BUREAU OF RECLAMATION

Long-Term Operation – Initial Alternatives

Appendix B – Seasonal Water Operations and Ecosystem Analyses

Central Valley Project, California

Interior Region 10 – California-Great Basin

U.S. Department of the Interior

September 2022

Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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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 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 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 D, *Seasonal Operation Stressors on Aquatic Species*. Analyses included the following scenarios:

- Run of the River: Impaired inflows into CVP reservoirs that are passed downstream subject to the channel capacity of downstream reaches.
- D-1641: Operation of the CVP and SWP under the assignment of responsibilities for the 1995 Bay-Delta Water Quality Control Plan and contracts for water deliveries.
- No Action: 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.

A future biological assessment will evaluate a new Proposed Action once it is developed. 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 E - Exploratory Modeling provides the details. Simulation of the seasonal operation relied upon available modeling, CalSim II under 2035 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: 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
\+ 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.

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

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 (State Water Boards) 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 (M&I), 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 Central Valley Project Improvement Act (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 and the Hoopa Valley Tribe Chairman signed the U.S. Department of the Interior Record of Decision Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement/Environmental Impact Report (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 State Water Board issued an update to the Bay-Delta WQCP. In 1999 (revised in 2000), the State 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 State Water Board Resolution No. 2018-0059, the State 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 (FWS) and National Marine Fisheries Service (NMFS) released their biological opinions (BiOps) on Reclamation's and DWR's new proposed coordinated operations of the CVP and SWP. The updated BiOps 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 State Water Project (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 (CDFW) 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.

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3. Sacramento River

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

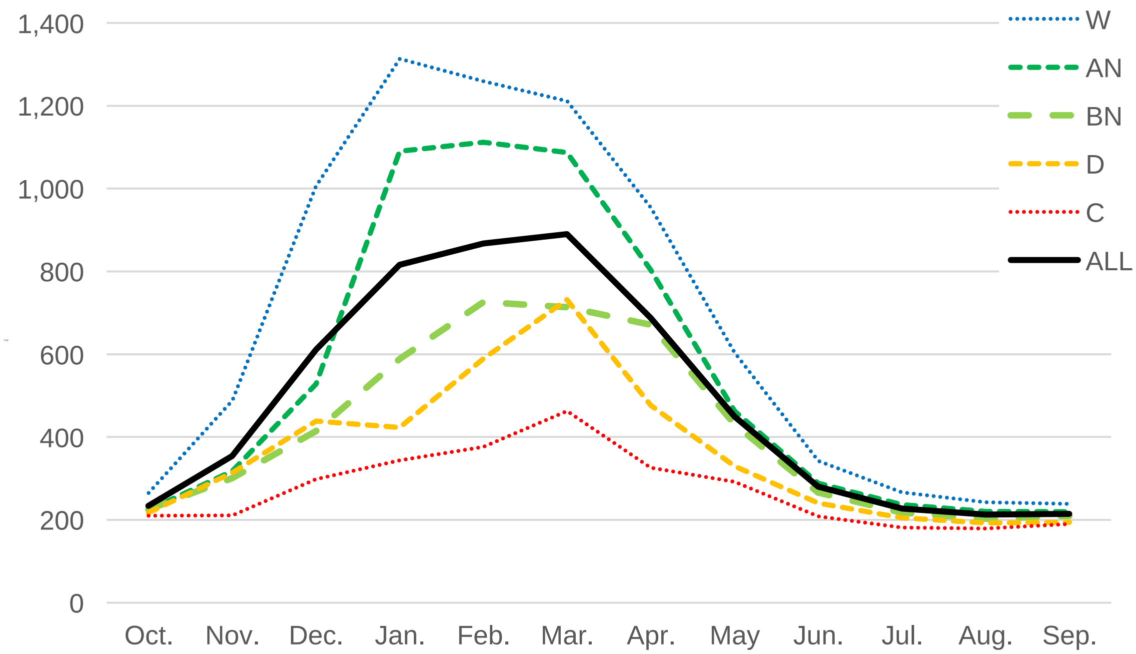

Figure 1. Inflow to Shasta Reservoir by Month and Water Year Type

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

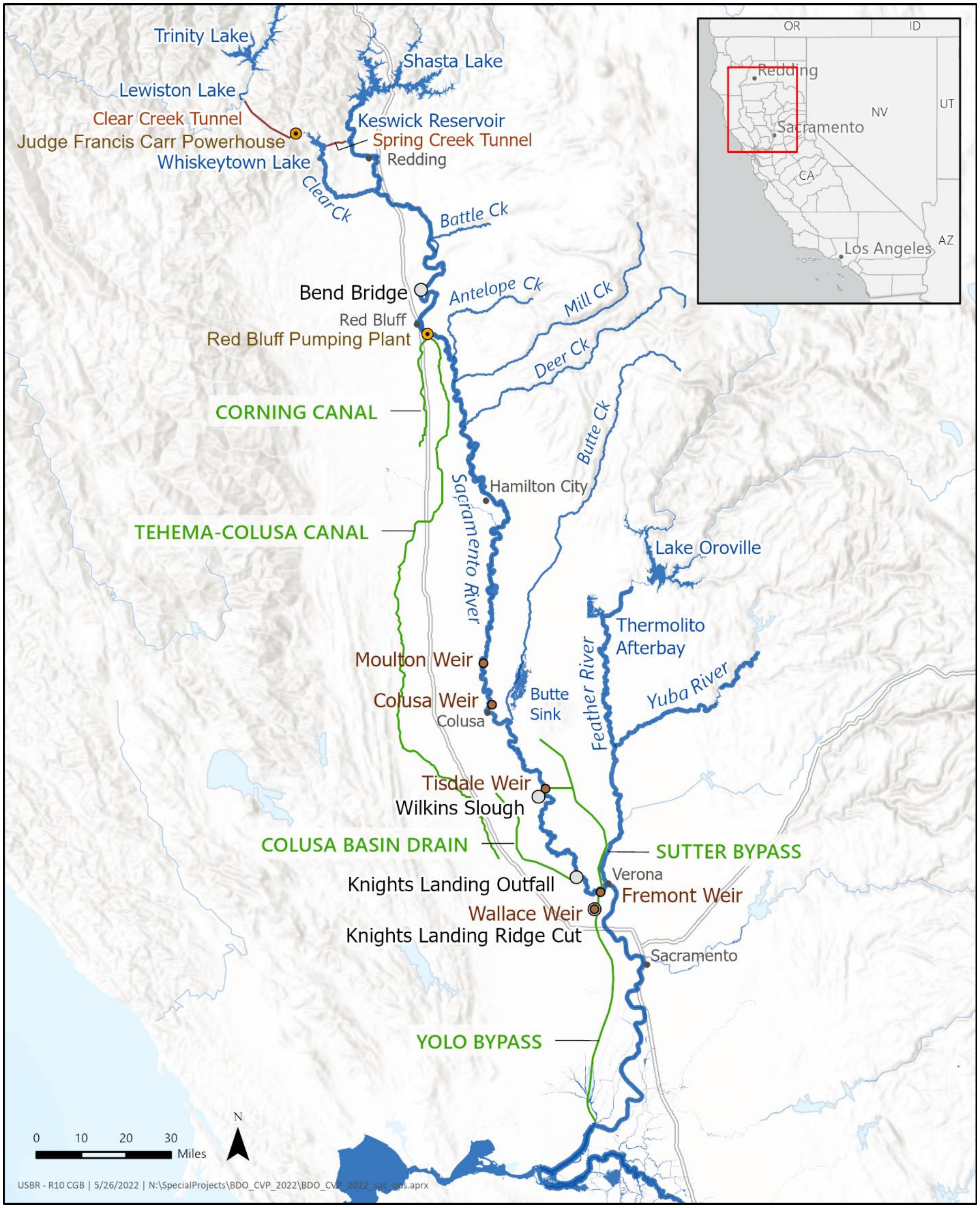

Figure 2. Sacramento River Watershed Water Operations Topology

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.

3.1 Water Operations

Figure 3 shows release from Keswick Dam for the “Run of the River”, D-1641, and No Action scenarios.

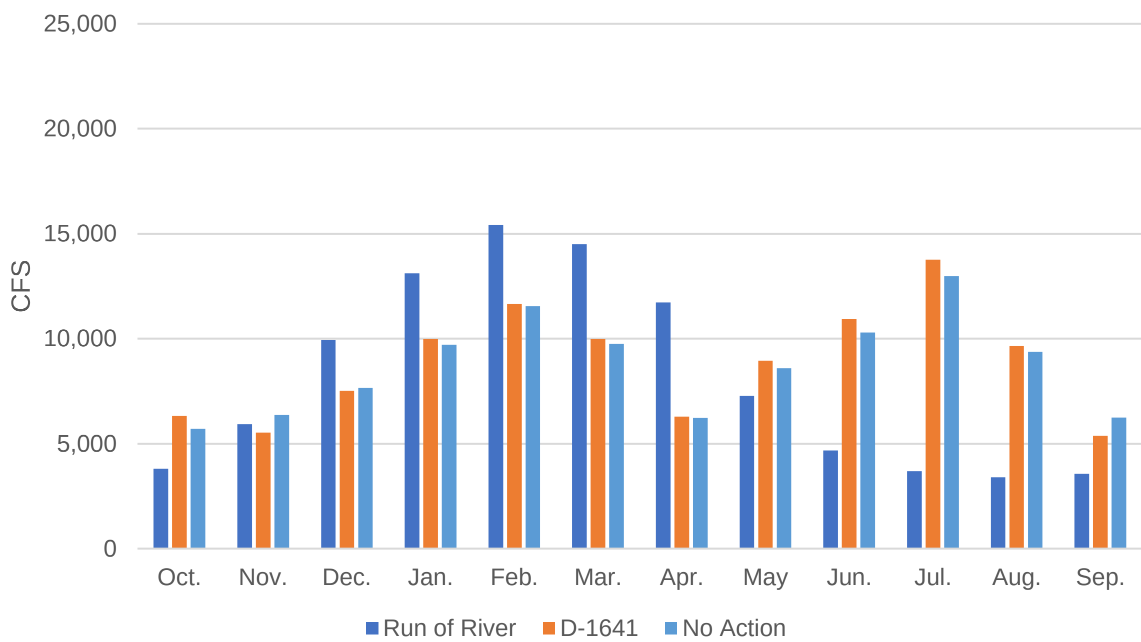

Figure 3. Sacramento River Flow below Keswick Dam Monthly Flows, All Water Year Types

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 the River and No Action scenarios, May flows in wet years are higher for

Run of the River than for No Action. In February, flows in critical years are higher for No Action than for D-1641.

Figure 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.

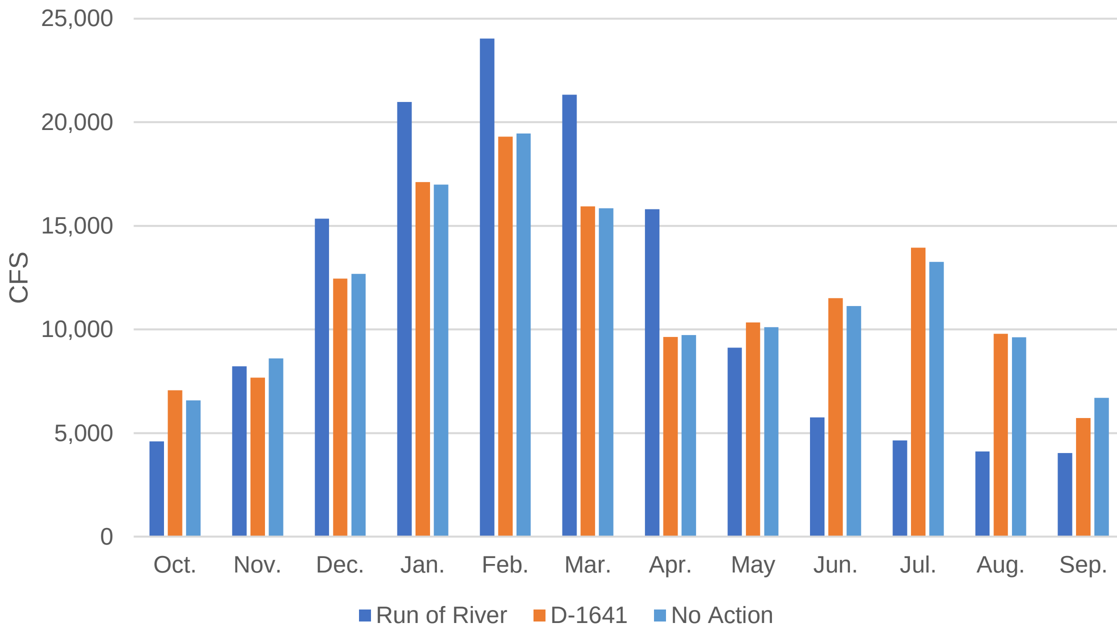

Figure 4. Sacramento River at Bend Bridge Monthly Flows, All Water Year Types

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 D-1641 and No Action scenarios year type, February flows in critical years are higher for No Action than for D-641. In comparing the three scenarios by year type, September flows in below normal years are higher for D-1641 than No Action.

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

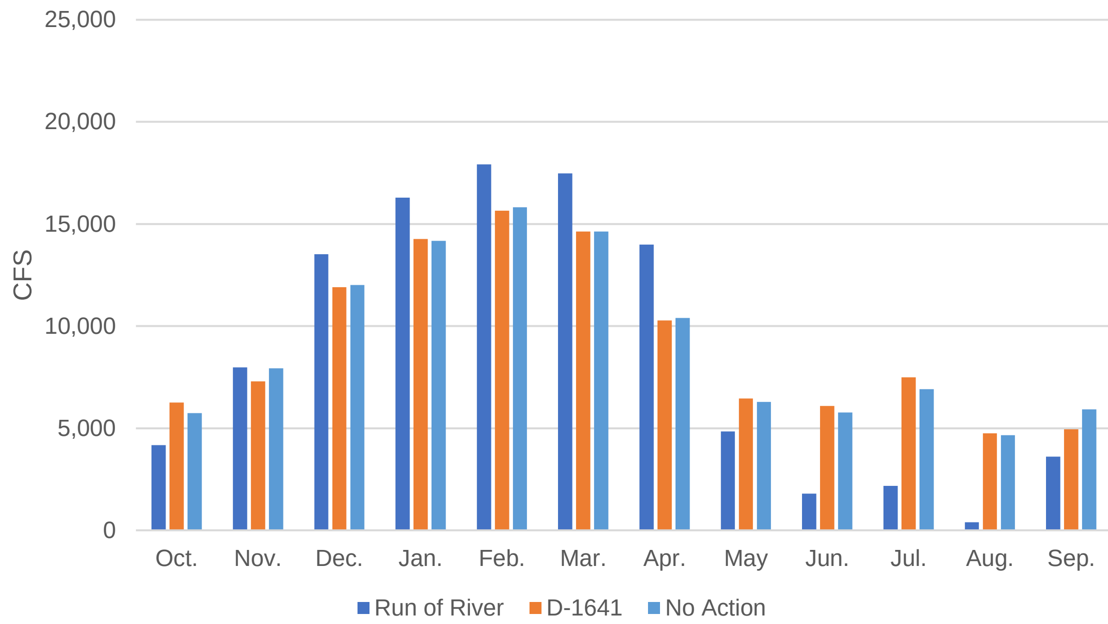

Figure 5. Sacramento River near Wilkins Slough Monthly Flows, All Water Year Types

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 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 D-1641 and No Action scenarios by year type, February flows in critical years are higher for No Action than for D-1641. In comparing the three scenarios by year type, September flows in below normal years are higher for D-1641 than No Action.

The U.S. Army Corps of Engineers directs the nondiscretionary operation of Shasta Reservoir to manage downstream flooding, including consideration of tributary inflows. Figure 6 shows peak annual flows (monthly average) at Bend Bridge, which is above flood diversions into the Sutter Bypass.

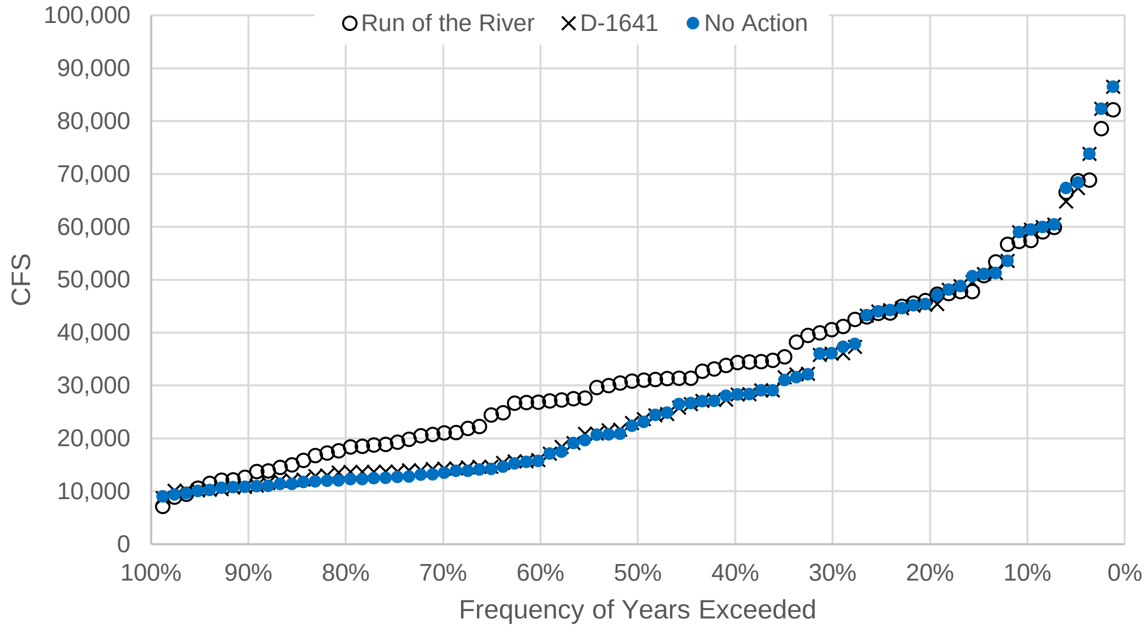

Figure 6. Sacramento River at Bend Bridge Annual Peak Flow Frequency

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 D-1641 and the No 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 7 shows peak flows at Wilkins Slough, below diversions into the Sutter Bypass.

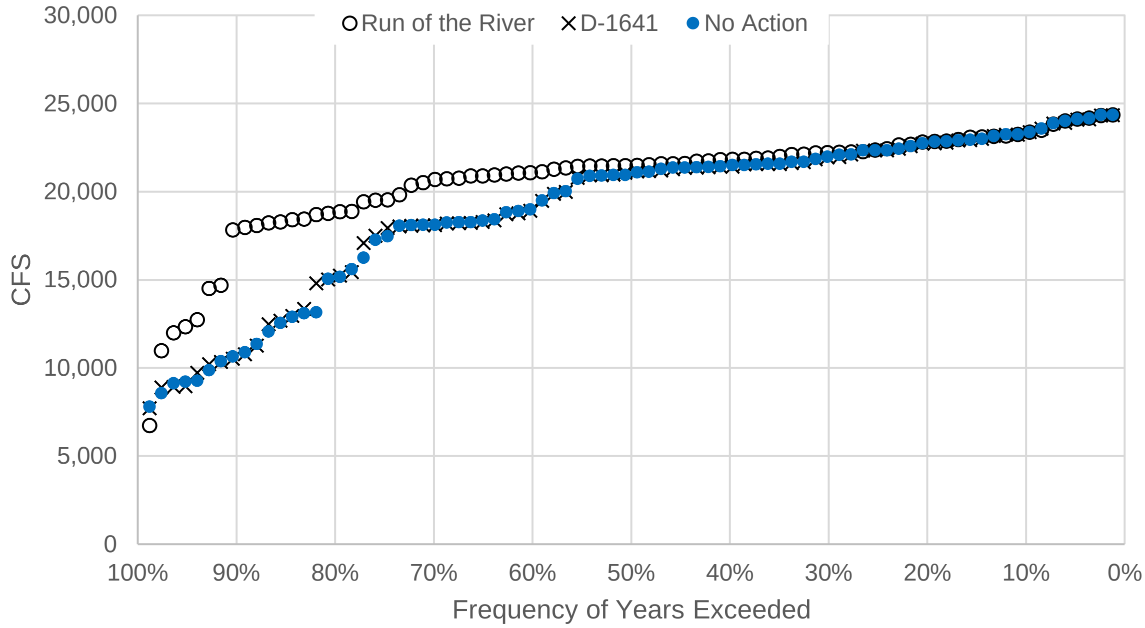

Figure 7. Sacramento River near Wilkins Slough Annual Peak Flow Frequency

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 8, *Delta*, below. Figure 8 shows Sacramento River flows at Verona.

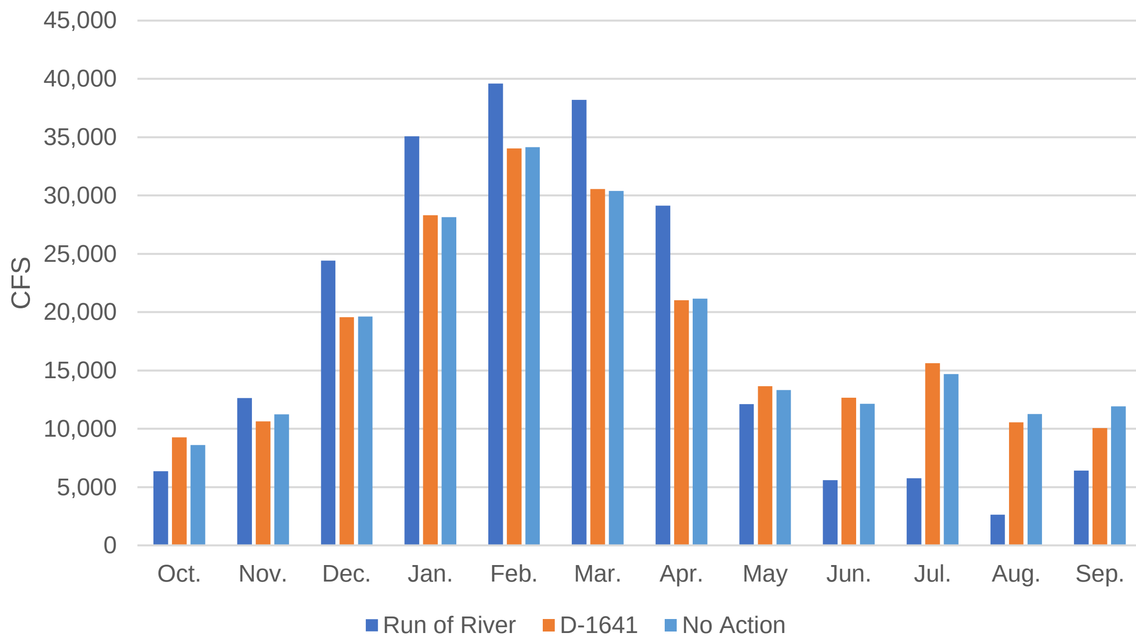

Figure 8. Sacramento River at Verona Monthly Flows, All Water Year Types

In comparing the three scenarios by year type, August flows in critical years are higher for D-1641 than No Action. Also, August flows in dry years are higher for D-1641 than No Action. In September, flows in below normal years are higher for D-1641 than No Action Flows below Verona are joined with flows from the American River and discussed in Section 8, *Delta*.

3.2 Water Temperatures

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 State 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 State Water Board may object to changes in the temperature compliance location. Figure 9 shows historical temperature compliance locations.

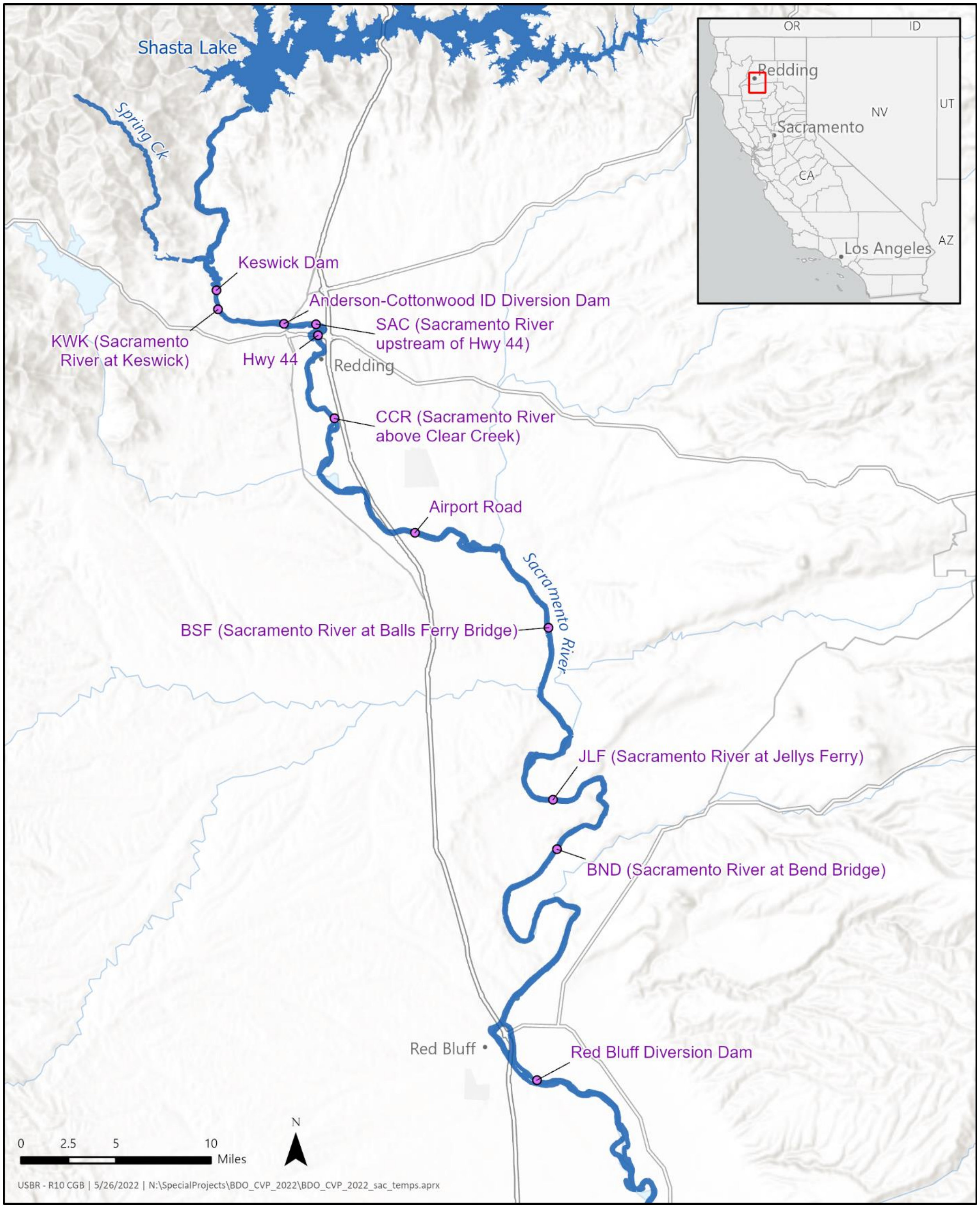

Figure 9. Historical Temperature Compliance Locations Used under 90-5

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 2035 central tendency climate change meteorology and CalSim II hydrology for the following scenarios:

- Run of the River: water temperatures released from Shasta are similar to the water temperatures flowing into Shasta reservoir. There are minor changes in storage that perturb the temperature of releases and buffer water temperatures.
- 56°F at Red Bluff: for the water operations scenario of D-1641, 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 using a Python wrapper to make writing computer programs easier by abstracting away the details of a subroutine's underlying implementation around the HEC-5Q temperature model 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.
- Tiered Temperature Management Strategy (Tiered Strategy): implementation of the 2020 ROD by targeting critical egg incubation life stages when Temperature Control Device configurations cannot achieve 53.5°F for the entire season. An analysis was performed using a Python wrapper around the HEC-5Q temperature model to optimize toward a target of 53.5°F at Clear Creek for the months of May through October; in years where the average October temperature was above 54°F after this optimization was completed, a second optimization was conducted to a target of 56°F in May, June, September, and October and 53.5°F in July and August.

Figure 10 shows monthly average of water temperatures below Red Bluff Diversion Dam for Run of the River, 56°F at Red Bluff Diversion Dam, and the Tiered Strategy across all water year types.

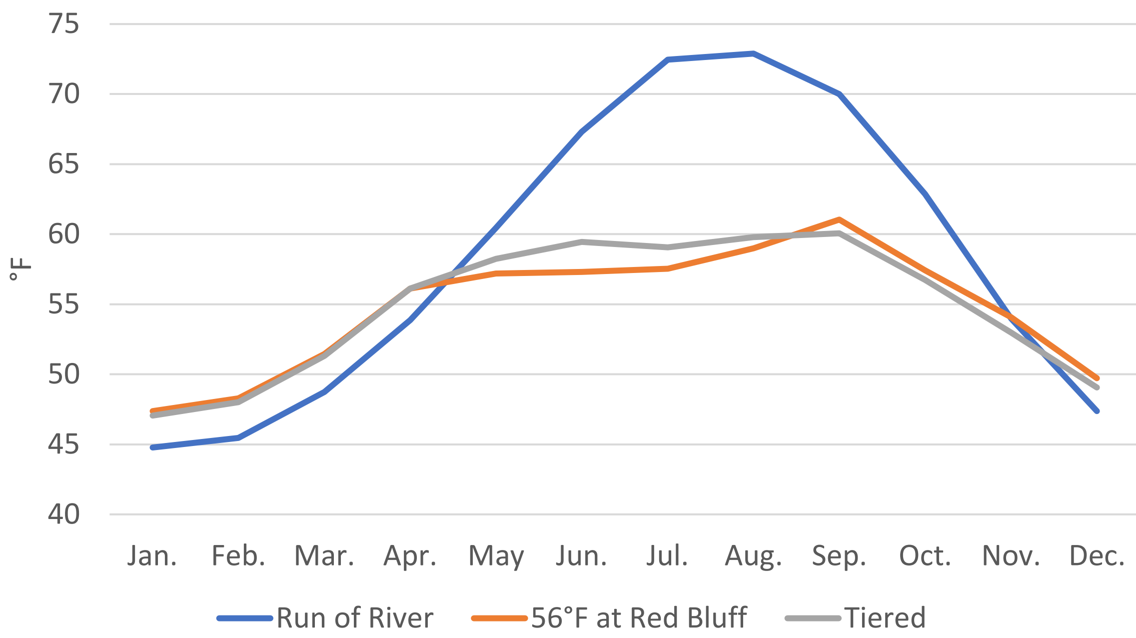

Figure 10. Sacramento River Water Temperatures below Red Bluff Diversion Dam, All Water Year Types

Run of the River temperatures in the Sacramento River follow a sinusoidal pattern in which 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 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.

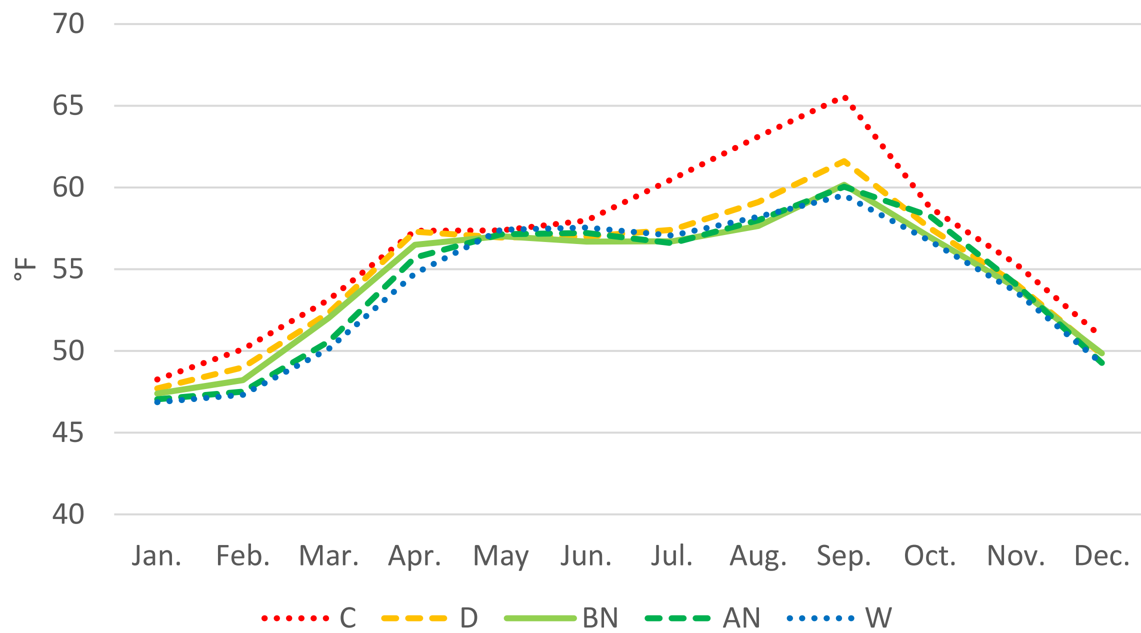

Figure 11. Sacramento River Water Temperatures below Red Bluff Diversion Dam when Targeting 56°F at Red Bluff Diversion Dam by Water Year Type

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

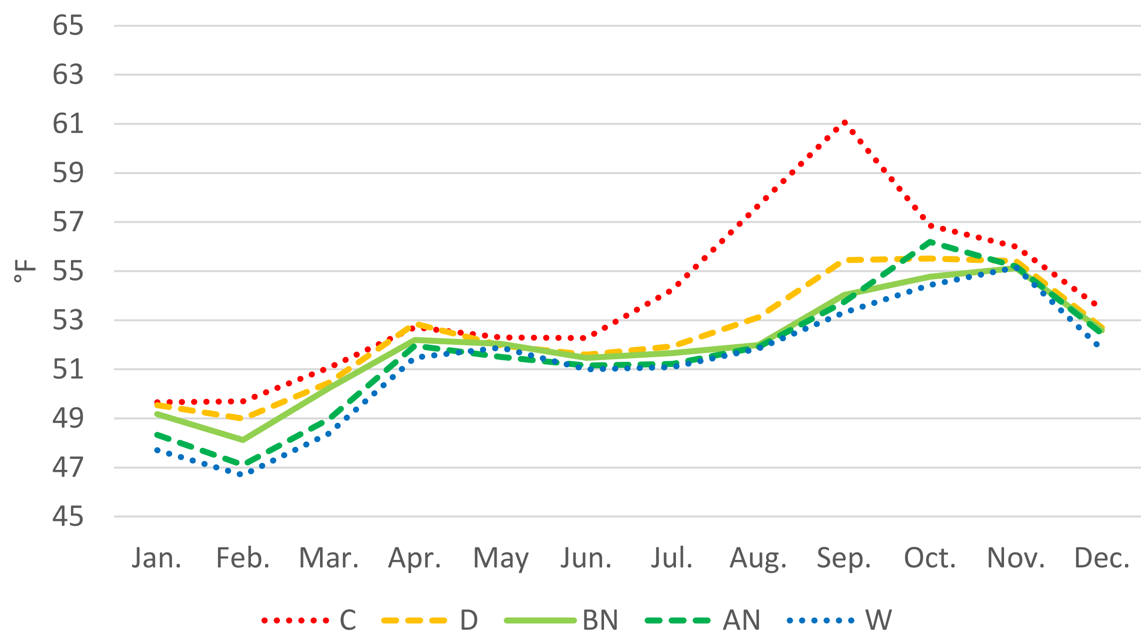

Figure 12. Sacramento River Water Temperatures Below Clear Creek when Targeting 56°F at Red Bluff Diversion Dam by Water Year Type

Temperatures may approach or exceed 56°F in September and October of Critical, Dry, and Below Normal years. Figure 13 shows temperature below Clear Creek under the Tiered Strategy.

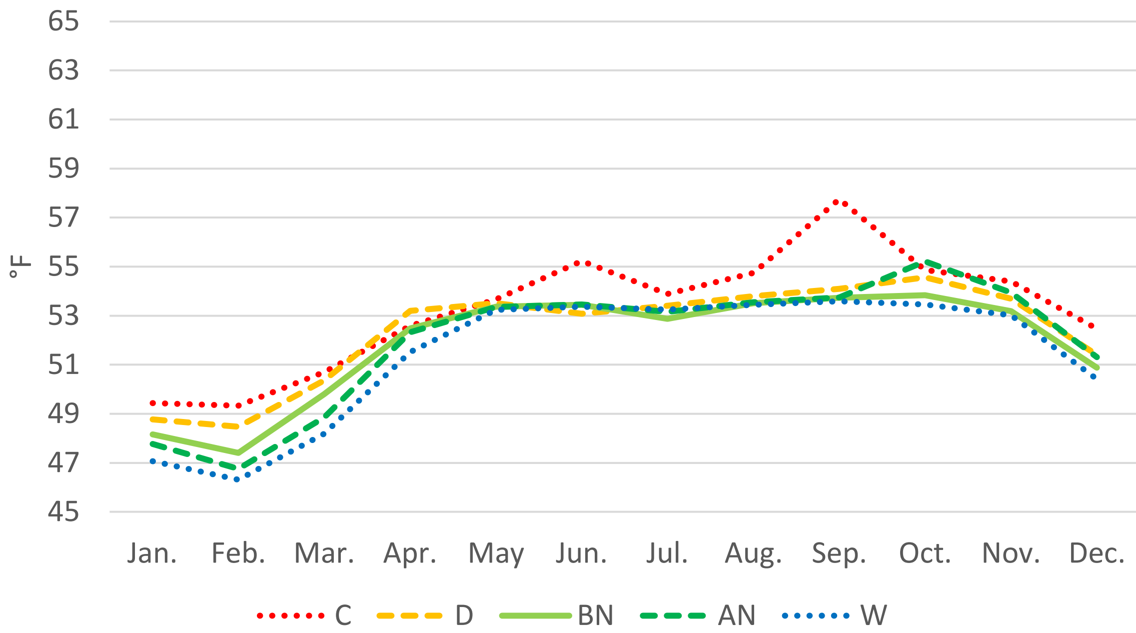

Figure 13. Sacramento River Water Temperatures Below Clear Creek under the Tiered Strategy by Water Year Type

In Critical years a higher temperature occurs in May and June under the Tiered scenario than the 56°F at Red Bluff scenario due to the shoulder-trough-shoulder pattern that delays depletion of the cold-water pool. However, insufficient cold-water pool is available to maintain temperatures below 56°F below Clear Creek for the entire season. Under the Tiered trategy, temperature targets may be reshaped. Moving the 56°F 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 cold-water pool within a year type classification can vary significantly.

3.3 Suitable Habitat

The Sacramento River includes winter-run Chinook salmon, spring-run Chinook salmon, and steelhead. Winter-run juveniles rear in the Sacramento River from August through January. Spring-run young of year can be rearing in the Sacramento River from November through April. Yearling spring-run can rear in the Sacramento River through the remainder of the year. Steelhead rear year-round with rearing in natal habitats primarily in March through May.

Two time periods are shown for suitable habitat. Figure 14 shows current CVPIA estimates of increases in suitable habitat in the winter and spring under conditions of lower flows after storing water for the Sacramento River from Keswick Dam (RM302) to Red Bluff Diversion Dam (RM244) (Upper Sacramento River), roughly 58 river miles.

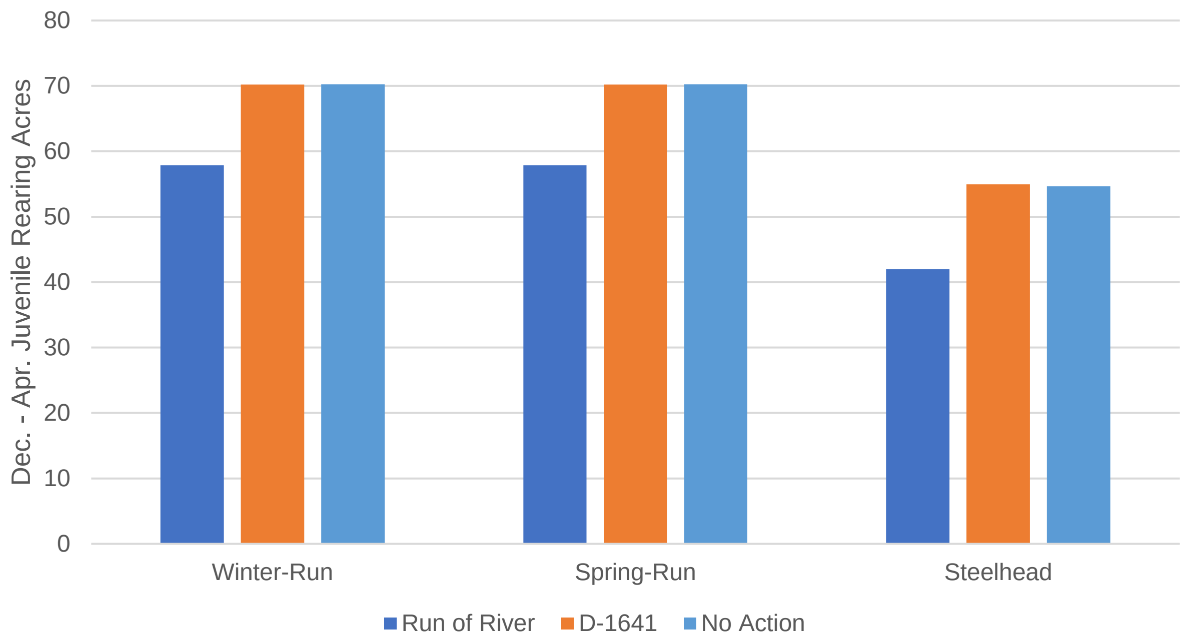

Figure 14. Suitable Habitat in the Upper Sacramento River from December through April

The hydraulics of the degraded channel conditions result in higher flows creating deeper faster water that exceed habitat suitability criterium of depth and velocity. For young of year steelhead, Figure 15 shows reductions in suitable habitat over the summer under conditions of higher flows.

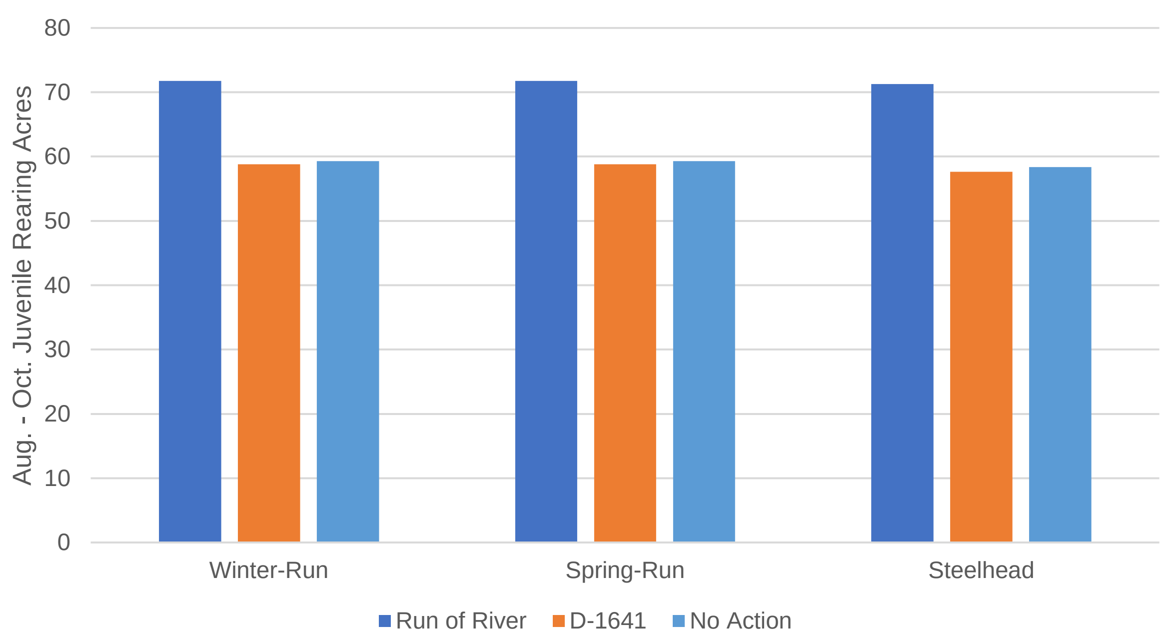

Figure 15 Suitable Habitat in the Upper Sacramento River from August through October

Higher flows in the summer similarly reduce the acreage of suitable habitat. More downstream reaches are used for rearing during migration in the winter and spring seasons. Figure 16 shows the reach from Red Bluff Diversion Dam (RM244) to Wilkins Slough (RM118) (Upper-Middle Sacramento River), roughly 126 river miles. In the reaches below Red Bluff, CVPIA uses estimates of Winter-Run habitat availability for Spring-Run and Steelhead.

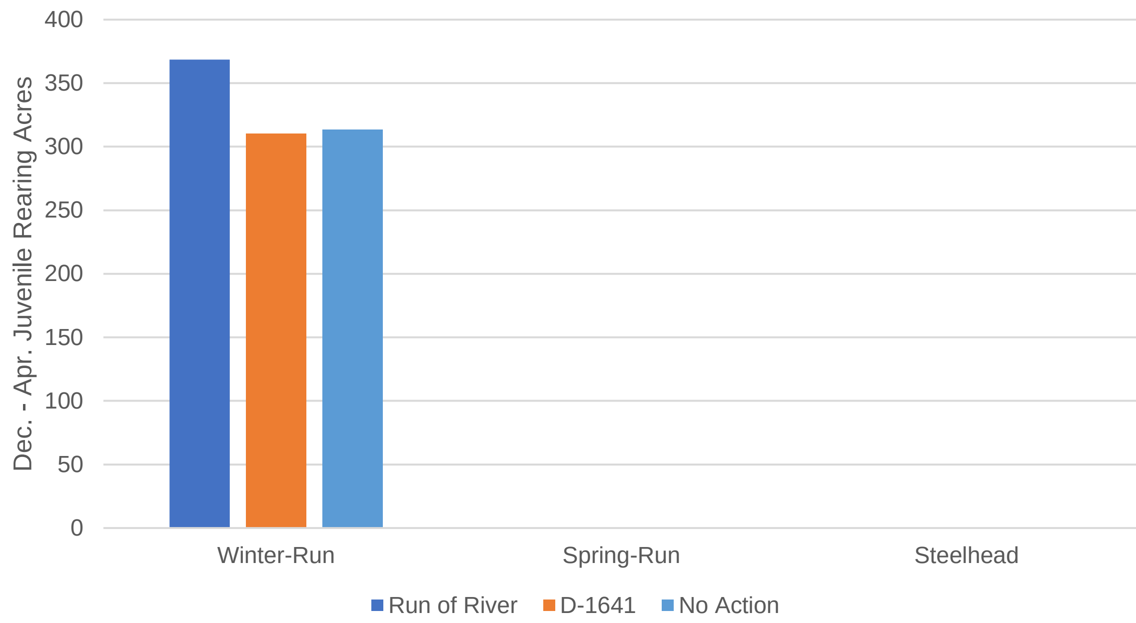

Figure 16. Suitable Habitat in the Upper-Middle Sacramento River from April through December

The pattern is different with less habitat under the operation of the CVP and SWP. In the reaches downstream of Wilkins Slough the amount of habitat changes, but the pattern remains the same.

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4. Clear Creek

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

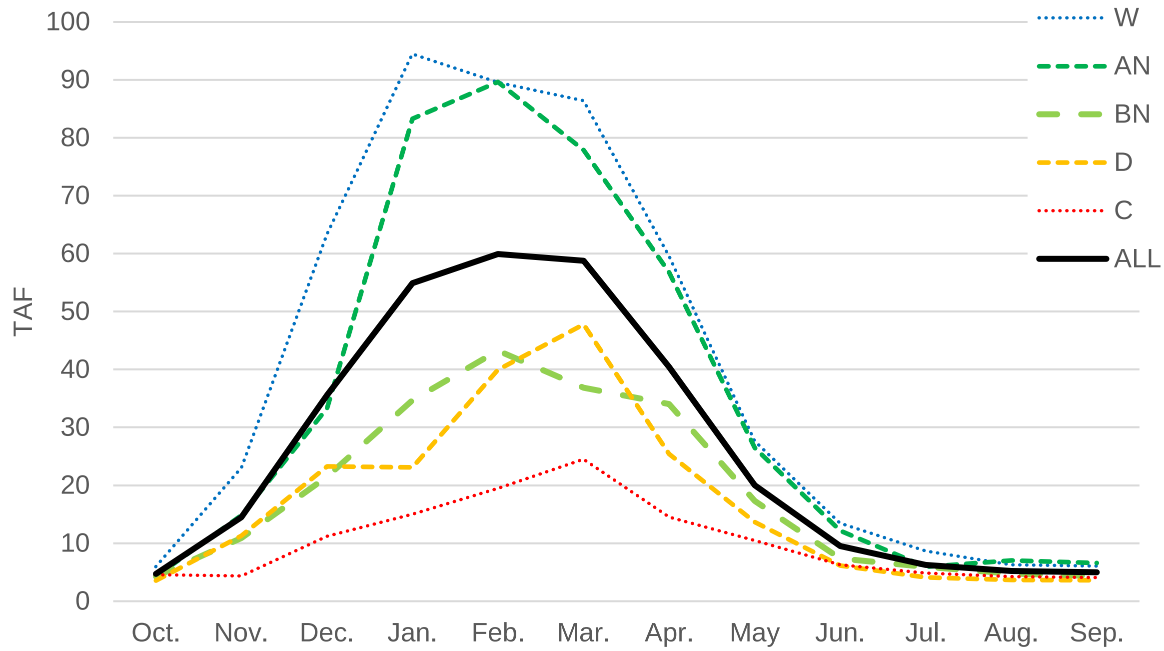

Figure 17. Inflow to Whiskeytown Reservoir from Clear Creek by Month and Water Year Type

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

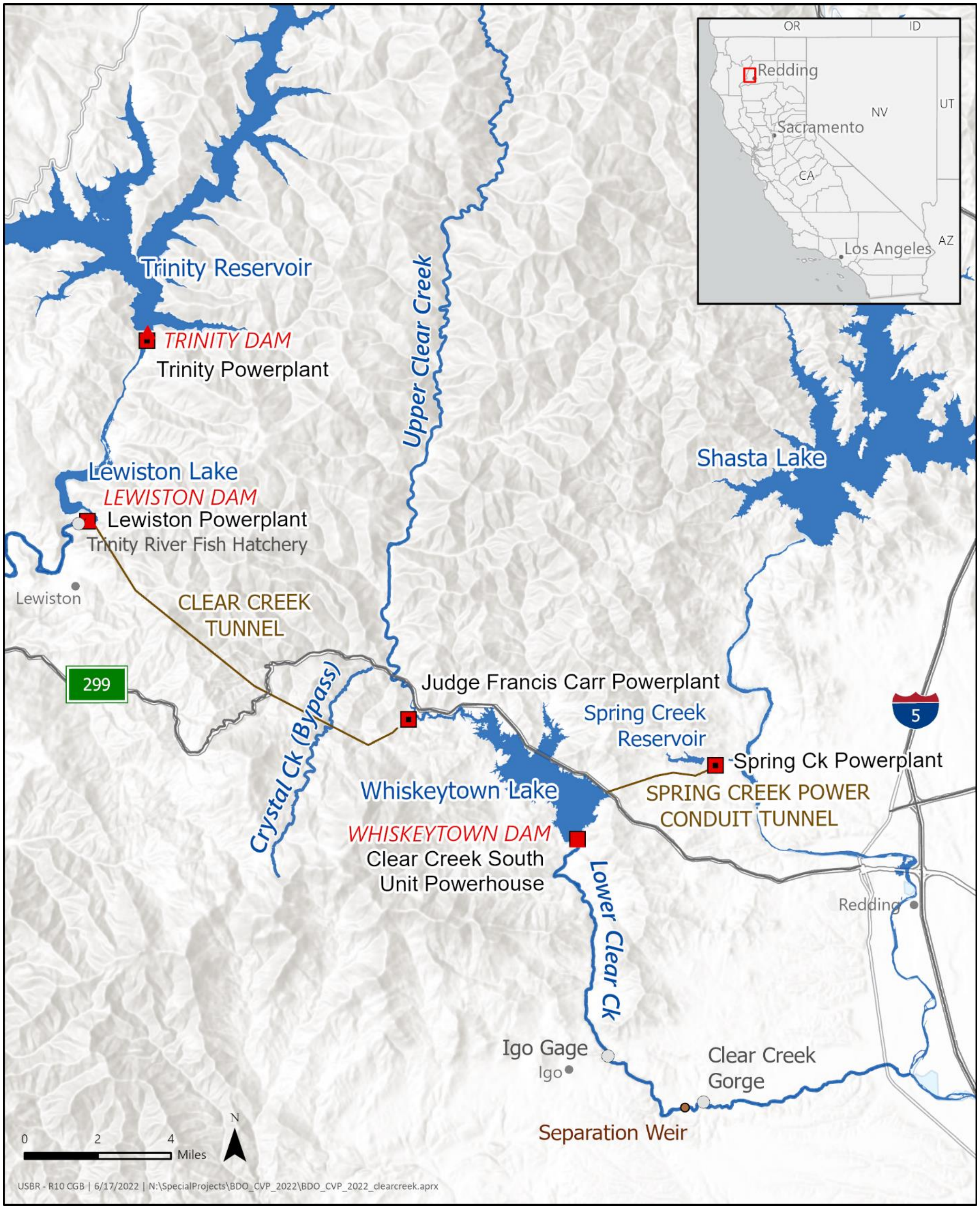

Figure 17. Clear Creek Water Operations Topology

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

4.1 Water Operations

Figure shows release from Whiskeytown Dam for the Run of the River, D-1641, and No Action.

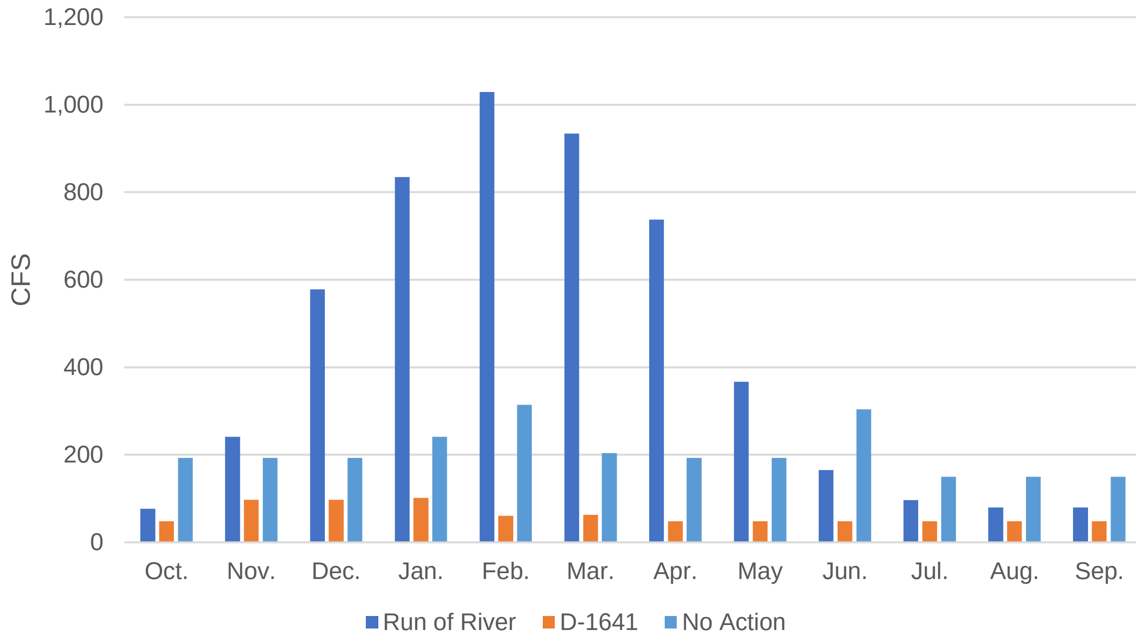

Figure 19. Clear Creek below Whiskeytown Monthly Flows, All Water Year Types

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 No Action scenario due to omission of attraction and channel maintenance pulses.

Figure shows peak annual flows (monthly average) on Clear Creek.

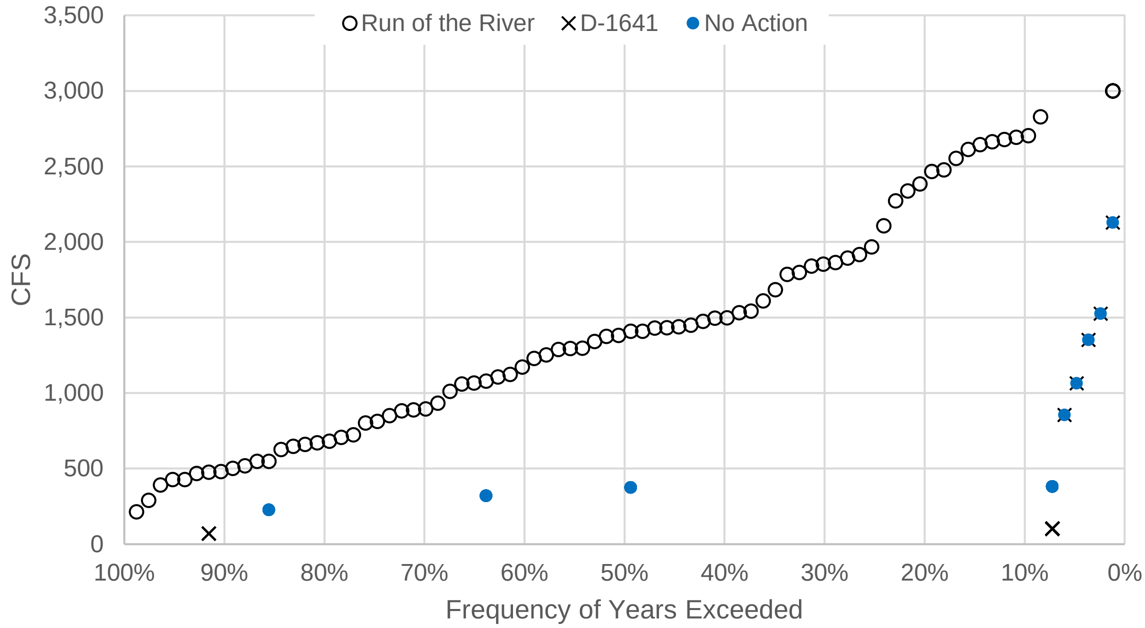

Figure 20. Clear Creek below Whiskeytown Dam Annual Peak Flow Frequency

Peak flows on Clear Creek under D-1641 (shown as an "x" above) occur from infrequent flood spills; therefore, Clear Creek is either a base flow or spilling. Under No Action, peak flows can occur from by controlled attraction and/or gravel mobilization releases. The distinct steps in peak flow releases under D-1641 and No Action contrast with the more continuous peak flows under Run of the River.

Figure 21 shows inflows to Whiskeytown Reservoir that are not released down Clear Creek are diverted into Keswick Reservoir through the Spring Creek tunnel.

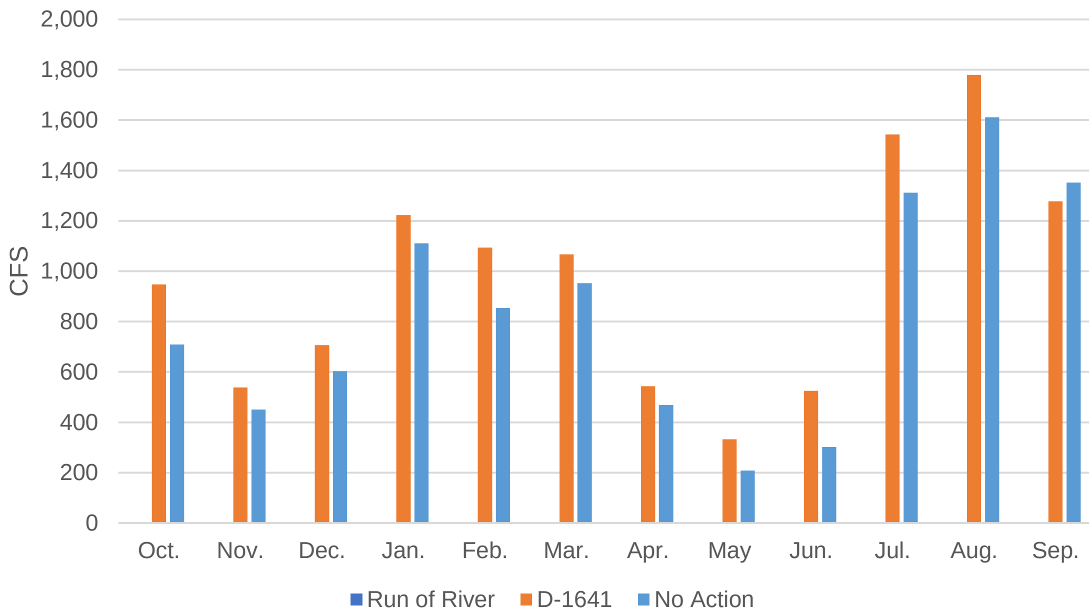

Figure 18. Spring Creek Inflows to Keswick Reservoir

No imports occur under the Run of the River.

4.2 Water Temperatures

Figure 2 shows temperatures on Clear Creek above the Sacramento River.

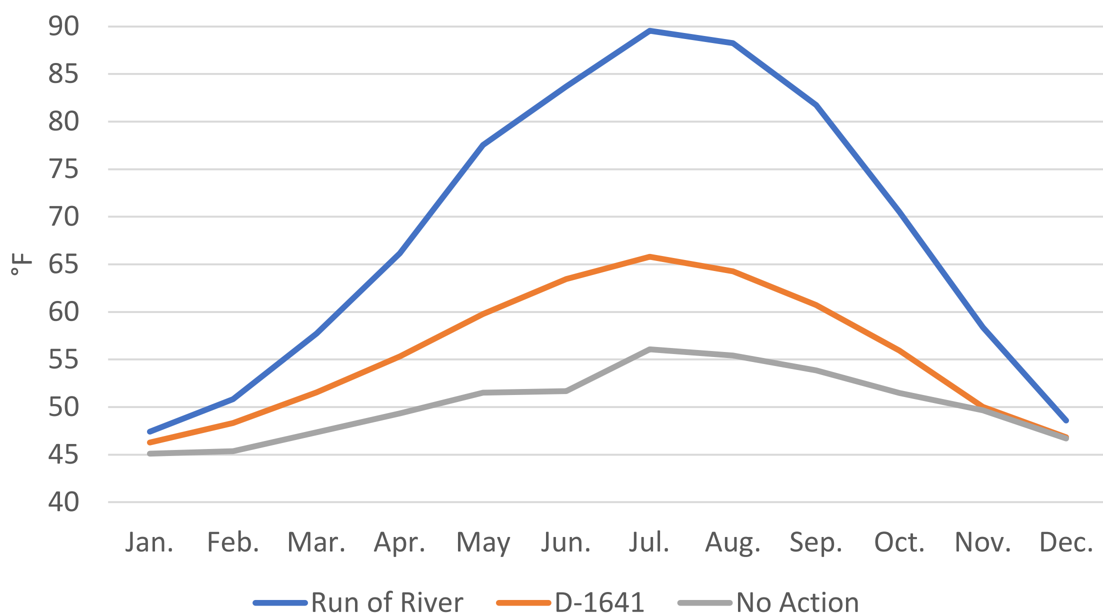

Figure 19 Clear Creek above Sacramento River Monthly Average Water Temperatures

Clear Creek temperatures are lower for the No Action Alternative scenario than the D-1641 scenario, following the pattern of lower Whiskeytown releases in the D-1641 scenario compared to the No Action Alternative scenario. The absence of Clear Creek Tunnel flows moving Trinity 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.

4.3 Suitable Habitat

Listed fish species in Clear Creek include spring-run Chinook salmon and steelhead. Spring-run Chinook salmon young of year may be rearing from October through April while yearlings may over-summer and remain year-round. Steelhead may be rearing in Clear Creek from March through May. Figure 203 shows the March through May period as representative of seasonal operations to store and divert water on Clear Creek.

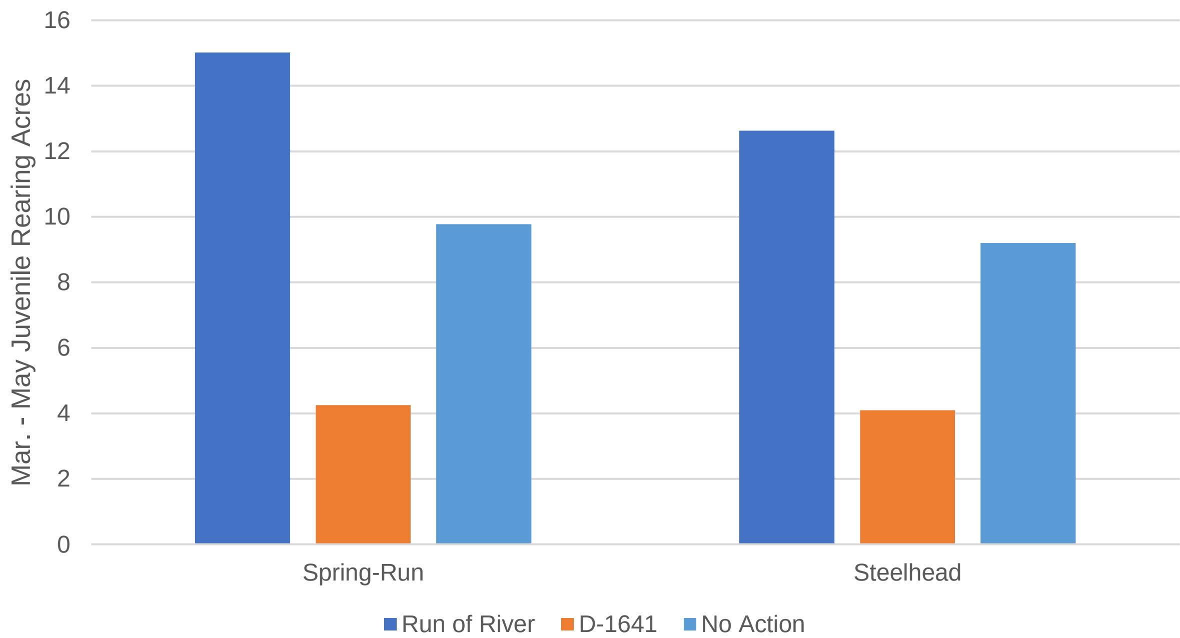

Figure 203. Suitable Habitat in Clear Creek from March through May for Spring-Run and Steelhead

Extensive habitat restoration, additional rearing habitat and gravel augmentations, on Clear Creek below Whiskeytown Dam caused increases in available habitats. These CVPIA sponsored restoration projects completed a multi-phase plan (1997-2021) for improving habitat conditions in lower Clear Creek (below Clear Creek Road Bridge). The Clear Creek Technical Team (CCTT) has identified additional projects to continue increasing available habitat in Lower Clear Creek. Most importantly, The CCTT hopes to activate disconnected floodplains by partially filling portions of the channel with gravel. This will both increase opportunities for floodplain rearing and in-channel spawning in this portion of the channel.

5. American River

Inflows to Folsom Reservoir come from the North Fork American River and South Fork American River. Figure 214 shows the inflow to Folsom Reservoir by month and 40-30-30 hydrologic water-year type.

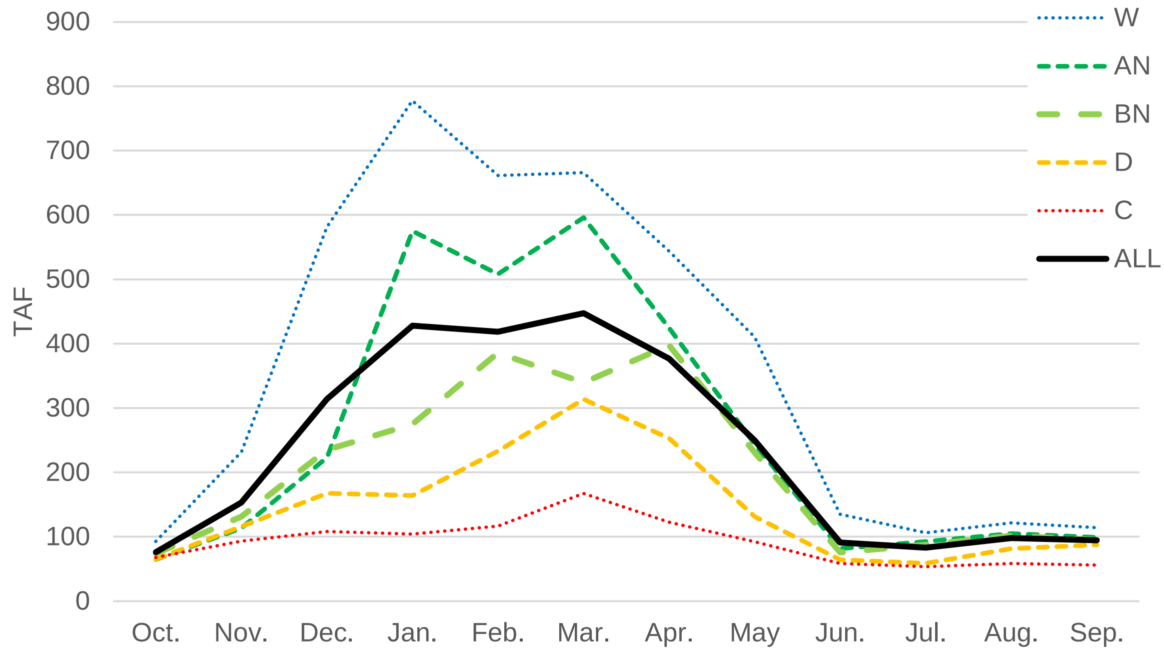

Figure 214. Inflow to Folsom Reservoir by Month and Water Year Type

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 25 shows a simplified hydrologic topology for the American River from Folsom Dam to the confluence with the Sacramento River

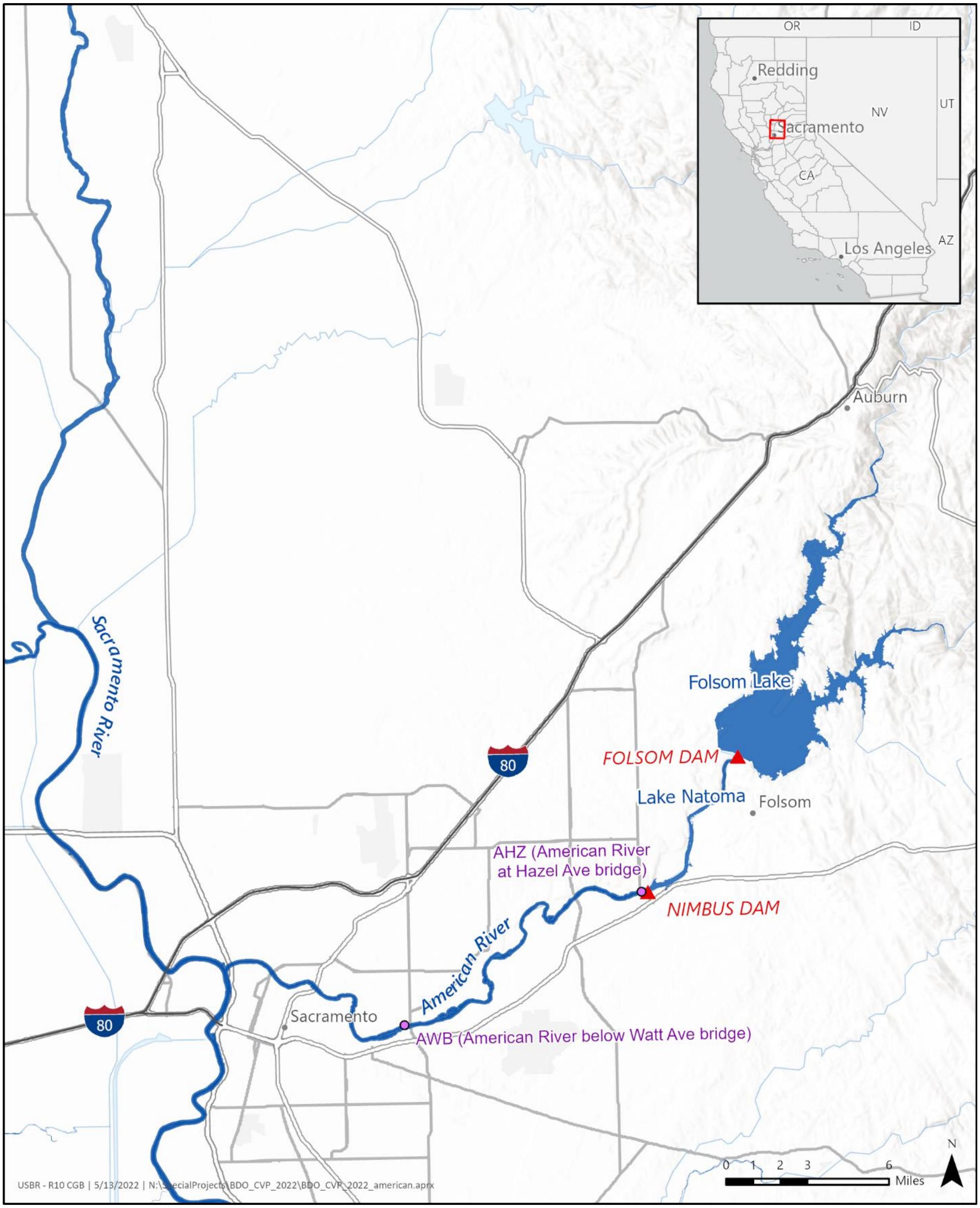

Figure 25. American River Water Operations and Temperature Topology.

5.1 Water Operations

Figure 26 shows releases from Nimbus Dam to the American River for the Run of the River, D-1641, and No Action scenarios.

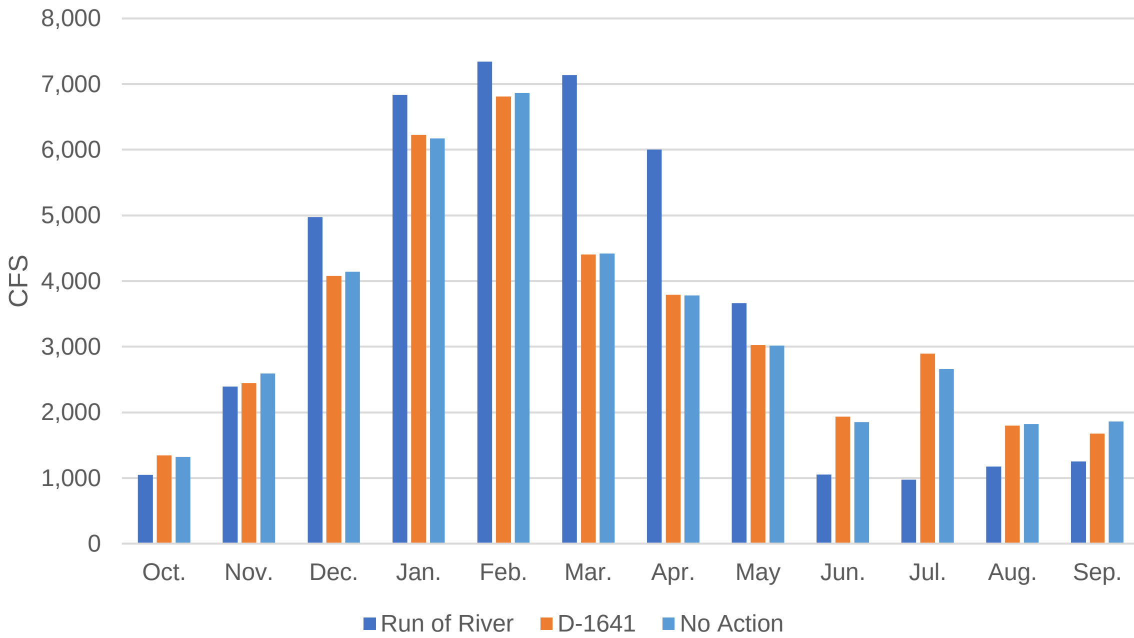

Figure 26. American River below Nimbus Dam Monthly Flows, All Water Year Types

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 D-1641 and No Action have higher flows than Run of the River. In November for above normal years, the D-1641 and No Action scenarios have lower flows compared to the Run of the River scenario.

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

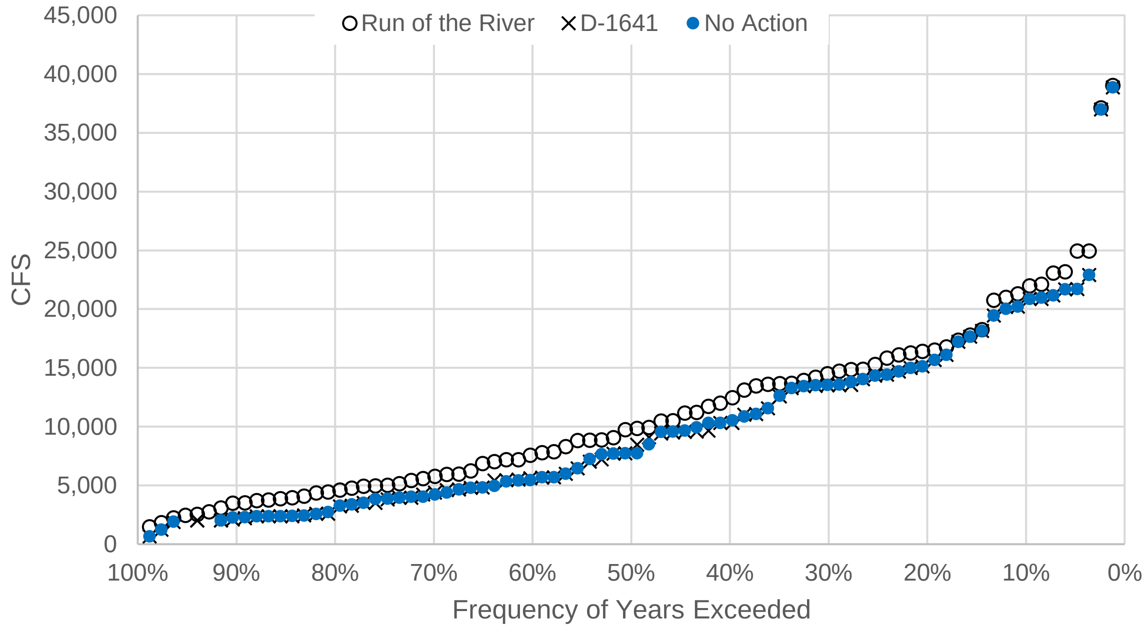

Figure 27. American River below Nimbus Dam Annual Peak Flow Frequency

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.

5.2 Water Temperatures

An analysis was performed using the HEC-5Q water quality model to estimate water temperatures on the American River under three scenarios: Run of the River, No Action Alternative, and D-1641. All scenarios used Folsom temperature release targets designed to mimic the American River Group's temperature release target process, which considers inflow and storage.

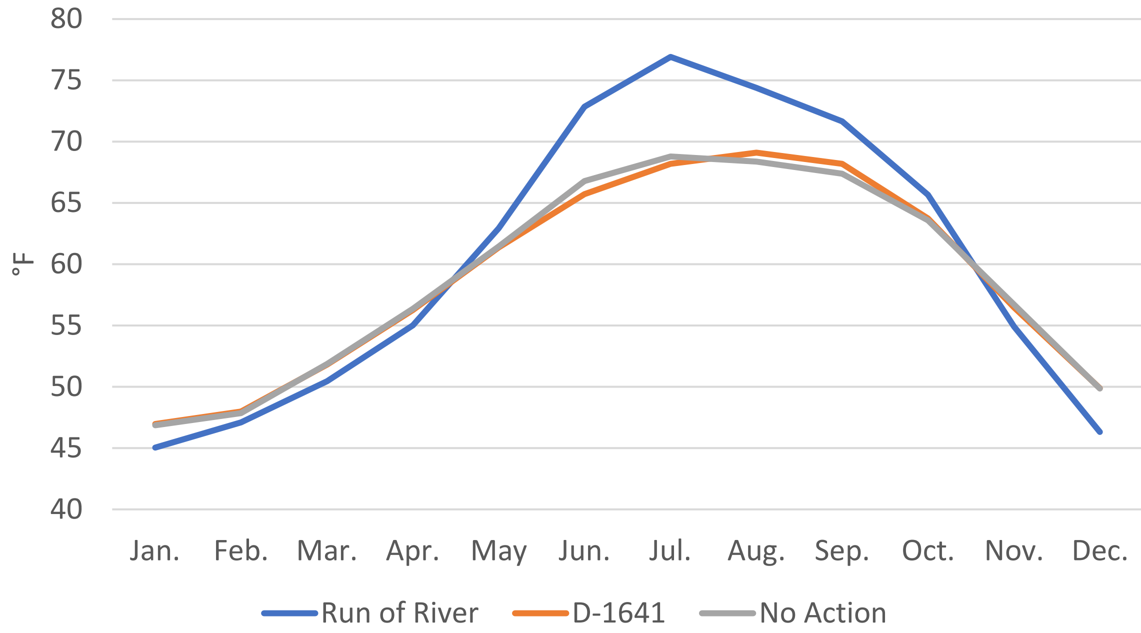

Figure 28. American River at Watt Avenue

The Run of the River scenario had the largest amplitude, peaking above and below the No Action Alternative and D-1641 scenarios. No Action Alternative and D-1641 downriver temperatures were similar for most of the year but peaked in July for No Action Alternative and August for D-1641, likely because of changes in Folsom temperature release targets driven by differences in storage.

5.3 Suitable Habitat

The listed fish species on the American River includes steelhead. Steelhead can rear year-round with natal young of year primarily March through May and the potential for over-summering fish. Two time periods are shown for suitable habitat. Figure shows increases in suitable habitat under conditions of lower flows and storing water in the spring.

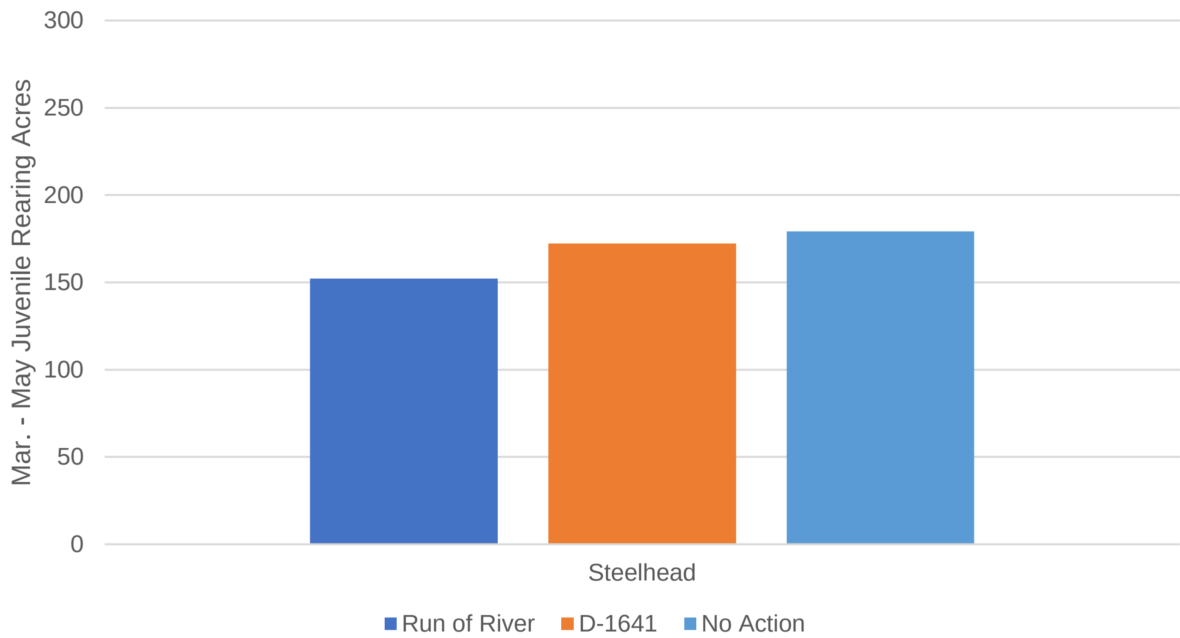

Figure 29. Suitable Habitat in the American River for Steelhead from March through May

The hydraulic conditions of the channel are such that increases in flows can wash out suitable habitat with excessive depths and velocities. Lower releases improve suitable habitat. Figure shows suitable habitat for the summer.

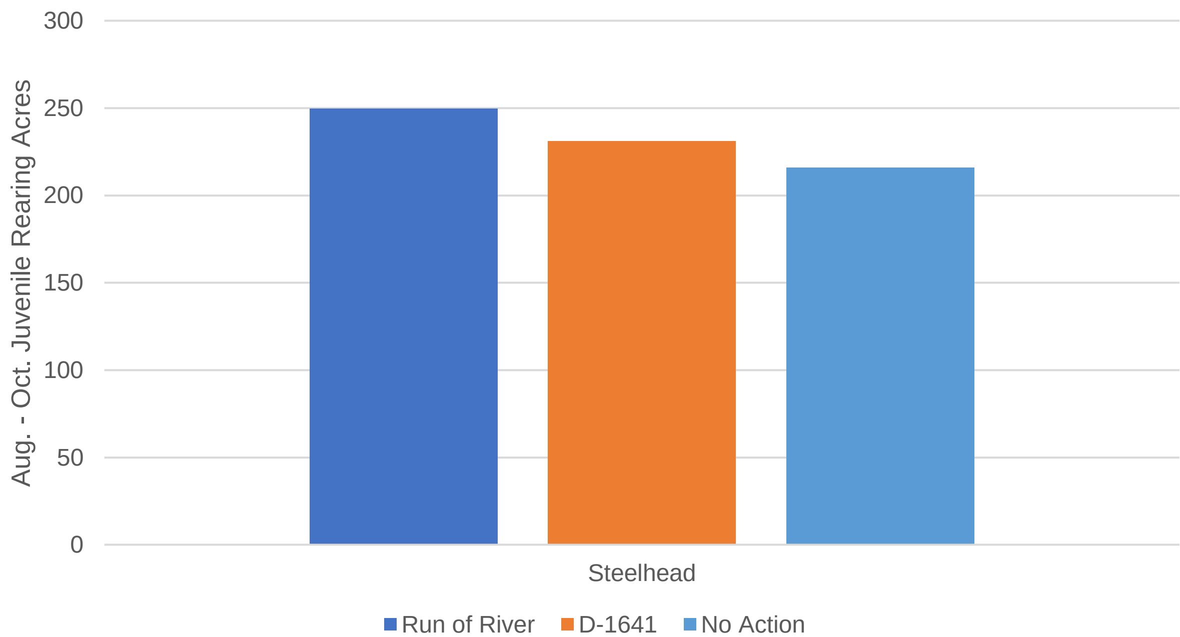

Figure 30. Suitable Habitat in the American River for Steelhead from August through October

Higher releases result in less suitable habitat than the lower flows under Run of the River.

6. Stanislaus River

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

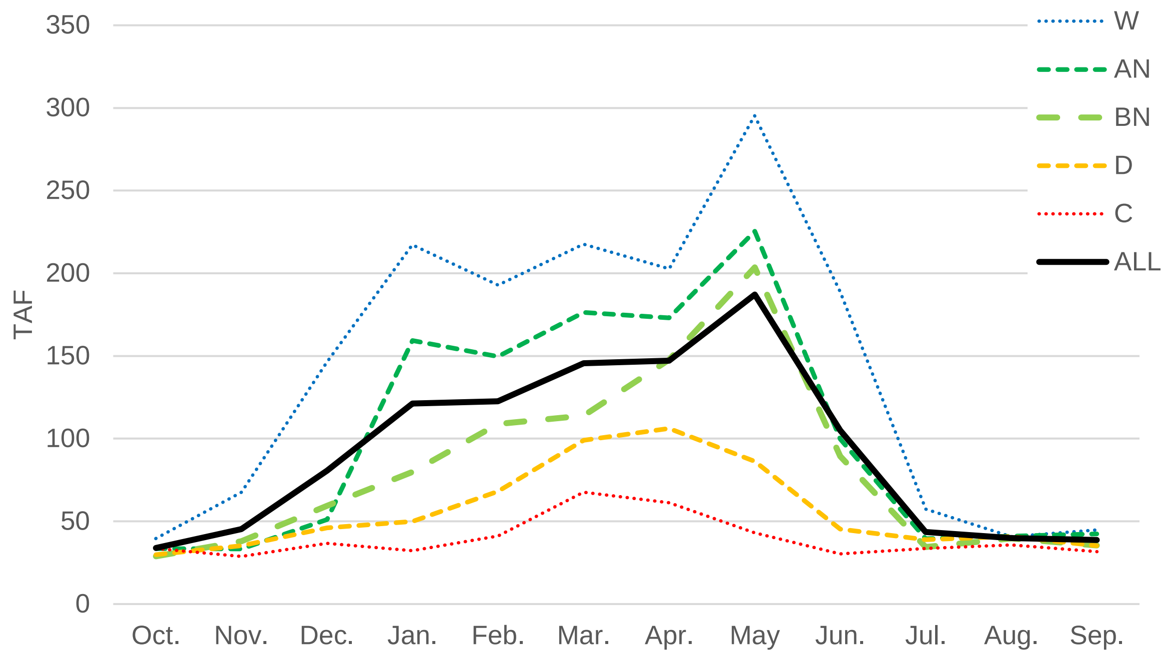

Figure 31. Inflow to New Melones Reservoir by Month and Water Year Types (40-30-30)

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

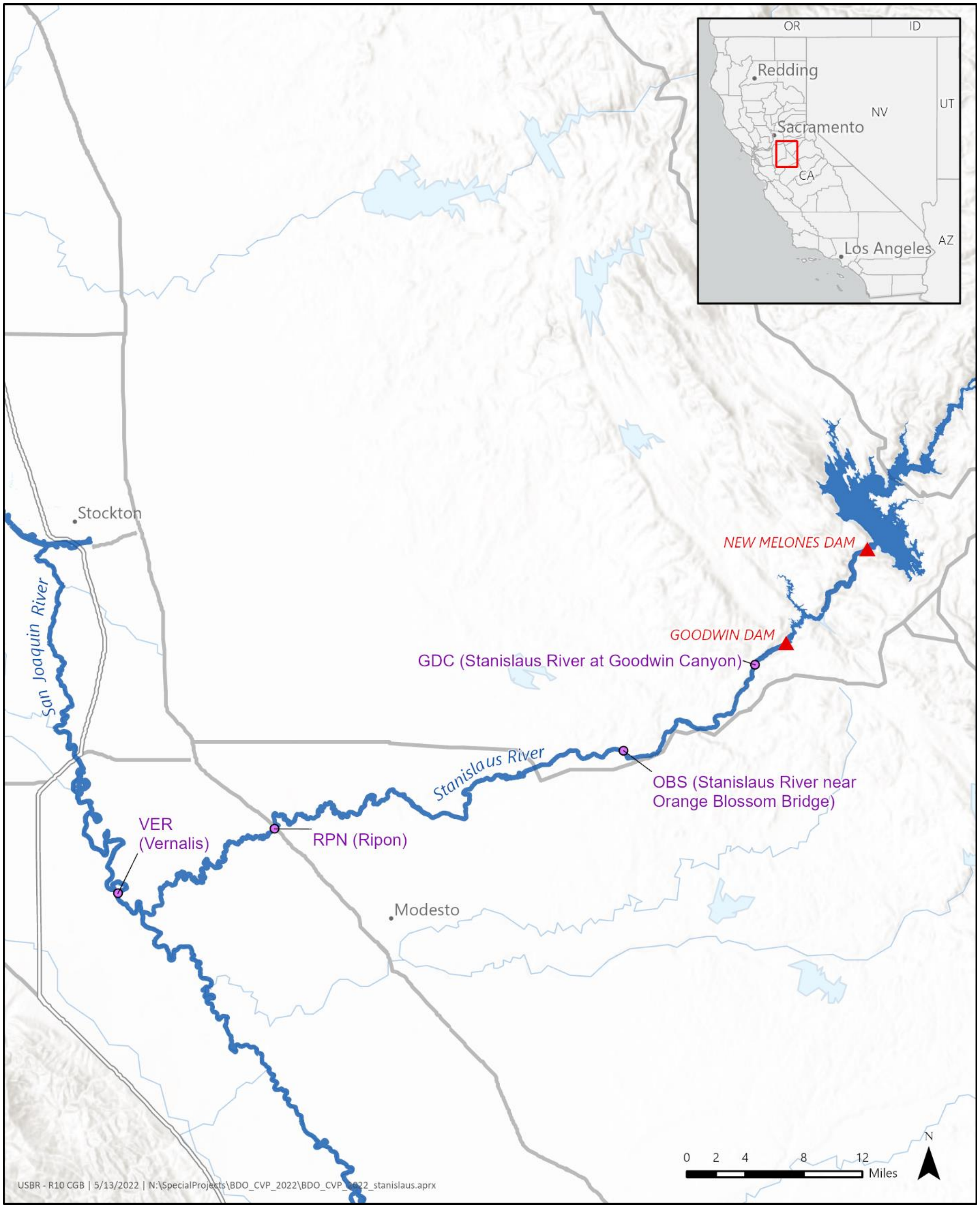

Figure 32. Stanislaus River Watershed Water Operations and Temperature Topology

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 temperature control device; 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.

6.1 Water Operations

Figure shows releases from Goodwin Dam to the Stanislaus River under the Run of the River, D-1641, and No Action scenarios. The D-1641 scenario does not include releases for meeting the flow requirement at Vernalis solely through releases from New Melones while the No Action scenario includes a Stanislaus portion of Vernalis flows. Flows at Vernalis are described in Section 8, *Delta*.

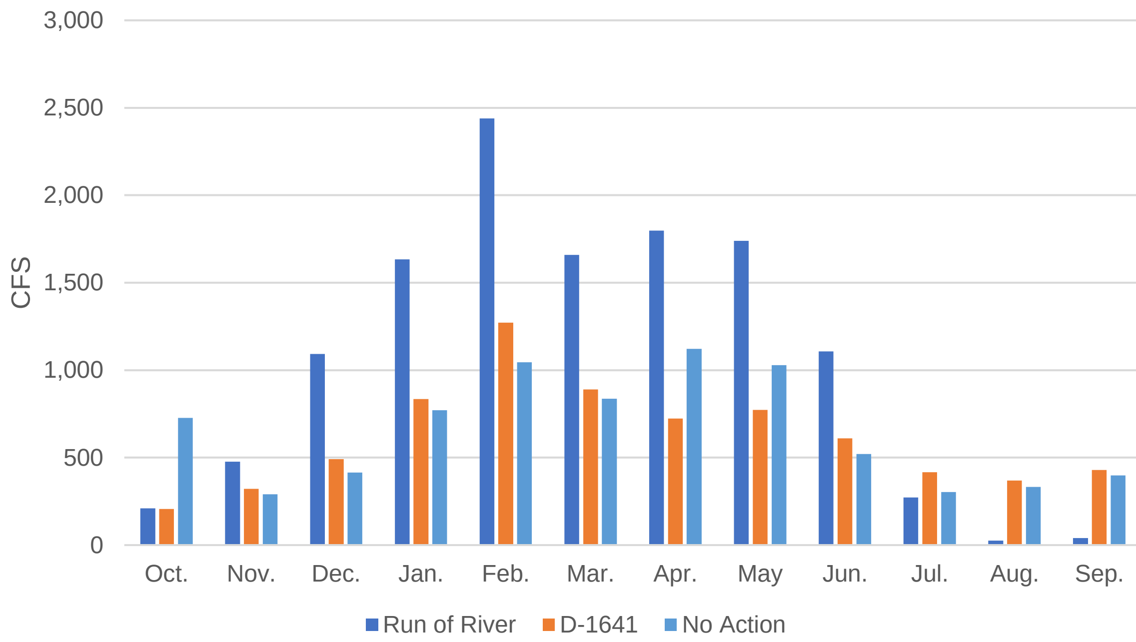

Figure 33. Stanislaus River below Goodwin Dam Monthly Flows, All Water Year Types

In comparing the D-1641 and No Action scenarios, no large differences exist for most months based on water year type. However, in April and May, flows in critical years are higher for D-1641 than No Action. In January for dry years, the flows are higher for No Action than D-1641. In March, flows for above normal years are higher for No Action than D-1641.

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

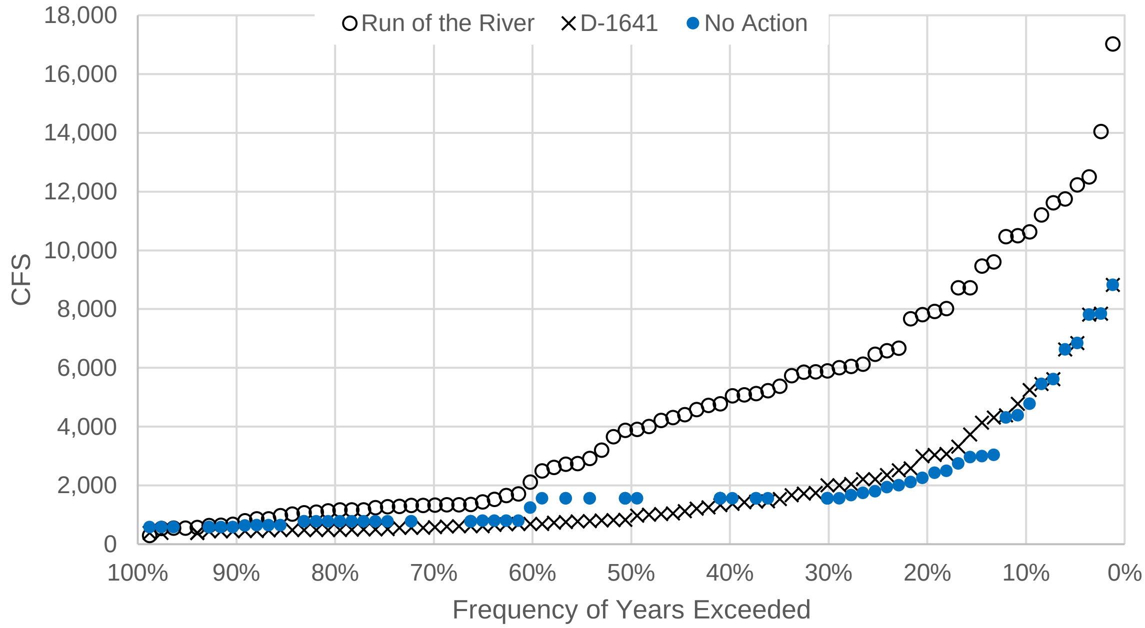

Figure 34. Stanislaus River below Goodwin Dam Annual Peak Flow Frequency

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.

6.2 Water Temperatures

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

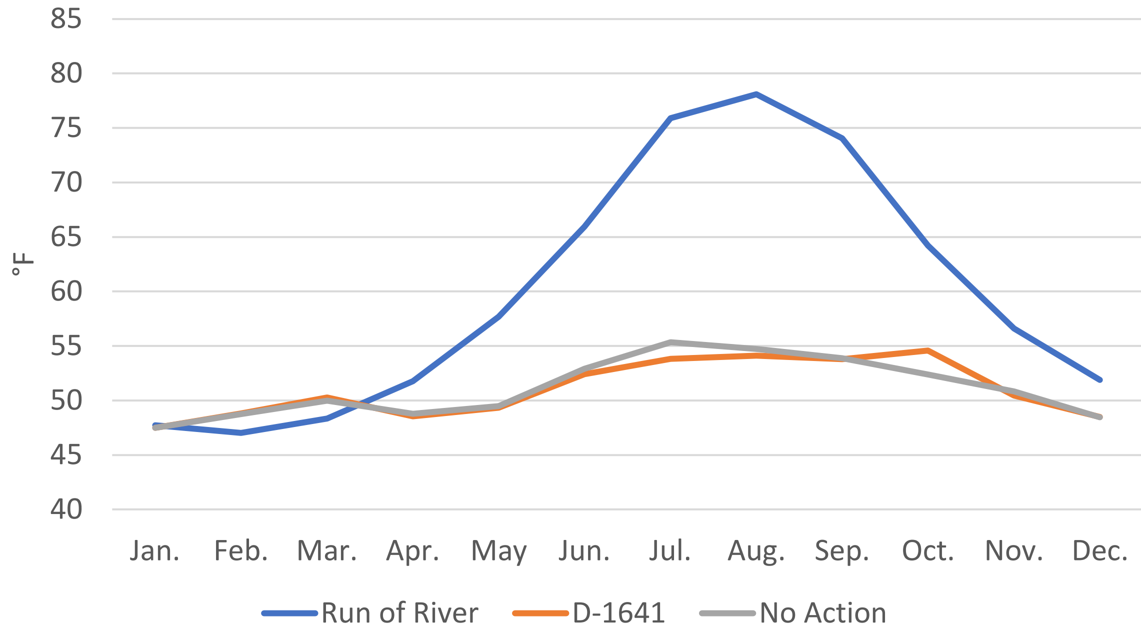

Figure 35. Stanislaus River at Orange Blossom

The Run of the River scenario features the greatest amplitude, peaking in the summer and dropping to its lowest temperatures in the winter. The No Action Alternative and D-1641 follow a similar pattern, but with a lesser amplitude, due to the buffering effect of storage in New Melones Lake. The No Action Alternative scenario is hotter than D-1641 in the summer but colder in October.

6.3 Suitable Habitat

Steelhead are present on the Stanislaus River and may rear year-round with natal young of year primarily in March through May. Figure shows suitable habitat in March through May.

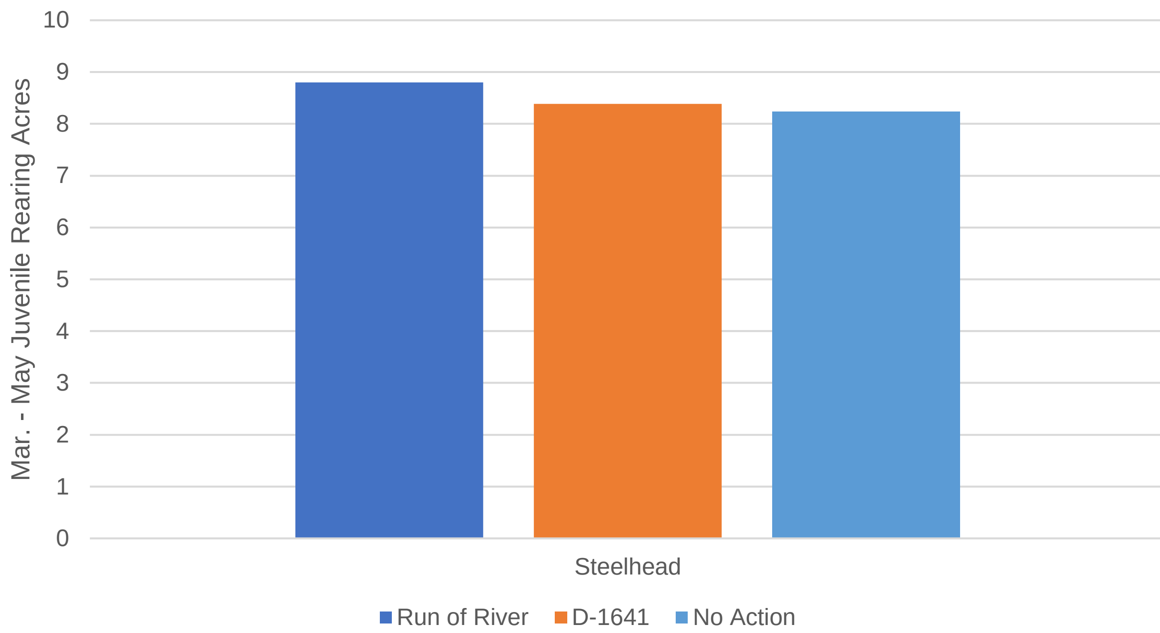

Figure 36. Suitable Habitat in the Stanislaus River from March through May for Steelhead

The channel geometry results in lower flows reducing suitable habitat, but the trapezoidal nature of the channel results in small changes. Figure shows suitable habitat in the summer.

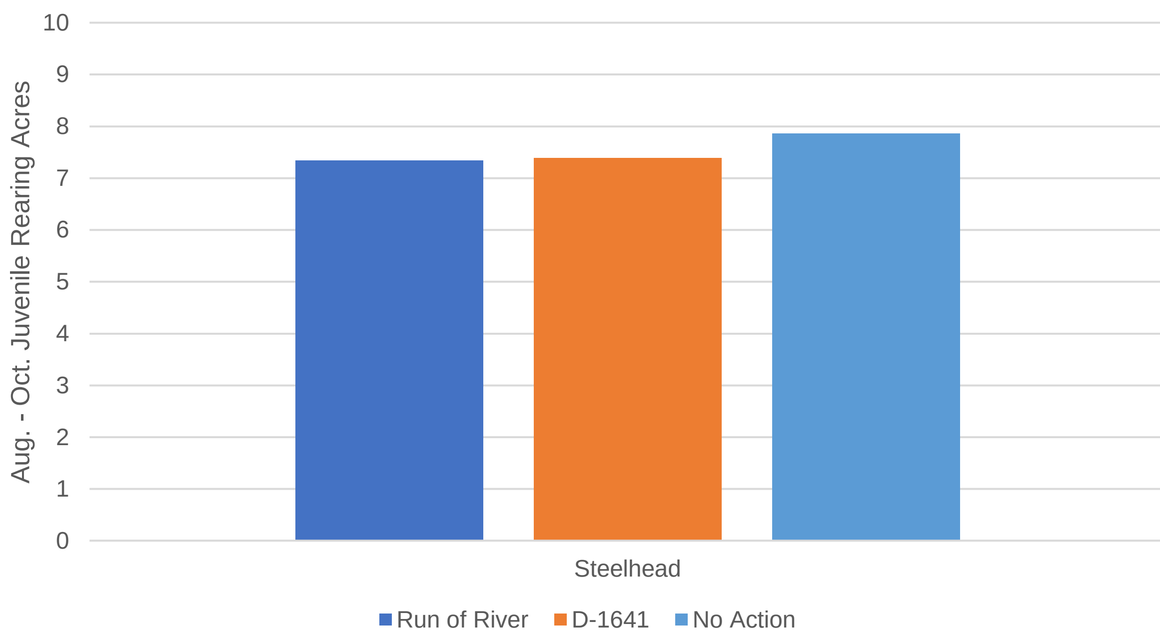

Figure 37. Suitable Habitat in the Stanislaus River from August through October for Steelhead

The higher releases in the summer result in slightly increased acres of suitable habitat.

7. San Joaquin River

Inflows to Millerton Reservoir behind Friant Dam come from the San Joaquin River. Figure shows the inflow to Millerton Reservoir by month and the 40-30-30 hydrologic water year type. The San Joaquin River Restoration Program uses a San Joaquin River Restoration Program (SJRRP) specific water year classification.

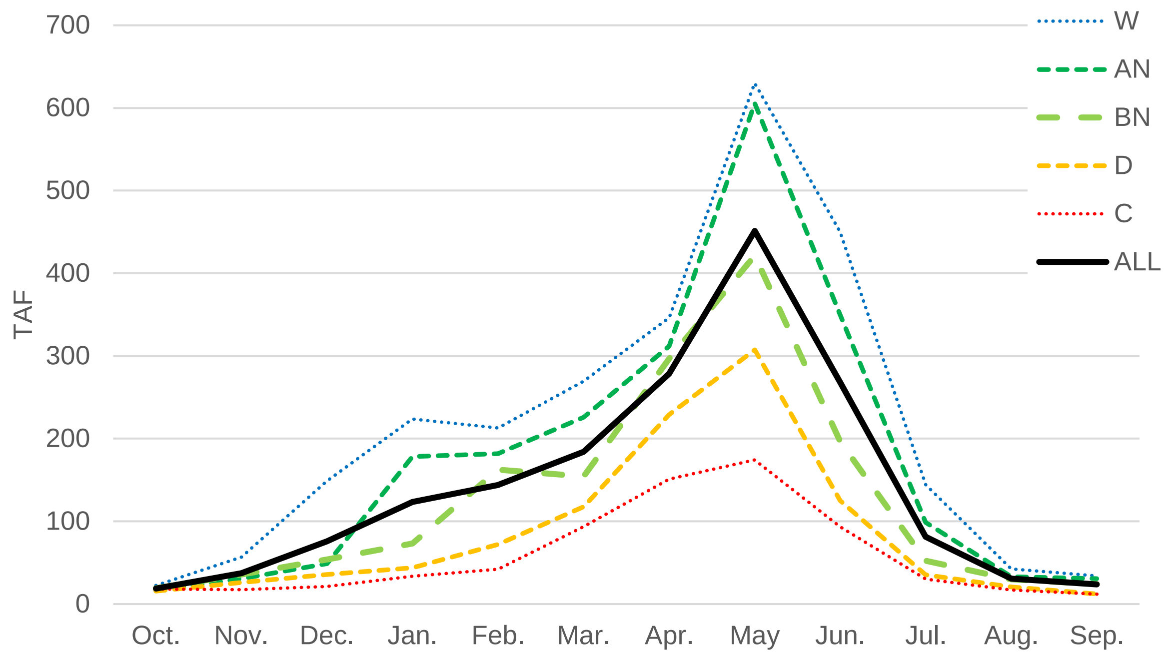

Figure 38. Inflow to Millerton Reservoir by Month and All Water Year Type

Figure 39 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.

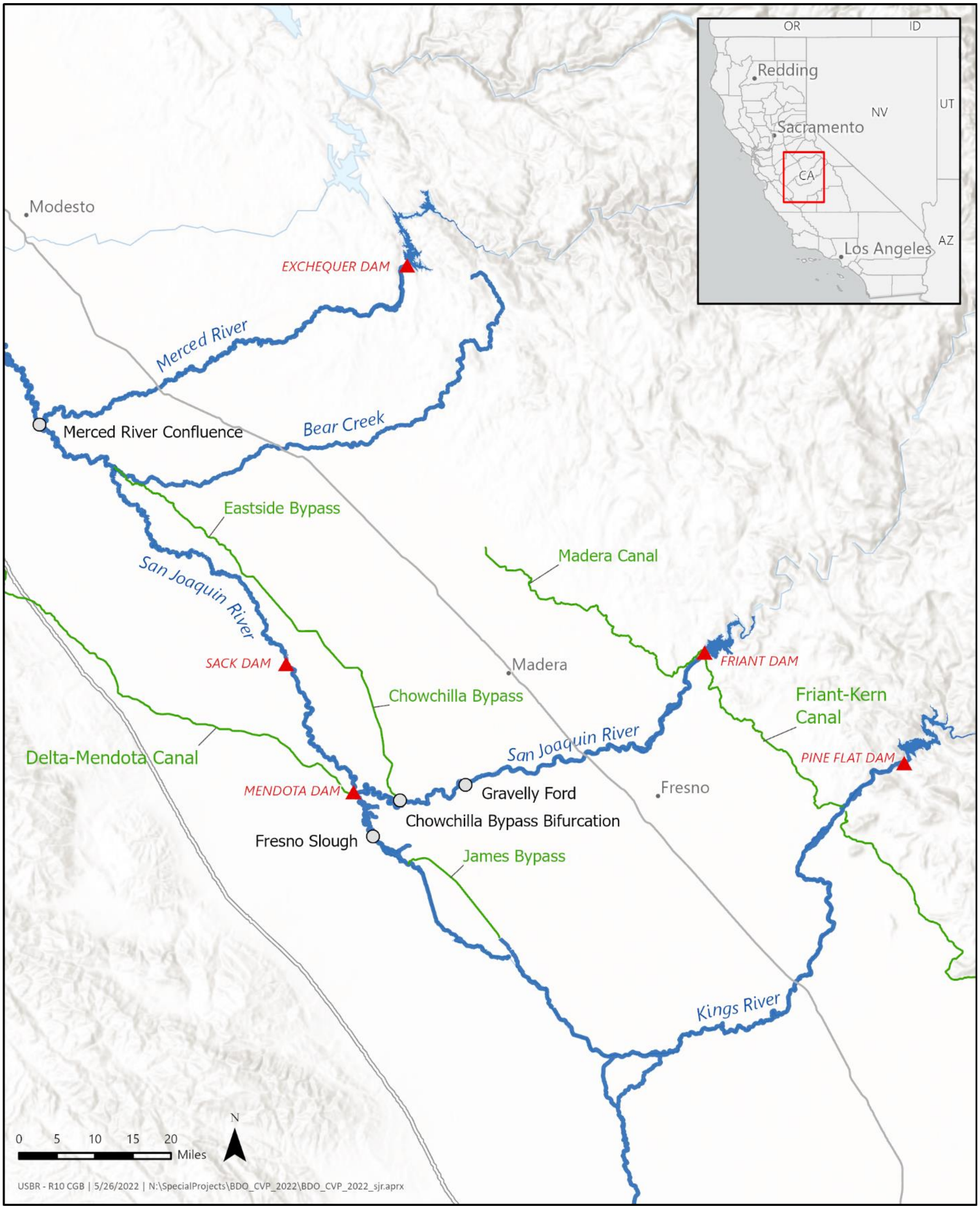

Figure 39. San Joaquin River Watershed Water Operations Topology

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.

7.1 Water Operations

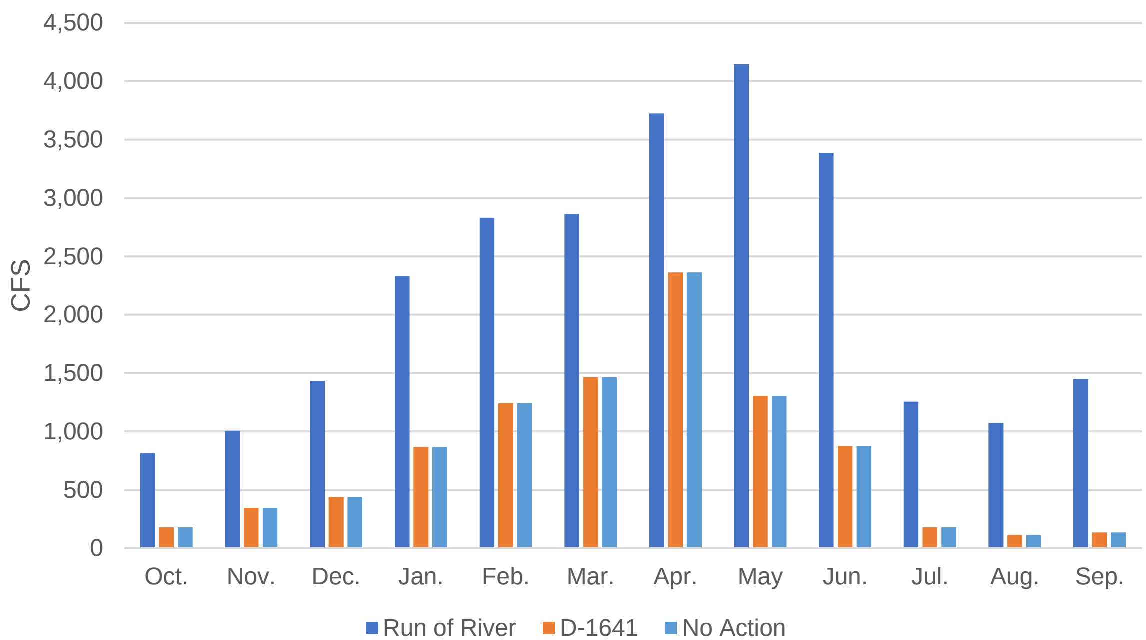

Figure 40. San Joaquin River at Gravelly Ford Monthly Flows, All Water Year Types

In critical and dry years, from October to March the flows distribution pattern for D-1640 and No Action are different than the average across all water year types. For wet years, from October to March, the flow distribution pattern for D-1641 and No Action are similar to all water year type. Figure 41 shows the flows below the Merced River confluence.

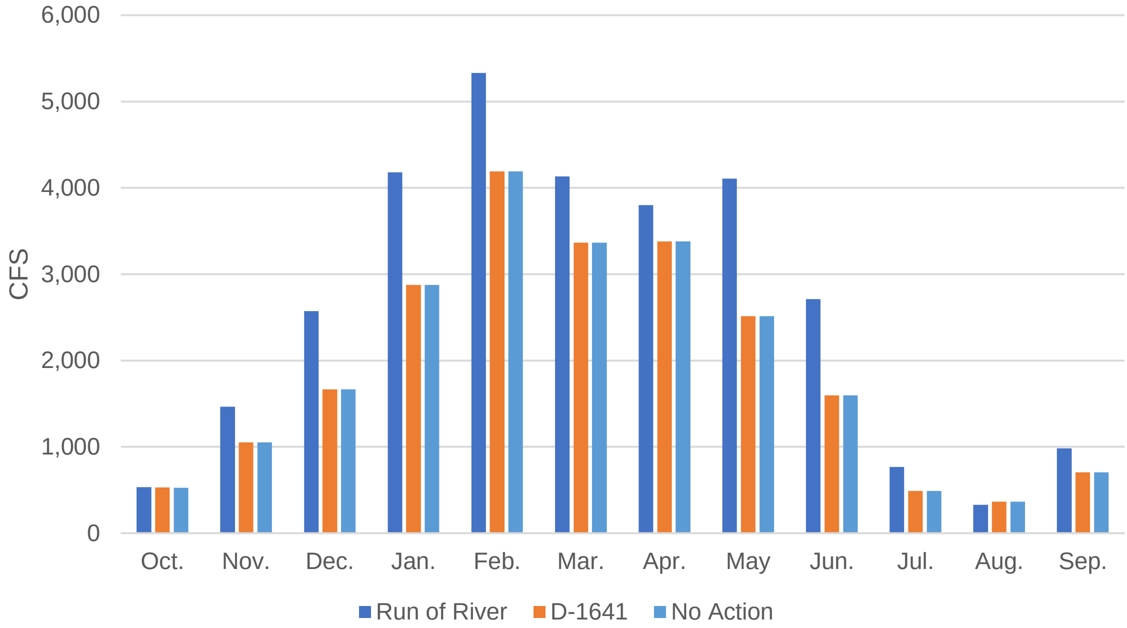

Figure 41. San Joaquin River below the Merced Confluence Monthly Flows, All Water Year Types

In critical and dry years, December and January flows for D-1641 and No 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 shows peak annual flows (monthly average) below the Merced River confluence.

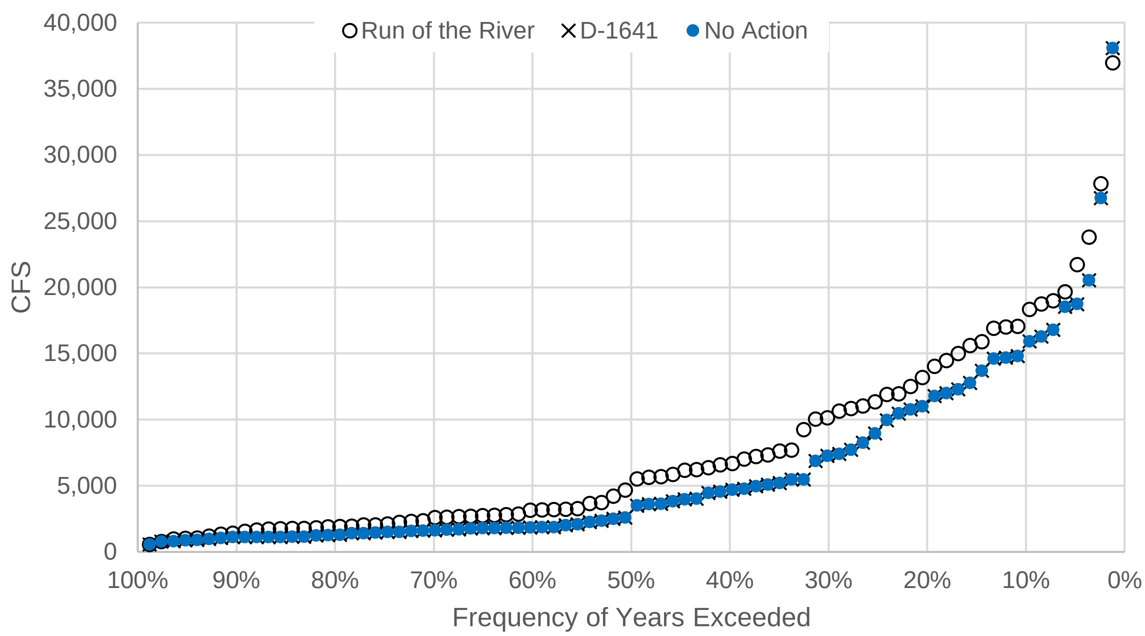

Figure 42. San Joaquin River below Merced River Confluence Annual Peak Flow Frequency

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*.

7.2 Water Temperatures

Water temperatures on the lower San Joaquin River at Vernalis were modeled using HEC-5Q.

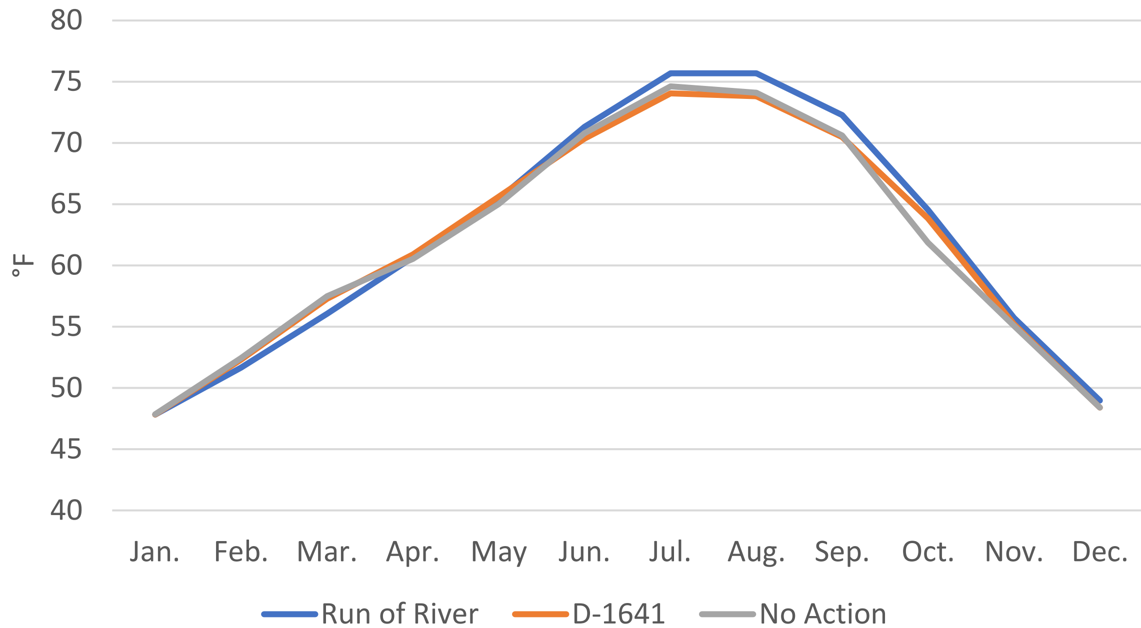

Figure 43. San Joaquin River at Vernalis

The Run of the River scenario features the greatest amplitude, but No Action Alternative and D-1641 are very similar. This is likely because San Joaquin River flows above the Stanislaus River are very similar in the three scenarios, and water temperatures are near ambient air temperatures.

7.3 Suitable Habitat

Steelhead and an experimental population of spring-run Chinook salmon use the San Joaquin River. Both species may be rearing and migrating in March through May (Figure).

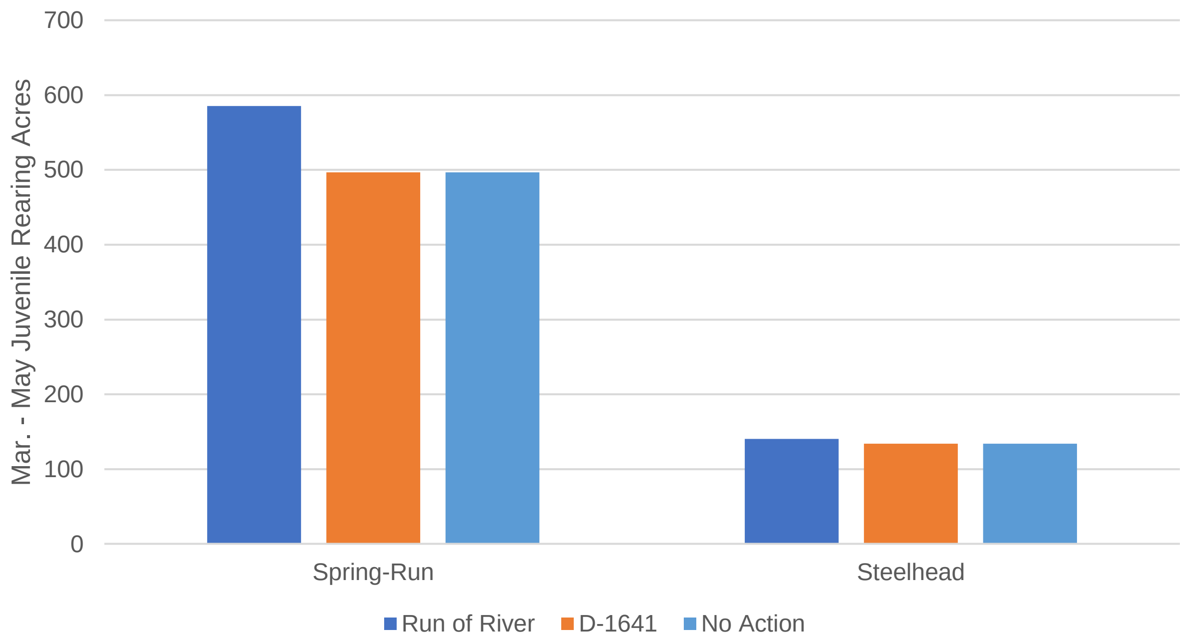

Figure 22. Suitable Habitat in the San Joaquin River from March through May

The D-1641 scenario includes the SJRRP; therefore, the D-1641 and No Action scenarios are the same. Differences with Run of the River are smaller for Steelhead due to degraded leveed channels.

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 shows the sum of modelled inflows to the Delta, including impaired inflows to major rim dams and impaired non-project tributary inflows.

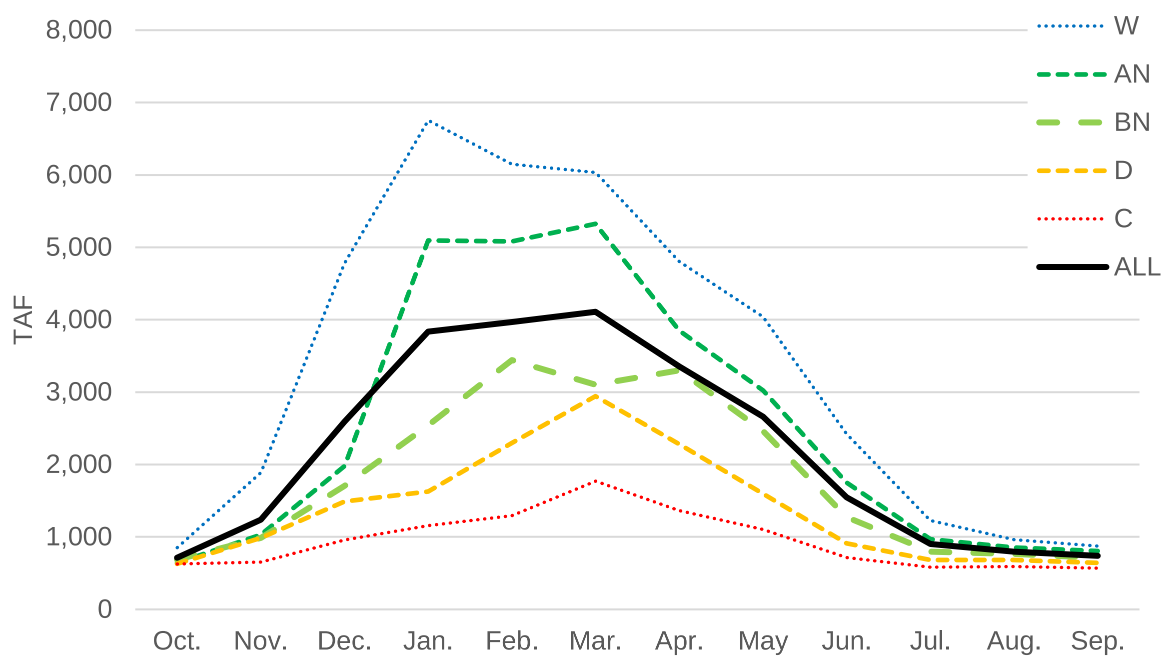

Figure 45. Inflows to the Central Valley by Month and Water Year Type

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 shows a simplified analytical topology.

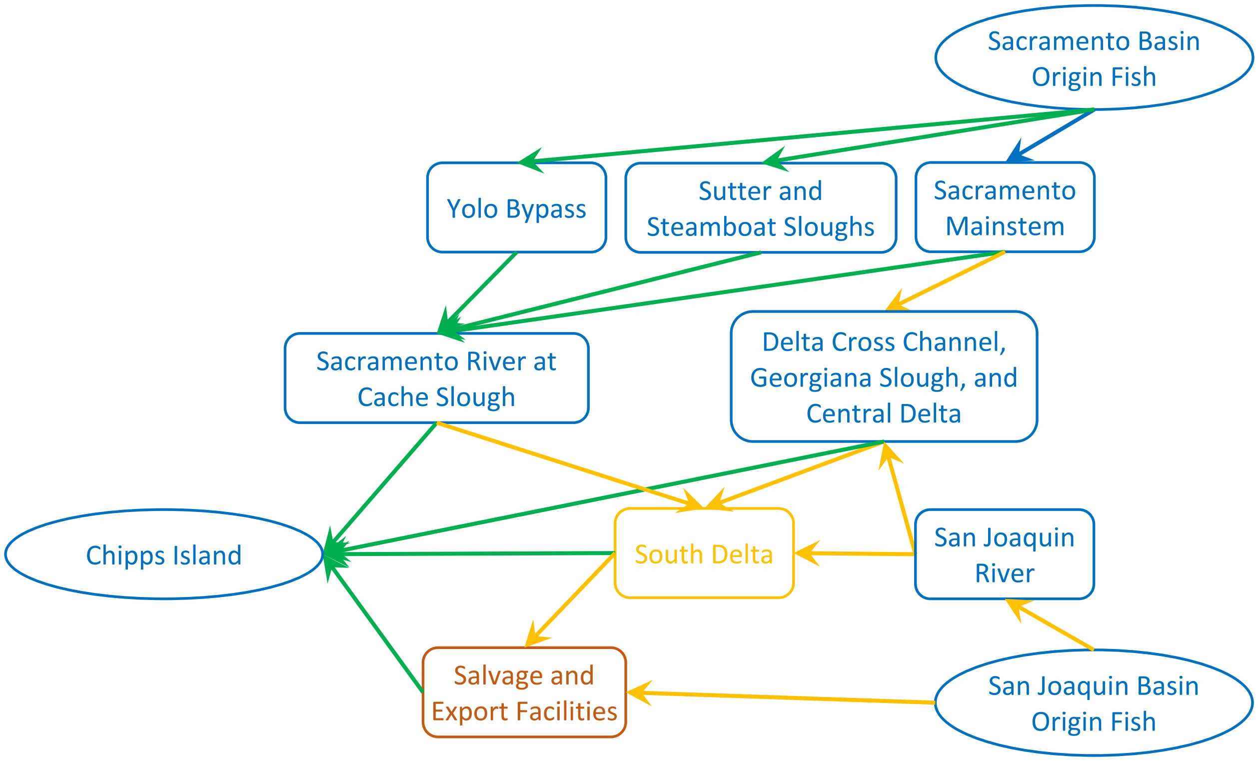

Figure 46. Delta Regions and Analytical Topology

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 State Water Board. Figure shows key locations in the Delta.

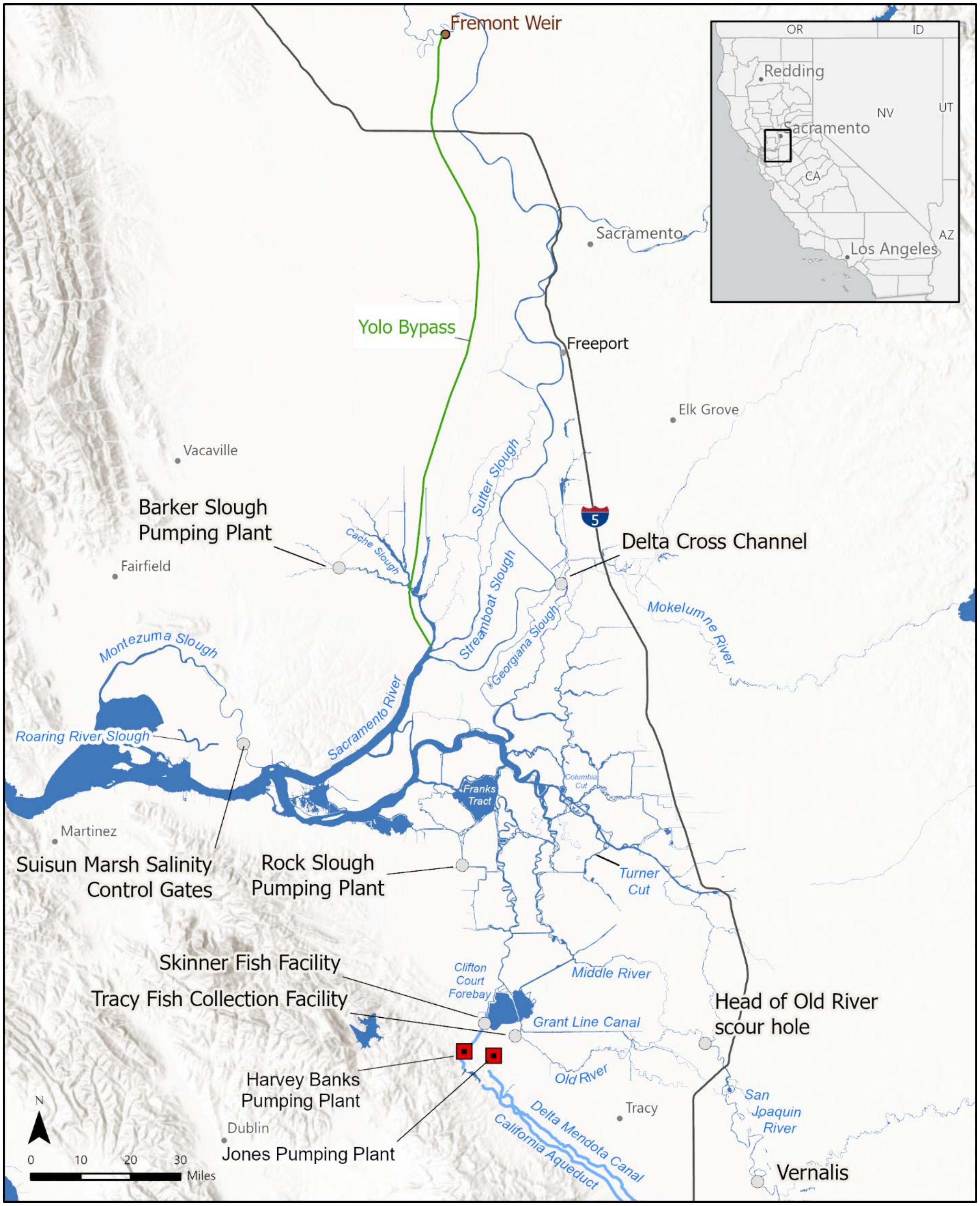

Figure 47. Referenced Delta Facilities and Landmarks

8.1 Water Operations

Figure shows average inflows to the Delta from the Sacramento River at Freeport for the Run of the River, D-1641, and No Action scenarios.

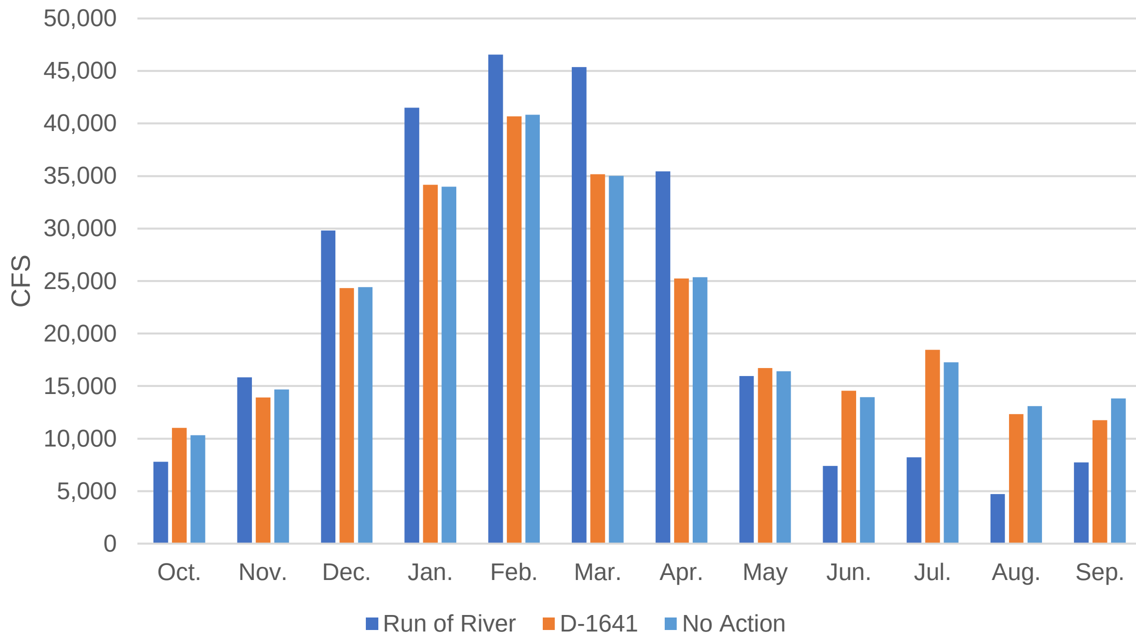

Figure 48. Sacramento River at Freeport Monthly Flows, All Water Year Types

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 shows average inflow flow through the Yolo Bypass.

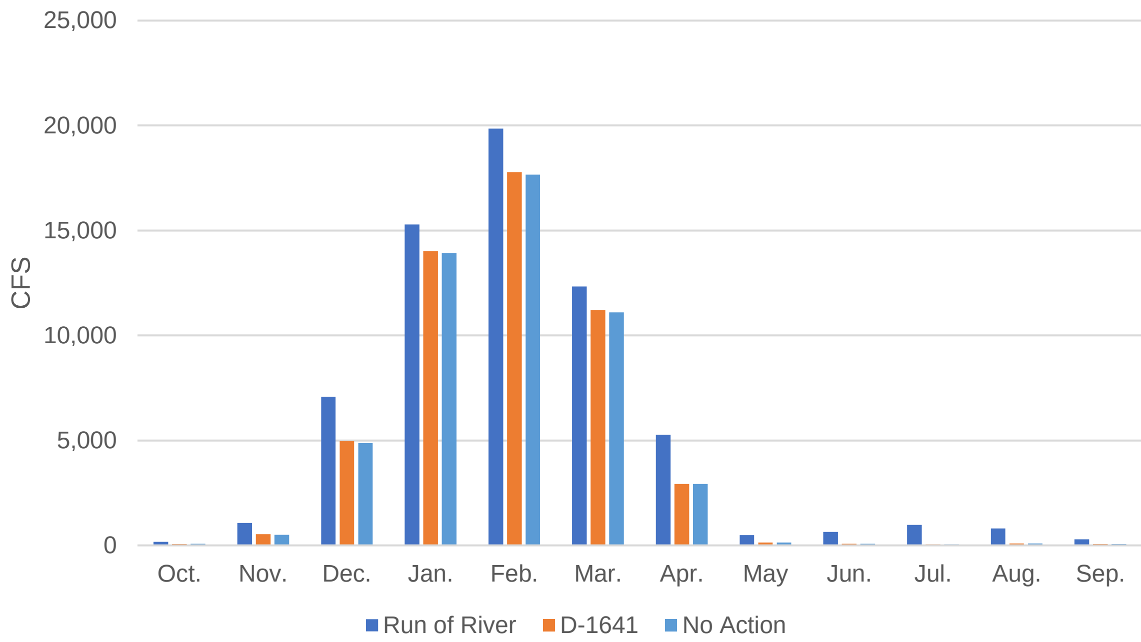

Figure 49. Flow through Yolo Bypass Monthly Flows, All Water Year Types

Yolo Bypass inflows can occur in any year type but are more common in Above Normal and Wet Years. The D-1641 and No Action scenarios include the proposed operation of the "Big Notch" on Fremont Weir. Figure shows inflow from the San Joaquin River at Vernalis.

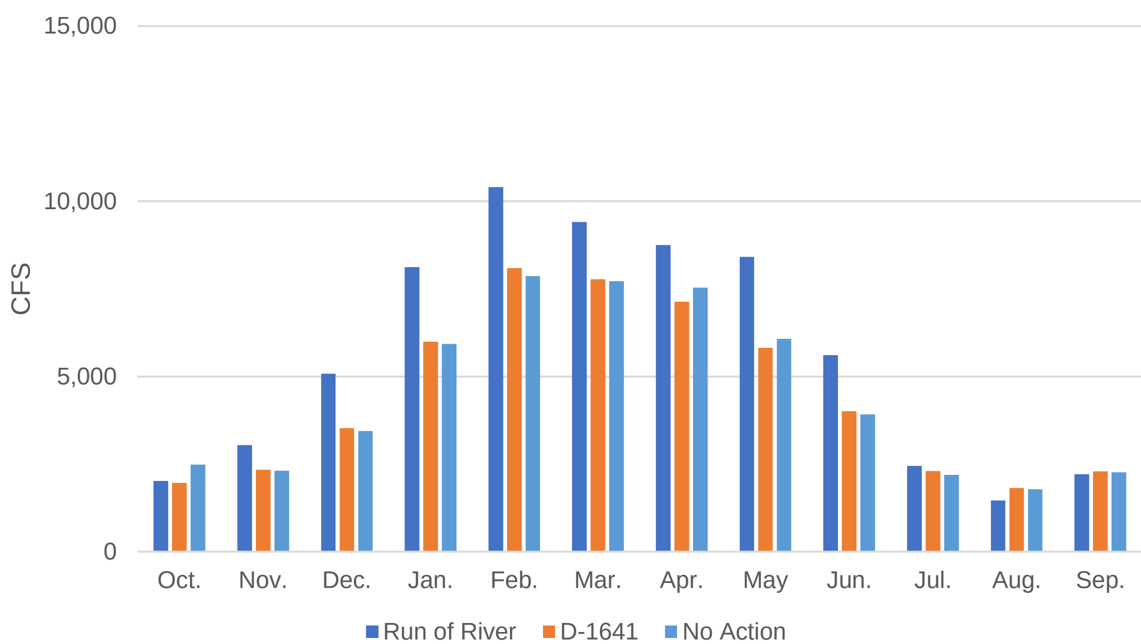

Figure 50. San Joaquin River at Vernalis Monthly Flows, All Water Year Types

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

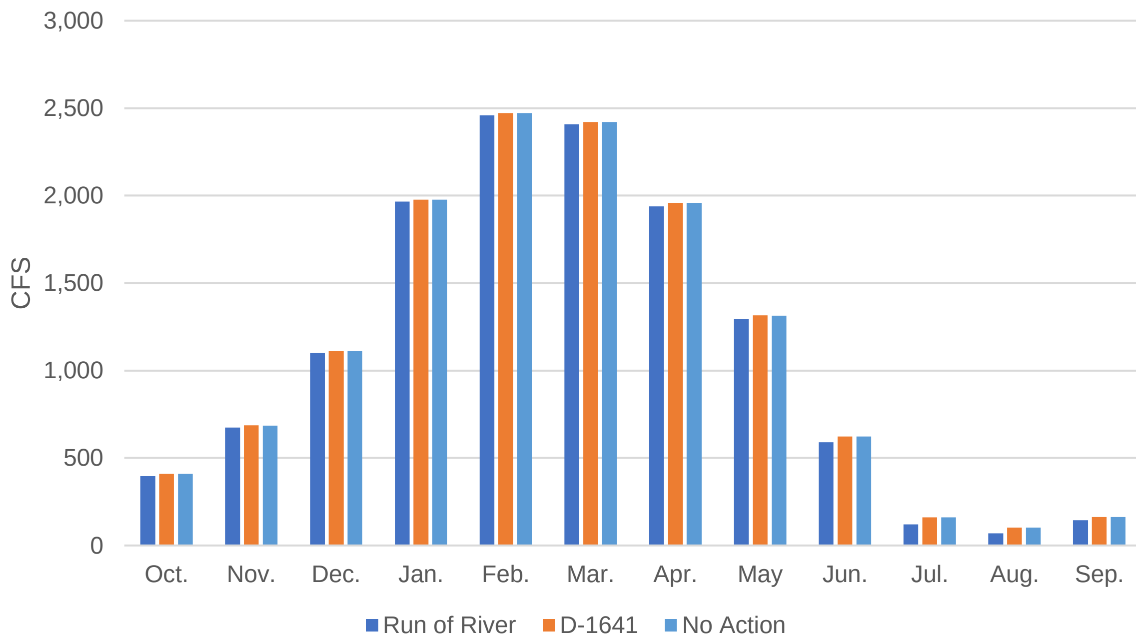

Figure 51. Mokelumne River Monthly Flows, All Water Year Types

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

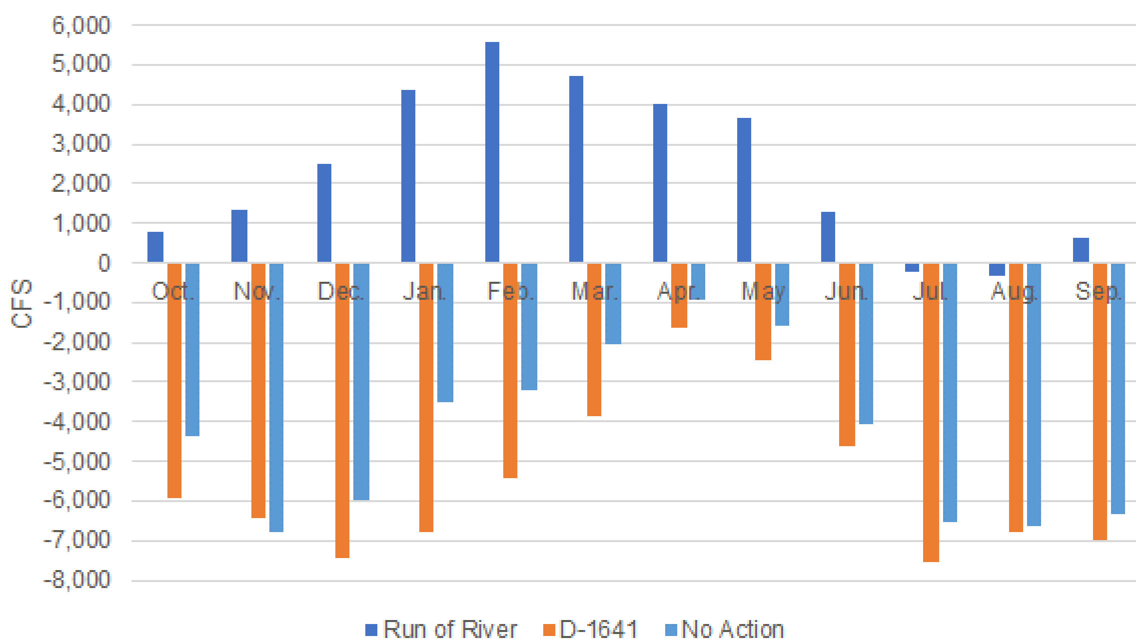

Figure 52. Old and Middle River Combined Monthly Flows, All Water Year Types

The Run of the River scenario shows that OMR can be negative in the summer months even without exports due to non-project in-Delta diversions. D-1641 does not include an OMR limitation; therefore, the No Action scenario has more positive flows. D-1641 does include a limitation on exports to a portion of inflows. Figure shows the resulting Delta outflow.

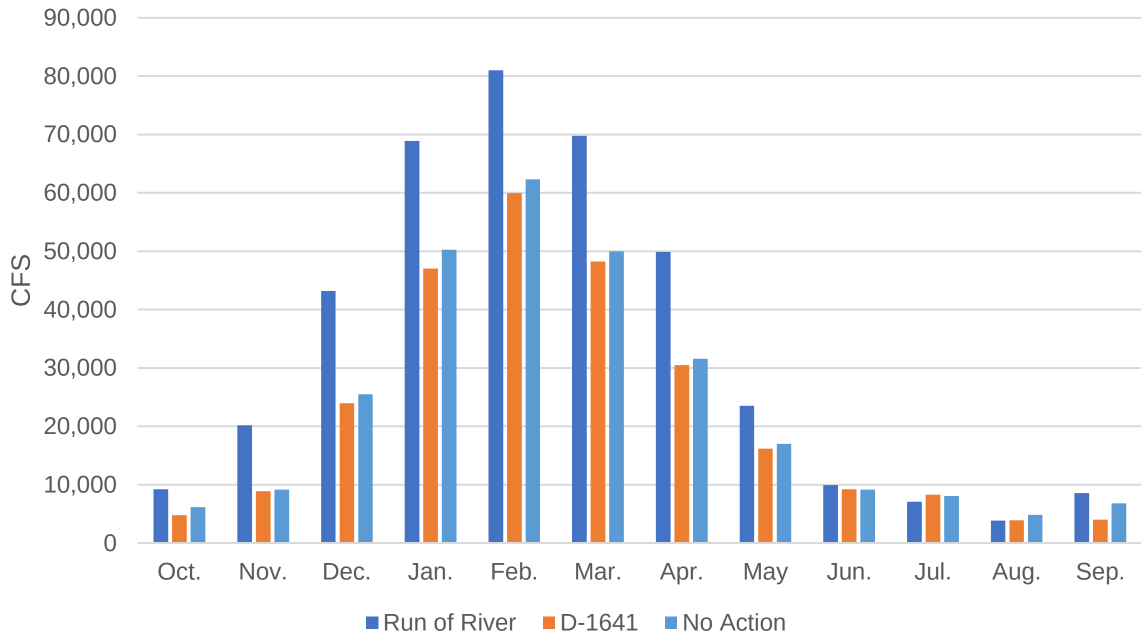

Figure 53. Delta Monthly Outflow, All Water Year Types

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 No Action Alternative 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 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.

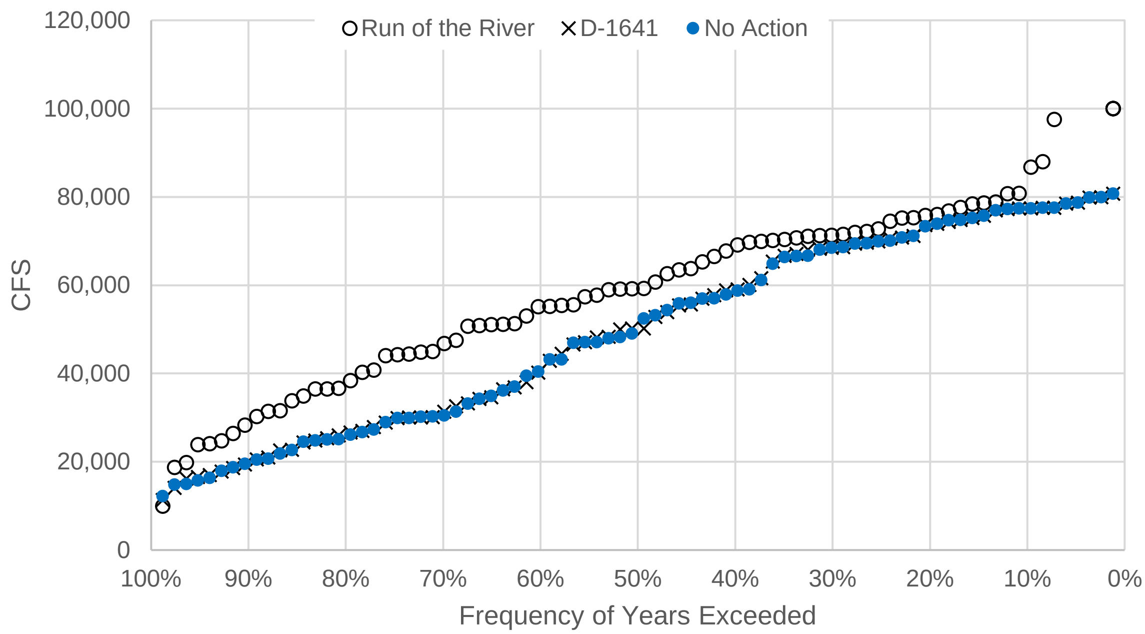

Figure 54. Sacramento River at Freeport Annual Peak Flow Frequency

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

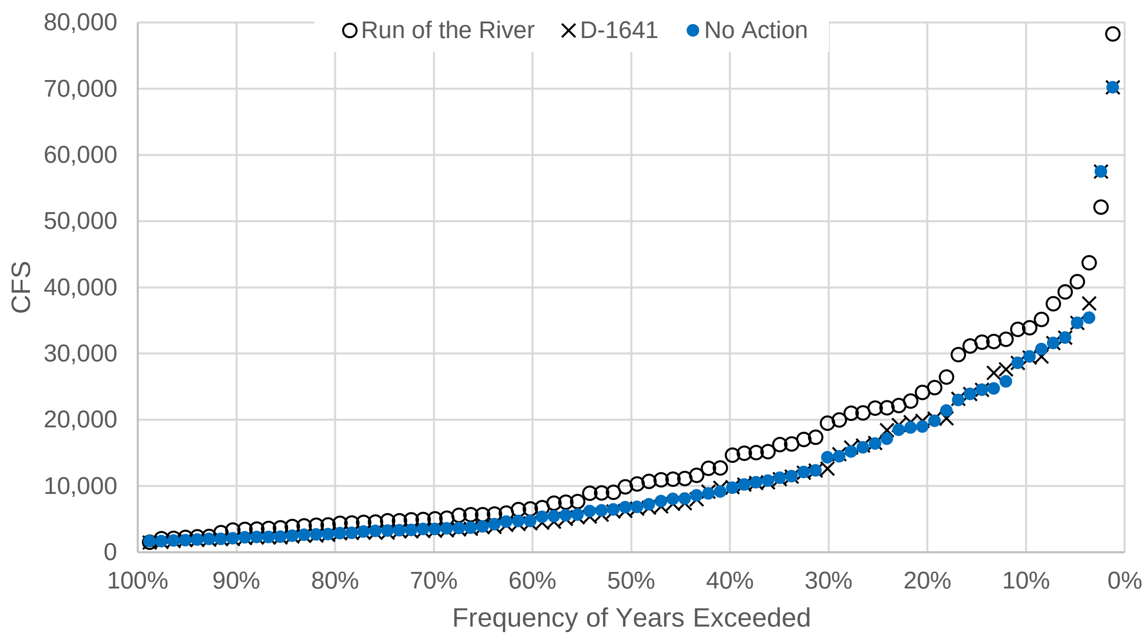

Figure 55. San Joaquin River at Vernalis Annual Peak Flow Frequency

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.

8.2 Water Temperatures

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 shows water temperatures at Prisoners Point along the San Joaquin River.

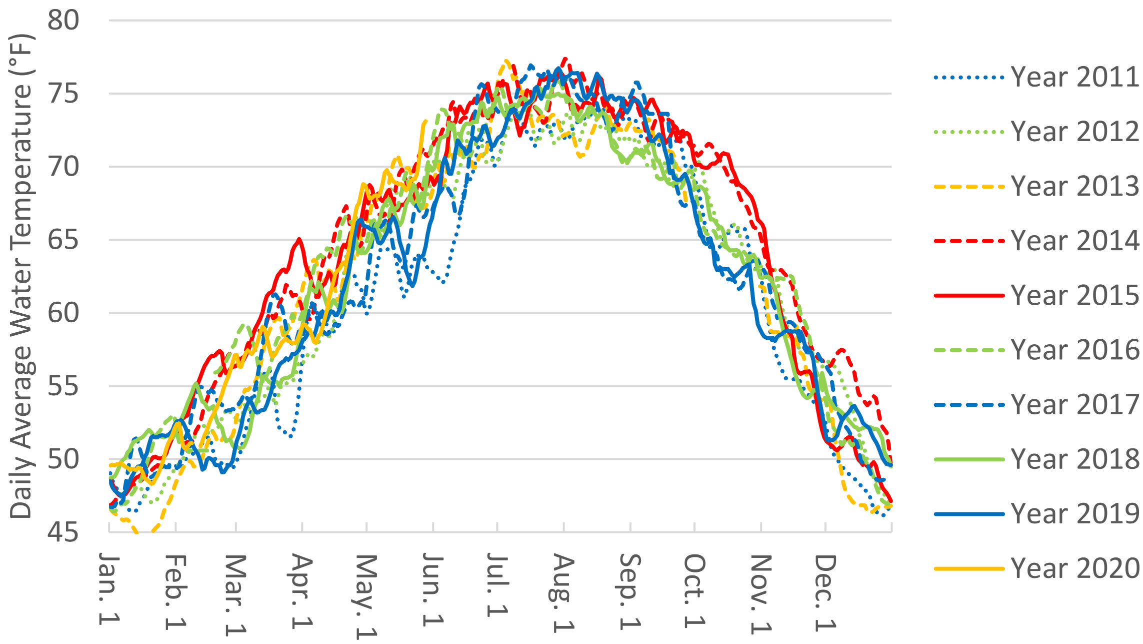

Figure 56. Historical Water Temperatures at Prisoners Point (PRI)

Hourly water temperatures were download from the California Data Exchange Center (CDEC) 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 shows temperatures at Port Chicago, which is between Grizzly and Honker Bays, around 67 km from the Golden Gate Bridge.

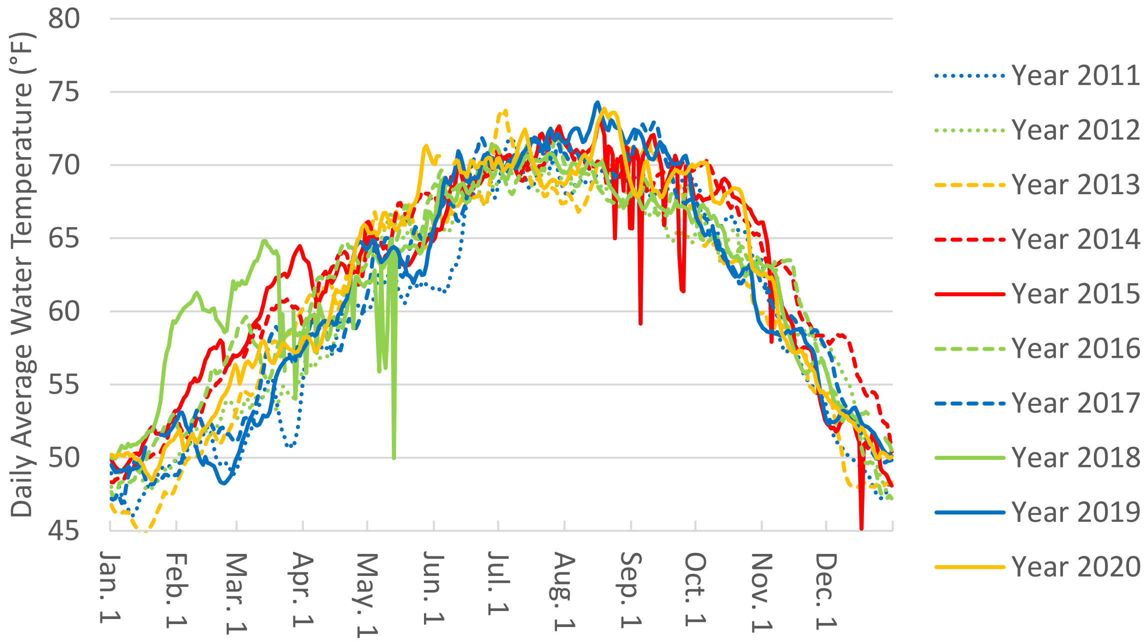

Figure 57. Historical Water Temperatures at Port Chicago (PCT)

8.3 Suitable Habitat

Chinook salmon, sturgeon, and Delta 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 shows an example for the month of March.

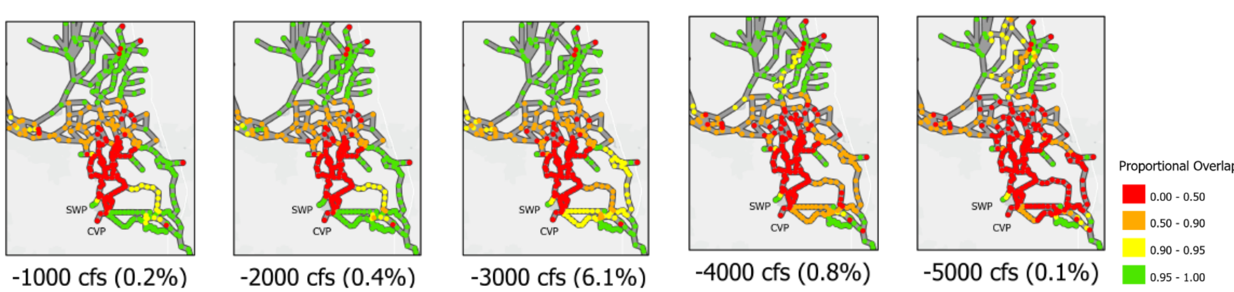

Figure 58. No Action March Proportional Overlap with and without Exports

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 15 shows the location of X2 under scenarios of Run of the River, D-1641, and No Action.

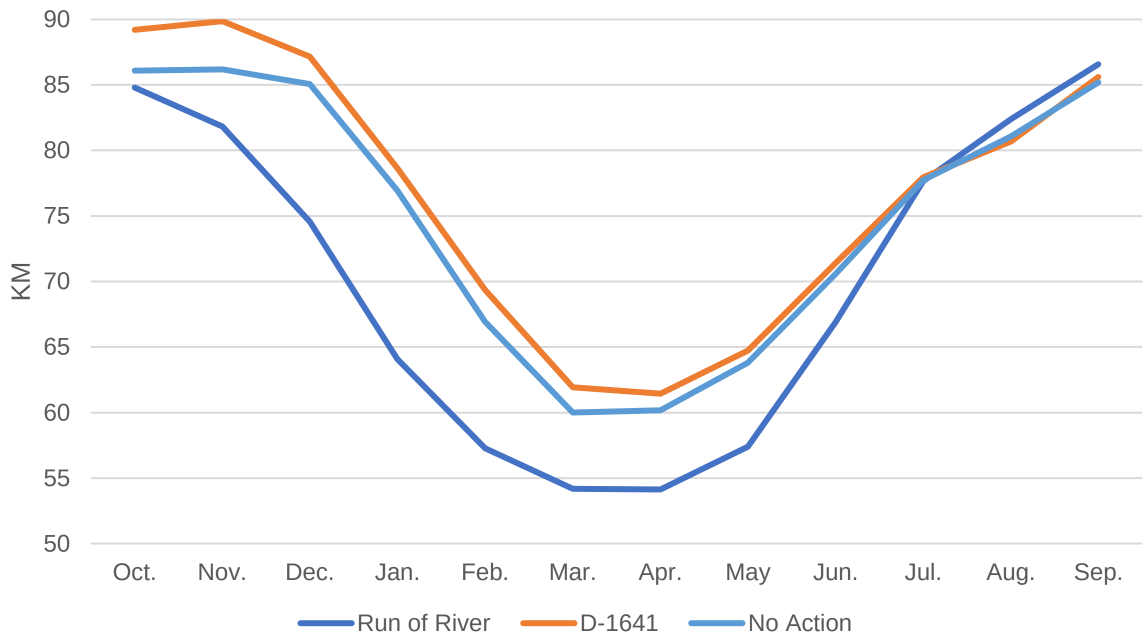

Figure 59. Location of X2

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.

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9. References

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