin River watersheds to the south. Due to water temperature increases associated with climate change, water temperatures in the Feather River are also expected to be less favorable for CCV steelhead.

Projected warming is expected to affect Central Valley salmonids. The runs are restricted to low elevations as a result of impassable rim dams. If the climate warms by 5°C (9°F), it is questionable whether any Central Valley Chinook salmon populations can persist (Williams 2006). Based on an analysis of an ensemble of climate models and emission scenarios and a reference temperature from 1951-1980, the most plausible projection for warming over Northern California is 2.5°C (4.5°F) by 2050 and 5°C (9.0°F) by 2100, with a modest decrease in precipitation (Dettinger 2005). CCV steelhead are also expected to be adversely affected by climate change. As with Chinook salmon, CCV steelhead are restricted to the floor of the Central Valley, and do not have access to most of their historic spawning habitat. CCV steelhead rear for a year or more before emigrating to the ocean. Therefore, CCV steelhead are subjected to the full range of increased temperatures that occur throughout the summer.

Because water temperatures are expected to increase in the action area due to air temperature warming (Lindley 2008, Beechie *et al*. 2012, Dimacali 2013) and reduced precipitation (i.e., more frequent drought conditions; Yates et al. 2008) from climate change, NMFS is including consideration of the impacts of climate change on species and habitat into the future.

Historically Altered Ecosystem

In summary, the landscape of the action area has been highly altered due to historical human activities such as gold mining, land development, and water exportation.

The action area on the Feather and American rivers was historically altered by hydraulic gold mining, and by gold mining with dredges. ESA listed species in the action area were also affected by Yuba River hydraulic gold mining, which resulted in large amounts (40 feet deep) of sediment being deposited on land adjacent to the Yuba River and large amounts of sediment being deposited into the Feather River. The use of gold dredges changed the route of rivers and changed the landscape significantly. Furthermore, the settlement of the area led to the construction of levees and removal of trees along the riverbanks. This has drastically altered riparian habitat in the action area. The area has also been altered through agricultural practices and urbanization. Orchards are present within the active floodplain adjacent to the action area. Areas adjacent to the action area are heavily developed and urbanized.

While the Sacramento River and Delta have not been subject to large scale gold mining, other human activities have significantly altered habitat for CCV steelhead. This has occurred through flood control measures such as levees and dikes, farming in the floodplain, removal of riparian vegetation, agriculture, land development, and water extraction.

The flows in the action area are also highly modified through dams and the export of water from upstream areas. Dams and water diversions have the potential to isolate salmonids from historical spawning and rearing habitat. Unscreened diversions in the areas occupied by CCV steelhead can result in losses due to entrainment. Further, water diversions can negatively affect CCV steelhead throughout the action area by causing low flows in migratory corridors and rearing areas. Lower flows in these areas can heighten the chance of fish mortality due to increased temperature and general loss of available migratory and rearing habitat.

The existing Folsom WCM results in altered flows due to the storing of water in Folsom Lake to reduce the magnitude of flows downstream of Folsom Dam. The duration of elevated flows downstream are also altered due to the creation of storage space for water within Folsom Lake. This results in lower peak flows, and extended periods of high flows, than would naturally occur downstream of Folsom Dam. The current flood management operations under the existing Folsom WCM, with only the original spillway, has resulted in high flows during CCV steelhead egg incubation and early rearing that have likely resulted in a portion of the CCV steelhead eggs and alevins being scoured out of the gravel in the American River in some years. These high flow events would have likely resulted in the mortality of the eggs and most of the alevins. In addition, in some areas all spawning gravels were lost and were no longer usable for spawning. Reclamation has implemented habitat restoration projects in the upper part of the lower American River, including gravel augmentation in areas that were devoid of gravel. It is not likely that current flood management operations in the American River have an effect on water temperatures in the American River or other river systems, due to the time of year and the temperature destratification of the water in Folsom Lake and other reservoirs.

Due to the limited amount of storage in Folsom Lake (997,000 acre feet at full pool), the size of the watershed, the amount of precipitation, the elevation of the spillway crests, and rain on snow events, Folsom Lake does not have the capacity to contain all of the water entering Folsom Lake during all high flow events. The extent to which Folsom Lake can store water is also dependent on how recently a high flow event occurred, and the water elevation in the Lake when a high flow event occurs. The flood management operations at Folsom Dam usually result in peak flows downstream of Folsom Dam that are less than the peak inflow to Folsom Lake.

Included in the operation objectives for the proposed action is to limit the release of water during a 1 in 100 year event to 100,000 cfs in the lower American River.

2.4.1 Status of California Central Valley Steelhead in the Action Area

Table 2 shows the temporal occurrence of (a) adult and (b) juvenile California Central Valley steelhead at locations in the action area. Darker shades indicate months of greatest relative abundance.

Table 2. The Temporal Occurrence of (a) Adult and (b) Juvenile California Central Valley Steelhead at Locations in the Action Area.

Relative	High					Medium				Low		
(a) Adult migration												
Location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Delta												
[1]Sacramento R. at Fremont Weir												
[2]Sacramento R. at RBDD												
[3]Feather R.												
[7]American R.												
(b) Juvenile migration												
Location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Delta												
[1,2]Sacramento R. near Fremont Weir												
[4]Sacramento R. at Knights												
[5]Chipps Island												
[5]Chipps Island (unclipped)												
[6]Feather R.												
[8]American R.												

Sources: [1](Hallock 1957); [2](McEwan 2001); [3]CDFG Steelhead Report Card Data 2007; [4]NMFS analysis of 1998-2011 CDFW data;

[5]NMFS analysis of 1998-2011 USFWS data; [6]CDWR 2007, [7]Chase 2010, Sellheim et al, 2015; [8]Snider and Titus 2001, 2002.

Spawning CCV steelhead adults enter the San Francisco Bay estuary and Delta from August to November [with a peak in September (Hallock et al. 1961)]. In the action area, spawning occurs in Sacramento River downstream of Keswick Dam down to Red Bluff, in the mainstem of the Feather River downstream of the Oroville Fish Barrier Dam (RM 67), and in the mainstem of the American River. The Sacramento River downstream of Red Bluff, and the Delta are likely utilized primarily as migratory corridors.

Historical accounts rarely mention CCV steelhead distribution and abundance in the Feather River Basin. Based on creel surveys and interim trap counts at the Oroville dam site, the California Department of Fish and Game estimated that at least 2,000 CCV steelhead passed into the habitat upstream of Oroville dam site. From run years 1963 to 1966, the trap counts of CCV steelhead passed upstream of the dam construction site were 416, 914, 434, and 563, respectively (Wooster 1996). Due to the construction and operation of hydropower projects, including the Oroville Facilities (*i.e.*, Oroville Dam and the Fish Barrier Dam), the upper Feather River basin is no longer accessible to CCV steelhead. The FRFH was designed and is operated to replace reduced CCV steelhead production, attributable to the construction of the Oroville Facilities.

The number of adult CCV steelhead entering the FRFH each year generally increased between 1967 and 2003. CCV steelhead returns to the FRFH have varied substantially over the past several years, with very low returns in some years (2009), and above average returns in others (2013 and 2014). Because almost all returning fish are of hatchery origin and stocking levels have remained fairly constant over the years, the data suggest that adverse freshwater or ocean survival conditions have caused or at least contribute to variability in hatchery returns. The Central Valley experienced three consecutive years of drought (2007 – 2009) which would likely have impaired survival of naturally-produced parr and smolts. However, hatchery origin CCV steelhead are reared and released as 1-year olds and quickly migrate to saltwater so drought conditions would likely not have affected hatchery CCV steelhead as much as naturally-spawned CCV steelhead. There may have been a drought effect during freshwater migration. However, poor ocean conditions have occurred in at least 2005 and 2006 (which impacted Chinook salmon populations in the Central Valley) and may well have also impacted CCV steelhead populations of both hatchery and natural origin. The most recent drought (2012-2015) and an area of warm water in the Pacific Ocean (the Blob) from 2013 to 2016 also likely impacted CCV steelhead populations.

CCV steelhead spawning occurs from December to April, with a peak in January through March, in rivers and streams where cold, well oxygenated water is available (Hallock et al.1961, McEwan and Jackson 1996, Williams 2006). Adults typically spend a few months in freshwater before spawning (Williams 2006), but very little is known about where they hold between entering freshwater and spawning in rivers and streams. Utilization of the Delta by adults is poorly understood.

Most naturally-produced CCV steelhead rear in freshwater for 2 years before emigration (McEwan and Jackson 1996). Feather River CCV steelhead generally emigrate from about February through September, with peak emigration occurring from March through mid-April. However, empirical and observational data show that juvenile CCV steelhead potentially emigrate during all months of the year from the Feather River. Water temperatures of 54°F or less are considered optimal for smolting and emigrating CCV steelhead.

CCV steelhead spawn in the Feather River between December and March, with the peak spawning occurring in late January (CDWR 2007). Most of the natural CCV steelhead spawning in the Feather River occurs in the Low Flow Channel (LFC), particularly in its upper reaches near the Hatchery Side Channel. Limited spawning has also been observed below the Thermalito Afterbay Outlet. The smaller substrate size and greater amount of cover in the side channels (compared to the main river channel) also make these areas more suitable for juvenile CCV steelhead rearing. Currently, this type of habitat comprises less than 1 percent of the available habitat in the LFC (CDWR 2007). Studies have confirmed that juvenile CCV steelhead rearing, and probably adult spawning, within the Feather River is associated with secondary channels within the LFC (CDWR 2005, 2007).

In February 2017, the Oroville Dam spillway experienced a major erosion event that resulted loss of the spillway and erosion of the hillside. The event resulted in high flows, gravel scour, high sediment loads, and high turbidity in the Feather River downstream of the Fish Barrier Dam. It is likely that the event resulted in CCV steelhead eggs being dislodged from the gravel and killed, and CCV alevins being dislodged from the gravel resulting in injuries or death. Eggs and alevins may have also died due to being smothered by sediment that blocked the flow of water through the gravel. CDWR, which operates Oroville Dam, conducted stranding surveys to identify fish that had been stranded due to rapidly reduced flows associated with the spillway failure. CDWR expanded the number of observed fish, by the wet areas that were not surveyed in which stranding could have occurred, to estimate the total number of fish that were stranded. From the stranding surveys CDWR observed 1 wild CCV steelhead fry and estimated that 70 CCV steelhead had been stranded. No estimates were made for pools that had dried out. In contrast, the stranding surveys identified 3,938 fall-run Chinook salmon juveniles, and estimated that 267,894 had been stranded (CDWR 2017).

The Lower American River contains a naturally-spawning population of CCV steelhead, which spawn downstream of Nimbus Dam. The dam is an impassable barrier to anadromous fish, isolating historical spawning habitat located in the North, Middle and South forks of the upper American River. The American River population is small, with only a few hundred individuals returning to spawn each year (Reclamation 2015). The first observations of CCV steelhead spawning in the American River occur in early January. In recent years, spawning adults have been observed with intact adipose fins indicating that a portion of the in-river population is of natural origin (Hannon 2013). Juvenile *O. mykiss* (anadromous and resident forms) have been observed to occupy fast-flowing riffle habitat in the Lower American River, which is consistent with known life history traits of this species. The current operating criteria for Folsom Dam limits the maximum release to 160,000 cfs for a 1 in 200 year inflow event. Flows in excess of 30,000 cfs result in scour of CCV steelhead redds, resulting in the mortality of CCV steelhead eggs and alevins. While Folsom Dam operations do reduce the magnitude of peak flows in the lower American River, the size of Folsom Lake and available flood storage capacity does not provide the capacity to limit all flow events to a maximum of 30,000 cfs.

The Nimbus Fish Hatchery, located on the Lower American River adjacent to Nimbus Dam, produces the anadromous form of *O. mykiss*; however, steelhead from the Nimbus Fish Hatchery are not included in the CCV steelhead DPS due to genetic integrity concerns from the use of out-of-basin broodstock (71 FR 834; January 5, 2006). To specifically address this issue and in response to RPA Action II.6.1 contained in the NMFS (2009) biological opinion for long-term operations of the CVP/SWP, genetic testing of the American River *O. mykiss* population was completed in 2014 to inform the planning for the Nimbus Fish Hatchery broodstock replacement that will support the CCV steelhead DPS (NMFS 2016a).

Juvenile CCV steelhead rear in cool, clear, fast-flowing streams and are known to prefer riffle habitat over slower-moving pools (NMFS 2014a, Reclamation 2015). The only portions of the action area containing optimal juvenile rearing habitat for CCV steelhead are the Feather River and the Lower American River, where juveniles are known to exhibit rearing behavior prior to outmigration (Reclamation 2015). The Sacramento River and Delta are likely utilized primarily as migratory corridors. Little is known about the rearing behavior of juveniles in the Delta; however, they are thought to exhibit short periods of rearing and foraging in tidal and nontidal marshes and other shallow areas prior to their final entry into the ocean.

High flows in the winter of 2016-17 and the Oroville Dam Spillway Emergency have negatively impacted survival of CCV steelhead in the Feather River. High flushing flows in the Feather River resulted in juvenile steelhead being stranded, eggs being scoured out of the gravel, and juvenile fish prematurely being moved downstream. The negative effects of the high flows in the winter of 2016-17, coupled with the drought conditions from 2012 through 2016, have likely negatively impacted the recovery of CCV steelhead.

The effects of climate change on CCV steelhead may be greater than other salmonids due to juvenile CCV steelhead rearing in freshwater over the summer prior to emigrating as smolts (Snider and Titus 2000). Several studies have found that steelhead require colder water temperatures for spawning and embryo incubation than salmon (McCullough et al. 2001). McCullough et al. (2001) recommended an optimal incubation temperature at or below 11°C to 13°C (52°F to 55°F), and successful smoltification in steelhead may be impaired by temperatures above 12°C (54°F) (Richter and Kolmes 2005). In some areas, stream temperatures that currently provide marginal habitat for spawning and rearing may become too warm to support naturally-spawning steelhead populations in the future.

In summary, the California Central Valley has experienced a severe drought (2012-2016), which has likely reduced the already limited habitat quality and range for CCV steelhead. The very low numbers of adults returning to the Nimbus Fish Hatchery in 2014 and 2015 may be related to drought, as well as elevated water temperatures in the lower American River (impacting survival of steelhead produced from natural spawning). The numbers of CCV steelhead returning to the Feather River Fish Hatchery were very low in 2009 and 2010, but numbers have since rebounded. However, most of the fish entering the hatchery are of hatchery origin. CCV steelhead historically dealt with periodic drought. The concern is that at current low levels of abundance and productivity, some populations may go extinct during long dry spells, and the re-establishment of these populations may be difficult due to the degraded habitat conditions (NMFS 2016a).

2.4.1.1 Status of California Central Valley Steelhead Critical Habitat in the Action Area

A significant portion of designated critical habitat for CCV steelhead is contained within the action area. PBFs are concurrently defined in 70 FR 52488 (September 2, 2005) and the following PBFs, in summary, for this species are present in the action area: (1) freshwater spawning sites, (2) freshwater rearing sites, (3) freshwater migration corridors, and (4) estuarine areas. Critical habitat for CCV steelhead includes portions of the north Delta, Feather River (up to the Fish Barrier Dam), the Sacramento River (up to Keswick Dam) and the lower American River (from the confluence with the Sacramento River to Nimbus Dam). With the exception of Clifton Court Forebay and the Sacramento Ship Channel, the entirety of the action area is designated critical habitat for CCV steelhead.

Historically, CCV steelhead spawned in many of the headwaters and upstream portions of the Sacramento River basin. Passage impediments have contributed to substantial reductions in the populations of these species by isolating them from much of their historical spawning habitat. Within the action area, spawning habitat is limited to the mainstem of the Sacramento River between Red Bluff and Keswick Dam, the Feather River downstream of the Fish Barrier Dam, and in the American River from Watt Avenue up to Nimbus Dam. The PBF of freshwater spawning sites for CCV steelhead has been degraded within the action area due to high water temperatures, redd dewatering, and loss of spawning gravel recruitment (Wright and Schoellhamer 2004, Good et al. 2005, NMFS 2009a, Jarrett 2015). These issues are actively being addressed by adaptive flow management, as well as spawning gravel augmentation projects (NMFS 2009, 2016b). The best chance for delisting of CCV steelhead is the expansion of their range, as it was the creation of dams that has removed CCV steelhead from over 80 percent of their original spawning and rearing habitat (NMFS 2016a).

Freshwater rearing and migration PBFs have been degraded from their historical condition within the action area. In the Sacramento River and Feather River, riverbank armoring has significantly reduced the quantity of floodplain rearing habitat for juvenile salmonids and has altered the natural geomorphology of the river (NMFS 2014a). CCV steelhead are only able to access large floodplain areas, such as the Yolo Bypass, under certain hydrologic conditions which do not occur in drier years. However, the Yolo Bypass Restoration Plan includes notching the Fremont Weir, which will provide access to floodplain habitat for juvenile CCV steelhead over a longer period (CDWR and Reclamation 2016). Levee construction involves the removal of riparian vegetation, resulting in reduced habitat complexity and shading, making juveniles more susceptible to predation. Additionally, loss of riparian vegetation reduces aquatic macroinvertebrate recruitment resulting in decreased food availability for rearing juveniles (Anderson and Sedell 1979, Pusey and Arthington 2003). On the Sacramento River, Reclamation has been implementing projects to restore habitat for rearing salmonids downstream of Keswick Dam. The lower American River has experienced similar losses of rearing habitat; however, projects sponsored by Reclamation are restoring rearing habitat for juvenile CCV steelhead through the creation of side channels and placement of instream large woody material (LWM) and spawning gravel (Reclamation 2015). CDWR has placed spawning gravel in the upper Feather River (downstream of the Fish Barrier Dam), and through a relicensing settlement agreement for the Oroville Facilities will be implementing additional habitat improvement projects after the Oroville Facilities are relicensed by the Federal Energy Regulatory Commission.

The high flows in 2017 produced some benefits to critical habitat through the recruitment of LWM. However, the high flows had many negative effects on habitat. The high flows resulted in large changes in the river, with erosion of the river banks and high loads of sediment being deposited into the river. It is likely that critical habitat has been degraded in the Feather River since the most recent status review for CCV steelhead.

Within the action area, the estuarine area PBF includes the legal Delta, encompassing significant reaches of the Sacramento and San Joaquin rivers that are tidally influenced (70 FR 52488; September 5, 2005). Estuarine habitat in the Delta is significantly degraded from its historical condition due to levee construction, shoreline development, and dramatic alterations to the natural hydrology of the system due to water export operations (NMFS 2014a). Reverse flows in the central and south Delta resulting from water exports may exacerbate interior Delta entrainment by confounding flow and temperature-related migratory cues in out migrating juveniles. The presence of these stressors, which cause altered migration timing and routing, degrade critical habitat PBFs related to rearing and migration.

2.4.2 Other Factors Affecting CCV Steelhead and Critical Habitat in the Action Area

2.4.2.1 Water Quality

Current land use in the Sacramento River basin and Delta has seen a dramatic increase in urbanization, industrial activity, and agriculture in the last century. In a Sacramento River Basin wide study, areas with relatively high concentrations of agricultural activity as well as areas that had previously experienced mining activity showed increased concentrations of dissolved solids and nitrite plus nitrate (Domagalski et al. 2000). Domagalski et al. (2000) also found varying concentrations of mercury and methylmercury throughout the Sacramento River Basin. Concentrations of these contaminants were greatest downstream of previous mining sites (primarily Cache Creek). Both studies showed lower concentrations of contaminants in the American River as compared to other sites sampled in the Sacramento River Basin. Multiple studies have documented high levels of contaminants in the Delta such as polychlorinated biphenyls (PCBs), organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), selenium, and mercury, among others (Stewart et al. 2004, Leatherbarrow et al. 2005, Brooks et al. 2011), suggesting that fish are exposed to them; however, the inability to characterize concentrations and loading dynamics makes it difficult to quantify transport and total contaminant loading in the system (Johnson et al. 2010). Harmful algal blooms also occur in the Delta and, although toxic exposure of estuarine fish has been documented, the extent of their impacts to the aquatic food web is unknown (Lehman et al. 2009). The U.S. Environmental Protection Agency developed an action plan in 2012 to address water quality concerns in the Delta (U.S. Environmental Protection Agency 2012). This plan included the following actions: (1) Strengthen estuarine habitat protection standards; (2) Advance regional water quality monitoring and assessment, (3) Accelerate water quality restoration through Total Maximum Daily Loads, (4) Strengthen selenium water quality criteria, (5) Prevent pesticide pollution, (6) Restore aquatic habitats while managing methylmercury, and (7) Support the Bay Delta Conservation Plan.

2.4.2.2 Water Temperature Management in the Sacramento River

The amount of cold water pool available for instream temperature management on the Sacramento River depends on carry-over storage, reservoir water temperature, and the amount, timing, and water temperature of inflows to and outflows from Shasta Reservoir. End of September storage targets of 1.9 MAF are part of the 2009 NMFS biological opinion RPA actions for the long-term operations of CVP/SWP intended to sustain cold water supply for SR winter-run Chinook salmon and CV spring-run Chinook salmon each year (NMFS 2009). This RPA action has not been met during some years (Swart 2016). Recent efforts to provide more cold water for SR winter-run Chinook salmon should be beneficial to CCV steelhead.

2.4.2.3 Water Temperature Management in the American River

RPA action II.3 in the NMFS biological opinion for the long-term operations of the CVP/SWP (NMFS 2009) requires Reclamation to implement physical and structural modifications to the American River Division of the CVP in order to improve water temperature management and develop an annual water temperature management plan for the lower American River. Some structural changes to Folsom Dam have been completed to facilitate more control over temperature and amount of water releases into the American River for spawning CCV steelhead, and migrating and rearing juveniles. Water temperature management plans for the lower American River have been developed annually starting in 2010. In addition, an Iterative Coldwater Pool Management Model was developed by Reclamation in 2010 and is being used annually to evaluate cold water pool availability in Folsom Reservoir and develop water temperature objectives in the lower American River that are as protective as possible for salmonids.

2.4.2.4 Predation of juvenile salmonids

Predation of juvenile salmonids is thought to be a contributing factor to high mortality at this life stage within the action area, though there is still more research needed on this topic in order to draw any substantial conclusions (Hanson 2009, Michel et al. 2015). Within the action area, there have been significant alterations to aquatic habitat that are conducive to the success of non-native piscivorous fish such as riverbank armoring and reduction of habitat complexity (NMFS 2014a). A study led by the NOAA Southwest Fisheries Science Center has attempted to develop a quantitative tool to measure predation in the Delta using a novel method of observing predation events at a fine spatial scale (Demetras et al. 2016). This study identified some fine scale dynamics of predation on salmonids; however, the results were not comprehensive enough to make any sort of system-wide conclusions regarding the magnitude of predation on juveniles in the Delta.

2.4.2.5 Conditions in the Feather River

Many of the alterations of the Feather River have resulted in negative effects to CCV steelhead and their designated critical habitats. For example, barriers to fish passage prevent CCV steelhead from utilizing habitat they previously occupied. Dams have not only blocked fish migrations, but also interrupted natural processes, such as the movement of gravel and LWM. This has degraded the quality of the habitat to which ESA listed anadromous fish species are limited (downstream of Oroville Dam). Hatchery operations have resulted in domestication of fish, such that they are not as successful in the wild. This also negatively impacts fish in the wild through interbreeding between wild and hatchery fish. Water management has affected habitat quality through lack of channel forming flows, and changes in the hydrograph. Dikes, levees, and flood management have also impacted habitat and natural channel forming processes. Water temperatures have also been modified from historic conditions; however, these changes have some beneficial effects. Areas to which fish such as CCV steelhead are now restricted likely have cooler temperatures than prior to the construction of the Oroville Facilities. However, downstream of the Thermalito Afterbay Outlet water temperatures may be warmer, due to the effects of the Thermalito facilities.

There are a number of factors in the Feather River for which data are not available, and for which the effects of multiple activities are intermixed and complex. For example, predation effects on CCV steelhead in the Feather River have not been quantified. Looking at survival between fish released at the hatchery and fish released in San Pablo Bay, the differences may be due to predation. But it is not possible to determine if the predation is worse than it was prior to the effects of various actions in the Feather River, because there is no baseline data to compare to today's conditions. Also, some of the differences in survival may be due to other factors such as water diversions, and/or pollution, and/or lack of floodplain rearing, and/or reduced flows during times when juvenile fish are migrating downstream. Additionally, the difference in survival based on hatchery release location is variable.

2.4.2.6 Diversion Entrainment

The many existing unscreened water diversions on the Sacramento River pose a threat to early life stages of listed species. A study of 12 unscreened, small to moderate sized diversions (< 150 cfs) in the Sacramento River, found that diversion entrainment was low for listed salmonids (majority were identified as fall-run Chinook based on length-at-date criteria; other evolutionarily significant units (ESUs) made up much smaller percentages), though the study points out that the diversions used were all situated relatively deep in the river channel (Vogel 2013). The 2009 RPA for the continued operation of CVP/SWP included actions related to entrainment, such as funding the screening of unscreened diversions, and operations to reduce entrainment in the Delta.

2.4.2.7 Dredging and Other Physical Disturbance

Dredging operations periodically occur within the action area for a variety of purposes, including the maintenance of shipping channels; maintenance of diversion intakes; and to remove accumulated sediments from recreational and commercial facilities such as boat docks and marinas. Dredging can have detrimental impacts to listed fish species through physical disturbance, and through the resuspension of sediment. ESA consultations are periodically conducted by NMFS for dredging projects of varying scope and scale within the action area.

2.4.2.8 Flow fluctuations

Flow fluctuations from Sacramento River operations of the CVP and SWP can cause CCV steelhead redd dewatering and scour to occur. Flow fluctuations in the upper Sacramento River, Feather River, and American River can also cause stranding of juvenile salmonids to varying degrees depending on water year type and subsequent water operations.

2.4.2.9 Vessel Traffic in the Action Area

Select portions of the action area currently experience heavy commercial and recreational vessel traffic, creating hazards to listed fish species through both physical and acoustic disturbance.

These impacts may lead to direct mortality or may induce changes in behavior that impair feeding, rearing, migration, and/or predator avoidance. The mainstem Sacramento River; American River; Delta; and remainder of Suisun, San Pablo, and San Francisco bays receive occasional commercial tugboat traffic as construction barges and other heavy equipment are transported upstream. Finally, recreational vessel traffic occurs throughout the action area. In a report on Delta boating needs through year 2020, the California Department of Boating and Waterways (2003) stated an expected increase in boating activity in the Delta area.

2.4.2.10 Acoustic Impacts in the Action Area

Construction activities in the action area occur periodically, and some involve pile driving, which generates acoustic effects potentially causing acute injury and/or behavioral impacts to fish. In the last few decades, observed acoustic impacts to fish have prompted research into physiological effects caused by excess sound generated in water (Gaspin 1975, Hastings 1995, Hastings and Popper 2005). Recent NMFS biological opinions for projects involving incidental take caused by acoustic-related effects in the action area include bridge replacements at Jellys Ferry (Sacramento River) and Miner Slough (north Delta) (NMFS 2014b, 2016b).

2.4.2.11 Restoration Activities

Specific smaller scale fish habitat restoration actions mandated as part of the NMFS biological opinion RPA (NMFS 2009) are occurring on the upper reaches of the Sacramento River between Keswick Dam and RBDD as well as on the lower American River between Nimbus Dam and the State Route 160 Bridge (NMFS 2015a, 2015b). At select sites within these areas, the projects involve creation of side channels, addition of spawning gravel, and placement of in-water LWM. NMFS has identified these types of actions as being important to the recovery of CCV steelhead (NMFS 2014a).

The RPA in the NMFS biological opinion for the long-term operations of the CVP/SWP (NMFS 2009) included actions to avoid jeopardy of CCV steelhead, and other ESA listed anadromous fish species. These actions within the action area include:

- Reduction of migratory delays at the Fremont Weir and other structures in the Yolo Bypass,
- Restoration of floodplain rearing habitat,
- Pilot reintroduction of ESA listed fish species, upstream of Shasta Dam and Folsom Dam,
- Consideration of engineering solutions to further reduce diversion of emigrating juvenile salmonids to the interior and southern Delta, and reduce exposure to CVP and SWP export facilities, and
- Habitat restoration.

2.5 Effects of the Action

Under the ESA, "effects of the action" means 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 (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

In NMFS' analysis of the proposed action, we identified the exposure, risk, and potential adverse effects of the proposed action to CCV steelhead and their designated critical habitat, from all aspects of the proposed action, as follows:

- CCV steelhead exposure to potential adverse effects
    - Sacramento River, Feather River, and Delta:
        - Changes in flows and water temperature
    - American River
        - Changes in flows and water temperature
        - Redd scour
        - Stranding

- CCV steelhead designated critical habitat exposure to potential adverse effects
    - Sacramento River, Feather River, and Delta
        - Changes to migratory corridor and rearing habitat (flows and water temperature)
        - Spawning habitat modifications (gravel scour)
        - Juvenile migratory corridor and rearing habitat modifications (resulting in stranding)

    - American River
        - Changes in flows and water temperature
        - Spawning gravel scour
        - Stranding

Analysis

Decreases in flows can result in adverse effects on CCV steelhead through decreased survival of juvenile salmonids, and changes in behavior of upstream migrating adult CCV steelhead. With lower flows, the water in rivers moves slower and fish may be more susceptible to predation under low flows than high flows. Under low flow conditions, migrating adult CCV steelhead may not return to their natal stream due to poor water quality conditions in that stream. This may affect their reproductive success. This could happen if they spawn in a stream with a higher percentage of hatchery fish spawning in the wild, or if they spawn in a stream with conditions to which they are not adapted.

Increases in water temperatures can result in reduced survival of CCV steelhead. This can happen at any life stage. Higher water temperatures can increase the occurrence of some diseases, which may reduce reproductive success in adult salmonids, reduce incubation success, and reduce rearing success. Water temperatures in the action area can reach levels that are lethal for salmonids. Water temperatures can be linked to the amount of flow; however, with the dams on the Sacramento River, Feather River, and American River, water temperatures are largely managed through the elevation at which water is withdrawn from the reservoirs.

Individual salmonids can be negatively affected by rapid decreases in flow, resulting in rapid decreases in water surface elevations. Depending on the type of habitat being utilized by fish this can result in stranding and isolation of fish from the water flowing in the river. These rapid down ramping events can strand fish on the banks of a river when the water elevation recedes quicker than the fish can follow. CCV steelhead can also be stranded through isolation when water elevations drop. When the water levels drop fish may become trapped in pools that are no longer connected to the stream. This can result in mortality from increased bird predation, loss of all water, loss of oxygen, or increased water temperatures. While isolation pool stranding is more common for juvenile salmonids, it can also happen with adult salmonids.

Scour of CCV steelhead spawning habitat can result in eggs or alevins being dislodged, resulting in death. Eggs that are dislodged from the gravel can die from exposure to light, physical disturbance, physical injury, or from predation. Dislodged alevins can die from physical injury or predation.

Changes in flows can result in reduced habitat for ESA listed anadromous fish species. If flows are reduced below the existing flows, the stream may be narrower and there will be less area for fish to live than under current conditions.

Similarly, if water temperatures increase to a level at which CCV steelhead cannot be successful, or die, the amount of available functioning habitat is reduced. This can occur with changes in operations of dams that result in less cold water being available downstream. As water flows downstream during hot weather, it warms. At some point the water temperature may become less than optimal, or lethal, for CCV steelhead. As water temperatures increase above the optimum temperature, the amount of viable habitat shrinks.

Gravel scour can also reduce the amount of available spawning and rearing habitat for ESA listed anadromous fish species. With the dams in the action area, gravel recruitment from upstream areas to the areas downstream of the dams does not occur. Changes in operations could result in more gravel being moved downstream and the upper areas of the river downstream from the dams becoming unsuitable for spawning due to armoring of the riverbed. Changes in the substrate from gravel to bedrock will also reduce the amount and value of habitat for rearing fish.

Modeling

As described in the Analytical Approach section, modeling was done based on the existing Folsom WCM to identify existing effects and conditions. Modeling was also done based on the updated Folsom WCM to identify the effects of the proposed action. Modeling of flows and temperatures was based on CalSim II, for which output is on a monthly basis. For flows in the American River, modeling was also done on a daily time step to analyze the magnitude of change in peak flow events. Assumptions for the modeling are identified in the Analytical Approach section.

2.5.1 Potential Adverse Effects to CCV Steelhead Individuals Outside of the American River

Because the operation of Folsom Dam is integrated with the rest of the CVP and SWP, operations at Folsom Dam have the potential to impact CCV steelhead and designated critical habitat in the Sacramento River downstream of Keswick Dam, downstream of the Oroville Fish Barrier Dam on the Feather River, and in the Sacramento-San Joaquin Delta. Changes in flows could result in increased predation, dewatering of redds, and stranding. Changes in water temperatures could reduce the viability of CCV steelhead.

River Flows and Temperatures

Modeled changes in probability of exceedance of Sacramento River, Feather River, and Sacramento-San Joaquin Delta criteria for mean monthly flows and for mean monthly water temperatures are presented in Table 3 through Table 5 for CCV steelhead.

Table 3 provides modeled information regarding changes in flows and temperatures under the proposed action compared to baseline conditions for CCV steelhead in the Sacramento River. The analysis shows little change in flows in most months and locations. Table 3 indicates that in low flow years, in January, at Verona and Freeport, mean monthly flows have a 3 percent probability of being 10 percent less than the baseline condition. If flows are less, adult CCV steelhead upstream immigration and juvenile downstream movement may be affected through behavioral responses. The modeling predicts a zero probability of flows being less than under baseline conditions for all other months and locations (other than January at Verona and Freeport).

The analysis of water temperatures shows there is little change in water temperatures in most months and locations. With the proposed action, the water temperature are cooler in several locations and months. The modeling does show warmer water temperatures in some months and locations with the proposed action.

It is important to note that negative effects on water temperatures, or flows, indicated by the modeling would to some extent be minimized by real-time operational management. NMFS does not have sufficient information to specifically describe the extent to which negative effects indicated by the modeling would be minimized by real-time operations. However, there are extensive real-time operations management processes currently in place for CVP/SWP operations that affect water temperatures upstream of the Delta. Those processes have minimized such impacts in the past (Swart 2016), and the proposed action does not propose changing the baseline real-time operational processes. Therefore, NMFS concludes that the real-time operations management process would minimize the negative effects indicated in the modeling for the proposed action to a similar extent as the real-time operations process has minimized such impacts in the past.

Table 3. CCV Steelhead Lifestage Summary Change in Flow and Temperature Exceedance Probability, Sacramento River – Proposed Action (scenario J602F3 FLD) Relative to Baseline Conditions (scenario J604 FLD, Corps 2018). Blue shading indicates more favorable conditions, and red shading less favorable conditions with implementation of the updated Folsom WCM. /1

Lifestage	Evaluation Period	Indicator of Potential Impact	Location	Metric		Range	Net Change in Probability of Exceedance under J602F3 FLD relative to J604 FLD (percent)											
			Description	Value	%		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Adult Immigration	August through March	Mean Monthly Flow (cfs)	Below Keswick		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
			Red Bluff		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
			Verona		10	Lower 40%	0.0	0.0	0.0	-3.0	0.0	0.0					0.0	0.0
			Freeport		10	Lower 40%	0.0	0.0	0.0	-3.0	0.0	0.0					0.0	0.0
		Mean Monthly Water Temperature (°F)	Below Keswick Dam	64		All Years	0.0	0.0	0.0	0.0	0.0	0.0					-0.9	0.2
				68		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
			Red Bluff	64		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	-0.2
				68		All Years	0.0	0.0	0.0	0.0	0.0	0.0					-1.3	0.5
			Feather River Confluence	64		All Years	0.4	0.0	0.0	0.0	0.0	0.0					0.0	0.0
				68		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	-0.7
			Freeport	64		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	-0.2
				68		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
Adult Holding	August through March	Mean Monthly Flow (cfs)	Below Keswick		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
			Bend Bridge		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
		Mean Monthly Water Temperature (°F)	Below Keswick Dam	61		All Years	-1.2	0.0	0.0	0.0	0.0	0.0					-0.3	0.4
				65		All Years	0.0	0.0	0.0	0.0	0.0	0.0					-1.3	0.7
			Bend Bridge	61		All Years	-0.2	0.0	0.0	0.0	0.0	0.0					0.5	-0.5
				65		All Years	0.0	0.0	0.0	0.0	0.0	0.0					-0.1	-0.1
Spawning and Embryo Incubation	December through April	Mean Monthly Flow (cfs)	Below Keswick		10	All Years			0.0	0.0	0.0	0.0	0.0					
			Bend Bridge		10	All Years			0.0	0.0	0.0	0.0	0.0					
	December through May	Mean Monthly Water Temperature (°F)	Below Keswick Dam	54		All Years			0.0	0.0	0.0	0.0	0.0	0.0				
				57		All Years			0.0	0.0	0.0	0.0	0.0	0.0				
			Bend Bridge	54		All Years			0.0	0.0	0.0	0.0	-0.2	0.4				
				57		All Years			0.0	0.0	0.0	0.0	0.0	-0.6				
Juvenile Rearing and Downstream Movement	Year-round	Mean Monthly Flow (cfs)	Below Keswick		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Bend Bridge		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Verona		10	Lower 40%	0.0	0.0	0.0	-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Mean Monthly Water Temperature (°F)	Below Keswick Dam	65		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.3	0.7
				68		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Bend Bridge	65		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
				68		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.3	0.0
			Feather River Confluence	65		All Years	-0.1	0.0	0.0	0.0	0.0	0.0	-0.3	0.0	0.0	0.0	0.0	-1.3
				68		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.1	0.0	-0.7
Smolt Emigration	January through June	Mean Monthly Flow (cfs)	Red Bluff		10	Lower 40%				0.0	0.0	0.0	0.0	0.0	0.0			
			Verona		10	Lower 40%				-3.0	0.0	0.0	0.0	0.0	0.0			
			Freeport		10	Lower 40%				-3.0	0.0	0.0	0.0	0.0	0.0			
		Mean Monthly Water Temperature (°F)	Red Bluff	52		All Years				0.0	0.0	0.6	0.0	0.0	0.0			
				55		All Years				0.0	0.0	0.0	0.0	0.0	0.0			
			Feather River Confluence	52		All Years				0.0	0.0	0.0	0.0	0.0	0.0			
				55		All Years				0.0	0.0	0.0	0.0	0.0	0.0			
			Freeport	52		All Years				0.0	0.0	1.2	0.0	0.0	0.0			
				55		All Years				0.0	0.0	1.3	0.0	0.0	0.0			

/1 Net changes in exceedance are shaded in blue when the resulting difference values for the following parameters are positive and are shaded in red when they are negative for the following parameters: (1) riverine flow parameters; (2) Delta outflow; (3) water temperature ranges (i.e., frequency of occurring within the range); and (4) frequency of X2 occurring within a range or less than a specific criterion. For flows a change of 10 percent or higher frequency resulted in shading. 10 percent change in probability was also used for the shading for temperature.

To facilitate real-time operational decisions, fish and wildlife agencies (consisting of USFWS, NMFS, and CDFW), Reclamation, and CDWR, utilize a set of processes to collect data, disseminate information, develop information, develop recommendations, make decisions, and provide transparency (U.S. Bureau of Reclamation 2008; NMFS 2009; USFWS 2008). This process consists of numerous teams that meet on a regular basis to review the most up-to-date data and information on fish status and water conditions, and develop recommendations to modify operations or criteria, to improve the protection of ESA listed species.

The temperature metrics that were used in the modeling analysis are the upper optimum value (smaller number) and the upper tolerance value (larger number) for each life stage (Corps 2018). Little difference was identified in flows and water temperature probabilities in the Sacramento River between the modeling of existing conditions and the proposed action. There are processes in place to minimize the effects of operations on CCV steelhead. The fish agencies involved in these processes regularly (monthly or more frequently) assess conditions and recommend adjustments in operations to Reclamation. Based on the modeling, and with regular input from fish agencies, the proposed action is expected to result in very minimal effects to CCV steelhead in the Sacramento River.

Table 4 provides modeled summary information regarding changes in flows and water temperatures for CCV steelhead in the Feather River. Other than a change in the probability of flows in September downstream of the Thermalito Afterbay Outlet, there is little or no change in the probability of exceedance of criteria for flows or water temperatures for steelhead in the Feather River, when operations of the current Folsom WCM and the proposed action are analyzed. During September, adult and juvenile CCV steelhead may be present, but no CCV steelhead eggs are expected to be incubating. The modeling shows the proposed action will result in flows that will be 10 percent less downstream of the Thermalito Afterbay Outlet in September, in dry years. The flows in September that result from the proposed action would be lower due to the flows being released from the Thermalito Afterbay Outlet (there are no changes in the probability of flow upstream). The change in flows would be expected to be gradual, and not result in any stranding. Nor would gravel scour resulting in loss of CCV steelhead eggs occur, due to no eggs being present, and flows in September being below the level that gravel movement occurs. Even if flows are lower, CDWR is expected to be required through the relicensing of the Oroville Facilities to maintain minimum flows and keep the water temperature below maximums. Based on very little changes in the probability of changes in flows and water temperatures, and the flow and temperature criteria that are expected to be in place for the operation of CDWR's Oroville Facilities, adverse effects to CCV steelhead in the Feather River are expected to be very minimal, such that the Feather River population is not expected to be reduced.

Table 5 provides modeled information regarding flow conditions in the Sacramento-San Joaquin Delta.

Table 4. CCV Steelhead Lifestage Summary Change in Flow and Temperature Exceedance Probability, Feather River – Proposed Action (scenario J602F3 FLD) Relative to the Baseline Condition Operations (scenario J604 FLD, Corps 2018). Blue shading indicates more favorable conditions, and red shading less favorable conditions with implementation of the updated Folsom WCM. /1

Lifestage	Evaluation Period	Indicator of Potential Impact	Location	Metric		Range	Net Change in Probability of Exceedance under J602F3 FLD relative to J604 FLD (percent)											
			Description	Value	%		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Adult Immigration	August through March	Mean Monthly Flow (cfs)	Low Flow Channel below the Fish Barrier Dam		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
			Below the Thermalito Afterbay Outlet		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0					0.0	-12.1
			Mouth of the Lower Feather River		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0					0.0	-9.1
		Mean Monthly Water Temperature (°F)	Low Flow Channel below the Fish Barrier Dam	64		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
				68		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
			Below the Thermalito Afterbay Outlet	64		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
				68		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
			Mouth of the Lower Feather River	64		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
				68		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
Adult Holding	August through March	Mean Monthly Flow (cfs)	Low Flow Channel below the Fish Barrier Dam		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
			Below the Thermalito Afterbay Outlet		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0					0.0	-12.1
			Mouth of the Lower Feather River		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0					0.0	-9.1
		Mean Monthly Water Temperature (°F)	Low Flow Channel below the Fish Barrier Dam	61		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	-0.1
				65		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0
			Below the Thermalito Afterbay Outlet	61		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	-0.6
				65		All Years	0.0	0.0	0.0	0.0	0.0	0.0					0.0	1.2
Spawning and Embryo Incubation	January through April	Mean Monthly Flow (cfs)	Low Flow Channel below the Fish Barrier Dam		10	All Years				0.0	0.0	0.0	0.0					
			Below the Thermalito Afterbay Outlet		10	All Years				0.0	0.0	0.0	0.0					
	January through May	Mean Monthly Water Temperature (°F)	Low Flow Channel below the Fish Barrier Dam	54		All Years				0.0	0.0	0.0	0.0	0.0				
				57		All Years				0.0	0.0	0.0	0.0	0.0				
			Below the Thermalito Afterbay Outlet	54		All Years				0.0	0.0	0.0	0.0	0.0				
				57		All Years				0.0	0.0	0.0	0.0	0.0				
Juvenile Rearing and Downstream Movement	Year-round	Mean Monthly Flow (cfs)	Low Flow Channel below the Fish Barrier Dam		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Below the Thermalito Afterbay Outlet		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-12.1
		Mean Monthly Water Temperature (°F)	Low Flow Channel below the Fish Barrier Dam	65		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				68		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Below the Thermalito Afterbay Outlet	65		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
				68		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.2	0.0	0.0	0.0
molt Emigration	October through April	Mean Monthly Flow	Below the Thermalito Afterbay Outlet		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
			Mouth of the Lower Feather River		10	Lower 40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
		Mean Monthly Water Temperature (°F)	Below the Thermalito Afterbay Outlet	52		All Years	0.0	-1.3	-0.1	0.0	0.7	0.0	0.0					
				55		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
			Mouth of the Lower Feather River	52		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
				55		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0					

/1 Net changes in exceedance are shaded in blue when the resulting difference values for the following parameters are positive and are shaded in red when they are negative for the following parameters: (1) riverine flow parameters; (2) Delta outflow; (3) water temperature ranges (i.e., frequency of occurring within the range); and (4) frequency of X2 occurring within a range or less than a specific criterion. For flows a change of 10 percent or higher frequency resulted in shading. 10 percent change in probability was also used for the shading for temperature

Table 5. CCV Steelhead Lifestage Summary Change in Flow Exceedance Probability, Sacramento-San Joaquin Delta – Proposed Action (scenario J602F3 FLD) Relative to the Baseline Condition Operations (scenario J604 FLD, Corps 2018). Blue shading indicates more favorable conditions, and red shading less favorable conditions with implementation of the updated Folsom WCM. /1

Lifestage	Evaluation Period	Indicator of Potential Impact	Location	Metric		Rang e	Net Change in Probability of Exceedance under J602F3 FLD relative to J604 FLD (Percent)											
			Description	Value	%		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Juvenile Rearing and Emigration	October through July	Mean Monthly Flow (cfs)	Rio Vista		10	Lower 40%	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		
	November through May	Mean Monthly Flow (cfs)	Yolo Bypass		10	All Years			0.0	0.0	0.0	0.0	0.0	0.0				
	October through July	Mean Monthly Delta Outflow (cfs)	Delta		10	All Years	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
		Mean Monthly OMR Flow (cfs)	Old and Middle Rivers	<2500 cfs		All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

/1 Net changes in exceedance are shaded in blue when the resulting difference values for the following parameters are positive and are shaded in red when they are negative for the following parameters: (1) riverine flow parameters; (2) Delta outflow; (3) water temperature ranges (i.e., frequency of occurring within the range); and (4) frequency of X2 occurring within a range or less than a specific criterion.

The modeling results show that the proposed action will result in a 10 percent drop in flows at Rio Vista during low flow conditions. The modeling also shows a slight change in the probability that outflows from the Yolo Bypass and the Delta in November will be lower. The modeling indicates little change in flows with the proposed action.

Due to the long distance between where the proposed action is occurring and the Delta, the small change in the probability of flows changing, and the proposed action having little effect on the amount of warming of the water occurring over the long distance between the dams and the Delta, temperature-related effects to all life stages of CCV steelhead are expected to be minimal in the Delta.

X2 is a location based on a measurement of salinity in the Sacramento-San Joaquin Delta. It is the geographical location of two parts per thousand, near-bottom salinity isohaline, measured in kilometers [km] upstream from the Golden Gate Bridge. The X2 location in general also shows minimal difference for the two scenarios. Long-term average changes are -0.1 km (-0.06 miles) for May through July, and 0.1 km for March. All other months show no changes in long-term average X2 location. The X2 location is similar for most months for all water years, with more negative shifts up to 0.3 km (0.19 miles) and a few positive shifts of 0.1 km. The maximum year-to-year change for each month in the 82-year period of record ranged from 0.3 km in August to 1.2 km (0.75 miles) in December.

Based on the modeling information, minimal changes in flows, water temperatures, and salinity in the Sacramento-San Joaquin Delta are expected upon implementation of the proposed action. The adverse effects to CCV steelhead are expected to be from reduced flows in the Sacramento River in January, in low flow years; in the High Flow Channel of the Feather River in September, low flow years; in the Yolo Bypass in January, and in the Sacramento-San Joaquin Delta in November. Because these are mostly one month events, it is expected that the actual change in flow will be less, due to real time management of flows that could not be incorporated into the modeling. Therefore, the modeled reduced flows are expected to only result in minimal adverse effects to CCV steelhead. The modeling indicates a potential benefit to water temperatures in August downstream of Keswick Dam. Salinity in the Sacramento-San Joaquin Delta is managed to meet water quality standards. The modeling indicates only small changes in the X2 salinity requirement, which is likely to be less due to management practices. The potential changes in salinity are not expected to result in measurable adverse effects to CCV steelhead.

2.5.2 Potential Adverse Effects to Designated Critical Habitat Outside of the American River

Based on the modeling results in Tables 3-5, there appears to be little to no change in flows or water temperatures in the Sacramento River, Feather River, or the Sacramento-San Joaquin Delta due to implementation of the proposed action. Effects of the proposed action to any of the PBFs of designated critical habitat for CCV steelhead outside of the American River are expected to be very minimal.

2.5.3 Potential Adverse Effects to CCV Steelhead in the American River

American River Flows affecting juvenile rearing/migration

Reduced flows in the American River may result in lower survival of juvenile CCV steelhead, likely due to increased predation. Table 6 summarizes the changes in flow due to the proposed action.

Table 6. Long-term and Water Year Type Average Lower American River Flow downstream of Nimbus Dam under the Proposed Action and Baseline Conditions (Corps 2018). Blue shading indicates more favorable conditions, and red shading less favorable conditions with implementation of the updated Folsom WCM. /4

Analysis Period	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
						Flow (cfs)						
Long-term												
Full Simulation Period[2]												
Baseline Condition (J604 FLD)	2,029	3,017	3,423	4,735	5,200	3,901	3,036	3,379	3,273	3,133	2,215	2,336
Proposed Action (J602F3 FLD)	1,928	2,883	3,339	4,482	4,818	4,147	3,422	3,526	3,555	3,296	2,170	2,435
Difference	-101	-134	-84	-253	-382	246	386	147	282	163	-45	99
Percent Difference[3]	-5.0	-4.4	-2.5	-5.3	-7.3	6.3	12.7	4.4	8.6	5.2	-2.0	4.2
Water Year Types[1]												
Wet												
Baseline Condition (J604 FLD)	2,265	3,821	5,892	8,855	9,094	6,124	4,894	5,826	5,620	3,267	2,918	3,565
Proposed Action (J602F3 FLD)	2,108	3,566	5,641	8,310	8,221	7,069	5,578	5,964	6,019	3,352	2,926	3,800
Difference	-157	-255	-251	-545	-873	945	684	138	399	85	8	235
Percent Difference[3]	-6.9	-6.7	-4.3	-6.2	-9.6	15.4	14.0	2.4	7.1	2.6	0.3	6.6
Above Normal												
Baseline Condition (J604 FLD)	1,927	3,847	3,347	6,150	6,836	5,680	3,154	2,982	2,520	3,702	2,355	3,136
Proposed Action (J602F3 FLD)	1,865	3,578	3,190	5,428	6,849	5,914	3,463	3,214	2,970	3,989	2,175	3,280
Difference	-62	-269	-157	-722	13	234	309	232	450	287	-180	144
Percent Difference[3]	-3.2	-7.0	-4.7	-11.7	0.2	4.1	9.8	7.8	17.9	7.8	-7.6	4.6
Below Normal												
Baseline Condition (J604 FLD)	2,031	2,401	2,290	2,337	3,873	2,574	2,807	3,009	2,447	3,890	2,144	1,609
Proposed Action (J602F3 FLD)	1,878	2,392	2,358	2,331	3,589	2,625	3,018	2,996	2,550	4,447	1,914	1,572
Difference	-153	-9	68	-6	-284	51	211	-13	103	557	-230	-37
Percent Difference[3]	-7.5	-0.4	3.0	-0.3	-7.3	2.0	7.5	-0.4	4.2	14.3	-10.7	-2.3
Dry												
Baseline Condition (J604 FLD)	1,948	2,464	1,807	1,680	1,832	2,280	1,530	1,430	1,853	3,020	1,773	1,440
Proposed Action (J602F3 FLD)	1,892	2,397	1,823	1,748	1,663	1,752	1,776	1,722	2,178	3,009	1,811	1,436
Difference	-56	-67	16	68	-169	-528	246	292	325	-11	38	-4
Percent Difference[3]	-2.9	-2.7	0.9	4.0	-9.2	-23.2	16.1	20.4	17.5	-0.4	2.1	-0.3
Critical												
Baseline Condition (J604 FLD)	1,661	1,941	1,374	1,168	1,109	1,060	996	1,216	1,426	1,484	1,133	921
Proposed Action (J602F3 FLD)	1,661	1,969	1,418	1,229	1,127	1,064	1,156	1,285	1,432	1,493	1,184	986
Difference	0	28	44	61	18	4	160	69	6	9	51	65
Percent Difference[3]	0.0	1.4	3.2	5.2	1.6	0.4	16.1	5.7	0.4	0.6	4.5	7.1

1 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995)

2 Based on the entire simulation period

3 Relative difference of the monthly average

/4 Net changes in exceedance are shaded in blue when the resulting difference values for the following parameters are positive and are shaded in red when they are negative for the following parameters: (1) riverine flow parameters; (2) Delta outflow; (3) water temperature ranges (i.e., frequency of occurring within the range); and (4) frequency of X2 occurring within a range or less than a specific criterion. Only differences of more than 1 percent change were shaded. Modeled changes of 1 percent or less are within the error limits of the modeling.

Exceedance values were calculated for flows in the American River and are summarized in Tables 7 and 8.

Table 7. Monthly Probability Changes in Flow of 10 percent or More for All Water Years below Nimbus Dam, at Watt Avenue and at the Mouth of the Lower American River (Corps 2018). Blue shading indicates more favorable conditions, and red shading less favorable conditions with implementation of the updated Folsom WCM. /1

Indicator of Potential Impact	**Location**	**Metric**	**Range**	**Net Change in Probability of Exceedance under the Proposed Action (Scenario J602F3 FLD) Relative to the Baseline (Scenario J604 FLD) (Percent)**											
	Description	**%**		**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Mean Daily Flow (cfs)	American River below Nimbus Dam	10	All Years	-2	6	7	-3	-25	33	54	37	42	29	6	17
	American River at Watt Avenue	10	All Years	-2	8	6	-3	-26	33	53	37	41	33	6	17
	Mouth of the American River (RM 1)	10	All Years	0	7	1	-5	-24	28	53	38	41	33	7	18

/1 Net changes in exceedance are shaded in blue when the resulting difference values for the following parameters are positive and are shaded in red when they are negative for the following parameters: (1) riverine flow parameters; (2) Delta outflow; (3) water temperature ranges (i.e., frequency of occurring within the range); and (4) frequency of X2 occurring within a range or less than a specific criterion.

Note: the unit for net change in probability of exceedances is the net number of occurrences on an exceedance plot that differences in flow exceedance were greater than +10% above baseline condition flows minus the number of occurrences where differences in flow exceedance were greater than -10%.

Table 8. Monthly Probability Changes in Flow of 10 percent or More during Low Flow Conditions below Nimbus Dam, at Watt Avenue and at the Mouth of the Lower American River (Corps 2018). Blue shading indicates more favorable conditions, and red shading less favorable conditions with implementation of the updated Folsom WCM. /1

Indicator of Potential Impact	**Location**	**Metric**	**Range**	**Net Change in Probability of Exceedance under the Proposed Action (Scenario J602F3 FLD) Relative to the Baseline (Scenario J604 FLD) (Percent)**											
	Description	**%**		**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Mean Daily Flow (cfs)	American River below Nimbus Dam	10	Lower 40%	10	7	4	4	-4	13	56	54	18	11	9	10
	American River at Watt Avenue	10	Lower 40%	10	7	4	5	-4	13	55	54	20	15	9	10
	Mouth of the American River (RM 1)	10	Lower 40%	13	7	1	6	0	12	53	55	19	17	8	10

/1 Net changes in exceedance are shaded in blue when the resulting difference values for the following parameters are positive and are shaded in red when they are negative for the following parameters: (1) riverine flow parameters; (2) Delta outflow; (3) water temperature ranges (i.e., frequency of occurring within the range); and (4) frequency of X2 occurring within a range or less than a specific criterion.

Note: the unit for net change in probability of exceedances is the net number of occurrences on an exceedance plot that differences in flow exceedance were greater than +10% above baseline condition flows minus the number of occurrences where differences in flow exceedance were greater than -10%.

Generally, the modeling shows small reductions in flows in wet to dry years from October through February. Generally, for March through September the proposed action results in higher flows, in all water year types. These changes are due to conservation storage starting during the spring refill of Folsom Reservoir on average at a higher storage than without the proposed action. The proposed action allows more storage in the first part of the water year. This allows the reservoir to reach its maximum amount of storage more frequently. With the reservoir full more frequently, the flows released in the second half of the water year tend to be higher than the baseline operations, because more water is available more frequently.

The modeling with the proposed action identified that in dry years, in March, flows would be 23.2 percent lower. This is due to the modeling for the proposed action set to maximize storage, to obtain the best possible water temperature over the summer for rearing CCV steelhead. Additionally, the proposed action has more space designated for conservation storage than the baseline condition.

As with the CVP/SWP operations on the Sacramento River and the Feather River, there is a technical team of agencies [American River Group (ARG)] that work with Reclamation on the American River to achieve temperature and flow criteria. Other stakeholders are also part of the ARG. One of the objectives for managing the American River is to maintain the best possible water temperatures for CCV steelhead at Watt Avenue Bridge. The 2009 biological opinion for the long-term operation of CVP/SWP identified minimum flows and water temperature objectives (NMFS 2009).

Based on the above modeling information, and the additional processes and measures identified in the CVP/SWP biological opinion to achieve the minimum flows, and ramping rates for juvenile CCV steelhead, the proposed action's flow modifications are not expected to result in decreased survival of juvenile CCV steelhead in the American River.

American River Flows affecting CCV Steelhead Redds/Spawning Gravel

NMFS looked at changes in flow events and how those changes could affect CCV steelhead eggs and alevins. The area that was assessed for spawning gravel scour as a result of proposed action flows was from river mile 15 to 23 (Ancil Hoffman Park to Nimbus Dam). The American River downstream of river mile 15 is low gradient and does not have suitable conditions for CCV steelhead spawning, and it is an area where gravel deposition is occurring now and is expected to occur in the future, with or without the proposed action. In addition, most CCV steelhead spawning occurs upstream of river mile 15. Scour can have two negative effects: 1) displacement or crushing of eggs and alevins from the gravel and 2) depletion of spawning gravel. Depletion of spawning-sized gravel can reduce the amount of spawning habitat available for CCV steelhead long-term. Because no new gravel can pass by the dams, the lack of natural spawning gravel movement occurs initially in rivers just downstream of the dams, such as Nimbus Dam. Over time the depletion of spawning gravels extends further downstream.

Steelhead have been observed spawning in river miles 15 through 23, and where velocities and depths provide suitable CCV steelhead spawning conditions. The Corps' analyses (2018) identified that the substrate (all material sizes) across the width of the river mobilizes at flows greater than 50,000 cfs, and that spawning gravels (0.25- 5 inches) in some locations in the American River begin to move at flows of 30,000 cfs.

Short-term impacts of spawning gravel scour can result in the loss of CCV steelhead eggs and alevins for that spawning season. Eggs that are mobilized are highly likely to die. Death can occur due to exposure to light, physical shock, injury, and predation. Similarly, young fish that have not yet absorbed their yolk sacs (alevins) that are prematurely forced out of the gravel are likely to die from physical injury, and predation because they cannot swim well to seek cover.

Table 9 provides information regarding the number of days that flows would occur within 10,000 cfs range increments for the baseline and proposed action conditions. This is based on daily average flow. Daily average flows may not represent all flows that can create scour that may result in the loss of steelhead eggs or alevins.

Table 9. Modeled Average Daily Discharge Frequencies for Baseline and Proposed Action – 82-year period of record (Corps 2018).

Discharge Range (cfs)	Baseline Discharge Frequencies (# of days)	Proposed Action Discharge Frequencies (# of days)	Change with proposed action (# of days)
< 10,000	28,388	28,348	-40
10,000 to < 20,000	830	967	137
20,000 to < 30,000	202	147	-55
30,000 to < 40,000	109	40	-69
40,000 to < 50,000	22	39	17
50,000 to < 60,000	8	15	7
60,000 to < 70,000	6	3	-3
70,000 to < 80,000	4	11	7
80,000 to < 90,000	1	3	2
90,000 to < 100,000	2	1	-1
100,000 to 115,000	6	4	-2

The information in Table 9 is based on the duration of flows within a range. To better determine the effects of peak flows, NMFS looked at when those peak flow events occur, and their magnitude. Peak flow events that occurred outside the incubation period (January 1 through May 31) would not result in redd scour, or mortality of eggs and alevins. Table 10 provides timing and magnitude information about modeled peak flows that exceeded 30,000 cfs under the updated Folsom WCM, during the steelhead egg incubation period.

Based on peak flows, NMFS and the Corps identified flow events within the CCV steelhead egg incubation period for the time period of 1921 to 2002 that would exceed 30,000 cfs under the updated Folsom WCM. This resulted in 38 flow events over 30,000 cfs. For the flow range of 30,000 cfs to 40,000 cfs, the proposed action resulted in 6 occurrences. For flows between 40,000 cfs and 50,000 cfs, the proposed action resulted in 16 occurrences. For flows between 50,000 and 60,000 cfs there were 7 occurrences. For flows between 60,000 and 70,000 cfs there were 5 occurrences. For flows above 70,000 cfs there were 4 occurrences.

	E504							J602F3 ELD							
Occ #	Start Date		End Date		Duration (hours)	Peak Q (cfs)	Occ #	Start Date		End Date		Duration (hours)	Peak Q (cfs)	Delta (Peak Q) J602F3 - E504	Legend
1	2/21/1927	6:00	2/24/1927	7:00	73	35,416	1	2/21/1927	7:00	2/22/1927	23:00	39	53,736	18,320	Same Storm Release, Same Start Date
2	3/26/1928	18:00	3/30/1928	1:00	79	73,736									Same Storm Release, Different Start Date
							2	3/27/1928	8:00	3/29/1928	15:00	55	65,685	(8,051)	Different Storm Release >30Kcfs
	4/9/1935	1:00	4/10/1935	6:00		27,838	3	4/8/1935	19:00	4/9/1935	15:00	20	49,934	22,096	Same Storm, Flows <30Kcfs but >20Kcfs
3	2/22/1936	11:00	2/25/1936	1:00	62	36,343	4	2/22/1936	14:00	2/24/1936	7:00	41	50,424	14,081	Peak Q Increase from <50kcfs to >50kcfs
4	12/12/1937	8:00	12/13/1937	1:00	17	30,592	5	12/12/1937	5:00	12/12/1937	21:00	16	40,513	9,921	
5	2/28/1940	2:00	3/2/1940	12:00	82	45,901	6	2/28/1940	6:00	3/1/1940	16:00	58	59,890	13,989	
6	3/30/1940	2:00	4/2/1940	4:00	74	56,817	7	3/30/1940	2:00	4/1/1940	10:00	56	66,092	9,275	
7	1/27/1942	21:00	1/29/1942	21:00	48	43,141	8	1/27/1942	8:00	1/28/1942	22:00	38	57,624	14,483	
8	2/6/1942	11:00	2/7/1942	4:00	17	30,800	9	2/6/1942	11:00	2/7/1942	2:00	15	30,800	-	
9	1/23/1943	9:00	1/25/1943	13:00	52	43,136	10	1/23/1943	11:00	1/25/1943	1:00	38	42,924	(212)	
10	3/9/1943	13:00	3/13/1943	10:00	93	46,009	11	3/9/1943	10:00	3/11/1943	20:00	58	68,416	22,407	
11	2/3/1945	1:00	2/4/1945	20:00	43	48,068	12	2/3/1945	5:00	2/4/1945	11:00	30	46,576	(1,492)	
12	12/29/1945	3:00	12/30/1945	3:00	24	31,748	13	12/29/1945	3:00	12/30/1945	1:00	22	32,949	1,201	
13	12/4/1950	3:00	12/12/1950	9:00	189	30,699									
							14	12/8/1950	2:00	12/10/1950	3:00	49	51,834	21,135	
	1/22/1951	14:00	1/25/1951	1:00		29,593	15	1/22/1951	21:00	1/23/1951	17:00	20	45,943	16,350	
14	12/23/1955	10:00	12/29/1955	10:00	144	94,993	16	12/23/1955	6:00	12/27/1955	18:00	108	79,998	(14,995)	
15	1/15/1956	4:00	1/18/1956	18:00	86	31,231	17	1/15/1956	4:00	1/16/1956	23:00	43	48,894	17,663	
16	2/25/1958	22:00	2/26/1958	8:00	10	31,759		2/25/1958	18:00	2/26/1958	18:00		27,879	(3,880)	
17	4/2/1958	16:00	4/4/1958	4:00	34	41,507	18	4/2/1958	16:00	4/3/1958	24:00:00	31	41,508	1	
	2/3/1963	4:00	2/15/1963	17:00		22,557	19	2/1/1963	24:00:00	2/4/1963	18:00	66	48,629	26,072	
	4/7/1963					4,850	20	4/7/1963	7:00	4/8/1963	3:00	20	31,560	26,710	
18	12/23/1964	15:00	12/30/1964	19:00	172	114,983	21	12/23/1964	14:00	12/28/1964	8:00	114	79,989	(34,994)	
19	1/5/1965	23:00	1/9/1965	4:00	77	30,350									
							22	1/6/1965	3:00	1/7/1965	15:00	36	44,428	14,078	
							23	1/20/1969	18:00	1/27/1969	9:00	131	52,035	(3,988)	
20	1/21/1969	9:00	1/29/1969	1:00	184	56,023									
21	1/16/1970	9:00	1/27/1970	4:00	235	49,379									
							24	1/20/1970	2:00	1/25/1970	6:00	124	49,944	565	
22	1/16/1973	21:00	1/17/1973	5:00	8	31,489	25	1/16/1973	21:00	1/17/1973	5:00	8	31,489	-	
23	1/17/1974	10:00	1/18/1974	24:00:00	38	32,539	26	1/17/1974	10:00	1/18/1974	4:00	18	36,672	4,133	
24	3/2/1974	8:00	3/3/1974	16:00	32	30,918	27	3/2/1974	12:00	3/3/1974	13:00	25	38,047	7,129	
25	3/30/1974	12:00	3/30/1974	24:00:00	8	31,865	28	3/30/1974	11:00	3/31/1974	14:00	27	32,045	180	
							29	1/12/1980	13:00	1/17/1980	10:00	113	79,947	9,359	
26	1/13/1980	6:00	1/19/1980	19:00	157	70,588									
27	2/19/1980	13:00	2/24/1980	24:00:00	131	30,841	30	2/19/1980	20:00	2/22/1980	8:00	60	48,877	18,036	
28	12/20/1981	13:00	12/24/1981	1:00	84	35,698									
							31	12/21/1981	2:00	12/23/1981	5:00	51	53,536	17,838	
	1/4/1982	18:00	1/6/1982	14:00		29,832	32	1/5/1982	2:00	1/6/1982	1:00	23	36,649	6,817	
29	2/15/1982	20:00	2/19/1982	3:00	79	32,081	33	2/15/1982	18:00	2/17/1982	24:00:00	54	83,103	51,022	
	4/3/1982	5:00	4/4/1982	22:00		23,393	34	3/31/1982	15:00	3/31/1982	24:00:00	9	32,582	9,189	
30	4/12/1982	8:00	4/14/1982	11:00	51	49,917	35	4/12/1982	2:00	4/14/1982	9:00	55	58,067	8,150	
31	12/23/1982	3:00	12/24/1982	13:00	34	39,954	36	12/23/1982	3:00	12/24/1982	9:00	30	40,131	177	
32	3/13/1983	11:00	3/16/1983	19:00	80	47,056	37	3/13/1983	10:00	3/15/1983	3:00	41	70,942	23,886	
33	12/26/1983	10:00	12/31/1983	4:00	114	30,598	38	12/26/1983	20:00	12/28/1983	12:00	40	49,919	19,321	
							39	2/14/1986	14:00	2/21/1986	18:00	172	115,021	6	
34	2/15/1986	23:00	2/25/1986	5:00	222	115,015									
35	3/8/1986	17:00	3/12/1986	19:00	98	30,672	40	3/8/1986	8:00	3/9/1986	21:00	37	68,507	37,835	
36	1/14/1995	1:00	1/16/1995	2:00	49	35,311	41	1/14/1995	1:00	1/15/1995	14:00	37	44,698	9,387	
37	3/10/1995	18:00	3/23/1995	19:00	146	45,588	42	3/10/1995	17:00	3/14/1995	10:00	89	58,861	13,273	
	3/23/1995	13:00				31,398	43	3/23/1995	4:00	3/23/1995	15:00	9	31,412	14	
38	5/1/1995	8:00	5/1/1995	24:00:00	16	44,794	44	5/1/1995	9:00	5/1/1995	24:00:00	15	44,793	(1)	
39	2/5/1996	18:00	2/7/1996	11:00	41	41,645	45	2/5/1996	20:00	2/6/1996	19:00	23	46,386	4,741	
40	12/12/1996	6:00	12/15/1996	21:00	87	31,427	46	12/12/1996	15:00	12/13/1996	9:00	18	44,377	12,950	
41	12/30/1996	5:00	1/8/1997	1:00	212	114,968	47	12/30/1996	2:00	1/4/1997	22:00	140	114,975	7	
42	1/26/1997	22:00	1/29/1997	14:00	64	30,282	48	1/26/1997	14:00	1/28/1997	19:00	53	62,261	31,979	
43	2/3/1998	17:00	2/4/1998	17:00	24	39,731	49	2/3/1998	17:00	2/4/1998	13:00	20	42,825	3,094	
44	2/9/1999	5:00	2/10/1999	20:00	39	31,549	50	2/9/1999	7:00	2/10/1999	11:00	28	45,343	13,794	
45	2/14/2000	20:00	2/16/2000	18:00	46	38,199									
							51	2/15/2000	2:00	2/16/2000	2:00	24	40,896	2,697	

Table 10. Flow events in the American River in which the modeled proposed action resulted in peak flows exceeding 30,000 cfs (Artho 2018b)

Figure 2 shows a modeling information regarding a February 1982 event. For the period analyzed, the February 1982 event is the most extreme increase in flows when comparing the modeled proposed action (red lines) to the modeled baseline condition (blue lines). This event occurred when CCV steelhead would have been spawning and CCV steelhead eggs would be in the gravel. With steelhead spawning starting at the beginning of January, the event at the end of February would result in flows of about 30,000 cfs under the baseline condition, and over 80,000 cfs under the proposed action. With gravel scour starting at about 30,000 cfs, and bedload movement occurring at 50,000 (Corps 2018), the modeled proposed action would result in significantly greater negative effects to incubating CCV steelhead eggs than the conditions modeled under baseline conditions.

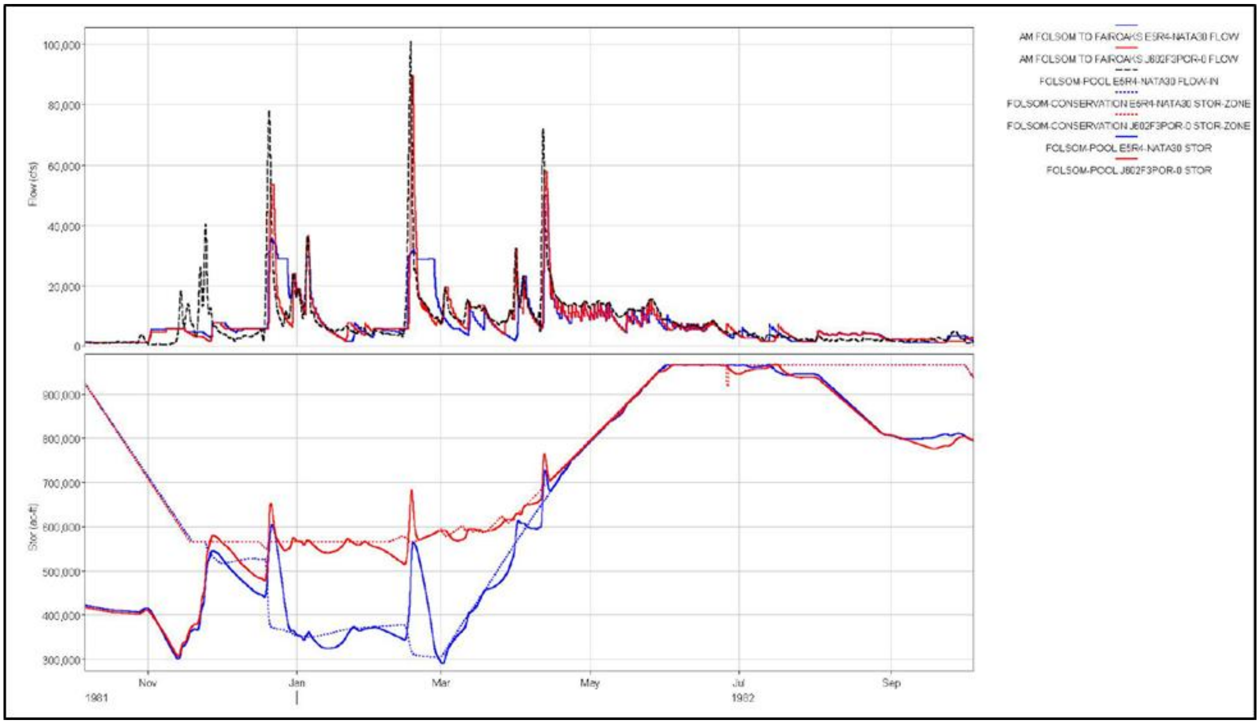

Figure 2. Information for Water Year 1982 American River Flows and Folsom Lake Water Elevations. In Figure 2, the upper graph shows the modeled flows released from Folsom Dam. The lower graph is the elevations of Folsom Reservoir. The blue lines are the modeled results for the baseline condition, and the red lines are the modeled results for the proposed action. In the upper graph, the dashed black line is inflow to Folsom Reservoir. In the lower graph the dashed red and blue lines identify the conservation storage zones (Artho 2018a).

In the case of the February 1982 event, under the baseline condition, the current Folsom WCM required a much lower water elevation than under the proposed action. This allowed for more space to store water than under the proposed action. However, under the proposed action, there still would have been about 200,000 acre feet of storage space available. It also appears that with the proposed action, weather information should be available earlier than when the flows were first increased. This would allow water to be released earlier than under the baseline condition. That is not reflected in the model results. With hindsight, it appears that it was about 2 weeks before another increase in flows into Folsom Reservoir occurred. This appears to be reflected in the flows under the baseline condition that were kept elevated for several days versus about 2 days under the proposed action.

The modeling shows that the proposed action will result in a number of peak flow events. The peak flow events are more important in analyzing redd scour than the duration, because once a redd is scoured, regarding injury and mortality to eggs and alevins, it does not matter how long the flows stay at that level. The modeling identified that with the proposed action 38 flow events over 30,000 would occur in the 81 years analyzed. In some years there was more than one event, and in other years there were no flow events over 30,000 cfs.

The proposed action will result in peak flow events in excess of 30,000 cfs that will result in redd scour, which will result in death and injury to CCV steelhead eggs and alevins.

It not possible to precisely quantify the number of individual CCV steelhead that will be present at any given time, due to the varying population size (annual and seasonal), variations in fecundity, annual variations in the timing of spawning and alevins emergence, and variations in habitat use. Due to CCV steelhead spawning data in the American River being incomplete, due to high flows and turbidity; CCV steelhead spawning timing being highly variable; and for some years the majority of the steelhead spawning in the American River are non-local non-ESA listed hatchery steelhead spawning in the American River, it is very difficult to estimate the spawning timing for CCV steelhead in the American River. CCV steelhead begin spawning at the beginning of January. Spawning is completed in early April and incubation and emergence is complete by the end of May.

In addition to the uncertainty identified above, there is uncertainty regarding when flow events in excess of 30,000 cfs will occur. The modeling identified that flow events greater than 30,000 cfs can occur as early as December 4, and as late as May 1. The occurrence of these events is dependent on weather conditions. Flow events that result in redd scour will result in variable amounts of egg and alevins mortalities, depending on the timing of spawning and the timing and magnitude of flow events.

The proposed action incorporates measures to minimize the occurrence of flow events over 30,000 cfs. It was not possible to include this in the modeling. The modeling does show that the proposed action is expected to reduce the number of natural flow events that would be greater than 30,000 cfs. However, Folsom Lake has limited space to store water from high inflow events. The modeling shows that the proposed action will result in a number of flows greater than 30,000 cfs. These flows will result in the scour of CCV steelhead redds. The scour of redds will result in mortalities of CCV steelhead eggs and alevins. Years in which multiple flow events occur spread out over the incubation period are expected to result in the loss of a high percentage of the CCV steelhead eggs production for that year. For years with only one flow event in excess of 30,000 cfs, the extent of the loss of CCV steelhead eggs and alevins may be very low, but will depend upon the timing of the spawning and incubation, and the timing of the flow event. For years with more than one flow event over 30,000 cfs, the loss of CCV steelhead eggs and alevins will depend on the factors identified above and how close the events are to each other. Over the 81 years that were modeled for the proposed action, 27 years had flows during CCV steelhead incubation that exceeded 30,000 cfs. Nine of these years had multiple flow events in excess of 30,000 cfs. Both 1982 and 1995 had 4 flow events in excess of 30,000 cfs. The modeling of the proposed action has identified that in one 10-year period, 9 flow events over 30,000 cfs occurred. During this period, 3 of the events were modeled to be less than 32,000 cfs with the existing Folsom WCM, but only 1 was modeled to be less than 32,000 cfs with the updated Folsom WCM. The information provided to NMFS indicates that Folsom Dam could be operated to reduce the peak flows in the 3 years in which flows were over 30,000 cfs, but less than 32,000 cfs.

American River Water Temperatures affecting CCV steelhead

Several factors influence water temperature in the lower American River. These include the amount of snow and timing of snow melt, the temperature of water entering Folsom Lake, when

Folsom Lake stratifies, releases from Folsom Dam, management of the temperature shutters, air temperatures, and when Folsom Lake fills. These factors affect the volume of the cold water pool in Folsom Lake. The volume of the cold water pool and how releases are made from Folsom Dam are the variables that have the largest effect on the water temperature in the lower American River. The NMFS biological opinion (2009) and amended RPA (2011a) for the operations of the CVP/SWP identify a temperature compliance location on the American River at the Watt Avenue Bridge. The temperature management goal is to not exceed 65°F at Watt Avenue. Due to the variables identified above, it is often not possible to achieve this goal. Each year Reclamation provides NMFS with a temperature management plan for the American River. This plan identifies the lowest possible water temperature that can be achieved over the summer, based on the information available at the time of the plan. This plan is usually modified over the summer and into the fall, as new information becomes available.

Table 11 provides a summary of end-of-month storage conditions by water year type, which is generally proportional to the amount of cold water pool. The changes in end of month storage volume are very slight between the updated Folsom WCM and the baseline condition, and for most months and most water year types result in an increase in storage.

Table 12 provides a summary of the modeled water temperatures under the proposed action and the baseline condition. With the proposed action temperature output from the model shows little change in temperature, with a slight decrease in water temperature in the second half of the water year. The second half of the water year is when temperatures often exceed the criterion identified in the biological opinion for CVP/SWP operations (NMFS 2009, 2011a). Table 13 provides information regarding water temperature exceedances. The results in Tables 12 and 13 indicate little change in water temperatures from the baseline condition to the proposed action in the American River.

Table 11. Folsom Reservoir End-of-Month Storage Volumes – Baseline and Proposed Action (Corps 2018). Blue shading indicates more favorable conditions, and red shading less favorable conditions with implementation of the updated Folsom WCM.

	Average Storage (TAF)											
Analysis Period	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Long-term												
Full Simulation Period[2]												
Baseline Condition (J604 FLD)	468	423	437	457	478	585	709	827	797	654	582	511
Proposed Action (J602F3 FLD)	469	429	451	482	527	616	724	836	805	661	588	514
Difference	1	6	14	25	49	31	15	9	8	7	6	3
Percent Difference[3]	0.2	1.4	3.2	5.5	10.3	5.3	2.1	1.1	1.0	1.1	1.0	0.6
Water Year Types[1]												
Wet												
Baseline Condition (J604 FLD)	493	451	493	504	490	621	781	953	951	861	758	629
Proposed Action (J602F3 FLD)	495	462	527	562	598	663	792	961	959	868	765	629
Difference	2	11	34	58	108	42	11	8	8	7	7	0
Percent Difference	0.4	2.4	6.9	11.5	22.0	6.8	1.4	0.8	0.8	0.8	0.9	0.0
Above Normal												
Baseline Condition (J604 FLD)	457	391	410	490	510	636	786	955	925	725	659	541
Proposed Action (J602F3 FLD)	461	410	433	533	576	688	808	966	934	733	666	546
Difference	4	19	23	43	66	52	22	11	9	8	7	5
Percent Difference	0.9	4.9	5.6	8.8	12.9	8.2	2.8	1.2	1.0	1.1	1.1	0.9
Below Normal												
Baseline Condition (J604 FLD)	486	449	445	488	537	626	774	908	882	661	611	590
Proposed Action (J602F3 FLD)	484	446	441	484	559	648	787	914	885	665	617	596
Difference	-2	-3	-4	-4	22	22	13	6	3	4	6	6
Percent Difference	-0.4	-0.7	-0.9	-0.8	4.1	3.5	1.7	0.7	0.3	0.6	1.0	1.0
Dry												
Baseline Condition (J604 FLD)	464	427	435	433	475	580	680	746	678	511	446	423
Proposed Action (J602F3 FLD)	466	429	435	433	484	608	707	766	695	521	454	430
Difference	2	2	0	0	9	28	27	20	17	10	8	7
Percent Difference	0.4	0.5	0.0	0.0	1.9	4.8	4.0	2.7	2.5	2.0	1.8	1.7
Critical												
Baseline Condition (J604 FLD)	408	356	336	325	351	413	441	452	414	343	296	267
Proposed Action (J602F3 FLD)	411	358	338	326	352	414	442	453	416	343	293	264
Difference	3	2	2	1	1	1	1	1	2	0	-3	-3
Percent Difference	0.7	0.6	0.6	0.3	0.3	0.2	0.2	0.2	0.5	0.0	-1.0	-1.1

1 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995)
2 Based on the 82-year simulation period
/4 3 Relative difference of the monthly average

/4 Net changes in exceedance are shaded in blue when the resulting difference values for reservoir volumes are positive and are shaded in red when they are negative. Only differences of more than 1 percent change were shaded. Modeled changes of 1 percent or less are within the error limits of the modeling.

Table 12. Long-term Water Year Type Average Lower American River Temperature at Watt Avenue under Baseline and Proposed Action Conditions (Corps 2018). Blue shading indicates more favorable conditions, and red shading less favorable conditions with implementation of the updated Folsom WCM. /3

Analysis Period	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Average Temperature (ºF)											
Long-term												
Full Simulation Period[2]												
Baseline Condition (J604 FLD)	62.6	56.5	49.8	46.5	47.7	52.1	57.2	61.8	65.6	68.1	67.8	66.8
Proposed Action (J602F3 FLD)	62.6	56.5	49.8	46.5	47.8	51.9	57.0	61.1	65.0	67.8	67.3	66.5
Difference	0.0	0.0	0.0	0.0	0.1	-0.2	-0.2	-0.7	-0.6	-0.3	-0.5	-0.3
Water Year Types[1]												
Wet												
Baseline Condition (J604 FLD)	62.1	56.4	49.3	46.0	46.7	50.5	54.5	58.9	62.1	66.6	65.3	64.2
Proposed Action (J602F3 FLD)	62.2	56.4	49.3	46.0	46.7	50.2	54.5	58.5	61.8	66.5	64.7	63.9
Difference	0.1	0.0	0.0	0.0	0.0	-0.3	0.0	-0.4	-0.3	-0.1	-0.6	-0.3
Above Normal												
Baseline Condition (J604 FLD)	62.1	56.3	50.2	46.8	47.4	50.7	55.9	60.9	64.8	67.2	66.7	65.6
Proposed Action (J602F3 FLD)	62.1	56.2	50.2	46.8	47.4	50.5	55.9	60.0	64.1	66.7	66.2	65.4
Difference	0.0	-0.1	0.0	0.0	0.0	-0.2	0.0	-0.9	-0.7	-0.5	-0.5	-0.2
Below Normal												
Baseline Condition (J604 FLD)	61.5	55.7	50.1	46.6	47.3	51.6	57.4	61.4	65.9	66.9	67.4	67.0
Proposed Action (J602F3 FLD)	61.6	55.7	50.1	46.7	47.3	51.7	57.1	61.0	65.5	66.5	67.2	66.7
Difference	0.1	0.0	0.0	0.1	0.0	0.1	-0.3	-0.4	-0.4	-0.4	-0.2	-0.3
Dry												
Baseline Condition (J604 FLD)	63.4	56.8	49.9	46.6	48.3	53.1	58.8	64.3	68.2	68.1	69.1	68.4
Proposed Action (J602F3 FLD)	63.4	56.8	49.9	46.6	48.3	53.2	58.5	62.9	67.1	67.9	68.6	68.2
Difference	0.0	0.0	0.0	0.0	0.0	0.1	-0.3	-1.4	-1.1	-0.2	-0.5	-0.2
Critical												
Baseline Condition (J604 FLD)	63.9	57.3	50.2	47.0	50.1	55.7	61.3	65.5	69.9	73.7	72.7	70.7
Proposed Action (J602F3 FLD)	63.7	57.2	50.3	47.1	50.0	55.0	60.7	65.0	69.3	73.0	72.0	70.4
Difference	-0.2	-0.1	0.1	0.1	-0.1	-0.7	-0.6	-0.5	-0.6	-0.7	-0.7	-0.3

1 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995)

2 Based on the entire simulation period

/3 Net changes in exceedance are shaded in blue when the resulting difference values for water temperature are positive and are shaded in red when they are negative.. Only differences of more than 0.3 degrees F change were shaded. Modeled changes of 0.3 degrees F are within the error limits of the modeling.

Table 13. Net Difference in Water Temperature Index Value Exceedance Probabilities for Steelhead in the American River (Corps 2018). J602F3 is the proposed action and J604 is the baseline condition, blue shading indicates more favorable conditions, and red shading less favorable conditions, gray shading is a time when the life stage is not present). /1

Lifestage	Evaluation Period	Indicator of Potential Impact	Location Description	Metric Value (°F)	Metric %	Range	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
							Net Change in Probability of Exceedance under J602F3 FLD relative to J604 FLD (percent)											
Adult Immigration	November through March	Mean Daily Water Temperature (°F)	American River at Watt Avenue	64		All Years		0	0	0	0	0						
				68		All Years		0	0	0	0	0						
			Mouth of the American River (RM 1)	64		All Years		0	0	0	0	0						
				68		All Years		0	0	0	0	0						
Adult Holding	November through March	Mean Daily Water Temperature (°F)	American River below Nimbus Dam	61		All Years		0	0	0	0	0						
				65		All Years		0	0	0	0	0						
			American River at Watt Avenue	61		All Years		-1	0	0	0	0						
				65		All Years		0	0	0	0	0						
Adult Spawning	January through mid-April	Mean Daily Water Temperature (°F)	American River below Nimbus Dam	54		All Years				0	0	0	6					
				57		All Years				0	0	0	0					
			American River at Watt Avenue	54		All Years				0	0	-1	6					
				57		All Years				0	0	-2	0					
Embryo Incubation	January through May	Mean Daily Water Temperature (°F)	American River below Nimbus Dam	54		All Years				0	0	0	2	-1				
				57		All Years				0	0	0	-2	-4				
			American River at Watt Avenue	54		All Years				0	0	-1	-1	0				
				57		All Years				0	0	-2	-2	-4				
Juvenile Rearing and Downstream Movement	Year-round	Mean Daily Water Temperature (°F)	American River below Nimbus Dam	65		All Years	-1	0	0	0	0	0	0	-2	-5	-5	-4	-3
				68		All Years	0	0	0	0	0	0	0	0	-1	-2	-1	-2
			American River at Watt Avenue	65		All Years	0	0	0	0	0	0	-1	-6	-4	-1	-5	-3
				68		All Years	0	0	0	0	0	0	-1	-3	-5	-7	-7	-5
			Mouth of the American River (RM 1)	65		All Years	0	0	0	0	0	0	-2	-7	-5	-1	-1	-1
				68		All Years	-1	0	0	0	0	0	-1	-7	-5	-5	-5	-5
Smolt Emigration	December through April	Mean Daily Water Temperature (°F)	American River at Watt Avenue	52		All Years			0	0	0	-3	2					
				55		All Years			0	0	0	-1	-2					
			Mouth of the American River (RM 1)	52		All Years			1	0	0	-1	1					
				55		All Years			-1	0	0	-2	-2					

/1 Net changes in exceedance are shaded in blue when the resulting difference values for water temperature are positive and are shaded in red when they are negative. Only differences of more than 1 percent change were shaded. Modeled changes of 1 percent or less are within the error limits of the modeling.

Table 13 identifies an increased probability in April of water temperatures for spawning exceeding 54 degrees F up to 6 percent of years. Fifty-four degrees represents the upper optimum temperature. The modeling also shows that for the same month that water temperatures are unlikely to exceed 57 degrees F, the upper tolerance threshold for spawning CCV steelhead. Together this information identifies that the water temperatures will be below 57 degrees in all years, and in 94 percent of the years the water temperature will be less than 54 degrees F. These water temperatures are not expected to result in injury to CCV steelhead.

Therefore, with end of month storage being similar or more, and with modeled water temperatures in the American river being similar to existing conditions or cooler, the proposed action is generally not expected to result in water temperatures in the American River that will result in adverse effects to CCV steelhead. Modeling shows cooler water temperatures in some months, which will be beneficial to juvenile CCV steelhead rearing in the American River.

Proposed Action resulting in juvenile CCV Steelhead Stranding in the American River

As identified above, stranding can result in mortalities of CCV steelhead. Usually, juvenile CCV steelhead is the life history stage most susceptible to stranding. Stranding is a result of reductions in water elevations, due to changes in flows. When the flows are decreased rapidly, fish cannot follow the receding water, and end up out of water and dying on the stream bank. Down ramping rates slow the rate of change in the stream water elevation decline, allowing juvenile fish to swim away from areas vulnerable to stranding as they follow the receding water levels. If the drop in water elevation is slow, fish have the opportunity to follow the receding water and avoid being stranded. Ramping rates that are protective of fish vary by species and the size of the fish. Typically, larger fish inhabit deeper water and are not as susceptible to stranding. Ramping rates only provide protection from gravel bar stranding, but not from stranding in isolation pools. Ramping rates only provide protection for fish when flows are within the banks of the stream. The proposed action will not change the ramping rates for the operation of Folsom Dam. Therefore, the proposed action is not expected to increase the exposure of CCV steelhead to stranding.

2.5.4 Potential Adverse Effects to Designated CCV Steelhead Critical Habitat in the American River

Modeling of available habitat was done on a monthly basis, due to potential daily fluctuations in factors that affect the amount of habitat available to a fish species life stage. Based on the modeling results above, there appears to be little to no change in water temperatures or monthly flows with the implementation of the proposed action. Therefore, the proposed action is expected to have little or no effect related to flow or water temperature on the amount of habitat available to CCV steelhead in the American River.

While monthly average flow provides a good metric for comparing the amount of habitat that is available, it does not provide a good measure of the effects of peak flows. The primary adverse effect from peak flows is scour, or movement of the gravel on the river bottom. The analysis of the difference between the baseline condition peak flows and the peak flows with the updated Folsom WCM greater than 30,000 cfs identified that many peak flow events would be greater with the updated Folsom WCM. The analysis identified that scour of CCV steelhead spawning gravel over the 82 years analyzed showed an average increase in the erosion of spawning gravel of 270 short tons (2,000 pounds/short ton) per year under the proposed action. The annual supplementation of $20,000 for 15 years to augment the existing gravel augmentation program by approximately 300 short tons of spawning gravel is expected to replace spawning gravels in the long-term that have moved downstream due to the proposed action. Nonetheless, decreased spawning gravel availability during the spawning season from earlier peak flow events are expected to result in degradation or depletion of spawning PBFs for CCV steelhead critical habitat in the short-term.

2.6 Cumulative Effects

"Cumulative effects" are 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). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

Agricultural practices within the action area are expected to continue and may degrade PBFs of critical habitat (e.g., cover, water quality) through the cumulative loss of riparian habitat due to bank stabilization projects, uncontrolled run-off, or the discharge of return flows with poor water quality.

Future non-Federal water withdrawals, diversions, and transfers within the action area may negatively affect listed fish species by entraining, injuring, or killing individual fish at unscreened, improperly screened, or poorly maintained diversions. In addition, these actions may result in depleted river flows in the action area.

Future population growth, urbanization, and agricultural development may negatively affect aquatic habitat through encroachment, point and non-point source contaminant discharges, non-Federal bank stabilization or flood control projects, and increased recreational use of the river corridor. Encroachment, bank stabilization, and flood control projects are anticipated to reduce or confine the riparian corridor along rivers in the action area and limit river channel migration, altering stream bank and channel morphology and reducing fish habitat quality and quantity. Urban and agricultural run-off is expected to introduce contaminants such as herbicides, pesticides, petroleum products and other contaminants into the action area waterways. These private and state activities are likely to adversely affect CCV steelhead and their designated critical habitat, and affect recovery of CCV steelhead. These potential factors are ongoing and expected to continue into the future. However, the extent of the adverse effects from these activities is uncertain. It is not possible to predict the extent of the effects of future non-Federal activities will have on CCV steelhead, their recovery, and their designated critical habitat.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.7.1 Summary of Status, Environmental Baseline, and Cumulative Effects to CCV Steelhead

Rangewide Status of CCV Steelhead

O. mykiss have long been recognized as having one of the most complex and diverse life histories among all the salmonids. Populations may be entirely anadromous, partly anadromous, or entirely resident, and levels of anadromy can vary by age and sex. One of the difficulties in assessing any steelhead data in the Central Valley is the possibility that some individuals may actually be resident fish, as it is nearly impossible to visually distinguish the two life history forms when they are juveniles.

CCV steelhead historically were well-distributed throughout the Sacramento and San Joaquin rivers (Busby *et al*. 1996) and were found from the upper Sacramento and Pit River systems (now inaccessable 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*. 2001). Lindley *et al*. (2006) estimated that historically there were at least 81 independant CCV steelhead populations distributed primarily throughout the eastern tributaries of the Sacramento and San Joaquin rivers. This distribution has been greatly affected by dams (McEwan and Jackson 1996). Presently, impassable dams block access to 80 percent of historically available habitat, and block access to all historical spawning habitat for about 38 percent of historical populations (Lindley *et al*. 2006).

Population viability is determined by four parameters: spatial structure, diversity, abundance, and productivity (growth rate). Both population spatial structure and diversity (behavioral and genetic) provide the foundation for populations to achieve abundance levels at or near potential carrying capacity and to achieve stable or increasing growth rates. Spatial structure on a watershed scale is determined by the availability, diversity, and utilization of properly functioning habitats and the connections between such habitats.

Indications are that natural-origin CCV steelhead have continued to decrease in abundance throughout the California Central Valley. The proportion of natural-origin fish has also decreased over the past 25 years (NMFS 2016c). Most natural-origin CCV steelhead populations are very small and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change. The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to natural-origin fish. NMFS identified that the DPS is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (NMFS 2016a).

Environmental Baseline

CCV steelhead in the action area watersheds have experienced significant declines in abundance and available habitat in the California Central Valley relative to historic conditions. The status of the species and critical habitat and environmental baseline sections of this biological opinion (Section 2.2 and 2.4) detail the current range-wide status of CCV steelhead and their designated critical habitat, including climate change predictions for the California Central Valley.

Past and present impacts within the Sacramento River basin and the Sacramento-San Joaquin Delta have caused significant loss of habitat. As a result, anadromous fish populations have declined drastically over the last century, and many subpopulations have been extirpated. The construction of dams has limited access to a large and significant portion of historical spawning and rearing habitats. Dam operations have changed downstream flow patterns, affecting stream dynamics (*i.e.*, geomorphology, habitat configuration, *etc*.), and affected available habitat through changes in water temperature characteristics, limiting gravel recruitment to available spawning reaches and limiting the introduction of LWM, which contributes to habitat diversity. Gold mining has occurred in the Feather and American rivers, and there are many dams, water diversions, and levees. These activities have had long lasting negative effects on CCV steelhead populations.

The operation of hatcheries in the Sacramento River basin have affected the diversity and abundance of natural spawning CCV steelhead. Hatchery fish spawning in the wild have affected the genetics of the natural fish, and this has impacted the diversity and abundance of ESA listed CCV steelhead. Most of the steelhead populations in the Central Valley have a high hatchery component, including the Sacramento River, the American River, and the Feather River. Assessing steelhead abundance is confounded by the fact that most of the dedicated monitoring programs in the Central Valley occur on rivers that are annually stocked.

Climate change poses a high threat to CCV steelhead within the action area. Temperatures in California's Central Valley are predicted to increase between 2°C and 7°C by 2100 (Dettinger *et al*. 2004, Hayhoe *et al*. 2004, Van Rheenen *et al*. 2004), with a drier hydrology predominated by precipitation rather than snowfall. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. Altered river runoff patterns will transform the tributaries that feed the Central Valley. This is expected to truncate the period of time that suitable cold-water conditions persist below existing reservoirs and dams due to the warmer inflow temperatures to reservoirs from rain runoff. Summer temperatures and flow levels in some areas of the Central Valley will become unsuitable for salmonid survival.

There are a number of measures that are being implemented to improve spatial structure, diversity, abundance and productivity of CCV steelhead in the Sacramento River basin. Some of these measures include improved flow and water temperature management, habitat enhancements, improved fish passage, and better hatchery management.

The cumulative effects identified in Section 2.6 have the potential to further reduce the viability of CCV steelhead in the Sacramento River basin. This could occur through changes in stream flows, increases in water temperature, and decreases in water quality. Changes in the climate could also negatively affect the viability of CCV steelhead in the Sacramento basin through changes in stream flows and increases in water temperatures.

The number of CCV steelhead redds in the American River has been less than 100 in 6 of 7 recent years (2009-2015) (NMFS 2016a), with an overall declining trend. All indications are that natural CCV steelhead in the California Central Valley have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (NMFS 2016a); the long-term trend remains negative. As with other areas of California Central Valley, hatchery production and returns are dominant. Most wild CCV populations are very small and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change. The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to wild fish (NMFS 2016a).

Existing wild CCV steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill creeks and the Yuba River. Populations may exist in Big Chico and Butte creeks, and a few wild CCV steelhead are produced in the American and Feather rivers (McEwan and Jackson 1996) .

Spatial structure for CCV steelhead is fragmented and reduced by elimination or significant reduction of the major core populations (*i.e.*, Sacramento River, Feather River, American River) that provided a source for the numerous smaller tributary and intermittent stream populations like Dry Creek, Auburn Ravine, Yuba River, Deer Creek, Mill Creek, and Antelope Creek. Tributary populations can likely never achieve the size and variability of the core populations in the long-term, generally due to the size and available resources of the tributaries.

2.7.2 Summary of Effects of the Proposed Action to CCV Steelhead

The effects to CCV steelhead from changes in monthly flows and temperatures in the Sacramento River, Feather River, American River, and Sacramento-San Joaquin Delta from the proposed action are expected to be minor and together they are not expected to be more than minor effects. Modeling indicates there will be some benefit in the amount of water stored in Folsom Lake and some potential benefit to rearing CCV steelhead, due to cooler water in the American River. The proposed action is expected to negatively affect CCV steelhead in the American River. The negative effects from the dislocation of incubating CCV steelhead eggs and alevins in the gravel will result in mortality and injury to CCV steelhead. This will occur through the scour of spawning gravels during some high flows events. While language will be included in the updated Folsom WCM to minimize the occurrence of flow events greater than 30,000 cfs, due to the size of the American River watershed and the size of Folsom Lake, we expect releases will occur that result in the loss of CCV steelhead eggs and alevins. Based on modeling, flows greater than 30,000 cfs will occur even without the proposed action. With the proposed action, some high flows events are expected to result in higher flows and result in a greater amount of CCV steelhead egg and alevin mortality.

Modeling indicates the proposed action will result in beneficial effects in the form of increased flows and decreased water temperatures. Because the proposed action allows increased storage in the late winter and spring, there is more water available for releases in the summer and fall, and there is more cold water. Increased flows will provide additional habitat, and more cold water in Folsom Lake will increase the ability of Reclamation to meet water temperature criteria.

The loss of spawning gravel over time would be expected to result in the reduced amount of spawning habitat, and thereby reduce the productivity of CCV steelhead in the American River. With the conservation measure of SAFCA's annual supplementation of $20,000 for 15 years to augment the existing gravel augmentation program by approximately 300 short tons of spawning gravel each year, the loss of spawning habitat is likely to only be temporary, during the season of scouring flows only. The annual addition of gravel is not linked to years in which scour events occur. This is expected to result in clean gravel being available for CCV spawning and potentially increasing the amount of available spawning habitat in years prior to a scour event.

While the proposed action is expected to result in adverse effects to CCV steelhead in the American River, measures are included in the proposed action to minimize the adverse effects. Additionally, there are some beneficial effects to CCV steelhead due to the proposed action. In summary:

- The scour of CCV steelhead eggs is not expected to occur annually. The scour of CCV steelhead eggs due to the proposed action will only occur in the American River,
- The scour of CCV steelhead eggs due to the proposed action will only affect a small portion of the CCV steelhead DPS, and
- The addition of spawning gravel may improve survival of incubating CCV steelhead eggs, due to the new gravel being cleaner and being more appropriately-sized than gravel in the American River. The newer gravel is expected to have better flow of water through the gravel than gravel that has been covered in fine sediment.

Based on our analysis of available evidence, NMFS concludes that the proposed action is not expected to appreciably reduce the likelihood of both the survival and recovery of the CCV steelhead DPS.

2.7.3 Summary of Effects of the Proposed Action to CCV Steelhead Critical Habitat

The minor effects of the proposed action when added together are not expected to result in more than minor negative effects to designated critical habitat for CCV steelhead in the Sacramento River, Feather River, or Sacramento-San Joaquin Delta. In the American River the minor effects of the proposed action on average flows and temperatures are not expected to result in measurable negative effects to the PBFs of CCV steelhead critical habitat. Through increased storage in Folsom Lake, there may be a benefit of cooler water in the American River. The proposed action is expected to negatively affect CCV steelhead designated critical habitat in the American River through peak flow events. The negative effects are from the scour of spawning gravels that will reduce the amount of area available to CCV steelhead for spawning and incubation. The proposed action will have some negative effects on the PBFs of spawning habitat, due to peak flows, that result in scour. With provisions to minimize flow events over 30,000 cfs, and with additional gravel augmentation, the proposed action is not expected to result in more than temporary negative effects to the PBFs of spawning habitat.

In the American River, the adult CCV steelhead migratory corridor PBFs are not expected to be affected by the proposed action. High flushing flows could cause some delay in upstream migration, but the delay would only be for the duration of the highest flows, which is expect to only last a few days, and the modeling indicated these highest flows would be of shorter duration with the proposed action than under baseline conditions.

Regarding rearing habitat and juvenile migratory corridor PBFs, the proposed action is not expected to result in more than minor changes in juvenile CCV steelhead rearing habitat. Higher flows during the juvenile CCV steelhead migratory period may improve the PBFs for migration through reduced predation mortality in the American River, by decreasing travel time and increased turbidity.

Based on the analysis of available evidence, NMFS concludes that the proposed action is not likely to appreciably diminish the value of the critical habitat for the conservation of CCV steelhead.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of CCV steelhead, or destroy or adversely modify their designated critical habitat.

2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

2.9.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

NMFS anticipates incidental take of CCV steelhead with this proposed action. Specifically, NMFS anticipates that CCV steelhead may be harassed, injured, or killed as a result of project implementation due to high scouring flows. Flows greater than 30,000 cfs are expected to result in scour of steelhead redds resulting in injury or death of CCV steelhead eggs and alevins. Incidental take has been estimated based on the project description and information provided by the Corps.

As described in the Effects of the Action section regarding scour of CCV steelhead redds, it is impossible to precisely quantify the number of individuals of fish that are expected to be incidentally taken (injury, harm, death, etc.) as a result of the scour of CCV steelhead redds in the American River. It not possible to precisely quantify the number of individual CCV steelhead that will be present at any given time, due to the varying population size (annual and seasonal), variations in fecundity, annual variations in the timing of spawning and alevins emergence, and variations in habitat use. Due to CCV steelhead spawning data in the American River being incomplete, due to high flows and turbidity; CCV steelhead spawning timing being highly variable; and for some years the majority of the steelhead spawning in the American River are non-local non-ESA listed hatchery steelhead spawning in the American River, it is very difficult to estimate the spawning timing for CCV steelhead in the American River. CCV steelhead begin spawning at the beginning of January. Spawning is completed in early April and incubation and emergence is complete by the end of May.

In addition to the uncertainty identified above, there is uncertainty regarding when flow events in excess of 30,000 cfs will occur. The modeling identified that flow events greater than 30,000 cfs can occur as early as December 4, and as late as May 1. The occurrence of these events is dependent on weather conditions. Flow events that result in redd scour will result in variable amounts of egg and alevins mortalities, depending on the timing of spawning and the timing and magnitude of flow events. However, it is possible to estimate the extent of incidental take by designating an ecological surrogate, incorporating those elements of the proposed action that are expected to result in incidental take, that are more predictable and/or measurable, with the ability to monitor those surrogates to determine the extent of take that is occurring. The incidental take that is expected to occur as a result of the proposed action is due to the magnitude and frequency of flows greater than 30,000 cfs.

NMFS' analysis of peak flow events identified that the occurrence of flows over 30,000 cfs is highly variable. Many years have no flows exceeding 30,000 cfs, and some years have multiple events. Analysis of events by decade showed from 3 to 9 peak flows over 30,000 cfs. The occurrence of weather events that result in flows greater than 30,000 cfs are highly variable. In addition, based on the limitation of Folsom Lake, it is not possible to avoid flows that exceed

30,000 cfs. Based on this information NMFS identified the most appropriate threshold for take associated with the proposed action is the number of flow events that result in CCV steelhead spawning gravel scour during egg incubation over a 10-year period. A flow event is defined by flows exceeding 30,000 cfs at Hazel Avenue for any length of time, during the CCV steelhead incubation period. The CCV steelhead egg incubation period starts on January 1st and ends on May 31st of each year. NMFS recognizes that due to the size of Folsom Lake, the size of the American River watershed, and the amount and types of precipitation in the watershed, that Folsom Dam operations cannot limit all flow events to less than 30,000 cfs. NMFS identified from the modeling of peak flows that up to 9 flow events exceeding 30,000 could occur in a 10 year period. Further analysis identified that 3 of those events were under 32,000 cfs and operations could have been modified to keep those modeled flows under 32,000 cfs. With language included in the proposed action to limit the occurrence of flows greater than 30,000 cfs (which was not included in the modeling), the expectation is that not more than 6 occurrences of flows exceeding 30,000 cfs would occur in a 10 year period. Based on this information and the information in the Effects of the Action section, NMFS has identified that the level of anticipated take will be exceeded if more than 6 flow events exceeding 30,000 cfs occur during the steelhead incubation period during rolling 10-year periods. The 10-year periods shall begin from the issuance of this biological opinion. Rolling 10-year periods will start with years 1 through 10, then years 2 through 11, then years 3 through 12, etc.

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species, or destruction or adverse modification of critical habitat.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

1) The Corps and Reclamation shall include operating conditions in the updated Folsom WCM that minimize impacts to CCV steelhead in the lower American River, without compromising flood management protection.

2) The Corps and Reclamation shall annually meet with NMFS and CDFW regarding future flood management operations at Folsom Dam.

3) The Corps and Reclamation shall provide NMFS with an annual report on the previous year's flood management operations and gravel augmentation.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the Corps and Reclamation or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The Corps and Reclamation or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following term and condition implements reasonable and prudent measure 1:

    a. The Corps and Reclamation shall include language in the updated Folsom WCM that directs operators of Folsom Dam to consider measures to minimize impacts to spawning and incubating CCV steelhead when making operational decisions that have the potential to result in scour of incubating CCV steelhead eggs and alevins, to the extent possible without interfering with measures necessary to protect lives or property.

2. The following terms and conditions implement reasonable and prudent measure 2:

    a. The Corps and Reclamation shall annually convene a meeting with NMFS and CDFW on or about the second week of November of each year to discuss flood management operations, including:

        i. The previous flood management season and any potential effects from Folsom Dam operations to CCV steelhead in the American River.

        ii. The upcoming flood management season and any potential effects from Folsom Dam operations to CCV steelhead in the American River.

        iii. Risks from Folsom Dam operations during the flood season to CCV steelhead in the American River.

        iv. Identifying and implementing measures to minimize impacts of Folsom Dam flood management operations on CCV steelhead (*e.g.*, stranding, egg scour, dislodging of alevins) in the American River.

    b. The Corps and Reclamation shall provide a report of past flood management operation to NMFS and CDFW at least 2 weeks prior to the meeting.

3. The following terms and conditions implement reasonable and prudent measure 3:

    a. The Corps and Reclamation shall provide a report to NMFS by October 20th of each year that includes:

i. A summary of any operations that resulted in flows that exceeded 30,000 cfs downstream of Nimbus Dam in the previous water year (October 1 – September 30).

ii. A summary of the implementation of gravel augmentation in the previous water year and gravel augmentation plans for the current water year.

iii. The report shall be submitted to the following address:

Maria Rea, Assistant Regional Administrator
California Central Valley Office
National Marine Fisheries Service
650 Capitol Mall, Suite 5-100
Sacramento California 95814
Phone: (916) 930-3600
FAX: (916) 930-3629

2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

The Corps and Reclamation should consider including information on their websites regarding fish conservation measures in the American River. This would improve the public's knowledge of potential effects to ESA listed anadromous fish, and how the Corps and Reclamation are working to protect ESA listed fish.

2.11 Reinitiation of Consultation

This concludes formal consultation for the Folsom Dam and Lake Water Control Manual.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this biological opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this biological opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

2.12 "Not Likely to Adversely Affect" Determinations

2.12.1 Sacramento River Winter-run Chinook Salmon

The SR winter-run Chinook salmon ESU was first listed as threatened in 1989 (54 FR 32085; August 4, 1989), reclassified as endangered in 1994 (59 FR 440; January 4, 1994), and reaffirmed as endangered in 2005 (70 FR 37160; June 28, 2005). This ESU includes all naturally spawned populations downstream of Keswick Dam on the Sacramento River, and the SR winter-run Chinook salmon at the Livingston Stone NFH.

Changes in the operations of Shasta Dam, Keswick Dam, the Oroville Facilities, Folsom Dam, and Nimbus Dam due to the proposed action have the potential to affect SR winter-run Chinook salmon. Modeling analysis in the biological assessment (Corps 2018) indicated that there would be little change in the flows and temperatures in the Sacramento River and Sacramento-San Joaquin Delta experienced by SR winter-run Chinook salmon due to the proposed action. The potential adverse effects from the proposed action to SR winter-run Chinook salmon are expected to be discountable. Based on this analysis, NMFS concurs with the Corps and Reclamation's determination that the proposed action is not likely to adversely affect SR winter-run Chinook salmon.

2.12.2 Sacramento River Winter-run Chinook Salmon Designated Critical Habitat

Critical habitat was designated for SR winter-run Chinook salmon in 1993 (58 FR 33212; June 16, 1993). This designation includes the following waterways: the Sacramento River from Keswick Dam to Chipps Island; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge (58 FR 33212; June 16, 1993). PBFs for SR winter-run Chinook salmon in the action area include access from the Pacific Ocean to spawning area in the upper Sacramento River; the availability of clean gravel for spawning substrate; adequate river flows for successful spawning, incubation of eggs, fry development and emergence and downstream transport of juveniles; water temperatures between 42.5 and 57.5 °F for successful spawning, egg incubation, and fry development; habitat area and adequate prey that are not contaminated; riparian habitat that provides for successful juvenile development and survival; and access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean.

The effects of the proposed action on SR winter-run Chinook salmon designated critical habitat were analyzed in the biological assessment (Corps 2018). That analysis identified that there would be little change to designated critical habitat due to changes in the flows and water temperatures due to the proposed action. The potential adverse effects from the proposed action to SR winter-run Chinook salmon designated critical habitat are expected to be discountable. Based on this analysis, NMFS concurs with the Corps and Reclamation's determination that the proposed action is not likely to adversely affect SR winter-run Chinook salmon designated critical habitat.

2.12.3 Central Valley Spring-run Chinook Salmon

The CV spring-run Chinook salmon ESU was first listed as threatened in 1999 (64 FR 50394, September 16, 1999), and reaffirmed in 2005 (70 FR 37160, June 28, 2005). This ESU consists of naturally-spawning spring-run Chinook salmon originating from the Sacramento River basin and the Feather River Fish Hatchery population of CV spring-run Chinook salmon.

Changes in the operations of Shasta Dam, Keswick Dam, the Oroville Facilities, Folsom Dam, and Nimbus Dam due to the proposed action have the potential to affect CV spring-run Chinook salmon. Analysis in the biological assessment (Corps 2018) identified that there would be little change in the flows and water temperatures experience by CV spring-run Chinook salmon due to the proposed action. Nor are significant changes in flows or water temperatures expected in the lower American River, due to the proposed action, where non-natal rearing may occur. The potential adverse effects from the proposed action to CV spring-run Chinook salmon are expected to be insignificant. Based on this analysis, NMFS concurs with the Corps and Reclamation's determination that the proposed action is not likely to adversely affect the CV spring-run Chinook salmon.

2.12.4 Central Valley Spring-run Chinook Salmon Designated Critical Habitat

Critical habitat for CV spring-run Chinook salmon was designated in 2005 (70 FR 52488, September 2, 2005). Critical habitat for the CV spring-run Chinook salmon includes stream reaches of the Feather, Yuba, and American rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, and the Sacramento River, as well as portions of the northern Sacramento-San Joaquin Delta.

PBFs for CV spring-run Chinook salmon in the action area include freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. Analysis in the biological assessment (Corps 2018) identified little change to designated critical habitat due to change in flows or water temperatures in the Sacramento River, Feather River, or Sacramento-San Joaquin Delta due to the proposed action. Nor are substantial changes in habitat expected in the lower American River, where non-natal rearing may occur. The potential adverse effects from the proposed action to CV spring-run Chinook salmon designated critical habitat are expected to be insignificant. Based on this analysis, NMFS concurs with the Corps' and Reclamation's determination that the proposed action is not likely to adversely affect CV spring-run Chinook salmon designated critical habitat.

2.12.5 Southern Distinct Population Segment of North American Green Sturgeon

SDPS green sturgeon were originally listed as threatened in 2006 (71 FR 17757, April 7, 2006). This DPS consists of naturally-spawning green sturgeon in the Sacramento River basin. SDPS green sturgeon are known to spawn in the upper Sacramento River, downstream of Keswick Dam, in the Feather River downstream of the Fish Barrier Dam, and have been observed in the Yuba River downstream of Daguerre Point Dam. They have not been observed in the American River.

Changes in the operations of Shasta Dam, Keswick Dam, the Oroville Facilities, Folsom Dam, and Nimbus Dam due to the proposed action have the potential to affect sDPS green sturgeon. Analysis in the biological assessment (Corps 2018) identified that there would be little change in the flows and water temperatures experience by sDPS green sturgeon due to the proposed action.

Nor are substantial changes in flows or water temperatures expected in the lower American River, due to the proposed action, where non-natal rearing may occur. The potential adverse effects from the proposed action to sDPS green sturgeon are expected to be discountable. Based on this analysis, NMFS concurs with the Corps' and Reclamation's determination that the proposed action is not likely to adversely affect sDPS green sturgeon.

2.12.6 Southern Distinct Population Segment of North American Green Sturgeon Designated Critical Habitat

NMFS designated critical habitat for sDPS green sturgeon in 2009 (74 FR 52300 October 9, 2009). Critical habitat for sDPS green sturgeon includes, (1) the Sacramento River from Keswick Dam to the I-Street Bridge in Sacramento, including the Sutter and Yolo Bypasses and the American River to the highway 160 bridge; (2) the Feather River from Fish Barrier Dam to the confluence with the Sacramento River; (3) the Yuba River from Daguerre Point Dam to the confluence of the Feather River; (4) the Sacramento-San Joaquin Delta (as defined by California Water Code Section 12220), but with many exclusions; (5) tidally influenced areas of San Francisco Bay, San Pablo Bay, and Suisun Bay; and (6) coastal marine areas to the 60-fathom depth bathymetry line, from Monterey Bay, California to the Strait of Juan de Fuca, Washington. PBFs for sDPS green sturgeon critical habitat include specific features of freshwater riverine systems, estuarine habitats, and nearshore coastal marine waters.

Analysis in the biological assessment (Corps 2018) identified little change to designated critical habitat due to changes in flows or water temperatures in the Sacramento River, Feather River, or Sacramento-San Joaquin Delta due to the proposed action. Nor are substantial changes in habitat expected in the lower American River, where non-natal rearing may occur. The potential adverse effects from the proposed action to sDPS green sturgeon designated critical habitat are expected to be discountable. Based on this analysis, NMFS concurs with the Corps' and Reclamation's determination that the proposed action is not likely to adversely affect sDPS green sturgeon designated critical habitat

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by the Corps and Reclamation, and descriptions of EFH for Pacific Coast salmon [Pacific Fisheries Management Council (PFMC) 2014] contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

The action area for the proposed action has been identified to include EFH for Pacific Coast salmon. SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CV fall-/late fall-run Chinook salmon are species managed under the Pacific Coast salmon fishery management plan that occur within the action area. The ESA Section 7(a)(2) biological opinion for the proposed action addresses effects of the action on ESA-listed SR winter-run and CV spring-run Chinook salmon and their critical habitat. Although fall-run and late fall-run Chinook salmon are not listed under the ESA, the analyses for winter-run and spring-run Chinook salmon apply to all Chinook salmon in the action area, including fall-run and late fall-run Chinook salmon. Critical habitat for CV spring-run Chinook salmon is designated upstream from the mouth to Watt Avenue in the American River. The American River downstream from Nimbus Dam has been designated as EFH. Chinook salmon utilize habitat in the American River downstream from Nimbus Dam that is designated as critical habitat for CCV steelhead. The PBFs of steelhead critical habitat are similar to the Habitat Areas of Particular Concern for Chinook salmon in the American River. Therefore, the EFH analysis for the action area is based on the critical habitat analysis in the biological opinion.

The ESA analysis determined that the proposed action would have only minimal adverse effects on PBFs of designated critical habitat outside the American River. This EFH consultation will concentrate on the Habitat Areas of Particular Concern (HAPC) that occur in the American River: (1) Complex Channels and Floodplain Habitats, (2) Thermal Refugia, and (3) Spawning Habitat Substrate.

3.2 Adverse Effects on Essential Fish Habitat

Complex Channels and Floodplain Habitats

While the proposed action will change the frequency of flows within certain ranges, with the highly modified channel (*e.g.*, mining, levees), and with the frequency of very high flows being dictated by inflows to Folsom Lake, it is unlikely that the changes in flow frequencies will negatively affect the complex channels and floodplain habitats in the lower American River.

Thermal Refugia

The water temperatures experienced by adult Chinook salmon in the fall in the lower American River are an issue in most years. With an improved ability to refill Folsom Lake with the proposed action, the amount of the cold water pool should be improved. This may result in an improvement in water temperatures for adult Chinook salmon in the fall. It is unlikely that the proposed action will negatively affect water temperatures for adult Chinook salmon.

Only fall-run Chinook salmon are known to spawn in the American River. Other runs of Chinook salmon may use the lower American River for non-natal rearing. Because juvenile fall-run Chinook salmon migrate out of the American River in the winter and early spring, water temperatures are not an issue. Based on information on non-natal rearing Chinook in the American River, they only spend time in the American River in the winter and early spring. Water temperatures are not an issue for rearing Chinook salmon at this time of year.

Spawning Habitat Substrate

Chinook salmon (fall-run) spawn in the same reaches of the lower American River as CCV steelhead. Chinook salmon spawning habitat will be impacted in the same manner as CCV steelhead designated critical habitat, due to scour of Chinook salmon redds and alevins.

We conclude that aspects of the proposed action would adversely affect EFH for Chinook salmon. We conclude that the following adverse effect on EFH designated for Pacific Salmon is reasonably certain to occur.

1. The proposed action is likely to result in the scour of Chinook salmon spawning gravels, which could result in the loss of function of this HAPC as the riverbed becomes armored and depleted of spawning gravel. With the conservation measure of SAFCA's annual supplementation of $20,000 for 15 years to augment the existing gravel augmentation program by approximately 300 short tons of spawning gravel into the lower American River, downstream of Nimbus Dam, the adverse effects on spawning habitat substrate from the proposed action should be minimized.

3.3 Essential Fish Habitat Conservation Recommendations

For effect 1 listed above, NMFS' EFH conservation recommendations is to implement the gravel supplementation identified in the conservation measures of the proposed action as described in the biological opinion. The gravel supplementation will address the adverse effects of spawning gravel scour.

Fully implementing this EFH conservation recommendation would protect, by minimizing the adverse effects described in Section 3.2, above, approximately 3 acres of designated EFH for Pacific Coast salmon.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the Corps and Reclamation must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5 Supplemental Consultation

The Corps and Reclamation must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

4. FISH AND WILDLIFE COORDINATION ACT

The purpose of the FWCA is to ensure that wildlife conservation receives equal consideration, and is coordinated with other aspects of water resources development (16 USC 661). The FWCA establishes a consultation requirement for Federal agencies that undertake any action to modify any stream or other body of water for any purpose, including navigation and drainage (16 USC 662(a)), regarding the impacts of their actions on fish and wildlife, and measures to mitigate those impacts. Consistent with this consultation requirement, NMFS provides recommendations and comments to Federal action agencies for the purpose of conserving fish and wildlife resources, and providing equal consideration for these resources. NMFS' recommendations are provided to conserve wildlife resources by preventing loss of and damage to such resources. The FWCA allows the opportunity to provide recommendations for the conservation of all species and habitats within NMFS' authority, not just those currently managed under the ESA and MSA.

The following recommendations apply to the proposed action:

The Corps and Reclamation should consider implementing measures to minimize effects of the proposed action on Chinook salmon spawning and incubation. This would include reduction of the occurrence of flows greater than 30,000 cfs during Chinook salmon spawning and incubation, and include discussion of potential adverse effects to Chinook salmon and how to avoid or minimize those effects in the annual coordination meeting. Implementation of these measures would minimize the adverse effects of the proposed action on Chinook salmon eggs and alevins due to scour of spawning gravels.

The action agencies must give these recommendations equal consideration with the other aspects of the proposed action so as to meet the purpose of the FWCA.

This concludes the FWCA portion of this consultation.

5. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the biological opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

5.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this biological opinion are the Corps and Reclamation. Other interested users could include American River stakeholders. Individual copies of this biological opinion were provided to the Corps and Reclamation. This biological opinion will be posted on the Public Consultation Tracking System Website. The format and naming adheres to conventional standards for style.

5.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

5.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this biological opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

6. REFERENCES

Anderson, N. H. and J. R. Sedell. 1979. Detritus Processing by Macroinvertebrates in Stream Ecosystems. Annual Review of Entomology 24(1): 27.

Artho, D. 2018a. Email from Dan Artho (Corps), to Gary Sprague (NMFS). Folsom WCM Update - LAR Flow Folsom Storage POR Model Output plots. April 9, 2018.

Artho, D. 2018b. Email from Dan Artho (Corps), to Gary Sprague (NMFS). [Non-DoD Source] Folsom WCM, updated spreadsheet of flows >30kcfs. May 4, 2018.

Beechie et al., T. J., Reidy Liermann, C. A., Olden, J. D., Kennard, M. J., Skidmore, P. B., Konrad, C. P., and H. Imaki. 2012. Hydrogeomorphic Classification of Washington State Rivers to Support Emerging Environmental Flow Management Strategies. River Research and Applications 28(9):1340-1358.

Bratovich, P, C. Addley, D. Simodynes, and H. Bowen. 2012. Water temperature Considerations for Yuba River Basin Anadromous Salmonid Reintroduction Evaluations. Prepared for the Yuba Salmon Forum Technical Working Group.

California Department of Fish and Wildlife. 2017. 2017 Grandtab Spreadsheet of Adult Chinook Escapement in the Central Valley.

CDFW data: ftp.delta.dfg.ca.gov/salvage

California Department of Water Resources. 2005. Addendum to Phase 2 Report Evaluation of Project Effects on Instream Flows and Fish Habitat SP-F16. Oroville Facilities Relicensing Team. 16 pp.

California Department of Water Resources. 2016. 2015/2016 Salmonids and Green Sturgeon Incidental Take and Monitoring Report. California Department of Water Resources, Division of Environmental Services, West Sacramento, California. December 22. 32 Pages.

California Department of Water Resources. 2017. Stranding of Chinook Salmon (*Oncorhynchus tshawytscha*) and Steelhead (*Oncorhynchus mykiss*) in the lower Feather River, 2017. October 19, 2017. 154 pp.

California Hatchery Scientific Review Group. 2012. Appendix Viii: Livingston Stone National Fish Hatchery, Winter Chinook Program Report. In: California Hatchery Review Report.

Chase, R. 2010. Lower American River Steelhead (*Oncorhynchus mykiss*) Spawning Surveys - 2010. Shasta Lake, California.

Cohen, S. J., K. A. Miller, A. F. Hamlet, and W. Avis. 2000. Climate Change and Resource Management in the Columbia River Basin. Water International 25(2):253-272.

Demetras, N. J., D. D. Huff, C. J. Michel, J. M. Smith, G. R. Cutter, S. A. Hayes, and S. T. Lindley. 2016. Development of Underwater Recorders to Quantify Predation of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in a River Environment. Fishery Bulletin 114(2): 179-185.

Dettinger, M. D. 2005. From Climate-Change Spaghetti to Climate-Change Distributions for 21st Century California. San Francisco Estuary and Watershed Science 3(1):14.

Dettinger, M. D. and D. R. Cayan. 1995. Large-Scale Atmospheric Forcing of Recent Trends toward Early Snowmelt Runoff in California. Journal of Climate 8(3):606-623.

Dettinger, M. D., D. R. Cayan, M. K. Meyer, and A. E. Jeton. 2004. Simulated Hydrologic Responses to Climate Variations and Changes in the Merced, Carson and American River Basins, Sierra Nevada, California, 1900-2099. Climatic Change 62(62):283-317.

Dimacali, R. L. 2013. A Modeling Study of Changes in the Sacramento River Winter-Run Chinook Salmon Population Due to Climate Change. Master of Science Thesis. Civil Engineering, California State University, Sacramento, California. 64 pp.

Domagalski, J. L., D. L. Knifong, P. D. Dileanis, L. R. Brown, J. T. May, V. Connor, and C. N. Alpers. 2000. Water Quality in the Sacramento River Basin, California, 1994-98. U.S. Geological Survey, Sacramento, California.

Elliott, J. 1981. Some aspects of thermal stress on freshwater teleosts. *In* Pickering, A.D. ed., Stress and Fish: Academic Press, London. pp. 209-245.

Garza, J. C. and D. E. Pearse. 2008. Population Genetic Structure of *Oncorhynchus mykiss* in the California Central Valley: Final Report for California Department of Fish and Game. University of California, Santa Cruz, and National Marine Fisheries Service, Santa Cruz, California.

Gaspin, J. B. 1975. Experimental Investigations of the Effects of Underwater Explosions on Swimbladder Fish, I: 1973 Chesapeake Bay Tests. DTIC Document.

Good, T. P., R. S. Waples, and P. Adams. 2005. Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead. NOAA Technical Memorandum NMFS-NWFSC-66.

Hallock, R. J., D. H. Fry Jr., and D. A. LaFaunce. 1957. The Use of Wire Fyke Traps to Estimate the Runs of Adult Salmon and Steelhead in the Sacramento River. California Fish and Game 43(4): 271-298.

Hallock, R. J., W. F. Van Woert, and L. Shapovalov. 1961. An Evaluation of Stocking Hatchery-Reared Steelhead Rainbow Trout (*Salmo gairdnerii*) in the Sacramento River System. Fish Bulletin 114.

Hannon, J. 2013. American River Steelhead (*Oncorhynchus mykiss*) Spawning - 2013, with Comparison to Prior Years. U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region, Sacramento, California.

Hannon, J., and B. Deason. 2008. American River Steelhead (*Oncorhynchus mykiss*) Spawning 2001 – 2007. U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region.

Hannon, J., M. Healey, and B. Deason. 2003. American River Steelhead (*Oncorhynchus mykiss*) Spawning 2001 – 2003. U.S. Bureau of Reclamation and California Department of Fish and Game, Sacramento, California.

Hanson, C. H. 2009. Striped Bass Predation on Listed Fish within the Bay-Delta Estuary and Tributary Rivers. Expert Report: Coalition for a Sustainable Delta et al. v. Koch, E.D. Cal Case No. CV 08-397-OWW. 63 pp.

Hastings, M. C. 1995. Physical Effects of Noise on Fishes. Inter-noise and Noise-con Congress and Conference Proceedings 1995(2): 979-984.

Hastings, M. C. and A. N. Popper. 2005. Effects of Sound on Fish. California Department of Transportation.

Hayhoe, K., D. Cayan, C. B. Field, P. C. Frumhoff, E. P. Maurer, N. L. Miller, S. C. Moser, S.H. Schneider, K. N. Cahill, E. E. Cleland, L. Dale, R. Drapek, R. M. Hanemann, L. S. Kalkstein, J. Lenihan, C. K. Lunch, R. P. Neilson, S. C. Sheridan, and J. H. Verville. 2004. Emissions Pathways, Climate Change, and Impacts on California. Proceedings of the National Academy of Science, U.S.A. 101:12422-12427.

Intergovernmental Panel on Climate Change. 2007. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jarrett, P and D. Killam. 2015. Redd dewatering and juvenile stranding in the Upper Sacramento River, Year 2014-2015. California Department of Fish and Wildlife. RBFO Technical Report No. 02-2015. 86 p.

Johnson, M. L., I. Werner, S. Teh, and F. Loge. 2010. Evaluation of Chemical, Toxicological, and Histopathologic Data to Determine Their Role in the Pelagic Organism Decline. University of California at Davis, Davis, California.

Leatherbarrow, J. E., L. J. McKee, D. H. Schoellhamer, N. K. Ganju, and A. R. Flegal. 2005. Concentrations and Loads of Organic Contaminants and Mercury Associated with Suspended Sediment Discharged to San Francisco Bay from the Sacramento-San Joaquin River Delta. San Francisco Estuary Institute, Oakland, California.

Lehman, P. W., S. Teh, R. H. Boyer, M. Nobriga, E. Bass, and C. Hogle. 2009. Initial Impacts of *Microcystis aeruginosa* Blooms on the Aquatic Food Web in the San Francisco Estuary. 22.

Lindley, S. 2008. California Salmon in a Changing Climate. National Oceanic and Atmospheric Administration Fisheries. PowerPoint. Southwest Fisheries Science Center, Santa Cruz, California.

Lindley, S. T., R. S. Schick, B. P. May, J. J. Anderson, S. Greene, C. Hanson, A. Low,, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2004. Population Structure of Threatened and Endangered Chinook Salmon ESUs in California's Central Valley Basin in U.S. Department of Commerce.

Lindley, S. T., R. S. Schick, A. Agrawal, M. Goslin, T. E. Pearson, E. Mora, J. J. Anderson, B. May, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2006. Historical Population Structure of Central Valley Steelhead and Its Alteration by Dams. San Francisco Estuary and Watershed Science 4(1): 19.

Lindley, S. T., R. S. 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 and Watershed Science 5:28.

Liu, Z. and B. Huang. 2000. Cause of tropical Pacific warming trend. Geophysical Research Letters 27(13): 1935-1938. July 1, 2000.

Maslin, P., M. Lennon, J. Kindopp, and W. McKinney. 1997. Intermittent Streams as Rearing of Habitat for Sacramento River Chinook Salmon. California State University, Chico, Department of Biological Sciences.

McCullough, D. S. 1999. A Review and Synthesis of Effects of Alterations to the Water Temperature Regime on Freshwater Life Stages of Salmonids with Special Reference to Chinook Salmon. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle, Washington. EPA 910-R-99-010.

McCullough, D., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Summary of Technical Literature Examining the Physiological Effects of Temperature on Salmonids. EPA-910-D-01-005.

McEwan, D. R. 2001. Central Valley Steelhead, in Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179:1-44. California Department of Fish and Game.

McEwan, D., and T. A. Jackson. 1996. Steelhead Restoration and Management Plan for California. 227 pp. California Department of Fish and Game.

Michel, C. J., A. J. Ammann, S. T. Lindley, P. T. Sandstrom, E. D. Chapman, M. J. Thomas, G. P. Singer, A. P. Klimley, and R. B. MacFarlane. 2015. Chinook Salmon Outmigration Survival in Wet and Dry Years in California's Sacramento River. Canadian Journal of Fisheries and Aquatic Sciences 72(11): 1749-1759.

Moyle, P. B. 2002. Inland Fishes of California. University of California Press, Berkeley and Los Angeles.

Myrick, C. A., and J. J. Cech. 2001. Temperature Effects on Chinook Salmon and Steelhead: A Review Focusing on California's Central Valley Populations. Bay-Delta Modeling Forum Technical Publication 01-1.

NMFS. 2009. Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project. U.S. Department of Commerce, National Marine Fisheries Service, Southwest Region, Long Beach, California. 844 pages plus appendices. June 4.

NMFS. 2011a. Letter from NMFS to Reclamation transmitting the amended Reasonable and Prudent Alternative for the 2009 Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project. U.S. Department of Commerce, National Marine Fisheries Service, Southwest Region, Long Beach, California. April 7, 2011. 189 pages.

NMFS. 2011b. 5-Year Review: Summary and Evaluation of Central Valley Spring-run Chinook Salmon ESU. U.S. Department of Commerce, Long Beach, California. 34 pp.

NMFS. 2014a. Final 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 California Central Valley Steelhead. West Coast Region. 427 pp.

NMFS. 2014b. Endangered Species Act Section 7(a)(2) Biological Opinion for the Jellys Ferry Bridge Replacement Project. U.S. Department of Commerce, Sacramento, California.

NMFS. 2015a. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response and Fish and Wildlife Act Recommendations for the Upper Sacramento River Anadromous Fish Habitat Restoration Programmatic, in Shasta and Tehama counties. U.S. Department of Commerce, Sacramento, California.

NMFS. 2015b. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response and

Fish and Wildlife Act Recommendations for the Lower American River Anadromous Fish Habitat Restoration Program. U.S. Department of Commerce, Sacramento, California.

NMFS. 2016a. 5-Year Review: Summary and Evaluation of California Central Valley Steelhead Distinct Population Segment. Page 44. U.S. Department of Commerce, NMFS, West Coast Region.

NMFS. 2016b. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response and Fish and Wildlife Act Recommendations for the Miner Slough Bridge Replacement Project. U.S. Department of Commerce, Sacramento, California.

NMFS. 2016c. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response and Fish and Wildlife Act Recommendations for the Oroville Facilities Hydroelectric Project Relicensing (Project No. 2100-134). U.S. Department of Commerce, Sacramento, California.

NMFS. 2017. Biological Opinion for the California Waterfix Project in Central Valley, California. U.S. Department of Commerce, Sacramento, California.

Nielsen, J. L., S. Pavey, G. K. Sage, and I. Williams. 2003. Genetic Analyses of Central Valley Trout Populations 1999-2003. CDFG, USFWS, Anchorage, Alaska.

Noakes, D. J., R. J. Beamish, L. Klyashtorin, and G. A. McFarlane. 1998. On the coherence of salmon abundance trends and environmental factors. North Pacific Anadromous Fish Commission Bulletin 1:454-463.

Nobriga, M. and P. Cadrett. 2001. Differences among Hatchery and Wild Steelhead: Evidence from Delta Fish Monitoring Programs. IEP Newsletter 14(3): 30-38.

PFMC. 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by Amendment 18. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. Pacific Fisheries Management Council.

Pacific States Marine Fisheries Commission. 2014. Juvenile Salmonid Emigration Monitoring in the Lower American River, California January – June 2013. Page 54. Prepared for the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife, Sacramento, California.

Petersen, J. H., and J. F. Kitchell. 2001. Climate regimes and water temperature changes in the Columbia River: bioenergetic implications for predators of juvenile salmon. Canadian Journal of Fisheries and Aquatic Sciences 58:1831-1841.

Phillis C. C., A. M. Sturrock, R. C. Johnson, and P. K. Weber. 2018. Endangered winter-run Chinook salmon rely on diverse rearing habitats in a highly altered landscape. Biological Conservation 217: 358-362.

Pusey, B. J. and A. H. Arthington. 2003. Importance of the Riparian Zone to the Conservation and Management of Freshwater Fish: A Review. Marine and Freshwater Research 54(1): 1- 16.

Richter, A. and S. A. Kolmes. 2005. Maximum Temperature Limits for Chinook, Coho, and Chum Salmon, and Steelhead Trout in the Pacific Northwest. Reviews in Fisheries Science 13:23-49.

Roos, M. 1987. Possible Changes in California Snowmelt Runoff Patterns. Department of Water Resources.

Roos, M. 1991. A Trend of Decreasing Snowmelt Runoff in Northern California. Pages 29-36 Western Snow Conference, April 1991, Washington to Alaska.

Sellheim, K., J. Merz, P. Haverkamp, and J. Sweeney. 2015. Lower American River Monitoring, 2015 Steelhead (*Oncorhynchus mykiss*) Spawning and Stranding Surveys, Central Valley Project, American River, California. 43 pp.

Snider, B. and R. G. Titus. 2000. Timing, Composition and Abundance of Juvenile Anadromous Salmonid Emigration in the Sacramento River near Knights Landing October 1998–September 1999. Stream Evaluation Program Technical Report No. 00-6.

Snider B., and R. G. Titus. 2001. Lower American River emigration survey, October 1997 – September 1998. California Department of Fish and Game Stream Evaluation Program Technical Report 01-6. 68 pp.

Snider B., and R. G. Titus. 2002. Lower American River emigration survey, October 1997 – September 1998. California Department of Fish and Game Stream Evaluation Program Technical Report 02-2. 47 pp.

Stachowicz, J. J., J. R. Terwin, R. B. Whitlatch, and R. W. Osman. 2002. Linking Climate Change and Biological Invasions: Ocean Warming Facilitates Nonindigenous Species Invasions. Proceedings of the National Academy of Sciences, U.S.A. 99:15497-15500.

Stewart, A. R., S. N. Luoma, C. E. Schlekat, M. A. Doblin, and K. A. Hieb. 2004. Food Web Pathway Determines How Selenium Affects Aquatic Ecosystems: A San Francisco Bay Case Study. Environmental Science & Technology 38(17): 4519-4526. April 15, 2005.

Stewart, I. T., D. R. Cayan, and M.D. Dettinger. 2005. Changes toward Earlier Streamflow Timing across Western North America. Journal of Climate (18) 1136-1155.

Swart, B. 2016. Shasta Operations Temperature Compliance Memo. 16 pp. U.S. Department of Commerce, Sacramento, California.

U.S. Army Corps of Engineers (Corps). 2018. Biological Assessment, Folsom Dam Water Control Manual Update. Sacramento, California.

U.S. Bureau of Reclamation. 2008. Biological Assessment on the Continued Long-Term Operations of the Central Valley Project and the State Water Project. Department of the Interior. 1089 pp.

U.S. Bureau of Reclamation. 2015. Biological Assessment for the Lower American River Anadromous Fish Habitat Restoration Program. 40 pp.

USFWS. 2015. Clear Creek Habitat Synthesis Report. U.S. Fish and Wildlife Service, Sacramento, California. 22 pp.

VanRheenen, N. T., A. W. Wood, R. N. Palmer, and D. P. Lettenmaier. 2004. Potential Implications of Pcm Climate Change Scenarios for Sacramento-San Joaquin River Basin Hydrology and Water Resources. Climatic Change 62(1-3):257-281.

Vogel, D. 2013. Evaluation of Fish Entrainment in 12 Unscreened Sacramento River Diversions. U.S. Fish and Wildlife Service and U.S. Bureau of Reclamation, CVPIA Anadromous Fish Screen Program.

Williams, J. G. 2006. Central Valley Salmon: A Perspective on Chinook and Steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science 4(3):416.

Williams, T. H., S. T. Lindley, B. C. Spence, and D. A. Boughton. 2011. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Update to January 5, 2011 Report. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California.

Williams, J. G. 2012. Juvenile Chinook Salmon in and around the San Francisco Estuary. San Francisco Estuary and Watershed Science 26.

Wooster, T. W. 1966. A Report to the California State Water Rights Board on the Fish and Wildlife Resources of the Feather River to be Affected by The Oroville Dam and Reservoir, Thermalito Diversion, Thermalito Forebay, and Thermalito Afterbay and Measures Proposed to Maintain These Resources.

Wright, S. A. and D. H. Schoellhamer. 2004. Trends in the Sediment Yield of the Sacramento River, California, 1957 – 2001. San Francisco Estuary and Watershed Science 2(2).

Yates, D., H. Galbraith, D. Purkey, A. Huber-Lee, J. Sieber, J. West, S. Herrod-Julius, and B. Joyce. 2008. Climate Warming, Water Storage, and Chinook Salmon in California's Sacramento Valley. Climatic Change 91(3):335.

Yuba County Water Agency, Department of Water Resources, and U.S. Bureau of Reclamation. 2007. Draft Environmental Impact Report/Environmental Impact Statement for the Proposed Lower Yuba River Accord. State Clearinghouse No: 2005062111. Prepared by HDR/Surface Water Resources, Inc.

54 FR 32085. August 4, 1989. Endangered and Threatened Species; Critical Habitat; Winter-run Chinook Salmon.

58 FR 33212. June 16, 1993. Designated Critical Habitat: Sacramento River Winter-Run Chinook Salmon. 8 pp.

59 FR 440. January 4, 1994. Endangered and Threatened Species; Status of Sacramento River Winter-run Chinook Salmon.

63 FR 13347. March 19, 1998. Endangered and Threatened Species; Threatened Status for Two ESUs of Steelhead in Washington, Oregon, and California.

64 FR 50394. September 16, 1999. Endangered and Threatened Species; Threatened Status for Two Chinook Salmon Evolutionarily Significant Units (ESUs) in California. 22 pp.

70 FR 37160. June 28, 2005. Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(D) Protective Regulations for Threatened Salmonid ESUs. 50 CFR Parts 223 and 224, 46 pp.

70 FR 52488. September 2, 2005. Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California; Final Rule. 141 pp.

71 FR 834. January 5, 2006. Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead.

71 FR 17757. April 7, 2006. Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. 10 pp.

74 FR 52300. October 9, 2009. Final Rulemaking to Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon. 53 pp.

81 FR 7214. February 11, 2016. Interagency Cooperation—Endangered Species Act of 1973, as Amended; Definition of Destruction or Adverse Modification of Critical Habitat. 13 pp.

81 FR 7414. February 11, 2016. Listing Endangered and Threatened Species and Designating Critical Habitat; Implementing Changes to the Regulations for Designating Critical Habitat.