Long-Term Operation – Biological Assessment

Appendix AB-B – Water Operations and Ecosystem Analyses

July 2024

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Appendix B Water Operations and Ecosystem Analyses

B.1 Introduction

The seasonal operation of the Central Valley Project (CVP) and State Water Project (SWP) moves water from the winter and spring into the summer; from the northern parts of California to the south, and from wetter years to drier years. The United States Department of the Interior, Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR) take actions to:

- Store water and reduce flows downstream
- Release water to increase flows downstream
- Divert water for fish and wildlife, municipal and industrial, and agricultural purposes
- Route water into different channels
- Blend water from different elevations in the reservoir for temperature management

Modeling of flow, water temperature, and habitat condition shows the potential hydrologic alteration and resulting environmental conditions under different long-term operation (LTO) operation scenarios. This appendix provides analyses to capture the broad trends and patterns of hydrologic alternation supporting the deconstruction of the seasonal operation of the CVP and SWP in Appendix AB-D, *Seasonal Operations Deconstruction*. Analyses included the following scenarios:

- Run of the River (EXP1): EXP1 shows conditions without the discretionary storage of water. Impaired inflows into CVP reservoirs are passed downstream subject to the channel capacity of downstream reaches. No storage of water would occur except temporarily to attenuate flood peaks; therefore, no water is available for later release and no blending would occur. No diversions would occur from CVP nor Sacramento–Joaquin Delta (Delta) SWP facilities. No flow routing would occur at the Delta Cross Channel nor Suisun Marsh Salinity Control Gates. Non-Project facilities would operate when water is available.
- Minimum Releases (EXP3): EXP3 shows conditions without the discretionary release of water. CVP reservoirs would maximize storage and make releases only when required to meet downstream requirements or for flood control or non-discretionary obligations. Similar to EXP1, no diversions would occur from CVP nor Delta SWP facilities. No flow routing would occur at the Delta Cross Channel nor Suisun Marsh Salinity Control Gates. Non-Project facilities would operate when water is available. EXP3 and EXP1 together

show Reclamation's discretion and approximate the environmental baseline under the Endangered Species Act (ESA).

- No Action Alternative: Operating rules for the CVP and SWP under the 2020 Record of Decision (ROD) and operating rules for the SWP under the SWP 2020 Incidental Take Permit. The No Action Alternative represents the current management direction of Reclamation and DWR, as required by the National Environmental Policy Act (NEPA). The No Action Alternative include some of the same elements of the Proposed Action and, thus, encompasses some of the effects of the current Proposed Action. Thus, the No Action Alternative is not appropriate for the environmental baseline condition but may inform analysis.
- Proposed Action Alternatives: The operation of the CVP and SWP under the Proposed Action analyzed in the Effects Analysis chapters (5 through 12).

This appendix identifies the potential direction and magnitude of hydrologic changes, based on the above scenarios. For each CVP watershed, analyses include:

- Water Operations: CalSim monthly average flows. Different trends in different water year types are narrated where they occur. Appendix AB-E, *Exploratory Modeling*, provides the details. Simulation of the seasonal operation relied upon available modeling, CalSim 3 under 2022 median climate conditions. Subsequent updates intend to use 2040 hydrology and CalSim 3.
- Water Temperatures: HEC-5Q and the methods documented in the 2020 Record of Decision (ROD). The different needs for each watershed are described within the text for that watershed.
- Suitable Habitat: Central Valley Project Improvement Act (CVPIA) Decision Support Model habitat data package (Gill et al. 2022) estimates of suitable habitat acreages for combined instream and floodplain rearing habitat types. Delta habitat included DSM2 hydrodynamics and X2 salinity conditions.

Unless otherwise noted, water year types are the 40-30-30 index, as defined by D-1641 on page 188. The water year type determination is based on the unimpaired inflow to reservoirs published in the Bulletin 120 Water Supply Forecasts.[1] For the Sacramento Valley, the year classification is determined by computation using the following equation:

INDEX = 40% current year April – July Sacramento Valley unimpaired runoff
+ 30% current year October – March Sacramento Valley unimpaired runoff
+ 30% previous year's index

Tributaries in the San Joaquin Valley use the 60-20-20 San Joaquin index. The year classification is determined by computation of the following equation:

INDEX = 60% current year April – July San Joaquin Valley unimpaired runoff
+ 20% current year October – March San Joaquin Valley unimpaired runoff

[1] https://cdec.water.ca.gov/water_supply.html

+ 20% previous year's index

Releases to the San Joaquin River from Friant Dam use a water year classification specific to the San Joaquin River Restoration Program.

B.2 Background

Operations of the CVP and SWP are limited by physical capacity and available water. Reclamation and DWR's operation of the CVP and SWP changed significantly in 1978 with the issuance of the Water Quality Control Plan (WQCP) under the State Water Resources Control Board (Water Board) Water Rights Decision 1485 (D-1485). D-1485 incorporated a variety of Delta flow actions; imposed on the water rights for the CVP and SWP new terms and conditions that required Reclamation and DWR to meet certain standards for water quality protection for agricultural, municipal and industrial, and fish and wildlife purposes; and set salinity standards in the Delta while allowing the diversion of flows into the Delta during the winter/spring. Generally, during the time D-1485 was in effect, natural flows met water supply needs in normal and wetter years, and reservoir releases generally served to meet export needs in drier years.

The D-1485 requirements applied jointly to both the CVP and SWP, requiring a joint understanding between the projects of how to share this new responsibility. To ensure operations of the CVP and SWP were coordinated, the *Agreement between the United States of America and the State of California for Coordinated Operation of the Central Valley Project and the State Water Project* (Coordinated Operation Agreement [COA]) was negotiated by the United States and the State of California and approved by Congress in 1986, establishing terms and conditions by which Reclamation and DWR would coordinate operation of the CVP and SWP. The 1986 COA envisioned Delta salinity requirements but did not address export restrictions during excess conditions; the COA was amended in 2018 and addresses export restrictions.

In 1992, the CVPIA amended previous authorizations of the CVP. Pursuant to these authorities, there are three hierarchical categories of project purposes. Reclamation operates the CVP first for the primary purposes of river regulation, navigation, and flood control; then for the secondary purposes of water supply for irrigation and domestic uses and fish and wildlife mitigation, protection, and restoration; and finally for the tertiary purposes of power and fish and wildlife enhancement. The CVPIA included a number of other provisions such as a dedication of 800 thousand acre-feet of project yield to fish, wildlife, and habitat restoration and increased coordination with the U.S. Fish and Wildlife Service.

In 2000, the U.S. Department of the Interior Secretary signed the U.S. Department of the Interior Record of Decision Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement/Environmental Impact Report; the Hoopa Valley Tribe Chairman concurred in the decision (Trinity River ROD; U.S. Department of the Interior 2000). This defined a minimum flow regime ranging from 369,000 acre-feet (AF) in critical dry years to 816,000 AF in wet years in the Trinity River. The Trinity River ROD decreased the amount of water Reclamation could bring from the Trinity River to the Sacramento River, reducing water supplies for Delta outflow and salinity and reducing the Shasta Reservoir cold-water pool flexibility. Per CVPIA § Section 3406(b)(23), this effort was intended to meet federal trust responsibilities to protect the fishery resources of the Hoopa Valley Tribe and to meet the fishery restoration goals of the act of October 24, 1984 (Pub. L. 98-541).

In 1995, the Water Board issued an update to the Bay-Delta WQCP. In 1999 (revised in 2000), the Water Board issued D-1641 to implement those elements of the 1995 Bay-Delta WQCP that were to be implemented through water rights. The 1995 Bay-Delta WQCP and D-1641 included a new export to total Delta inflow export/inflow (E/I) ratio of 35% from February to June. The 35% E/I ratio from February to June was a significant change from D-1485. The 2006 WQCP (frequently referred to as the 1995 WQCP) and D-1641 also imposed spring X2 requirements and pumping limitations based on San Joaquin River flow, which in combination with the E/I ratio, reduced the availability of "unstored" flow for the CVP and SWP. (X2 refers to the horizontal distance from the Golden Gate Bridge up the axis of the Delta estuary to where tidally averaged near bottom salinity concentration of 2 parts of salt in 1,000 parts of water occurs.) February to June became an unreliable season for conveying water across the Delta.

In addition, D-1641 imposed a flow requirement for the San Joaquin Basin at Vernalis that included both base flows and a large spring pulse flow. However, it did not address how the requirement would be shared between the three major San Joaquin tributaries. Several interested parties entered into the San Joaquin River Agreement, which included flow commitments from all three tributaries, funding commitments, transfers, and voluntary demand reductions, but the agreement expired in 2012. On December 12, 2018, through Water Board Resolution No. 2018-0059, the Water Board adopted the Bay-Delta Plan amendments establishing the lower San Joaquin River flow objectives and revised southern Delta salinity objectives, but the Plan does not address how specific water right holders will meet the revised objectives.

In 2016, the U.S. Department of the Interior, Reclamation, and DWR jointly requested the Reinitiation of Consultation on the Coordinated Long-Term Operation (ROC on LTO). On Oct. 21, 2019, the U.S. Fish and Wildlife Service and National Marine Fisheries Service released their Biological Opinions on Reclamation's and DWR's new proposed coordinated operations of the CVP and SWP. The updated Biological Opinions include tributary-specific actions and Delta actions. On the Upper Sacramento River, actions include a spring pulse flow, cold water pool management, and actions to stabilize flows in the fall and winter. Actions on the Trinity River include additional flows for attraction and channel maintenance. The American River is operated to the 2017 Flow Management Standard, and the Stanislaus River is operated to the Stepped Release Plan. Delta actions include Old and Middle River (OMR) flows, Delta Cross Channel operations, and Delta Smelt Summer–Fall Habitat actions.

Under the California Endangered Species Act (CESA), DWR is required to obtain an Incidental Take Permit (ITP) to minimize, avoid and fully mitigate impacts to threatened or endangered species as a result of SWP operations. In past years, DWR obtained coverage for SWP operations under CESA by securing a consistency determination from the California Department of Fish and Wildlife based on federal Biological Opinions issued by federal regulatory agencies. In February 2019, DWR announced they would for the first time pursue a separate state permit to ensure SWP's compliance with CESA, and this went into effect in March 2020 with the issuance of the ITP and certification of the related environmental documents. The ITP applies only to the SWP, but actions of the ITP include water blocks for adaptive management and changes to OMR and Delta Smelt Summer–Fall Habitat implementation.

In addition to the evolving regulatory environment, hydrology continues to change, with a prominent warming trend that affected the fills and releases from the reservoirs.

B.3 Sacramento River

Inflows to Shasta Reservoir come from the Sacramento, Pitt, and McCloud Rivers.

Figure B-1 shows the inflow to Shasta Reservoir by month and water year type.

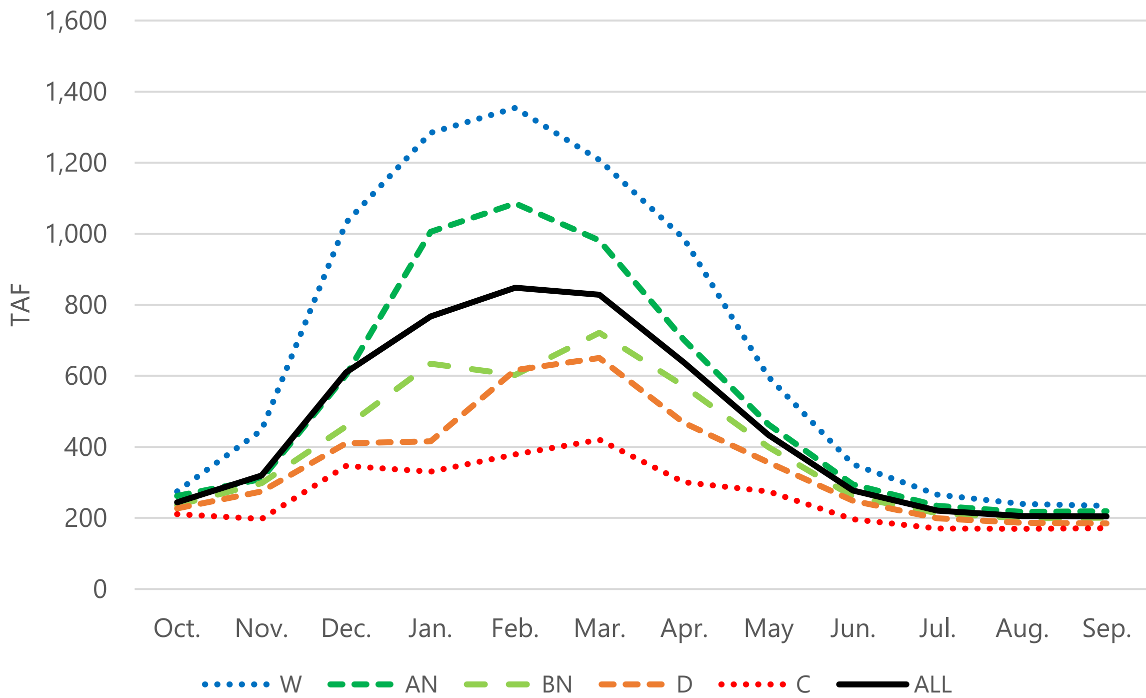


Figure B-1. Inflow to Shasta Reservoir by Month and Water Year Type

Releases from Shasta Reservoir and imports from the Trinity River Basin flow into Keswick Reservoir, impounded by Keswick Dam. Figure B-2 shows a simplified hydrologic topology for the Sacramento River from Keswick Dam to the Delta.

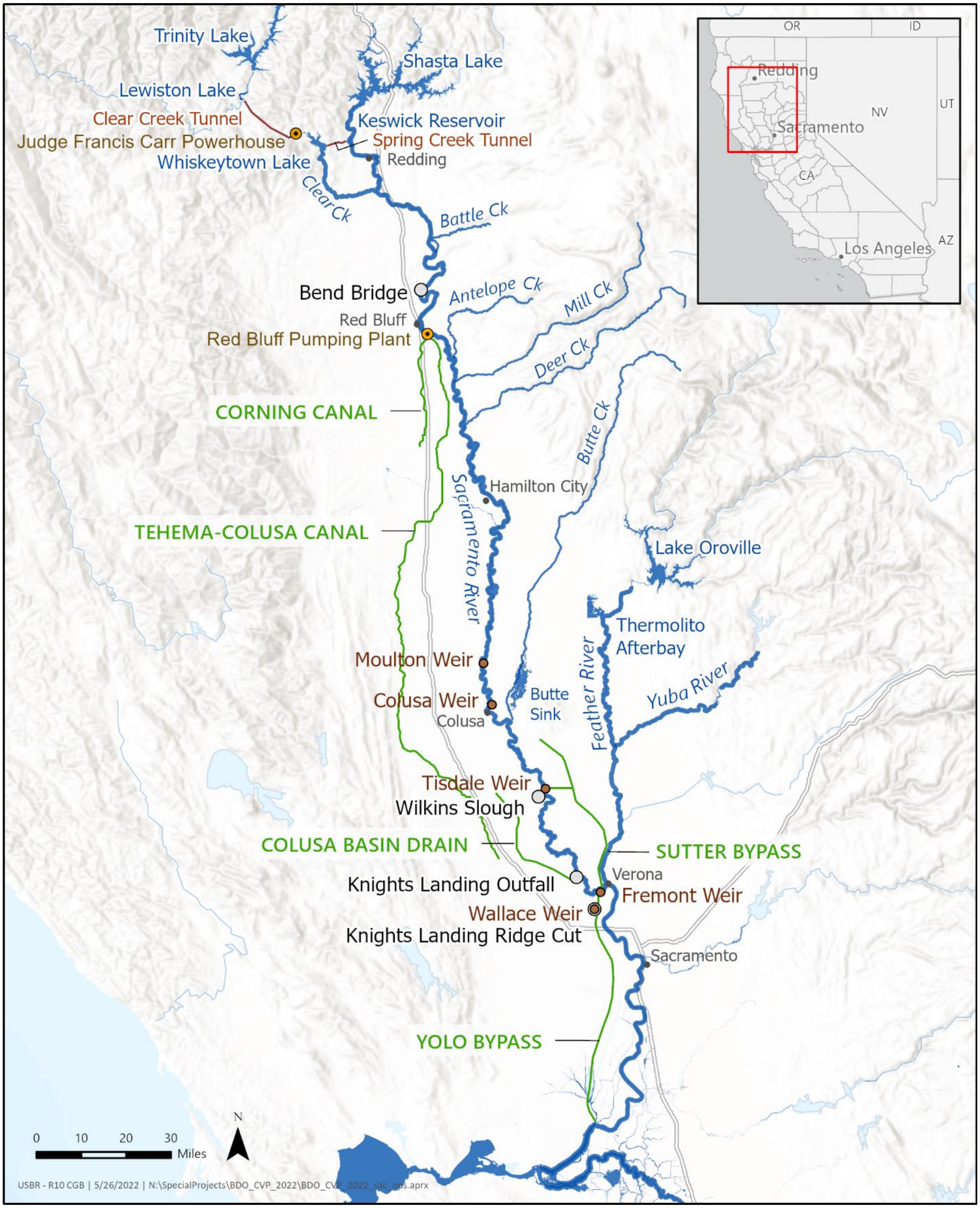


Figure B-2. Sacramento River Watershed Water Operations Topology

The measurement of flows on the Sacramento River at Bend Bridge captures tributary inflows upstream of the Red Bluff Pumping Plant and upstream of most diversions under Sacramento

River Settlement Contracts (e.g., inflows from Clear Creek, Battle Creek). Flood flows are diverted into the Sutter Bypass at Colusa Weir and Tisdale Weir. The Sacramento River near Wilkins Slough is upstream of the Feather River confluence, this location is used to measure local diversion flows in the vicinity at the Sacramento River with navigation criteria and represents the approximate downstream extent of diversion under Sacramento River Settlement Contracts. A portion of the runoff and drainage on the west side of the Sacramento Valley returns to the Sacramento River at the Knights Landing Outfall Gates from the Colusa Basin Drain. The Sacramento River at Verona captures flow downstream of the Feather River and downstream of the Fremont Weir diversion into the Yolo Bypass where it joins the remainder of the flows from the Colusa Basin Drain through the Ridge Cut and passes Wallace Weir. Flows diverted into the Yolo Bypass and past Freeport are addressed in the Delta watershed.

B.3.1 Water Operations

Figure B-3 shows release from Keswick Dam for the "Run of River (EXP1)", "Minimum Releases (EXP3)", "No Action Alternative (NAA)", "Proposed Action no VAs No TUCP (ALT2v1)", and "Proposed Action with Delta VAs no TUCP (ALT2v2)" scenarios.

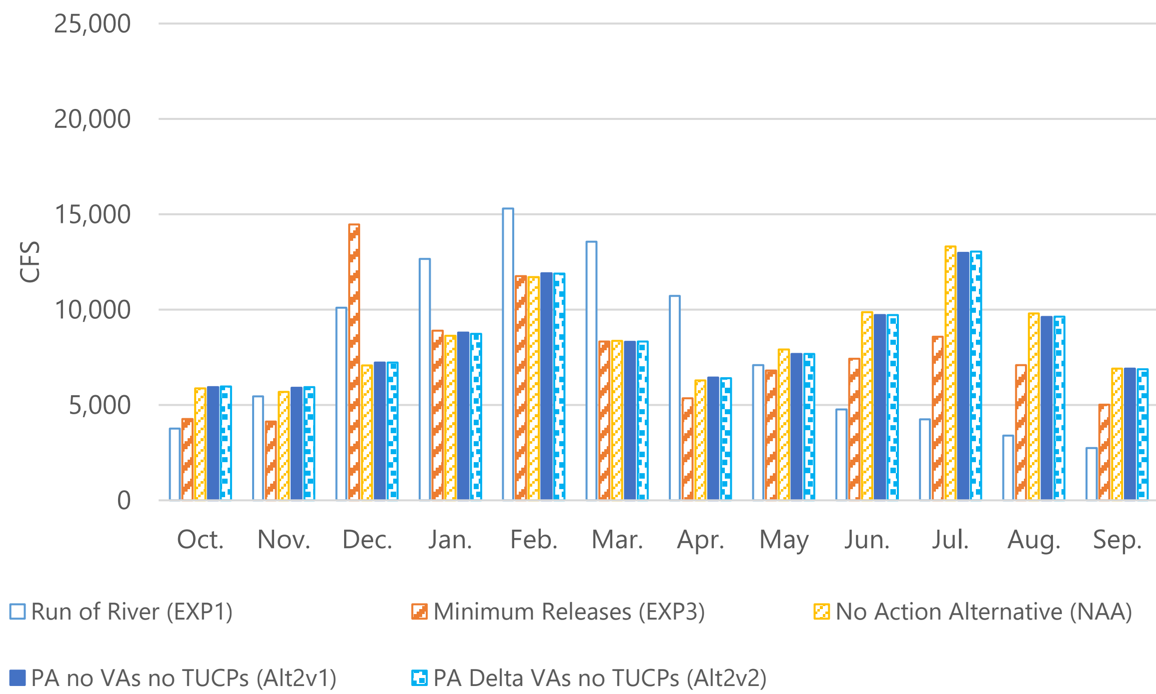


Figure B-3. Sacramento River Flow below Keswick Dam Monthly Flows, All Water Year Types

On average, Reclamation stores water in the winter and spring months for release in the summer and fall. Reclamation reviewed differences by year type and found the direction of the trend remains the same for most months, but the magnitude changes. In comparing months by year type (Figure B-4 and Figure B-5) for the Run of River and the Proposed Action scenarios, May flows in wet years are higher for Run of River than for the Proposed Action scenarios. In February, flows in critical years are higher for Run of River than the Proposed Action scenarios.

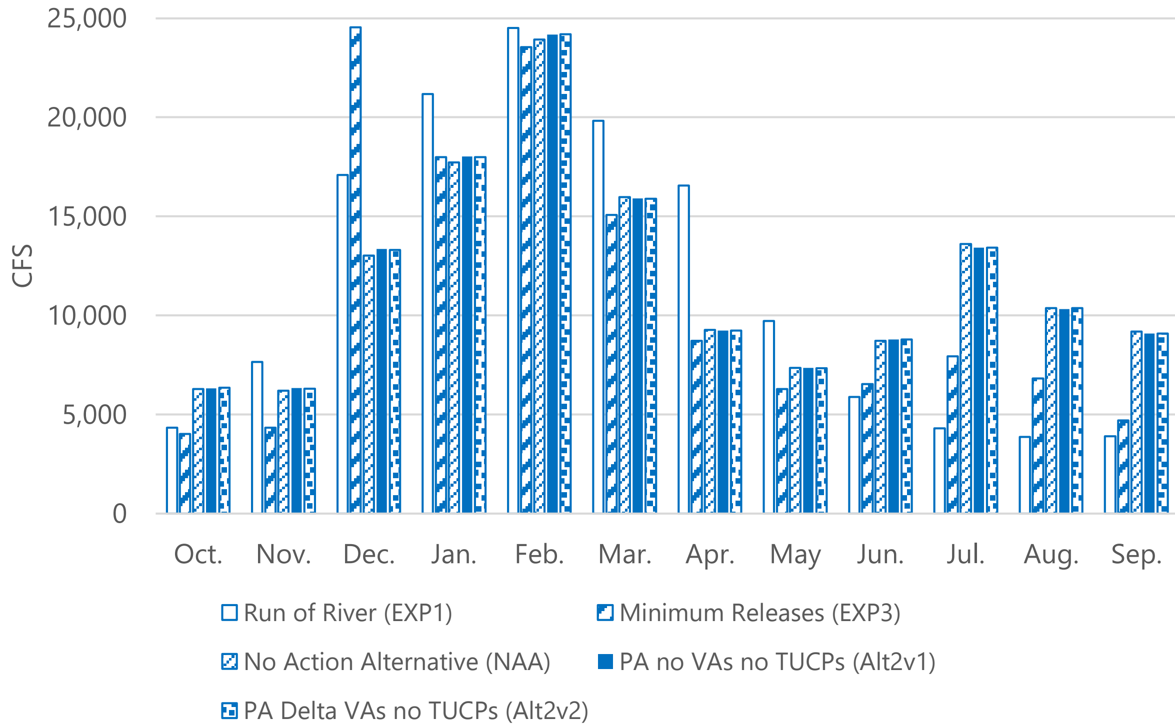


Figure B-4. Sacramento River below Keswick Dam Monthly Flows, Wet Water Year Type

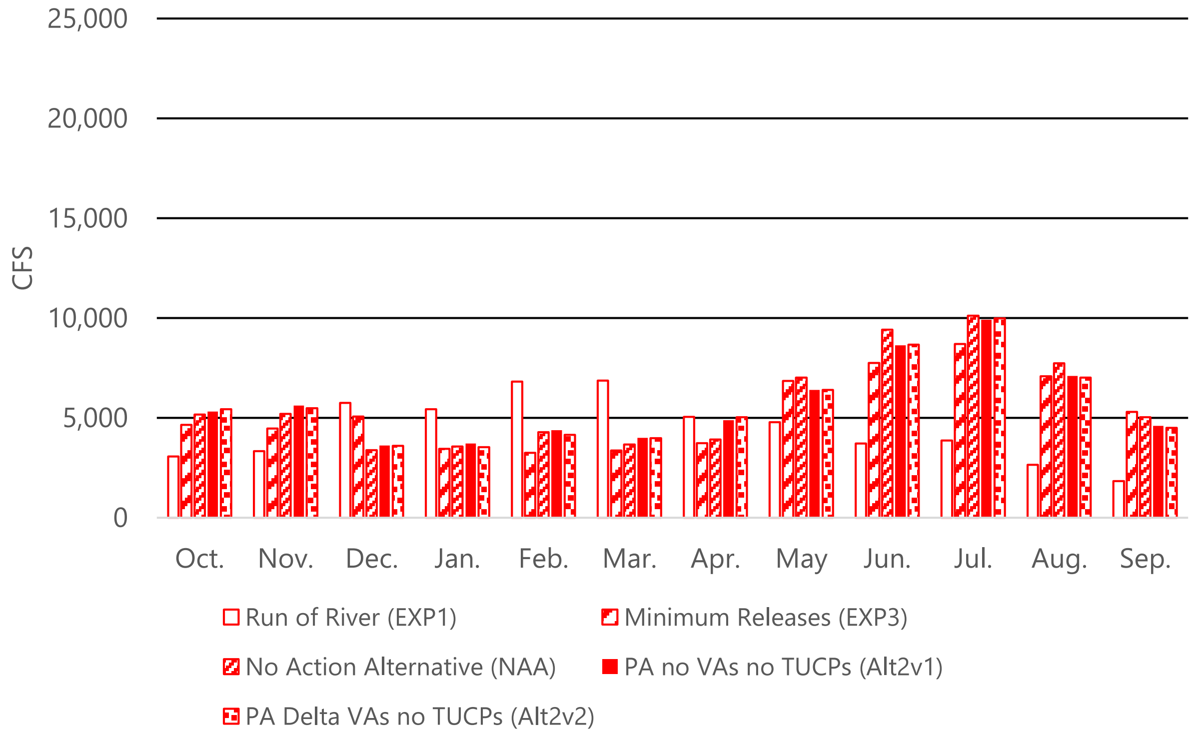


Figure B-5. Sacramento River below Keswick Dam Monthly Flows, Critical Water Year Type

Figure B-6, Figure B-7, and Figure B-8 show flows at Bend Bridge, upstream of most diversions under the Sacramento River Settlement Contracts and Sacramento Water Service Contracts. Approximately one-third of the flow in the spring comes from tributaries to the Sacramento River downstream of Keswick.

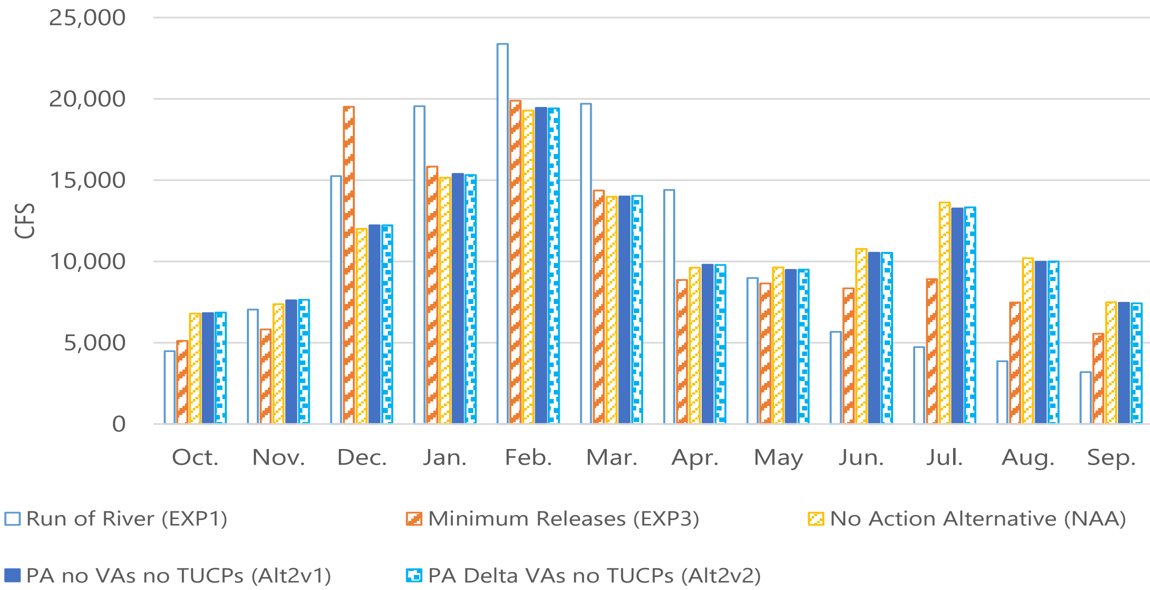


Figure B-6. Sacramento River at Bend Bridge Monthly Flows, All Water Year Types

In reviewing by water year type, the direction of the trend remains the same as the average across year types for most months, but the magnitude changes. In comparing the Minimum Release and Proposed Action scenarios year type, February flows in critical years are higher for the Proposed Action scenarios than for Minimum Release. In comparing the five scenarios by year type, September flows in wet years are higher for the Proposed Action than Minimum Release.

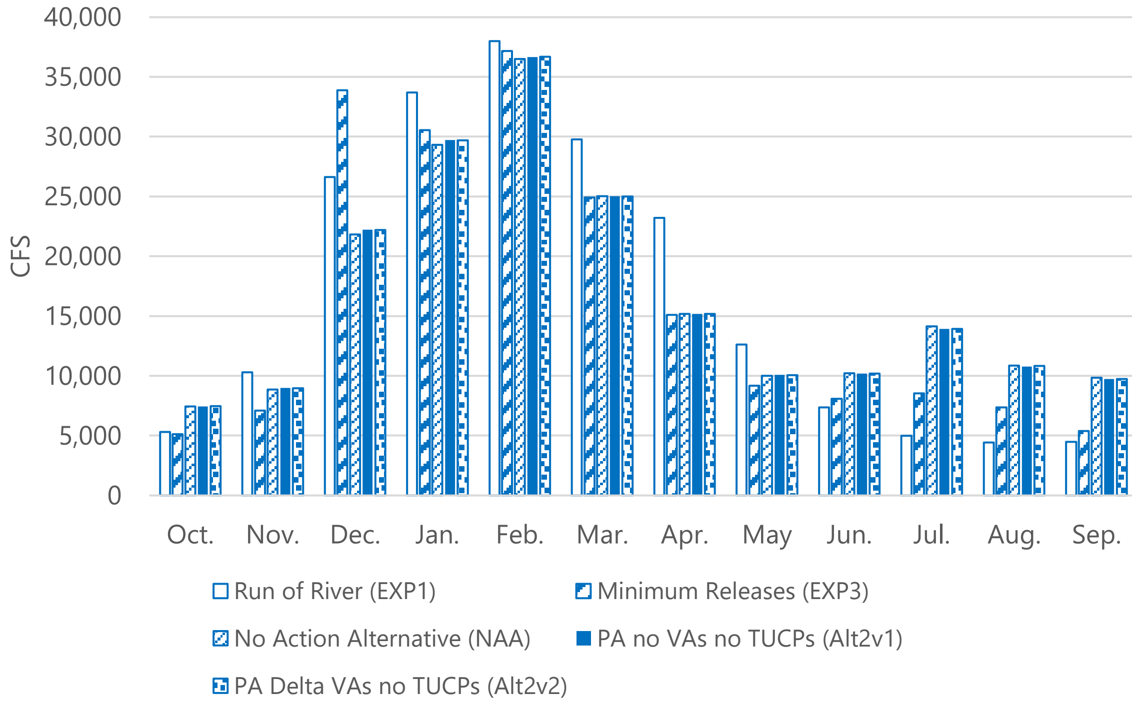


Figure B-7. Sacramento River at Bend Bridge Monthly Flows, Wet Water Year Type

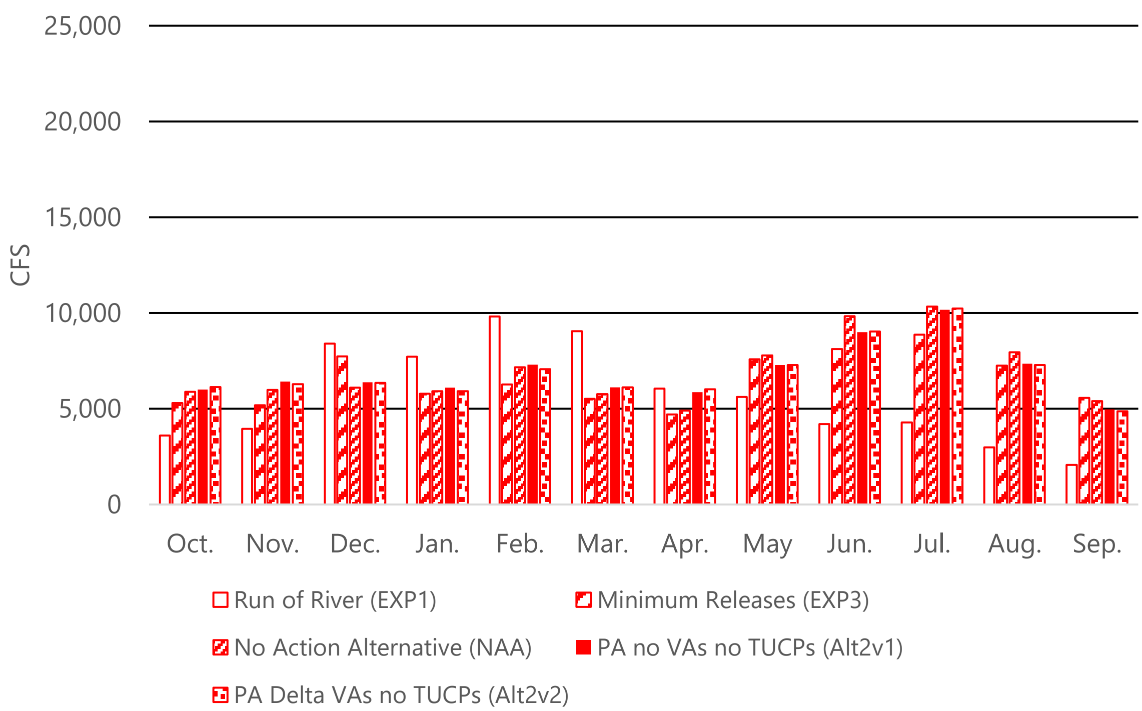


Figure B-8. Sacramento River at Bend Bridge Monthly Flows, Critical Water Year Type

Figure B-9, Figure B-10 and Figure B-11 shows flows at Wilkins Slough. Wilkins Slough is downstream of most diversions by Sacramento River refuge, settlement, and water service contractors.

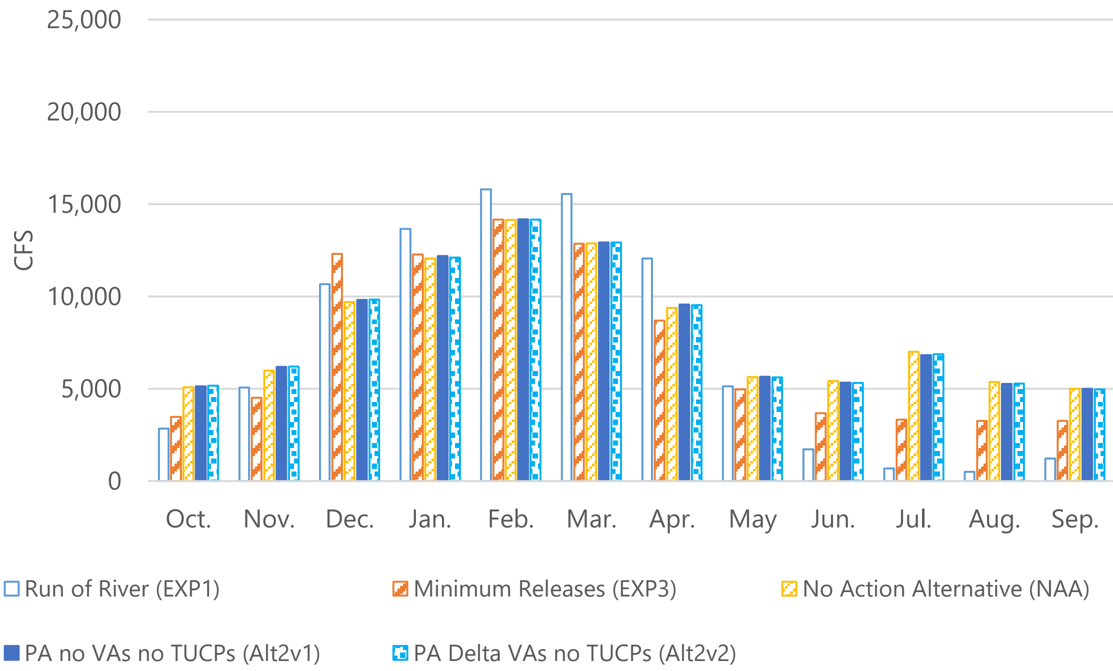


Figure B-9. Sacramento River near Wilkins Slough Monthly Flows, All Water Year Types

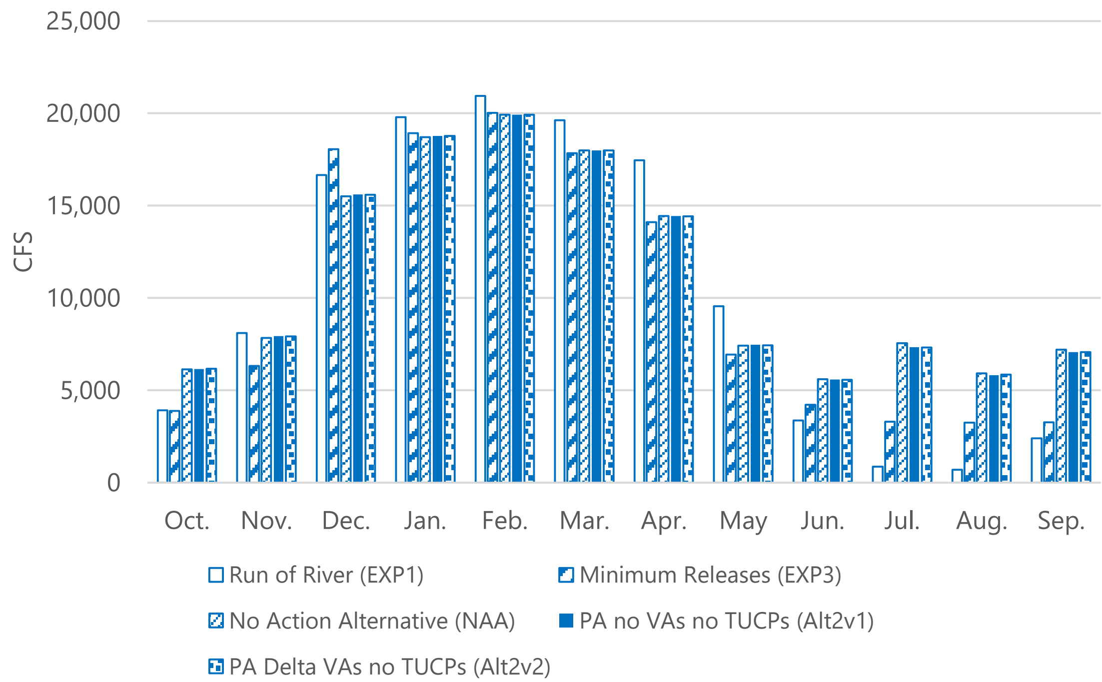


Figure B-10. Sacramento River near Wilkins Slough Monthly Flows, Wet Water Year Type

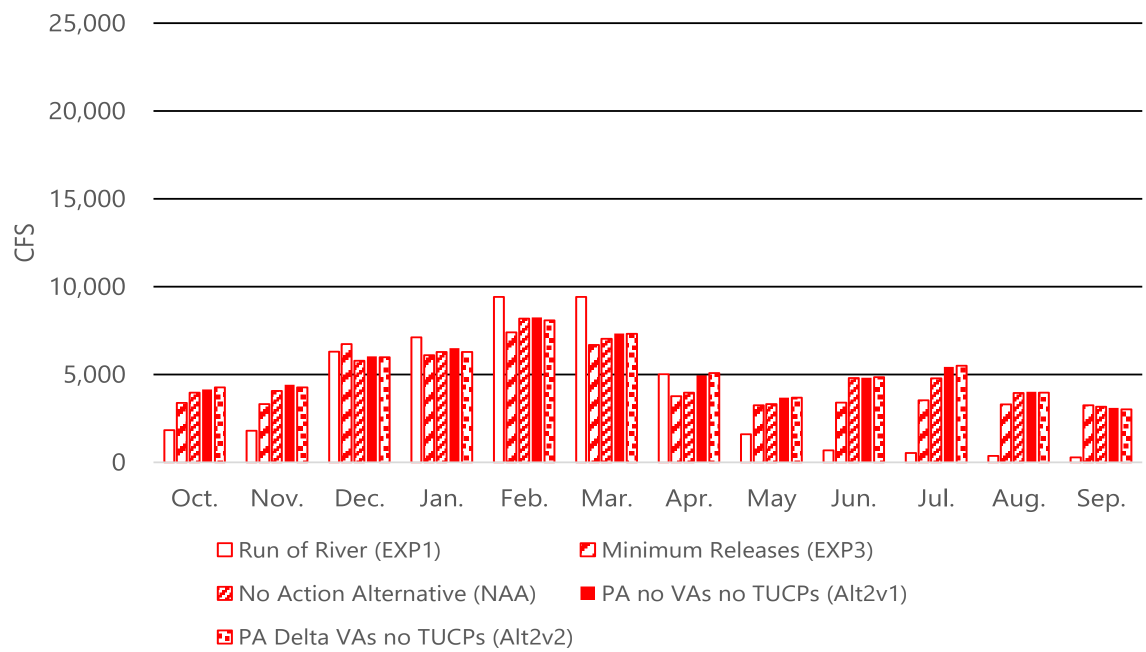


Figure B-11. Sacramento River near Wilkins Slough Monthly Flows, Critical Water Year Type

The Run of River scenario assumes senior water right diversions continue when water is available but no releases from Keswick Dam augment flows. Historically, Reclamation operates to maintain approximately 3,250-4,500 cfs for flow rates in the river based on the elevation for many of the non-project diversion facilities and regulatory criteria. In comparing the Minimum Release and Proposed Action scenarios by year type, February flows in critical years are higher for Proposed Action than for Minimum Release. In comparing the five scenarios by year type, September flows in wet years are higher for the Proposed Action than Minimum Release.

The U.S. Army Corps of Engineers directs the nondiscretionary operation of Shasta Reservoir to manage downstream flooding, including consideration of tributary inflows. Figure B-12 shows peak annual flows (monthly average) at Bend Bridge, which is above flood diversions into the Sutter Bypass.

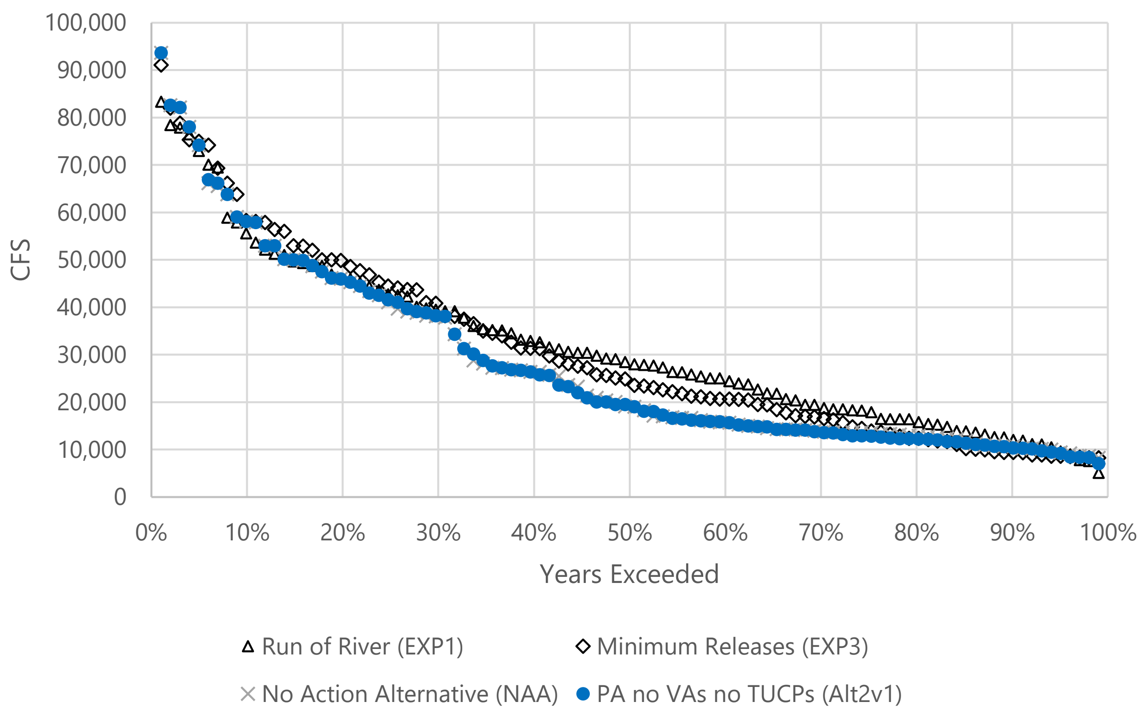


Figure B-12. Sacramento River at Bend Bridge Annual Peak Flow Frequency

The reduction of flows to ~80,000 cfs or less is part of the operation of Shasta Reservoir for flood control. In addition to downstream flood concerns, the Proposed Action influences the 1.5-year to 3-year return period peak flows by 5,000 to 10,000 cfs compared to an operation that passes inflow. Changes between Minimum Release and the Proposed Action are minimal. CalSim provides monthly averages while operations are managed daily. Most flood operations occur over a period of multiple weeks.

In wetter years, the flood control system diverts water into Sutter Bypass at the Moulton, Colusa, and Tisdale Weirs. Figure B-13 shows peak flows at Wilkins Slough, below diversions into the Sutter Bypass.

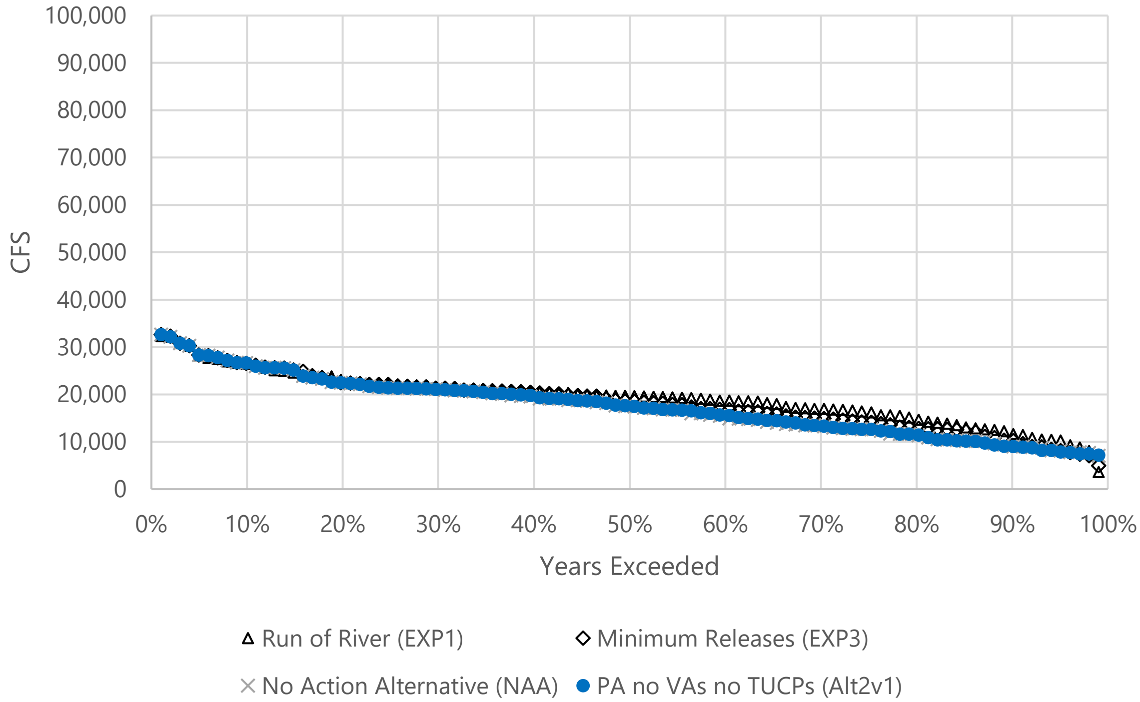


Figure B-13. Sacramento River near Wilkins Slough Annual Peak Flow Frequency

In the drier years, Reclamation stores water in the winter and spring and does not make releases for flood control. Tributary inflows below Keswick Reservoir provide flows to the system.

High flows from the Sutter Bypass return to the Sacramento River, join with flows from the Feather and Yuba Rivers, and may be partially diverted into the Yolo Bypass over the Fremont Weir above Verona. Flows in the Yolo bypass are discussed in Section 8, *Delta*, below.

Figure B-14, Figure B-15, and Figure B-16 show Sacramento River flows at Verona.

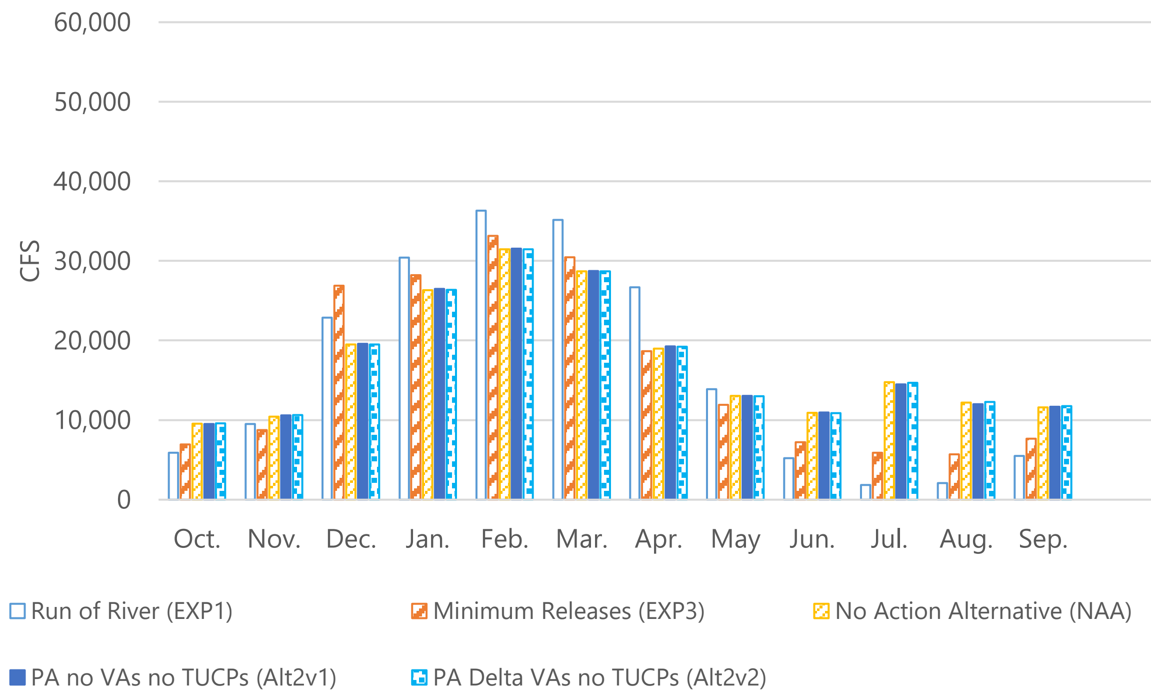


Figure B-14. Sacramento River at Verona Monthly Flows, All Water Year Types

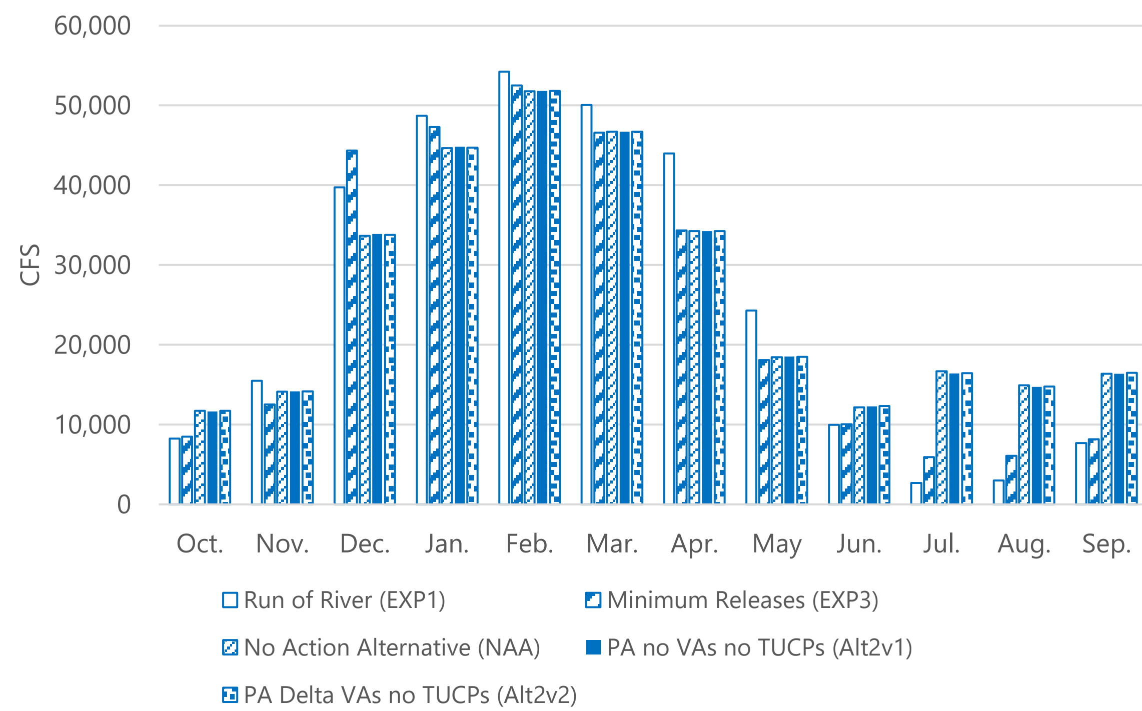


Figure B-15. Sacramento River at Verona Monthly Flows, Wet Water Year Type

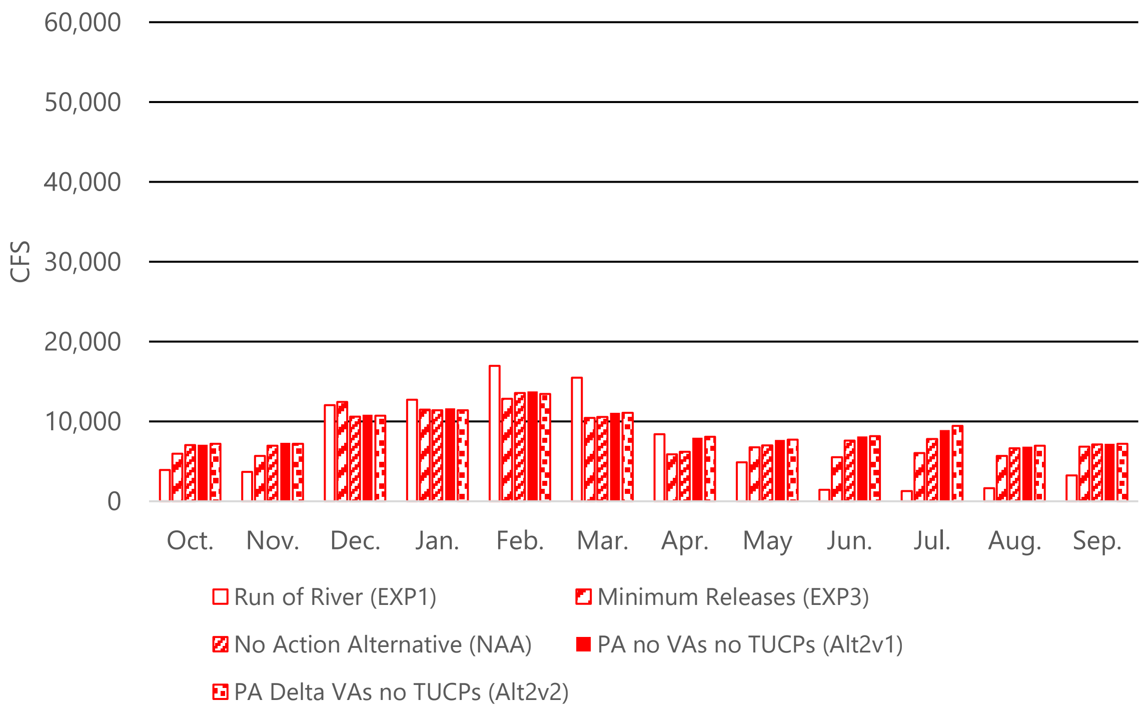


Figure B-16. Sacramento River at Verona Monthly Flows, Critical Water Year Types

In comparing the five scenarios by year type, August flows in critical years are higher for Proposed Action than Minimum Release. Also, August flows in dry years are higher for Proposed Action phases than Minimum Release. In September, flows in wet years are higher for Proposed Action than Minimum Release. Flows below Verona are joined with flows from the American River and discussed in Section 8, *Delta*.

B.3.2 Water Temperatures and Dissolved Oxygen

Reclamation operates a Temperature Control Device on Shasta Dam primarily for the protection of winter-run Chinook salmon during egg incubation in the summer. Under Water Board Order 90-5, Reclamation must meet 56°F at Red Bluff Diversion Dam unless (1) daily average temperatures higher than 56°F will be detrimental to the fishery, and (2) factors beyond the reasonable control of Reclamation prevent maintaining 56°F as the Red Bluff Diversion Dam such as (1) conditions where protection of the fishery can best be achieved by allowing a higher temperature in order to conserve cool water for later release, and (2) conditions where allowing a higher temperature is necessary to implement measures to conserve winter-run Chinook salmon. The Chief of the Division of Water Rights for the Water Board may object to changes in the water temperature compliance location. Figure B-17 shows historical temperature compliance locations.

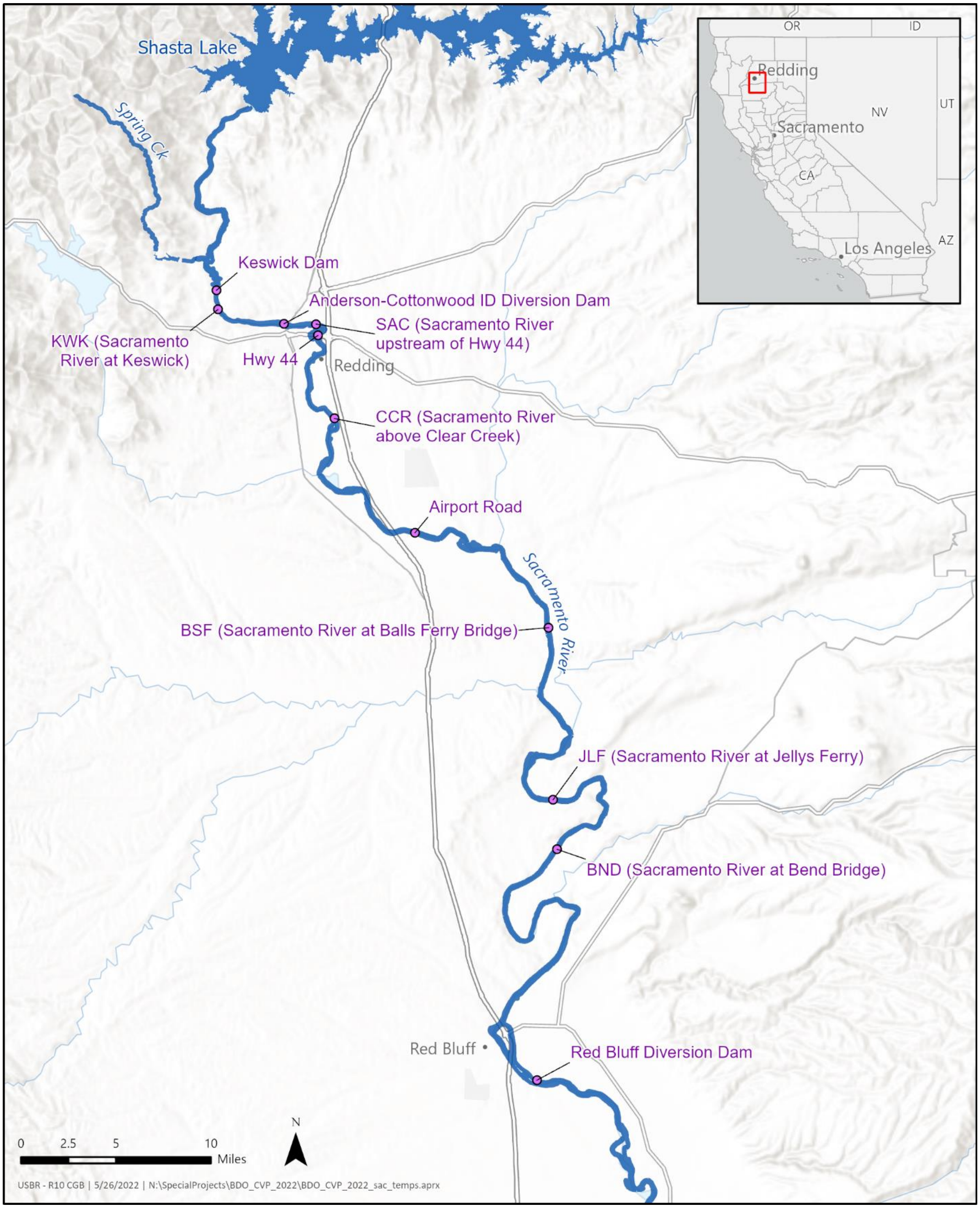


Figure B-17. Historical Temperature Compliance Locations Used under 90-5

The Clear Creek confluence is the approximate downstream extent of the majority of winter run Chinook salmon spawning; however, a large proportion spawn above the highway 44 Bridge, which becomes an important consideration during drought. Temperature scenarios used the 2022 median climate change meteorology for the following scenarios:

- Run of River (EXP1): water temperatures released from Shasta are similar to the mixture of water temperatures flowing into Shasta reservoir from multiple tributaries. There are minor changes in storage that perturb the temperature of releases and buffer water temperatures.
- Minimum Releases (EXP3): Given the reservoir and flow conditions of EXP3, the temperature control device (TCD) is operated according to the tiered strategy to target use of cold water during critical egg incubation stages when the majority of winter-run Chinook salmon redds are present.
- No Action Alternative: The reservoir and flow conditions from the No Action Alternative are used with the Shasta Reservoir TCD operated according to the tiered strategy.
- Red Bluff 56°F Temperature Target: for the reservoir and flow conditions of the Proposed Action, a target of 56°F at Red Bluff Diversion Dam starting May 15 until the available cold water in storage is depleted. An analysis was performed to optimally use the cold water and keep target temperatures at Red Bluff Diversion Dam at 56°F as long as possible throughout the months of May through October.
- Proposed Action Bin Objectives no Temporary Urgency Change Petition (TUCP): for the reservoir and flow conditions of the Proposed Action, the targets were set according to the objectives in the Shasta Reservoir Water Temperature Management Framework. No shaping was assumed.
- Proposed Action Tier Strategy no TUCP: for the reservoir and flow conditions of the Proposed Action, the targets were set according to the tiered strategy.

Figure B-18 shows monthly average of water temperatures below Red Bluff Diversion Dam average across all water year types.

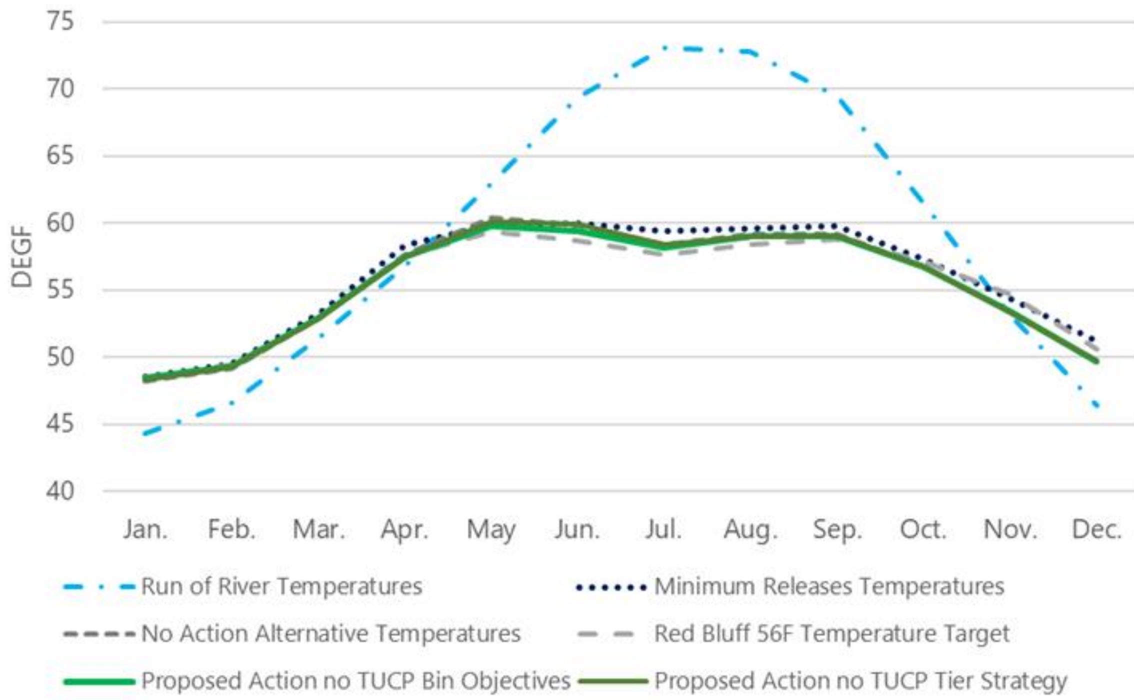


Figure B-18. Sacramento River Water Temperatures below Red Bluff Diversion Dam, All Water Year Types

Run of River temperatures in the Sacramento River follow a sinusoidal pattern in which temperatures are low in the winter and high in the summer (August). Temperatures targeting 56°F at Red Bluff Diversion Dam and the Tiered Strategy are also low in the winter but peak in the fall (September–October). When the cold-water pool is limited, the Tiered strategy provides warmer waters earlier in the temperature management season to delay depletion of the cold-water pool and support colder waters later in the season. Flows under the Tiered Strategy additionally start with more cold water than the flows under 56°F at Red Bluff Diversion Dam due to measures in the 2020 ROD that increase the cold-water pool in Shasta Reservoir.

Figure B-19 shows the results from targeting 56°F at Red Bluff Diversion Dam by year type to illustrate when the temperature compliance location may need to be moved upstream.

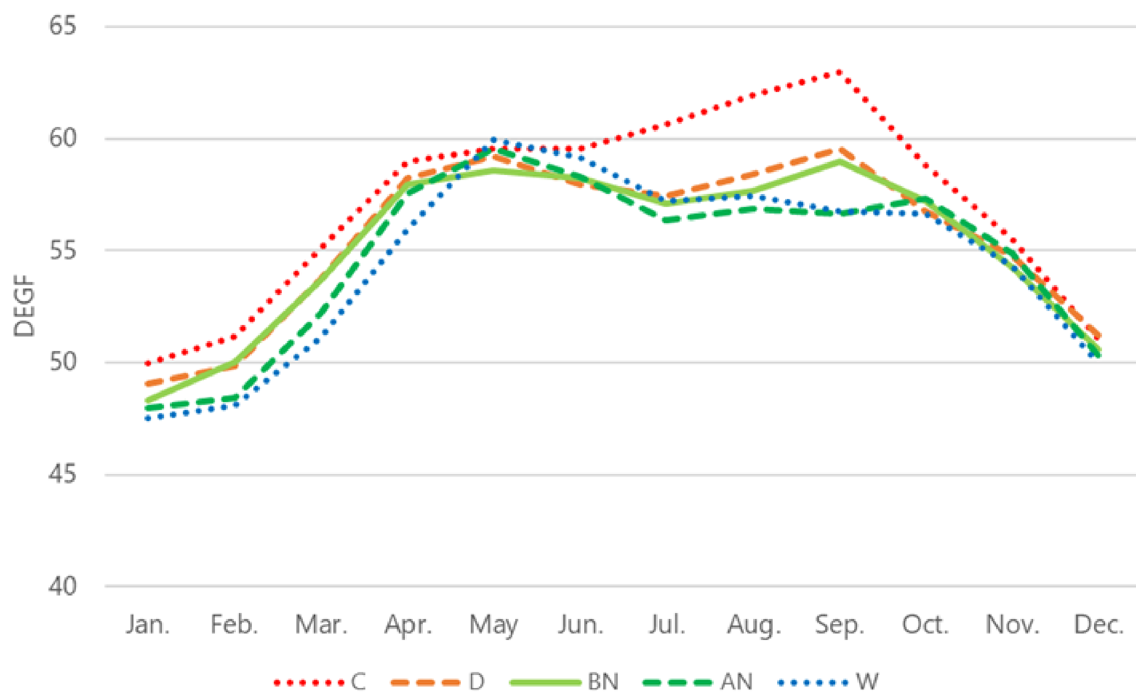


Figure B-19. Sacramento River Water Temperatures below Red Bluff Diversion Dam when Targeting 56°F at Red Bluff Diversion Dam by Water Year Type

Critical and Dry years may deplete the cold-water pool by June or July. Figure B-20 shows the water temperatures below Clear Creek for the same scenario.

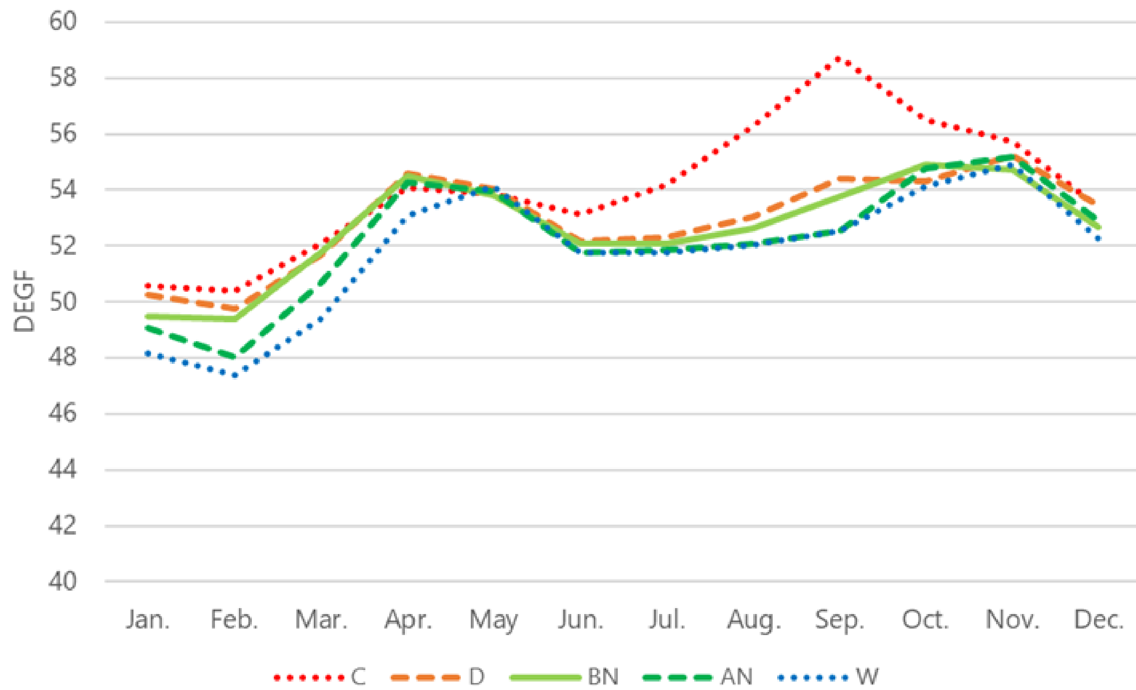


Figure B-20. Sacramento River Water Temperatures Below Clear Creek when Targeting 56°F at Red Bluff Diversion Dam by Water Year Type

Temperatures may approach or exceed 56°F in September and October of Critical, Dry, and Below Normal years. Figure B-21 shows temperature below Clear Creek under the Proposed Action following the objectives identified in the Shasta management framework bins.

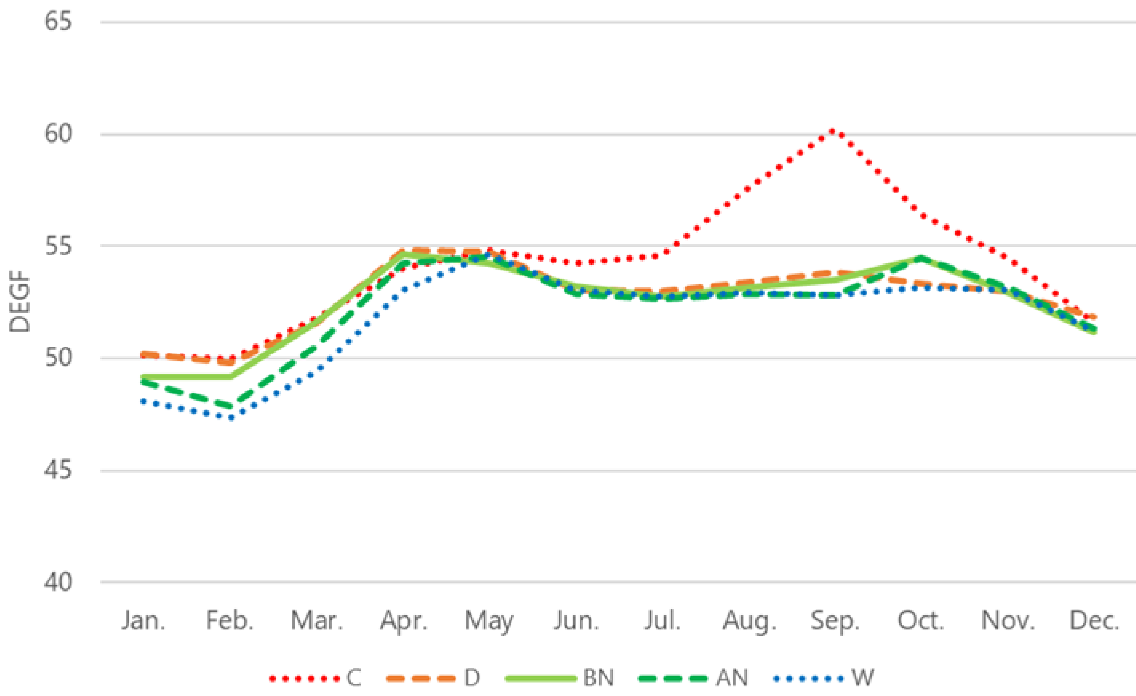


Figure B-21. Sacramento River Water Temperatures Below Clear Creek under the Proposed Action Bin Objectives by Water Year Type

All year types except for Wet years lack sufficient cold water to maintain 53.5°F throughout the temperature management season with Critical years resulting in lethal temperatures. The Proposed Action allows for some shaping of temperatures. Figure B-22 show the application of the tiered strategy to reduce temperatures during critical egg incubation stage when the most redds are present.

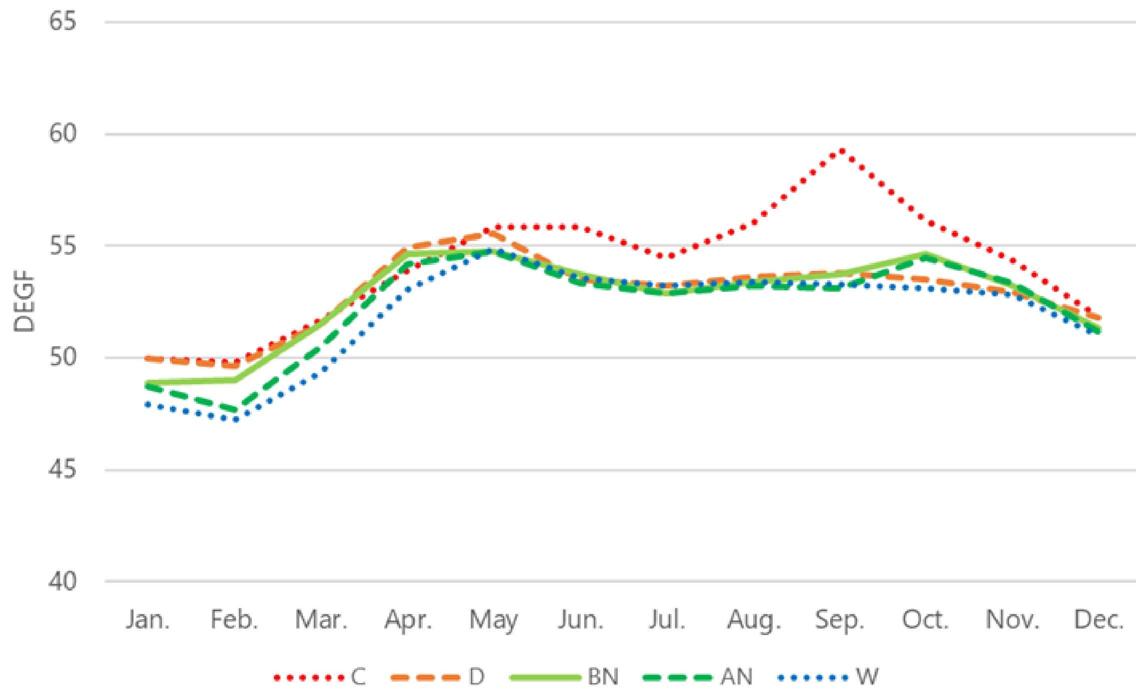


Figure B-22. Sacramento River Water Temperatures Below Clear Creek under the Proposed Action with the Tiered Strategy by Water Year Type

In Critical years a higher water temperature occurs in May and June under the Tiered strategy than the 53.5°F at Clear Creek strategy due to the shoulder-through-shoulder pattern that delays depletion of the col-water pool. However, insufficient coldwater pool is available to maintain water temperatures below Clear Creek for the entire season. Under the Tiered strategy, temperature targets may be reshaped. Moving the 56°F water temperature compliance location under Order 90-5 can accomplish the same pattern as the Tiered strategy.

Year types generalize the potential available cold-water pool; however, the actual coldwater pool within a year type classification can vary significantly.

Figure B-23 shows historical water temperatures on the Sacramento River at Bend Bridge and Figure B-24 shows dissolved oxygen.

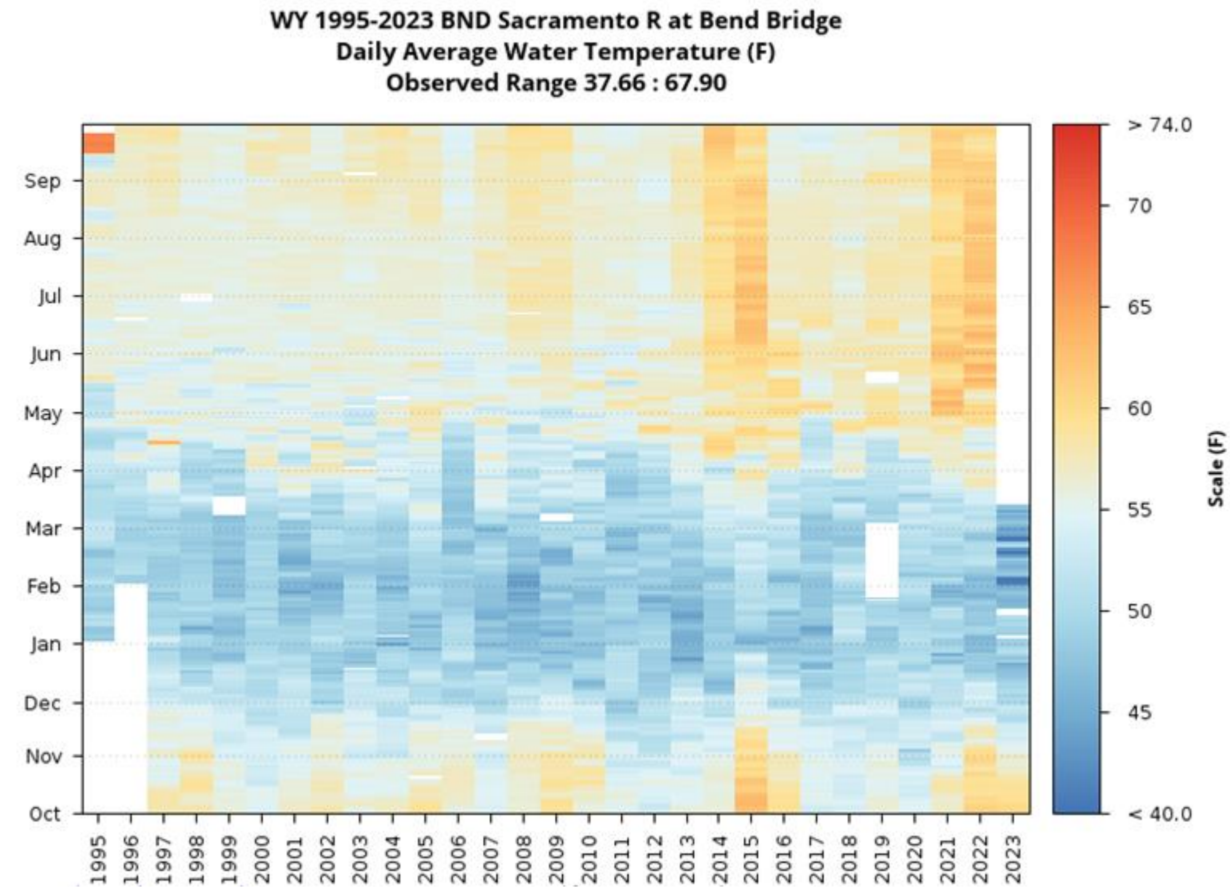


Figure B-23. Sacramento River at Bend Bridge Daily Average Water Temperature (°F) for WY 1995-2023

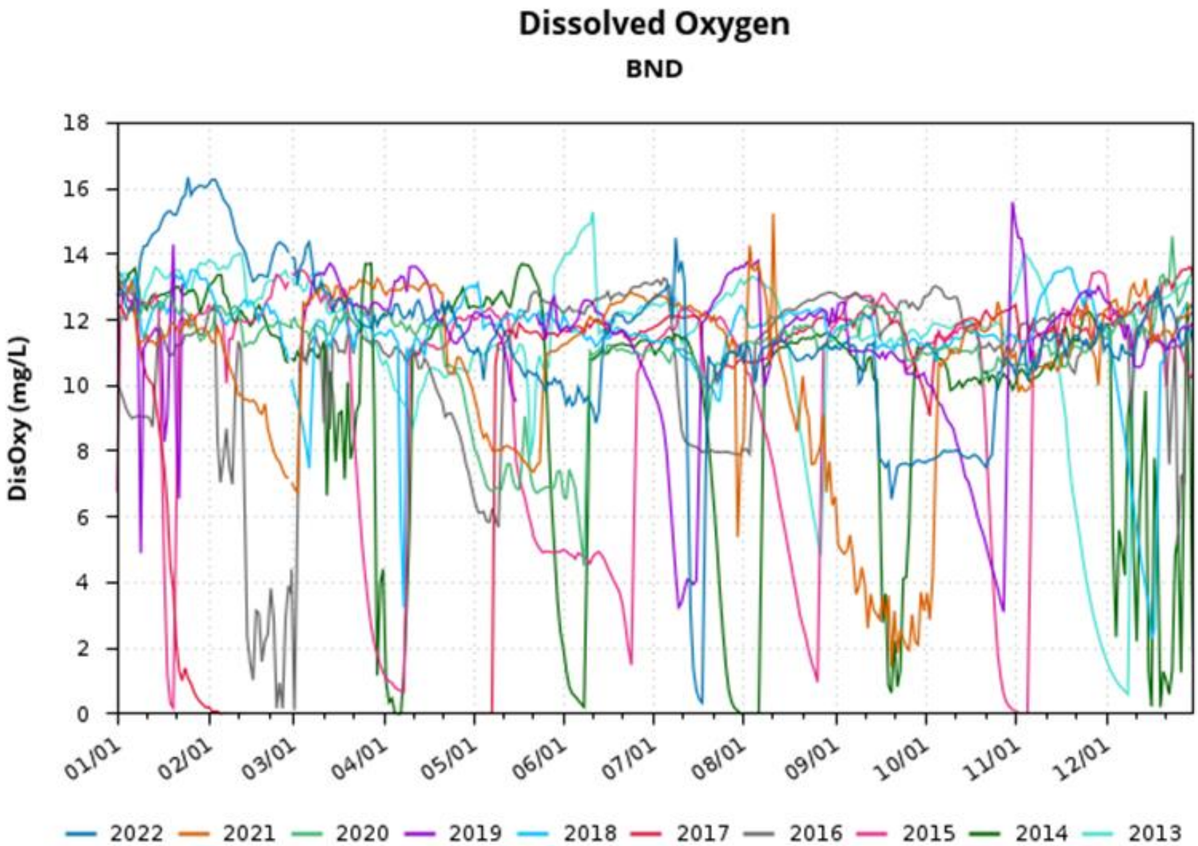


Figure B-24. Sacramento River at Bend Bridge Daily Average Dissolved Oxygen (mg/L) for WY 2013-2022

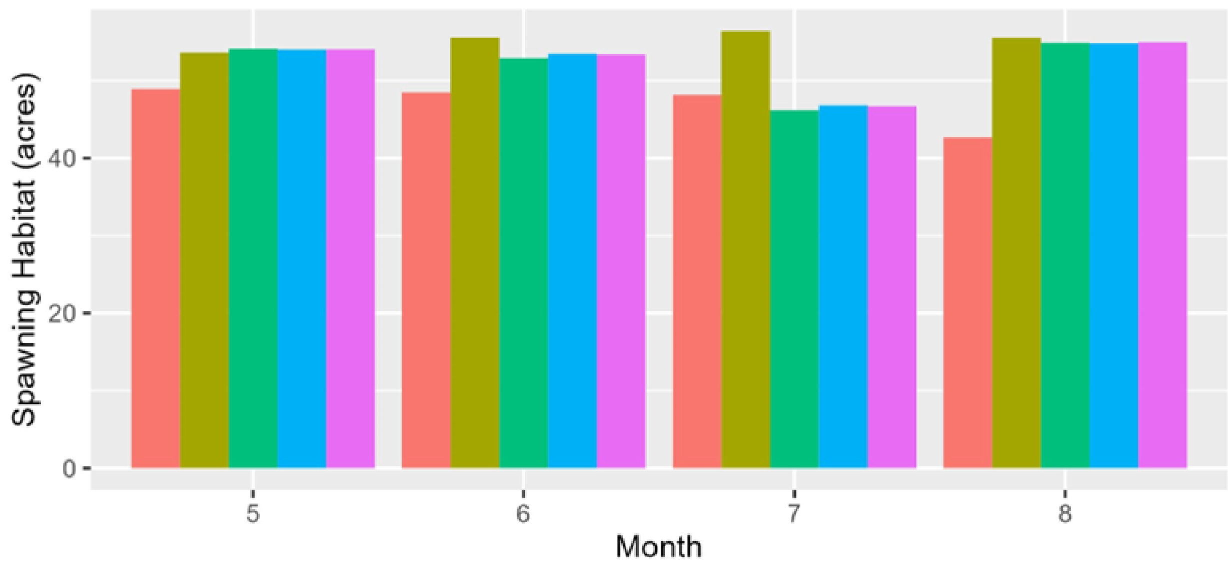
B.3.3 Suitable Habitat

The Sacramento River includes winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon. Winter-run Chinook salmon adults in the upper Sacramento River spawn in May through August and juveniles rear in the Sacramento River from August through January (Appendix AB-D). The upper Sacramento River encompasses the region from Keswick Dam (RM302) to Red Bluff Diversion Dam (RM244) (Upper Sacramento River), roughly 58 river miles. Spring-run Chinook salmon adults generally spawn in September and October in the upper Sacramento River, young of year juveniles rear in the Sacramento River from November through April, and yearling spring-run Chinook salmon can rear in the Sacramento River through the remainder of the year. Steelhead adults generally spawn in January through April and juveniles rear year-round, with rearing in natal habitats primarily in March through May. Green sturgeon juveniles likely rear in the Sacramento River year-round.

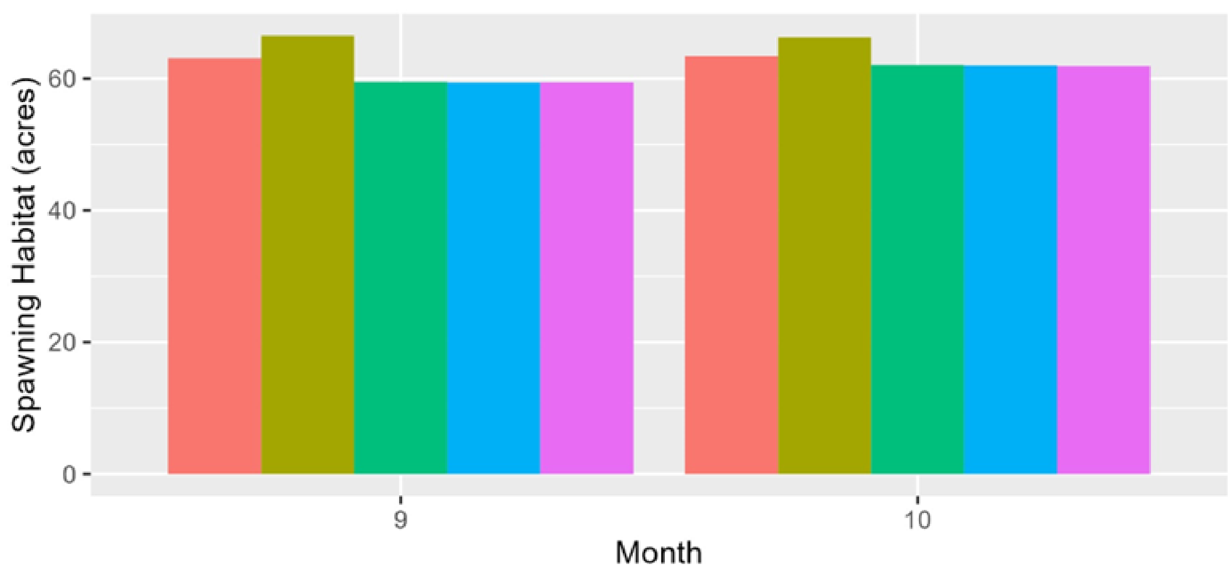
Expected spawning habitat quantities for adult winter-run Chinook salmon, spring-run Chinook salmon, and steelhead are presented for expected spawning months in the Upper Sacramento River (Fig. 24). All flow-habitat relationships, including those for juvenile rearing habitat below and in other watersheds, were obtained from the CVPIA Science Integration Team (SIT) decision support models for salmonids (i.e., see the SIT DSM Habitat Estimates attachment in

Appendix AB-O, *Tributary Habitat Restoration*. Tributary Habitat for additional details). Relatively stable flows from May to August for all scenarios but EXP1 result in relatively stable spawning habitat availability for winter-run Chinook salmon; the same is true for spawning habitat for spring-run Chinook salmon from September to October. Increased steelhead spawning habitat availability in April corresponds with decreased monthly flow.

a)



b)



c)

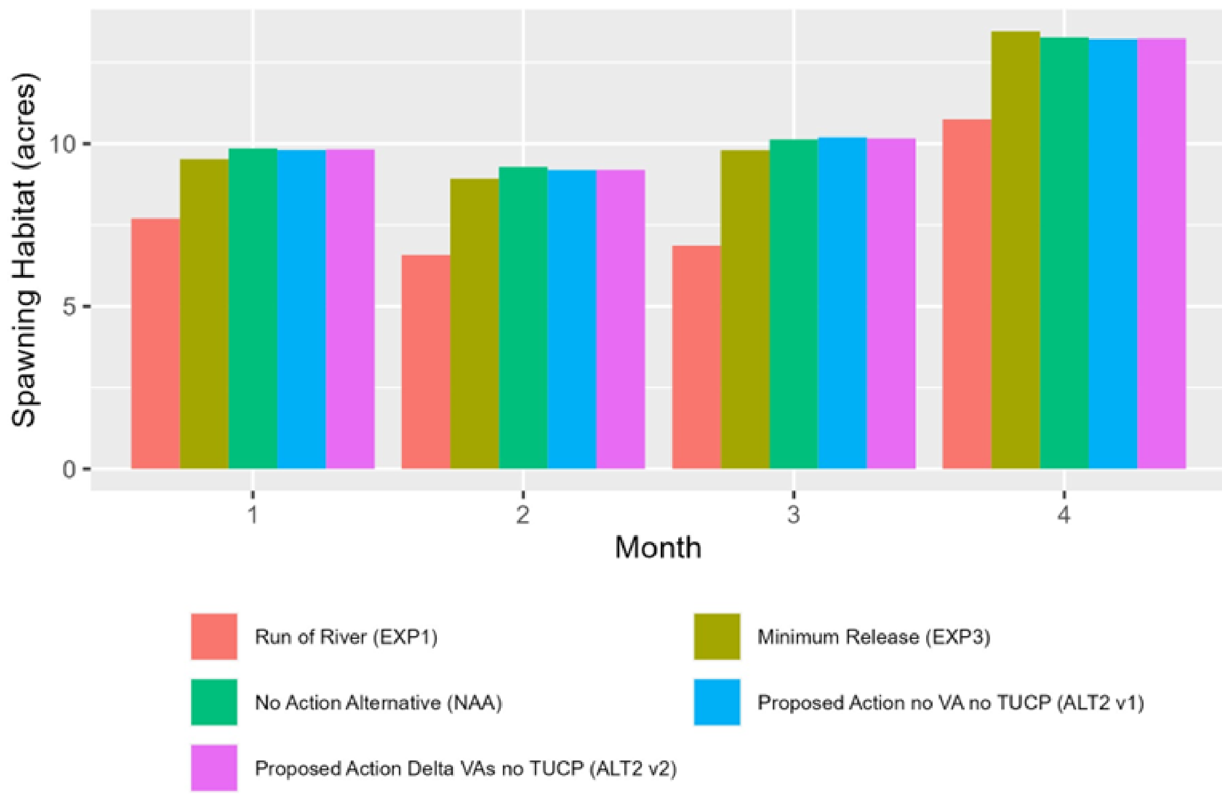


Figure B-25. Estimated spawning habitat area for adult winter-run Chinook salmon (a), spring-run Chinook salmon (b), and steelhead (c) in the upper Sacramento River. Values represent means across CalSim WYs.

Suitable instream and floodplain rearing habitat quantities, presented separately, are provided for every month in the upper Sacramento River; available flow-habitat relationships are assumed to be the same across winter-run Chinook salmon, spring-run Chinook salmon, and steelhead in the upper Sacramento River based on the availability on data and analyses. (Figure B-26, Figure B-27). Reductions in instream rearing habitat availability in June through August for all scenarios but EXP1 correspond to months of elevated flow. Increased mean floodplain rearing availability in December through March occurs because infrequent, wet water years produce year-specific floodplain rearing habitat estimates orders of magnitude above those observed in other years for those months (see the SIT DSM Habitat Estimates attachment). These occurrences are not necessarily reflected in the results presented in Section 3.1, *Water Operations*, because presented flow values do not illustrate expected variability in flow across water years.

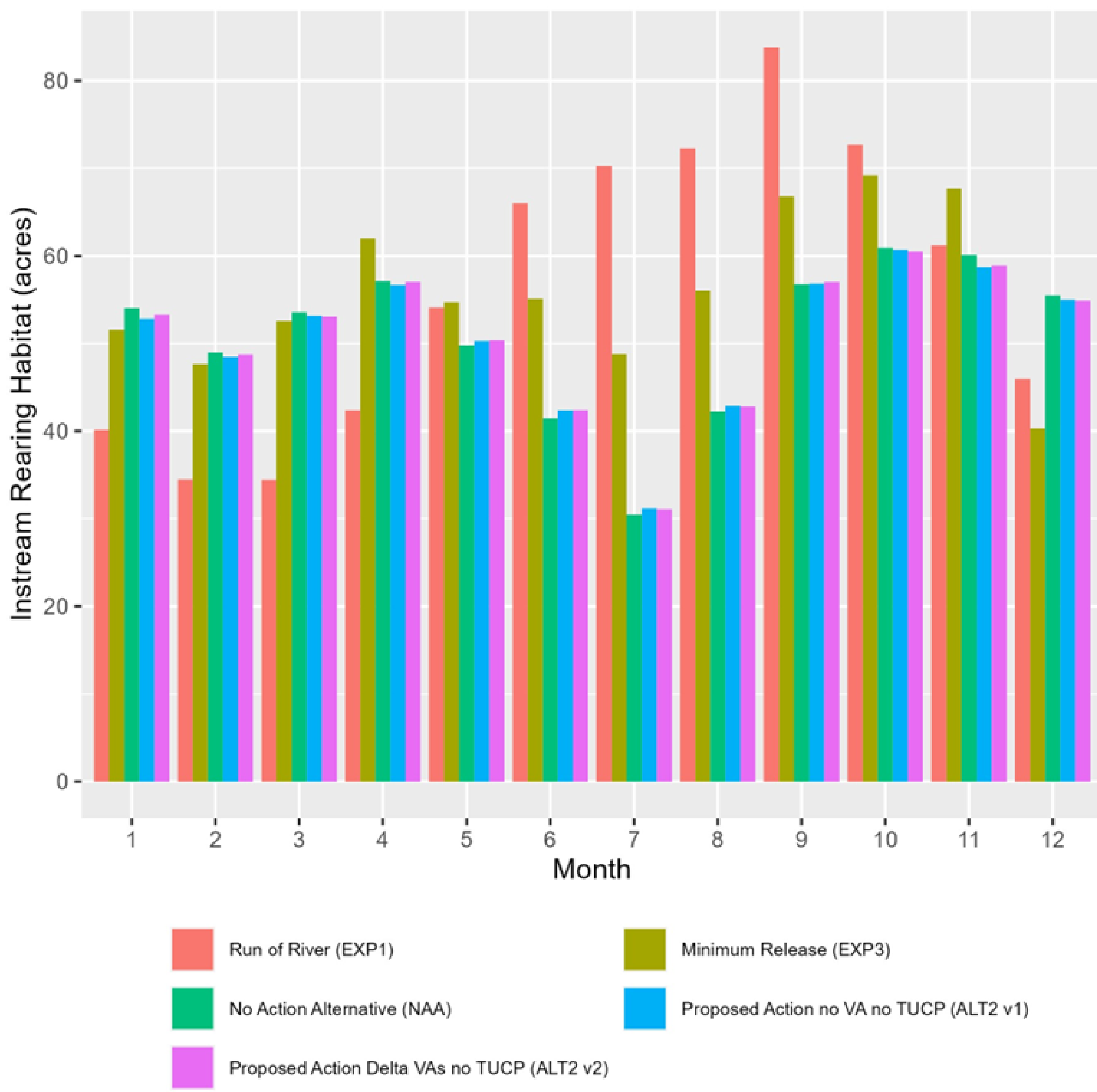


Figure B-26. Estimated instream rearing habitat for juvenile winter-run Chinook salmon, spring-run Chinook salmon, and steelhead in the upper Sacramento River. Values represent means across CalSim WYs.

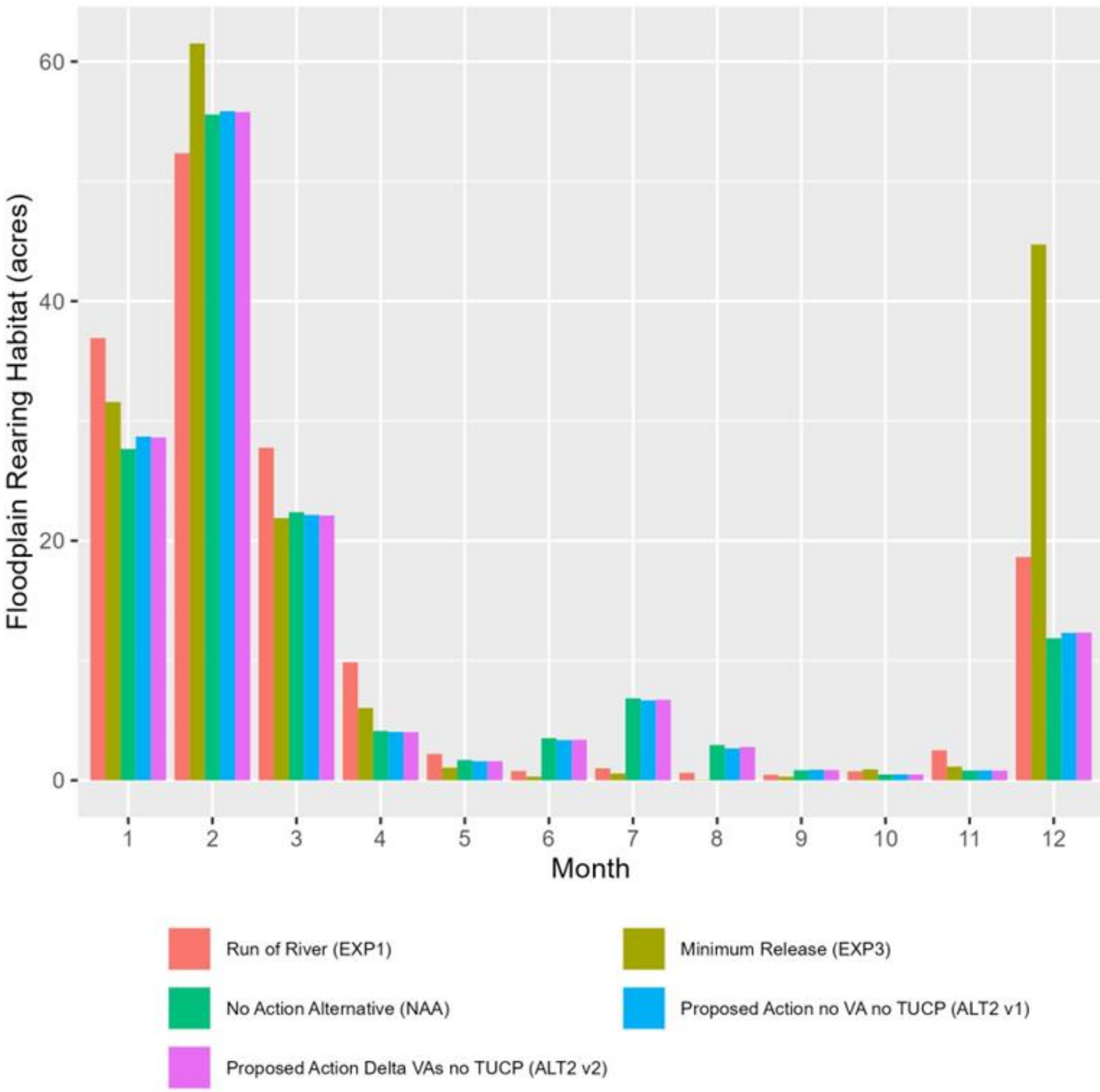


Figure B-27. Estimated floodplain rearing habitat for juvenile winter-run Chinook salmon, spring-run Chinook salmon, and steelhead in the upper Sacramento River. Values represent means across CalSim WYs.

B.4 Clear Creek

Inflows to Whiskeytown Reservoir come from Clear Creek and imports from the Trinity River Basin. Figure B-28 show inflows from the Clear Creek Watershed only according to the 40-30-30 hydrologic water year type.

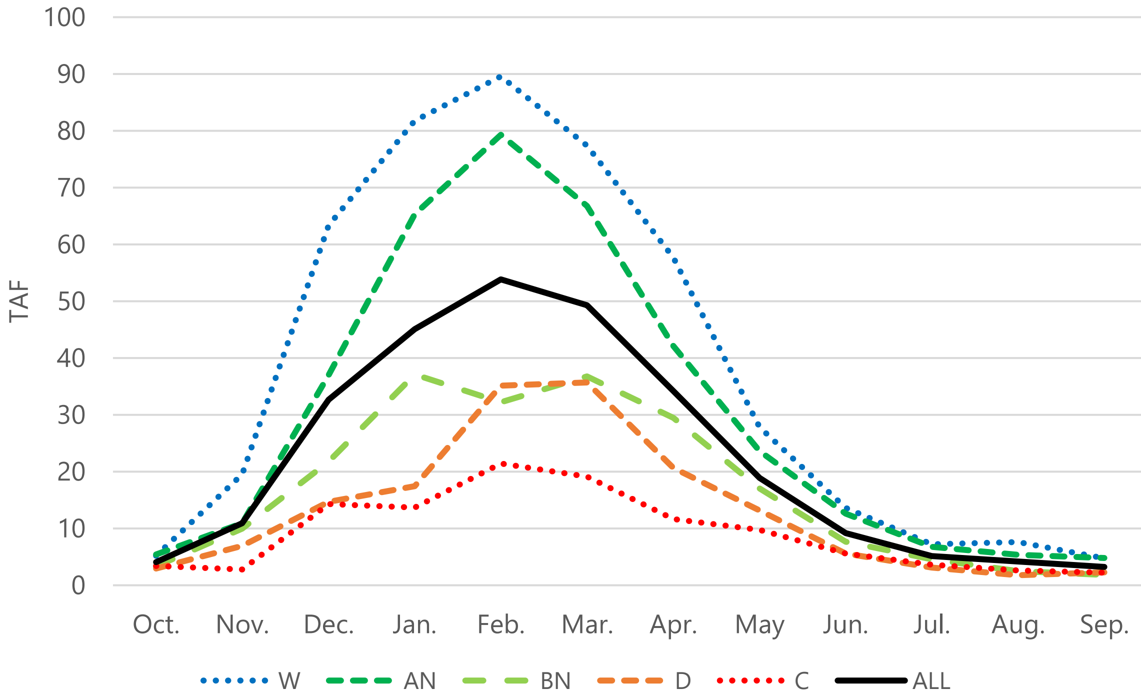


Figure B-28. Inflow to Whiskeytown Reservoir from Clear Creek by Month and Water Year Type

Whiskeytown Reservoir supplies water to Keswick Reservoir through the Spring Creek tunnel.

Figure B-29 shows Clear Creek Water Operation Topology.

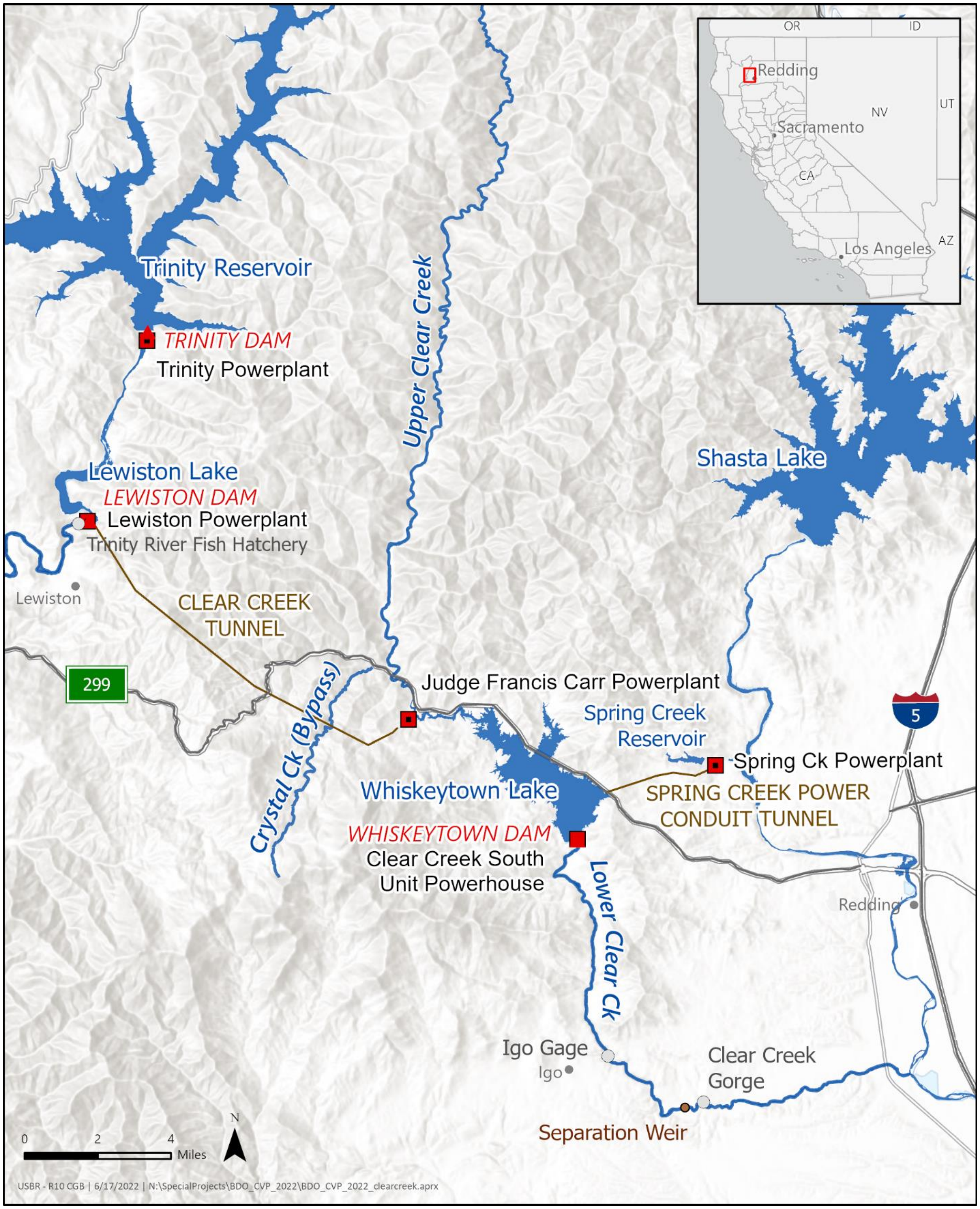


Figure B-29. Clear Creek Water Operations Topology

Releases from Whiskeytown Reservoir are measured at the Igo stream gage, with flows targeting hydraulic conditions at various downstream locations (e.g., the Gorge).

B.4.1 Water Operations

Figure B-30, Figure B-31, and Figure B-32 show release from Whiskeytown Dam for the "Run of River", "Minimum Releases", "No Action Alternative (NAA)", "Proposed Action without VAs and no TUCPs (ALT2v1)", and "Proposed Action with Delta VAs and no TUCPs (ALT2v2)" scenarios.

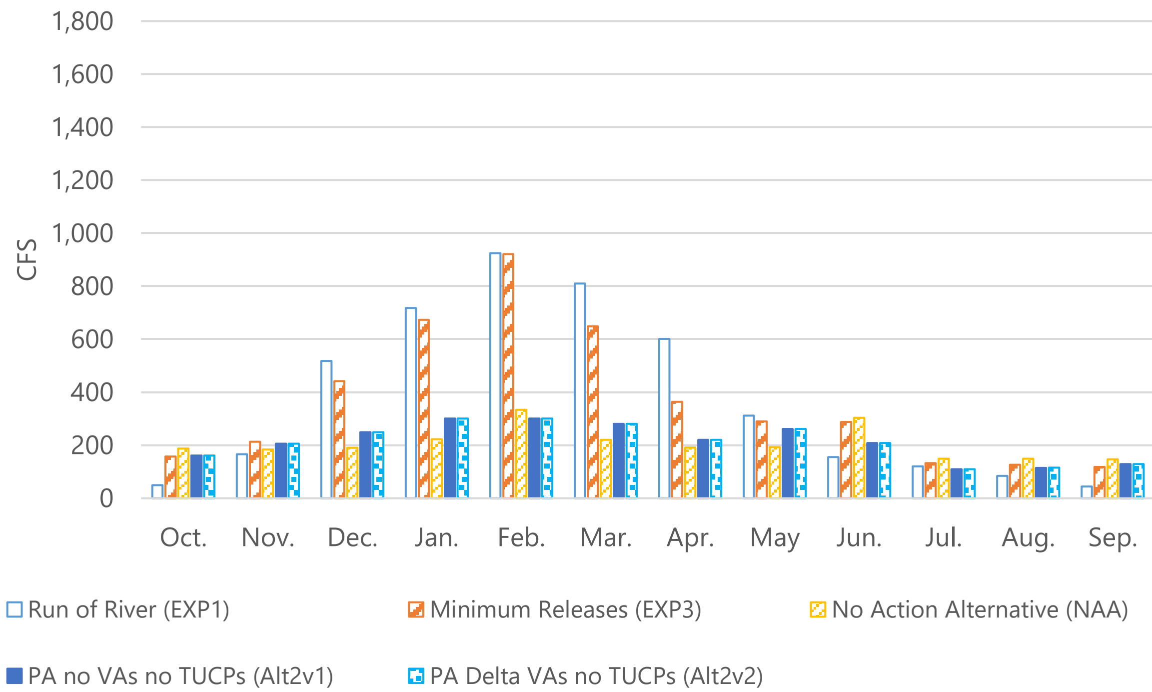


Figure B-30. Clear Creek below Whiskeytown Monthly Flows, All Water Year Types

Reclamation reviewed difference by year type and found the direction of the trend remains the same for most months, but the magnitude changes. Figure B-31 and Figure B-32 show the wet and critical years conditions for this location. October through January flows in critical and dry years show a constant pattern of flows in the Proposed Action phases due to omission of attraction and channel maintenance pulses.

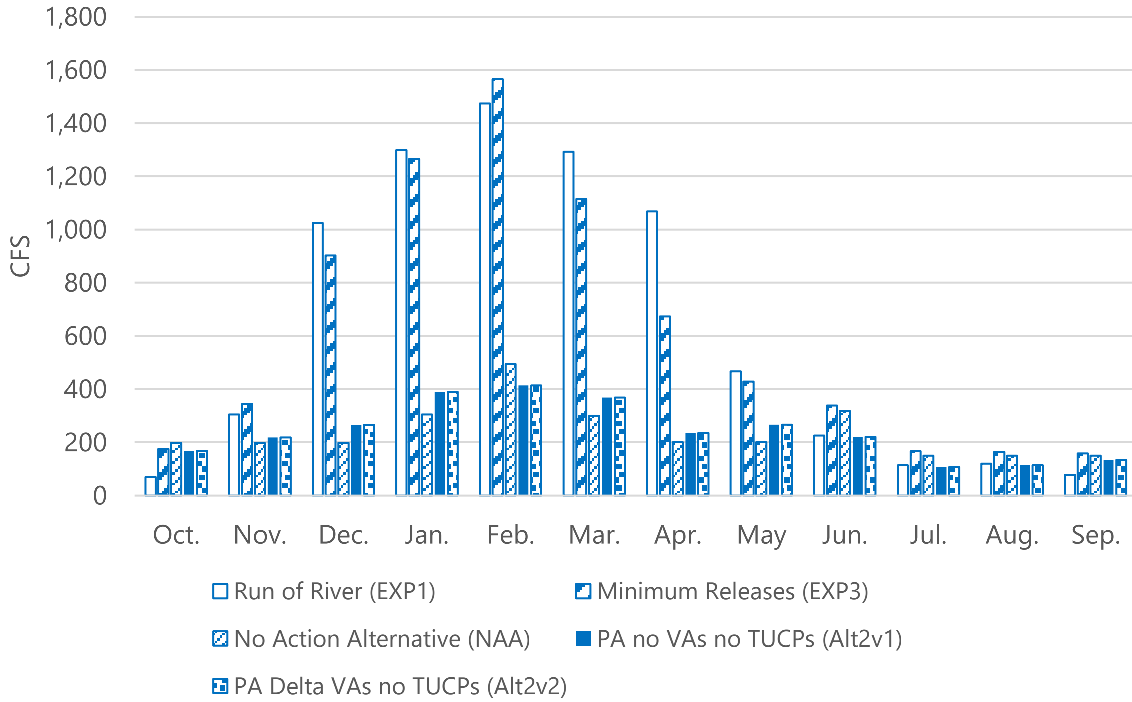


Figure B-31. Clear Creek below Whiskeytown Monthly Flows, Wet Water Year Types

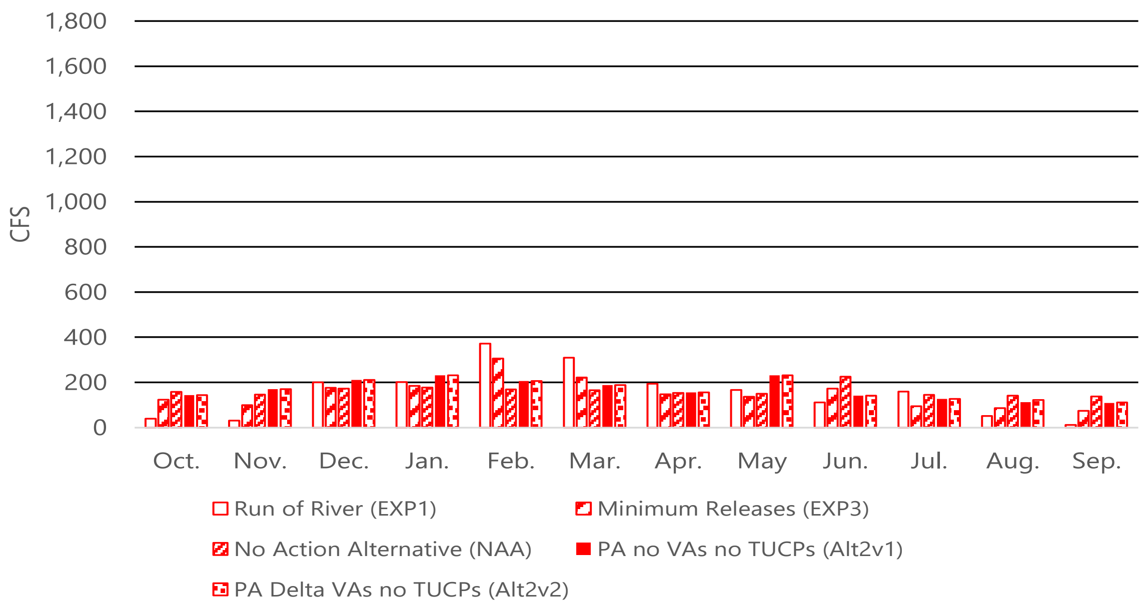


Figure B-32. Clear Creek below Whiskeytown Monthly Flows, Critical Water Year Types

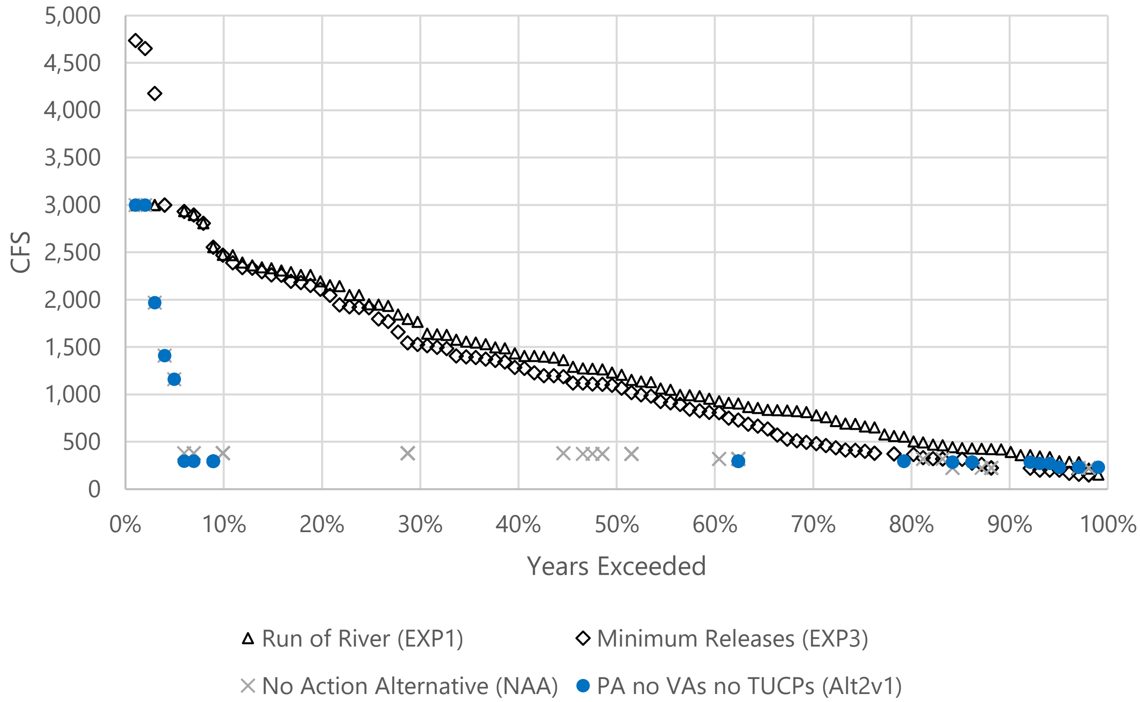


Figure B-33. Peak Annual Flows (Monthly Average) on Clear Creek

Figure B-33 shows Clear Creek below Whiskeytown Dam annual peak flow frequency for four scenarios, peak flows on Clear Creek under No Action Alternative (shown as an "x" above) occur from infrequent flood spills; therefore, Clear Creek is either a base flow or spilling. Under the Proposed Action phases, peak flows can occur from by controlled attraction and/or gravel mobilization releases. The distinct steps in peak flow releases under the Proposed Action with no VAs and no TUCPs contrast with the more continuous peak flows under Run of River.

Figure B-34 shows inflows to Whiskeytown Reservoir that are not released down Clear Creek are diverted into Keswick Reservoir through the Spring Creek tunnel.

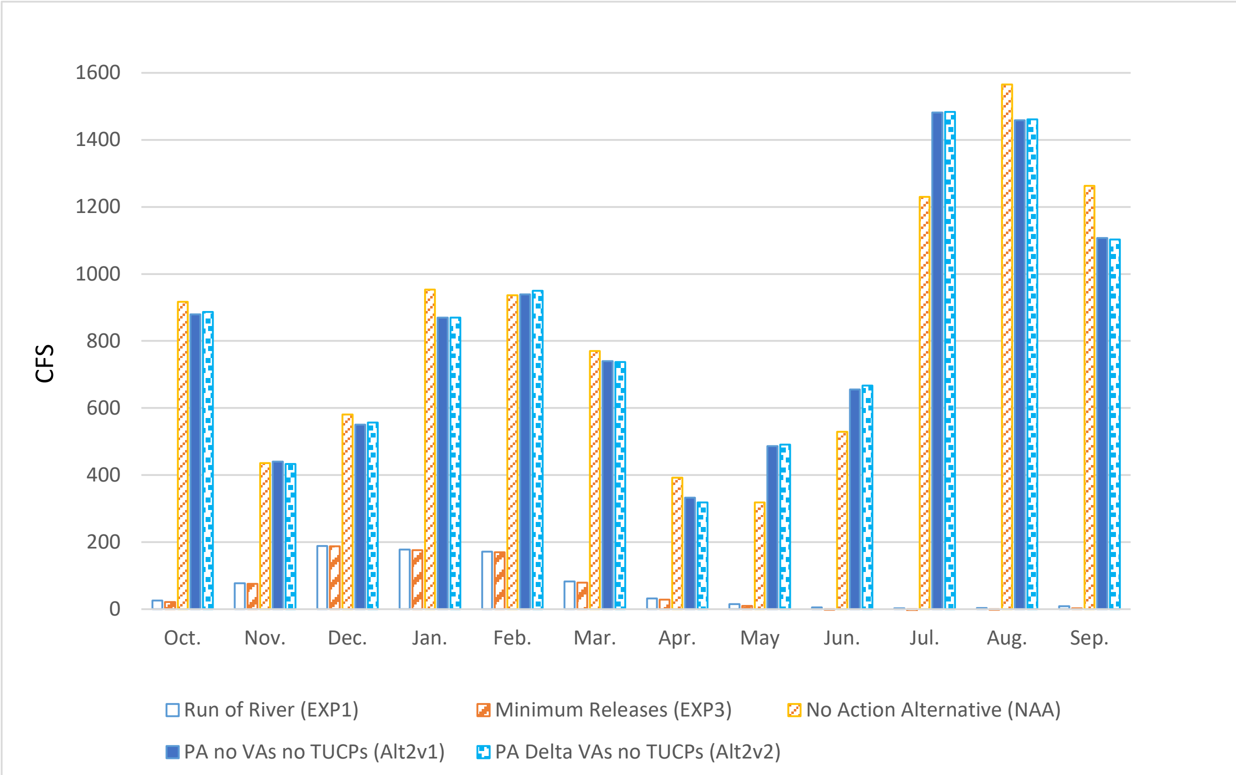


Figure B-34. Spring Creek Inflows to Keswick Reservoir

No imports occur under the Run of the River.

B.4.2 Water Temperatures and Dissolved Oxygen

Figure B-35 shows modeled water temperatures on Clear Creek above the Sacramento River.

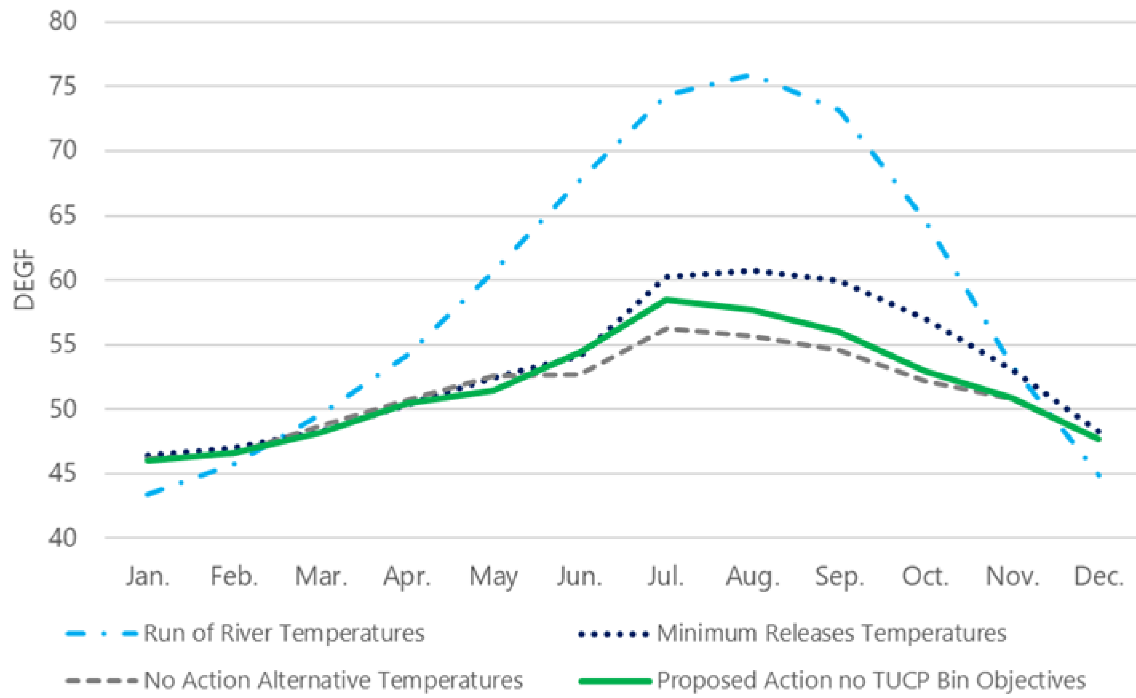


Figure B-35. Clear Creek above Sacramento River Monthly Average Water Temperatures

The absence of Clear Creek Tunnel flows moving Trinity River water to Whiskeytown in the Run of the River scenario likely leads to warmer releases into Clear Creek in this scenario, as the HEC-5Q model represents Trinity Reservoir as having colder inflows than Whiskeytown Lake.

Figure B-36 shows historical water temperatures and Figure B-37 shows dissolved oxygen.

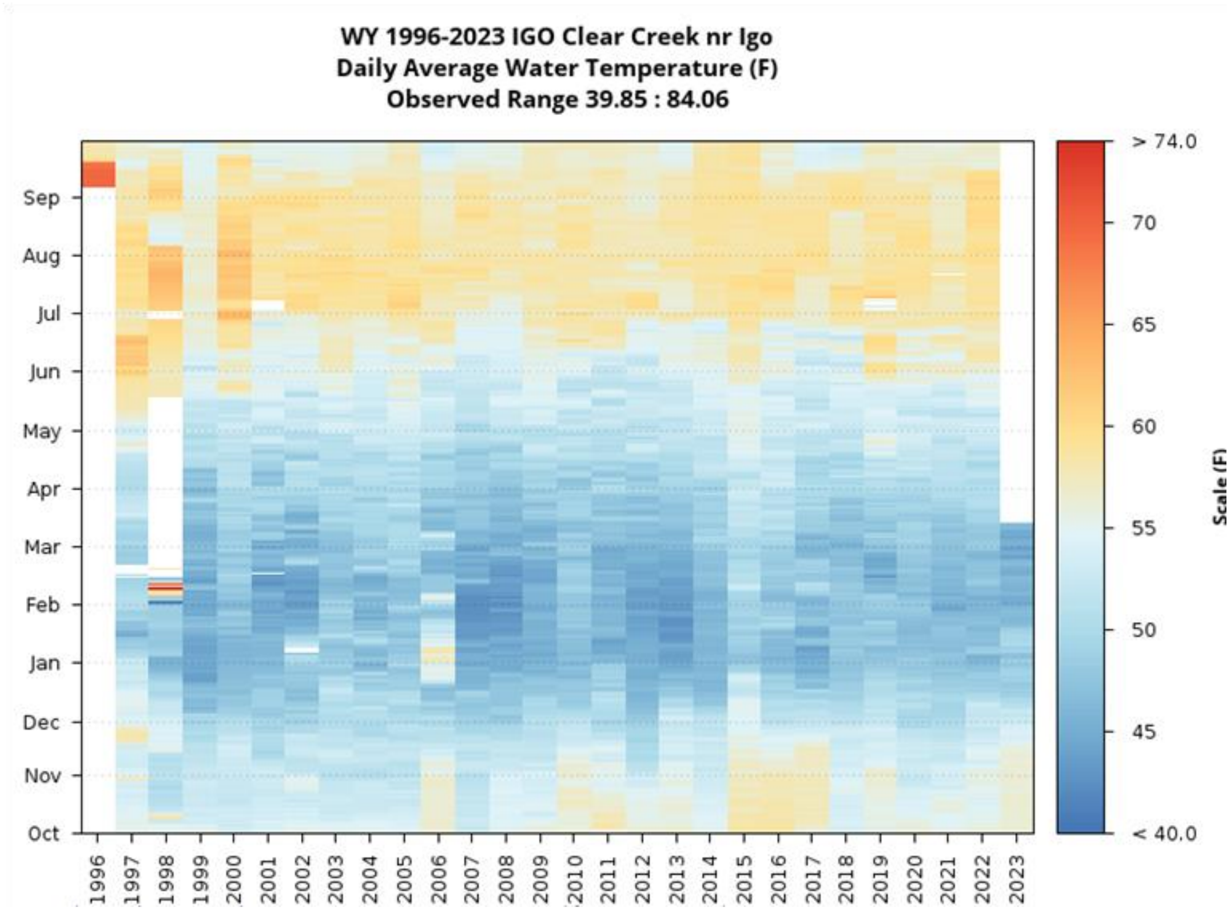


Figure B-36. Clear Creek near Igo Daily Average Water Temperature (°F) for WY 1996-2023

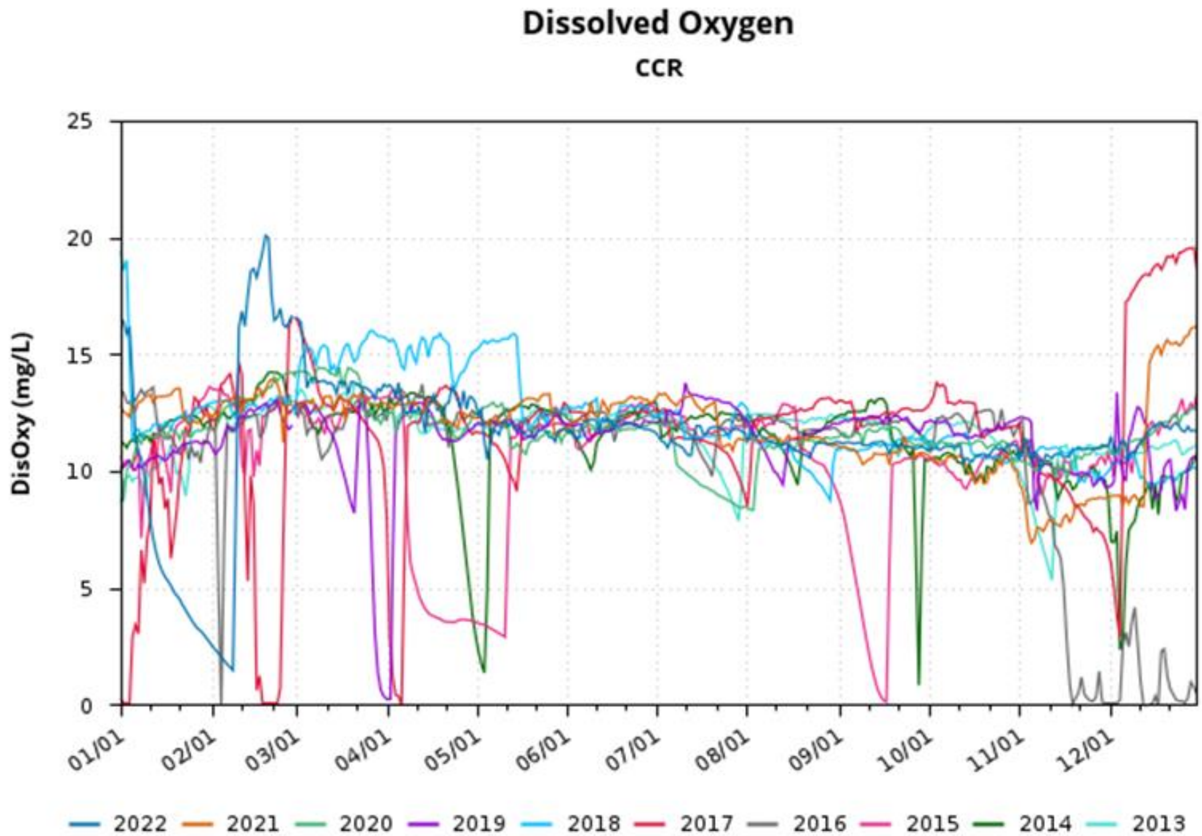


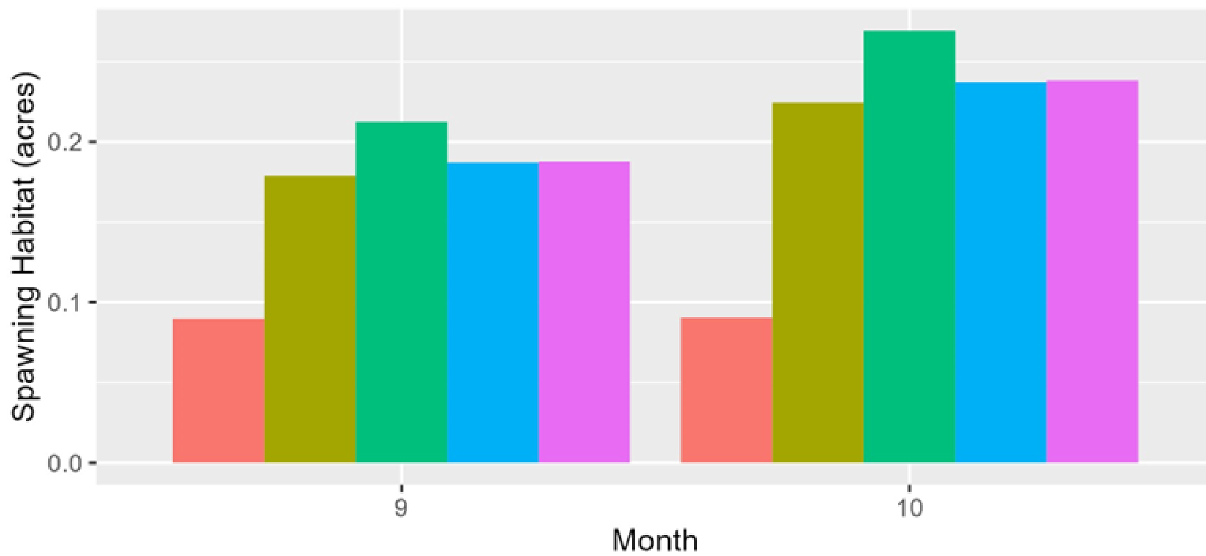
Figure B-37. Sacramento River above Clear Creek Daily Average Dissolved Oxygen (mg/L) for WY 2013-2022

B.4.3 Suitable Habitat

Listed fish species in Clear Creek include spring-run Chinook salmon and steelhead. Spring-run Chinook salmon adults generally spawn in September and October, young of year may be rearing from November, through April, and yearlings may over-summer and remain year-round (Appendix AB-D). Steelhead adults generally spawn in January through April and juveniles rear year-round, with rearing in natal habitats primarily in March through May.

Expected spawning habitat quantities for adult spring-run Chinook salmon and steelhead are presented for expected spawning months in Clear Creek (Figure B-38). Increasing spawning habitat for spring-run Chinook salmon from September to October corresponds to increasing expected flows (Section 4.1, *Water Operations*). Stable spawning habitat availability for steelhead in January through April corresponds to somewhat variable but high flows during these months.

a)



b)

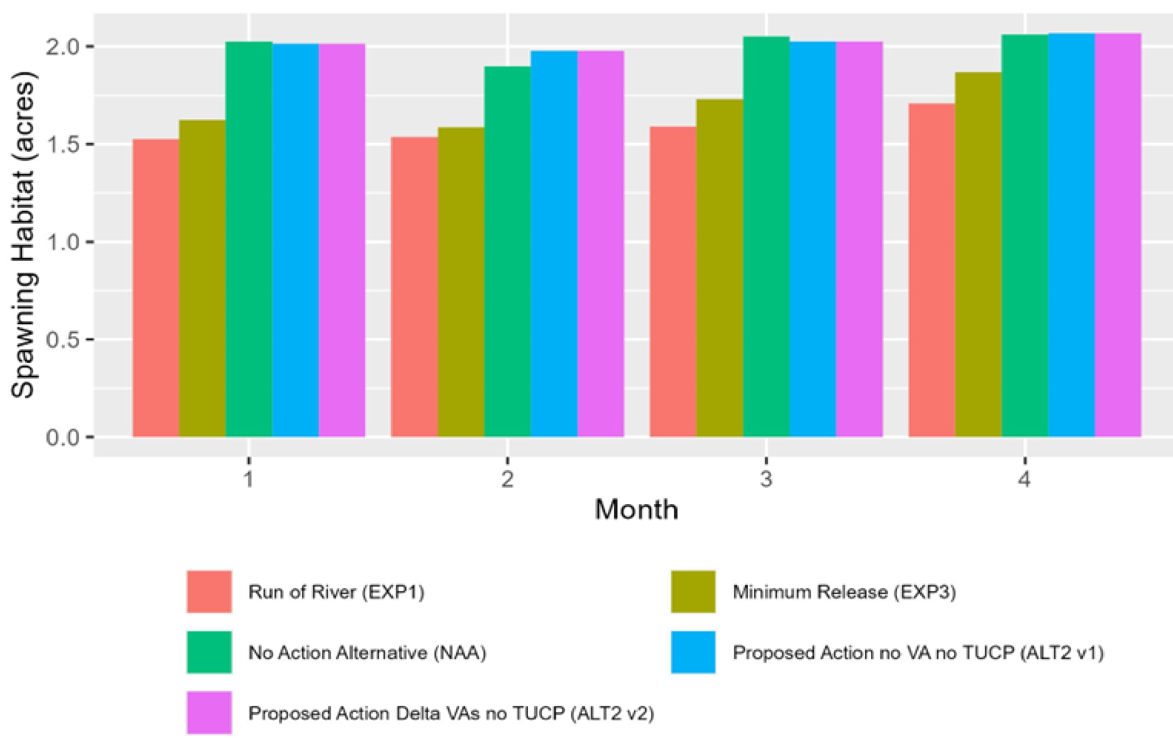


Figure B-38. Estimated spawning habitat area for adult spring-run Chinook salmon (a) and steelhead (b) in Clear Creek. Values represent means across CalSim WYs, and do not account for extensive gravel augmentations that have occurred on Clear Creek in recent years (1997-2021)

Suitable instream and floodplain rearing habitat quantities, presented separately, are provided for every month in Clear Creek; available flow-habitat relationships are assumed to be the same for spring-run Chinook salmon and steelhead in Clear Creek for floodplain habitat based on the availability on data and analyses (Figs. 38, 39). Reductions in instream rearing habitat availability in July through October correspond to months of reduced flow. Increased mean floodplain rearing availability in December through April corresponds with months of elevated winter and spring flows.

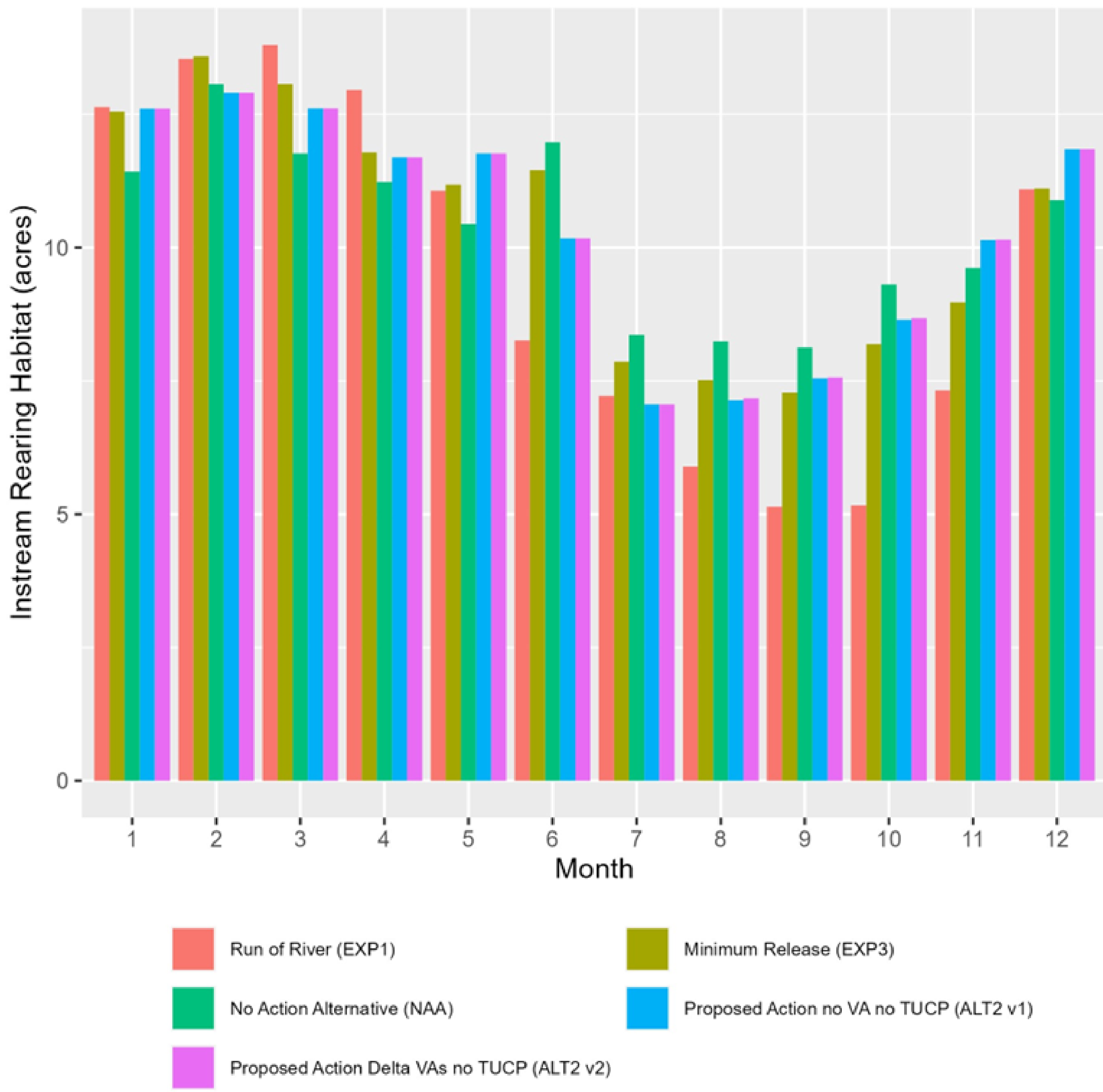
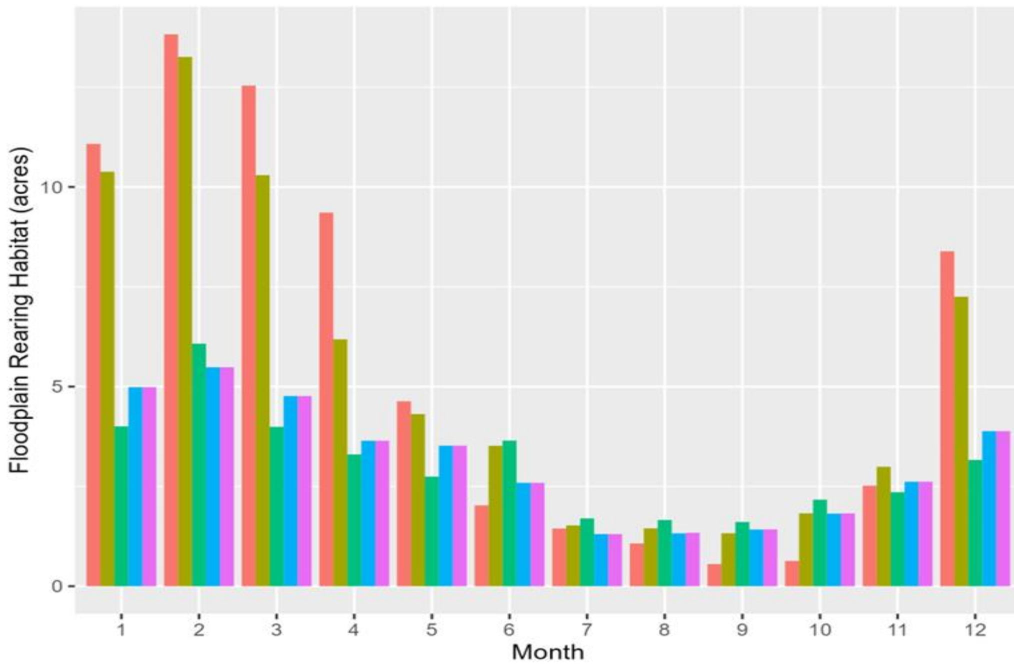


Figure B-39. Estimated instream rearing habitat for juvenile spring-run Chinook salmon and steelhead in Clear Creek. Values represent means across CalSim WYs. Flow-habitat relationships were assumed to be identical for spring-run Chinook salmon and steelhead.

a)



b)

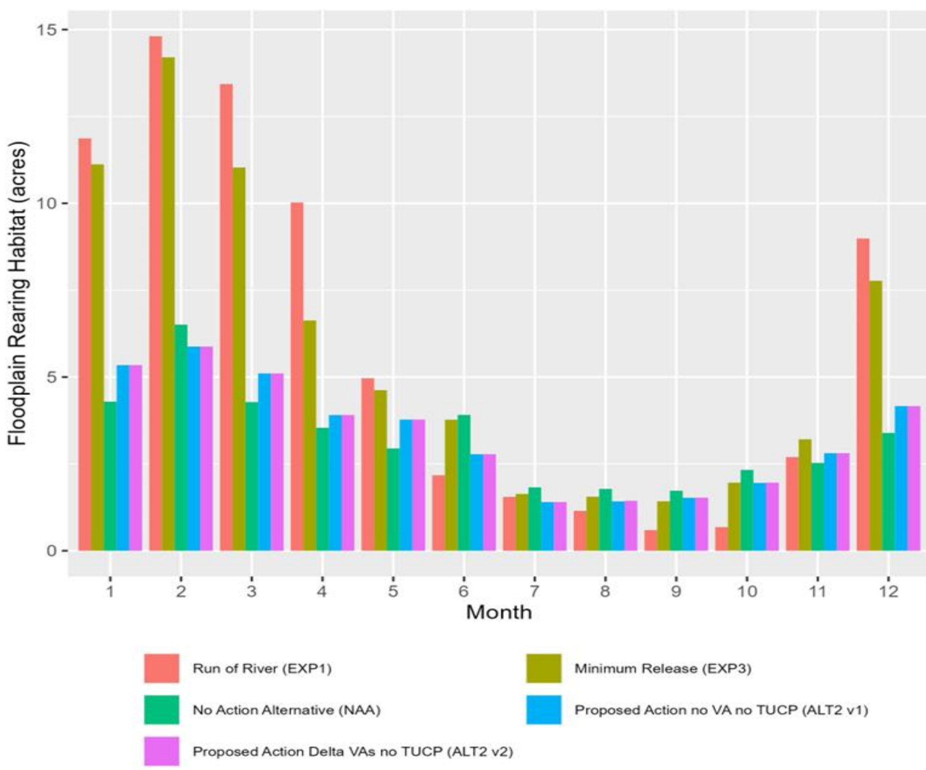


Figure B-40. Estimated floodplain rearing habitat for juvenile spring-run Chinook salmon (a) and steelhead (b) in Clear Creek. Values represent means across CalSim WYs.

B.5 American River

Inflows to Folsom Reservoir come from the North Fork American River and South Fork American River. Figure B-41 shows the inflow to Folsom Reservoir by month and 40-30-30 hydrologic water-year type.

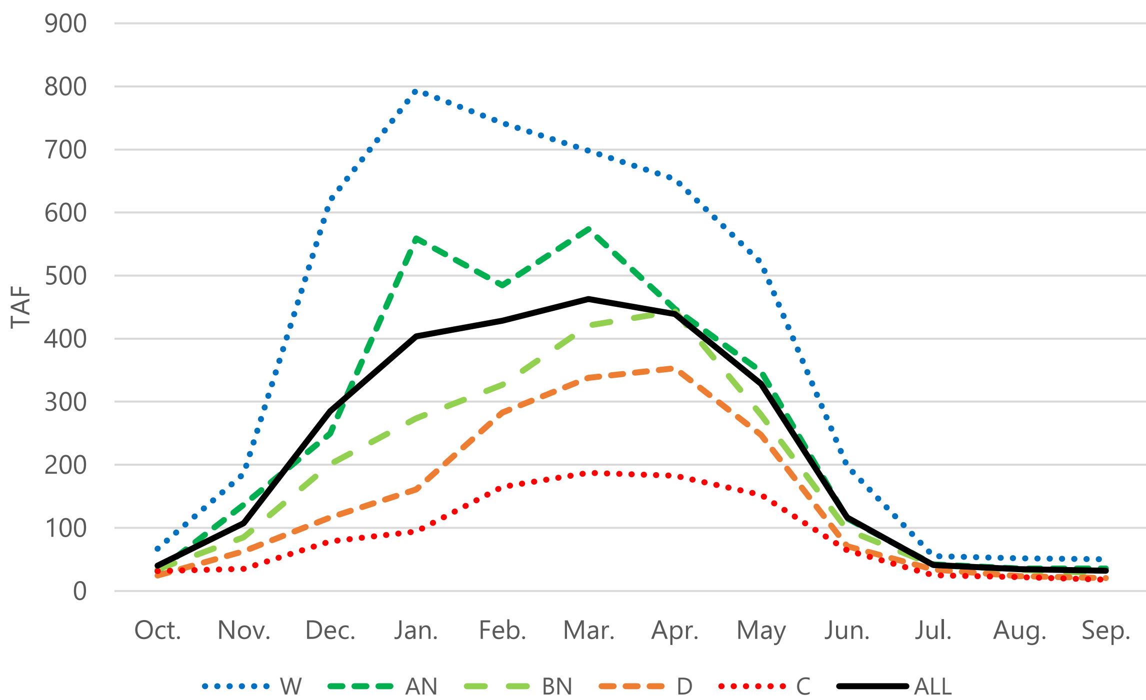


Figure B-41. Inflow to Folsom Reservoir by Month and Water Year Type

Releases from Folsom Reservoir flow into Lake Natoma and are impounded by Nimbus Dam. No major tributaries provide additional flow; however, temperature compliance locations at Watt Avenue and Hazel Avenue provide holding and spawning locations. Figure B-42 shows a simplified hydrologic topology for the American River from Folsom Dam to the confluence with the Sacramento River.

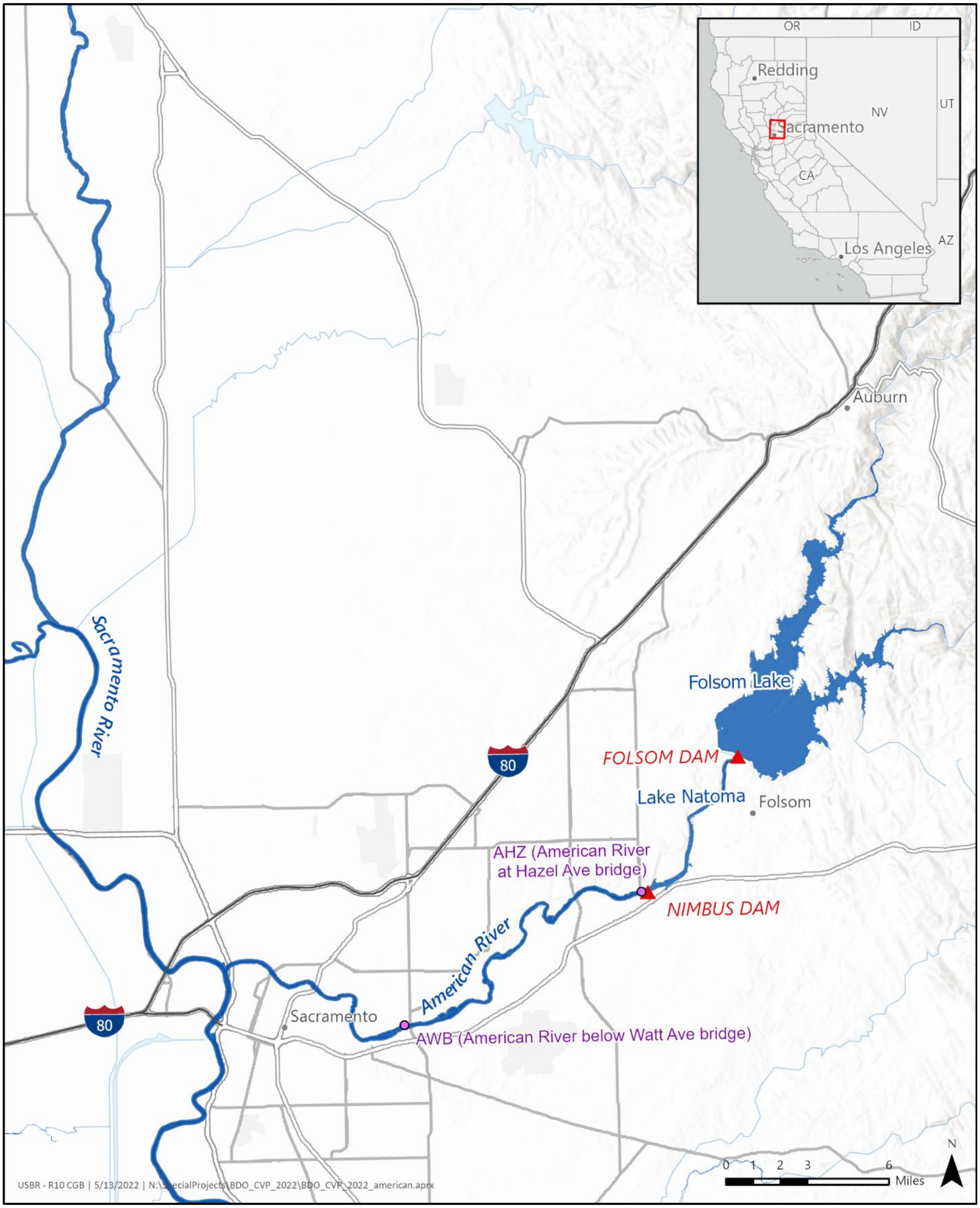


Figure B-42. American River Water Operations and Temperature Topology

B.5.1 Water Operations

Figure B-43, Figure B-44, and Figure B-45 show releases from Nimbus Dam to the American River for the “Run of River”, “Minimum Releases”, “No Action Alternative”, “Proposed Action without VAs, no TUCPs”, and “Proposed Action with Delta VAs, no TUCPs” scenarios.

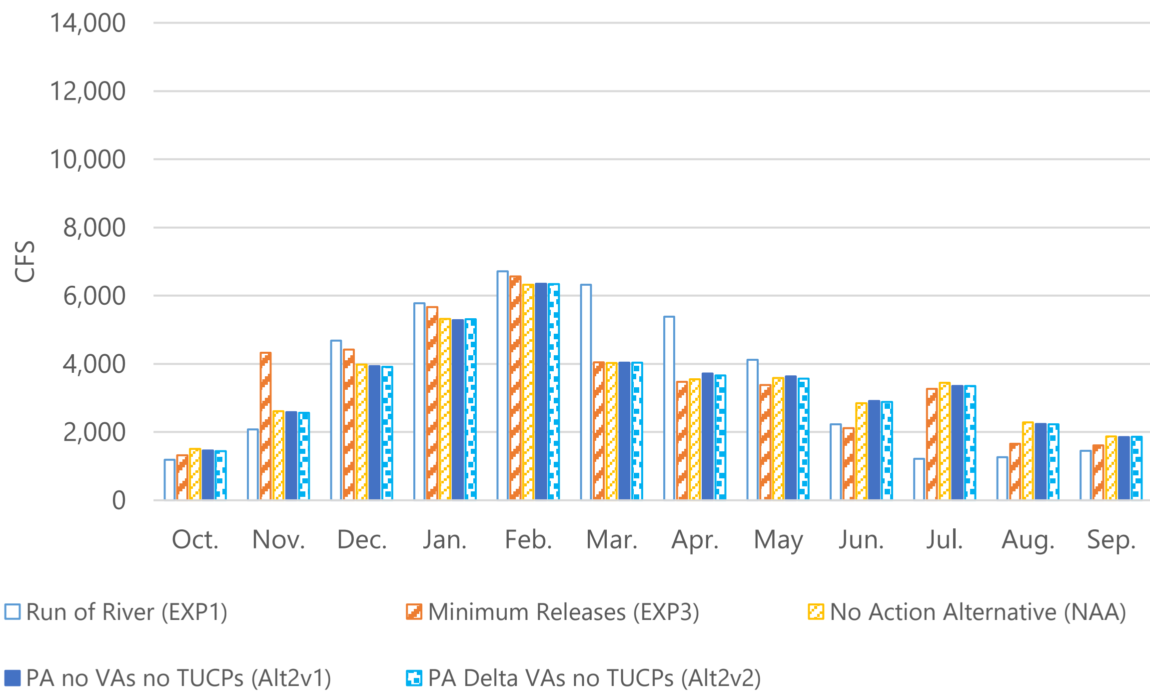


Figure B-43. American River below Nimbus Dam Monthly Flows, All Water Year Types

Reclamation reviewed differences by year type and found the direction of the trend remains the same for most months, but the magnitude changes. In critical years in November, flows under Minimum Release and the Proposed Action phases have higher flows than Run of River. In November for wet years, all four scenarios have high flows compared to the Run of River scenario.

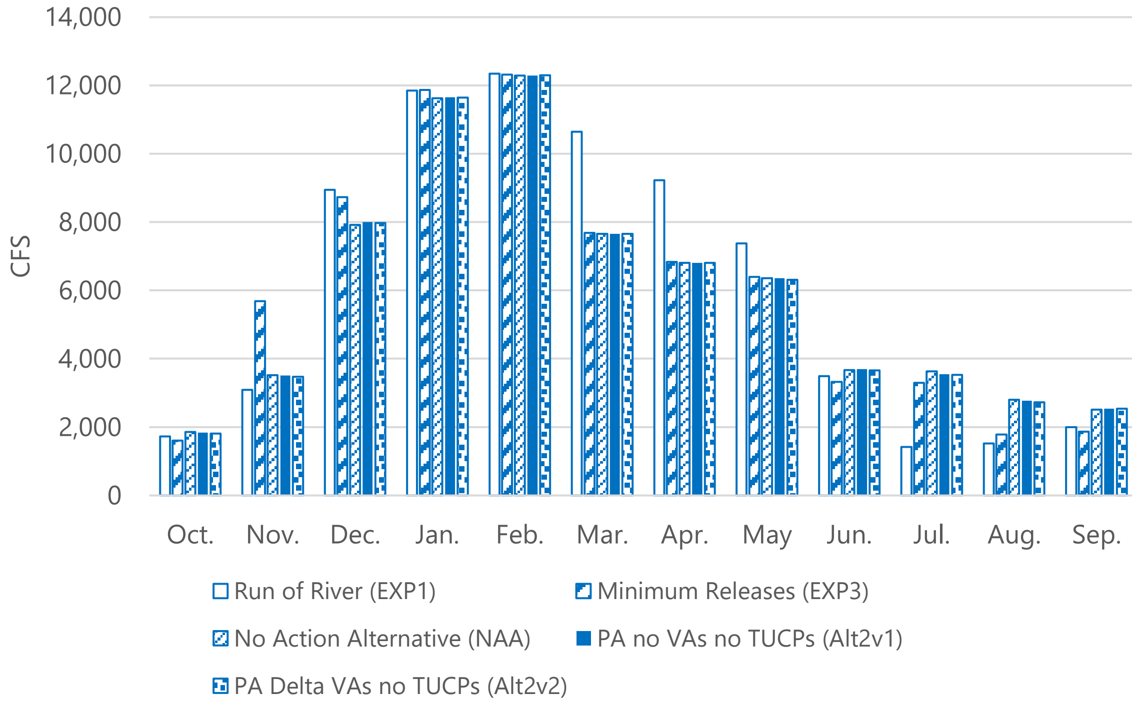


Figure B-44. American River below Nimbus Dam Monthly Flows, Wet Water Year Type

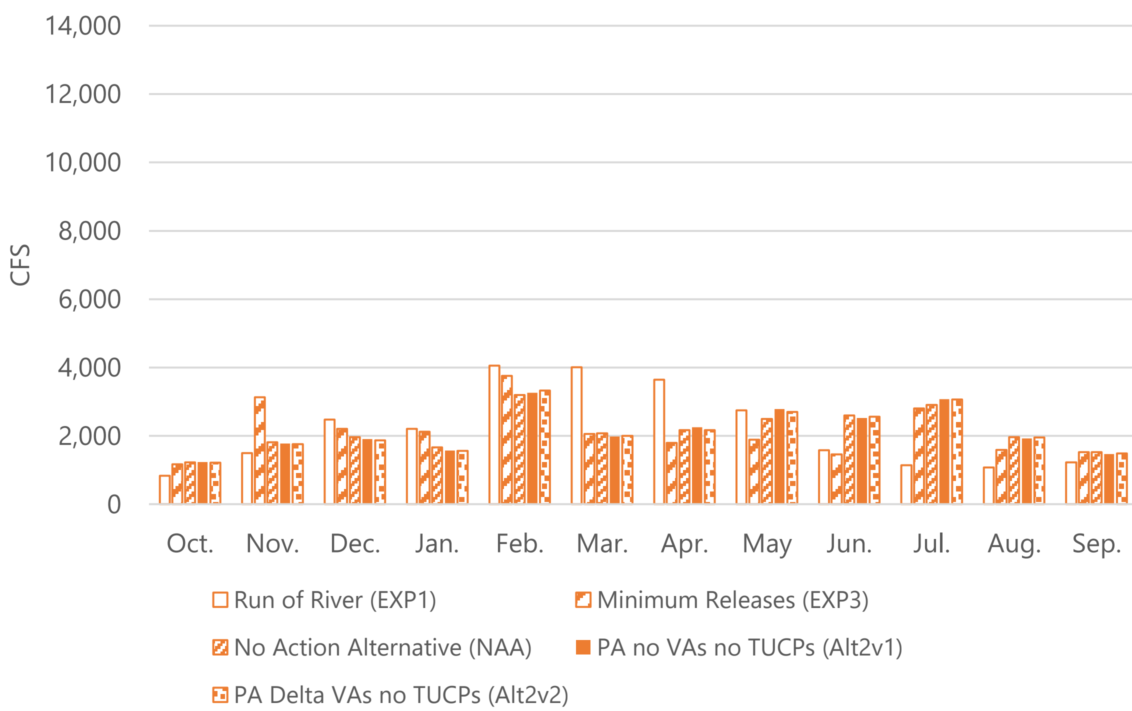


Figure B-45. American River below Nimbus Dam Monthly Flows, Critical Water Year Type

Figure B-46 shows peak annual flows (monthly average) on the American River below Nimbus Dam.

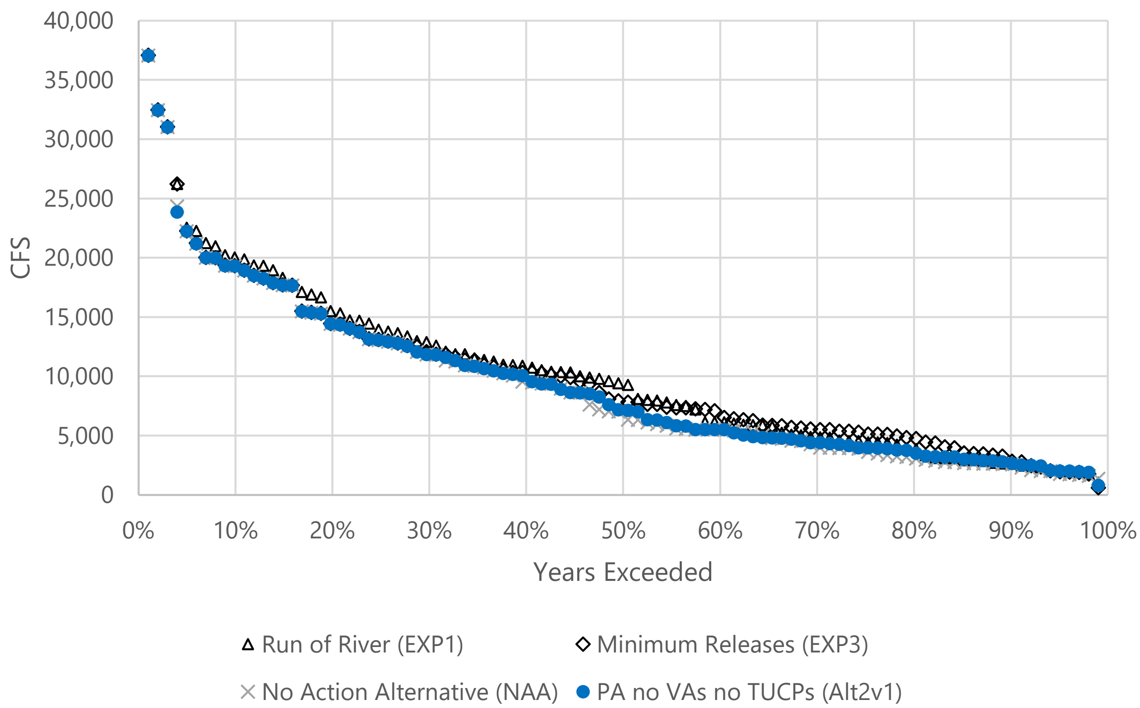


Figure B-46. American River below Nimbus Dam Annual Peak Flow Frequency

The small size of Folsom Reservoir compared to the annual watershed yield results in frequent filling of Folsom Reservoir and releases for flood conservation space.

B.5.2 Water Temperatures and Dissolved Oxygen

An analysis was performed using the HEC-5Q water quality model to estimate water temperatures on the American River (Figure B-47). All scenarios used Folsom Dam water temperature release targets designed to mimic the American River Group's Automated Temperature Selection Procedure, which considers inflow and storage.

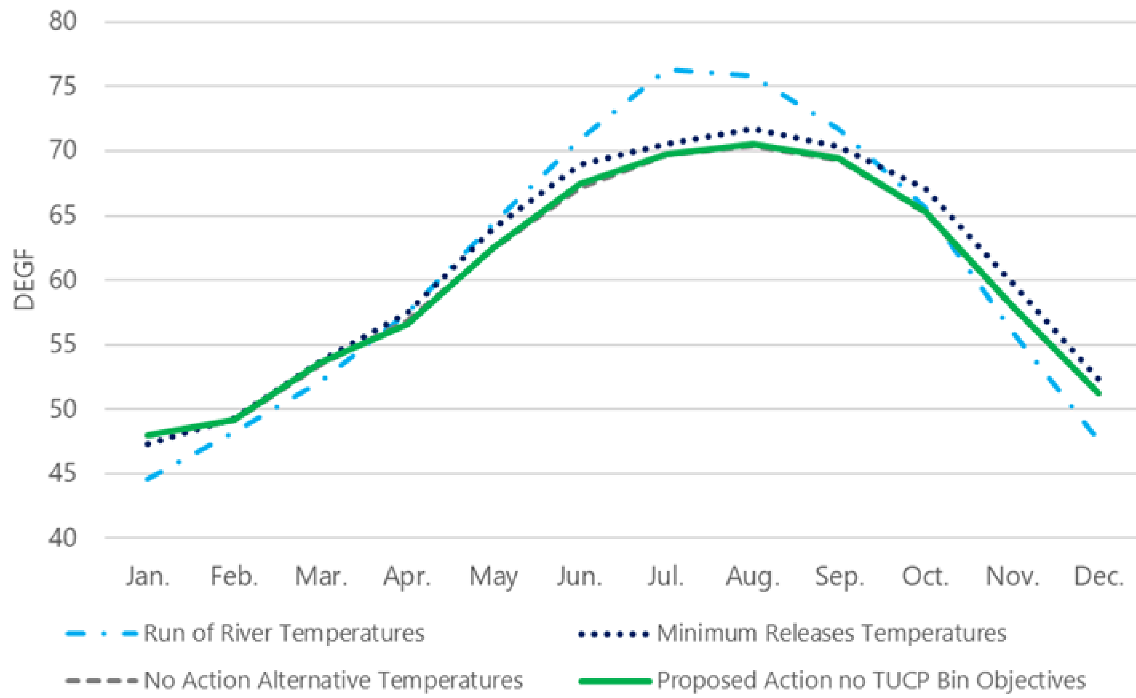


Figure B-47. American River Modelled Water Temperatures at Watt Avenue

The Run of River scenario had the largest amplitude. The No Action Alternative and Proposed Action phases water temperatures were similar for most of the year. Figure B-48 shows historical water temperatures.

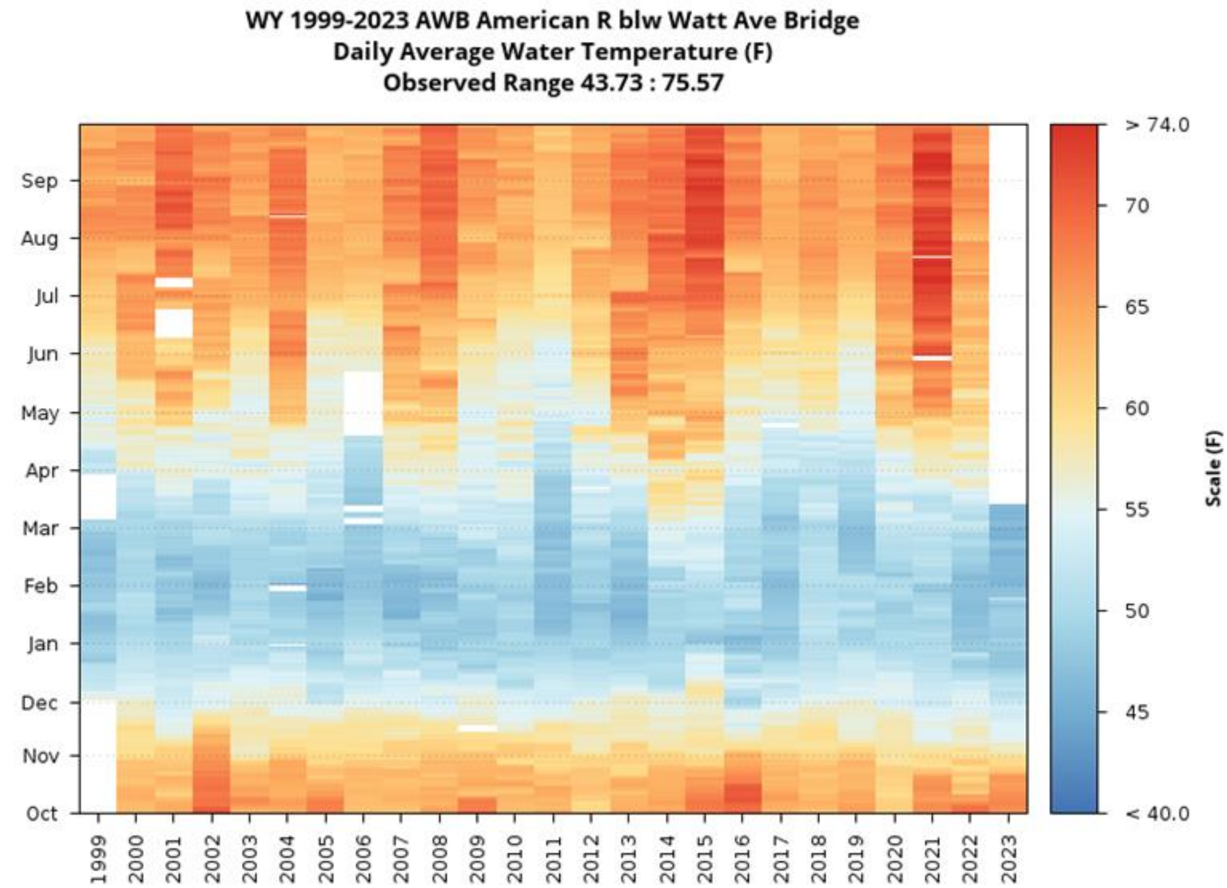


Figure B-48. American River below Watt Ave Bridge Daily Average Water Temperature (°F) for WY 1999-2023

B.5.3 Suitable Habitat

Steelhead is the only aquatic listed species in the lower American River. Steelhead adults generally spawn in January through April and juveniles can rear year-round with natal young of year rearing primarily March through May. Suitable instream and floodplain rearing habitat quantities, presented separately, are provided for every month in the lower American River (Figure B-49 and Figure B-50). Increases in expected instream rearing habitat availability in September and October corresponded with reductions in monthly flows (Section 5.1, *Water Operations*). The greatest floodplain habitat availability estimates, occurring in January and February, corresponded with the highest expected monthly flows.

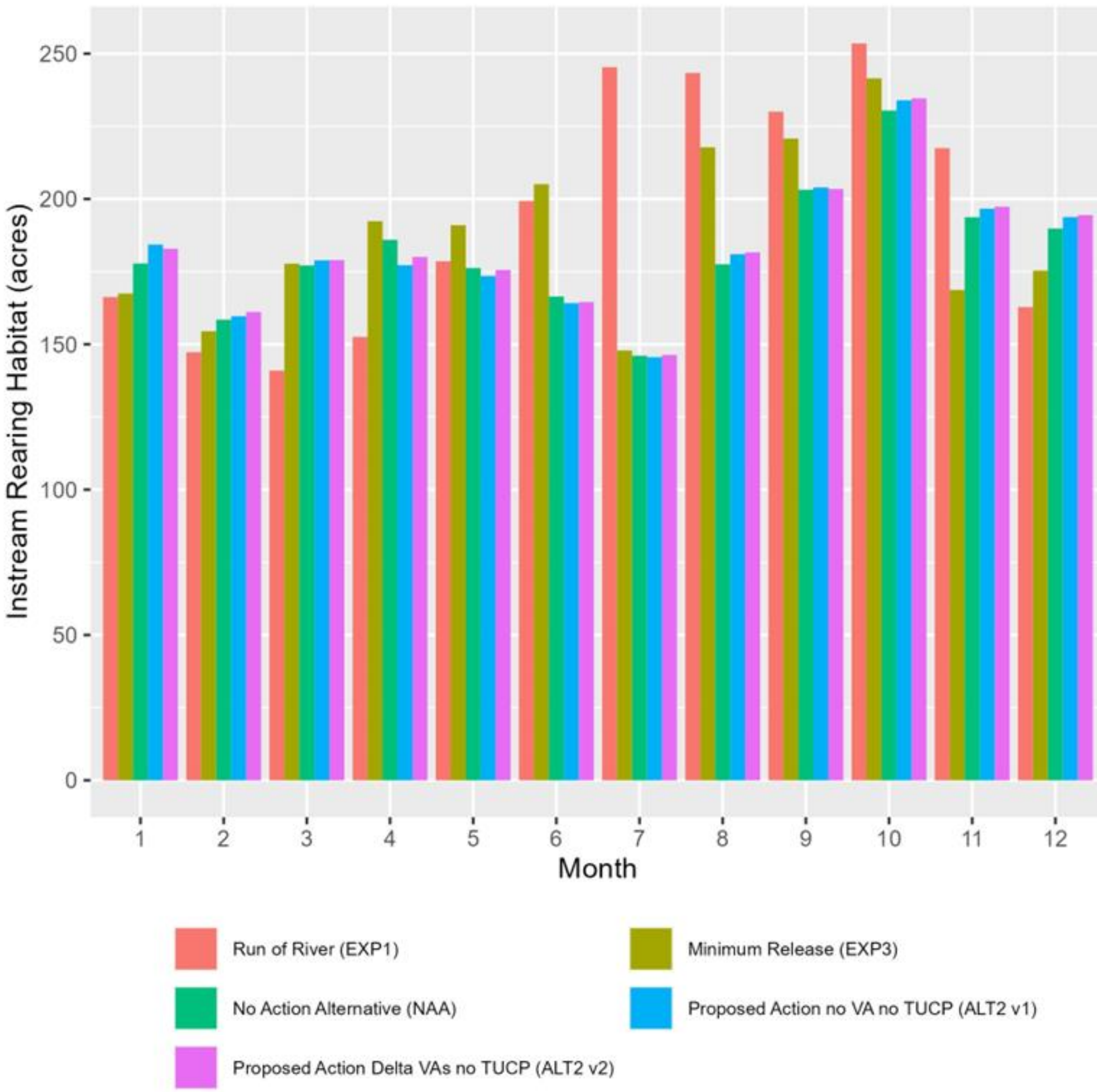


Figure B-49. Estimated instream rearing habitat for juvenile steelhead in the lower American River. Values represent means across CalSim WYs.

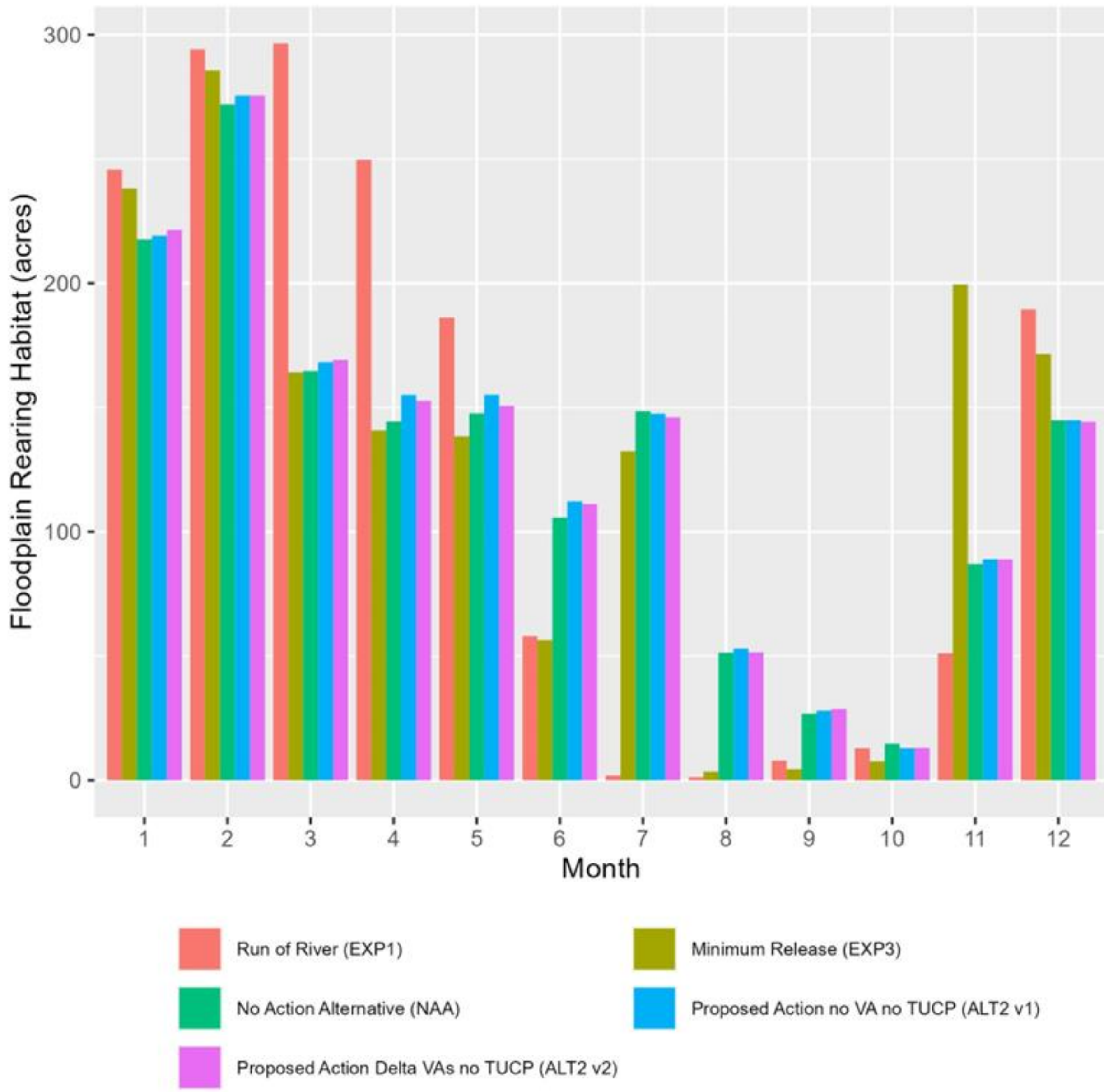


Figure B-50. Estimated floodplain rearing habitat for juvenile steelhead in the lower American River. Values represent means across CalSim WYs.

Juvenile winter-run Chinook salmon have been confirmed in the lower American River. Lower American River catch data is readily available through the Pacific States Marine Fisheries Commission (PSMFC) on http://CalFish.org. At the rotary screw traps located near the Watt Avenue Bridge, PSMFC reports small numbers of winter-run Chinook salmon passage, suggesting use of the area as rearing habitat. However, the American River is not considered natal habitat for winter-run Chinook salmon.

B.6 Stanislaus River

Inflows to New Melones Reservoir come from the Stanislaus River. Figure B-51 shows the inflow to New Melones Reservoir by month and the 40-30-30 hydrologic water year type. The San Joaquin Basin uses a different hydrologic index. The Stepped Release Plan uses the 60-20-20 San Joaquin River Index for water year classification.

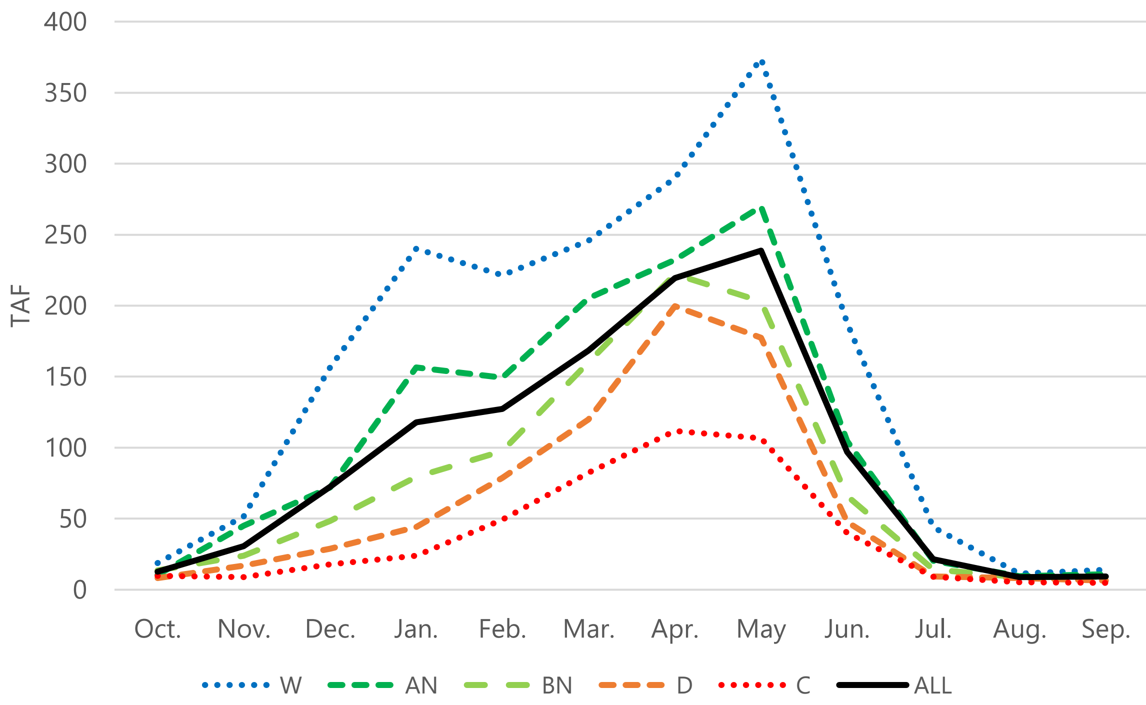


Figure B-51. nflow to New Melones Reservoir by Month and Water Year Types (40-30-30)

Releases from New Melones Reservoir flow to Goodwin Dam. Figure B-52 shows a simplified hydrologic topology in the Stanislaus River from New Melones Dam to the confluence with the San Joaquin River.

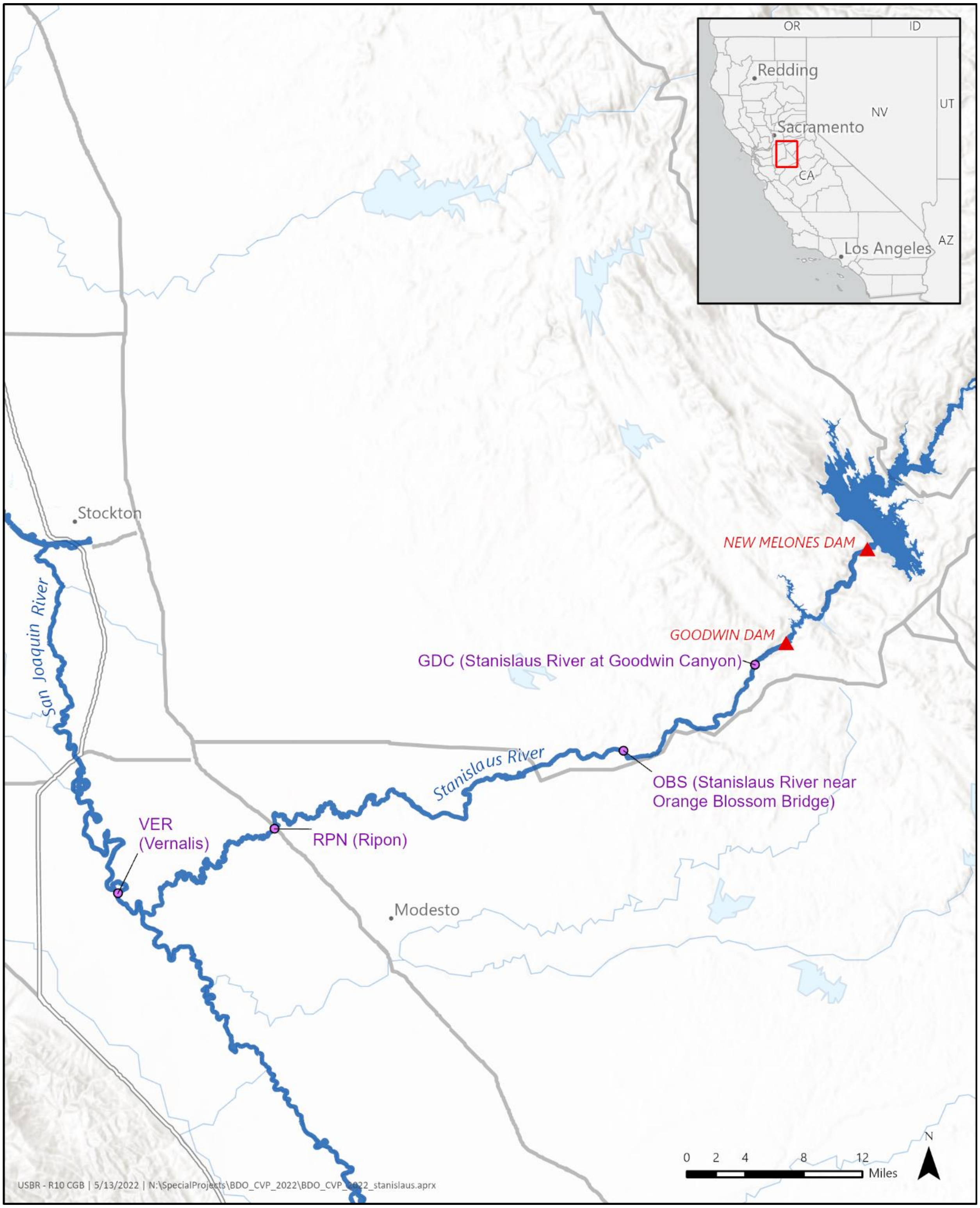


Figure B-52. Stanislaus River Watershed Water Operations and Temperature Topology

Diversions at Goodwin Dam serve Oakdale Irrigation District and South San Joaquin Irrigation District. The measurement of flows below Goodwin Dam represents the release to the river. New

Melones Reservoir lacks a TCD; therefore, water temperatures to Orange Blossom are managed through the thermal mass of flows and the preservation of sufficient storage to keep the thermocline above the intakes to the New Melones Power Plant. Similarly, Reclamation makes releases for dissolved oxygen at Ripon.

B.6.1 Water Operations

Figure B-53, Figure B-54, and Figure B-55 show releases from Goodwin Dam to the Stanislaus River under the “Run of River”, “Minimum Releases”, “No Action Alternative”, “Proposed Action without VAs, no TUCPs”, and “Proposed Action with Delta VAs, no TUCPs” scenarios. The EXP 1 scenario does not include releases for meeting the flow requirement at Vernalis solely through releases from New Melones while the Proposed Action phases includes a Stanislaus River portion of Vernalis flows. Flows at Vernalis are described in Section 8, *Delta*.

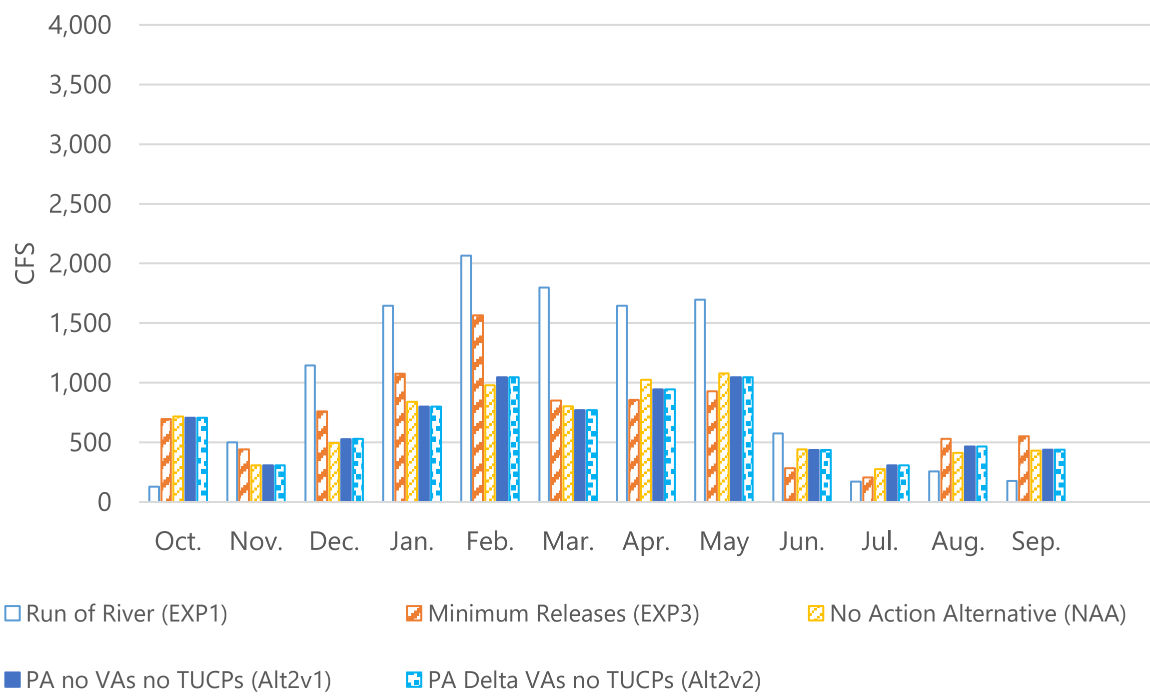


Figure B-53. Stanislaus River below Goodwin Dam Monthly Flows, All Water Year Types

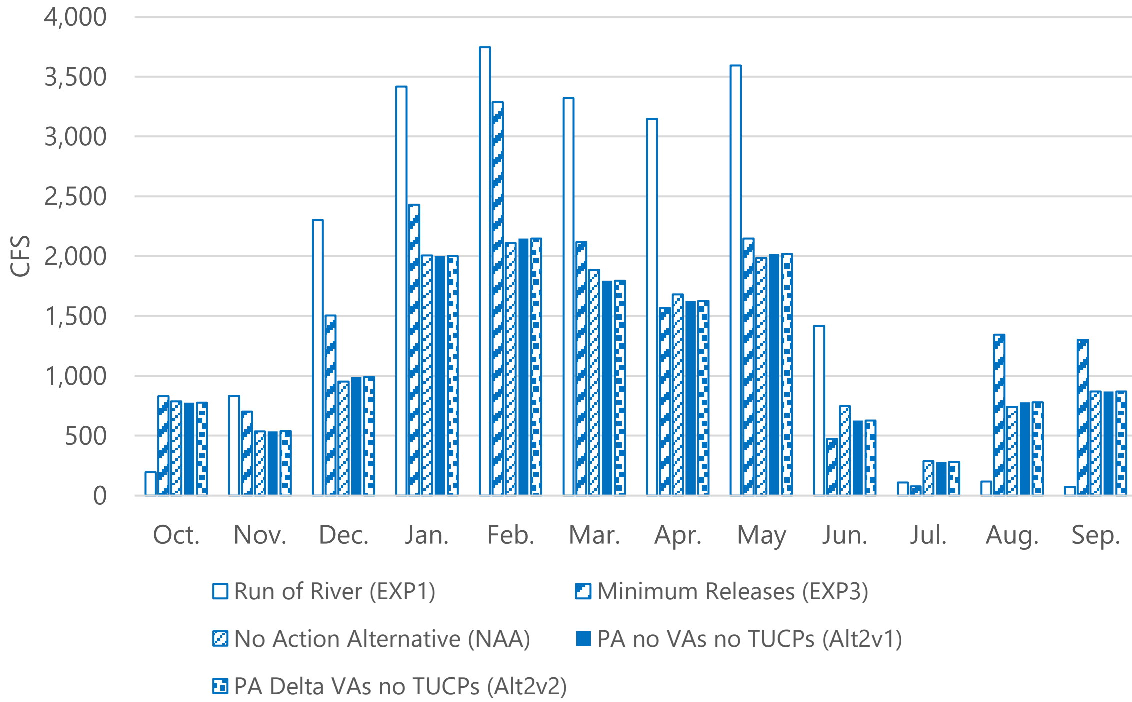


Figure B-54. Stanislaus River below Goodwin Dam Monthly Flows, Wet Water Year Type

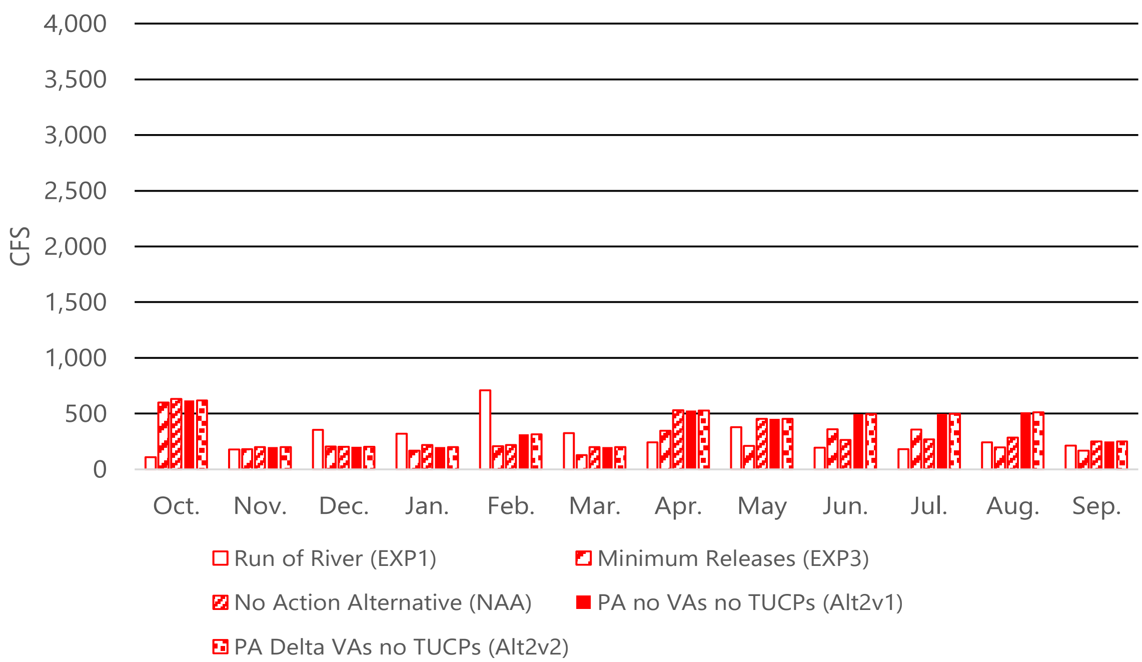


Figure B-55. Stanislaus River below Goodwin Dam Monthly Flows, Critical Water Year Type

In comparing the Minimum Release and Proposed Action scenarios, no large differences exist for most months based on water year type. However, in April and May, and August and September flows in critical years are higher for the Proposed Action phases than Minimum Release. In June and July for wet years, the flows are higher for the Proposed Action phases than Minimum Release.

Figure B-56 shows peak annual flows (monthly average) below Goodwin Dam.

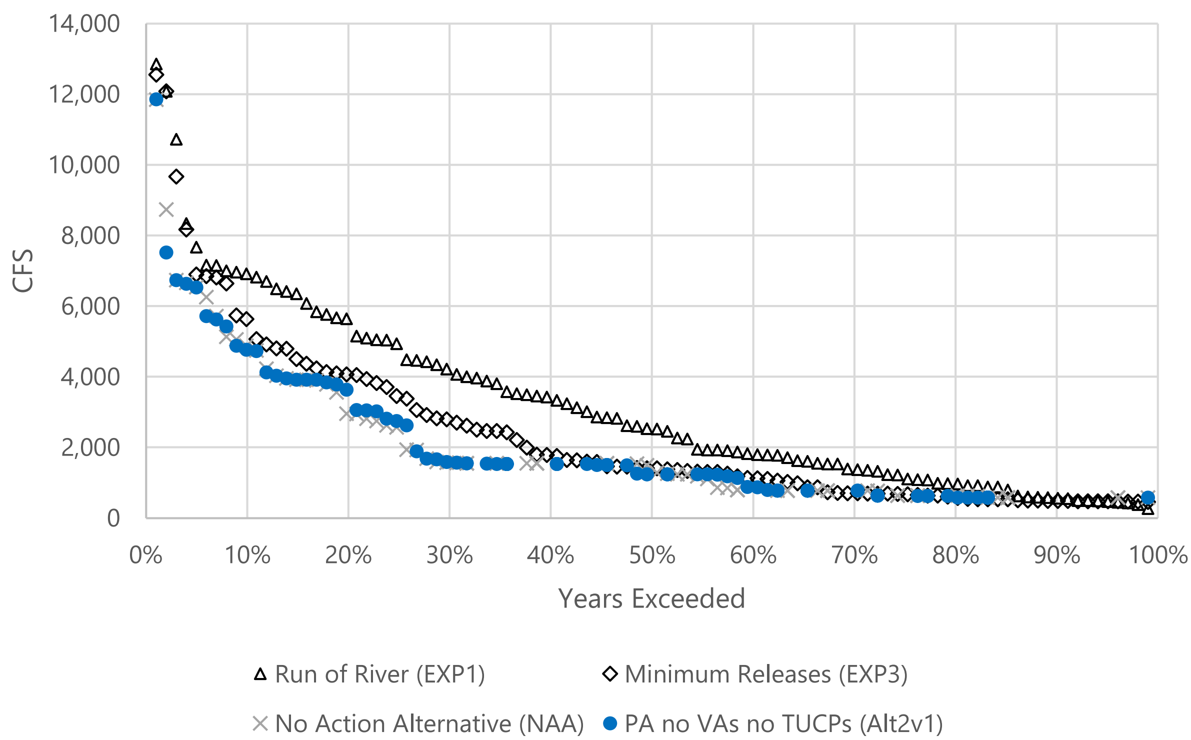


Figure B-56. Stanislaus River below Goodwin Dam Annual Peak Flow Frequency

New Melones is a large reservoir compared to the watershed, and large downstream demands frequently deplete storage. As a result, Reclamation is rarely required to release water to maintain flood conservation space. Peak flows are driven by managed schedules.

B.6.2 Water Temperatures and Dissolved Oxygen

Water temperatures on the Stanislaus River were modeled using HEC-5Q. No TCD exists at New Melones Dam, so selective withdrawal was not simulated.

Figure B-57 and Figure B-58 show water temperatures on the Stanislaus River at Orange Blossom.

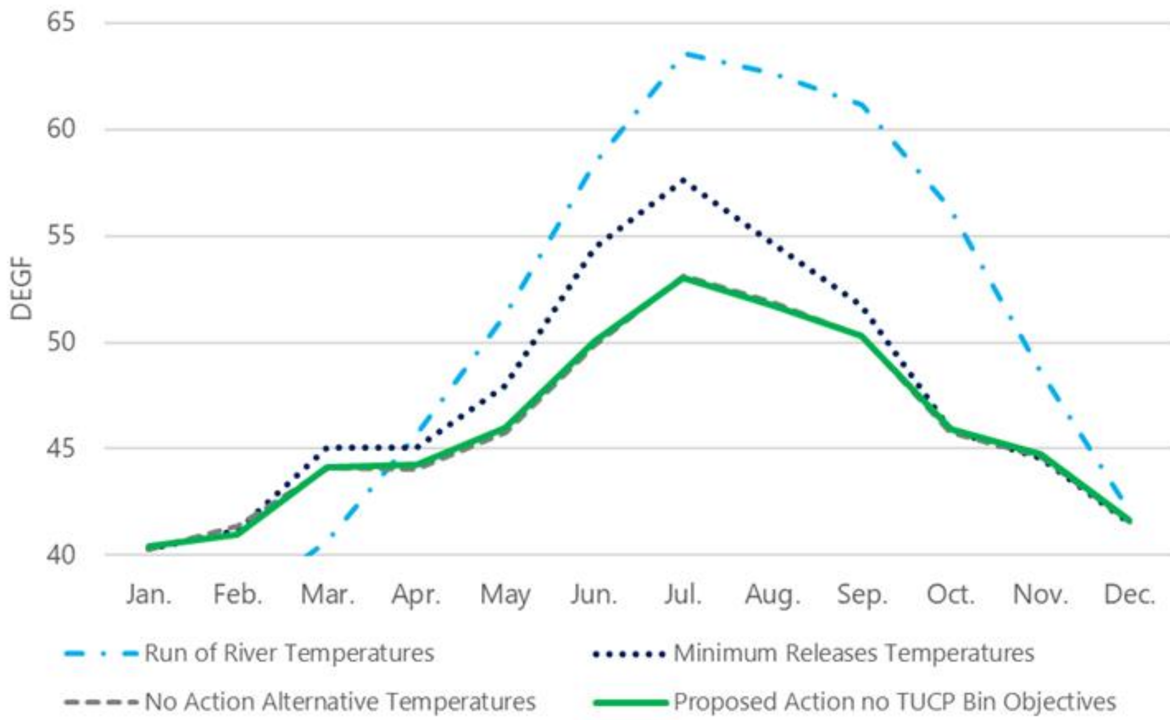


Figure B-57. Stanislaus River at Orange Blossom

The Run of River scenario features the greatest amplitude, peaking in the summer and dropping to its lowest temperatures in the winter. The Proposed Action phases follow a similar pattern, but with a lesser amplitude, due to the buffering effect of storage in New Melones Reservoir.

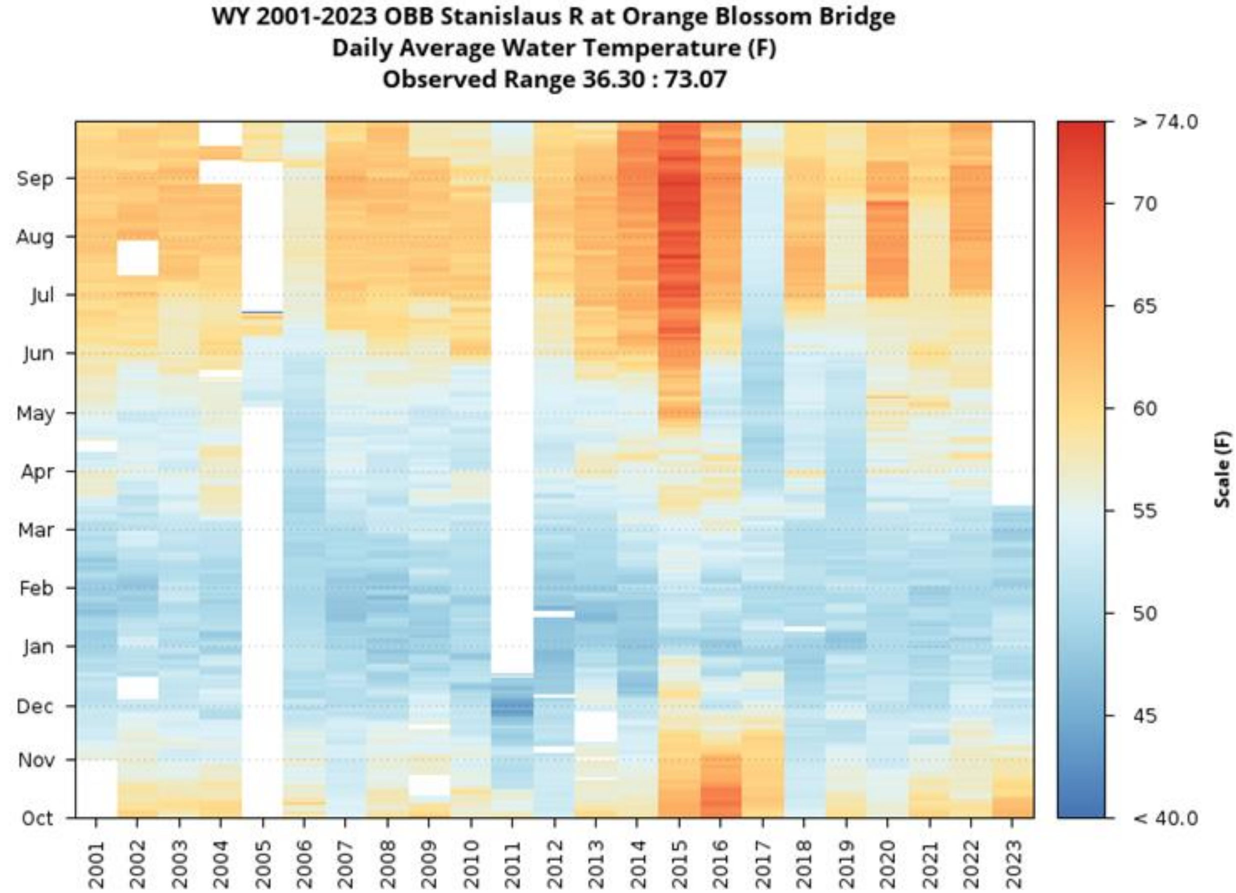


Figure B-58. Stanislaus River at Orange Blossom Bridge Daily Average Water Temperature (°F) for WY 2001-2023

Figure B-59 shows the Stanislaus River at Ripon Daily Average Dissolved Oxygen levels for water years 2013-2022.

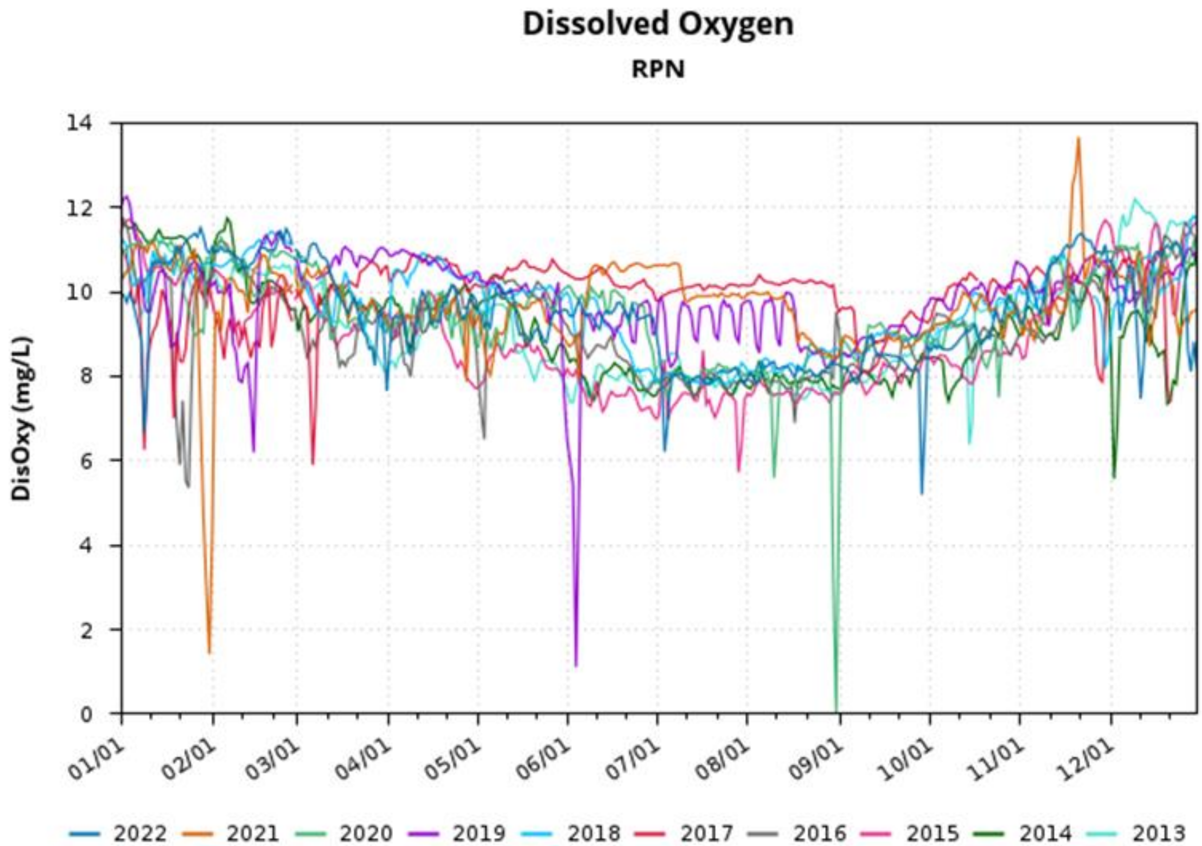


Figure B-59. Stanislaus River at Ripon Daily Average Dissolved Oxygen (mg/L) for WY 2013-2022

B.6.3 Suitable Habitat

Steelhead are present on the Stanislaus River. Steelhead adults generally spawn in January through April and juveniles may rear year-round with natal young of year primarily rearing in March through May. Suitable instream and floodplain rearing habitat quantities, presented separately, are provided for every month in the Stanislaus River (Figure B-60, Figure B-61). Although expected instream rearing habitat availability is relatively stable across months, slight reductions in habitat availability in June through September correspond to reductions in monthly flows (Section 6.1, *Water Operations*). Peaks in floodplain rearing habitat availability from December through May correspond to elevated monthly flows.

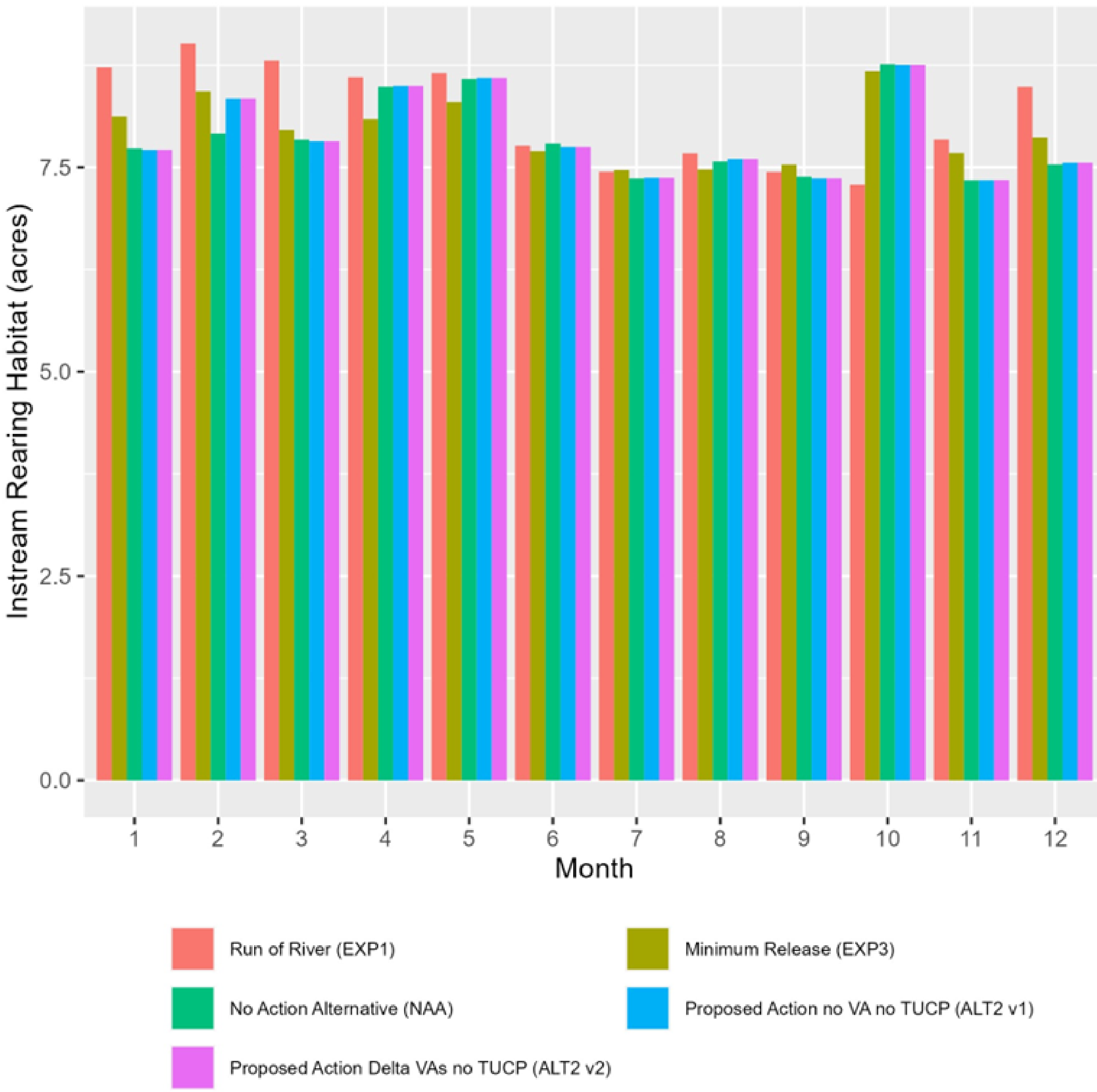


Figure B-60. Estimated instream rearing habitat for juvenile steelhead in the Stanislaus River. Values represent means across CalSim WYs.

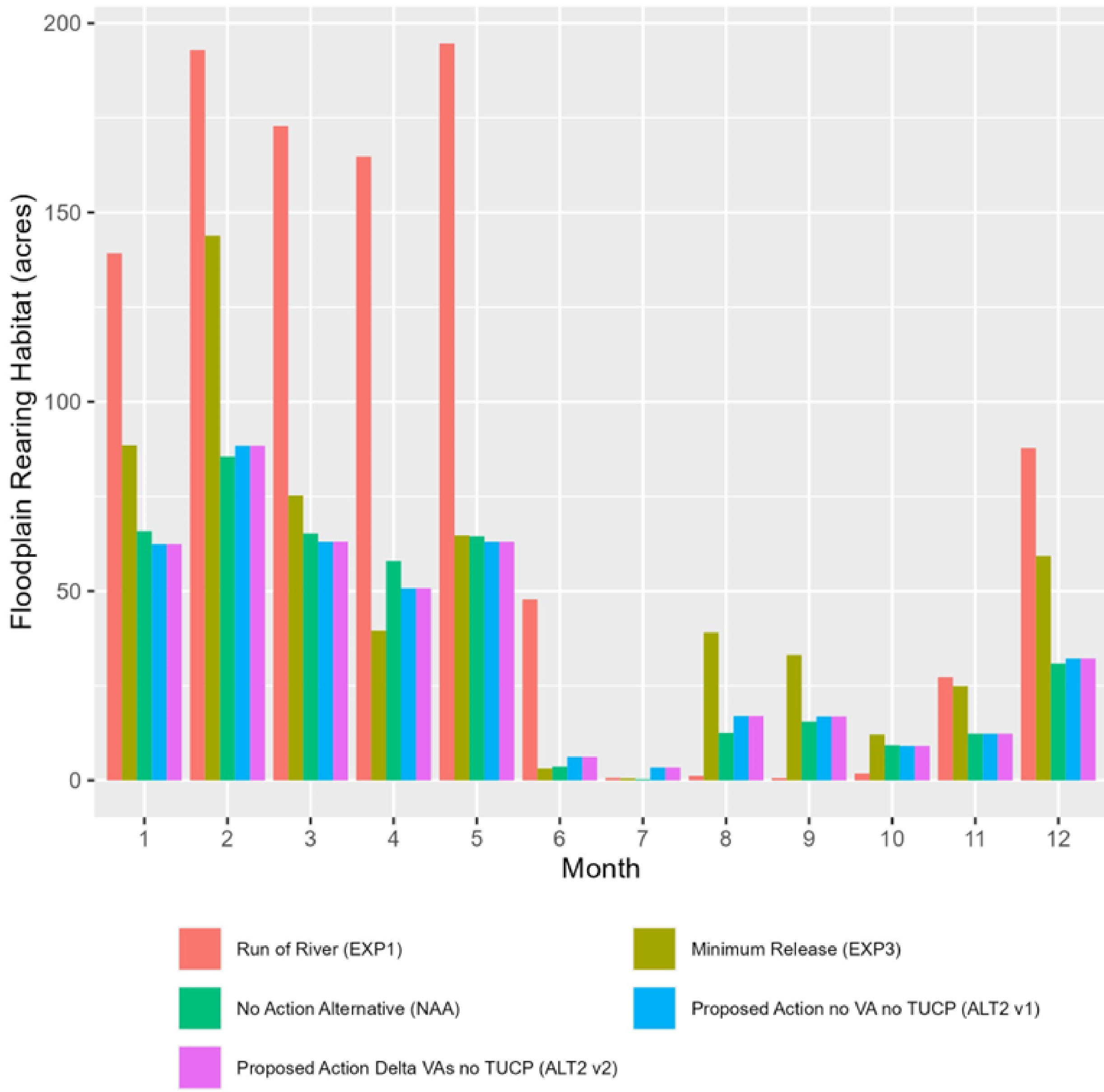


Figure B-61. Estimated floodplain rearing habitat for juvenile steelhead in the Stanislaus River. Values represent means across CalSim WYs.

B.7 San Joaquin River

Inflows to Millerton Reservoir behind Friant Dam come from the San Joaquin River. Figure B-62 shows the inflow to Millerton Reservoir by month and the 40-30-30 hydrologic water year type so that it can be compared to the Delta and Sacramento tributaries. The San Joaquin Basin more typically uses a 60-20-20 hydrologic water year type, and the San Joaquin River Restoration Program (SJRRP) uses a program-specific water year classification.

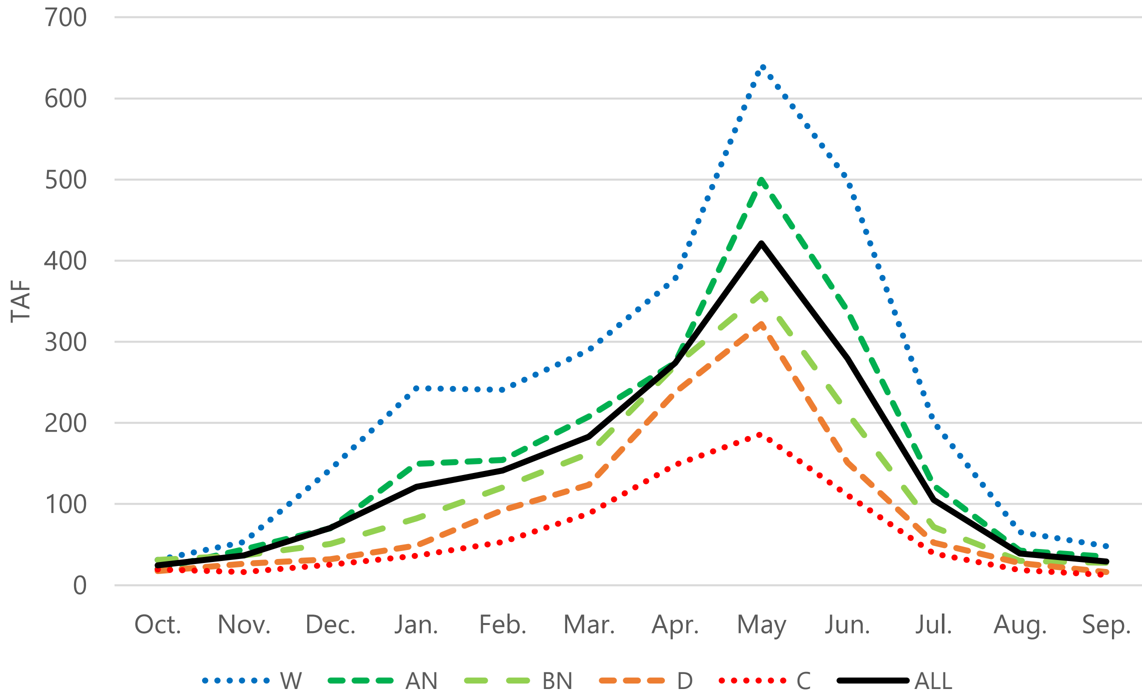


Figure B-62. Inflow to Millerton Reservoir by Month and All Water Year Type

Figure B-63 shows releases from Friant Dam for the SJRRP flow past riparian diverters down to Gravelly Ford, bypass Mendota Dam, and then are maintained to the Merced River Confluence.

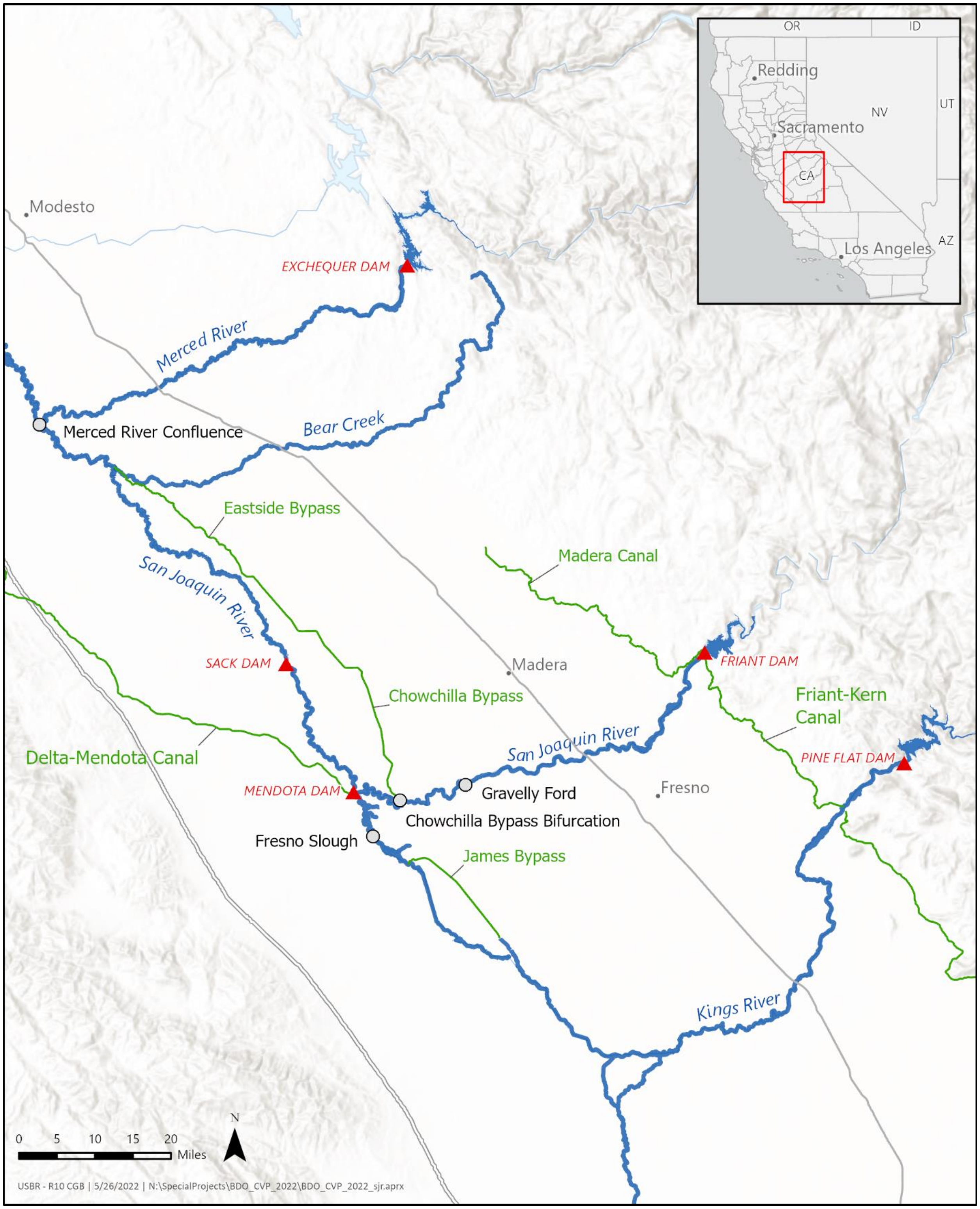


Figure B-63. San Joaquin River Watershed Water Operations Topology

The flood control system may divert water around Mendota Pool at the Chowchilla Bypass Bifurcation Structure. Flood releases from Pine Flat on the King's River may enter the San Joaquin at Mendota Pool through the James Bypass on Fresno Slough. Flows in the San Joaquin River that pass Sack Dam are diverted into the Eastside Bypass where they rejoin the San Joaquin River through Bear Creek. Other releases (e.g., flood) may be diverted at Mendota Pool. Reclamation delivers water from the Delta down the Delta-Mendota Canal and to the Mendota Pool.

Inflow from the Merced, Tuolumne, and Stanislaus Rivers joins release from Friant and flows to the Vernalis, which is addressed in the Delta watershed. Releases from the SJRRP may be diverted at non-project facilities operated by West Stanislaus ID, Patterson ID, or Banta Carbona ID prior to reaching the Delta.

B.7.1 Water Operations

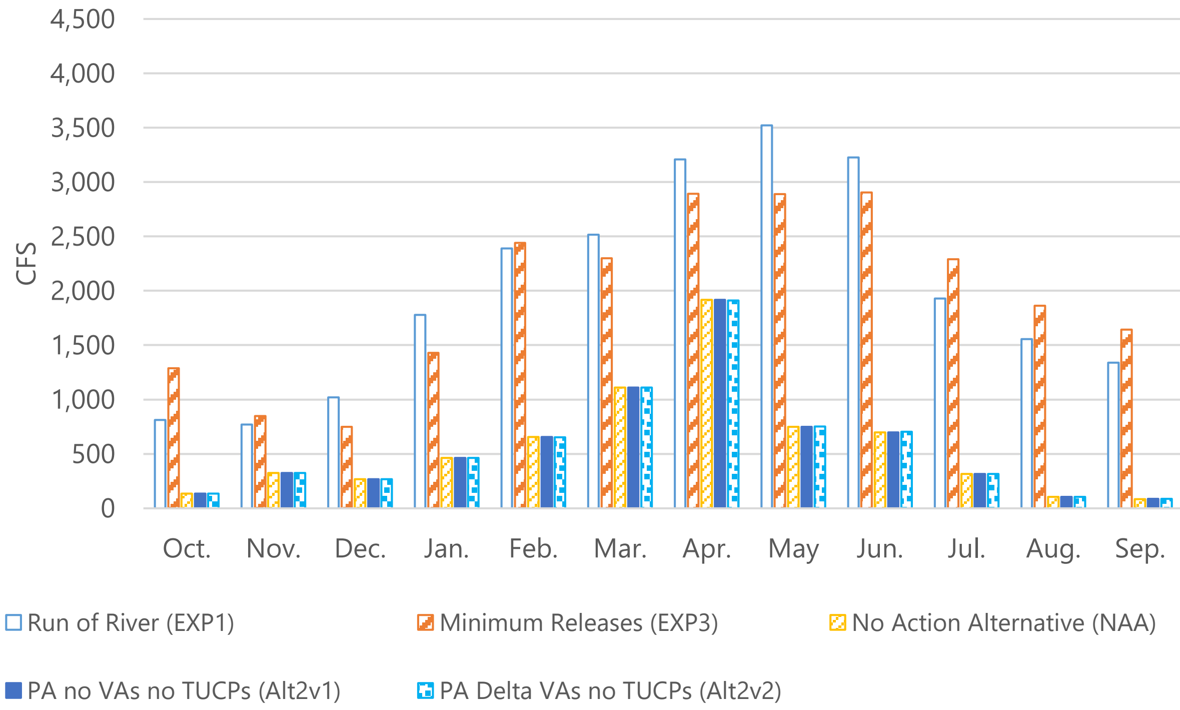


Figure B-64. San Joaquin River at Gravelly Ford Monthly Flows, All Water Year Types

Figure B-64 shows the flows at San Joaquin River at Gravelly Ford. In critical years from October to March, the flows distribution pattern for Minimum Release and the Proposed Action phases are similar to all water year types but with less flows volume. For wet years, from October to March, the flow distribution pattern for Minimum Release and the Proposed Action phases are similar to all water year type but with higher flows volume. Figure B-65 shows the flows at San Joaquin River below the Merced confluence.

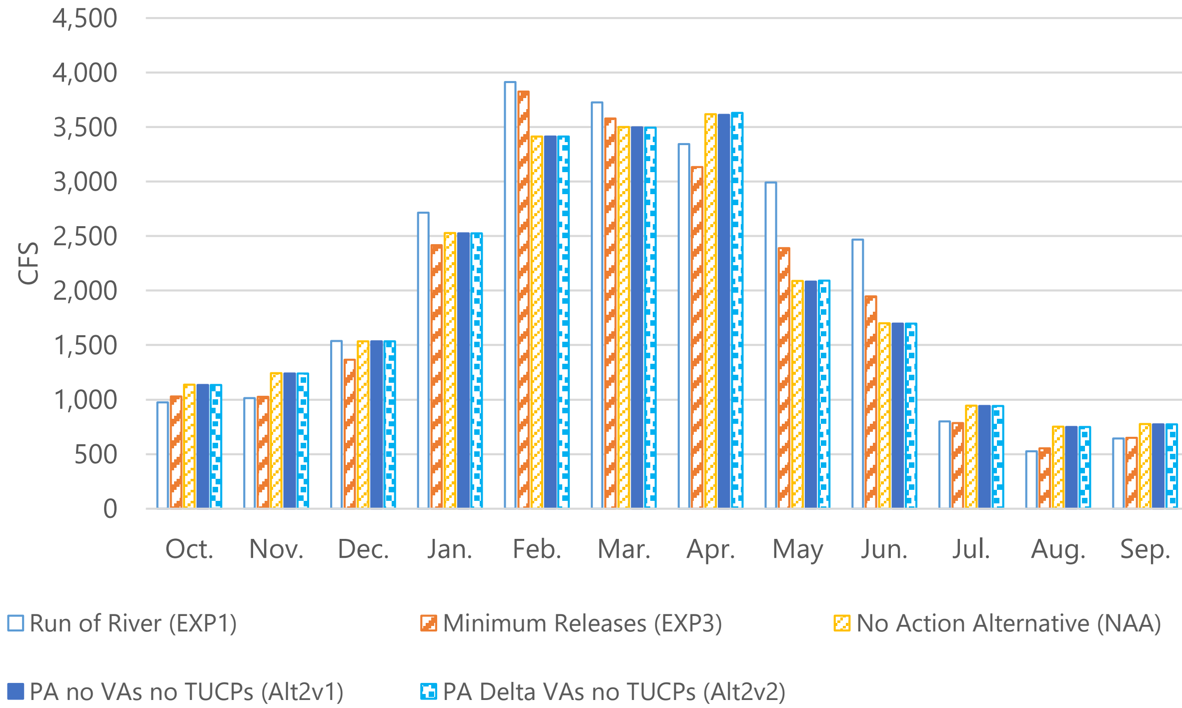


Figure B-65. San Joaquin River below the Merced Confluence Monthly Flows, All Water Year Types

In critical and dry years, December and January flows for Minimum Release and the Proposed Action are smaller than typical years. However, for wet water years, the flow distribution patterns are similar to all water year types (high between January and April) for both scenarios. Figure B-66 shows peak annual flows (monthly average) below the Merced River confluence.

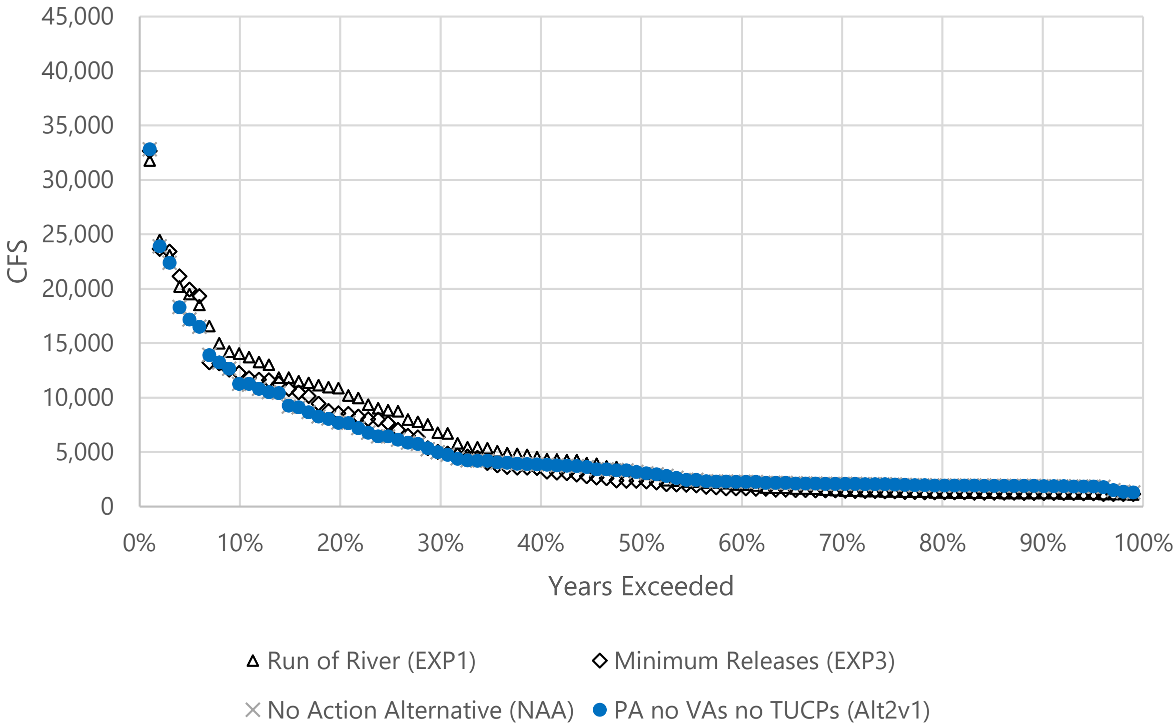


Figure B-66. San Joaquin River below Merced River Confluence Annual Peak Flow Frequency

The SJRRP operates under a separate Biological Opinion that is not proposed for reinitiation under this consultation. Flows at Vernalis on the San Joaquin River are described in Section 8, *Delta*.

B.7.2 Water Temperatures and Dissolved Oxygen

Water temperatures on the lower San Joaquin River at Vernalis were modeled using HEC-5Q (Figure B-67).

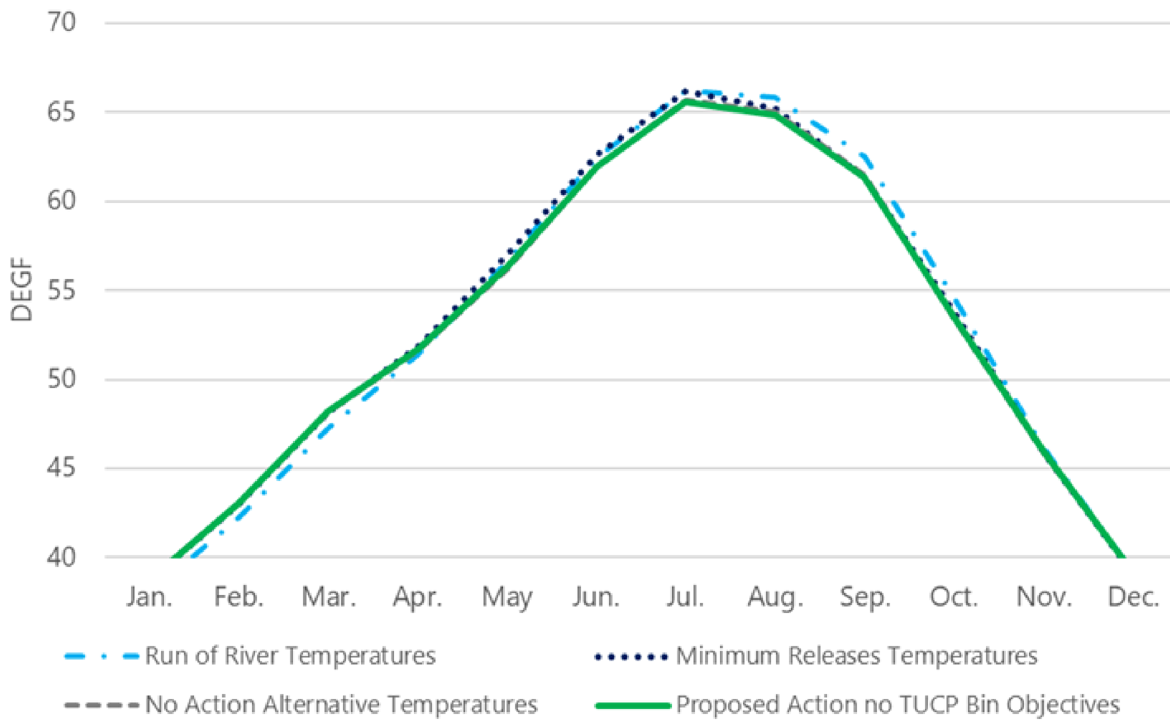


Figure B-67. San Joaquin River at Vernalis

The Run of River scenario features the greatest amplitude, but the Proposed Action phases are very similar. This similarity is likely because San Joaquin River flows above the Stanislaus River are very similar in the two phases, and water temperatures are near ambient air temperatures.

Figure B-68 shows the daily water temperatures on the San Joaquin River at Mossdale Bridge for water years 2002-2023.

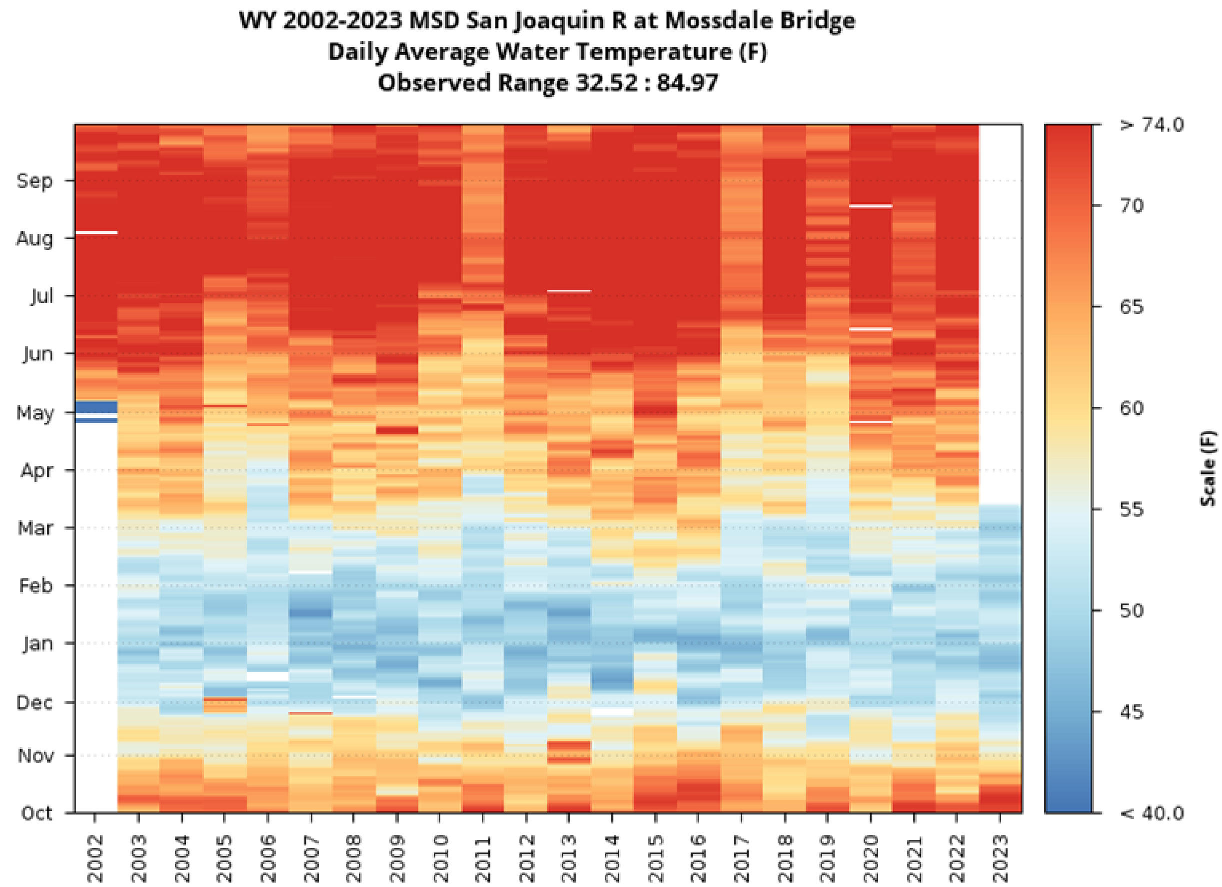


Figure B-68. San Joaquin River at Mossdale Bridge Daily Average Water Temperature (°F) for WY 2002-2023

Figure B-69 shows the daily average dissolved oxygen levels on the San Joaquin River at Mossdale Bridge for the water years 2013-2023.

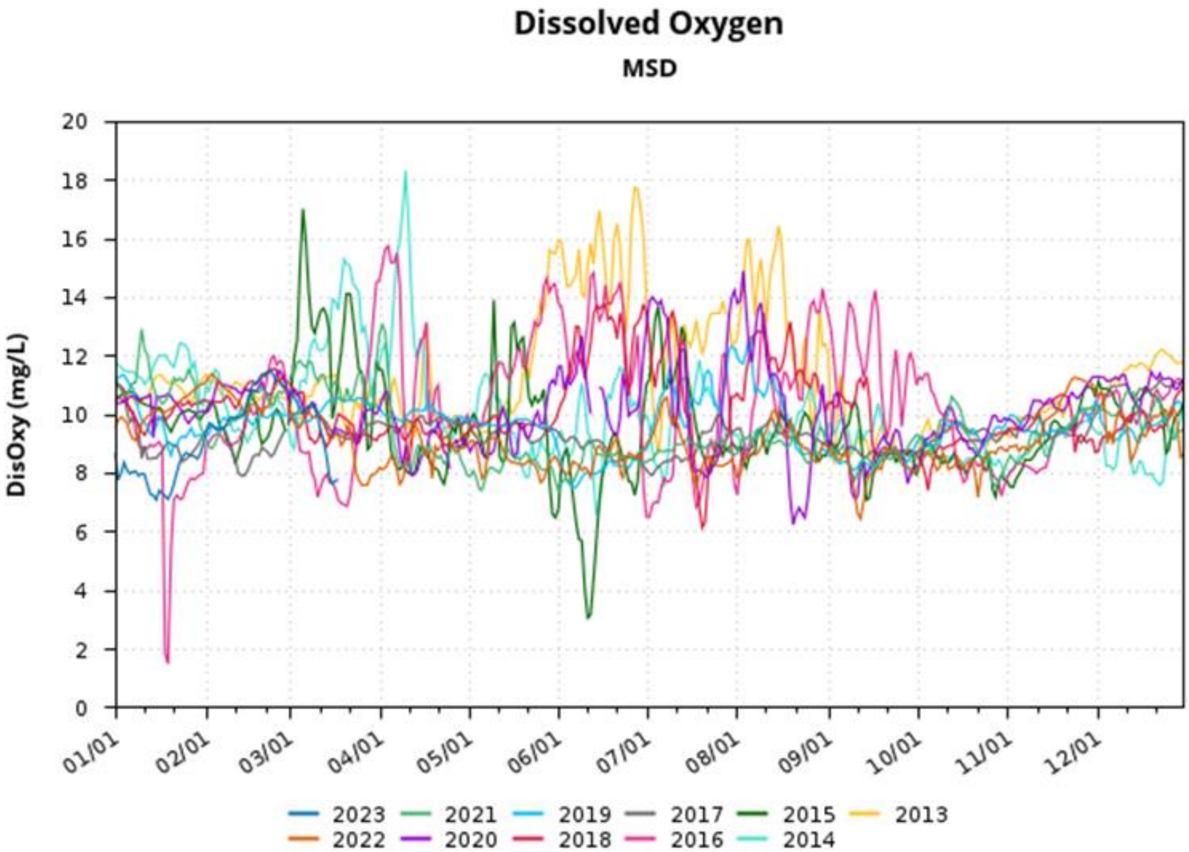


Figure B-69. San Joaquin River at Mossdale Bridge Daily Average Dissolved Oxygen (mg/L) for WY 2013-2023

B.7.3 Suitable Habitat

Steelhead and an experimental population of spring-run Chinook salmon use the San Joaquin River. Both species may be primarily rearing and migrating in March through May, but both may rear year-round.

Suitable instream and floodplain rearing habitat quantities, presented separately, are provided for every month in the San Joaquin River; available flow-habitat relationships are assumed to be the same across spring-run Chinook salmon and steelhead in the San Joaquin River for floodplain habitat specifically based on the availability on data and analyses (Figure B-71, Figure B-72). Reduced instream rearing habitat availability in October through December corresponds to intermediate monthly flows relative to other months (Section 7.1, *Water Operations*). Increased floodplain habitat availability in February through April corresponds to increased monthly flows.

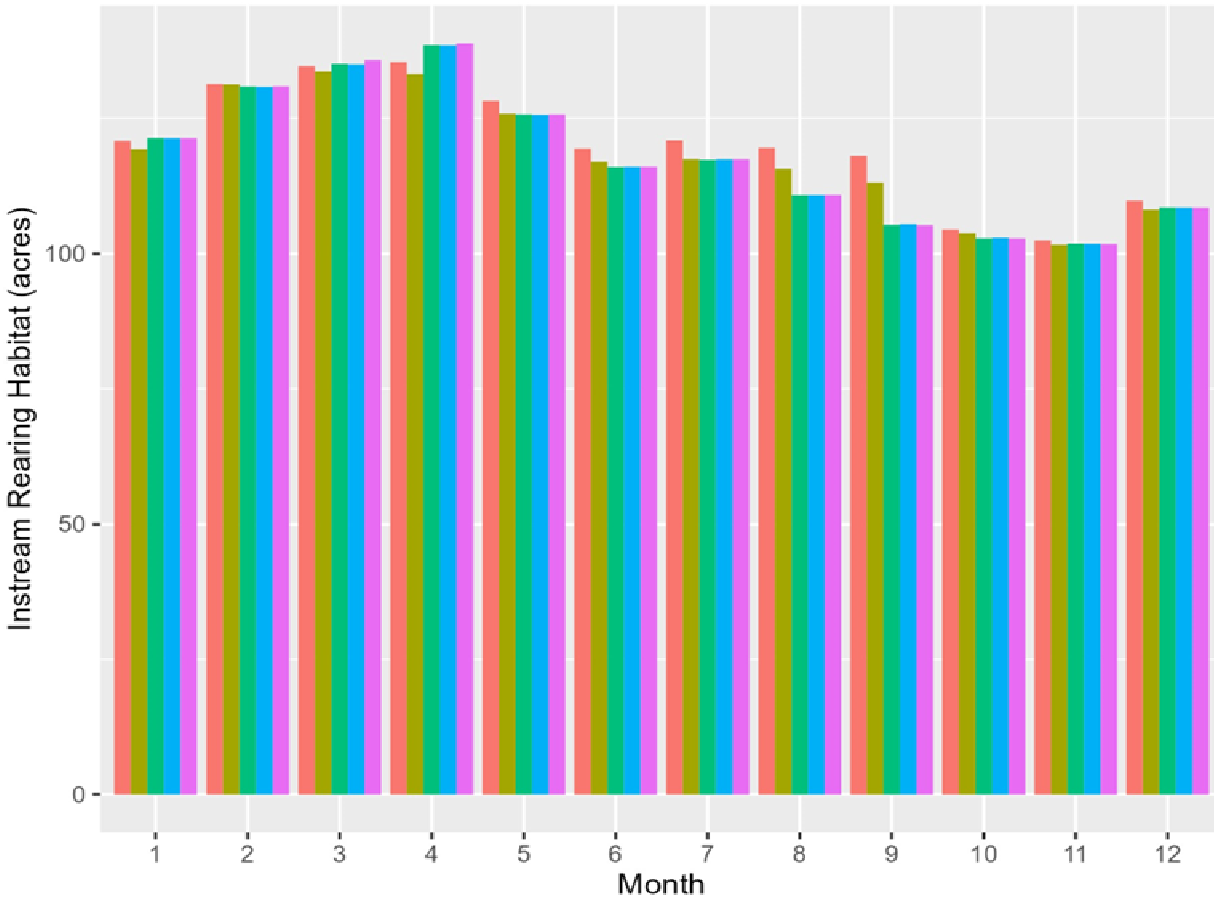


Figure B-70a. Estimated instream rearing habitat for juvenile spring-run Chinook salmon in the San Joaquin River. Values represent means across CalSim WYs.

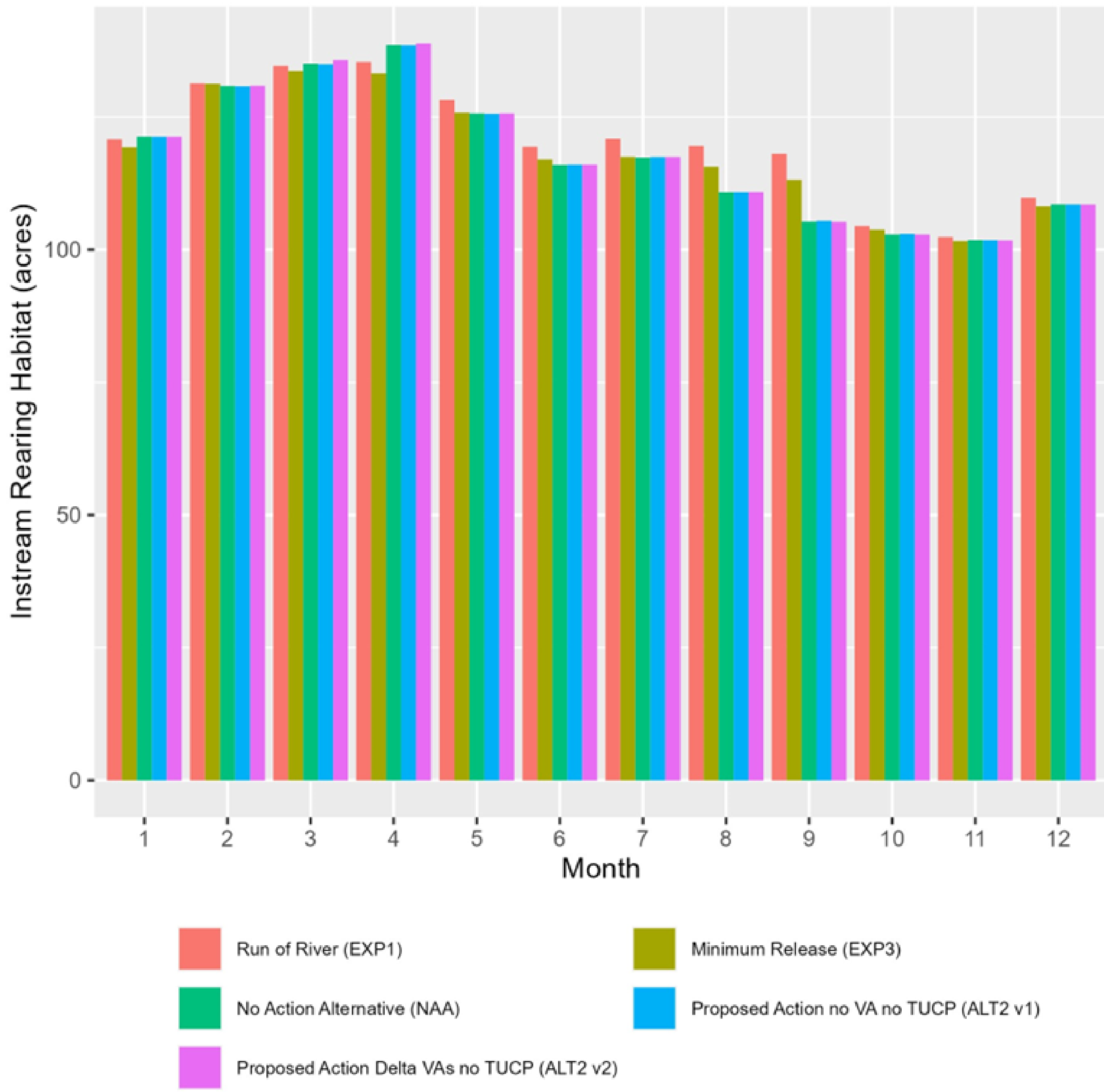


Figure B-71b. Estimated instream rearing habitat for juvenile steelhead in the San Joaquin River. Values represent means across CalSim WYs.

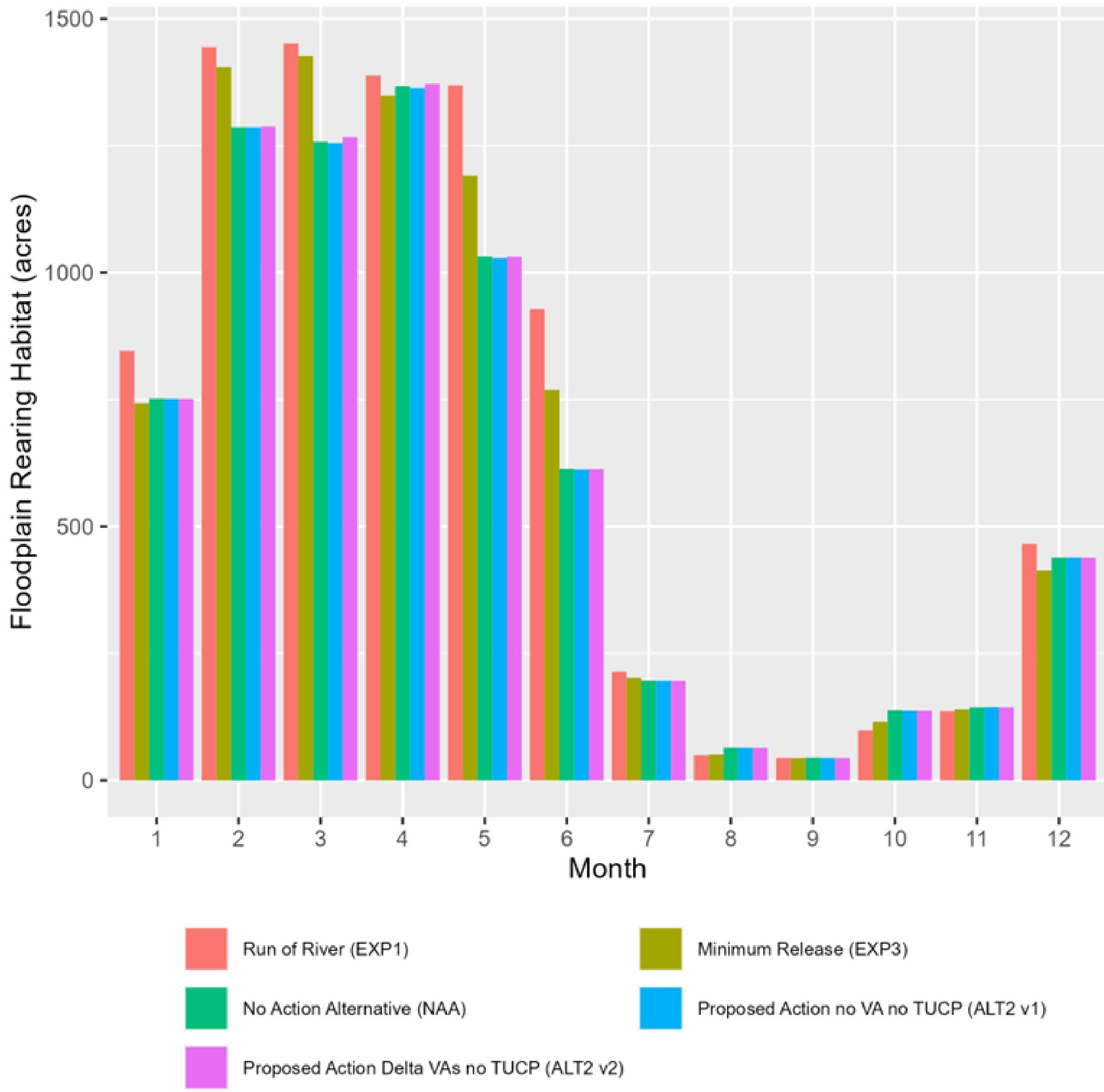


Figure B-72. Estimated floodplain rearing habitat for juvenile spring-run Chinook salmon and steelhead in the San Joaquin River. Values represent means across CalSim WYs.

B.8 Delta

Inflows to the Delta come from the Sacramento Basin at Freeport, the San Joaquin River at Vernalis, the Yolo Bypass and Colusa Basin drain at Cache Slough, and direct tributaries to the Delta, most prominently the Mokelumne River. In general, approximately 77% of water enters the Delta from the Sacramento River, approximately 15% enters from the San Joaquin River, and approximately 8% enters from the eastside tributaries (California Department of Water

Resources 1994). Figure B-73 and Figure B-74 show the sum of modeled inflows to the Delta, including impaired inflows to major rim dams and impaired non-project tributary inflows for EXP1 and Proposed Action scenarios.

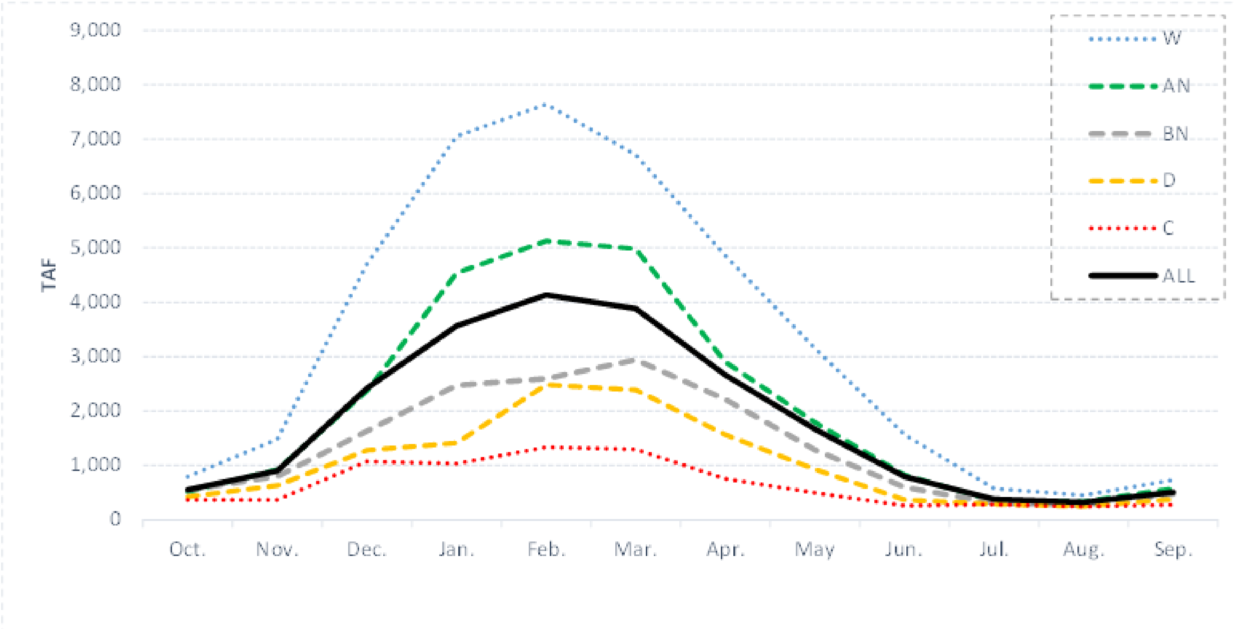


Figure B-73. Inflows to the Central Valley by Month and Water Year Type (EXP1)

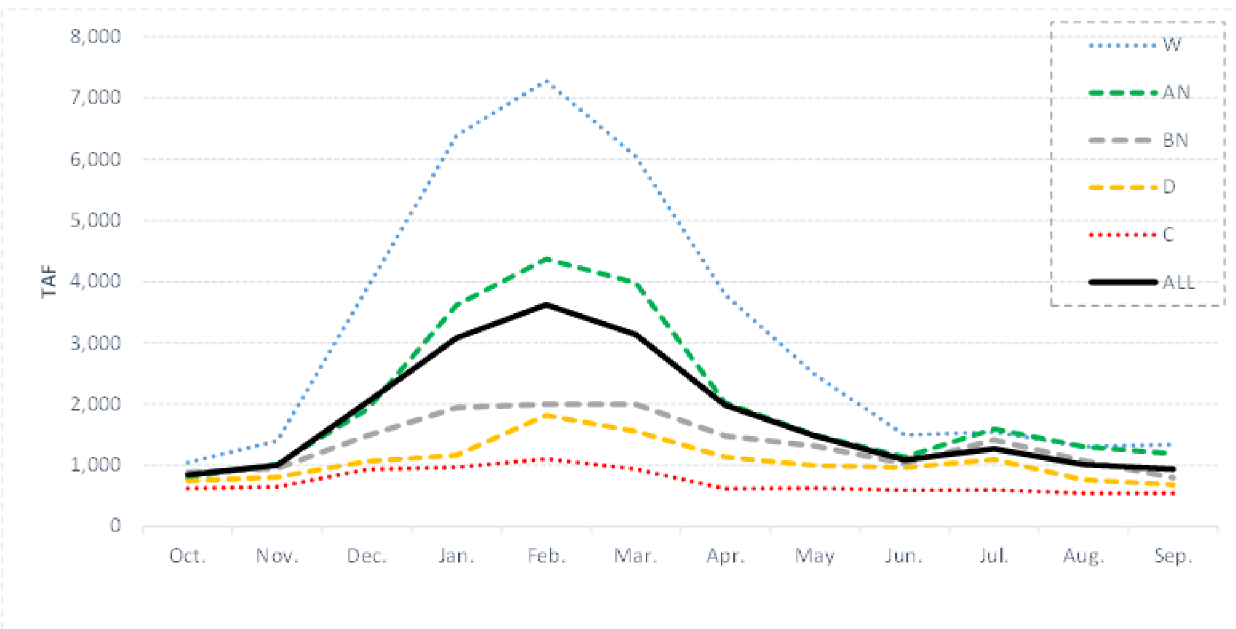


Figure B-74. Inflows to the Central Valley by Month and Water Year Type (Proposed Action)

Water entering the Delta from the Sacramento River can flow through sloughs in the north Delta, be routed into the central Delta at the Delta Cross Channel, or flow naturally into the central Delta through Georgiana Slough (and other paths). Water entering the Delta from the south can flow towards the export pumps or continue along the San Joaquin River to the central and south Delta. Ultimately, water is passed as Delta outflow, used within the Delta, or exported at the Federal and State pumping plants. The Delta is tidally influenced; rise and fall varies from less than 1 foot in the eastern Delta to more than 5 feet in the western Delta (DWR, 2013). Figure B-75 shows a simplified analytical topology.

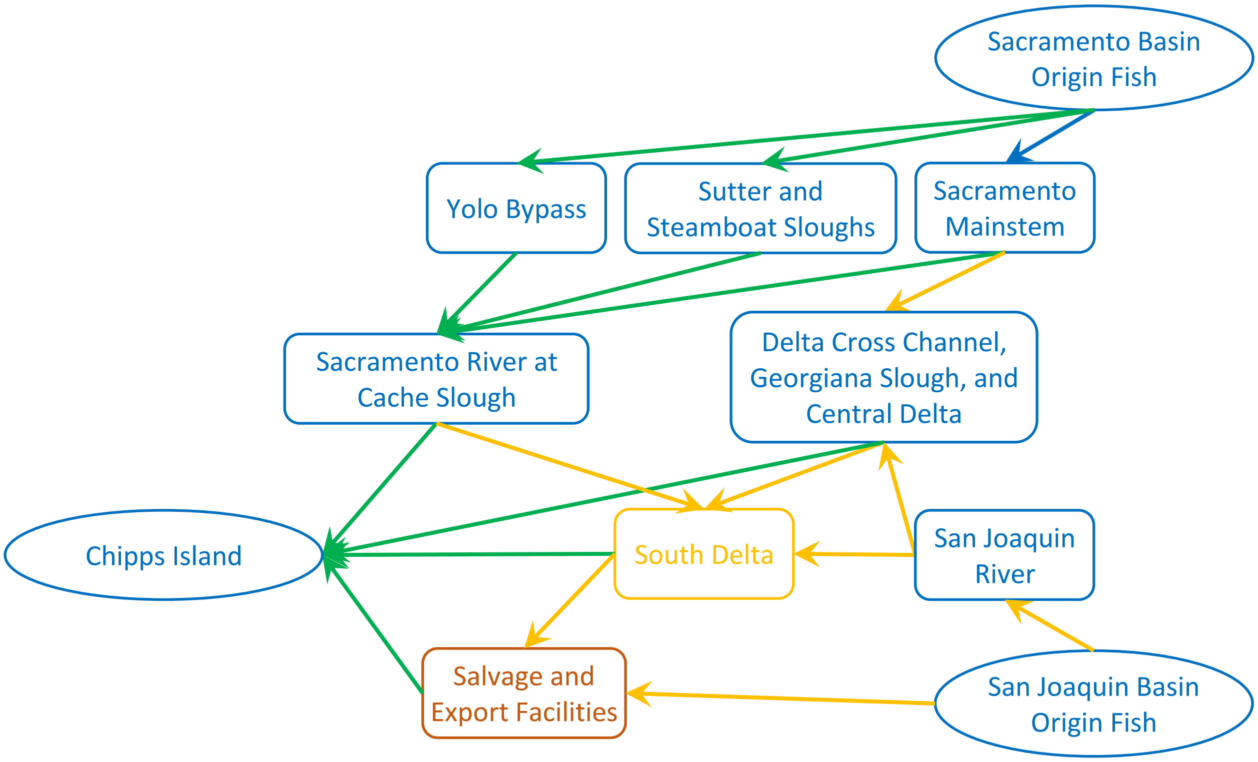


Figure B-75. Delta Regions and Analytical Topology

The measurement of combined flows on OMRs provides a surrogate for the hydraulic influence of exports. The measurement of outflow provides a surrogate for the relative influence of exports and upstream operations on biological processes as well as serving as a water quality parameter for the Water Board. Figure B-76 shows key locations in the Delta.

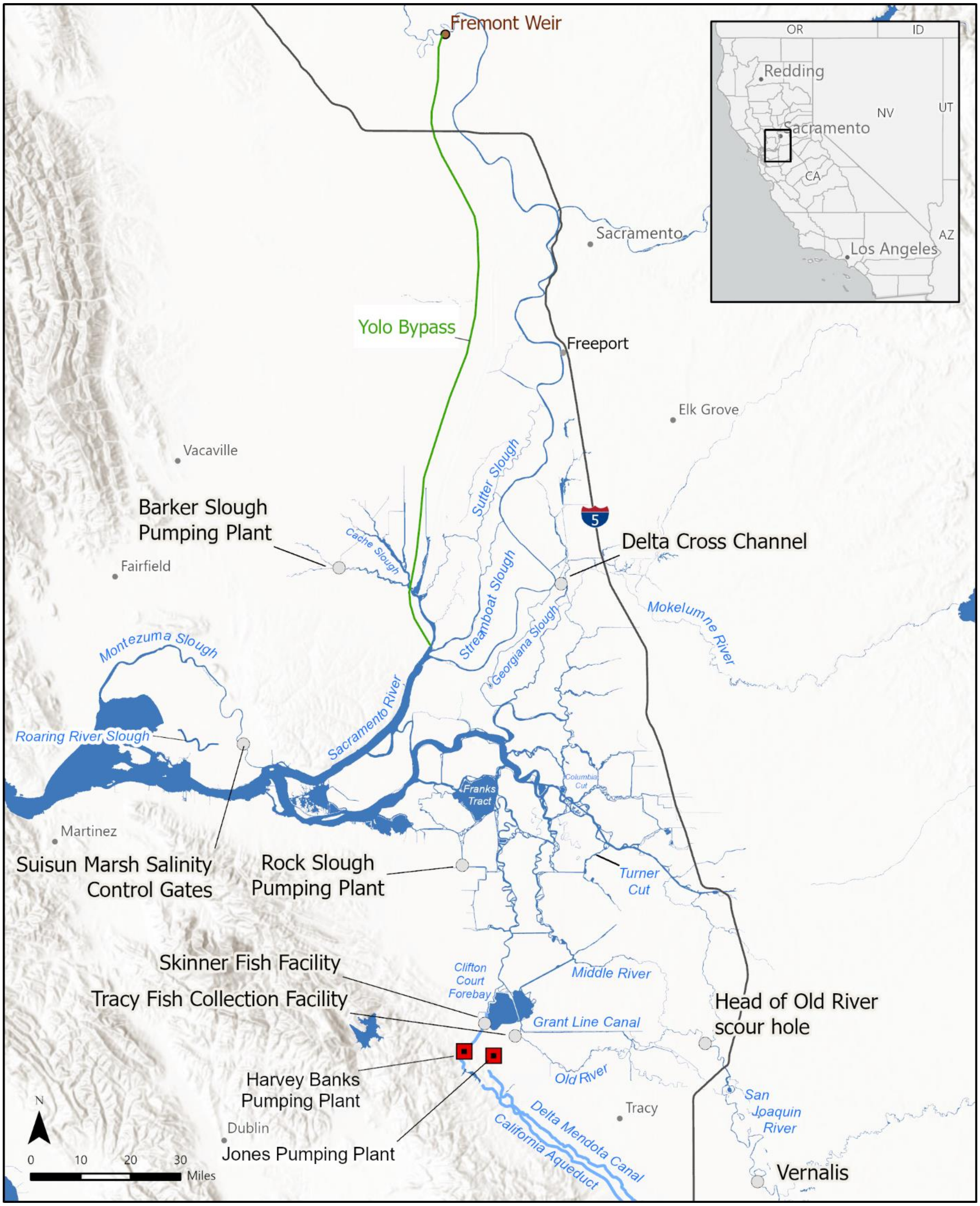


Figure B-76. Referenced Delta Facilities and Landmarks

B.8.1 Water Operations

Figure B-77 shows average inflows to the Delta from the Sacramento River at Freeport for the “Run of River”, “Minimum Release”, “No Action Alternative”, “Proposed Action without VAs, no TUCPs”, and “Proposed Action with Delta VAs, no TUCPs” scenarios.

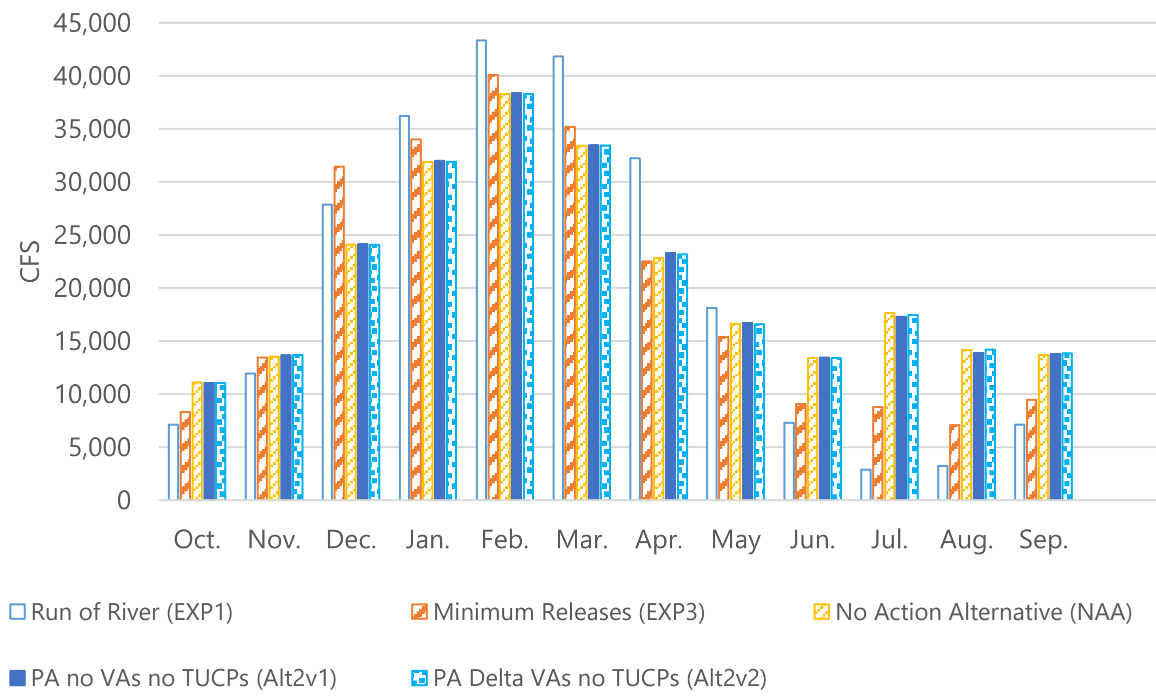


Figure B-77. Sacramento River at Freeport Monthly Flows, All Water Year Types

On average, water is stored upstream in the winter and spring, released summer and late-spring, and to a lesser extent, released in the early fall. In drier years, releases from storage to augment natural May flows increase to greater proportion. In November of critical years, releases from storage to augment natural flows also occur. Figure B-78 shows average inflow flow through the Yolo Bypass.

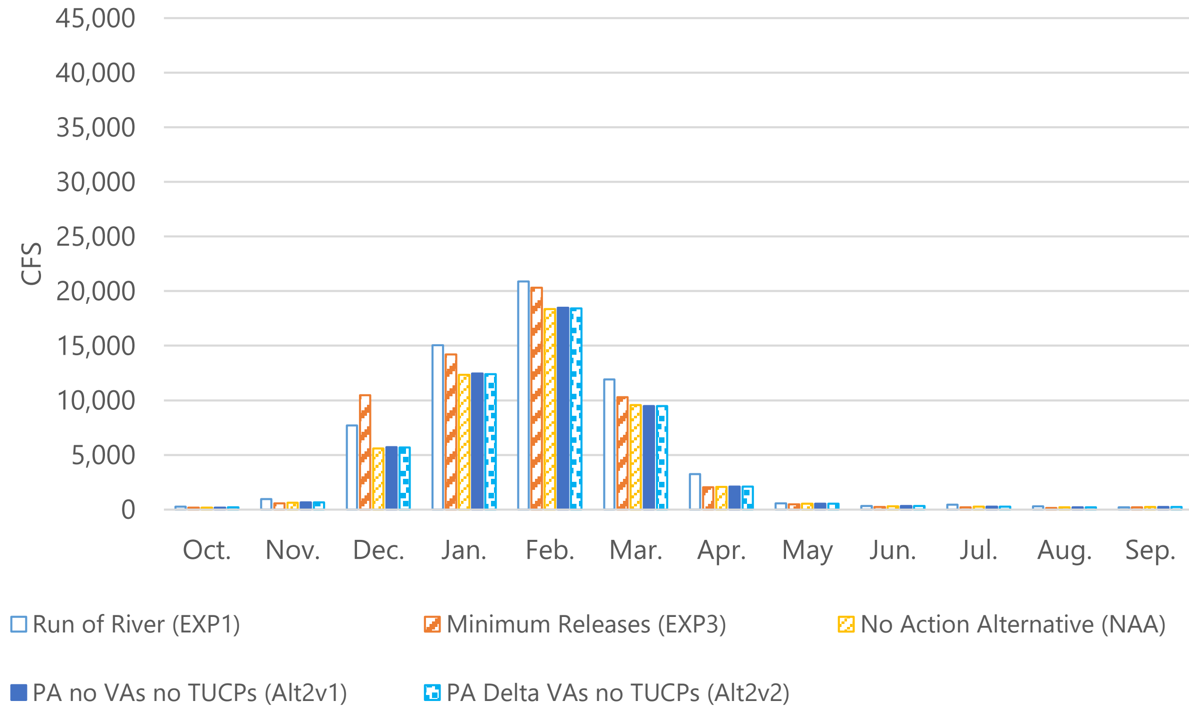


Figure B-78. Flow through Yolo Bypass Monthly Flows, All Water Year Types

Yolo Bypass inflows can occur in any year type but are more common in Above Normal and Wet Years. The Minimum Release, the No Action scenario and the Proposed Action phases include the proposed operation of the "Big Notch" on Fremont Weir. Figure B-79 shows inflow from the San Joaquin River at Vernalis.

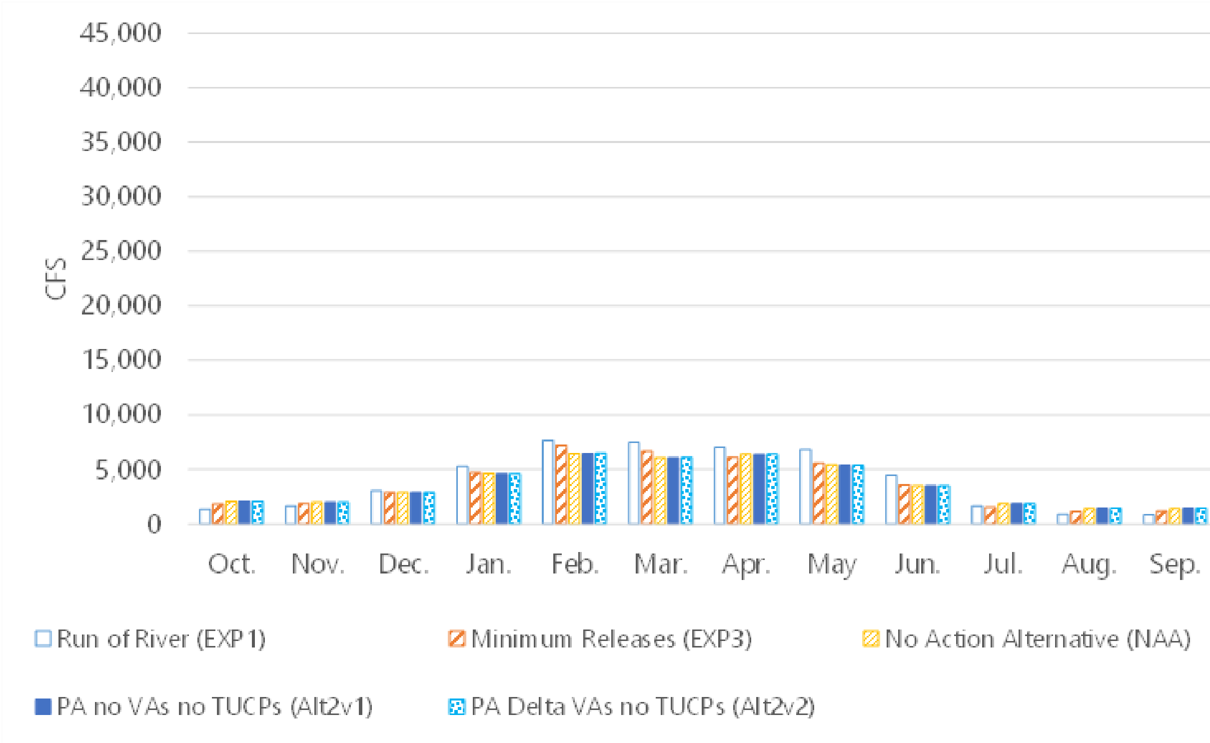


Figure B-79. San Joaquin River at Vernalis Monthly Flows, All Water Year Types

Wet year flows are nearly twice the flows in Below Normal years. Figure B-80 shows inflow from the Mokelumne River.

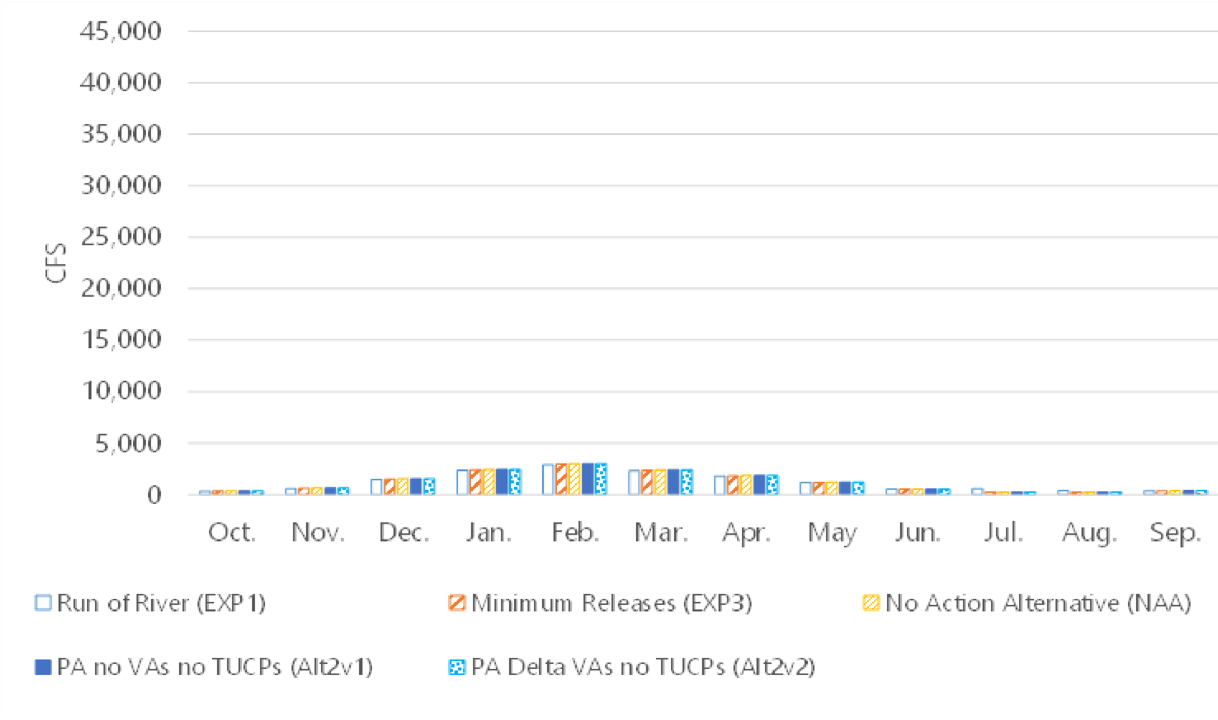


Figure B-80. Mokelumne River Monthly Flows, All Water Year Types

Flows are identical between scenarios because the Mokelumne is not a CVP nor SWP stream. Figure B-81 shows combined flow on Old and Middle Rivers.

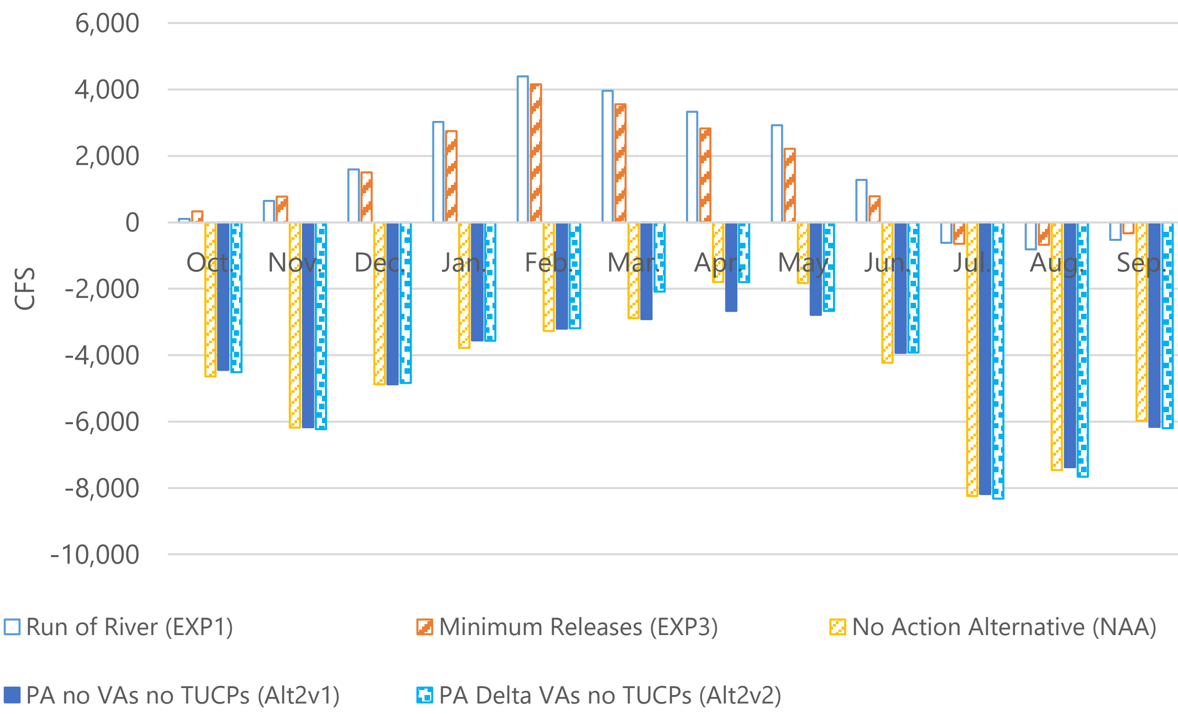


Figure B-81. Old and Middle River Combined Monthly Flows, All Water Year Types

The Run of River scenario shows that OMR can be negative in the summer months even without exports due to non-project in-Delta diversions. Figure B-82 shows the resulting Delta outflow.

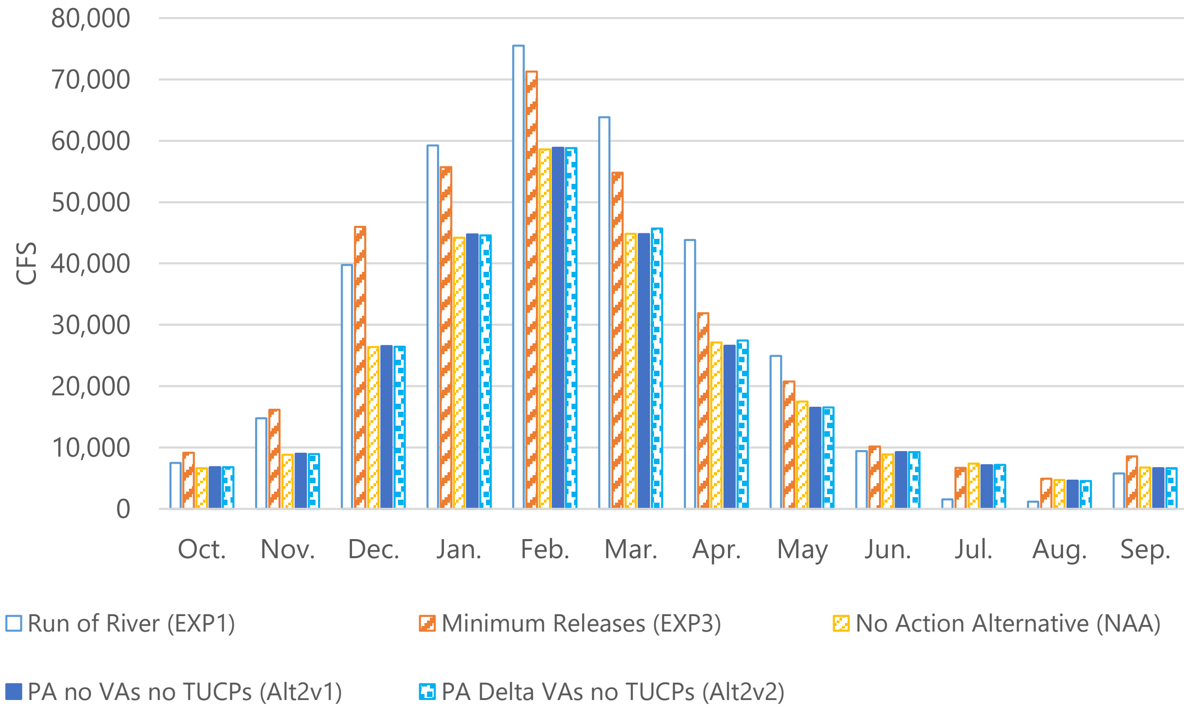


Figure B-82. Delta Monthly Outflow, All Water Year Types

Operation of the CVP and SWP reduces Delta outflow on average by 20% to 40% in the spring through storing water in upstream reservoirs and through exports. In the fall, Delta outflow with Proposed Action Alternative is approximately one half compared to the Run of River scenario. ESA requirements increase Delta outflow from December through May above D-1641.

Figure B-83 shows peak annual flows (monthly average) at Freeport. Flows at Freeport are correlated with Sacramento origin salmonid survival; however, increasing flows from the CVP and SWP would require more releases from upstream reservoirs and less storage cold water for water temperature management.

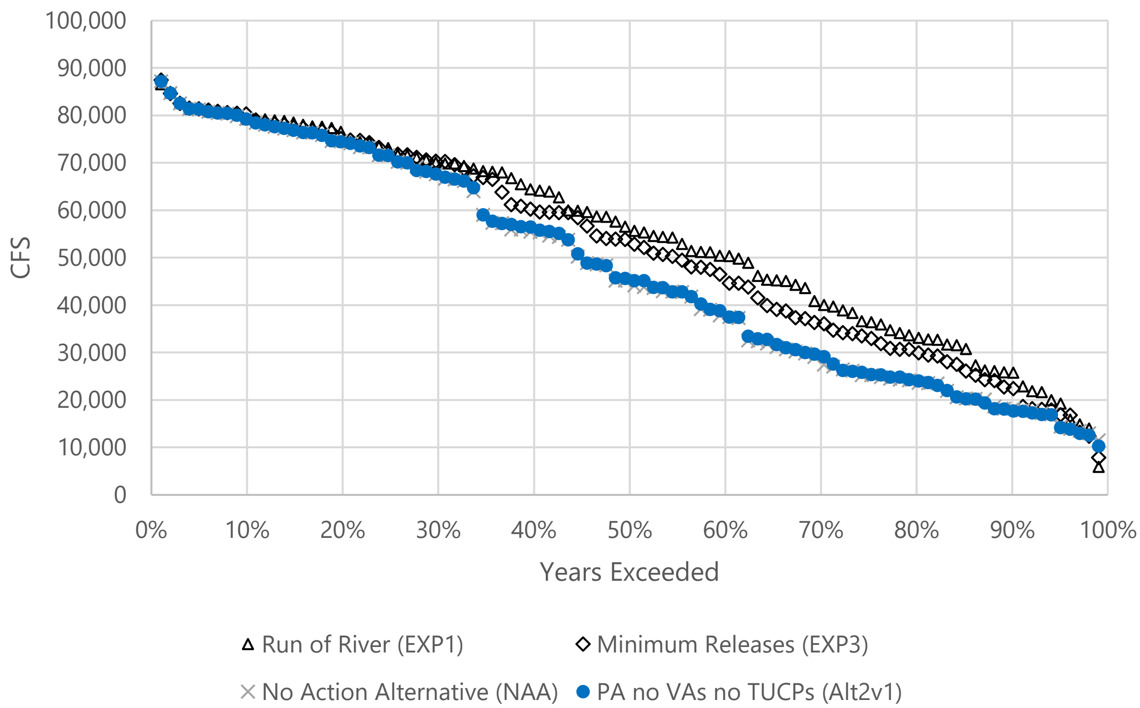


Figure B-83. Sacramento River at Freeport Annual Peak Flow Frequency

Figure B-84 shows peak annual flows (monthly average) at Vernalis. Flows at Vernalis are correlated with San Joaquin origin salmonid survival.

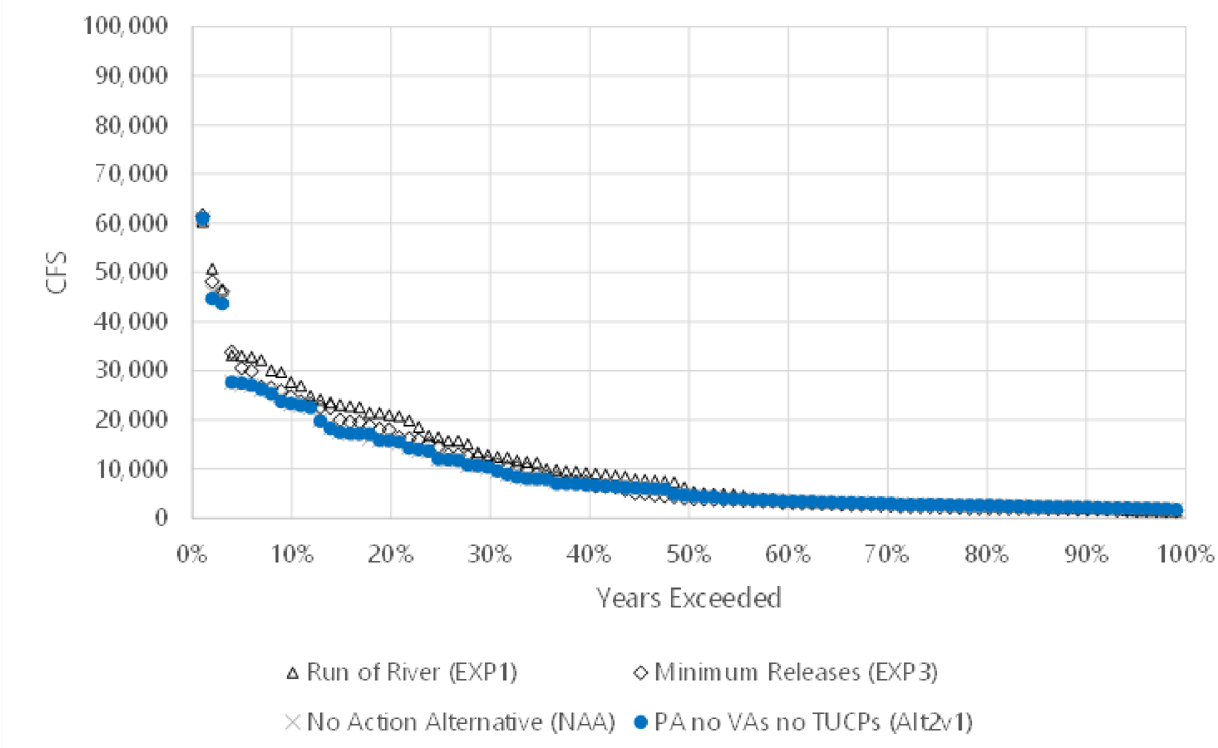


Figure B-84. San Joaquin River at Vernalis Annual Peak Flow Frequency

Changes in peak are a combination storage in Millerton Reservoir and New Melones Reservoir. The Run of River scenario includes CVP non-project operations on the Tuolumne and Merced Rivers.

B.8.2 Water Temperatures and Dissolved Oxygen

Water temperatures in the Delta depend upon ambient air temperatures and mixing with colder ocean water from the San Francisco Bay. Temperatures above 71.6°F are believed to indicate Chinook salmon and steelhead are no longer successfully migrating through the Delta. Figure B-85 shows water temperatures at Prisoners Point along the San Joaquin River.

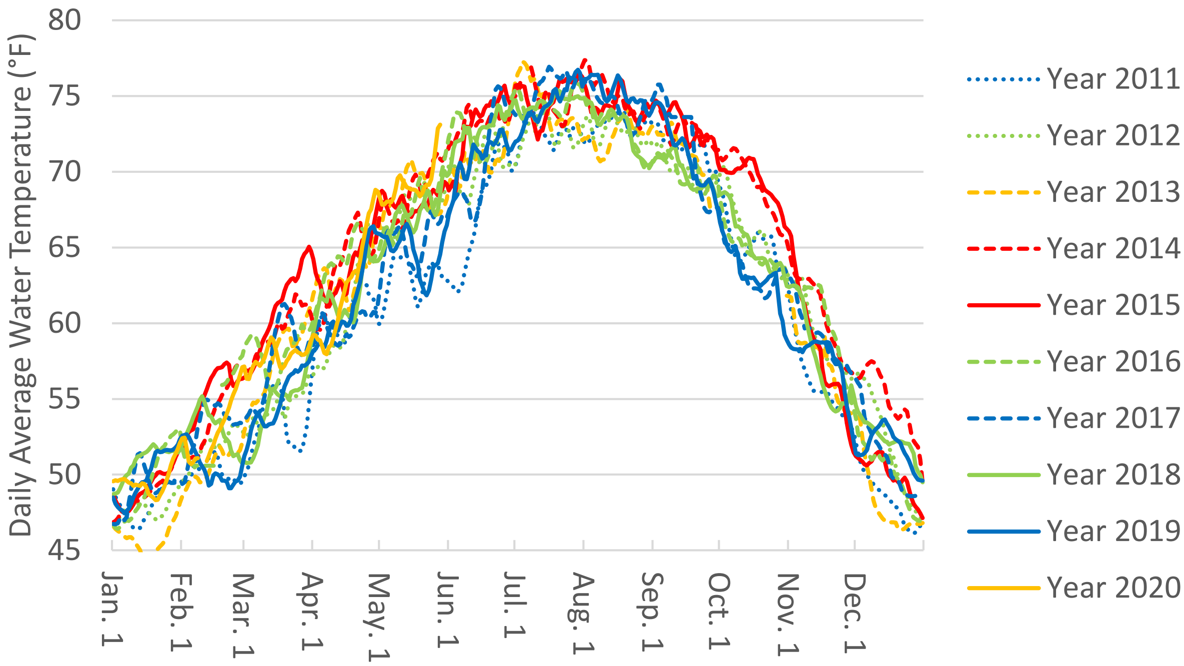


Figure B-85. Historical Water Temperatures at Prisoners Point (PRI)

Hourly water temperatures were downloaded from the California Data Exchange Center and averaged to obtain a daily value. Missing data was omitted from the average, and no processing occurred to address missing data or address outliers and potential instrumentation errors.

Delta smelt are most frequently found at temperatures less than 72°F but have been found at temperatures as warm as 77°F. Figure B-86 shows temperatures at Port Chicago, which is between Grizzly and Honker Bays, around 67 km from the Golden Gate Bridge.

Figure B-86 shows water temperatures at Port Chicago along the San Joaquin River.

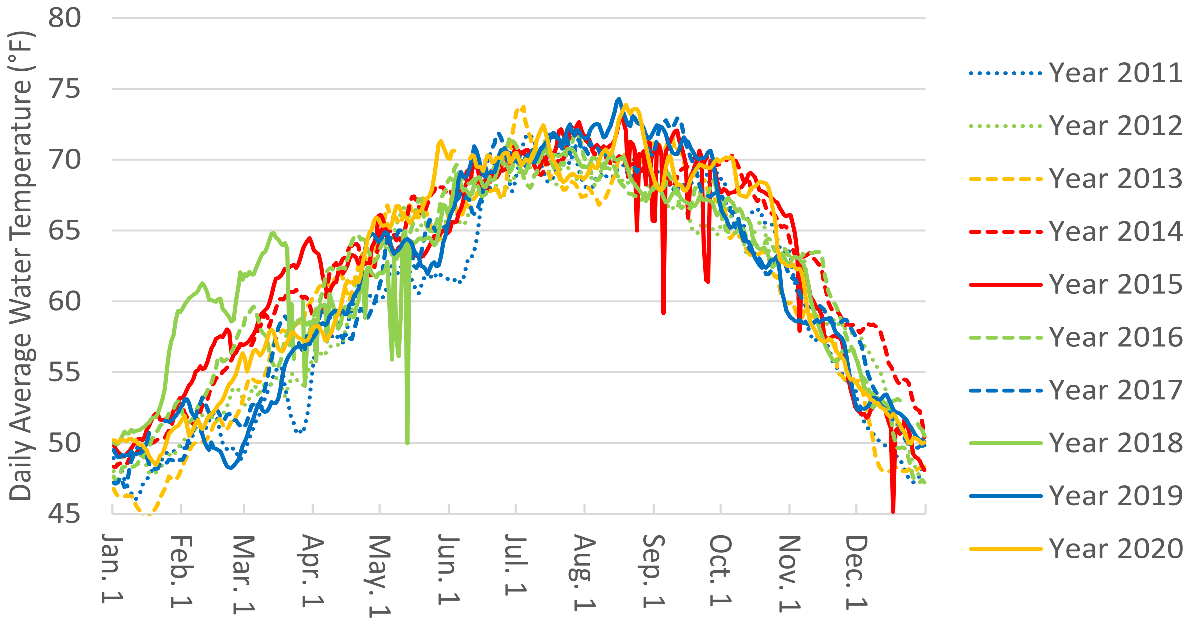


Figure B-86. Historical Water Temperatures at Port Chicago (PCT)

Figure B-87 shows the daily average water temperatures at Prisoners Point for water years 2007-2023.

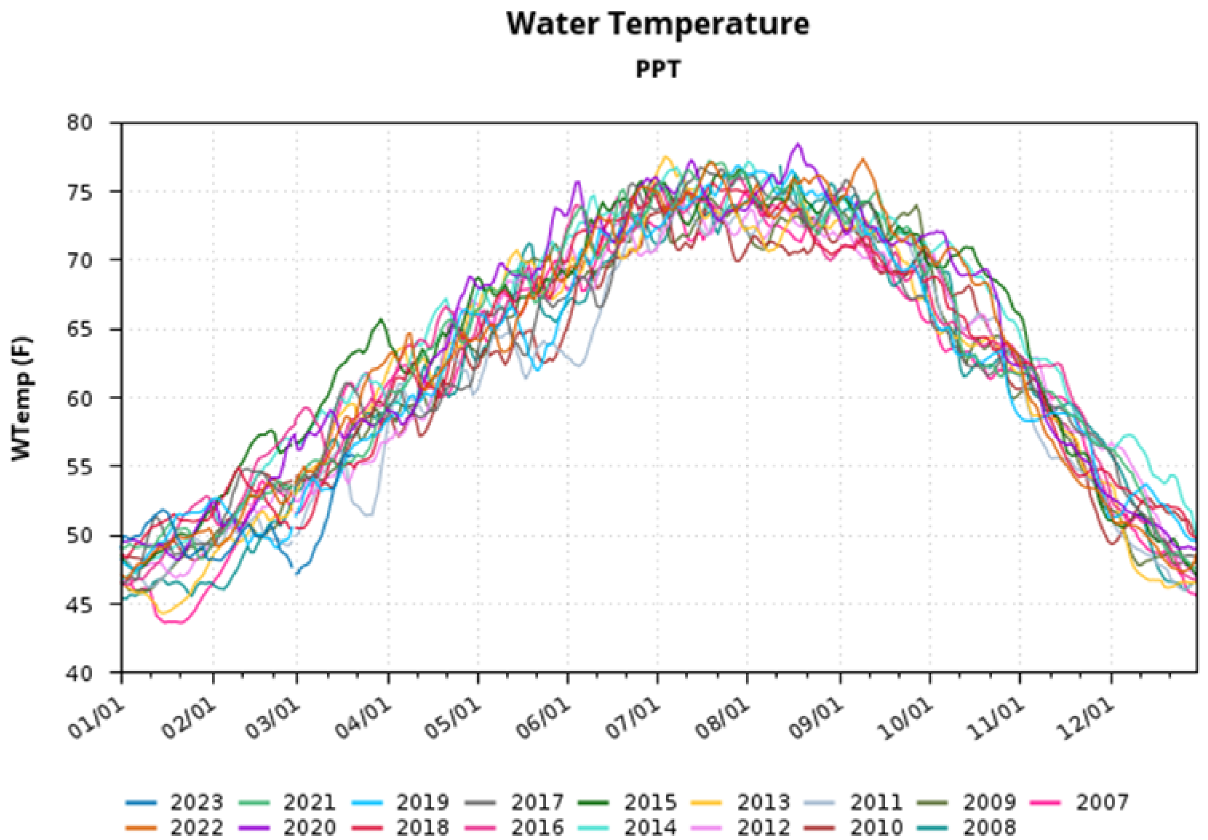


Figure B-87. Prisoners Point Daily Average Water Temperature (°F) for WY 2007-2023

Figure B-88 shows the daily average dissolved oxygen levels at Prisoners Point for water years 2013-2023.

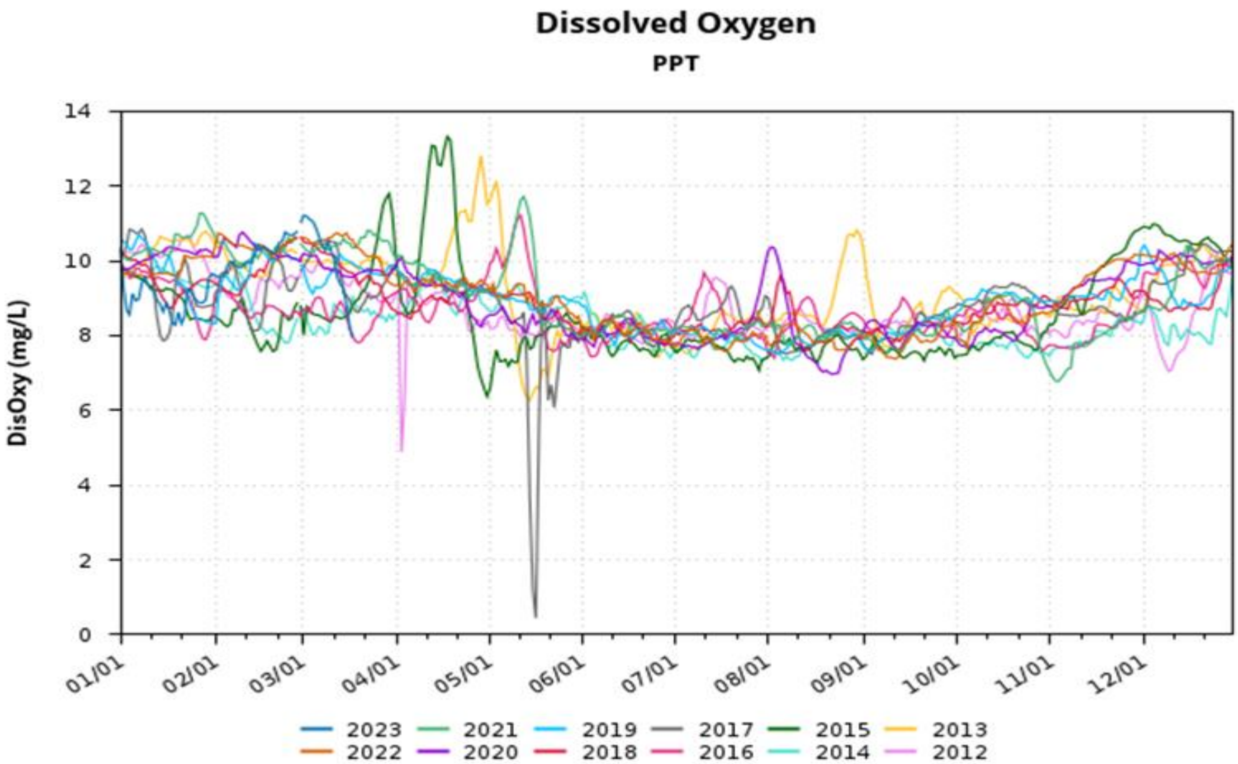


Figure B-88. Prisoners Point Daily Average Dissolved Oxygen (mg/L) for WY 2013-2023

Figure B-89 shows the daily average water temperatures on Old River at Franks Tract for water years 2009-2023.

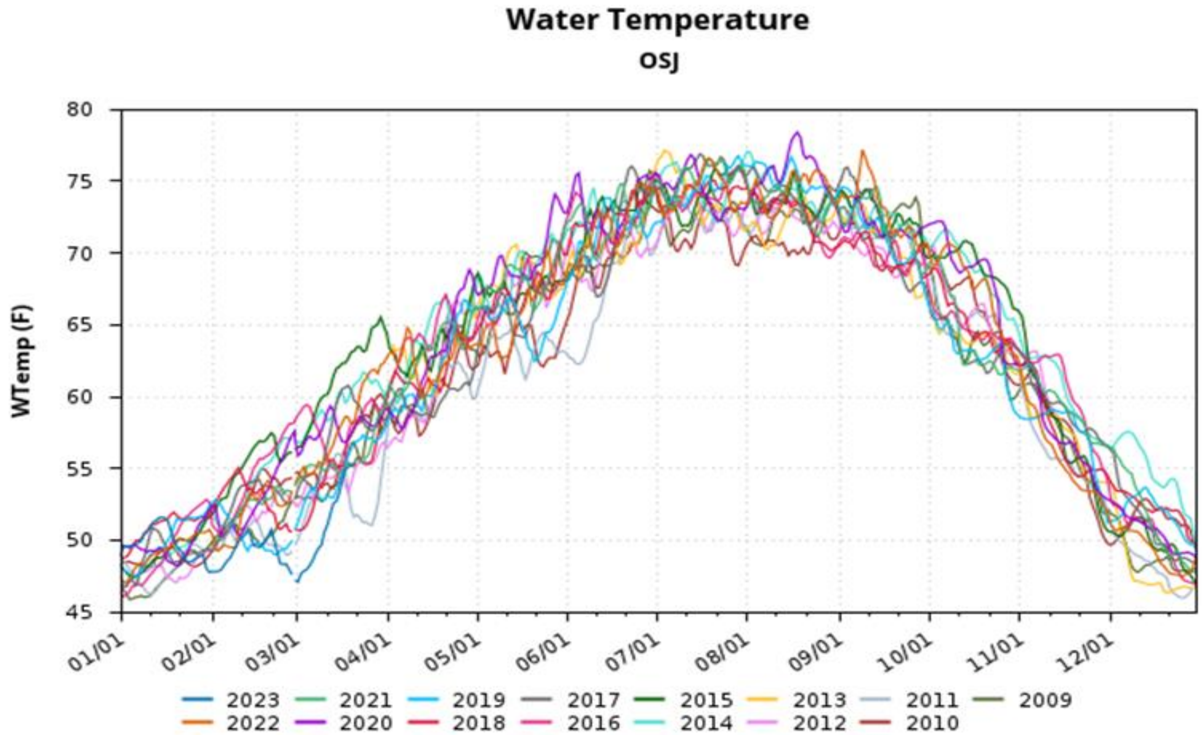


Figure B-89. Old River at Franks Tract Daily Average Water Temperature (°F) for WY 2009-2023

Figure B-90 shows the daily average dissolved oxygen levels on Old River at Franks Tract for water years 2014-2023.

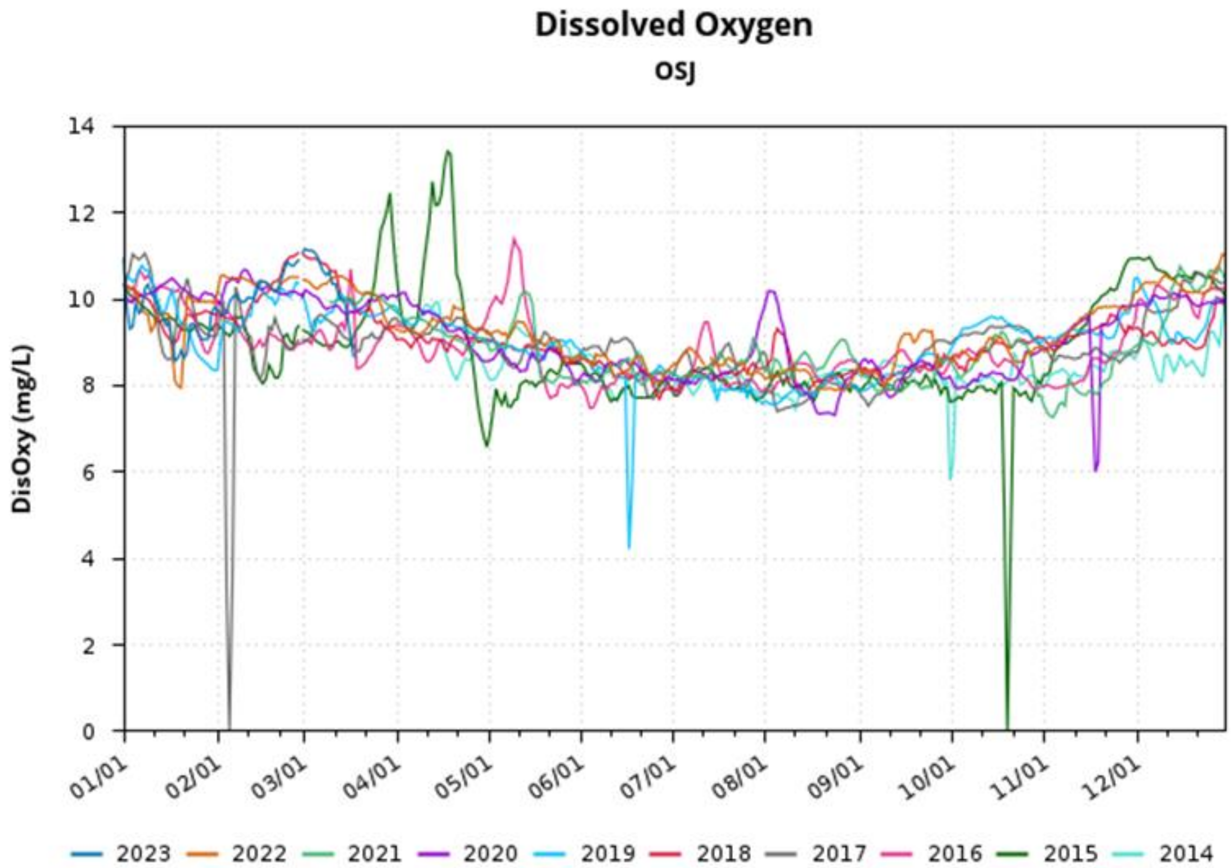


Figure B-90. Old River at Franks Track Daily Average Dissolved Oxygen (mg/L) for WY 2014-2023

B.8.3 Suitable Habitat

Chinook salmon, sturgeon, Delta smelt, and Longfin smelt all use the Delta for migration and rearing in the spring. The Delta is a tidal system with twice daily fluctuations in flows spanning +/- 150,000 cfs near the confluence with the Sacramento and the San Joaquin Rivers. Upstream regions experience less tidal influence.

The closer to the export facilities, the greater the influence of the export operations of the CVP and SWP. Modeling OMR conditions with and without exports identifies a zone of influence for regions where habitat is affected by exports. Figure B-91 shows an example for the month of March.

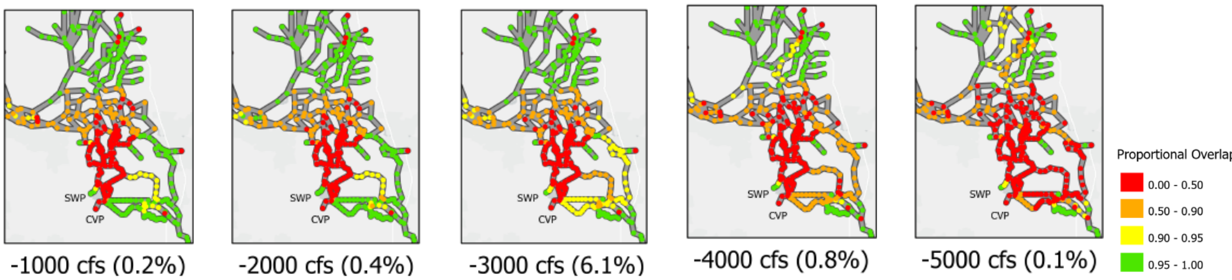


Figure B-91. No Action March Proportional Overlap with and without Exports

This extent of the zone increases with increased exports. For an OMR no more negative than -5,000 cfs, the zone of influence does not enter the northern Delta. Between an OMR of -3,000 cfs and -4,000 cfs, the zone of influence retreats west of the San Joaquin River at the Head of Old River. The zone includes all changes, including changes that result in increased outflow. Entrainment considers where the changes in velocities result in more velocities towards the pumps. The lower San Joaquin River and downstream of the confluence with the Sacramento River generally show increased outflow and reduced reverse flow that is in part governed by Delta inflows.

The location of X2 indicates the extent of low salinity zone habitat as a surrogate for Delta Smelt habitat. Figure B-92 shows the location of X2 under “Run of River (EXP1)”, “Minimum Release (EXP3)”, “No Action Alternative (NAA)”, “Proposed Action without VA no TUCP (ALT2 v1)”, and “Proposed Action with Delta VAs no TUCP (ALT2 v2)”

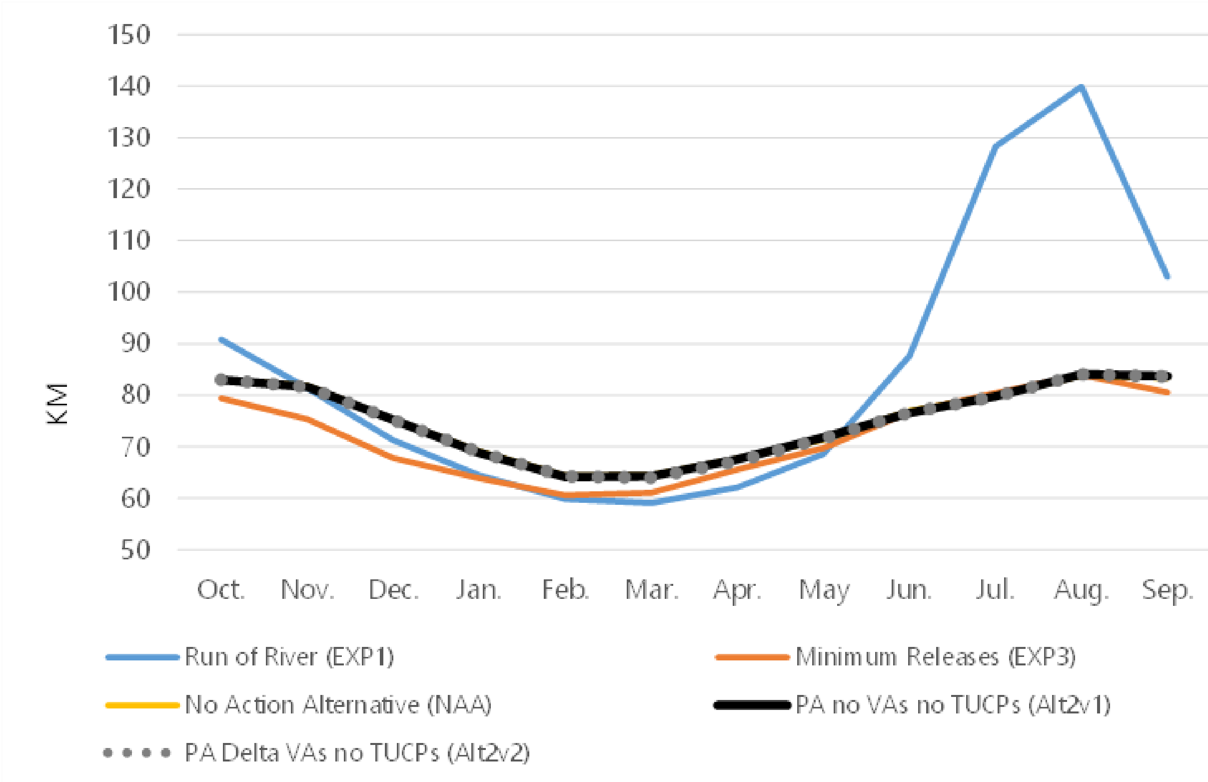


Figure B-92. Location of X2

Chipps Island, the downstream extent of the Delta is located at approximately 74 km and the end of Sherman Island (the confluence of Sacramento and San Joaquin Rivers) at approximately 86 km.

B.9 References

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U. S. Department of the Interior. 2000. Record of Decision: Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement/Environmental Impact Report. December 2000.