Long-Term Operation – Biological Assessment

Chapter 4 – Seasonal Operations

October 2024

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Contents

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Acronyms and Abbreviations

cfs	cubic feet per second
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
DSM2	Delta Simulation Model II
DWR	California Department of Water Resources
ESA	Endangered Species Act
mg/L	milligrams per liter
NAA	No Action Alternative
OMR	Old and Middle River
PSMFC	Pacific States Marine Fisheries Commission
Reclamation	Bureau of Reclamation
ROD	Record of Decision
SIT	Science Integration Team
SJRRP	San Joaquin River Restoration Program
Water Board	State Water Resources Control Board
SWP	State Water Project
TCD	Temperature Control Device
TUCP	Temporary Urgency Change Petition

Chapter 4 Seasonal Operations

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

The purpose of this chapter is to describe the range of environmental conditions from the discretionary operation of the CVP and SWP under the Proposed Action. Modeling of flow, water temperature, and physical habitat shows the potential consequence from hydrologic alteration by the Proposed Action and the conditions without the consequences caused by the Proposed Action. Appendix E, *Exploratory Modeling*, of the Initial Alternative Report developed operational scenarios by layering permits and programs on hydrology to evaluate the tradeoffs on the availability of water within a year and with subsequent years. The magnitude and trends of hydrologic alteration informs the deconstruction of the seasonal operation of the CVP and SWP. The modeling presented in this chapter supports the effect analysis of the Proposed Action that are provided in subsequent species-specific chapters.

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--San 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 (NAA): 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 NAA represents the current management direction of Reclamation and DWR, as required by the National Environmental Policy Act. The NAA includes some of the same elements of the Proposed Action and, thus, encompasses some of the effects of the current Proposed Action. Thus, the NAA is not appropriate for the environmental baseline condition but may inform analysis.
- Proposed Action Alternative: The operation of the CVP and SWP under the Proposed Action analyzed in the Effects Analysis chapters (5 through 12).

For each CVP watershed, analyses include:

- Water Operations: CalSim monthly average flows. Different trends in different water year types are narrated where they occur. Simulation of the seasonal operation relied upon CalSim 3 with 2022 median climate conditions.
- Water Temperatures: HEC-5Q with different temperature management strategies. 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 Delta Simulation Model II (DSM2) hydrodynamics and X2 salinity conditions.
- Unless otherwise noted, water year types are the 40-30-30 index. 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

+ 20% previous year's index

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

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

4.1 Sacramento River

Inflows to Shasta Reservoir come from the Sacramento, Pitt, and McCloud rivers. Figure 4-1 shows the inflow to Shasta Reservoir by month and water year type.

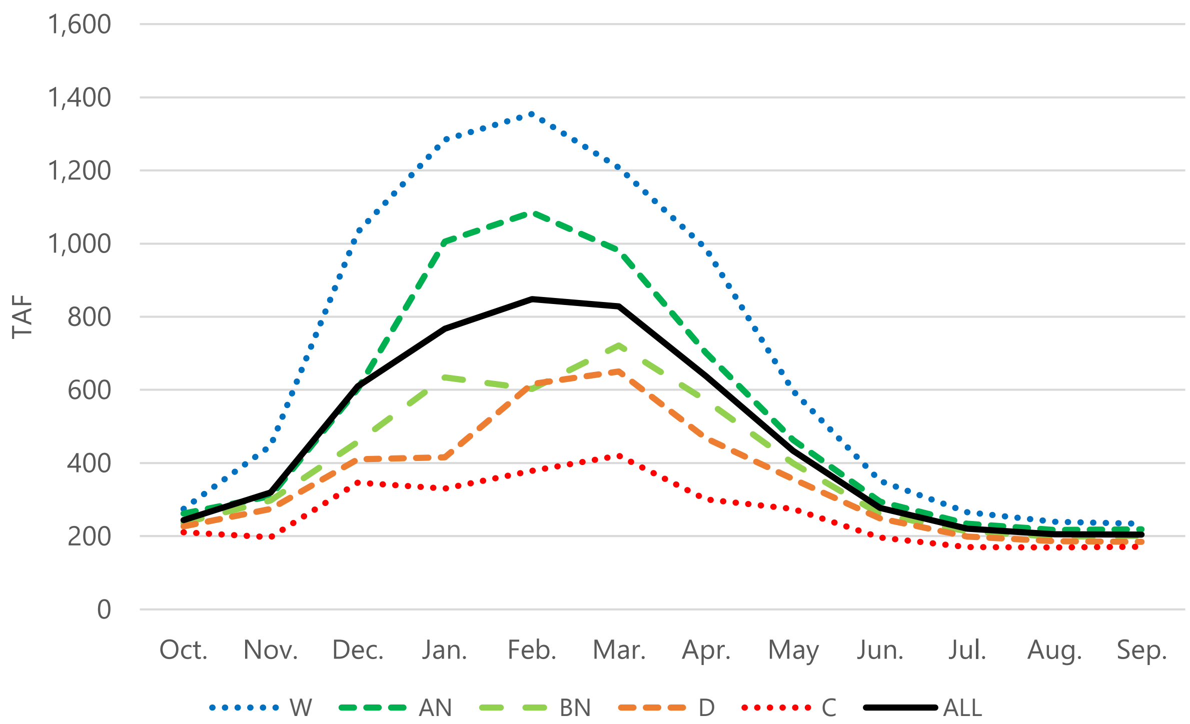


Figure 4-1. Inflow to Shasta Reservoir by Month and Water Year Type

Releases from Shasta Reservoir and imports from the Trinity River Basin flow into Keswick Reservoir, impounded by Keswick Dam. Figure 4-2 shows a simplified hydrologic topology for the Sacramento River from Keswick Dam to the Delta.

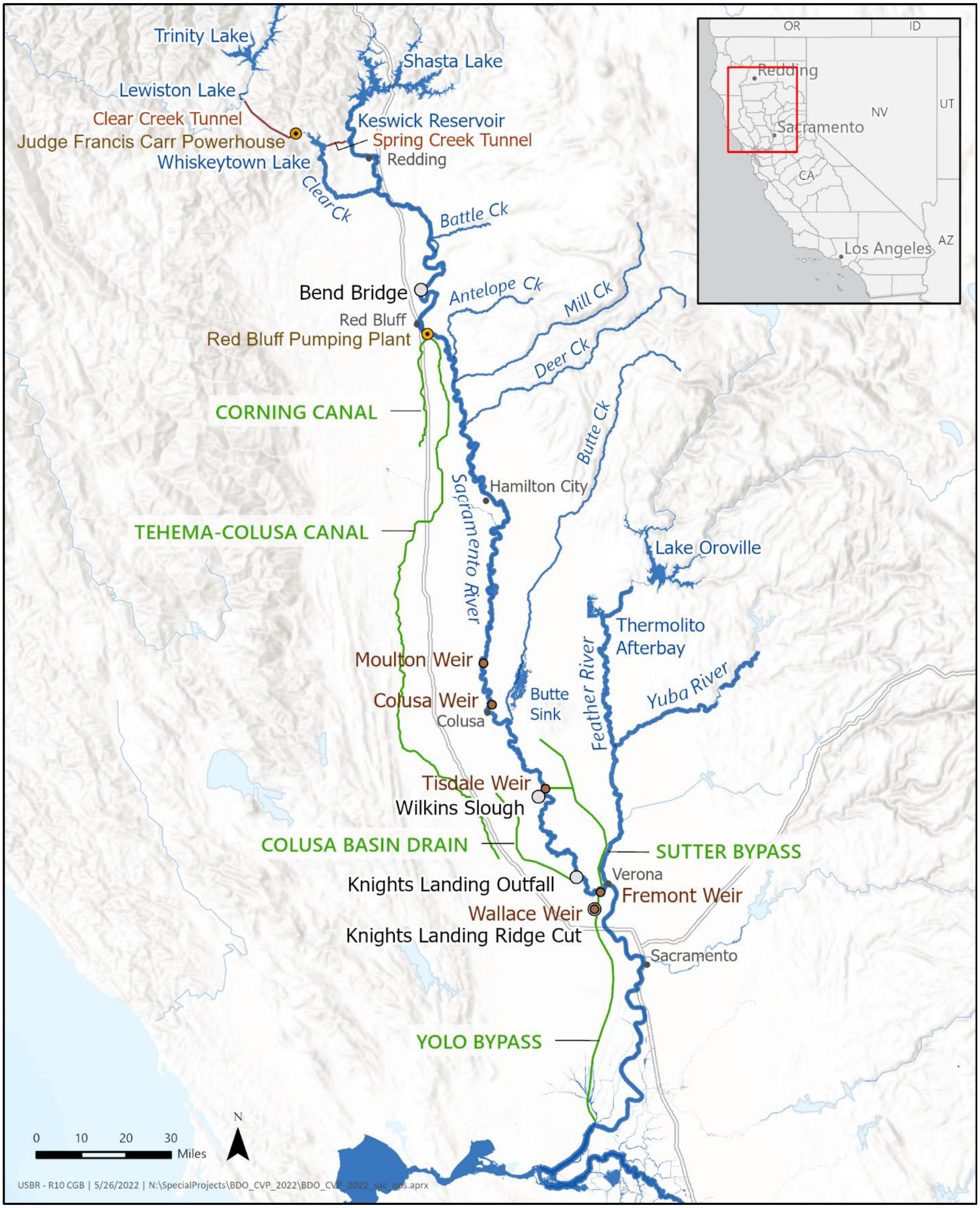


Figure 4-2. Sacramento River Watershed Water Operations Topology

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

4.1.1 Water Operations

Figure 4-3 shows release from Keswick Dam for the Run of River (EXP1), Minimum Release (EXP3), NAA, Proposed Action no Voluntary Agreement (VA) and no Temporary Urgency Change Petition (TUCP) (Alt2 v1), and Proposed Action with Delta VAs and no TUCP (Alt2 v2) scenarios.

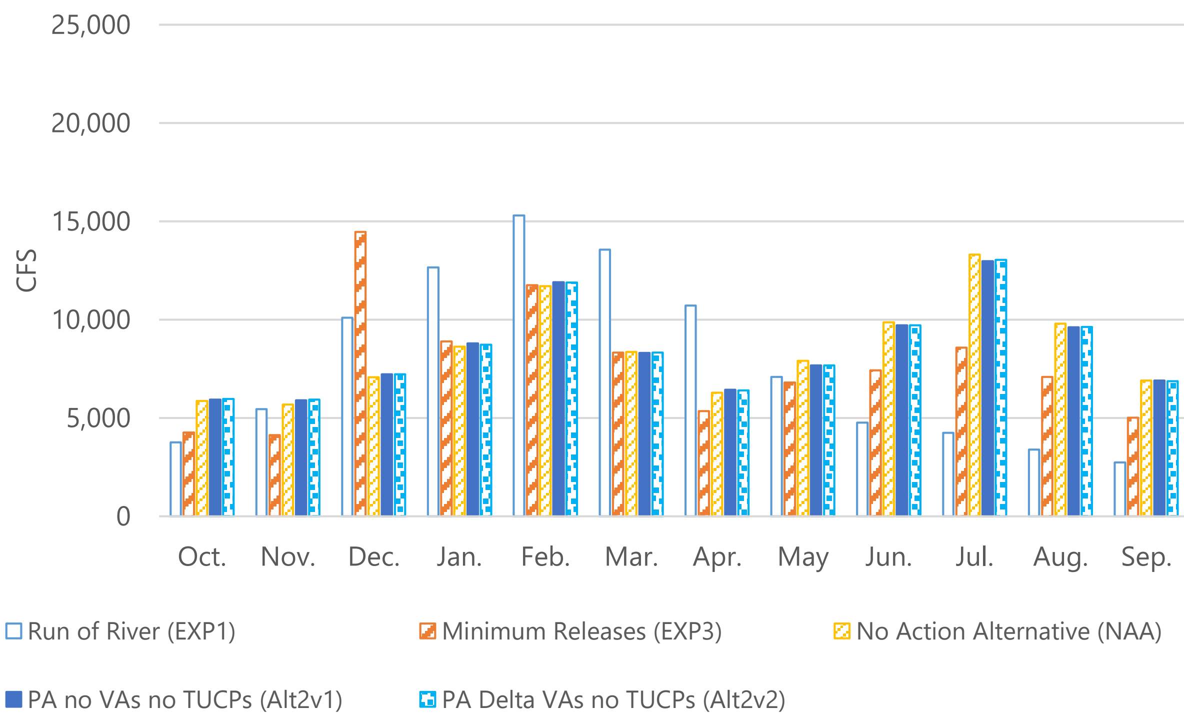


Figure 4-3. Sacramento River Flow below Keswick Dam Monthly Flows, All Water Year Types

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 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 4-4 shows 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.

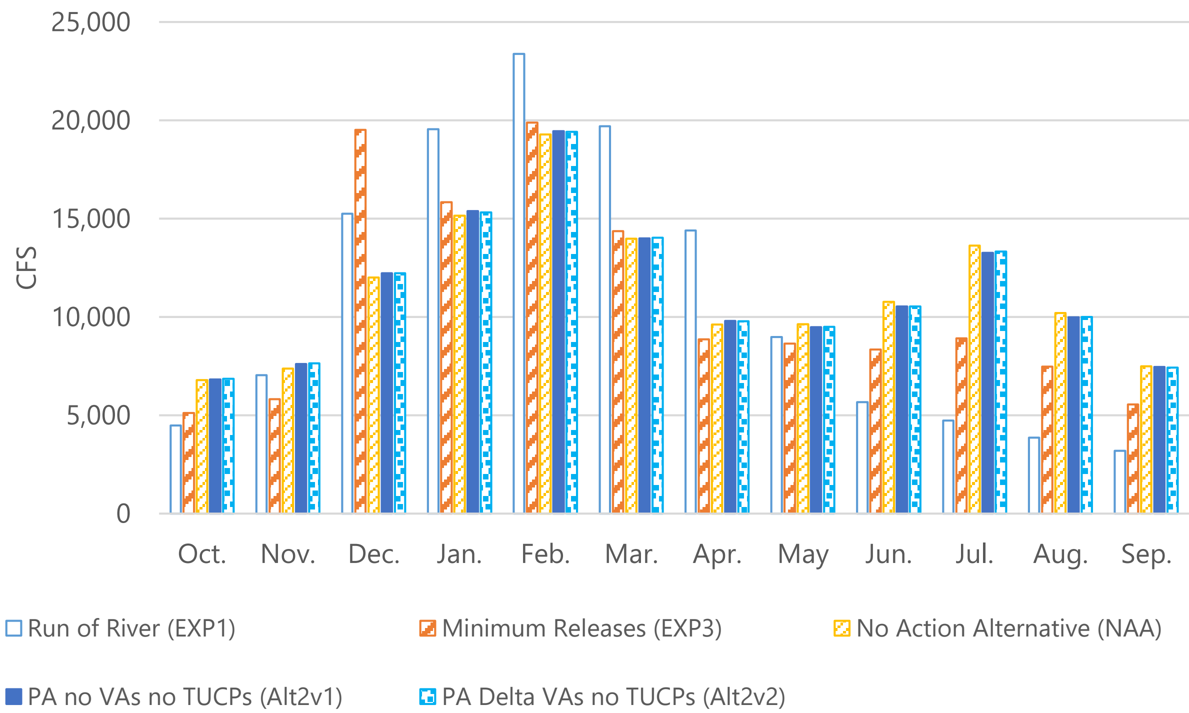


Figure 4-4. Sacramento River at Bend Bridge Monthly Flows, All Water Year Types

In reviewing by 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 4-5 shows flows at Wilkins Slough. Wilkins Slough is downstream of most diversions by Sacramento River refuge, settlement, and water service contractors.

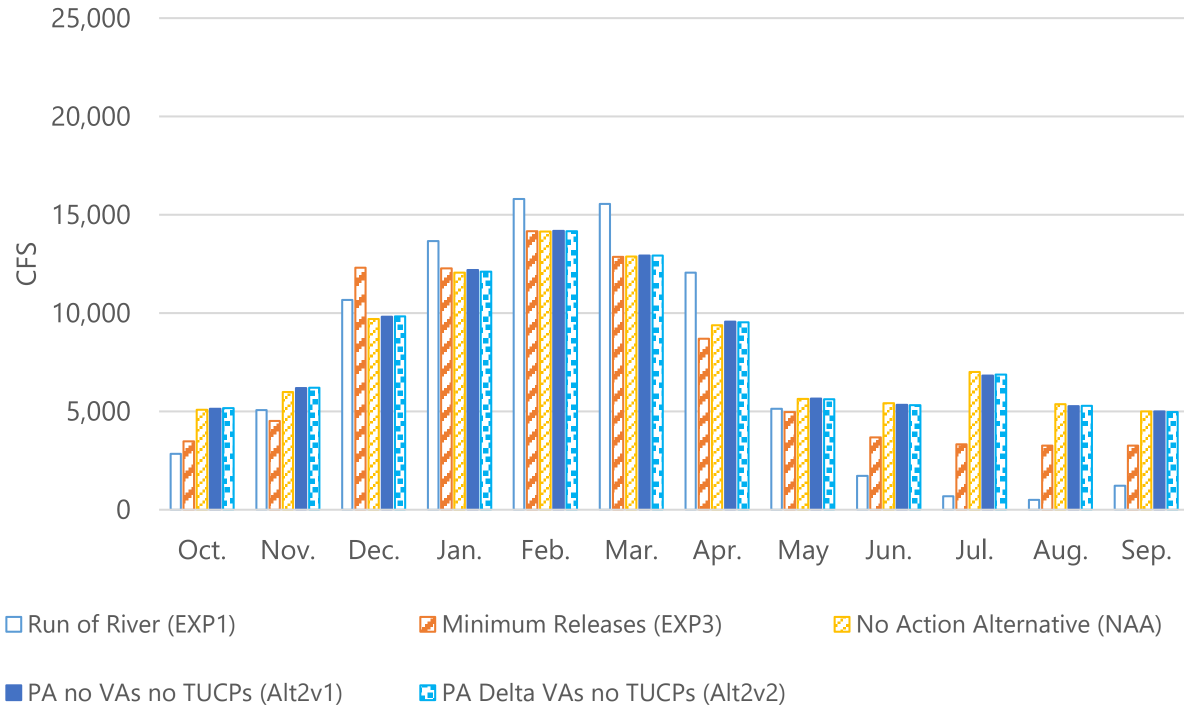


Figure 4-5. Sacramento River near Wilkins Slough Monthly Flows, All Water Year Types

The Run of the 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 cubic feet per second (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 the Proposed Action phases by year type, February flows in critical years are higher for No Action than for Minimum Release. In comparing the five scenarios by year type, September flows in wet years are higher for the Proposed Action phases 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 4-6 shows peak annual flows (monthly average) at Bend Bridge, which is above flood diversions into the Sutter Bypass.

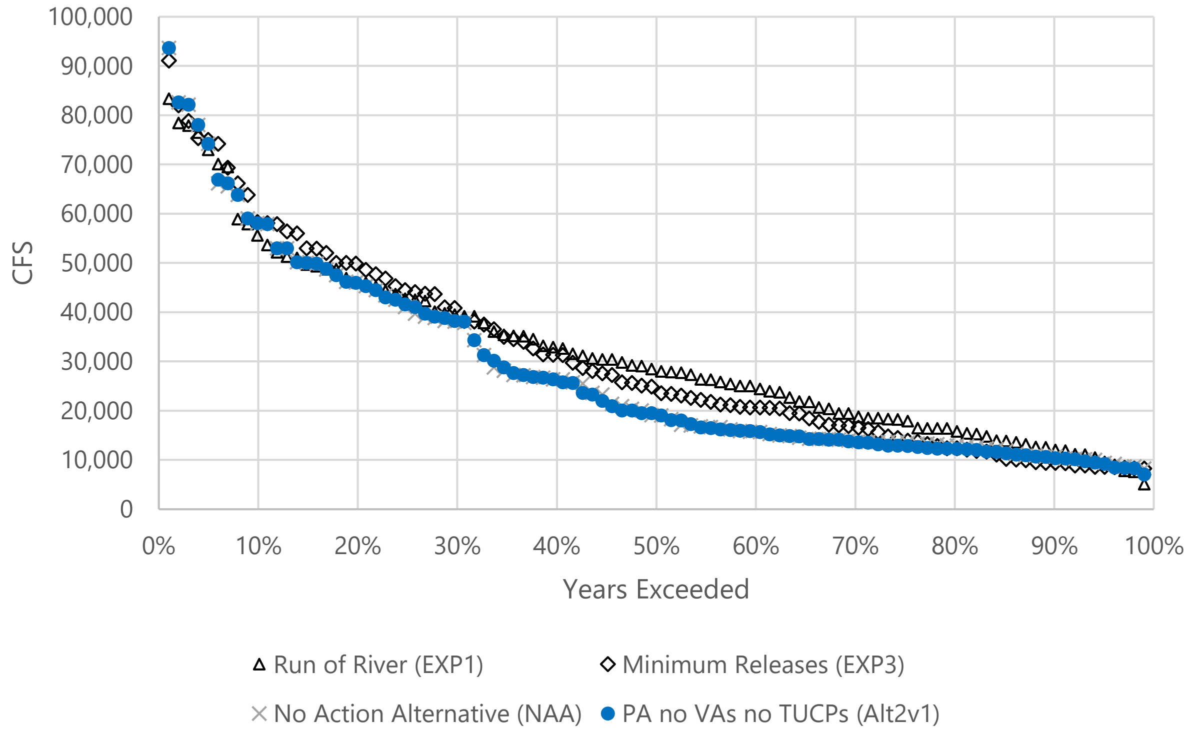


Figure 4-6. Sacramento River at Bend Bridge Annual Peak Flow Frequency

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 phases 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 4-7 shows peak flows at Wilkins Slough, below diversions into the Sutter Bypass.

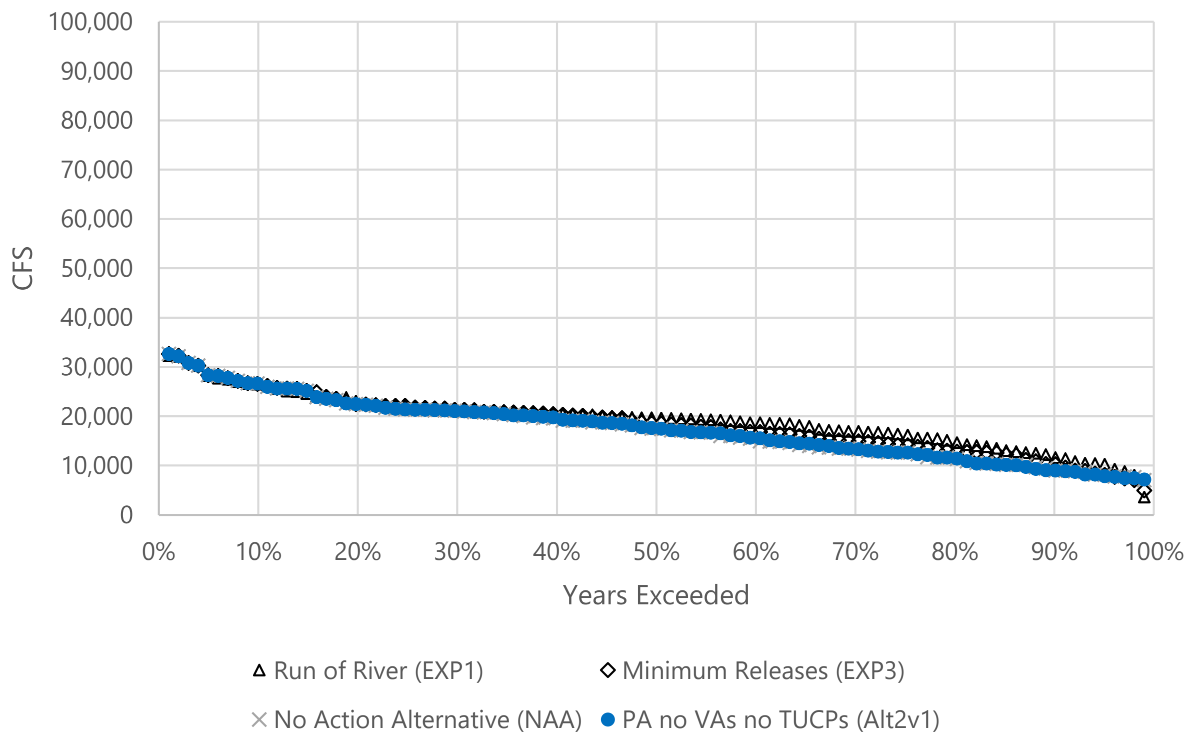


Figure 4-7. Sacramento River near Wilkins Slough Annual Peak Flow Frequency

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 4.6, *Delta*. Figure 4-8 shows Sacramento River flows at Verona.

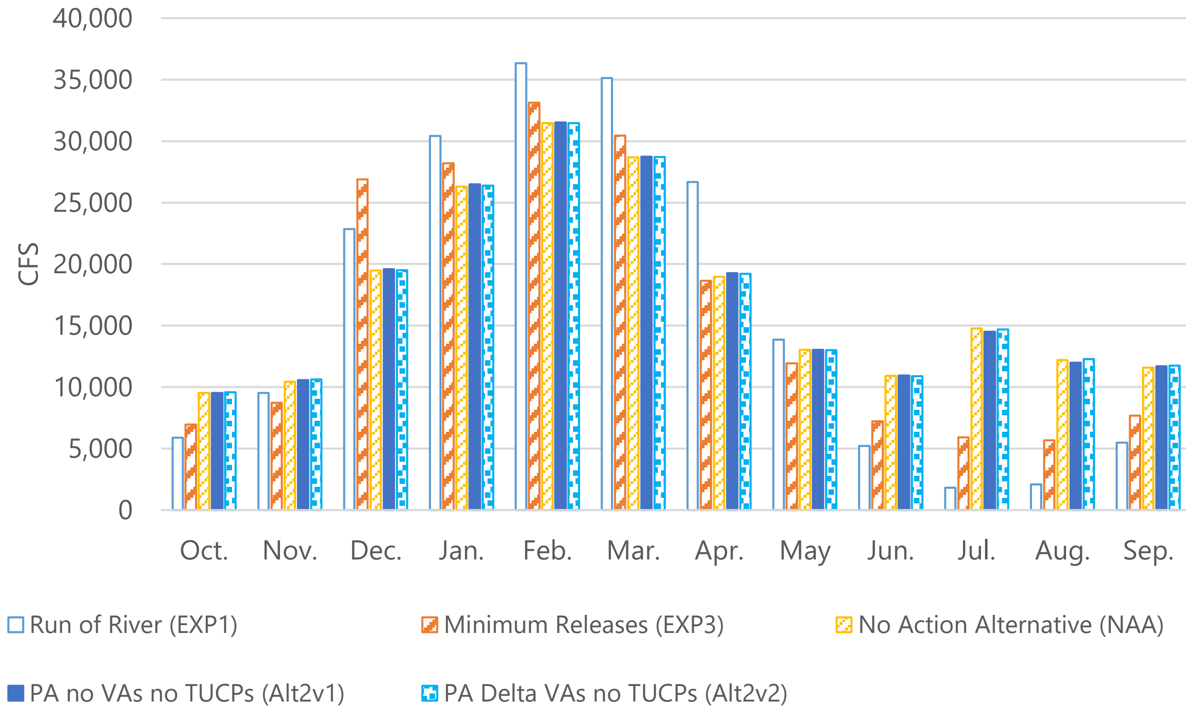


Figure 4-8. Sacramento River at Verona Monthly Flows, All Water Year Types

In comparing the five scenarios by year type, August flows in critical years are higher for the Proposed Action phases than Minimum Release. Also, August flows in wet years are higher for the Proposed Action phases than Minimum Release. In September, flows in below normal years are higher for the Proposed Action phases than Minimum Release. Flows below Verona are joined with flows from the American River and discussed in Section 4.6.

4.1.2 Water Temperatures and Dissolved Oxygen

Reclamation operates a Temperature Control Device (TCD) on Shasta Dam primarily for the protection of winter-run Chinook salmon during egg incubation in the summer. Under State Water Resources Control Board (Water Board) Order 90-5, Reclamation must meet 56°F at Red Bluff Diversion Dam unless:(1) daily average water 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 water 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 4-9 shows historical water temperature compliance locations.

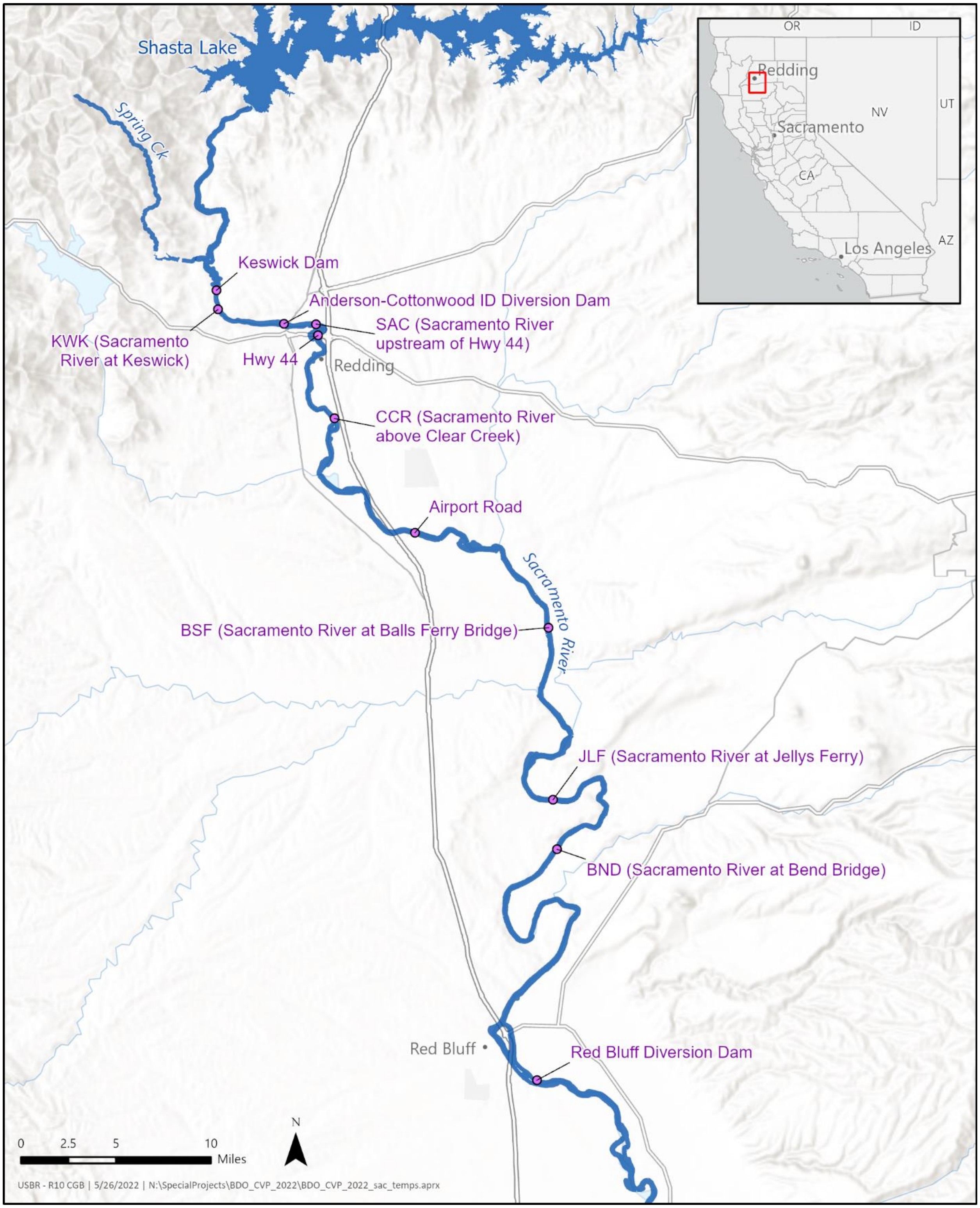


Figure 4-9. Historical Water Temperature Compliance Locations Used under Order 90-5

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. Water Temperature scenarios used the 2022 median climate change meteorology for the following scenarios:

- Run of River (EXP1): Water temperatures released from Shasta Dam 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 TCD is operated according 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 (NAA): The reservoir and flow conditions from the NAA 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 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 4-10 shows monthly average of water temperatures below Red Bluff Diversion Dam averaged across all water year types.

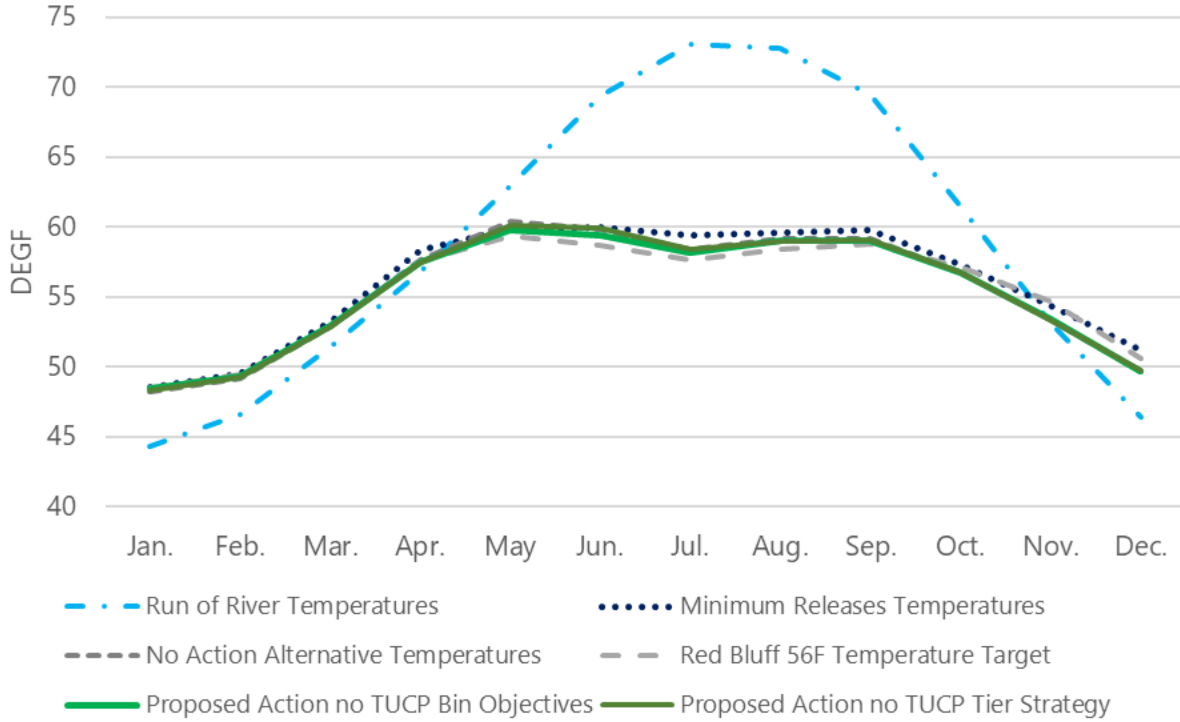


Figure 4-10. Sacramento River Water Temperatures below Red Bluff Diversion Dam, All Water Year Types

Run of the River temperatures in the Sacramento River follow a sinusoidal pattern in which water temperatures are low in the winter and high in the summer (August). Water 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 coldwater pool is limited, the Tiered strategy provides warmer waters earlier in the temperature management season to delay depletion of the coldwater 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 coldwater pool in Shasta Reservoir.

Figure 4-11 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.

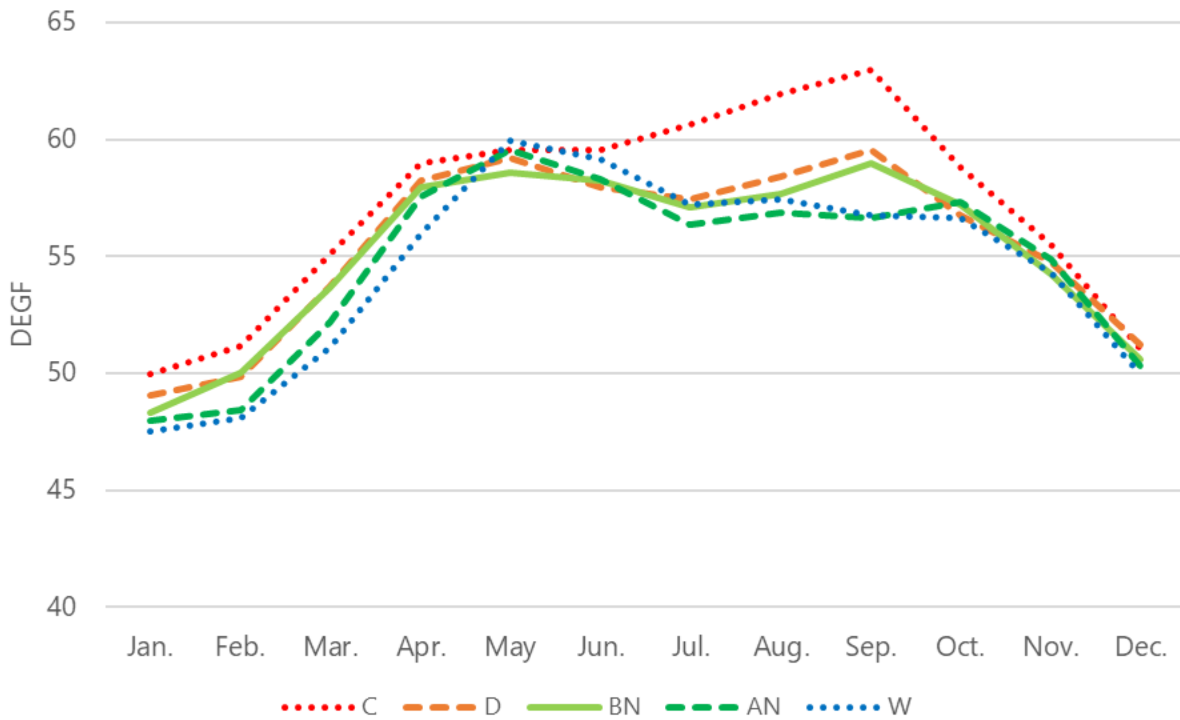


Figure 4-11. Sacramento River Water Temperatures below Red Bluff Diversion Dam when Targeting 56°F at Red Bluff Diversion Dam by Water Year Type

Critical and Dry years may deplete the cold-water pool by June or July. Figure 4-12 shows the water temperatures below Clear Creek for the same scenario.

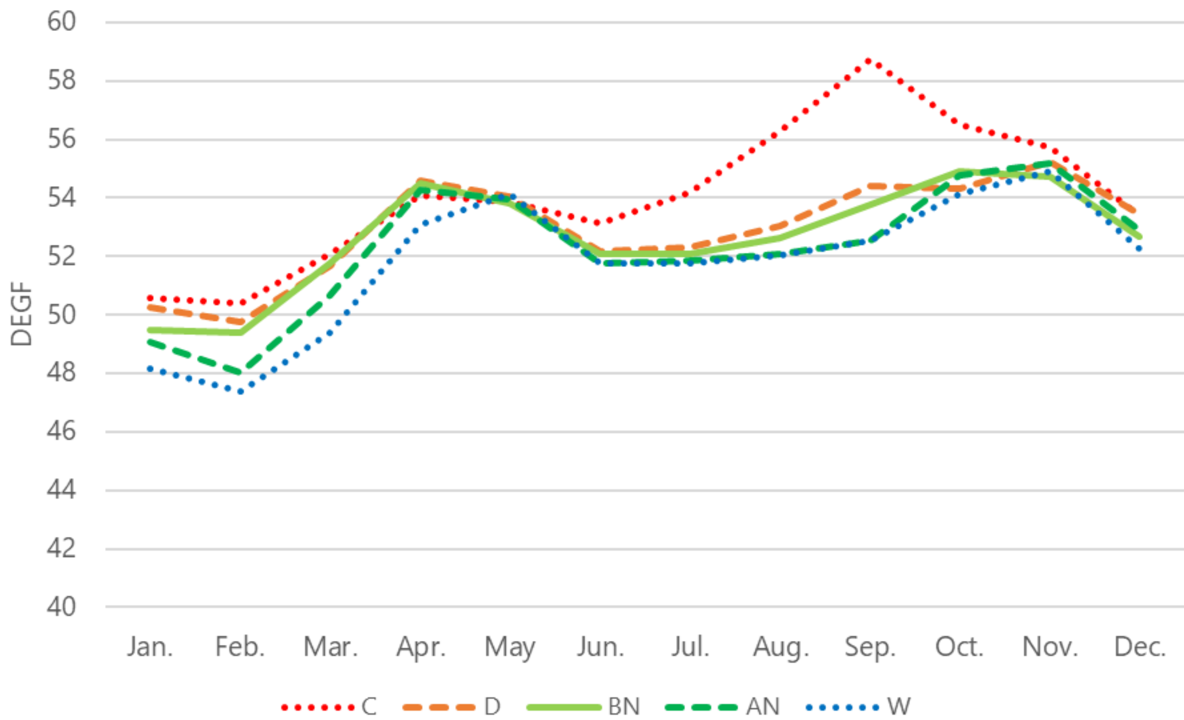


Figure 4-12. Sacramento River Water Temperatures Below Clear Creek when Targeting 56°F at Red Bluff Diversion Dam by Water Year Type

Temperatures may approach or exceed 56°F in September and October of Critical, Dry, and Below Normal years. Figure 4-13 shows temperature below Clear Creek under the Proposed Action following the objectives identified in the Shasta management framework bins.

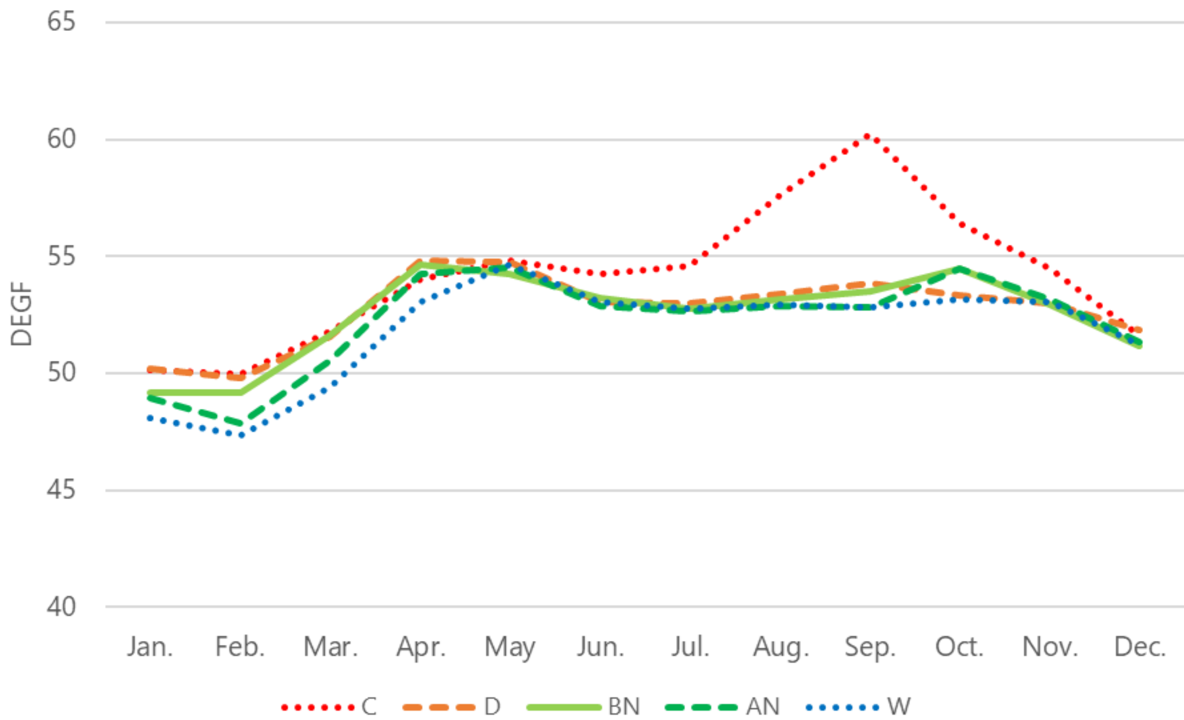


Figure 4-13. Sacramento River Water Temperatures Below Clear Creek under the Proposed Action Bin Objectives by Water Year Type

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 4-14 show the application of the tiered strategy to reduce temperatures during critical egg incubation stage when the most redds are present.

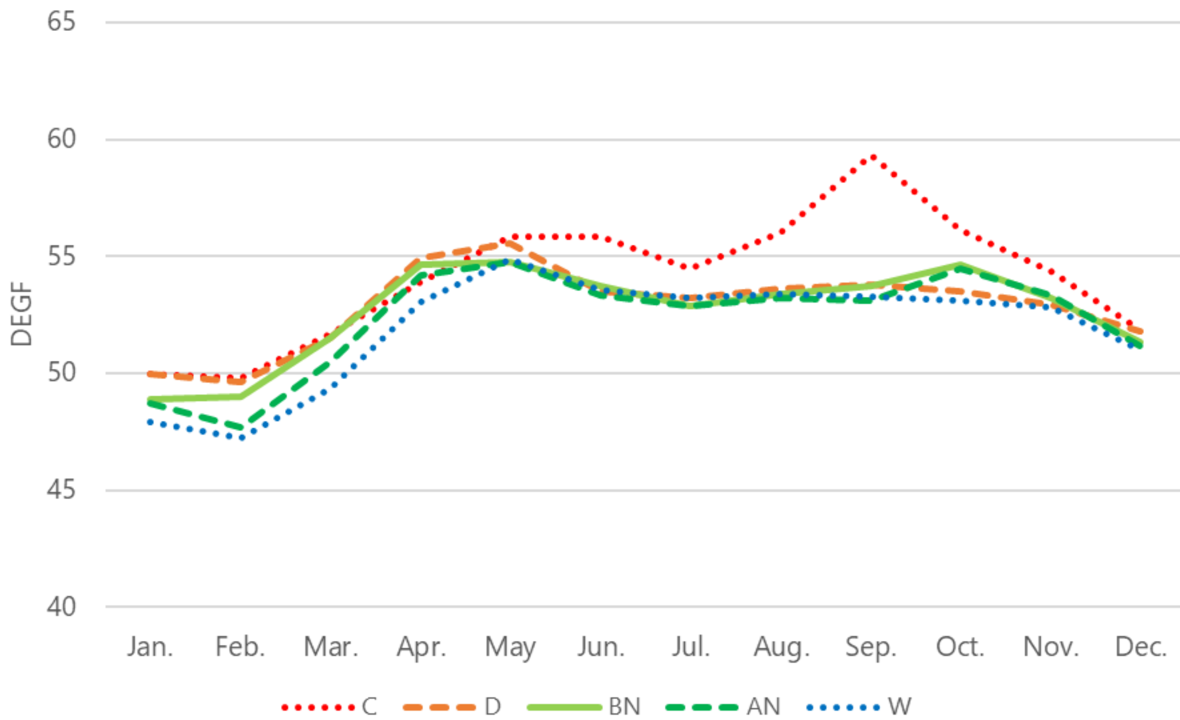


Figure 4-14. Sacramento River Water Temperatures Below Clear Creek under the Proposed Action with the Tiered Strategy by Water Year Type

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 cold-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 coldwater pool; however, the actual coldwater pool within a year type classification can vary significantly.

Figure 4-15 shows historical water temperatures on the Sacramento River at Bend Bridge and Figure 4-16 shows dissolved oxygen.

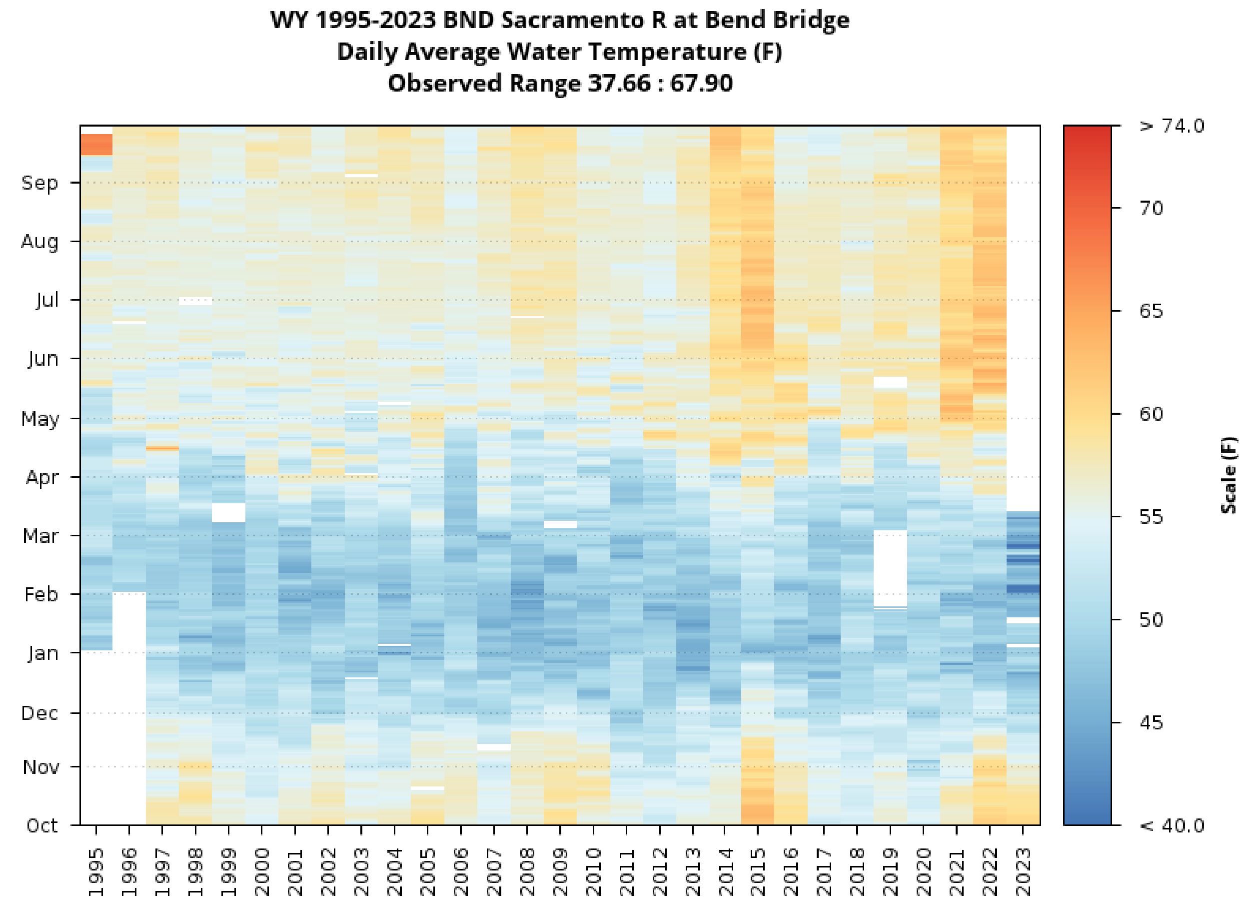


Figure 4-15. Sacramento River at Bend Bridge Daily Average Water Temperature (°F) for Water Years 1995–2023

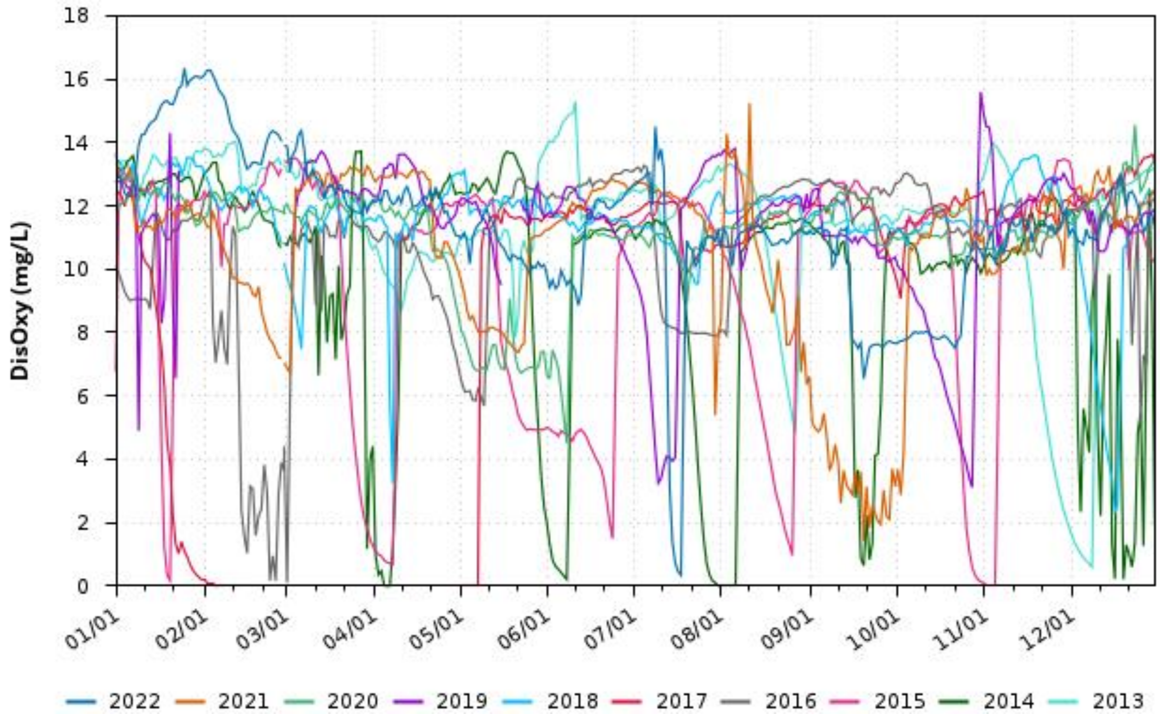
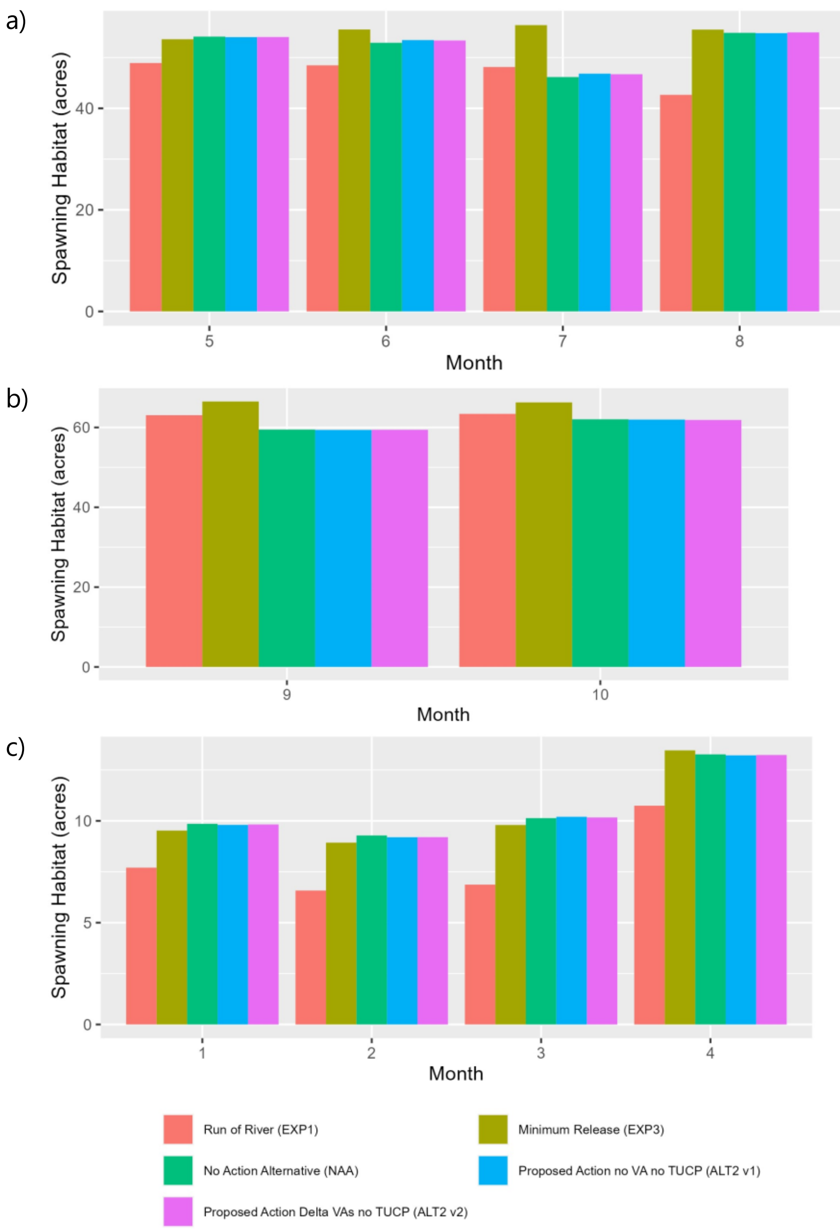


Figure 4-16. Sacramento River at Bend Bridge Daily Average Dissolved Oxygen (mg/L) for Water Years 2013–2022

4.1.3 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 D, *Seasonal Operations Deconstruction*). The upper Sacramento River encompasses the region from Keswick Dam (River Mile 302) to Red Bluff Diversion Dam (River Mile 244) (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 (Figure 4-17). 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 Appendix O, *Tributary Habitat Restoration*, Attachment O.2, *SIT LCM Habitat Modeling*). 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.

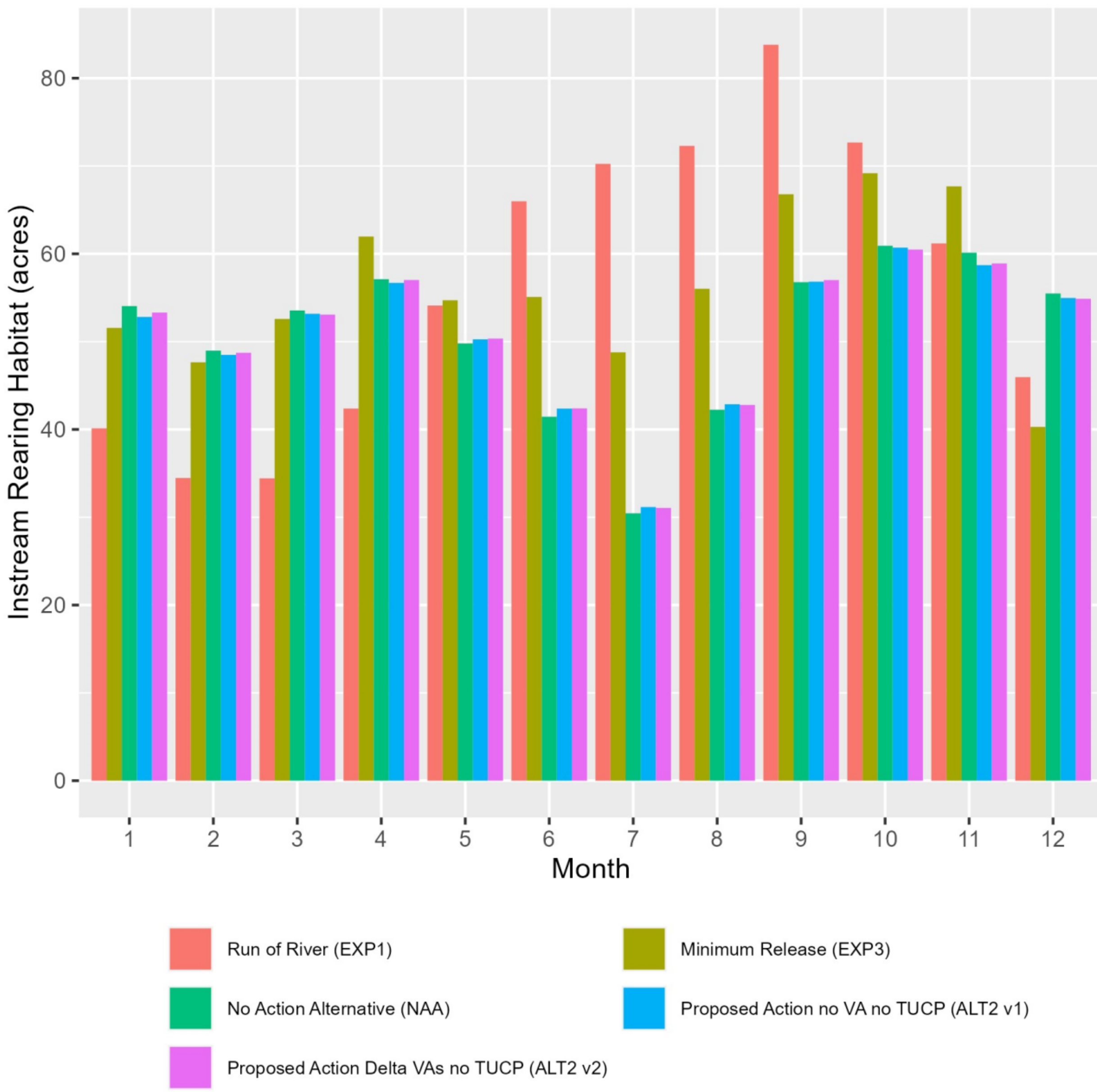


Values represent means across CalSim Water Years.

Figure 4-17. Estimated spawning habitat area for adult winter-run Chinook salmon (a), spring-run Chinook salmon (b), and steelhead (c) in the upper Sacramento River

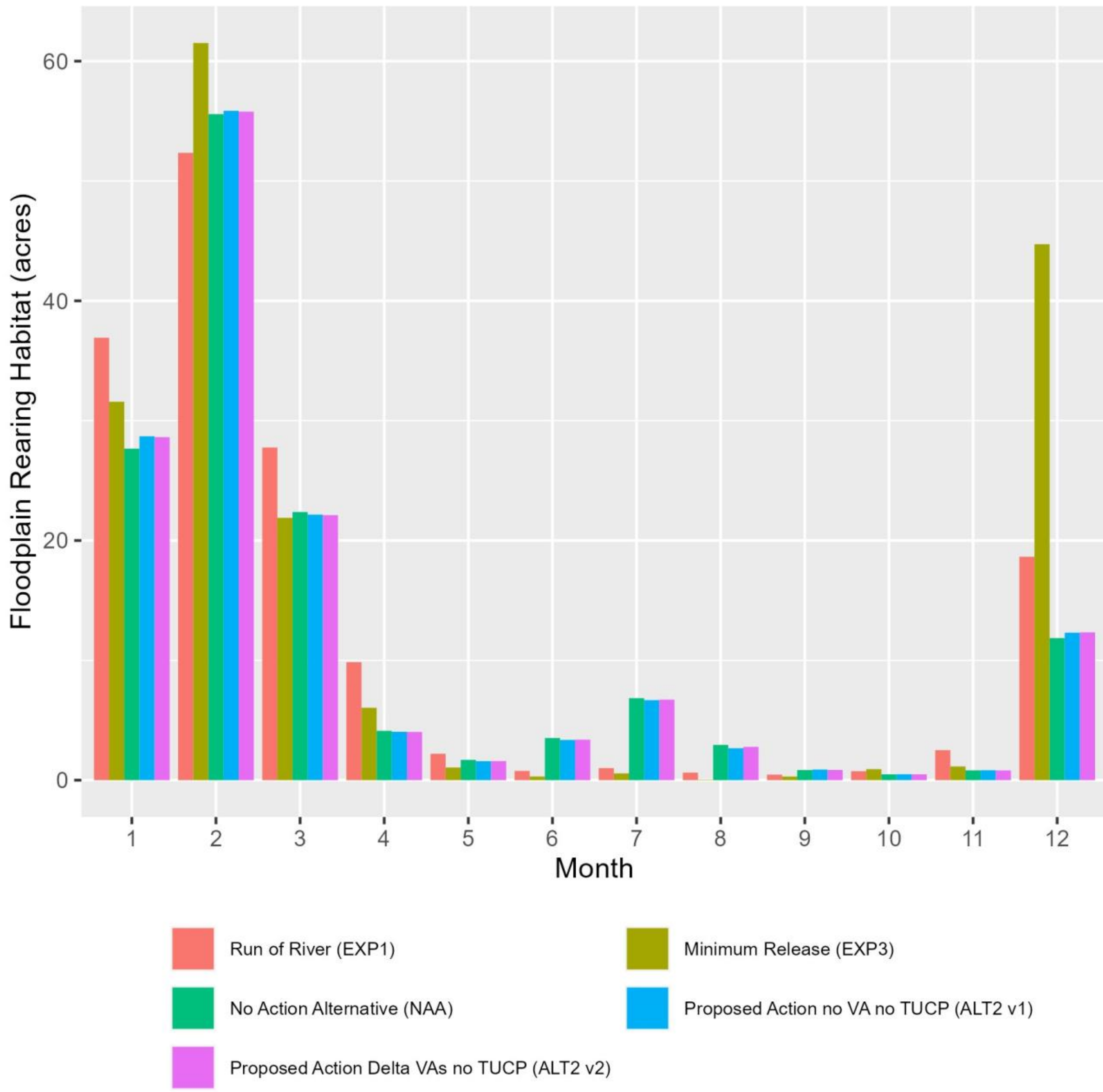
Suitable instream and floodplain rearing habitat quantities, presented separately, are provided for every month in the upper Sacramento River; available flow-habitat relationships are assumed to be the same across winter-run Chinook salmon, spring-run Chinook salmon, and steelhead in the upper Sacramento River based on the availability on data and analyses. (Figure 4-18 and Figure

4-19). 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 Attachment O.2). These occurrences are not necessarily reflected in the results presented in Section 4.1.1, *Water Operations*, because presented flow values do not illustrate expected variability in flow across water years.



Values represent means across CalSim Water Years.

Figure 4-18. 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 Water Years.

Figure 4-19. Estimated floodplain rearing habitat for juvenile winter-run Chinook salmon, spring-run Chinook salmon, and steelhead in the upper Sacramento River

4.2 Clear Creek

Inflows to Whiskeytown Reservoir come from Clear Creek and imports from the Trinity River Basin. Figure 4-20 show inflows from the Clear Creek Watershed only according to the 40-30-30 hydrologic water year type.

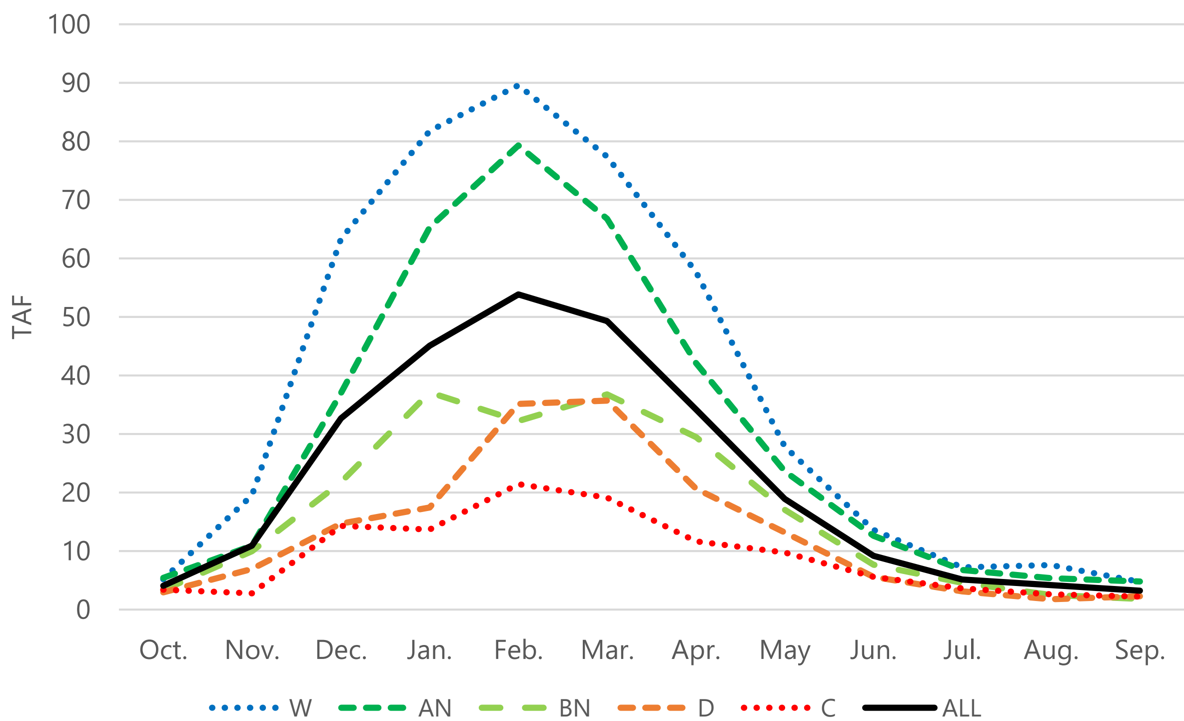


Figure 4-20. Clear Creek Inflow to Whiskeytown Reservoir by Month and Water Year Type

Whiskeytown Reservoir supplies water to Keswick Reservoir through the Spring Creek tunnel. Releases from Whiskeytown Reservoir are measured at the Igo stream gage, with flows targeting hydraulic conditions at various downstream locations (e.g., the Gorge). Figure 4-21 shows the Clear Creek water operations topology, including the Trinity River Basin.

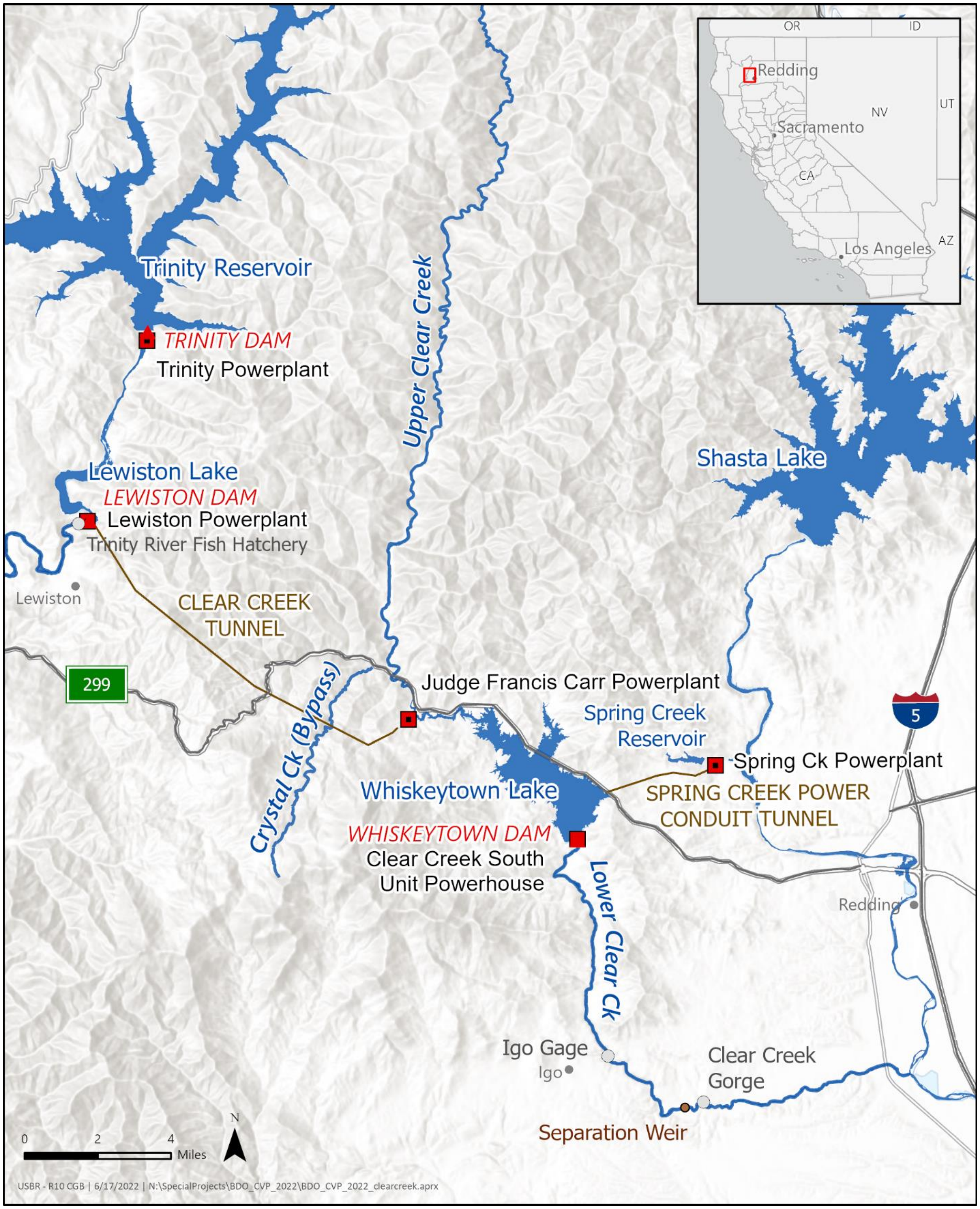


Figure 4-21. Clear Creek Water Operations Topology

4.2.1 Water Operations

Figure 4-22 shows release from Whiskeytown Dam for the EXP1, EXP3, NAA, Alt2 v1, and Alt2 V2 scenarios.

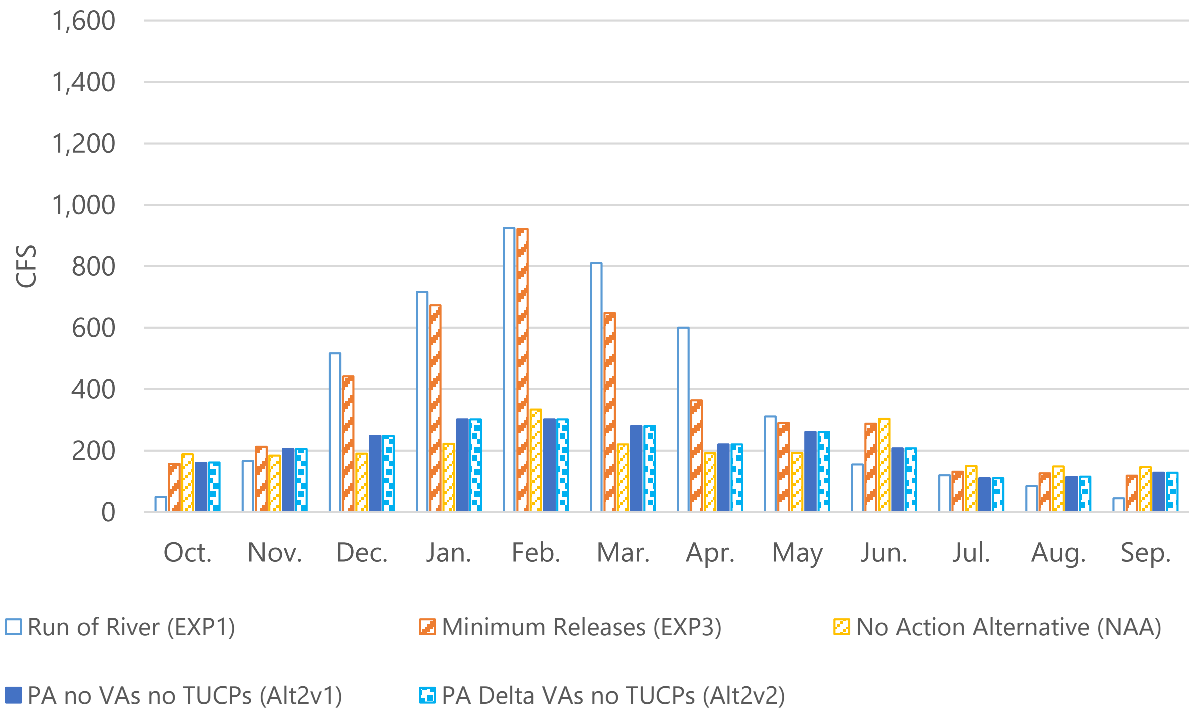


Figure 4-22. Clear Creek below Whiskeytown Monthly Flows, All Water Year Types

Reclamation reviewed difference by year type and found the direction of the trend remains the same for most months, but the magnitude changes. 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 4-23 shows Clear Creek below Whiskeytown Dam annual peak flow frequency for four scenarios, Peak flows on Clear Creek under NAA (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 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.

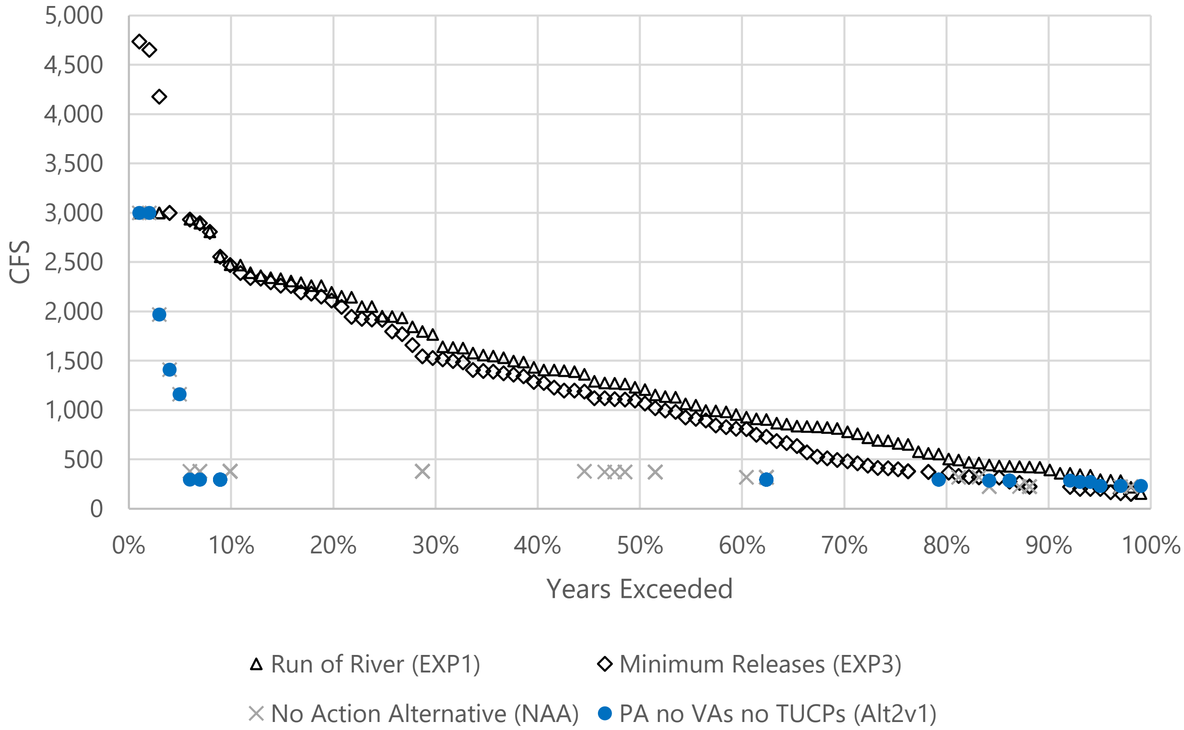


Figure 4-23. Peak Annual Flows (Monthly Average) on Clear Creek

Figure 4-24 shows inflows to Whiskeytown Reservoir that are not released down Clear Creek are diverted into Keswick Reservoir through the Spring Creek tunnel.

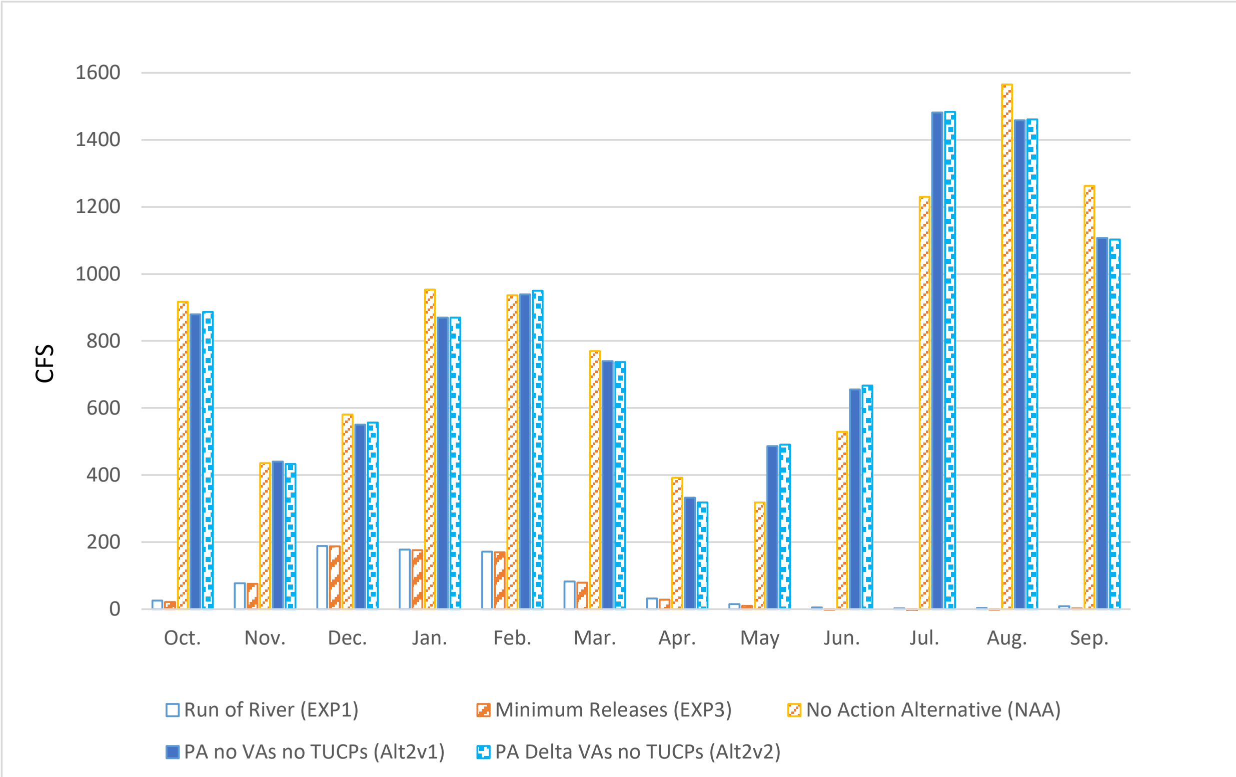


Figure 4-24. Spring Creek Inflows to Keswick Reservoir

No imports occur under the Run of River.

4.2.2 Water Temperatures and Dissolved Oxygen

Figure 4-25 shows modeled water temperatures on Clear Creek above the Sacramento River.

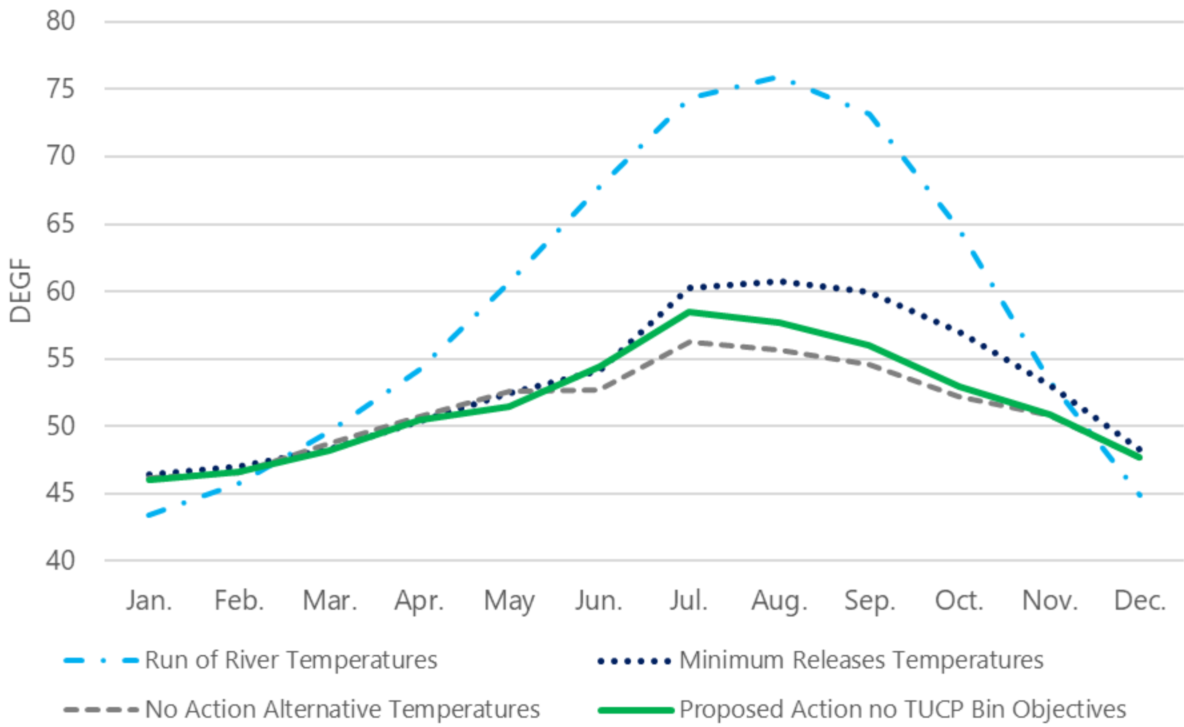


Figure 4-25. Clear Creek above Sacramento River Monthly Average Water Temperatures

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 4-26 shows historical water temperatures and Figure 4-27 shows dissolved oxygen.

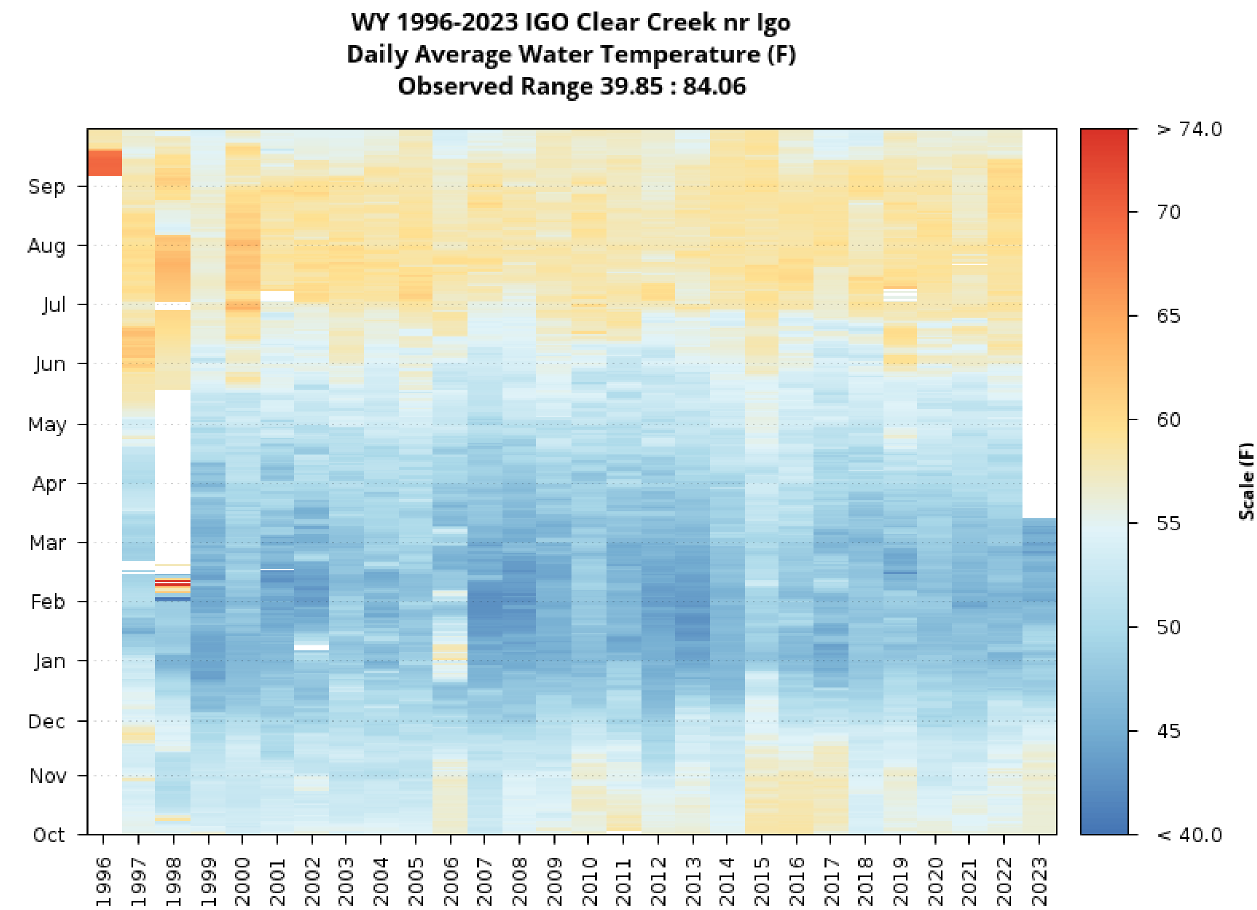


Figure 4-26. Clear Creek near Igo Daily Average Water Temperature (°F) for Water Years 1996-2023

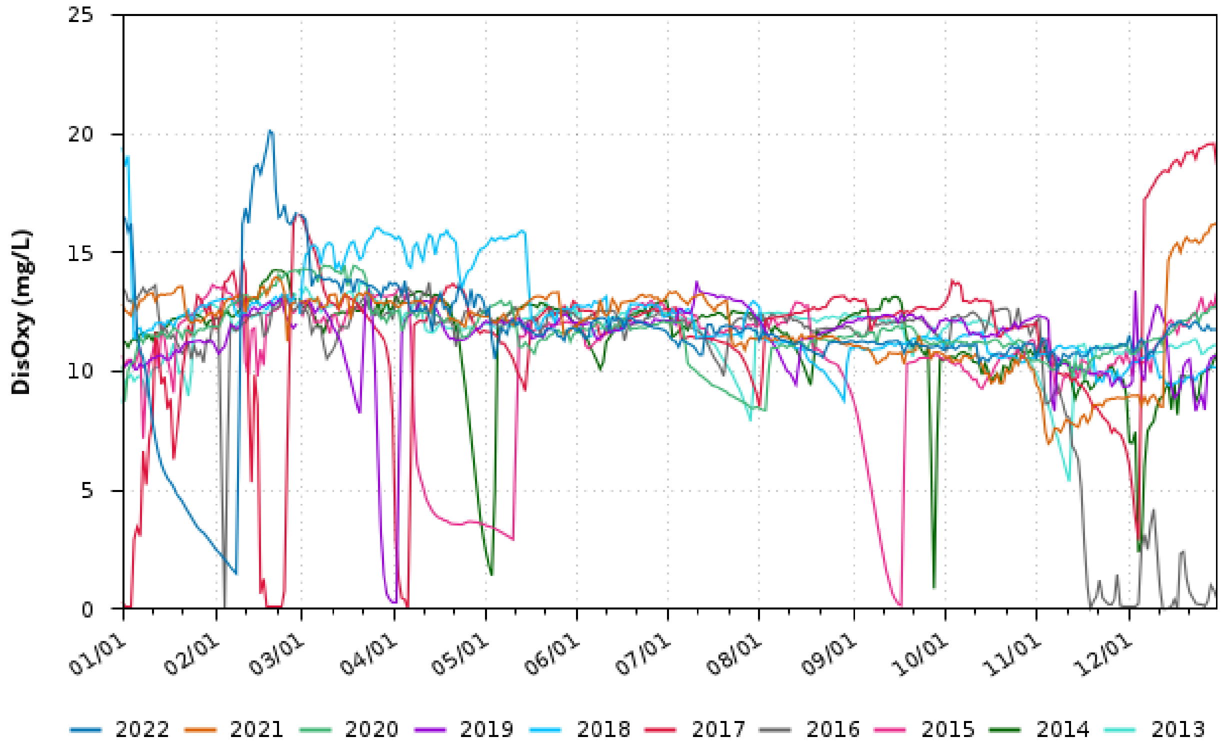
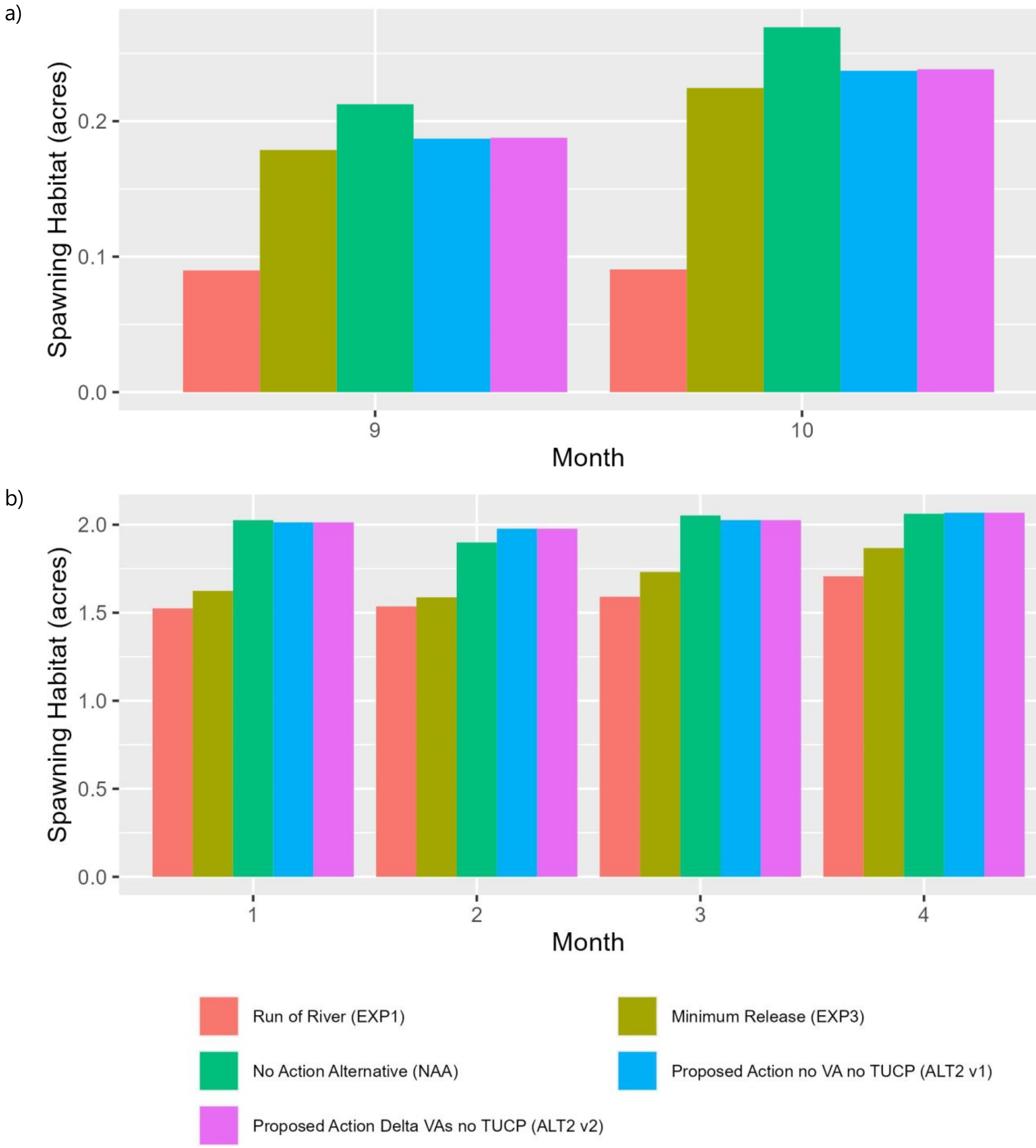


Figure 4-27. Sacramento River above Clear Creek Daily Average Dissolved Oxygen (mg/L) for Water Years 2013–2022

4.2.3 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 D). Steelhead adults generally spawn in January through April and juveniles rear year-round, with rearing in natal habitats primarily in March through May.

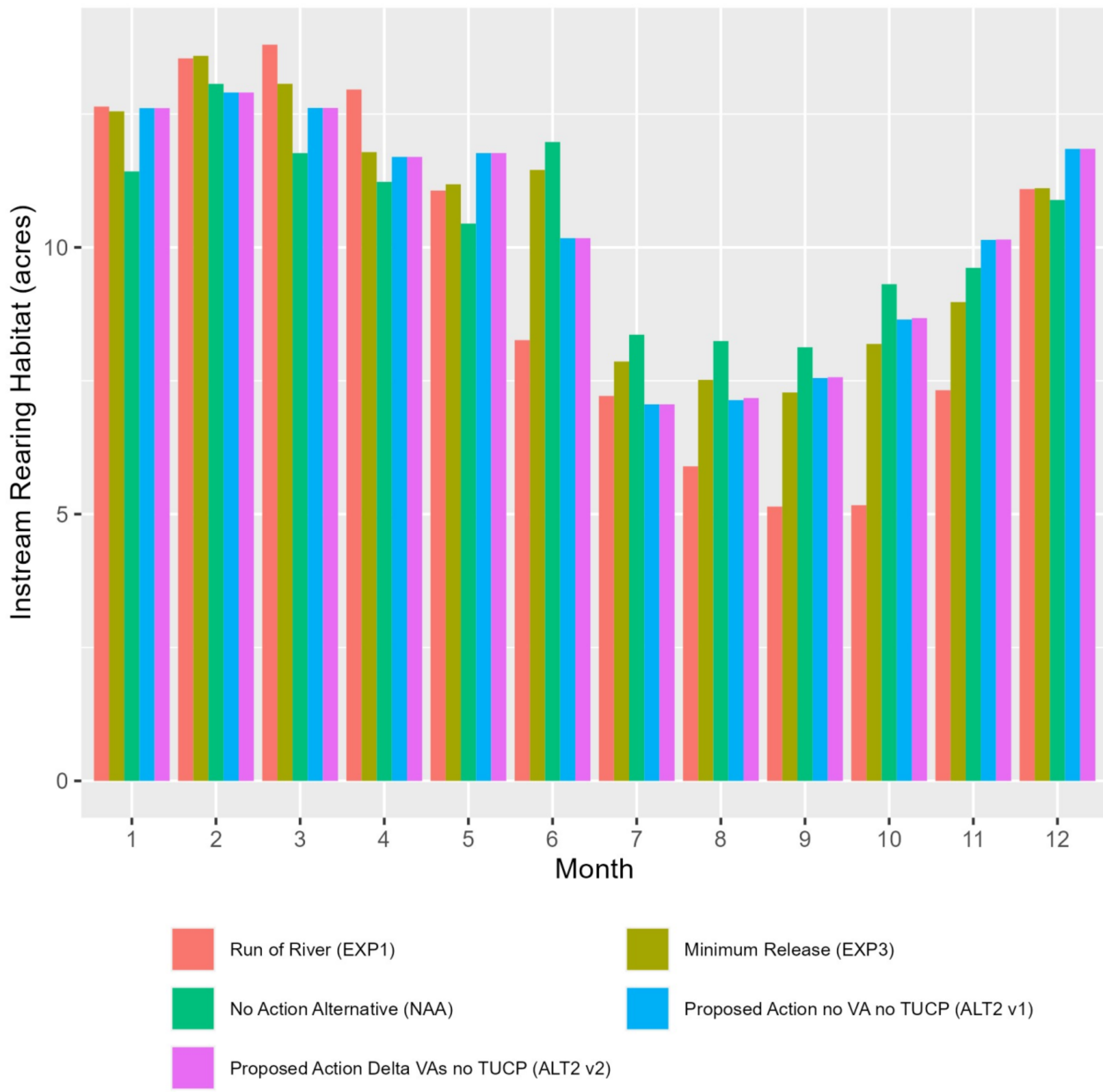
Expected spawning habitat quantities for adult spring-run Chinook salmon and steelhead are presented for expected spawning months in Clear Creek (Figure 4-28). Increasing spawning habitat for spring-run Chinook salmon from September to October corresponds to increasing expected flows (Section 4.2.1, *Water Operations*). Stable spawning habitat availability for steelhead in January through April corresponds to somewhat variable but high flows during these months.



Values represent means across CalSim Water Years, and do not account for extensive gravel augmentations that have occurred on Clear Creek in recent years (1997-2021).

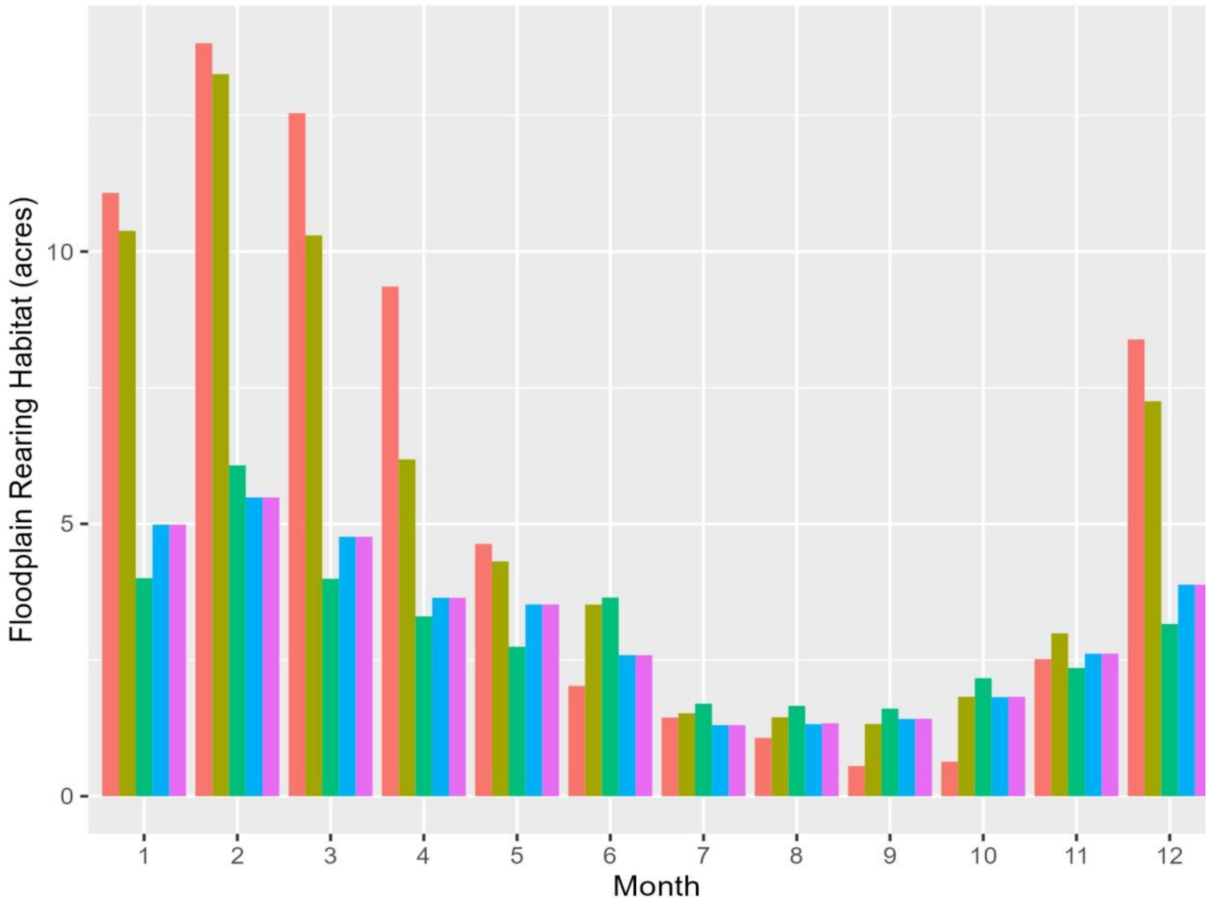
Figure 4-28. Estimated spawning habitat area for adult spring-run Chinook salmon (a) and steelhead (b) in Clear Creek

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 (Figure 4-29 and Figure 4-30). 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.

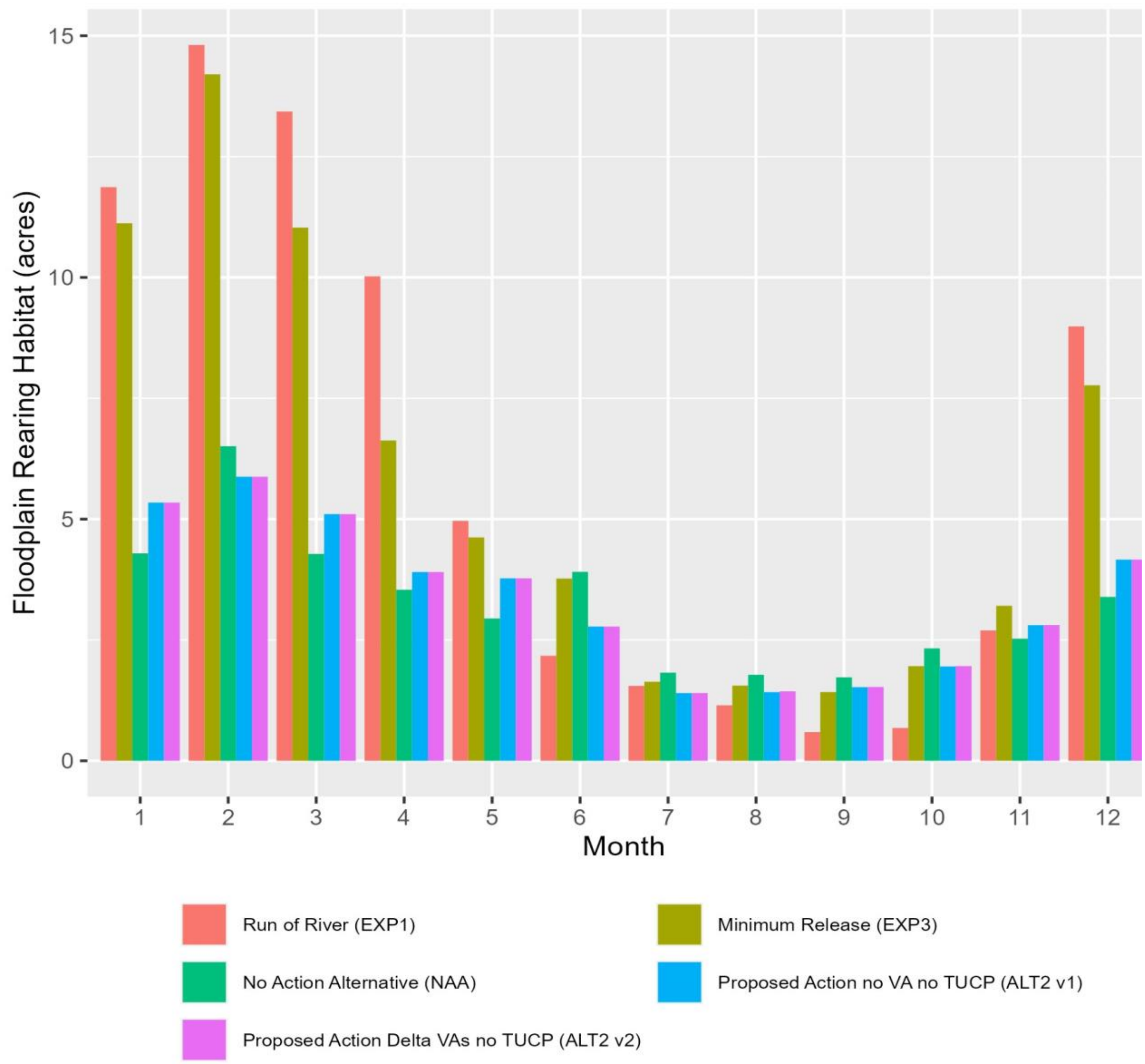


Values represent means across CalSim Water Years. Flow-habitat relationships were assumed to be identical for spring-run Chinook salmon and steelhead.

Figure 4-29. Estimated instream rearing habitat for juvenile spring-run Chinook salmon and steelhead in Clear Creek a)


Floodplain Rearing Habitat (acres)
0
5
10
1
2
3
4
5
6
7
8
9
10
11
12
Month

b)



Values represent means across CalSim Water Years.

Figure 4-30. Estimated floodplain rearing habitat for juvenile spring-run Chinook salmon (a) and steelhead (b) in Clear Creek

4.3 American River

Inflows to Folsom Reservoir come from the North Fork American River and South Fork American River. Figure 4-31 shows the inflow to Folsom Reservoir by month and 40-30-30 hydrologic water-year type.

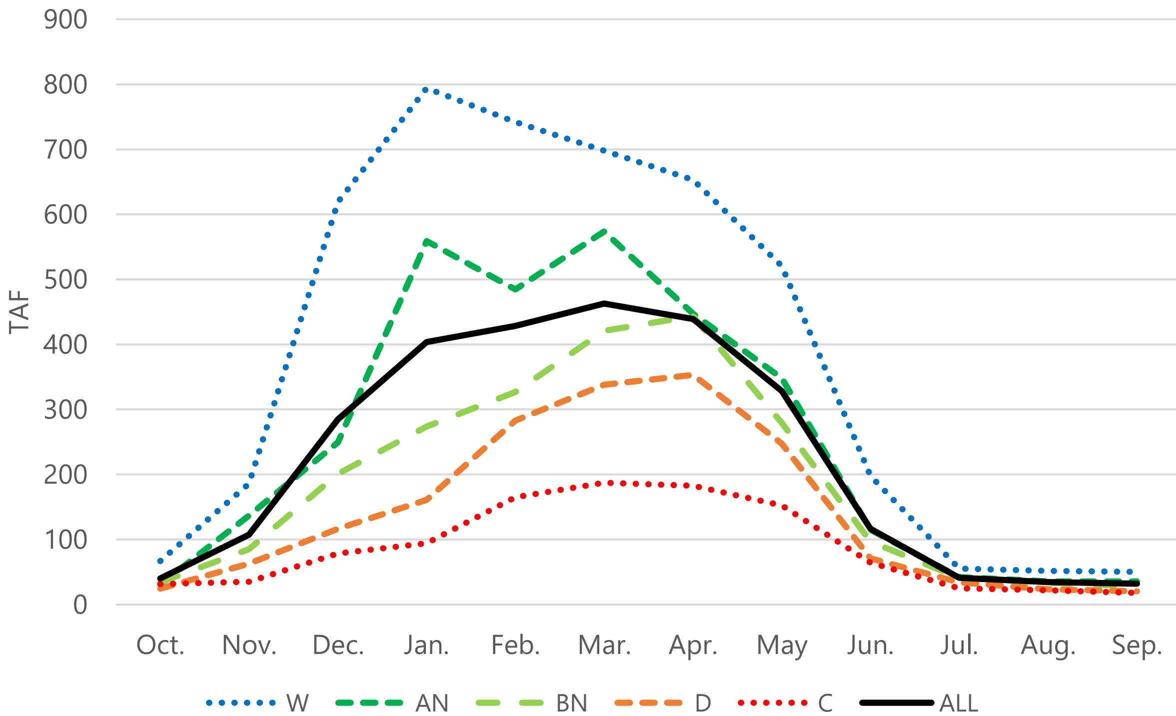


Figure 4-31. Inflow to Folsom Reservoir by Month and Water Year Type

Releases from Folsom Reservoir flow into Lake Natoma and are impounded by Nimbus Dam. No major tributaries provide additional flow; however, water temperature compliance locations at Watt Avenue and Hazel Avenue provide holding and spawning locations. Figure 4-32 shows a simplified hydrologic topology for the American River from Folsom Dam to the confluence with the Sacramento River.

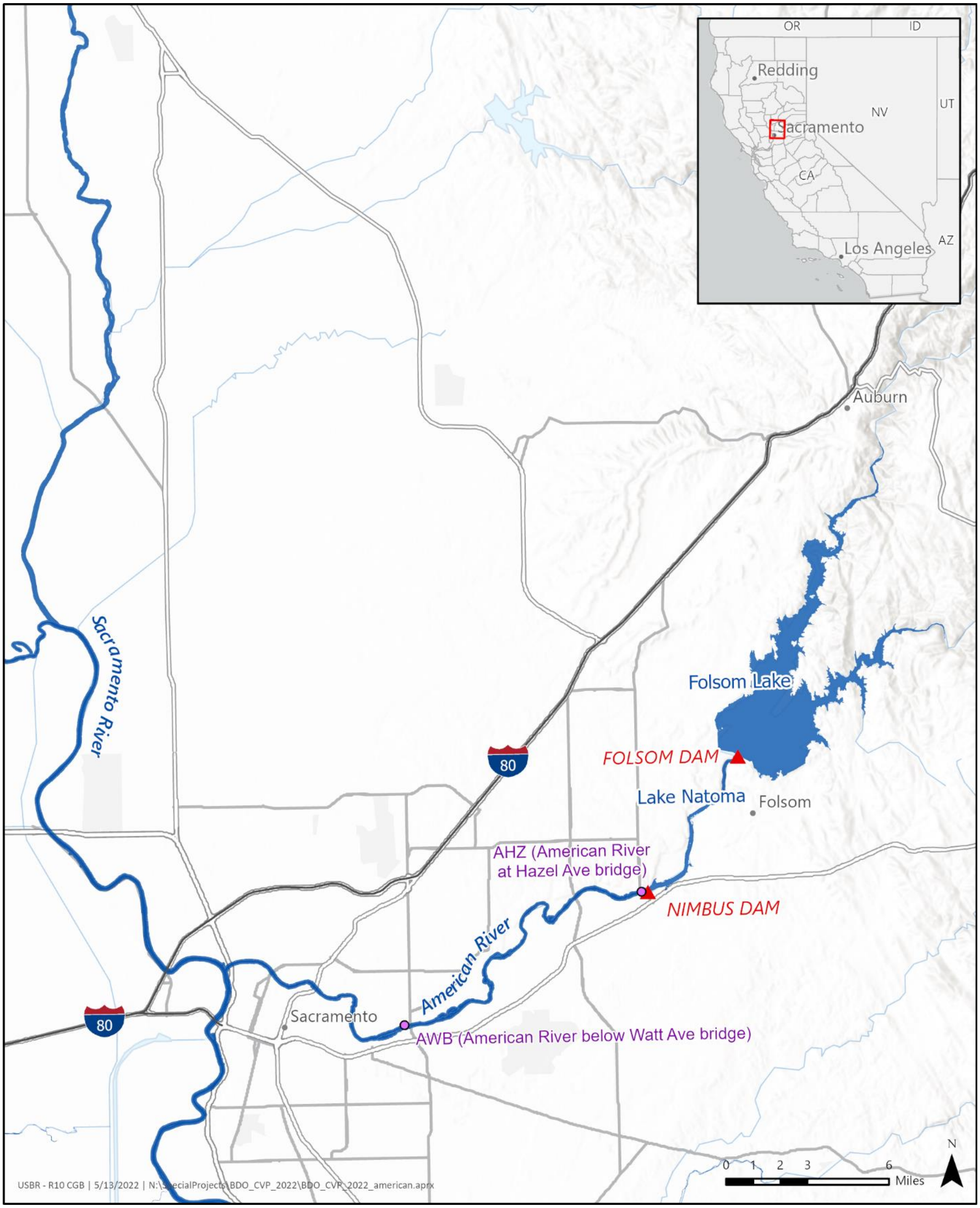


Figure 4-32. American River Water Operations and Temperature Topology

4.3.1 Water Operations

Figure 4-33 shows releases from Nimbus Dam to the American River for the EXP1, EXP3, NAA, Alt2 v1, and Alt2 v2 scenarios.

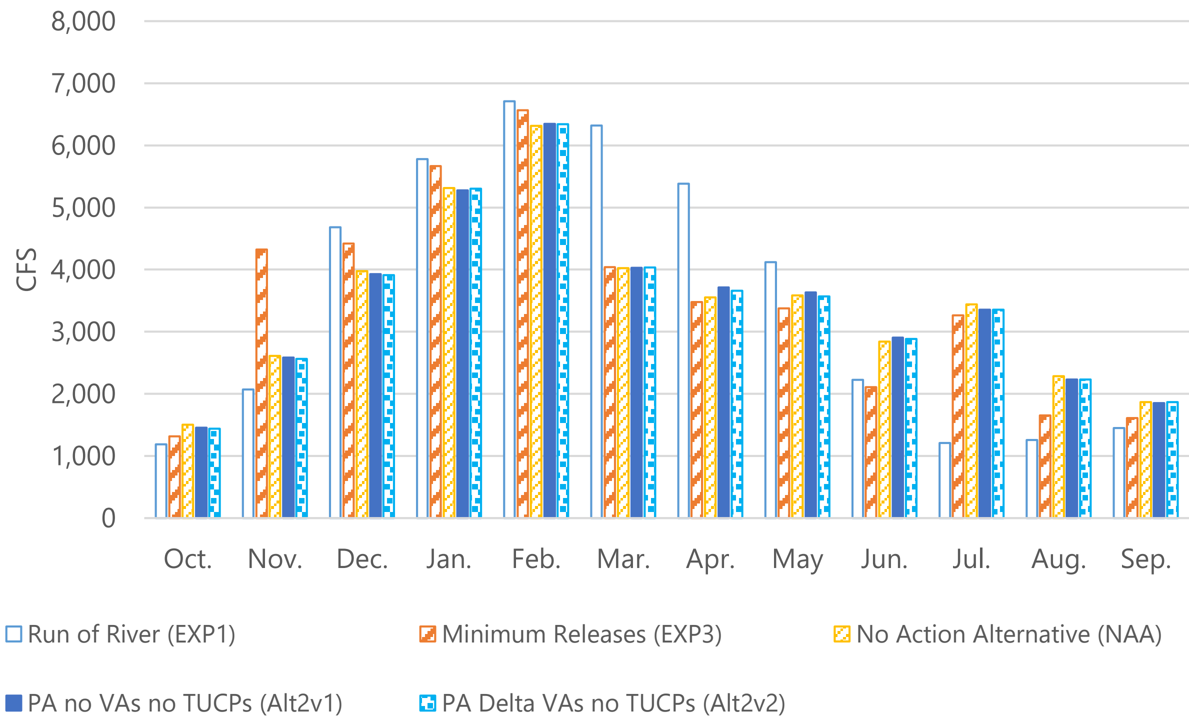


Figure 4-33. American River below Nimbus Dam Monthly Flows, All Water Year Types

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 4-34 shows peak annual flows (monthly average) on the American River below Nimbus Dam.

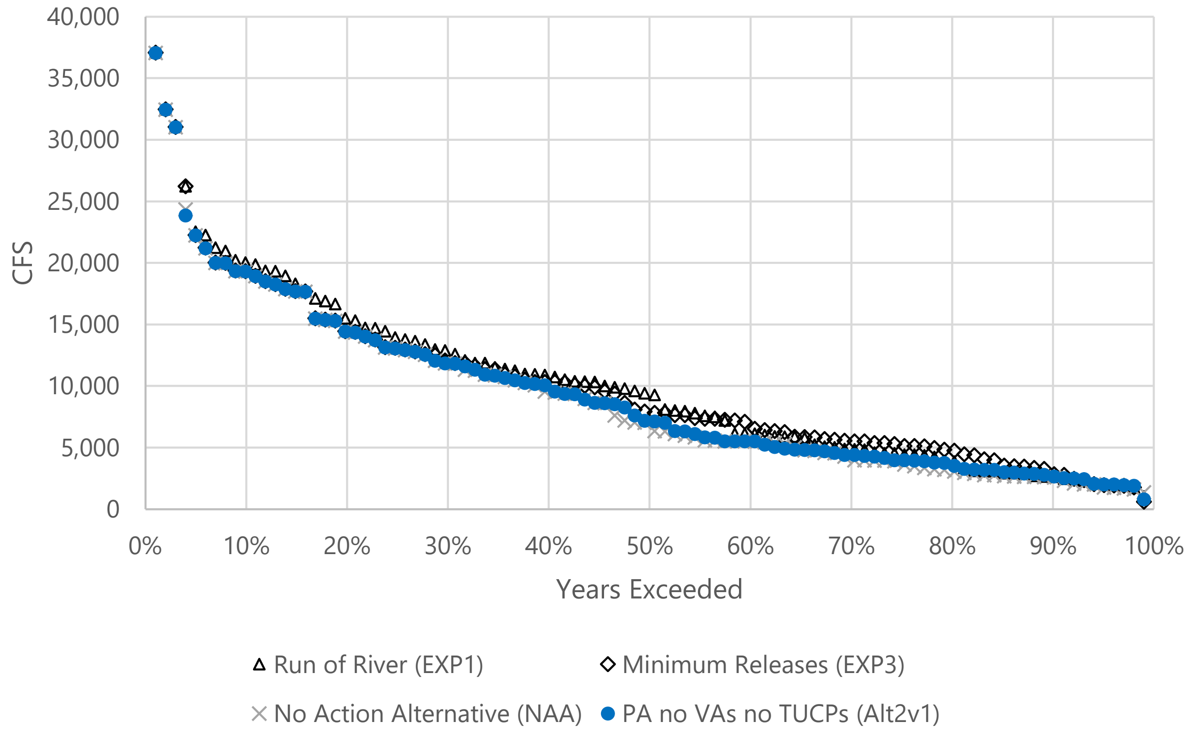


Figure 4-34. American River below Nimbus Dam Annual Peak Flow Frequency

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.

4.3.2 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 4-35). 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.

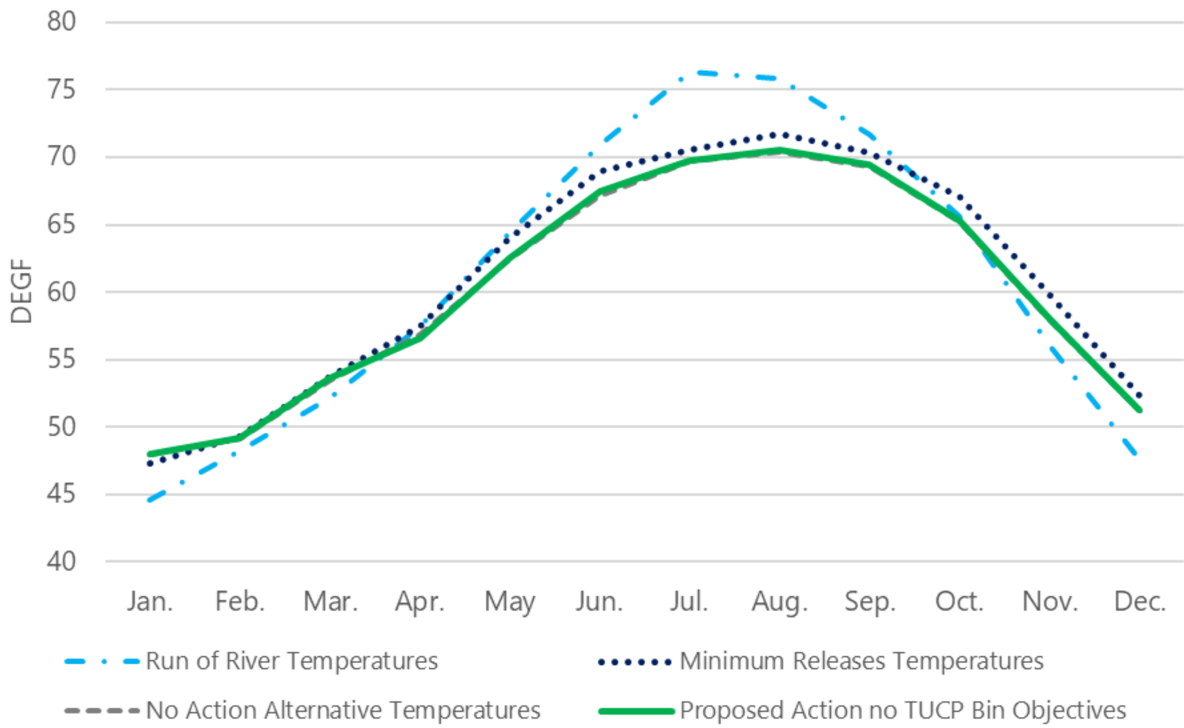


Figure 4-35. American River Modelled Water Temperatures at Watt Avenue

The Run of the River scenario had the largest amplitude. The NAA and Proposed Action phases water temperatures were similar for most of the year. Figure 4-36 shows historical water temperatures.

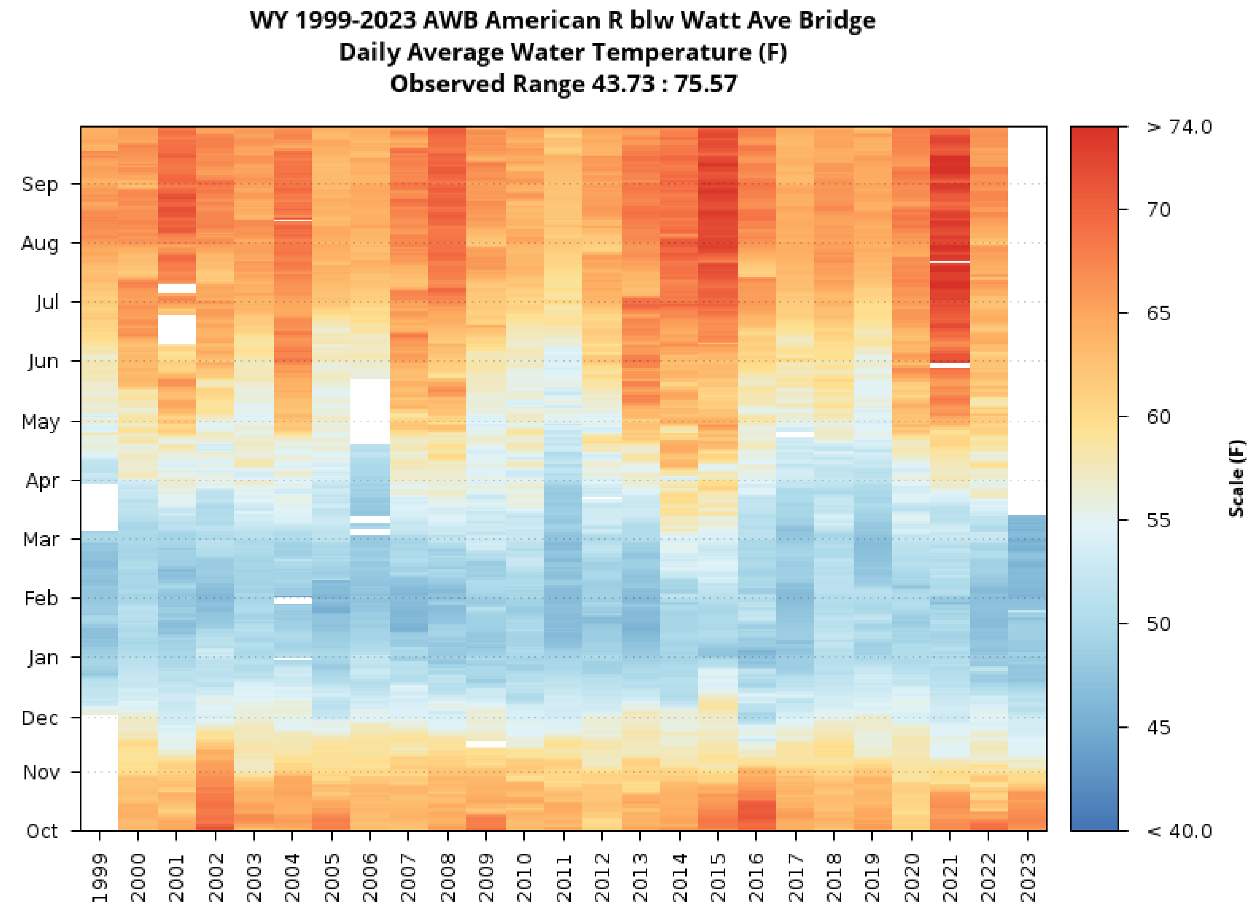
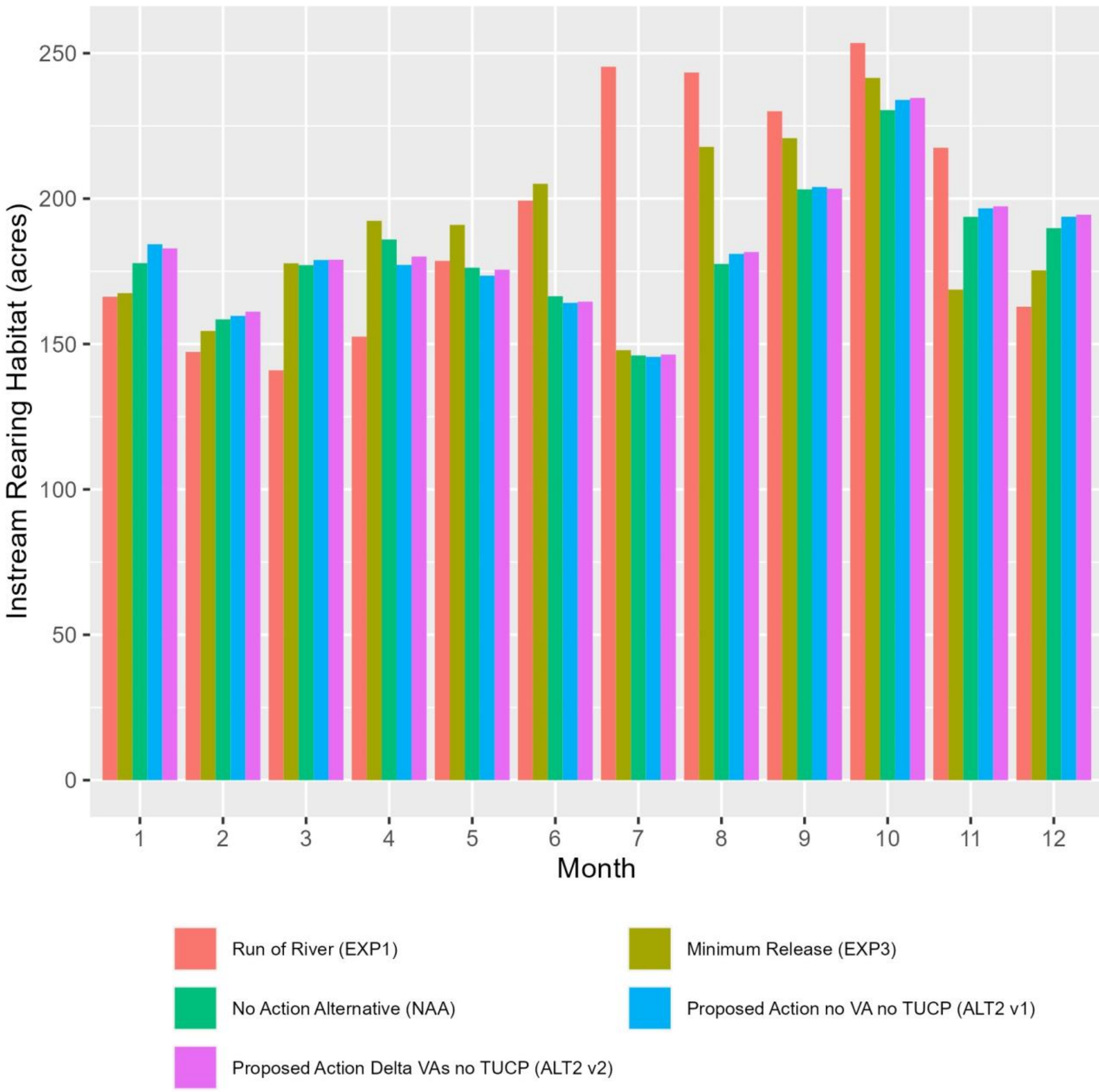


Figure 4-36. American River below Watt Ave Bridge Daily Average Water Temperature (°F) for Water Years 1999–2023

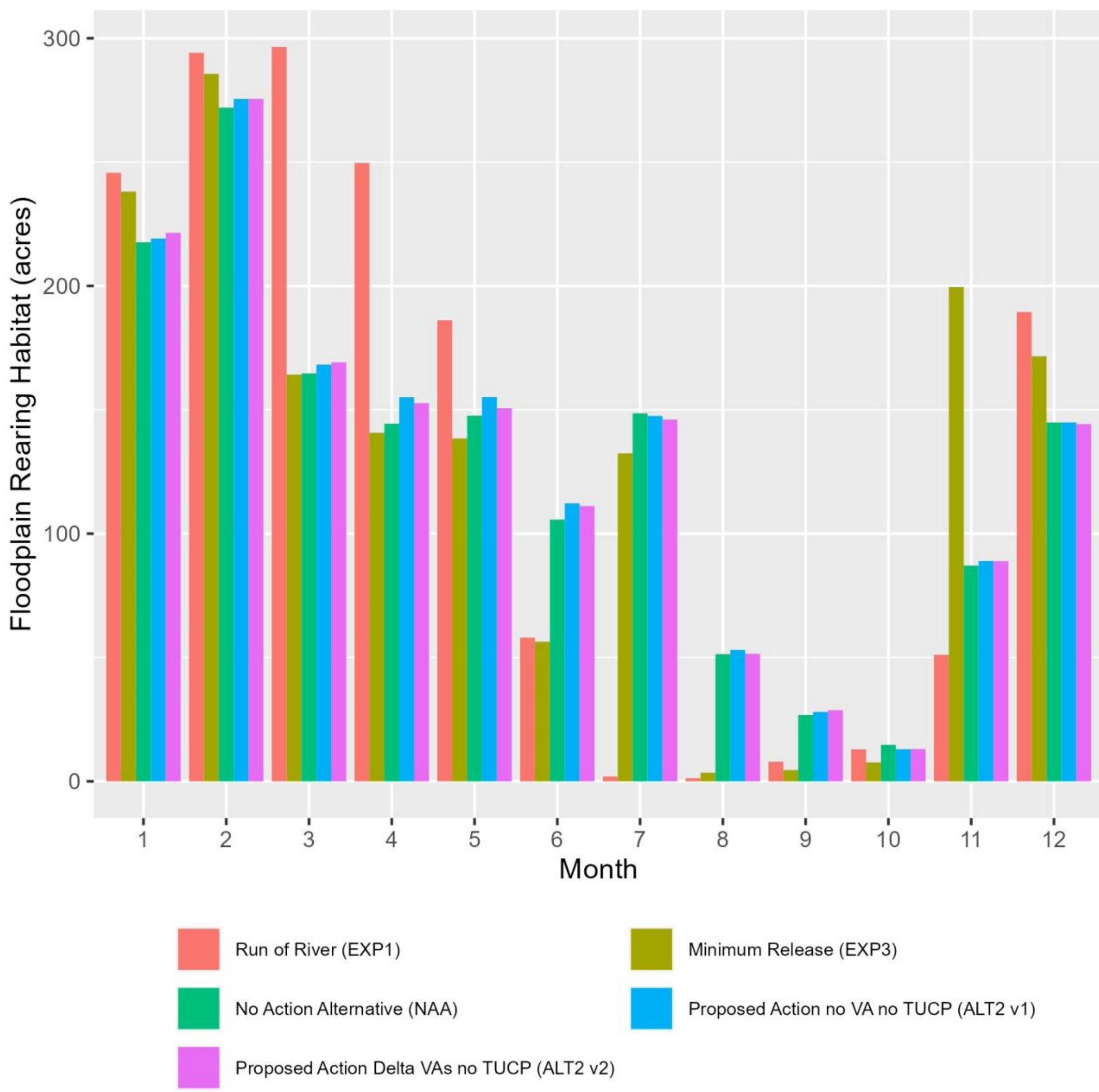
4.3.3 Suitable Habitat

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 4-37 and Figure 4-38). Increases in expected instream rearing habitat availability in September and October corresponded with reductions in monthly flows (Section 4.3.1, *Water Operations*). The greatest floodplain habitat availability estimates, occurring in January and February, corresponded with the highest expected monthly flows.



Values represent means across CalSim Water Years.

Figure 4-37. Estimated instream rearing habitat for juvenile steelhead in the lower American River



Values represent means across CalSim Water Years.

Figure 4-38. Estimated floodplain rearing habitat for juvenile steelhead in the lower American River

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.

4.4 Stanislaus River

Inflows to New Melones Reservoir come from the Stanislaus River. Figure 4-39 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.

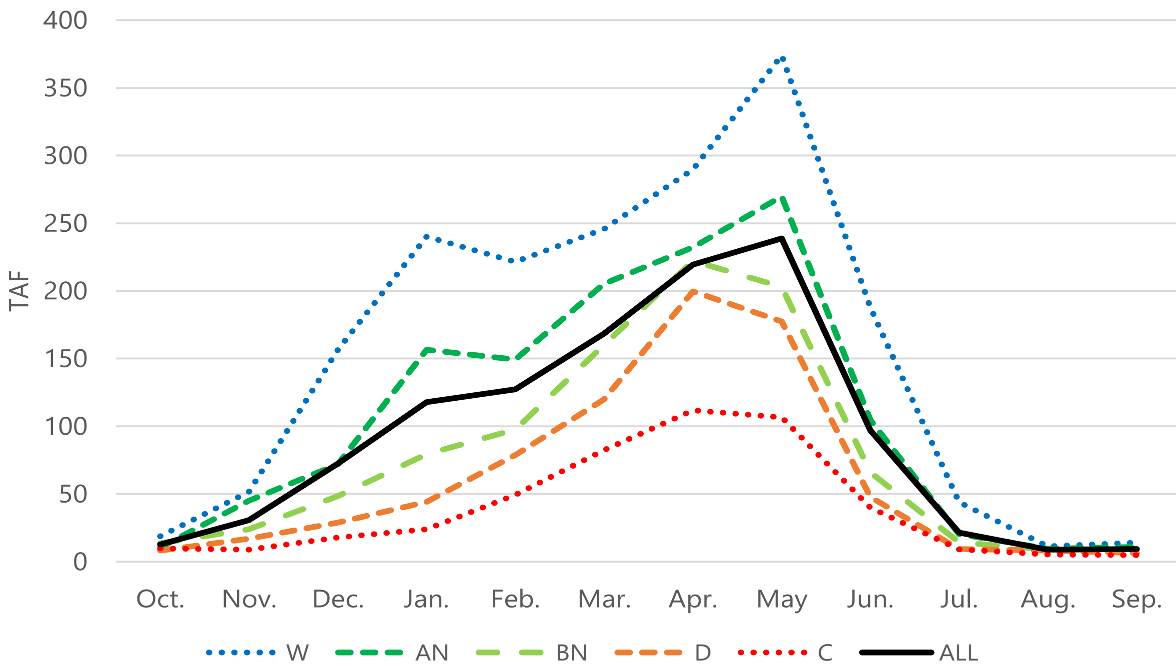


Figure 4-39. Inflow to New Melones Reservoir by Month and Water Year Types (40-30-30)

Releases from New Melones Reservoir flow to Goodwin Dam. Figure 4-40 shows a simplified hydrologic topology in the Stanislaus River from New Melones Dam to the confluence with the San Joaquin River.

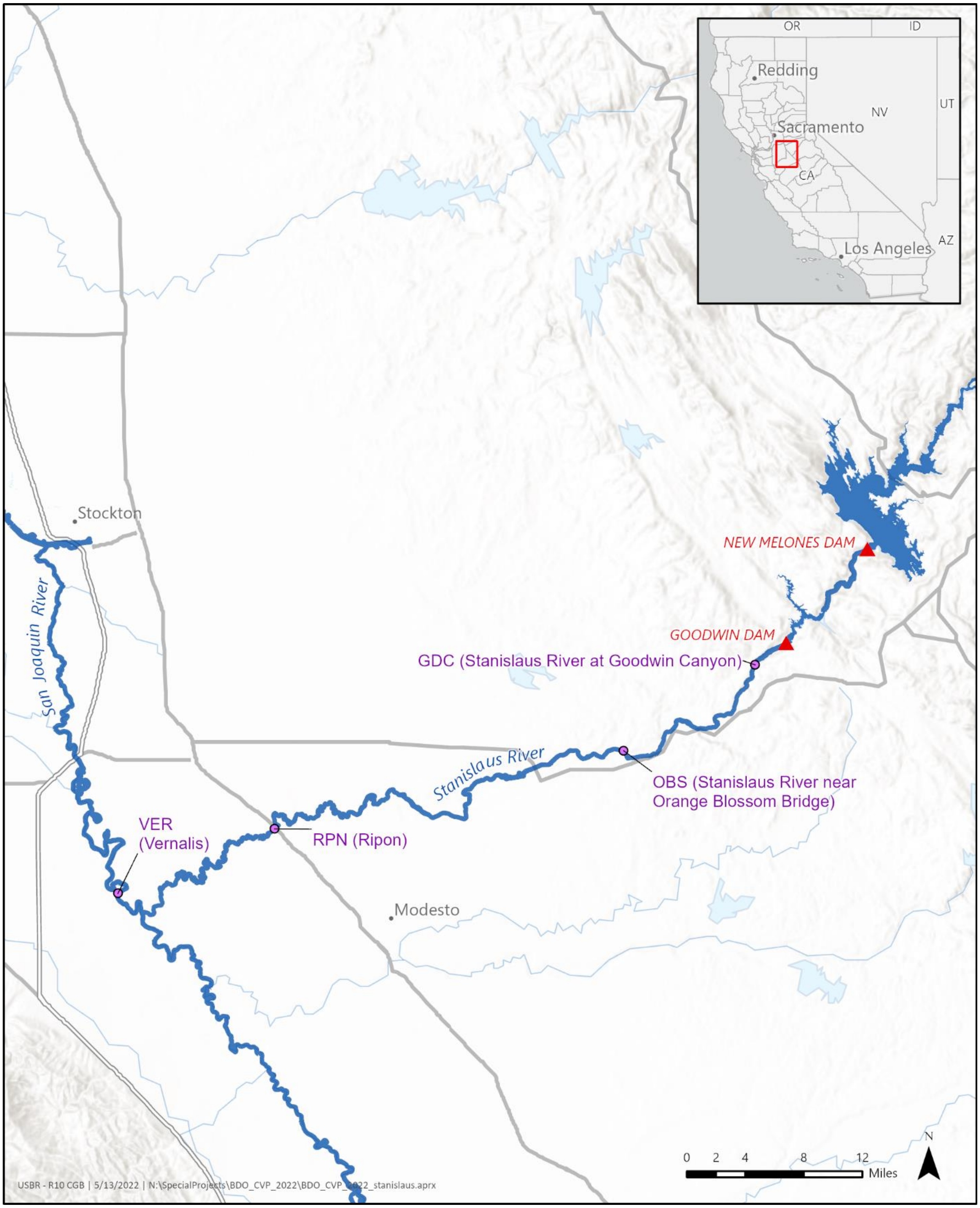


Figure 4-40. Stanislaus River Watershed Water Operations and Temperature Topology

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.

4.4.1 Water Operations

Figure 4-41 shows releases from Goodwin Dam to the Stanislaus River under the EXP1, EXP3, NAA, Alt2 v1, and Alt2 v2 scenarios. The EXP1 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 4.6.

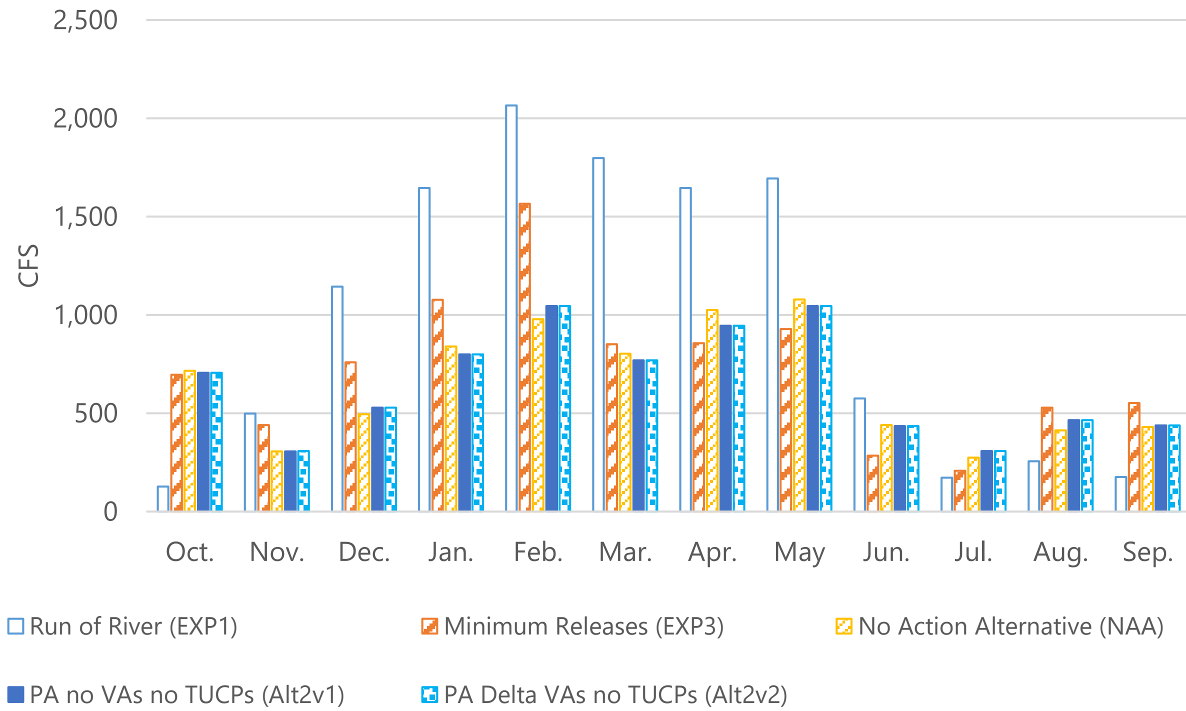


Figure 4-41. Stanislaus River below Goodwin Dam Monthly Flows, All Water Year Types

In comparing the Minimum Release and Proposed Action phases, 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 4-42 shows peak annual flows (monthly average) below Goodwin Dam.

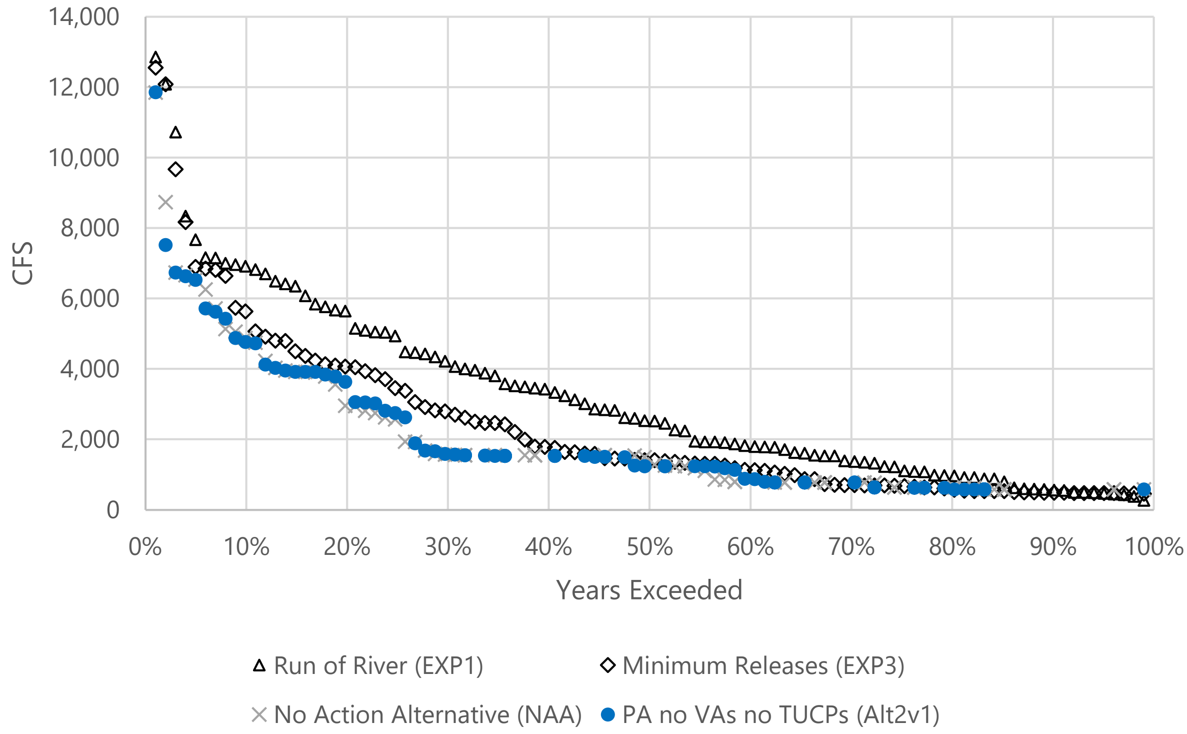


Figure 4-42. Stanislaus River below Goodwin Dam Annual Peak Flow Frequency

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.

4.4.2 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 4-43 illustrates that the Run of the River scenario features the greatest amplitude, peaking in the summer and dropping to its lowest water 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.

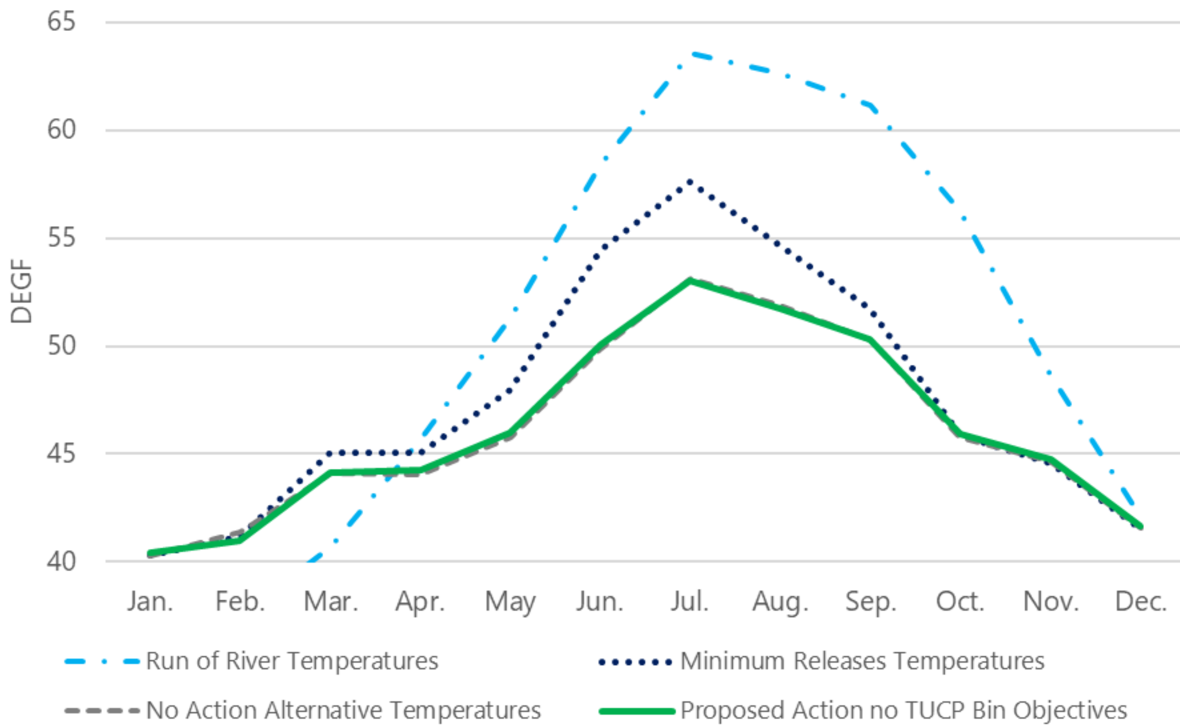


Figure 4-43. Stanislaus River at Orange Blossom

Figure 4-44 shows historical water temperatures and Figure 4-45 shows dissolved oxygen.

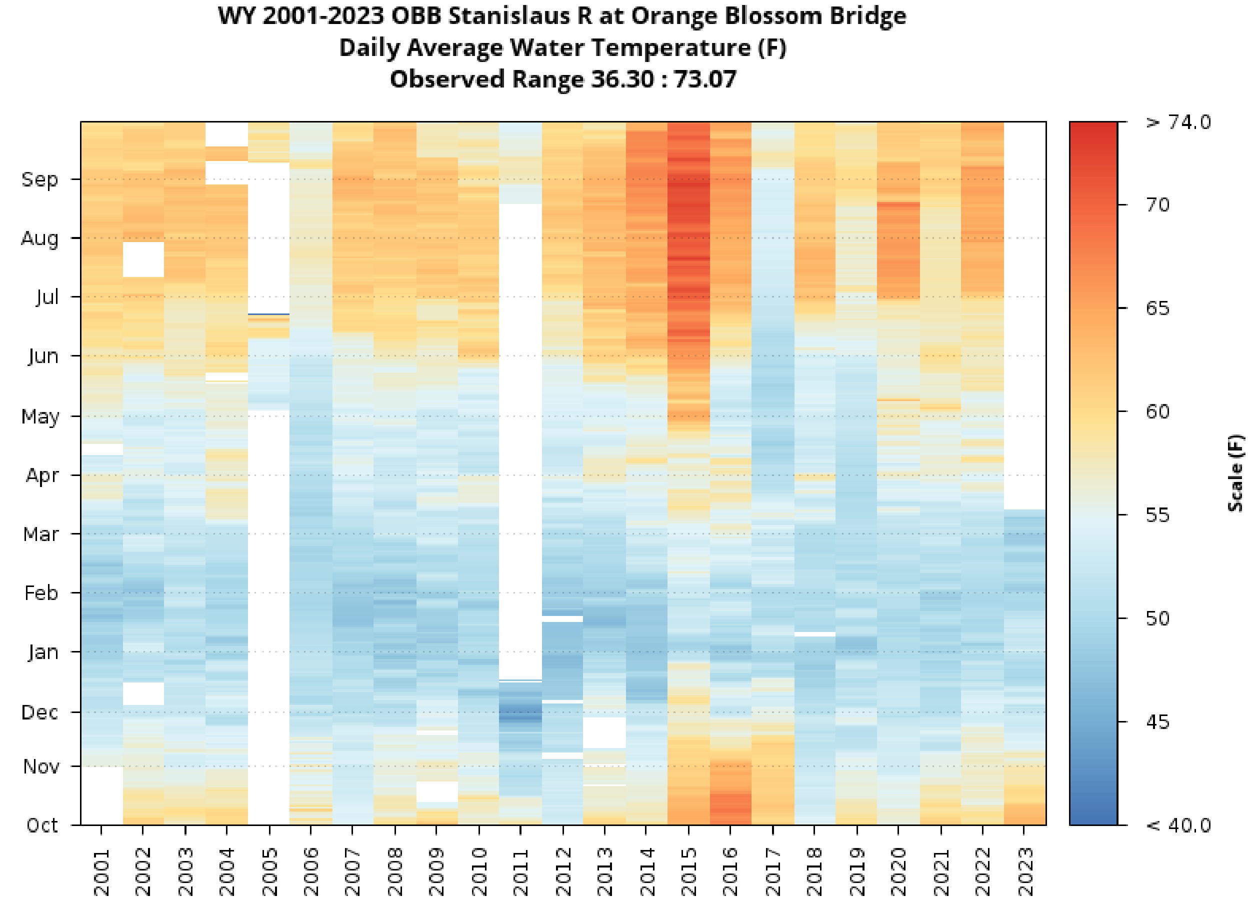


Figure 4-44. Stanislaus River at Orange Blossom Bridge Daily Average Water Temperature (°F) for Water Years 2001–2023

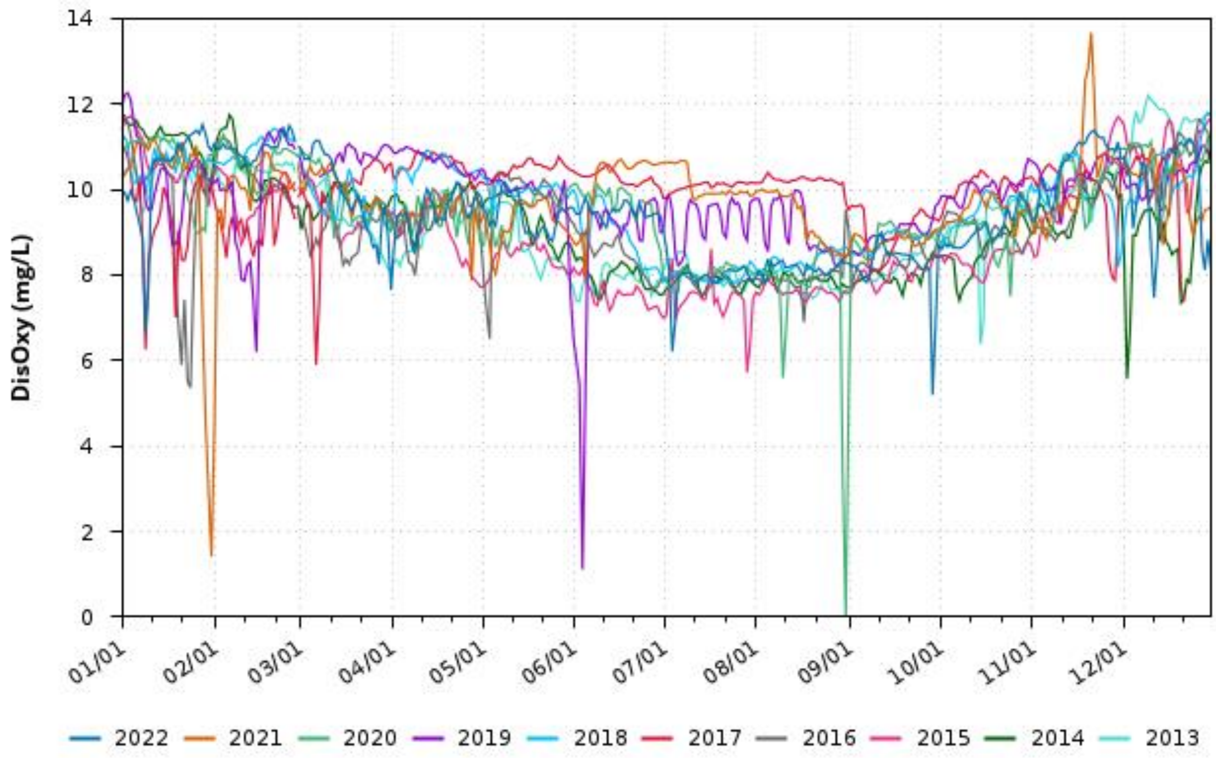
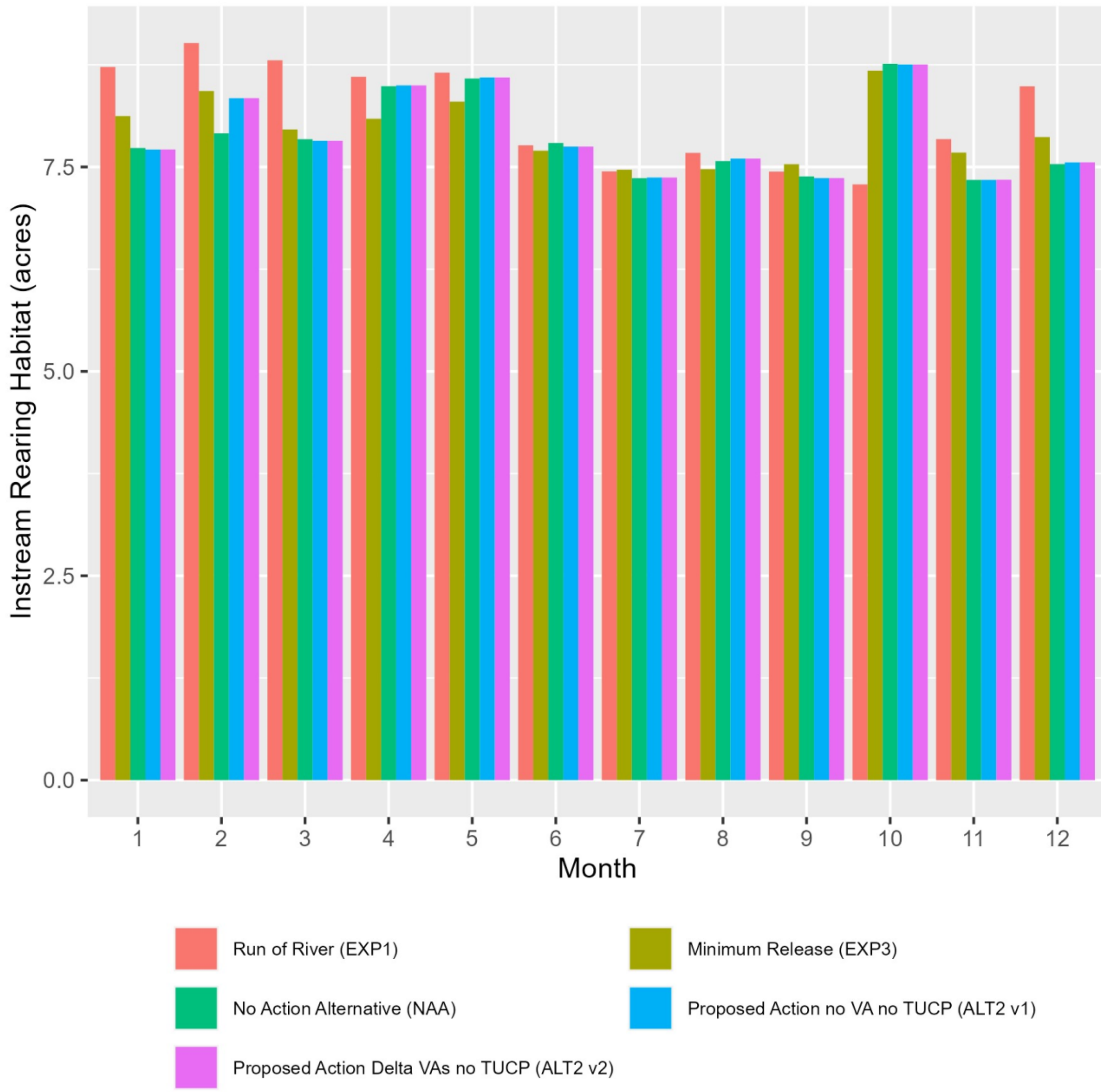


Figure 4-45. Stanislaus River at Ripon Daily Average Dissolved Oxygen (mg/L) for Water Years 2013–2022

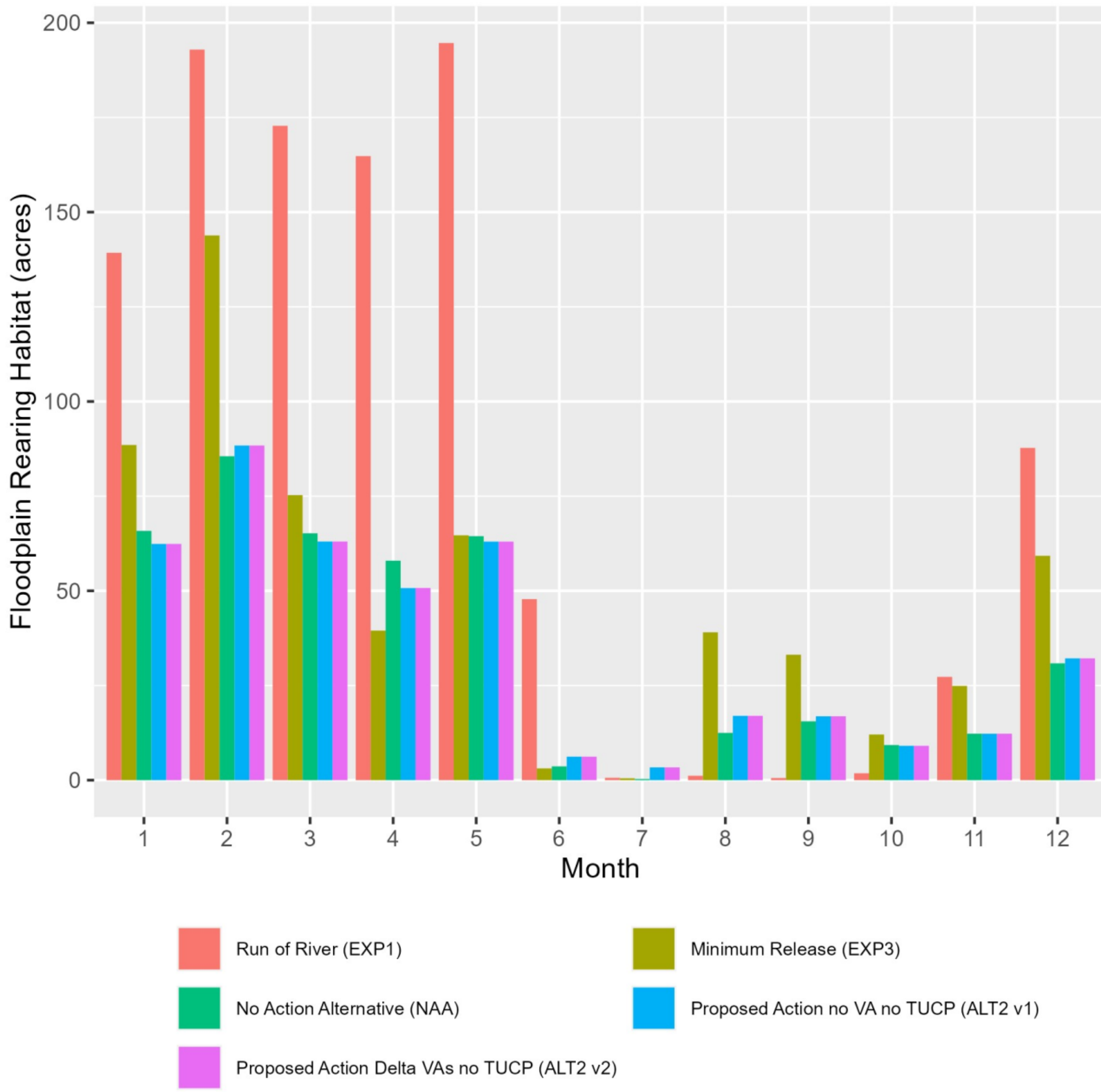
4.4.3 Suitable Habitat

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 4-46 and Figure 4-47). 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 4.4.1, *Water Operations*). Peaks in floodplain rearing habitat availability from December through May correspond to elevated monthly flows.



Values represent means across CalSim Water Years.

Figure 4-46. Estimated instream rearing habitat for juvenile steelhead in the Stanislaus River



Values represent means across CalSim Water Years.

Figure 4-47. Estimated floodplain rearing habitat for juvenile steelhead in the Stanislaus River

4.5 San Joaquin River

Inflows to Millerton Reservoir behind Friant Dam come from the San Joaquin River. Figure 4-48 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 SJRRP uses a program-specific water year classification.

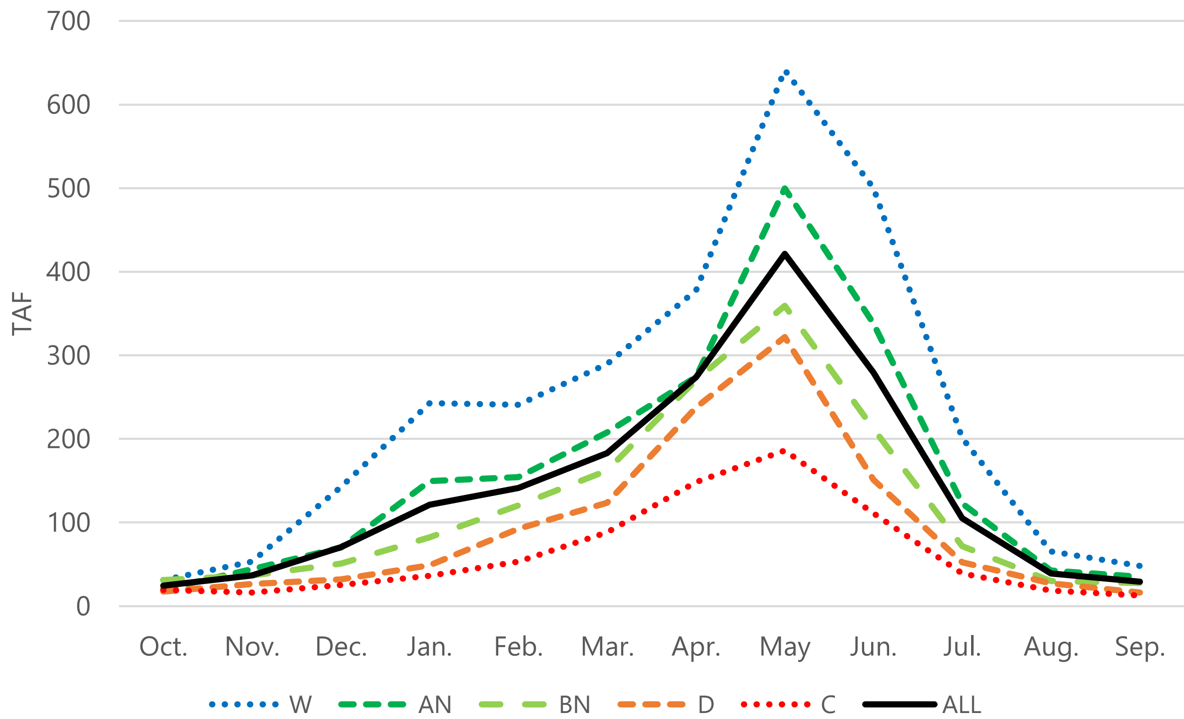


Figure 4-48. Inflow to Millerton Reservoir by Month and All Water Year Type

Figure 4-49 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.

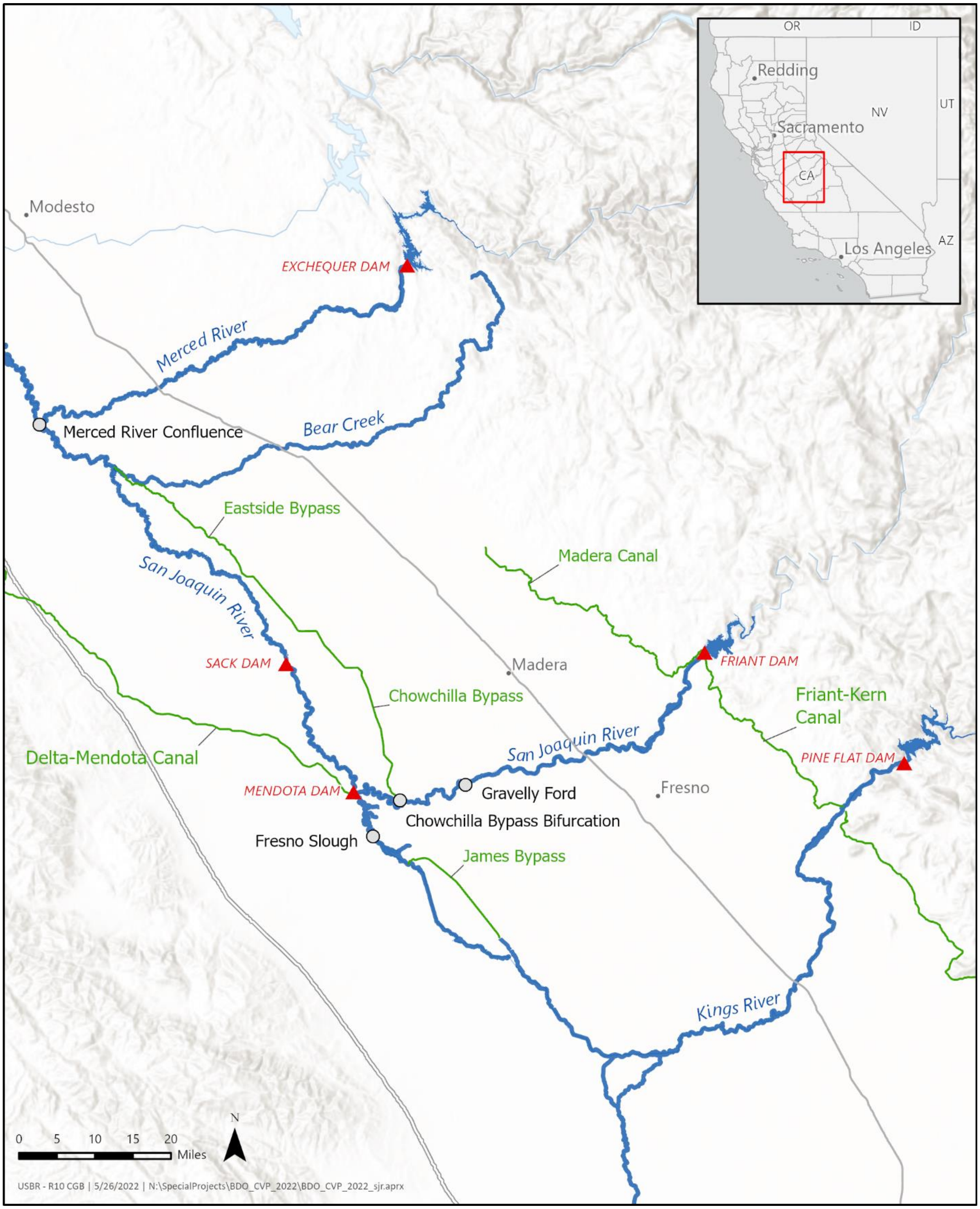


Figure 4-49. San Joaquin River Watershed Water Operations Topology

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 Reservoir 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 Irrigation District, Patterson Irrigation District, or Banta Carbona Irrigation District prior to reaching the Delta.

4.5.1 Water Operations

Figure 4-50 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 types but with higher flows volume. Figure 4-51 shows the flows at San Joaquin River below the Merced confluence.

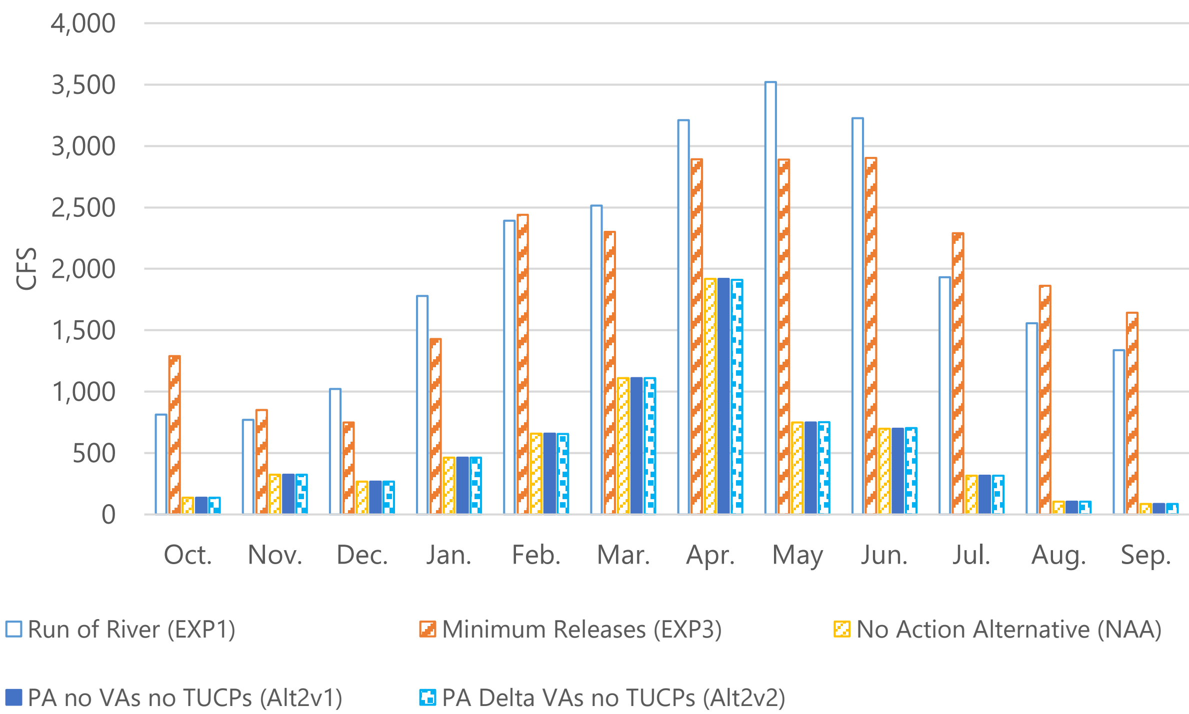


Figure 4-50. San Joaquin River at Gravelly Ford Monthly Flows, All Water Year Types

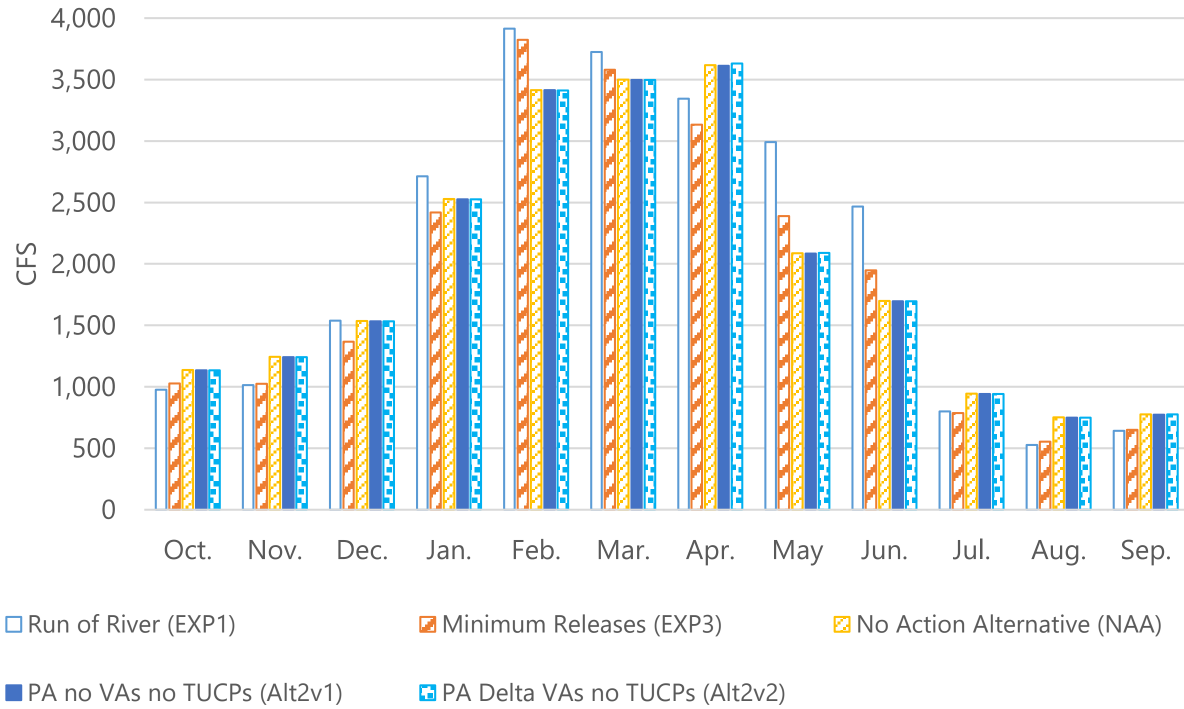


Figure 4-51. San Joaquin River below the Merced Confluence Monthly Flows, All Water Year Types

In critical and dry years, December and January flows for Minimum Release and the Proposed Action phases 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 4-52 shows peak annual flows (monthly average) below the Merced River confluence.

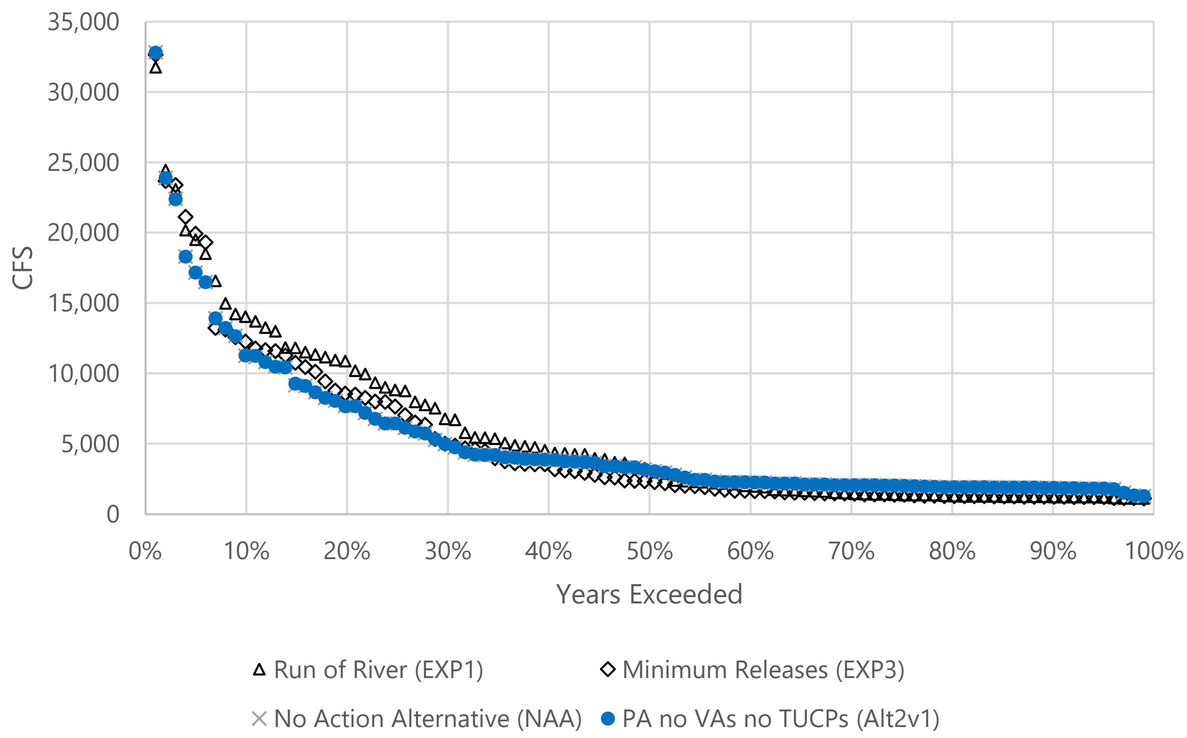


Figure 4-52. San Joaquin River below Merced River Confluence Annual Peak Flow Frequency

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 4.6.

4.5.2 Water Temperatures and Dissolved Oxygen

Water temperatures on the lower San Joaquin River at Vernalis were modeled using HEC-5Q. Figure 4-53 illustrates that 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.

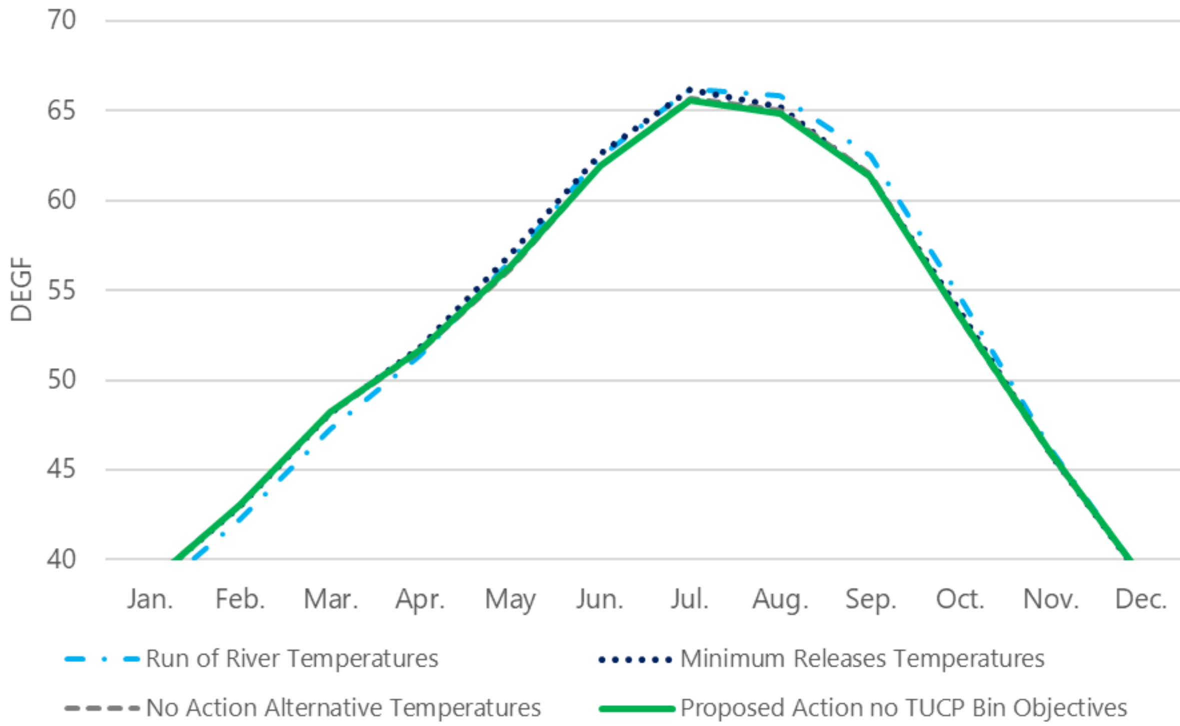


Figure 4-53. San Joaquin River at Vernalis

Figure 4-54 shows historical water temperatures and Figure 4-55 shows dissolved oxygen.

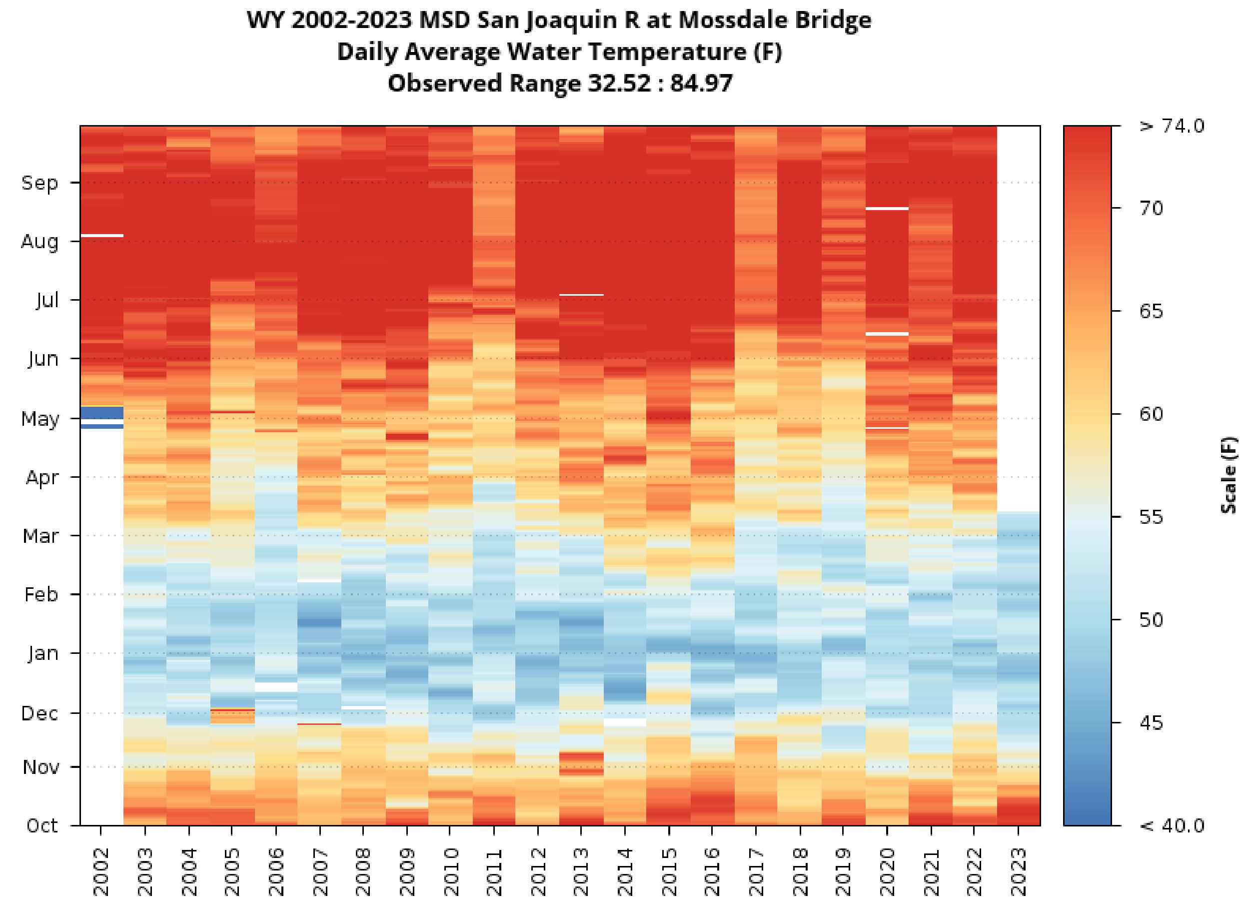


Figure 4-54. San Joaquin River at Mossdale Bridge Daily Average Water Temperature (°F) for Water Years 2002–2023

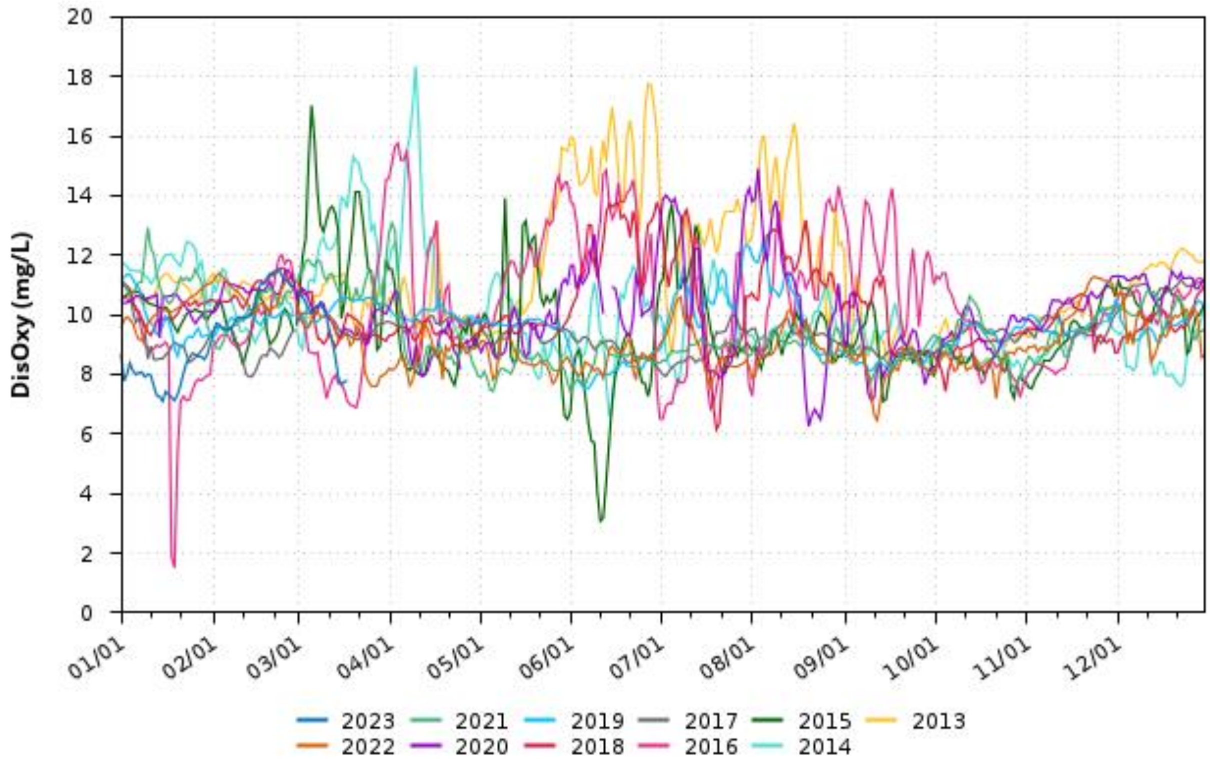


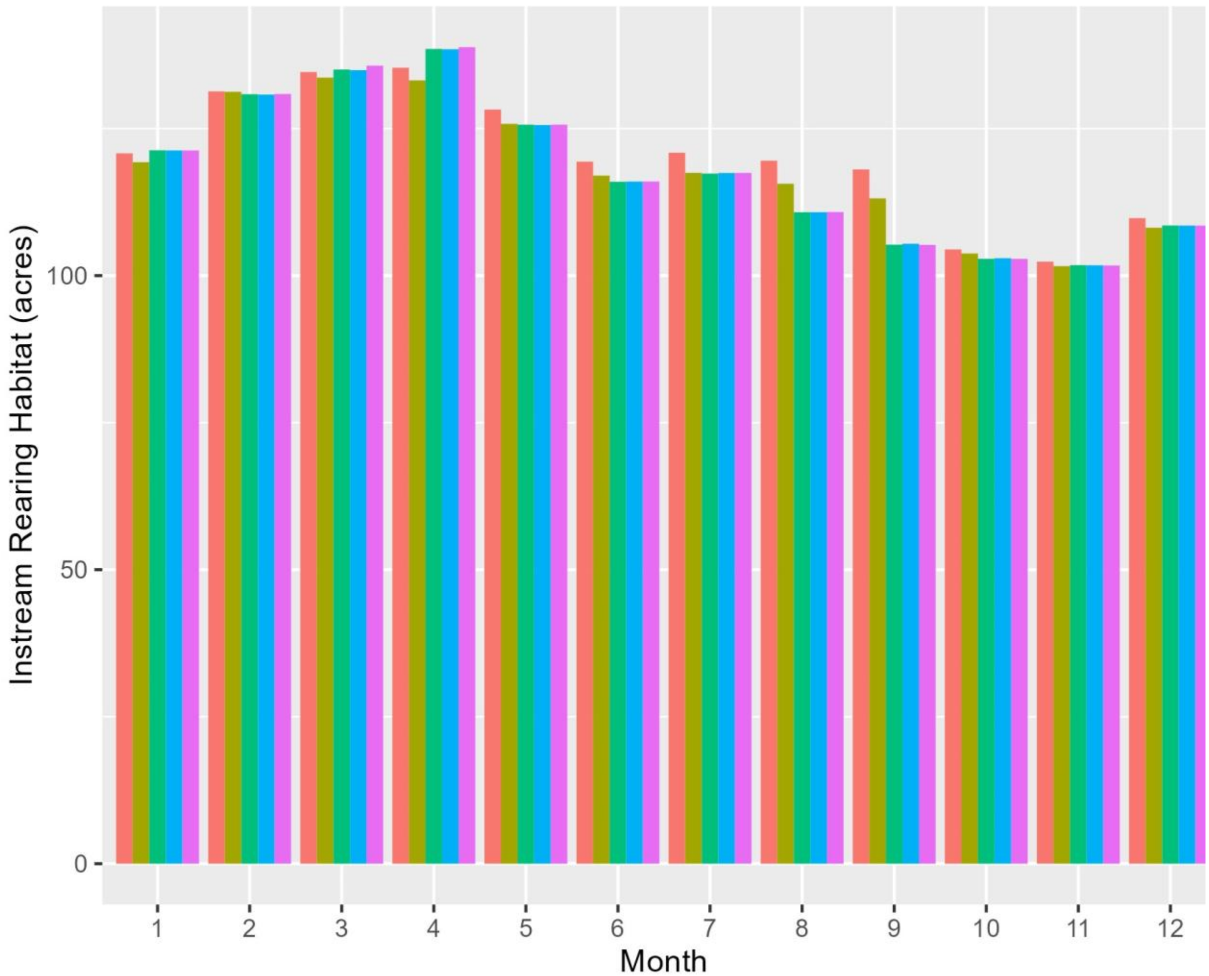
Figure 4-55. San Joaquin River at Mossdale Bridge Daily Average Dissolved Oxygen (mg/L) for Water Years 2013–2023

4.5.3 Suitable Habitat

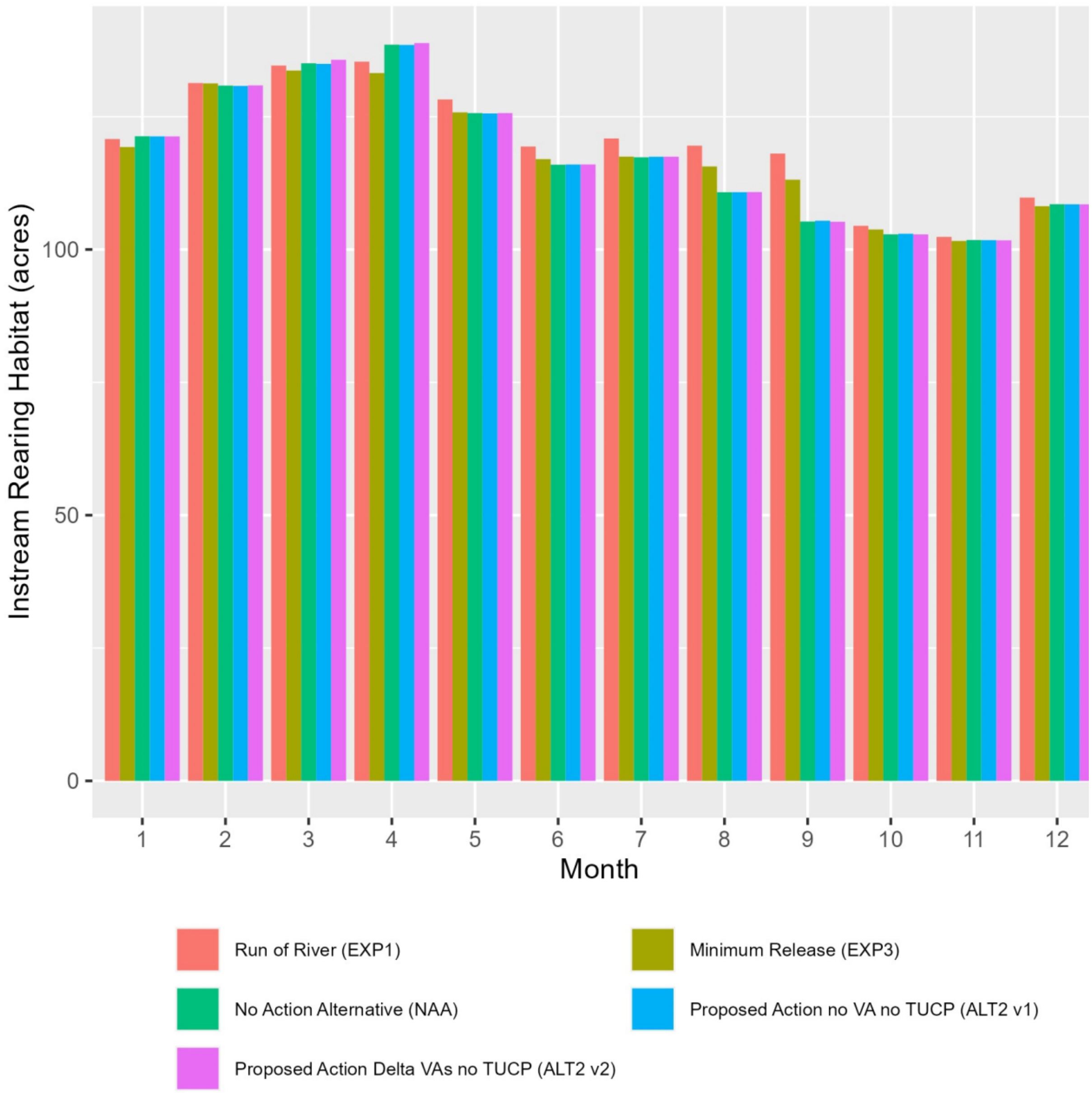
Steelhead and an experimental population of spring-run Chinook salmon use the San Joaquin River. Both species may be primarily rearing and migrating in March through May, but both may rear year-round.

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 4-56, Figure 4-57). Reduced instream rearing habitat availability in October through December corresponds to intermediate monthly flows relative to other months (Section 4.5.1, *Water Operations*). Increased floodplain habitat availability in February through April corresponds to increased monthly flows.

a)

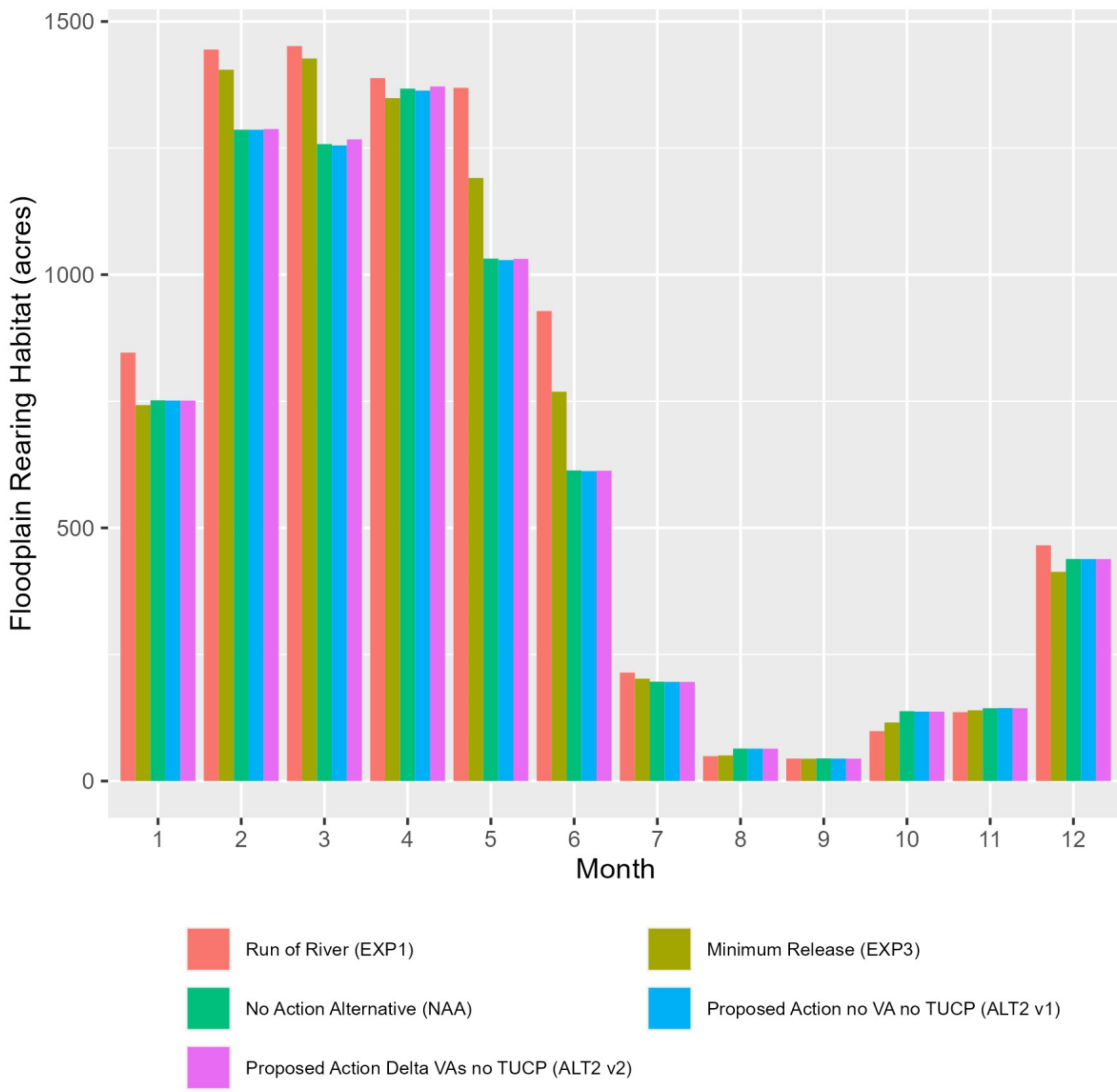

Instream Rearing Habitat (acres)
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
Month

b)



Values represent means across CalSim Water Years.

Figure 4-56. Estimated instream rearing habitat for juvenile spring-run Chinook salmon (a) and steelhead (b) in the San Joaquin River



Values represent means across CalSim Water Years.

Figure 4-57. Estimated floodplain rearing habitat for juvenile spring-run Chinook salmon and steelhead in the San Joaquin River

4.6 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 (GILL 1994). Figure 4-58 and Figure 4-59 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.

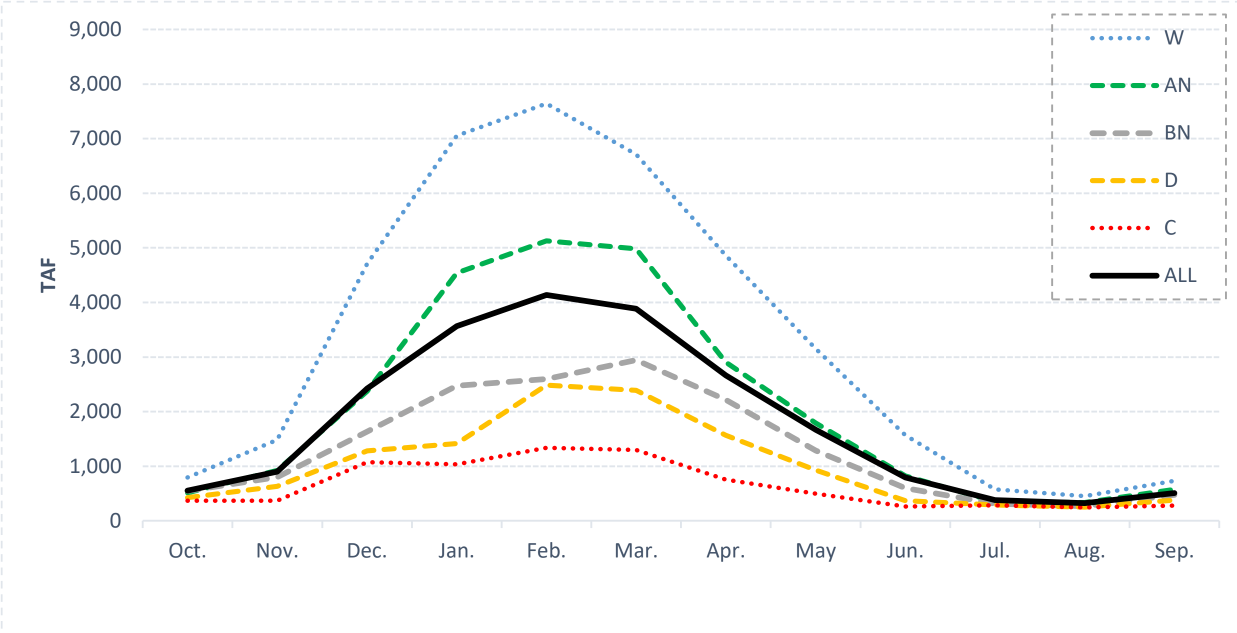


Figure 4-58. Inflows to the Delta from Central Valley by Month and Water Year Type (EXP1)

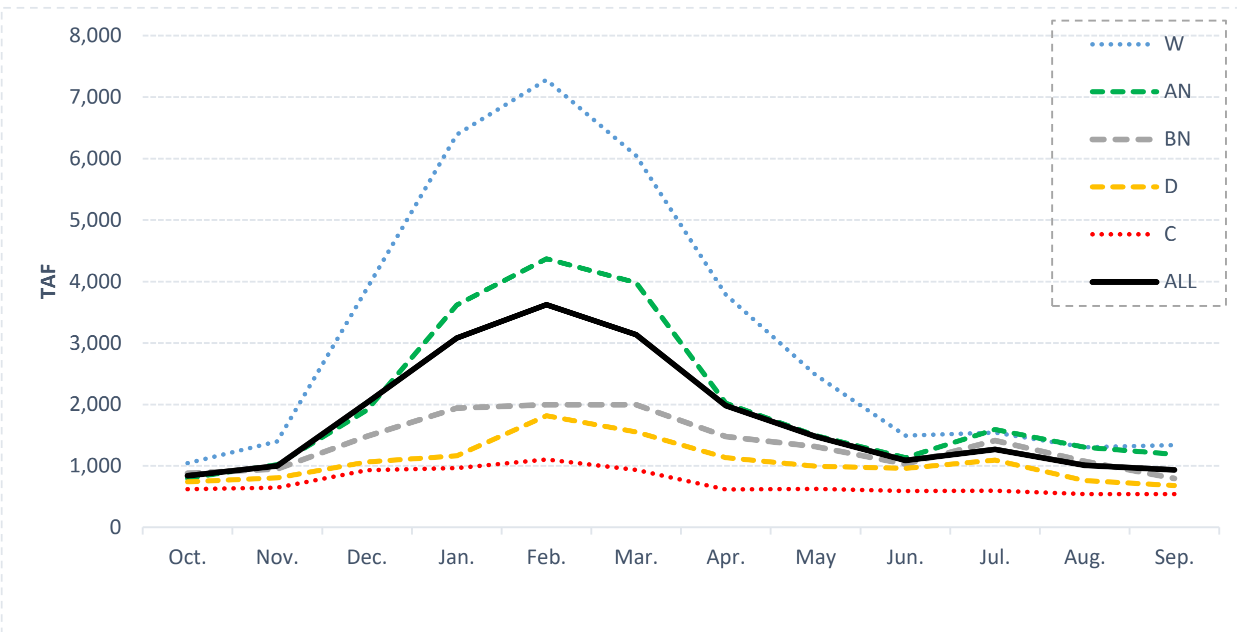


Figure 4-59. Inflows to the Delta from Central Valley by Month and Water Year Type (Proposed Action)

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 (California Department of Water Resources 2013). Figure 4-60 shows a simplified analytical topology.

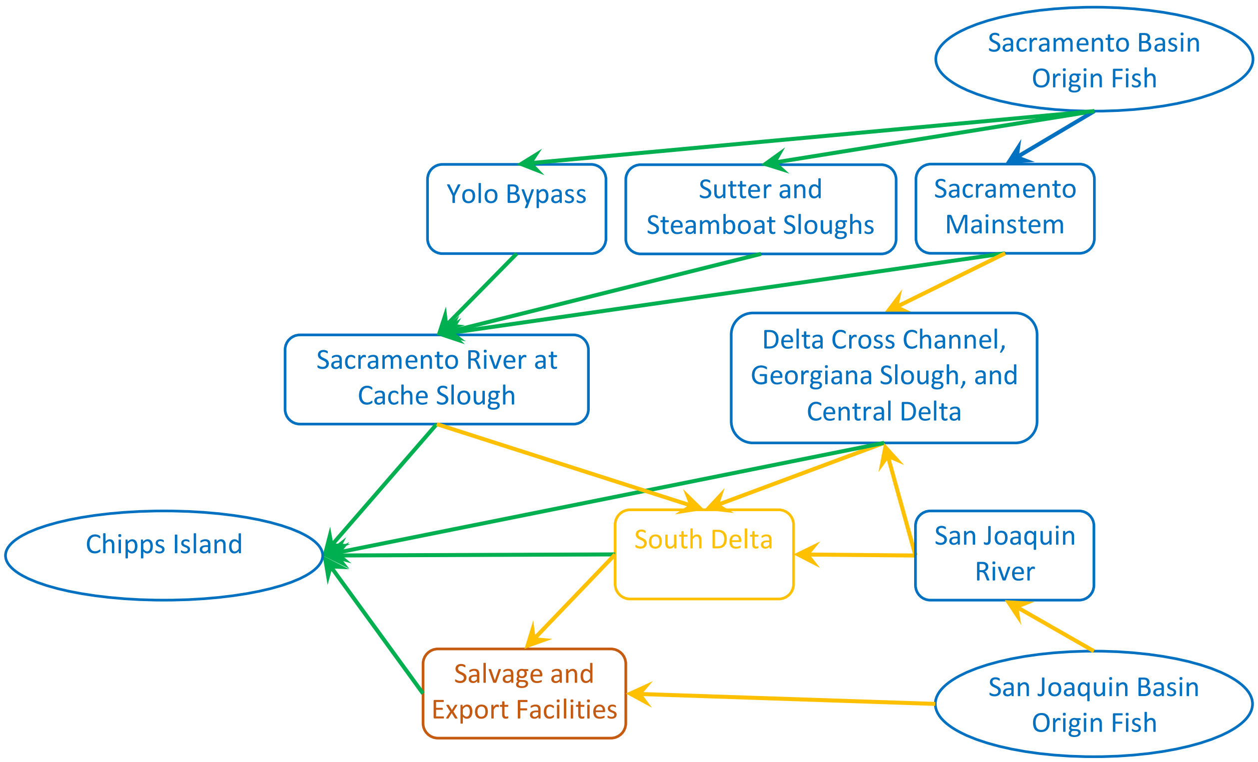


Figure 4-60. Delta Regions and Analytical Topology

The measurement of combined flows on Old and Middle rivers 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 4-61 shows key locations in the Delta.

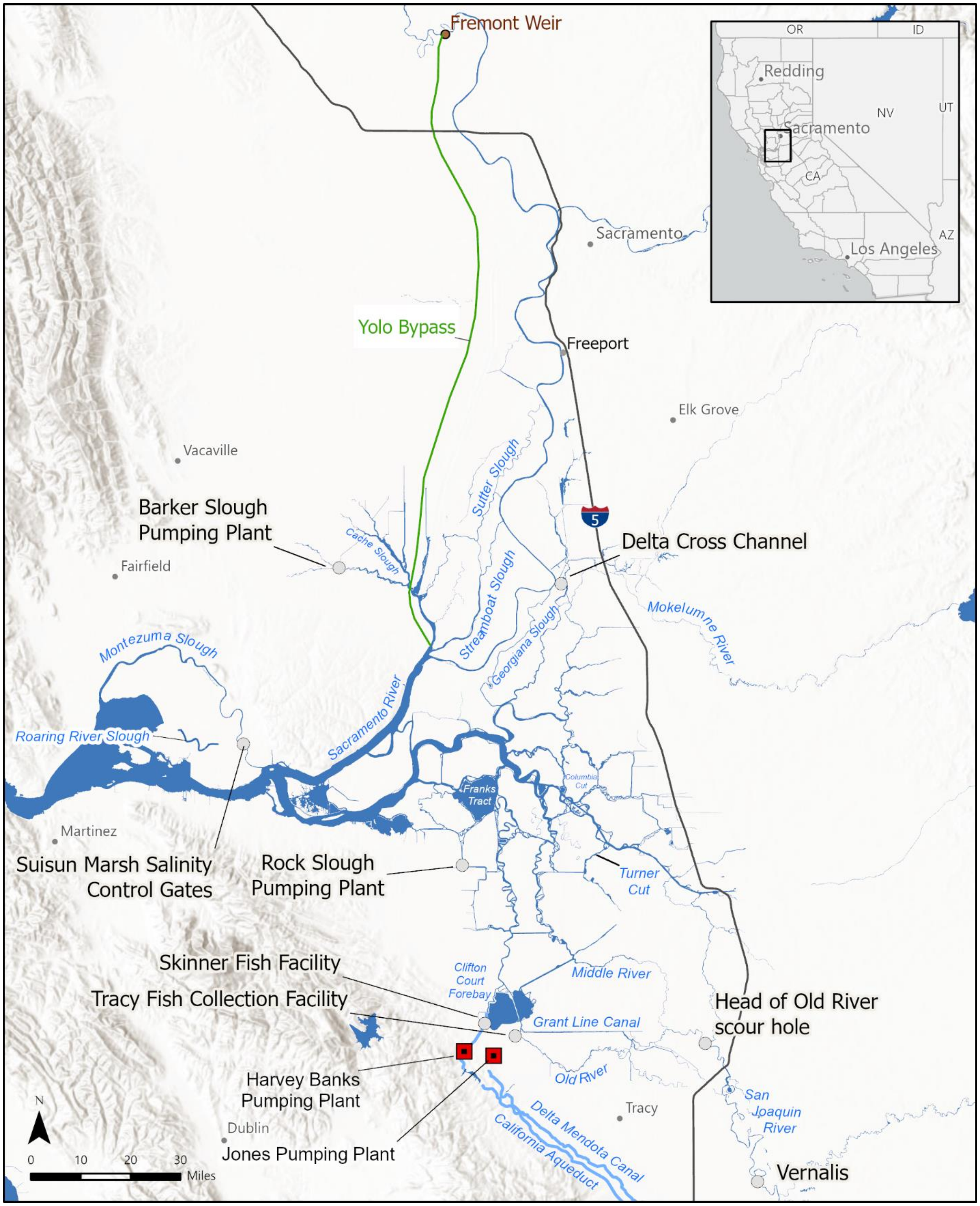


Figure 4-61. Referenced Delta Facilities and Landmarks

4.6.1 Water Operations

Figure 4-62 shows average monthly inflows to the Delta from the Sacramento River at Freeport for the EXP1, EXP3, NAA, Alt2 v1, and Alt2 v2 scenarios.

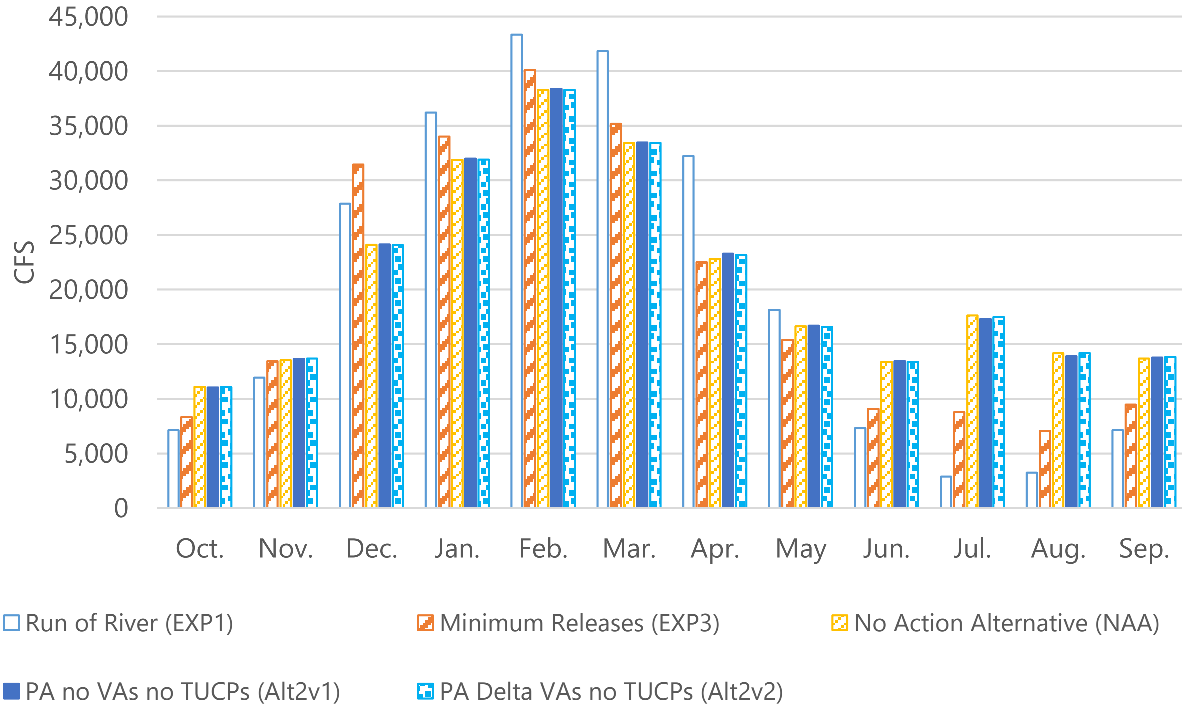


Figure 4-62. Sacramento River at Freeport Monthly Flows, All Water Year Types

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 4-63 shows average inflow flow through the Yolo Bypass.

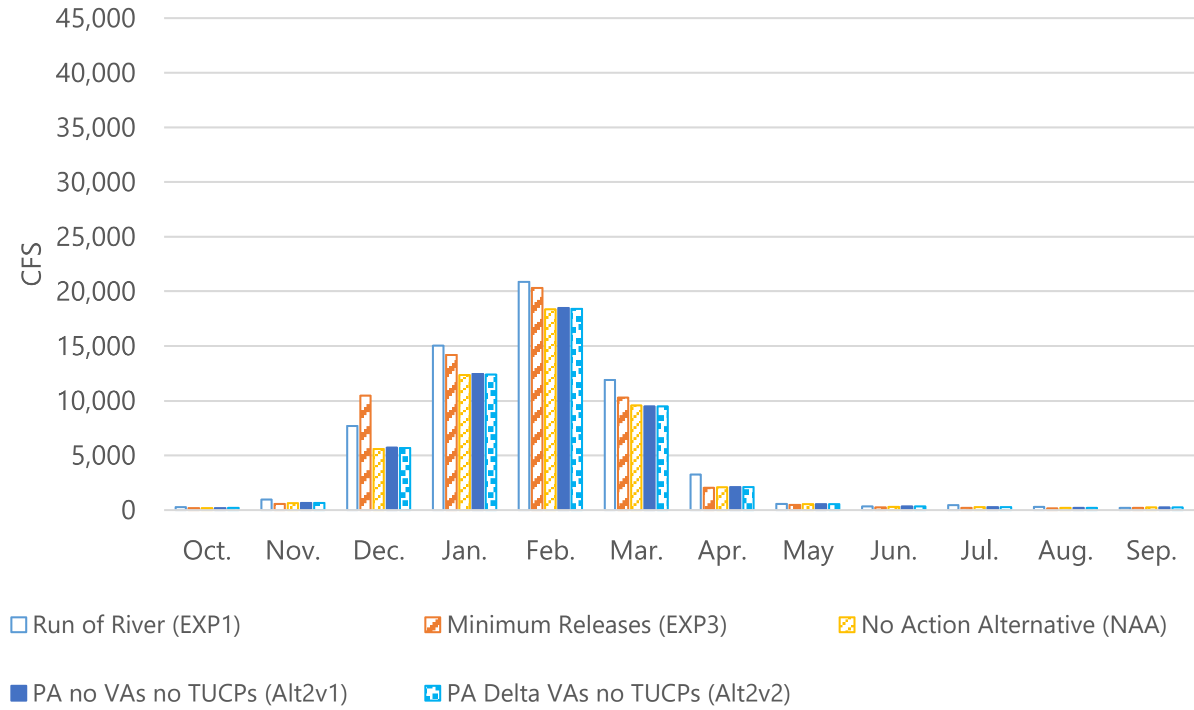


Figure 4-63. Flow through Yolo Bypass Monthly Flows, All Water Year Types

Yolo Bypass inflows can occur in any year type but are more common in Above Normal and Wet Years. The Minimum Release scenario, the No Action scenario and the Proposed Action phases include the proposed operation of the "Big Notch" on Fremont Weir. Figure 4-64 shows inflow from the San Joaquin River at Vernalis.

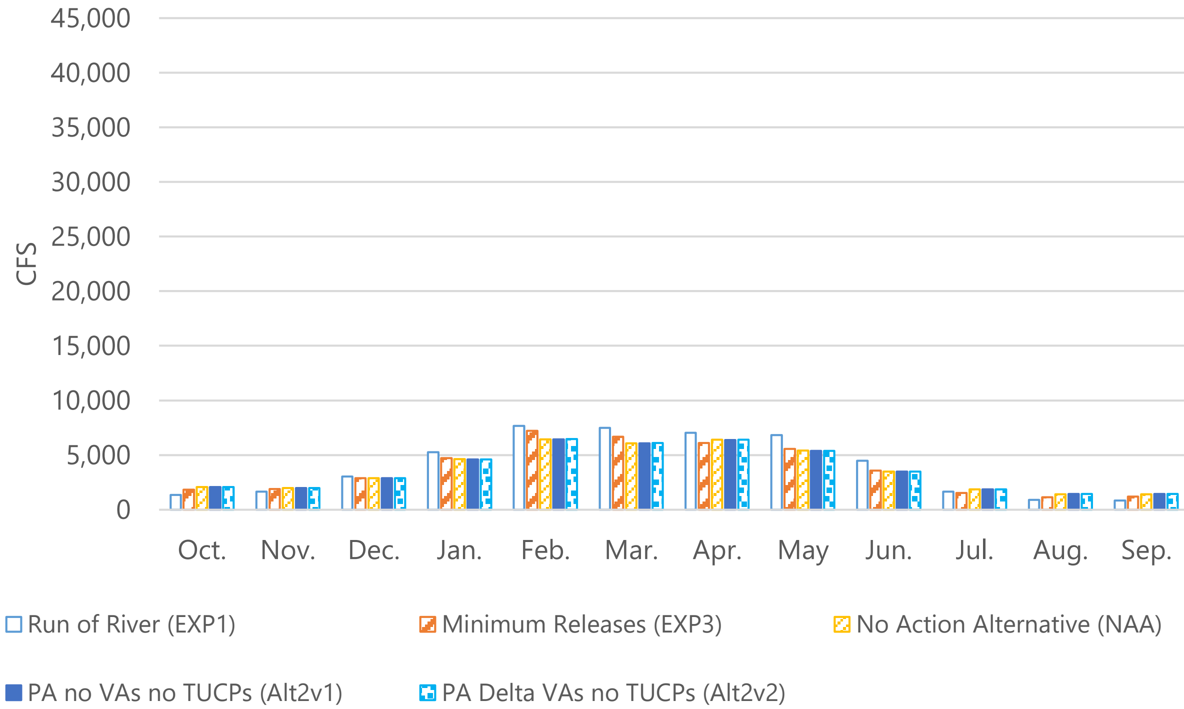


Figure 4-64. San Joaquin River at Vernalis Monthly Flows, All Water Year Types

Wet year flows are nearly twice the flows in Below Normal years. Figure 4-65 shows inflow from the Mokelumne River.

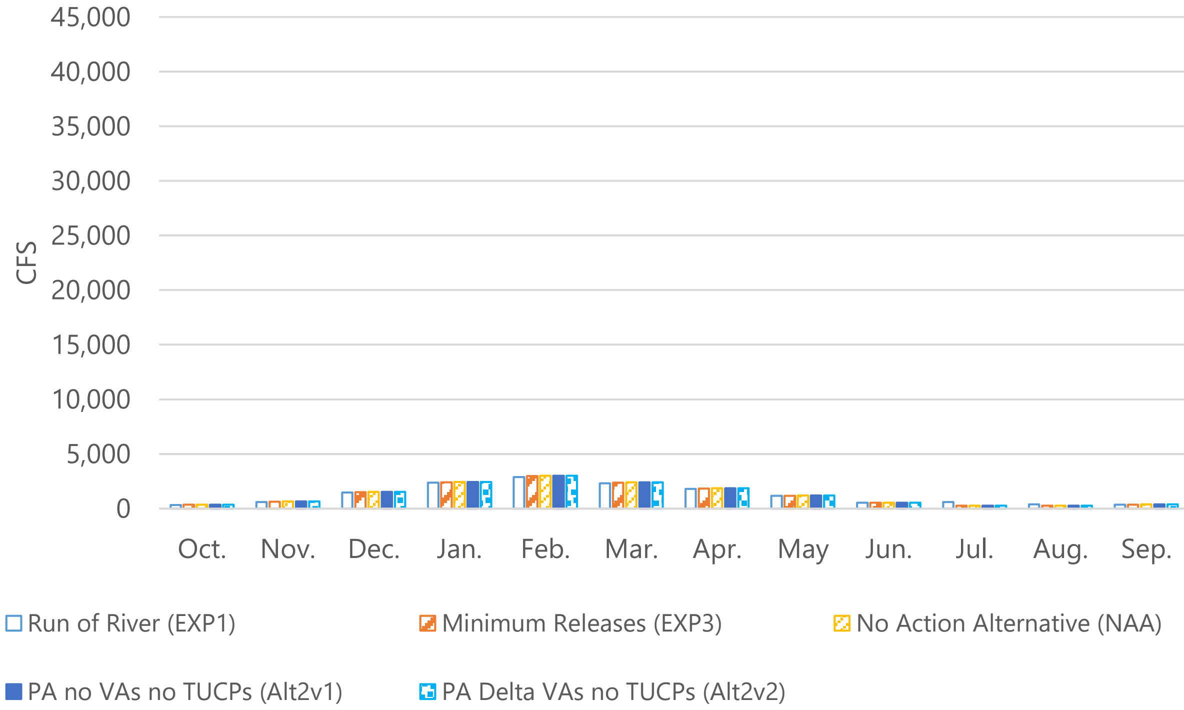


Figure 4-65. Mokelumne River Monthly Flows, All Water Year Types

Flows are identical between scenarios because the Mokelumne is not a CVP nor SWP stream. Figure 4-66 shows combined flow on Old and Middle Rivers (OMR).

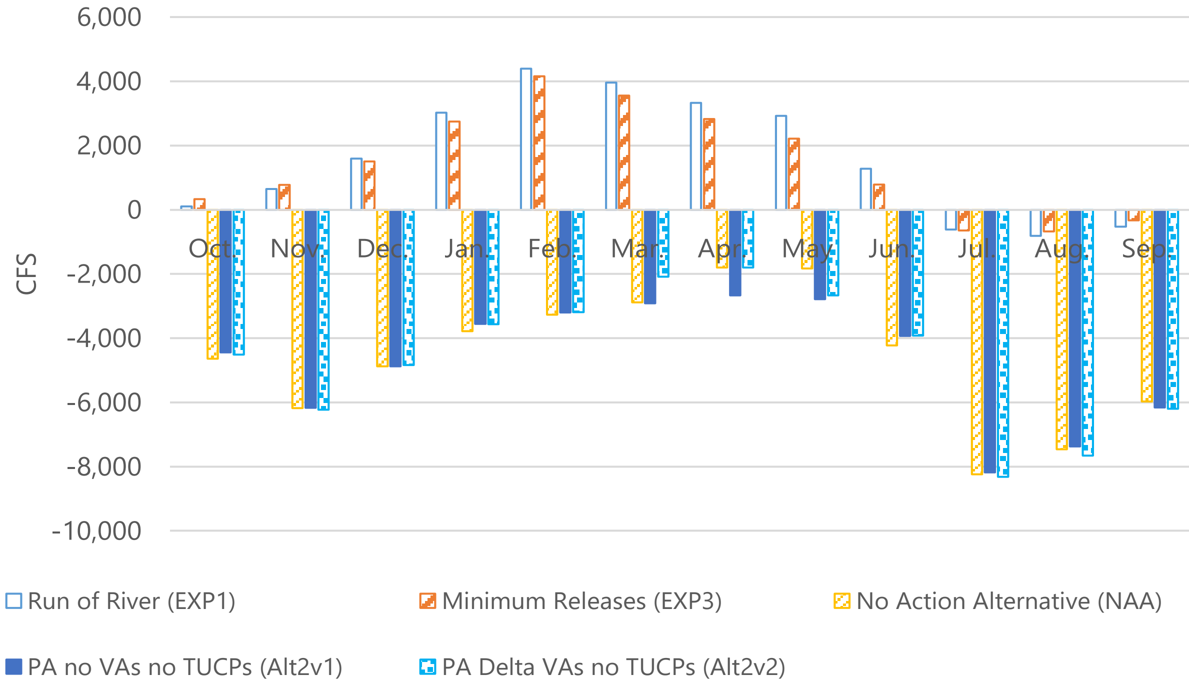


Figure 4-66. Old and Middle River Combined Monthly Flows, All Water Year Types

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 4-67 shows the resulting Delta outflow.

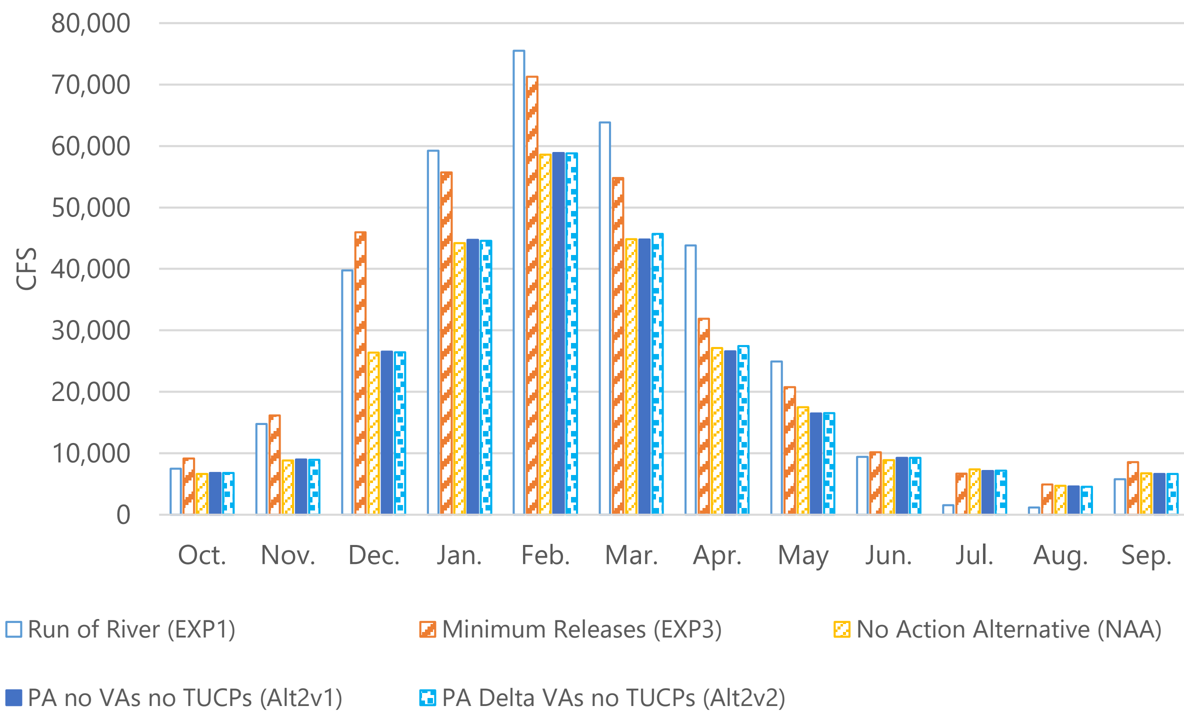


Figure 4-67. Delta Monthly Outflow, All Water Year Types

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 phases is approximately one half compared to the Run of the River scenario. ESA requirements increase Delta outflow from December through May above D-1641.

Figure 4-68 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.

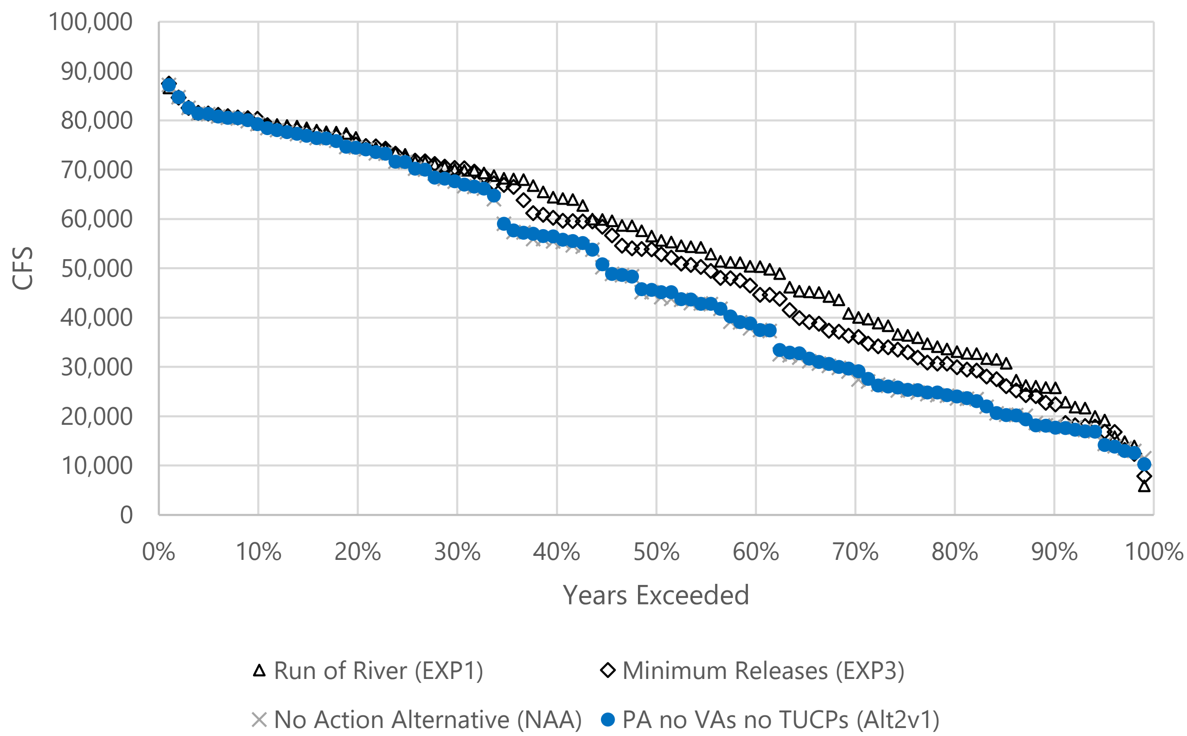


Figure 4-68. Sacramento River at Freeport Annual Peak Flow Frequency

Figure 4-69 shows peak annual flows (monthly average) at Vernalis. Flows at Vernalis are correlated with San Joaquin origin salmonid survival.

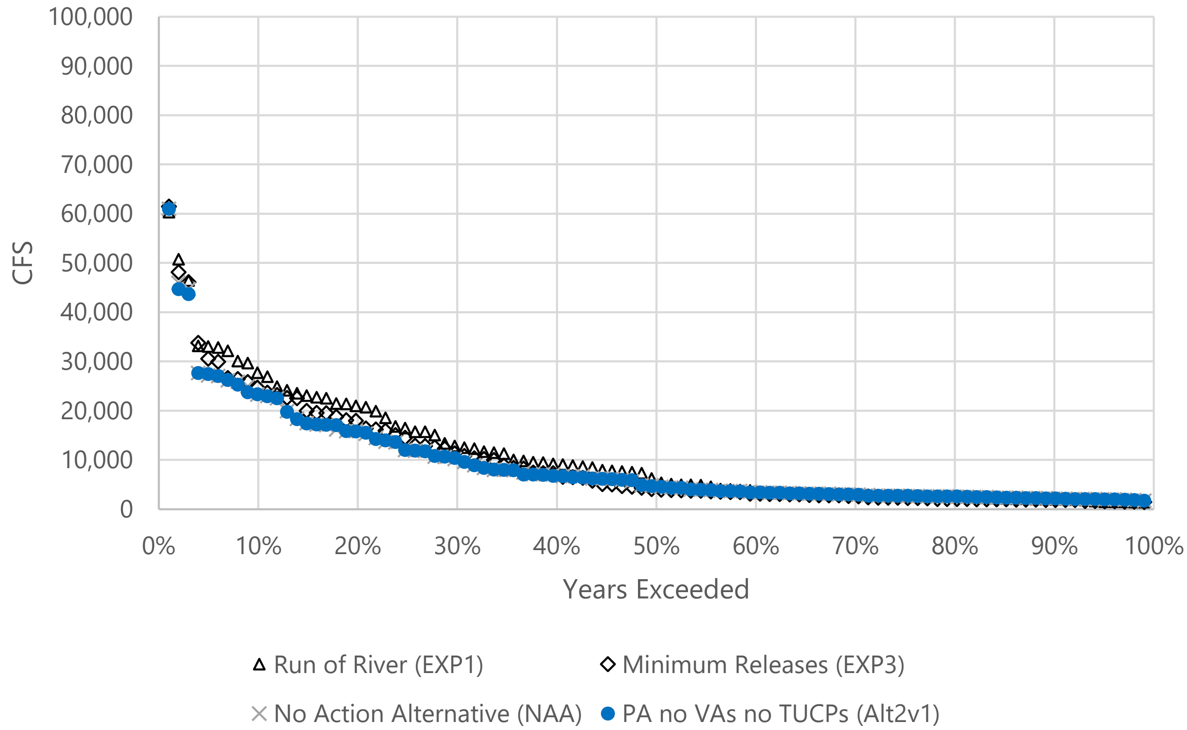


Figure 4-69. San Joaquin River at Vernalis Annual Peak Flow Frequency

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

4.6.2 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 4-70 shows water temperatures at Prisoners Point along the San Joaquin River.

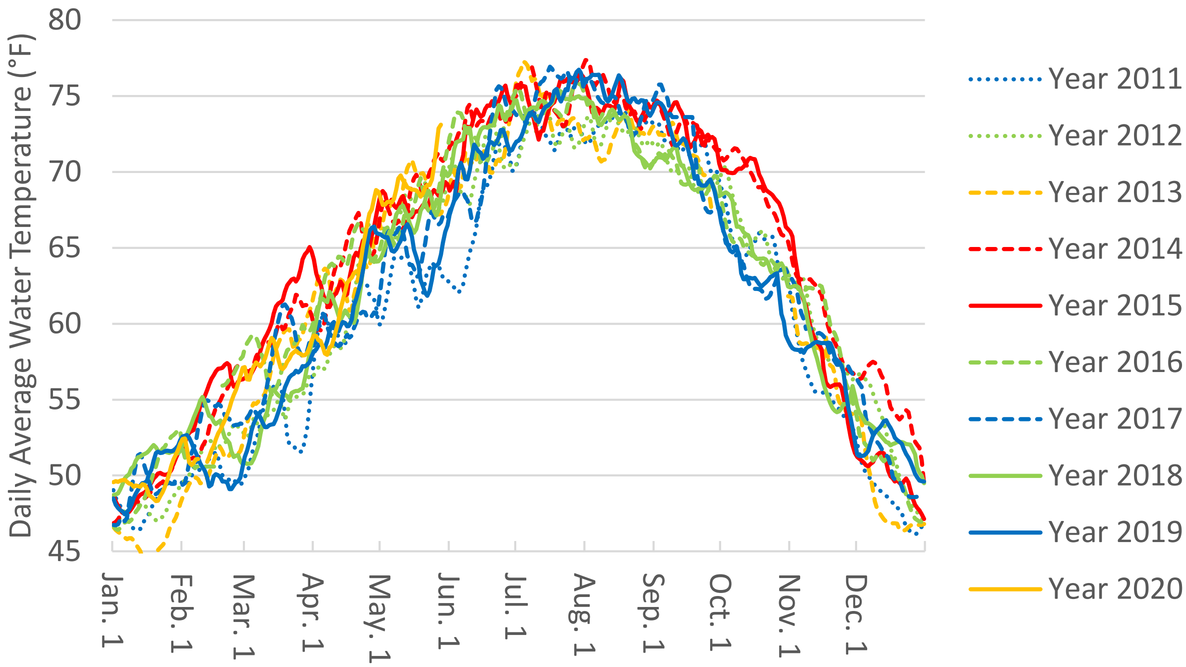


Figure 4-70. Historical Water Temperatures at Prisoners Point

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 4-71 shows temperatures at Port Chicago, which is between Grizzly and Honker Bays, around 67 km from the Golden Gate Bridge. Figure 4-72 and Figure 4-74 show daily average water temperatures for Prisoners Point and Old River at Franks Tract, respectively. Figure 4-73 and Figure 4-75 show daily average dissolved oxygen for Prisoners Point and Old River at Franks Tract, respectively.

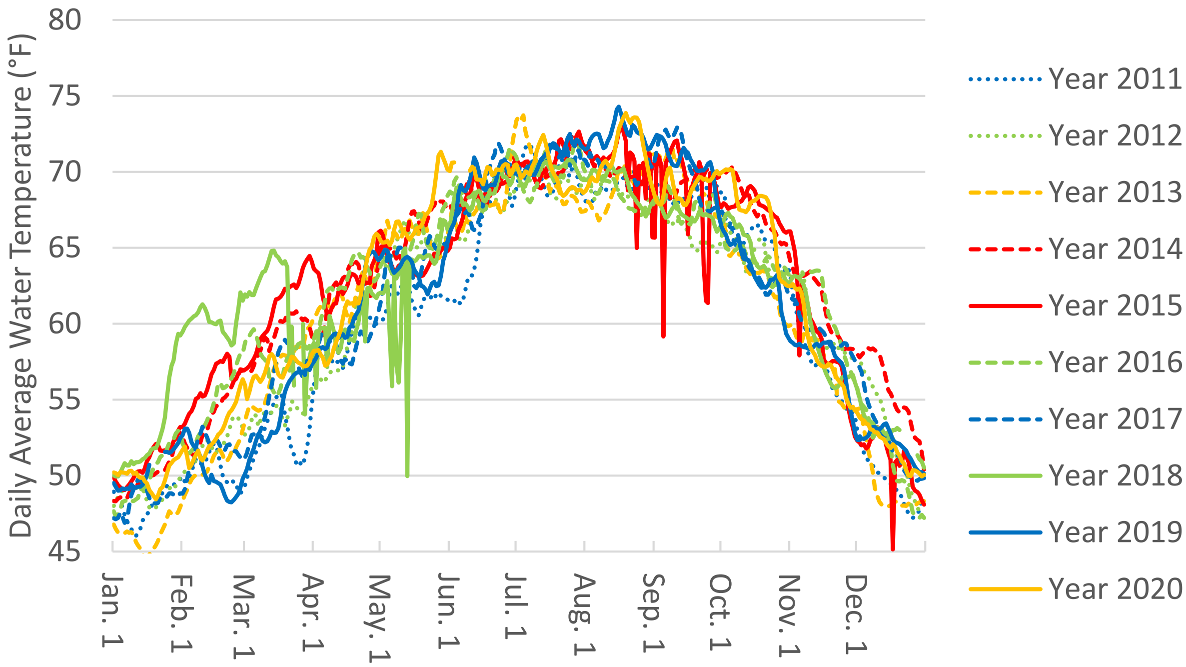


Figure 4-71. Historical Water Temperatures at Port Chicago

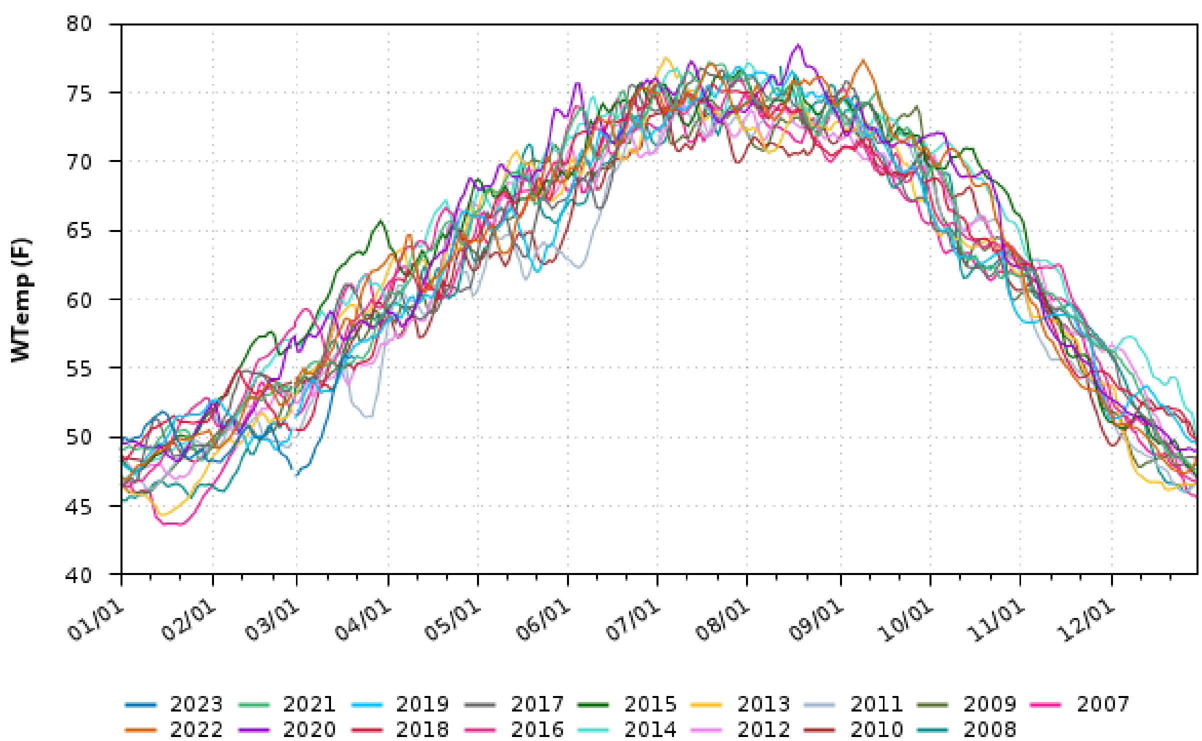


Figure 4-72. Prisoners Point Daily Average Water Temperature (°F) for Water Years 2007–2023

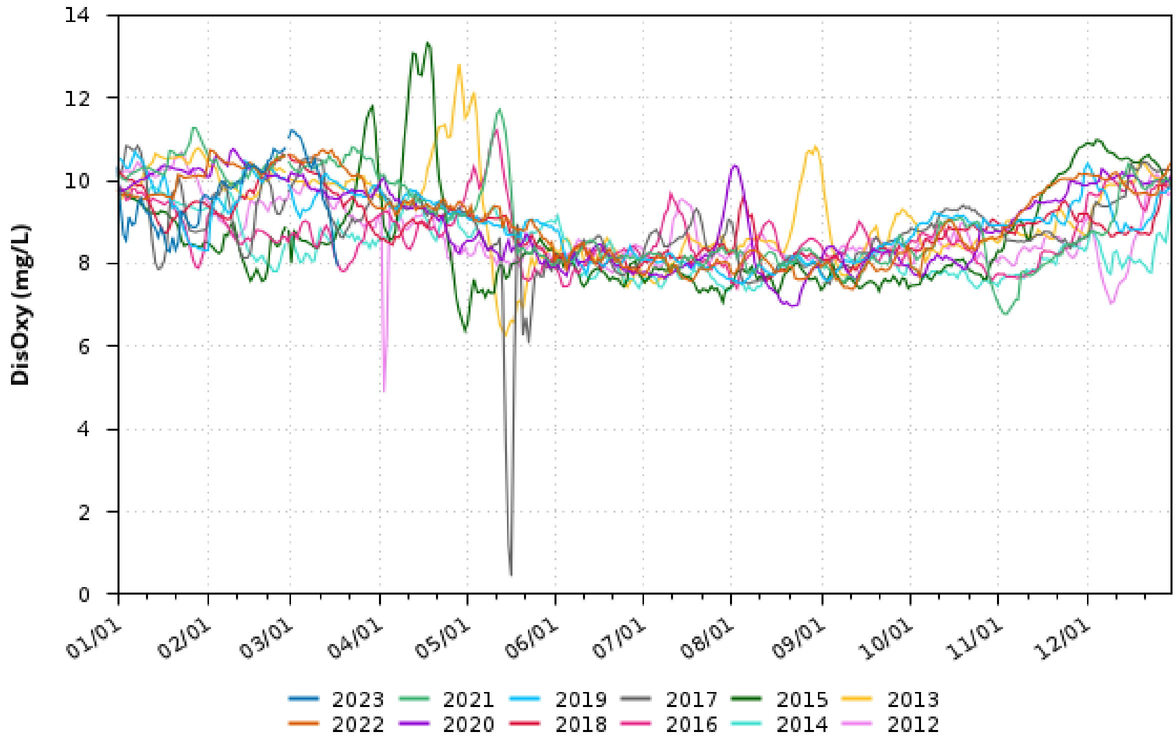


Figure 4-73. Prisoners Point Daily Average Dissolved Oxygen (mg/L) for Water Years 2013–2023

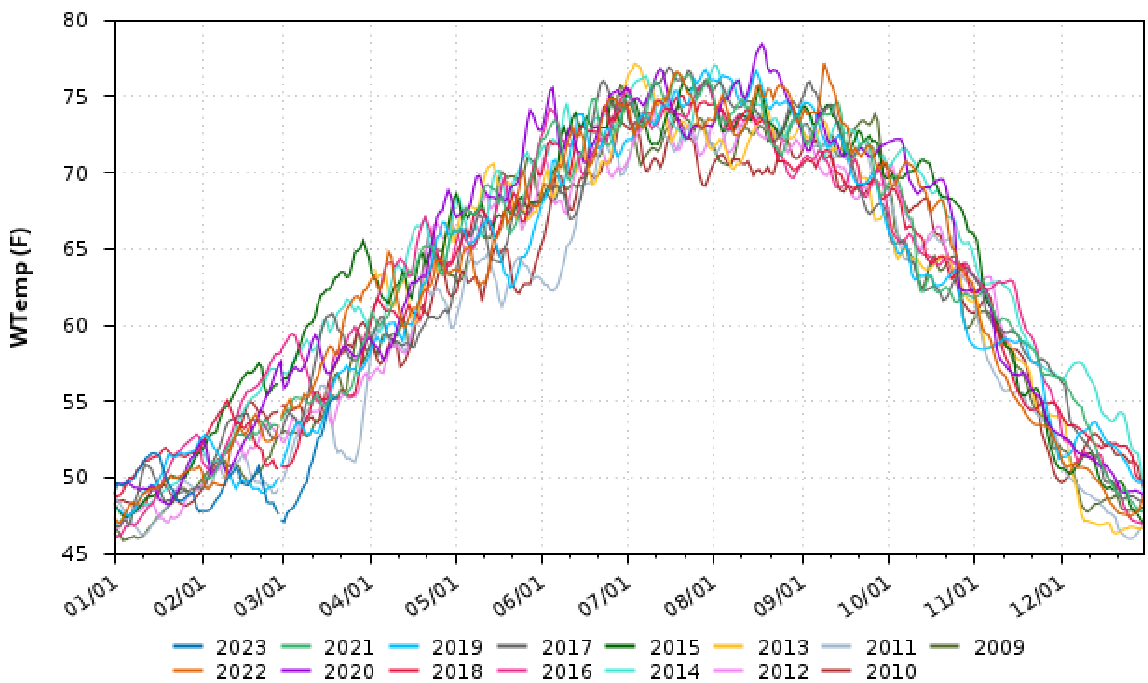


Figure 4-74. Old River at Franks Tract Daily Average Water Temperature (°F) for Water Years 2009–2023

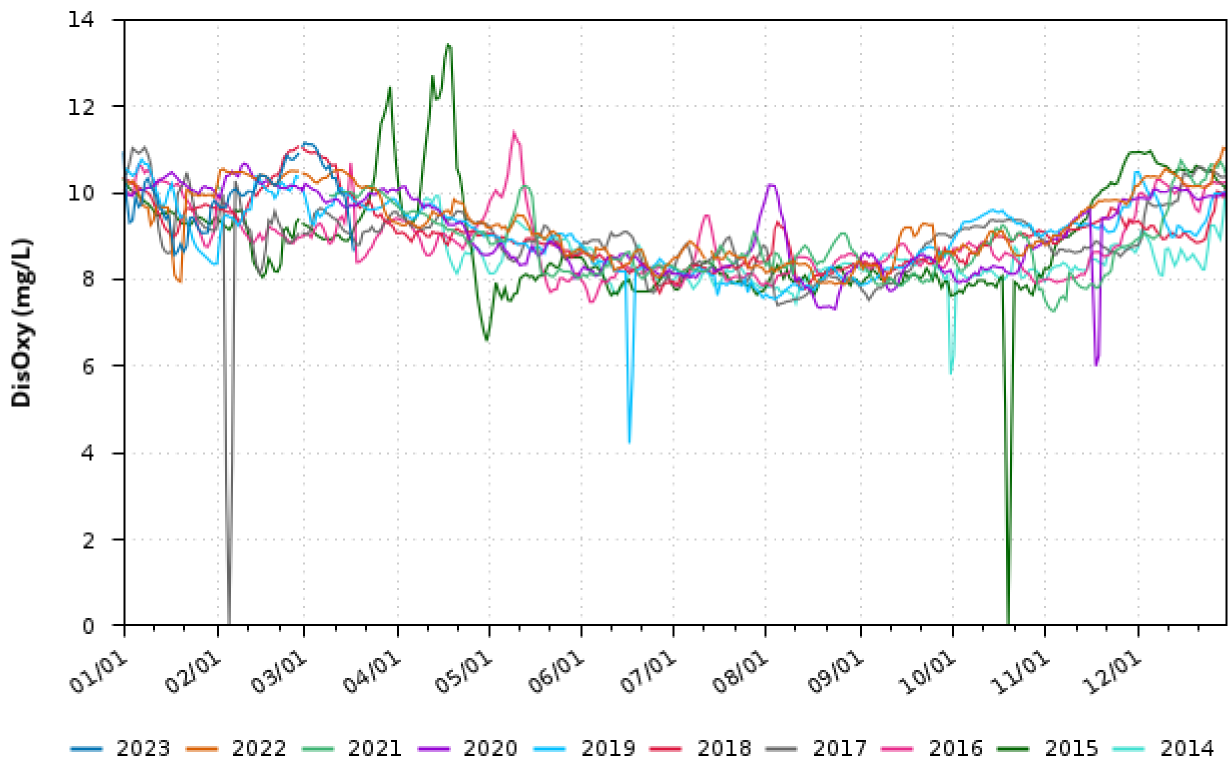


Figure 4-75. Old River at Franks Track Daily Average Dissolved Oxygen (mg/L) for Water Years 2014–2023

4.6.3 Suitable Habitat

Chinook salmon, green 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 4-76 shows an example for the month of March.

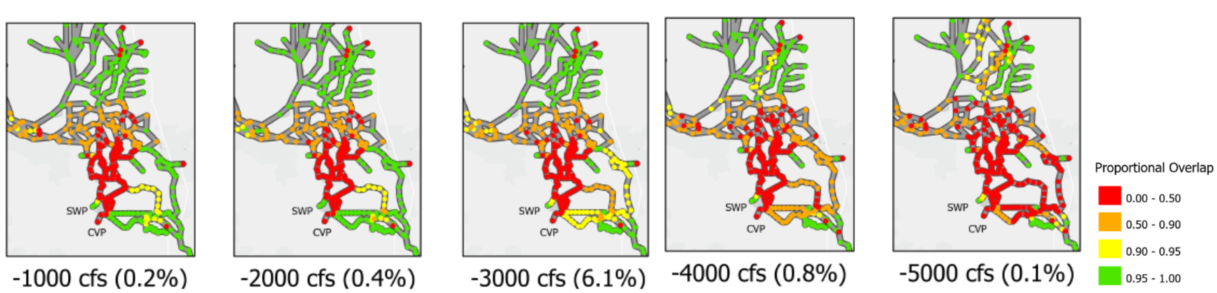


Figure 4-76. No Action March Proportional Overlap with and without Exports

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 4-77 shows the location of X2 under the EXP1, EXP3, NAA, Alt2 v1, and Alt2 v2 scenarios.

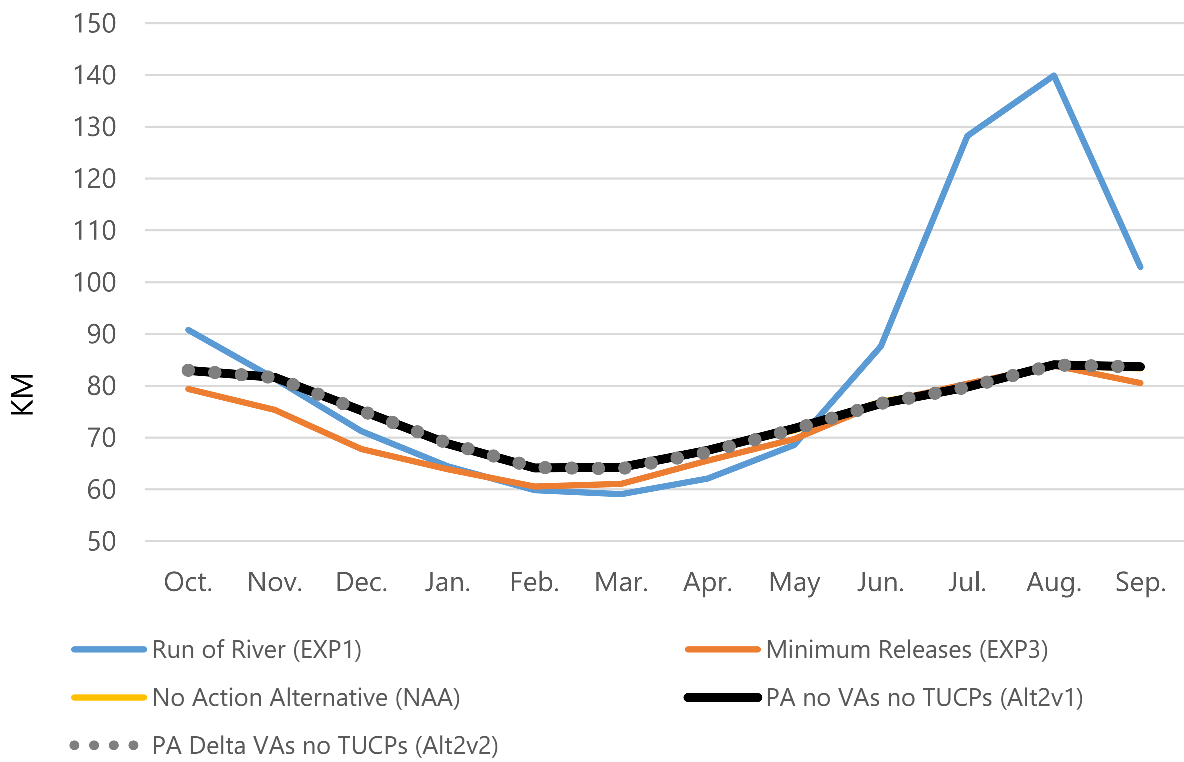


Figure 4-77. Location of X2

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.

4.7 References

California Department of Water Resources. 1994. *California Water Plan Update, Volume 1, Bulletin 160-93*. October 1994. Sacramento, CA.

California Department of Water Resources. 2013. *California Water Plan Update, Volume 2, Regional Reports*. California Department of Water Resources.

Gill S., E. Rodriguez, and M. Tompkins. 2022. DSMhabitat: Estimate Spawning and Rearing Habitat. R package version 1.0. Available: https://cvpia-osc.github.io/DSMhabitat/.