BUREAU OF RECLAMATION

Long-Term Operation – Biological Assessment

Appendix M – Folsom Reservoir Flow and Temperature Management

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Appendix M Folsom Reservoir Flow and Temperature Management

M.1 Introduction

Folsom Reservoir flow and temperature management address the tradeoffs for minimum releases and the use of available cold water pool in Folsom Reservoir for water supply, power production and steelhead and fall-run Chinook salmon in the American River.

M.2 Initial Alternatives Report

An Initial Alternative Report (*LTO 2021 Consultation Initial Alternatives Appendix M – Folsom Reservoir Flow and Temperature Management)* developed potential options for the long-term operation of the Central Valley Project (CVP) and State Water Project (SWP) to inform alternative formulation by seeking the bounds of potential decisions and a contrast between approaches. Initial alternative options generally considered flow actions, non-flow actions, and the use of real-time information. Management questions, analyses, and findings provided information for Public Draft Environmental Impact Statement alternatives.

M.2.1 Management Questions

The United States Department of the Interior, Bureau of Reclamation's (Reclamation) management questions to inform the formulation of alternatives included:

- What habitat is created for steelhead and fall-run Chinook salmon at different releases?
- What is the additional water temperature capability at different storage levels?
- How does planning minimum storage for both the end of September and the end of December improve potential cold water habitat?
- What planning-minimum reservoir storage maintains water supply intakes in Folsom Reservoir?
- What risks occur from operating to a 50% exceedance forecast early in the water year?
- What water temperature targets reasonably protect steelhead, while leaving sufficient cold water for fall-run Chinook salmon?
- How do releases on the American River affect Shasta Reservoir, the *Bay–Delta Water Quality Control Plan*, and exports?

M.2.2 Initial Analyses

Reclamation completed a literature and data review regarding Folsom operations related to redd dewatering and stranding.

M.2.3 Initial Findings

Folsom Reservoir flow and temperature management address the tradeoffs for minimum releases and the use of the available cold water pool for water supply and steelhead and fall-run Chinook salmon in the American River. The alternatives analyzed and compared the effects of American River operations in the No Action Alternative to Alternative 1, Alternative 2, and Alternative 3. The Calsim II and HEC-5Q models were used to conduct the analysis for the flows and temperature elements of cold water pool management for Folsom Reservoir. Assumptions were made based on criteria for the current Folsom Reservoir flow and temperature conditions, regulatory requirements and projection for future conditions.

The Alternatives for Folsom flow and temperature management focus on analyzing changes to the Modified Flow Management Standard by adjusting the end-of-December carryover target and the Modified Flow Management Standard Minimum Required Release.

M.3 Public Draft Environmental Impact Statement Scenarios

Under the National Environmental Policy Act (NEPA), Reclamation compares action alternatives to a “no action” alternative. Under the Endangered Species Act, Reclamation’s discretionary actions over an environmental baseline determine the effects on listed species.

M.4 Performance Metrics

Performance metrics describe criteria that can be measured, estimated, or calculated relevant to informing trade-offs for alternative management actions.

M.4.1 Biological

Biological metrics consider direct observations and environmental surrogates.

- Days of 65 degrees Fahrenheit (°F) or lower water temperature at Watt Avenue, starting from May through September for steelhead juveniles
- Days of 56°F or lower water temperature at Watt Avenue starting from mid-October through December for fall-run Chinook salmon spawning
- Juvenile survival probability downstream of Watt Avenue
- Juvenile survival probability to Chipps Island
- Redd dewatering numbers

M.4.2 Water Supply

Water supply metrics consider the multipurpose beneficial uses of Folsom Reservoir.

- North-of-Delta agricultural deliveries (average and critical/dry years)

- South-of-Delta agricultural deliveries (average and critical/dry years)
- State Water Resources Control Board Water Right Decision 1641 standards
- Flood conservation pool releases ("spills")

CalSim II would support the evaluation of water supply metrics.

M.4.3 National Environmental Policy Act Resources

Analysis of the range of alternatives, as required by NEPA, is anticipated to describe changes in multiple resource areas. Key resources are anticipated to include surface water supply, water quality, power, aquatic resources, terrestrial biological resources, regional economics, land use and agricultural resources, recreation, cultural resources, socioeconomics, environmental justice, and climate change.

M.5 Methods

Reclamation solicited input from the stakeholders and agencies for the knowledge base paper focused on steelhead biology and life-history expression (Steelhead Juvenile Production Estimate). Reclamation identified the following datasets, literature, and models to help in evaluating Folsom reservoir flow and temperature management.

M.5.1 Datasets

Several efforts to characterize historical and ongoing steelhead monitoring programs in the California Central Valley have been completed over the past two decades. A few years after the completion of the Central Valley Steelhead Monitoring Plan, a series of related monitoring projects, identified as the Central Valley Steelhead Monitoring Program, were initiated on the Sacramento River and its tributaries (Fortier et al. 2014).

- Annual American River steelhead spawning survey reports completed mostly annually since 2002.
- Annual American River Chinook salmon escapement survey reports
- CalFish (2019). CalFish – A California cooperative anadromous fish and habitat data program. Middle Sacramento River salmon and Steelhead monitoring. Available: https://www.calfish.org/ProgramsData/ConservationandManagement/CentralValleyMonitoring/SacramentoValleyTributaryMonitoring/MiddleSacramentoRiverSalmonandSteelheadMonitoring.aspx.
- SacPAS: Central Valley Prediction & Assessment of Salmon provides a platform for data queries of juvenile steelhead salvage and loss. Available: http://www.cbr.washington.edu/sacramento/data/juv_salvage_loss.html.
- Use CalFishTrack to understand juvenile steelhead routing and survival into the Delta. Available: https://oceanview.pfeg.noaa.gov/CalFishTrack/

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- https://www.waterforum.org/habitat2022/
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M.5.2 Literature

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M.5.3 Models

Models support testing alternative operations and predicting environmental responses. The following models were available to Reclamation and relevant to addressing management questions:

M.5.3.1 Water Operations

CalSim II is a generalized reservoir-river basin simulation model that allows for specification and achievement of user-specified allocation targets, or goals (Draper et al. 2004). CalSim II represents the best available planning model for CVP and SWP system operations and has been used in previous system-wide evaluations of CVP and SWP operations (Bureau of Reclamation 2015). Reclamation and the California Department of Water Resources are advancing CalSim 3, but the model was not ready for these purposes.

M.5.3.2 Temperature

HEC-5Q is a reservoir routing and temperature model. Over the past 15 years, various temperature models were developed to simulate temperature conditions on the rivers affected by CVP and SWP operations (e.g., Sacramento River Water Quality Model San Joaquin River HEC-5Q model) (Bureau of Reclamation 2008). Recently, these models were compiled and updated into a single modeling package referred to here as the HEC-5Q model. Further updates were performed under the long-term operation Environmental Impact Statement modeling that included improved meteorological data and subsequent validation of the Sacramento and American River models, implementation of the Folsom Temperature Control Devices and low-level outlet, implementation of the Trinity auxiliary outlet, improved temperature targeting for Shasta and Folsom Dams, as well as improved documentation and streamlining of the models and improved integration with the CalSim II model (Bureau of Reclamation 2015). A summary of previous model calibration and validation details can be found at the following link: DWR-1084 RMA 2003 SRWQM.pdf (ca.gov). Reclamation is developing an updated water temperature modeling platform, but the model is not yet available for broad use.

M.5.3.3 Redd Dewatering Analysis

The redd dewatering analysis for the American River is based on the maximum reduction in flow from the initial flow, or *spawning flow*, that occurs during the incubation period of embryos (fertilized egg and alevin) to fry emergence. This period may vary from about two to three months, depending primarily on water temperature (Bratovitch et al. 2017). The minimum flow of the incubation period is referred to herein as the *dewatering flow*. If all flows during the incubation/development period are greater than or equal to the spawning flow, no dewatering is assumed to occur.

Bratovich et al. (2017) developed redd dewatering analyses for fall-run Chinook salmon and steelhead in the American River. These analyses use the depth distributions of redds at different spawning locations in the river, as determined from field studies, with the stage (water elevation) versus flow relationships at different river locations to estimate the percentage of fall-run and steelhead redds dewatered at different river flows. The redd dewatering was determined for the same river reach that was included in the spawning weighted usable area (WUA) study described above.

M.5.3.4 Weighted Usable Area (Spawning)

WUA analysis provides estimates of the amount of suitable spawning and rearing habitat of fishes available in rivers and streams at various levels of flow (Bovee et al. 1998). WUA is computed as the surface area of physical habitat available weighted by its suitability. Habitat suitability is determined from field studies of the distributions of redds or rearing juveniles with respect to flow velocities, depths, and substrate or cover characteristics in the river (Bovee et al. 1998). These data are used in hydraulic and habitat model simulations (PHABSIM and/or RIVER2D) that estimate the availability of suitable habitat in a portion of the river at a given flow. WUA curves showing suitable habitat availability versus flow are generated from the simulations. These curves are typically used to evaluate effects of proposed changes in a river's flow regime on the river's spawning and rearing habitat availability. The results of the WUA curves can be expressed as the amount of suitable habitat per unit distance of stream, which can be multiplied by length of habitat in the stream to estimate the total amount of suitable habitat.

The U.S. Fish and Wildlife Service (2003b) developed spawning WUA curves for American River fall-run Chinook salmon and steelhead. More recently, Bratovich et al. (2017) conducted studies related to the lower American River Modified Flow Management Standard that prepared spawning WUA curves for fall-run Chinook and steelhead. Both studies evaluated spawning habitat from Nimbus Dam up to about 10 miles downstream.

M.6 Lines of Evidence

Reclamation's management questions for the formulation of an alternative include the following.

M.6.1 Habitat Suitability

Steelhead and fall-run Chinook salmon experience optimal flows for spawning at approximately 2000 cubic feet per second (cfs) in the lower American River (U.S. Fish and Wildlife Service 2003). However, close to 80% of the maximum spawning habitat is still available to these species at flows of 800 cfs to just over 3500 cfs. Below 800 cfs, spawning habitat availability drops off precipitously. Likewise, low flows may be problematic for rearing habitat. Yearling steelhead are found in bar complex and side channel areas characterized by habitat complexity in the form of velocity shelters, hydraulic roughness elements, and other forms of cover (Surface Water Resources Inc. 2001). At low flow levels, the availability of these habitat types becomes limited, forcing juvenile steelhead densities to increase in areas that provide less cover from predation. With high densities in areas of relatively reduced habitat quality, juvenile steelhead become more susceptible to predation as well as disease.

Not only is the magnitude of releases important to salmonid habitat, but fluctuations in flow in the lower American River have been documented to result in steelhead redd dewatering and isolation (American River Group 2017, 2018; Hannon and Deason 2008; Hannon et al. 2003; Water Forum 2005). Redd dewatering can affect salmonid eggs and alevins by impairing development and causing direct mortality due to desiccation, insufficient oxygen levels, waste metabolite toxicity, and thermal stress (Becker et al. 1982; Reiser and White 1983). Isolation of redds in side channels can result in direct mortalities due to these factors, as well as starvation and predation of emergent fry. Isolation of juvenile fish exposes individuals to warm water temperatures and fish and avian predation within habitats that are disconnected from the river, likely increasing their mortality risk. If the isolated habitat is not reconnected to the river with a subsequent increase in river stage, all steelhead in that habitat are assumed to die.

M.6.2 Weighted Usable Area (Spawning)

This section will summarize results from Attachment M.3, *American River Weighted Usable Area Analysis*. This line of evidence was used in the Initial Alternatives Report.

M.6.2.1 Biological Assessment Results

The following key takeaways are applicable for all modeled species estimated suitable spawning habitat. The WUA analyses use the same variables for each species: habitat suitability assessed from field studies of redd distribution with respect to flow velocities, depths, and substrate/cover and CalSim 3 flows.

- **Driver of Variation:** CalSim 3 flows are the primary driver of variation in WUA analyses. The WUA curves and tables are used to look up the amount of spawning WUA available at different flows during the corresponding spawning period of the race or species.
- **Calibration and Calibration Method:** Spawning WUA were estimated for the Biological Assessment modeled scenarios from CalSim 3 flow data for each month of the 100-year period of record. The CalSim 3 operations model used to estimate spawning WUA under the scenarios employs a monthly timestep. Therefore, the WUA results should be treated as monthly averages. Monthly average WUA results faithfully represent the average conditions affecting the fish. Therefore, using monthly averages to compare WUA results is acceptable for showing differences in the effects of the different flow regimes under baseline and alternatives conditions. Weighting by the weighting factors ensures that the comparisons account for differences in the amount of spawning occurring in each month, improving the validity of the results.
- **Uncertainties:** Suitability of physical habitat for salmonids is largely a function of substrate particle size, cover, water depth, and flow velocity. Other unmeasured factors (e.g., flow vortices, water quality, food supply, etc.) could influence habitat suitability, contributing to uncertainty in the results. Data used to develop the habitat suitability criteria for spawning included information from rivers other than the American River (Bratovich et al. 2017). Furthermore, if channel characteristics have substantially changed since the initial field studies, the relationship of stage to flow might no longer be applicable.
- **Performance Measures:** Outputs of the WUA analyses are an index of habitat suitability, not an absolute measure of habitat surface area. In the literature, WUA is often expressed as square feet, square meters, or acres for a given linear distance of stream, which is misleading and can result in unsupported conclusions (Payne 2003; Railsback 2016; Reiser and Hilgert 2018). For WUA analyses, we recommend looking at the values relative to other scenarios. For the American River, the results are the means for all years analyzed, weighted by monthly spawning use factors.
    - Overall, the WUA habitat values for California Central Valley steelhead do not vary much among the three phases of the Proposed Action and are lowest in wet and above normal water years and highest in the drier water year types. This difference is attributable to the relatively low flows at which steelhead spawning

WUA in the American River peaks. Across all water year types, the No Action Alternative had the highest WUA value (79,117) and EXP1 had the lowest value (70,990). Between the three phases of the Proposed Action, Alt2 Without TUCP Without VA had the highest value (77,344).

California Central Valley Steelhead

Spawning WUA for steelhead peaks at approximately 1,400 cfs. The mean WUA habitat value under the Proposed Action phases ranges from 29,222 in wet water years to 116,305 in critical years (Table M-1).

Table M-1. Expected Weighted Usable Area for Steelhead Spawning in the American River Downstream of Nimbus Dam for the Three Baseline Scenarios and Three Biological Assessment Modeled Alternative 2 Scenarios

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	25,901	28,572	29,391	29,247	29,222	29,291
Above Normal	50,660	54,778	58,460	57,398	56,892	56,581
Below Normal	81,326	89,033	93,488	91,796	92,772	93,000
Dry	99,404	105,807	110,795	108,278	107,496	107,809
Critical	113,433	119,216	120,525	116,305	115,424	115,178
All	70,990	76,164	79,117	77,344	77,113	77,165

M.6.2.2 Environmental Impact Statement Results

[EIS key takeaways]

California Central Valley Steelhead

Table M-2. Expected Weighted Usable Area for Steelhead Spawning in the American River Downstream of Nimbus Dam for the Environmental Impact Statement Modeled Baseline Scenario, No Action Alternative, and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	29,391	28,692	29,246	29,247	29,222	29,291	28,596	29,392
Above Normal	58,460	55,129	57,361	57,398	56,892	56,581	56,888	57,338
Below Normal	93,488	85,702	91,604	91,796	92,772	93,000	92,608	90,881
Dry	110,795	96,053	108,104	108,278	107,496	107,809	110,040	107,547
Critical	120,525	105,814	116,689	116,305	115,424	115,178	122,231	117,633
All	79,117	71,161	77,323	77,344	77,113	77,165	78,607	77,248
PERCENT DIFFERENCES OF THE ALTERNATIVES AND THE NO ACTION ALTERNATIVE								
Wet	29,391	-2.38	-0.49	-0.49	-0.57	-0.34	-2.71	0.00
Above Normal	58,460	-5.70	-1.88	-1.82	-2.68	-3.22	-2.69	-1.92
Below Normal	93,488	-8.33	-2.02	-1.81	-0.77	-0.52	-0.94	-2.79
Dry	110,795	-13.31	-2.43	-2.27	-2.98	-2.70	-0.68	-2.93
Critical	120,525	-12.21	-3.18	-3.50	-4.23	-4.44	1.42	-2.40
All	79,117	-10.06	-2.27	-2.24	-2.53	-2.47	-0.64	-2.36

Fall-run Chinook Salmon

Table M-3. Expected Weighted Usable Area for Fall-run Chinook Spawning in the American River Downstream of Nimbus Dam for the Environmental Impact Statement Modeled Baseline Scenario, No Action Alternative, and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	110,031	104,927	109,091	109,186	108,538	108,806	109,743	109,148
Above Normal	140,579	123,537	139,812	139,838	139,380	139,640	137,001	139,916
Below Normal	136,602	116,729	134,816	134,092	133,095	132,691	137,595	135,800
Dry	126,078	115,099	125,677	125,258	126,034	123,862	127,786	124,645
Critical	134,075	123,463	126,791	123,661	124,507	125,010	131,242	126,721
All	126,854	115,064	124,965	124,295	124,179	123,774	126,400	124,916
PERCENT DIFFERENCES OF THE ALTERNATIVES AND THE NO ACTION ALTERNATIVE								
Wet	110,031	-4.64	-0.85	-0.77	-1.36	-1.11	-0.26	-0.80
Above Normal	140,579	-12.12	-0.55	-0.53	-0.85	-0.67	-2.54	-0.47
Below Normal	136,602	-14.55	-1.31	-1.84	-2.57	-2.86	0.73	-0.59
Dry	126,078	-8.71	-0.32	-0.65	-0.04	-1.76	1.35	-1.14
Critical	134,075	-7.92	-5.43	-7.77	-7.14	-6.76	-2.11	-5.49
All	126,854	-9.29	-1.49	-2.02	-2.11	-2.43	-0.36	-1.53

M.6.3 Redd Dewatering Analysis

This section summarizes results from Attachment M.1, *American River Redd Dewatering Analysis*. This line of evidence was used in the Initial Alternatives Report.

M.6.3.1 Biological Assessment Results

The following key takeaways are applicable for steelhead estimated percent redds dewatered. The redd dewatering analysis for the lower American River used relationships between flow, river stage, and redd depth distribution (developed by Bratovich et al. 2017) and CalSim 3 flows.

- **Driver of Variation:** CalSim 3 flows are the primary driver of variation in redd dewatering analyses. CalSim 3 flow estimates at Nimbus Dam were used to estimate stage at the spawning and dewatering flows, and the redd depth frequency distribution was queried to determine the percentage of the redds that occur between those two stages and would therefore be dewatered. The dewatering flow is the lowest flow for the post spawning period of incubation.
- **Calibration and Calibration Method:** Percent redds dewatered were estimated for the Biological Assessment modeled scenarios from CalSim 3 flow data for each month of the 100-year period of record. The CalSim 3 operations model used to estimate redd dewatering under the scenarios employs a monthly timestep.
- **Uncertainties:** The use of monthly time-step flow estimates like those obtained from CalSim 3 modeling likely underestimates redd dewatering rates because they smooth out short-term flow fluctuations. The duration of egg and alevin incubation for fall-run Chinook salmon and steelhead is assumed to be the same regardless of the time of year, which ignores water temperature effects on egg and alevin development times. Both potential biases are expected to affect the Project and No Action Alternative scenarios equally. If the channel characteristics substantially changed, the stage versus flow relationship might no longer be applicable.
- **Performance Measures:** The analysis compared CalSim 3 flow and the corresponding stage estimates below Nimbus Dam for each spawning month with the minimum flow (and stage) during 2 months (for steelhead) or 3 months (for fall-run) following the spawning month to estimate the percentage of redds dewatered at least once based on the redd depth cumulative frequencies.
  - Under all scenarios, steelhead redd dewatering increases from critical to wet water year types, which reflects the greater frequency of large flow fluctuations in wetter years. Across all water year types, the No Action Alternative had the lowest value (25.6%) and EXP3 had the highest value (29.4%).

California Central Valley Steelhead

The percentage of steelhead redds dewatered are greater in wetter water year types than in drier years but are relatively consistent among the Proposed Action scenarios and No Action Alternative (Table M-4). The percentage of redds dewatered under the three phases of the Proposed Action ranged from 5.1% to 49.1% for mean values grouped by water year type. The highest mean percent of redds dewatered occurred in wet years under EXP3 at 49.7%, relatively close to the No Action Alternative at 49.1%. The lowest values were in critically dry years across the scenarios, with the No Action Alternative as the lowest of those values at 4.6%. The results for steelhead redd dewatering grouped by months indicate that for the modeled scenarios redd dewatering peaks in February and is roughly similar in January and March (Figure M-1). February also has the highest variability in flows.

Table M-4. Mean Percent Steelhead Redds Dewatered for the American River by Water Year Type for January through March Spawning Period

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	39.6	49.7	49.1	49.1	49.1	48.9
Above Normal	37.6	41.2	38.6	39.5	40.2	39.8
Below Normal	23.6	26.0	20.6	23.2	22.6	21.1
Dry	18.6	17.1	8.4	10.6	10.5	10.9
Critical	15.8	6.1	4.6	5.1	6.7	5.8
All	27.6	29.4	25.6	26.8	27.0	26.6

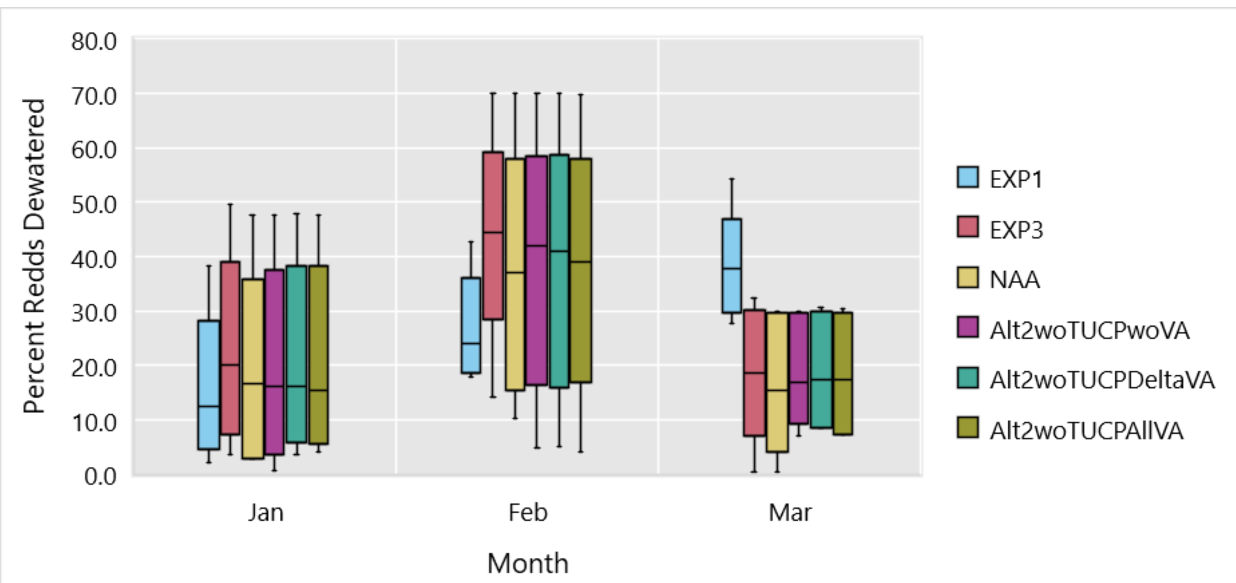


Figure M-1. Mean Percent Steelhead Redds Dewatered for the American River by Month, Biological Assessment Modeled Scenarios

M.6.3.2 Environmental Impact Statement Results

California Central Valley Steelhead

Table M-5. Mean Percent Steelhead Redds Dewatered for the American River by Water Year Type for January through March Spawning Period, Environmental Impact Statement Modeled Scenarios

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	49.1	50.5	49.1	49.1	49.1	48.9	46.6	46.6
Above Normal	38.6	46.9	39.7	39.5	40.2	39.8	33.4	33.4
Below Normal	20.6	36.7	23.4	23.2	22.6	21.1	13.6	13.6
Dry	8.4	29.2	10.7	10.6	10.5	10.9	9.4	9.4
Critical	4.6	18.5	8.2	5.1	6.7	5.8	3.6	3.6
All	25.6	37.3	27.4	26.8	27.0	26.6	23.0	23.0

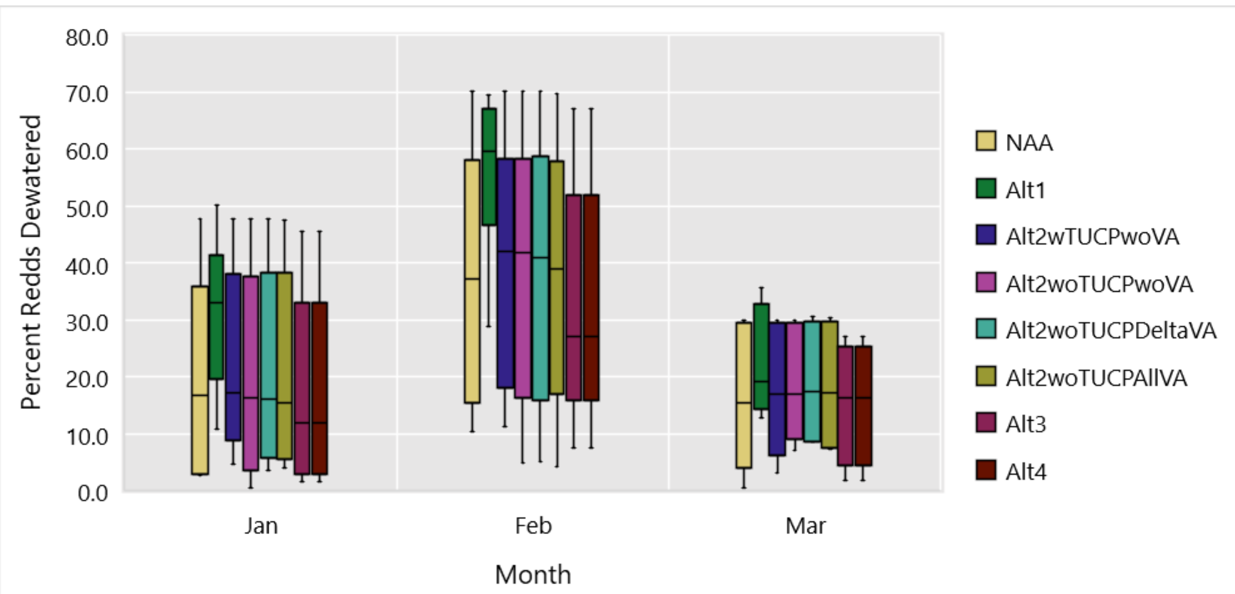


Figure M-2. Mean Percent Steelhead Redds Dewatered for the American River by Month, Environmental Impact Statement Modeled Scenarios

Fall-run Chinook Salmon

Table M-6. Mean Percent Fall-run Chinook Redds Dewatered for the American River by Water Year Type for October through December Spawning Period, Environmental Impact Statement Modeled Scenarios

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	9.9	14.6	10.8	10.8	11.0	10.9	10.2	10.2
Above Normal	6.1	15.8	6.5	6.5	6.7	6.6	5.8	5.8
Below Normal	4.3	9.3	4.5	4.6	4.7	5.1	4.5	4.5
Dry	6.9	12.1	6.6	6.6	6.5	7.8	6.6	6.6
Critical	4.3	8.9	2.8	4.7	4.0	4.3	2.0	2.0
All	6.8	12.4	6.8	7.1	7.1	7.5	6.4	6.4

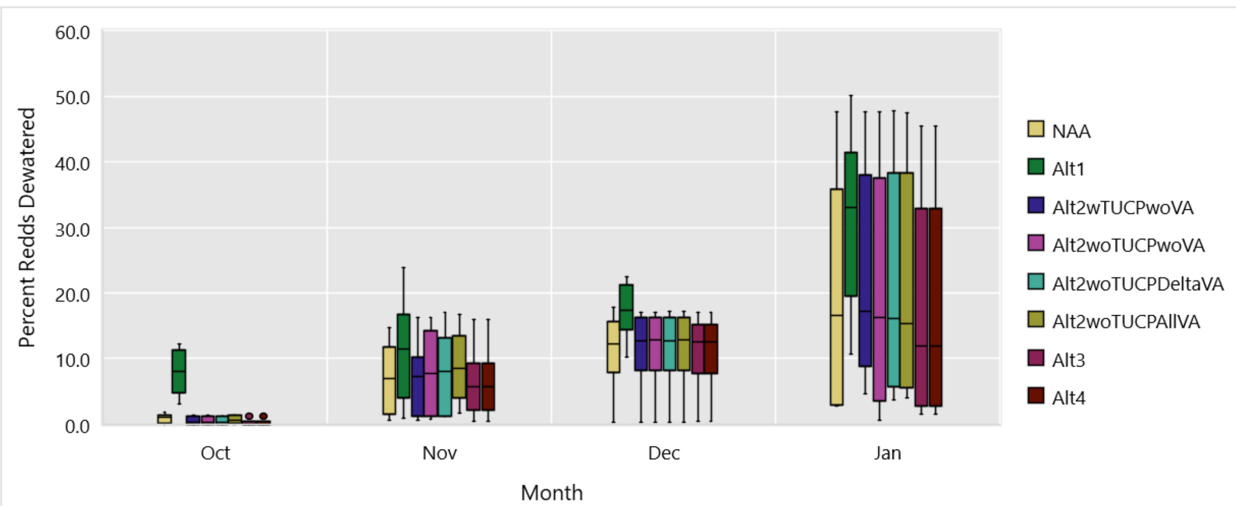
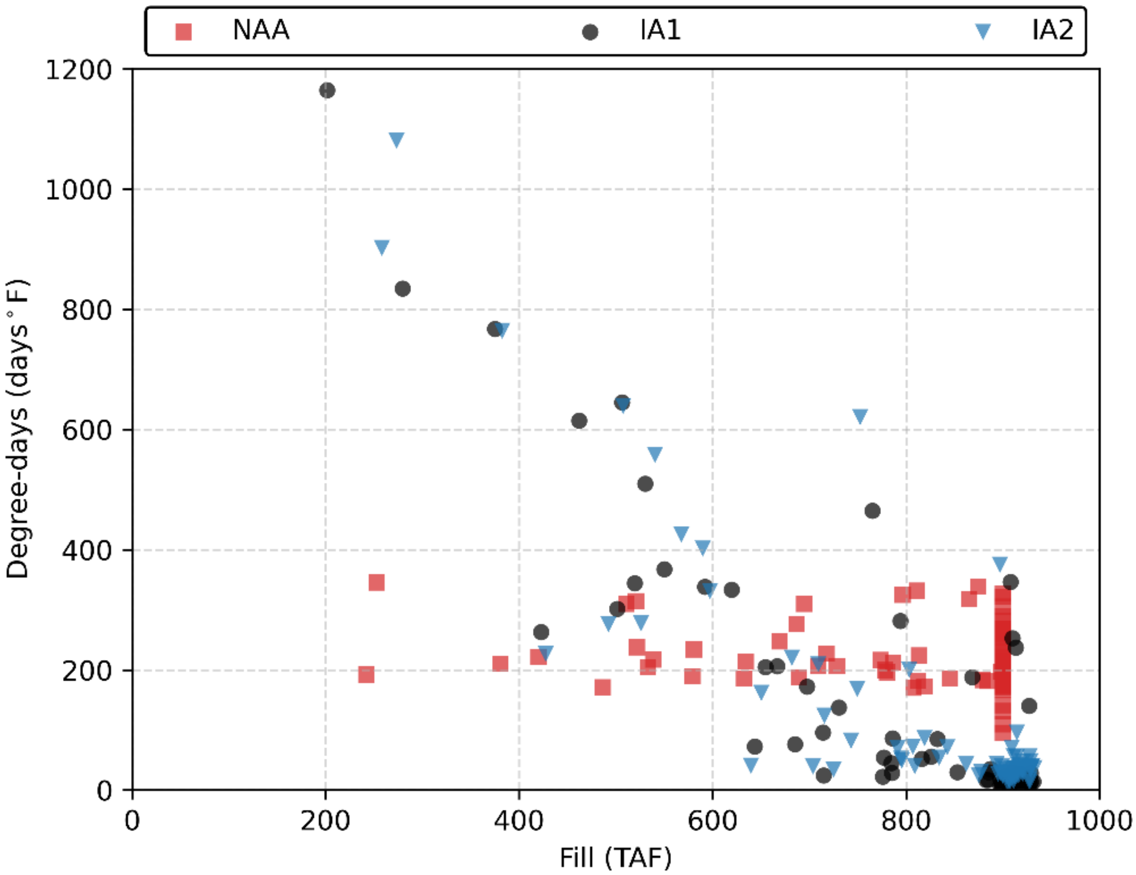


Figure M-3. Mean Percent Fall-run Chinook Salmon Redds Dewatered for the American River by Month

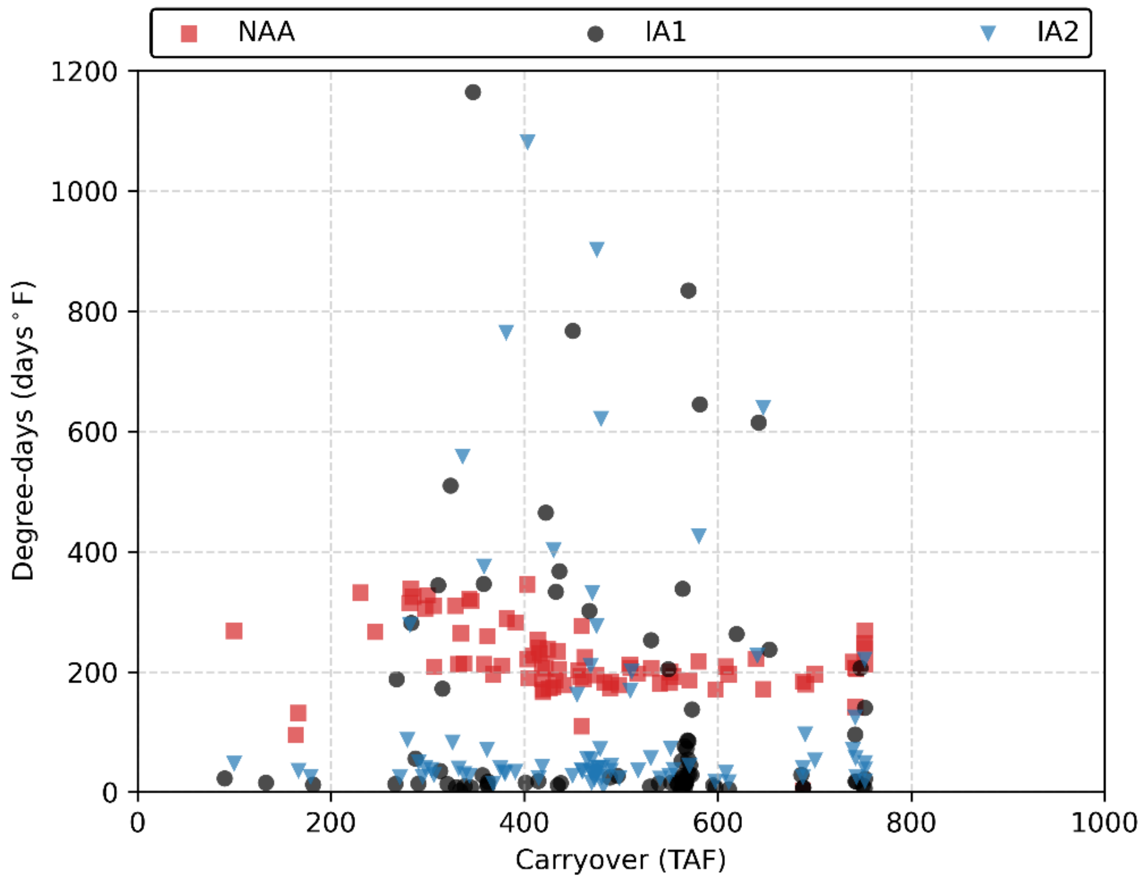
M.6.4 Temperature and Storage Levels

Figure M-4 and Figure M-5 show the degree days above a May through October temperature target of 65°F at Watt Avenue Watt Avenue as a function of Folsom end-of-April and end-of-September storage level.



IA1 = Initial Alternative 1; IA2 = Initial Alternative 2; °F = degrees Fahrenheit; TAF = thousand acre-feet.

Figure M-4. Degree Days above the Temperature Target as a Function of Folsom End-of-April Storage



IA1 = Initial Alternative 1; IA2 = Initial Alternative 2; °F = degrees Fahrenheit; TAF = thousand acre-feet.

Figure M-5. Degree Days above the Temperature Target as a Function of Folsom September Carryover Storage

M.6.5 Storage Planning Minimum and Coldwater Bypasses

Saving water over the summer until the fall period with implementation of planning minimums for end-of-September and end-of-December storage provides opportunity to provide cooler fall water temperatures. Cooler fall water temperature increases survival for juvenile steelhead rearing and for adult steelhead entering the river in the fall. Cooler water in the fall will reduce temperature related stress on holding Chinook salmon and increase survival for those eggs spawned prior to around the Thanksgiving time period. After about Thanksgiving, environmental cooling results in water temperature reaching and then dropping below 56°F. Egg survival is highest in water below 56°F at spawning time and then cooling through the winter period.

Cold water bypasses have occurred in the fall to reduce overall temperature of Folsom Dam releases. Cold water bypasses may (1) reduce prespawn mortality in fall-run Chinook salmon, (2) reduce fall-run Chinook salmon egg mortality, and (3) provide more suitable temperatures for hatchery operations. By releasing water from the lower river outlet at elevation approximately 210 feet (lowest elevation is 205.5 feet and highest elevation is 214.5 feet, average elevation is 210 feet) rather than through the powerplant penstocks, which pull from approximate elevation of 389 feet, it may reduce warm temperatures released into the lower American River. Fall releases of warmer water have been occurring more frequently since cold water accessed through the Folsom Shutters is used primarily for summer cold water releases for fisheries benefit. Summer cold water releases occur to maintain suitable rearing habitat for juvenile Central Valley steelhead.

In water year 2021, Reclamation used a cold water bypass by bypassing up to 350 cfs through the lower river outlet rather than the powerplant to target downstream temperatures close to 60°F. This bypass started on October 11 and ended on December 5, when destratification resulted in similar temperatures across reservoir elevations. All cold water was used during the bypass.

In water year 2022, Reclamation used a cold water bypass by bypassing up to 500 cfs through the lower river outlet rather than through the Folsom powerplant to target downstream temperatures. This bypass lasted from October 11 through November 26, 2022 resulting in 28,711 acre-feet bypassed, $641,852 daily weighted MWh hydropower not realized, and 5,180 tons of CO_2 production caused by replacement power.

The end-of-December storage planning minimum provides some insurance that in a critically dry winter there will be a level of storage left in the reservoir to provide operational flexibility to provide cooler water through the following summer than would otherwise be possible.

M.6.6 Planning Minimum and Water Supply Intakes in Folsom Reservoir

At storage levels below 90,000 acre-feet, the water level falls below the water supply intakes at Folsom Dam and El Dorado Hills, thereby preventing local water agencies from making critical water deliveries.

M.6.7 50% Exceedance Forecast Early in the Water Year

See Attachment M.1, *American River Redd Dewatering Analysis.*

M.6.8 Effects of Releases on the American River to Shasta Reservoir, the Bay-Delta Water Quality Control Plan, and Exports

See Attachment M.1, *American River Redd Dewatering Analysis.*

M.6.9 Historic Steelhead Redd Dewatering

Steelhead redd surveys were conducted in the American River and results reported in annual steelhead reports (Hannon et al. 2003; Hannon and Deason 2004, 2005, 2007; Chase 2010; Hannon 2013; Sellheim 2015, 2016, 2019, 2020; Sweeney 2017, 2021, 2022; Scrivin 2018). Steelhead redd dewatering was detected in the Sunrise side channel in 2003–2005, with 5 steelhead redds dewatered in each of 2003 and 2004 and 4 redds dewatered in 2005. Flow management and habitat modification completed in 2008 resolved the dewatering in that location, and dewatering has not been documented on the American River in subsequent reports.

M.6.10 Historic Steelhead Juvenile Stranding

Juvenile stranding surveys were conducted in the American River and results reported in annual reports in 2015–2022 (Sellheim 2015, 2016, 2019, 2020; Sweeney 2017, 2021, 2022; Scrivin 2018; Table M-7). Cramer Fish Sciences conducted the stranding surveys under contract with Reclamation. The 2015 and 2016 surveys documented visual counts of juvenile salmonids stranded in disconnected pools and no attempts were made to move stranded fish back into the main channel. Surveys in 2017–2022 were conducted with assistance from California Department of Fish and Wildlife to include seining the isolated pools and the stranded fish were moved to the main river channel. During the seining surveys salmonids were identified to species (steelhead or Chinook) and counted before being released into the main channel. Mortalities were enumerated when observed during the surveys.

Table M-7. Juvenile Salmonid Stranding Survey Results in the American River

Year	Species	Stranding Events	Effort (Survey Days)	Stranding Mortalities	Rescued
2022	Steelhead	1	6	233	8,164
2021	Steelhead	2	4		25
2020	Steelhead	2	5		35
2019	Steelhead	5	9	1	273
2018	Steelhead	6	8		370
2017	Steelhead	7	14		22
2016 [a]	Salmonids	3	5	1,595	
2015 [a]	Salmonids	3	4	4,226	

[a] Mortalities not specified; no fish salvage attempts.

M.7 Uncertainty

There are no identified long-term operation special studies to reduce uncertainty regarding CVP operations on the American River.

M.8 References

Literature referenced for Folsom Reservoir Flow and Temperature Management are listed in Section M.5.2, *Literature*. Additional references cited or used for informational material in the document are included below.

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