DRAFT 2026 Sacramento River Temperature Management Plan

Executive Summary

This Temperature Management Plan (Plan) describes how the U.S. Bureau of Reclamation (Reclamation) proposes to operate Shasta Reservoir and the Temperature Control Device (TCD) on Shasta Dam for the 2026 temperature management season. The Plan utilizes data from various sources including Reclamation's April 90% exceedance forecast of Central Valley Project (CVP) operations, recent reservoir temperature profiles, seasonal meteorological forecasts, and estimated winter-run chinook salmon temperature dependent mortality. The Plan is consistent with the 2025 Record of Decision (ROD) to implement the "Action 5" Operations Plan for the Long-Term Operation of the Central Valley Project and State Water Project (LTO) (Reclamation 2025) and State Water Resources Control Board (SWRCB) Water Right Order 90-5 (WRO 90-5) (SWRCB 1990). This year is currently categorized as a Bin 2A in which water temperatures are managed for winter-run spawning habitat on the Sacramento River at Clear Creek (CCR) to a daily average of 53.5°F and to shape temperatures through Governance. For the purposes of WRO 90-5, this translates to meeting a daily average temperature requirement of 56.0°F on the Sacramento River at Balls Ferry Bridge (BSF). Throughout the season, Reclamation will continue to analyze actual conditions and tradeoffs of establishing alternate temperature locations and increased Shasta Reservoir storage levels. Operational updates, and any needed changes to the TMP as the season progresses, including changes to the location of temperature targets along the Sacramento River, would be reported and discussed through the Sacramento River Group (SRG), Fish and Water Operations Group (FAWOG), and the SWRCB.

Introduction

The Shasta Division of the CVP is operated for many purposes including fish and wildlife, water supply, power generation and Sacramento River water quality. Major facilities include the Shasta Dam and Powerplant, Keswick Dam and Powerplant and a TCD on the upstream face of Shasta Dam. This Plan focuses on the fishery management aspect and attempts to maximize suitable water temperature regimes for the endangered Sacramento River winter-run Chinook salmon.

This Plan describes how Reclamation proposes to operate Shasta Reservoir and the TCD on Shasta Dam consistent with:

- 2025 ROD on the LTO of the Central Valley Project (Section 2.19 Water Temperature Management) Reclamation will coordinate through the SRG to prepare a draft Temperature Management Plan (TMP) in April. The draft TMP will include: projected reservoir releases, assumed meteorological conditions, anticipated water temperatures and target locations along the Sacramento River, and temperature dependent mortality (TDM) estimates based on both Martin (2017) and Anderson (2022). Reclamation will finalize the TMP in May or later through coordination with the SRG and FAWOG. Reclamation may update the TMP through coordination with the SRG and FAWOG throughout the temperature management season.
- WRO 90-5 to consult with the California Department of Fish and Wildlife (CDFW), U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and Western Area Power Administration on the designation of a location upstream of the Red Bluff Diversion Dam where Reclamation will meet a daily average water temperature of 56°F.
- WRO 90-5 to provide an operation plan to Chief of the Division of Water Rights of SWRCB, on Reclamation's strategy to meet the temperature requirement at a location upstream of the Red Bluff Diversion Dam.

The temperature management strategy provided by the Plan is based on technical review and input received from the SRG (and FAWOG if applicable). The Plan establishes temperature locations and targets through October 31, 2026 and estimates winter-run Chinook salmon egg mortality, dates for operation of the side gates on the TCD, and end of September cold water pool in Shasta reservoir. Reclamation will monitor the cold water pool, compare measured conditions to actual performance during implementation, and provide regular updates through the SRG throughout Plan implementation.

Background

Shasta Reservoir management considers drought protection actions in nearly every year and identifies actions that protect storage for multiple project purposes including temperature management. A key principle of Shasta management is that drought protection and fish protections are linked. The strategy is framed around an objectives-based management framework that establishes different objectives depending on hydrologic conditions and identifies actions that can be taken for fishery management and drought protection. The framework approach is described in Section 2.5 of the Operation Plan of the LTO and includes the establishment of "Bins" to manage water temperature and storage. This includes three Bins that are each divided into two categories: standard (Bin A) and drought protection (Bin B). The Bin number (1, 2, or 3) is defined by the projected End of April (EOA) storage which is primarily driven by hydrology. The letter of the Bin (A or B) is primarily driven by the expected demands on the reservoir which are a function of hydrology, meteorology, system-wide conditions, contractual requirements and other conditions. The approach establishes biological objectives for each Bin and identifies potential actions based on forecasted End-of April (EOA) storage and forecasted End-of September (EOS) storage. Table 1 is a summary of the temperature management objectives.

Table 1. Water Temperature and Storage Management Framework

Water Temperature & Storage Management Bins	**Category**	**EOA Shasta Storage (MAF)**	**EOS Shasta Storage (MAF)**	**Temperature management objective**
Bin 1 (Enhance)	A	Greater than or equal to 3.7	Greater than or equal to 3.0	53.5°F downstream from CCR
Bin 1 (Enhance)	B	Greater than or equal to 3.7	Greater than or equal to 2.4	53.5°F downstream from CCR
Bin 2 (Recover and Maintain)	A	Greater than or equal to 3.0	Greater than or equal to 2.2	53.5°F at CCR (seasonal shaped if necessary)
Bin 2 (Recover and Maintain)	B	Greater than or equal to 3.0	Greater than or equal to 2.0	53.5°F at CCR (seasonal shaped if necessary)
Bin 3 (Protect)	A	Less than 3.0	Greater than or equal to 2.0	53.5°F upstream from CCR (seasonal shaped if necessary)
Bin 3 (Protect)	B	Less than 3.0	Less than 2.0	53.5°F upstream from CCR (seasonal shaped if necessary)

Footnote:

MAF = million acre-feet

Current Conditions Summary

The Northern California winter of Water Year 2026 has been mild for the most part with only a few periods of heavy wetness, and consequently, Shasta storage is above average but the cold water pool volume is below average. Downstream water temperature performance is expected to be more challenging than the last few water years (i.e., 2024 and 2025) but still much improved over the previous drought years of 2020 to 2022. The Northern Sierra Precipitation 8-Station Index indicates that this year's hydrologic conditions are similar to the 30-year average. However, Shasta Reservoir's cold water pool is projected to be comparable to other below average years such as 2015 and 2022. Coordination and active water temperature management began in February 2026 taking advantage of real-time management opportunities to increase storage and cold water pool. These conditions along with the March 90% forecast supported implementation of a spring pulse flow action as described in the 2026 Sacramento River Spring Pulse Operations Plan (Attachment 1).

Methodology: Modeling Assumptions, Limitations, and Other Uncertainties

Reclamation uses a physically-based simulation model, WTMP, to develop a seasonal water temperature strategy which describes future expected downstream water temperature. This forecast, or simulation of expected water temperature performance is based on the targets specified in the Plan. Future water temperature is forecasted using computational tools, offering insight at various elevations in the reservoirs and downstream in the river. These tools are based on conservative assumptions regarding hydrology, operations, and meteorology. Because this forecast (using conservative estimates to estimate what might happen at the end of October) can never exactly predict the actual hydrology, operations, and meteorology, the model results are not expected to precisely match actual water temperatures. The expectation is, however, that forecasted downstream water temperatures generally have an accepted measure of error regardless of the uncertain future conditions.

In this case, there are generally two types of simulation error: uncertainty of the future conditions (e.g. inputs such as hydrology and meteorology) and inherent model error or bias. Reclamation has used NOAA-NWS' Local Three-Month Temperature Outlooks (L3MTO) and historical meteorology as a means of estimating air temperature expectations for modeling purposes. In coordination with SRG, Reclamation has the choice of five meteorological exceedance threshold options, varying from those that serve more conservative stream temperature planning (e.g., 10% exceedance) to those that serve more aggressive planning scenarios (e.g., 90% exceedance). In past years, SRG has recommended the use of a conservative approach that uses the 25% exceedance L3MTO forecast. Operational decisions on the upper Sacramento River are influenced by local and CVP and

SWP system-wide multi-purpose objectives, including those that are planned (e.g., powerplant maintenance) and uncertain (e.g., weather). Many factors contribute to operational actions including, but not limited to: flood protection operations, forecasted inflows, forecasted meteorology, reservoir stratification, pulse flow schedules, facility maintenance, physical/mechanical facility limitations, upstream operations, minimum in-stream flow criteria, public health and safety criteria, downstream Delta regulatory requirements, Delta exports, power generation, recreation, fish hatchery accommodations, temperature management capabilities, and others. In addition, uncertain or unplanned events can also influence real-time operation decisions (e.g., wildfires and equipment malfunctions). To address uncertainty, Reclamation typically uses conservative estimates of future conditions in the modeling assumptions (e.g., hydrology, operations, and meteorology) and projections are updated through the management period.

Model Inputs

The Shasta Reservoir release strategy included in this plan and temperature modeling is based on the CVP's April 90% exceedance forecast of operations. This release schedule is intended to guide the monthly average releases from Keswick Dam. Daily releases may vary from these flows to adjust for real-time operations. Trinity River releases below Lewiston Dam were based on a forecasted Dry year type per the 2000 Trinity Record of Decision and diversions through Carr Powerplant were adjusted to balance storage, flow and water temperature goals. Meteorologic inputs use the 25% exceedance L3MTO data, and the initial conditions use a Shasta Lake temperature profile based on April 23rd observations. Table 2 describes the monthly forecasted operations for releases and storage targets referenced in the CVP's April 90% exceedance forecast of operations (Attachment 2).

Table 2. Monthly forecasted operations for Shasta and Keswick reservoir releases and storage estimates from April 90% exceedance forecast.

Operations Information	May	June	July	August	September
Shasta Releases (TAF)	481	544	653	610	336
Keswick Releases (cfs)	9,700	11,000	12,500	11,800	7,500
Keswick Releases (TAF)	596	654	768	725	446
Spring Creek Power Plant (TAF)	115	110	115	115	110
Shasta End-of-Month Storage (TAF)	3,814	3,420	2,892	2,409	2,205

Footnotes:

TAF = thousand acre-feet
cfs = cubic feet per second

Water Temperature Strategy, Results and Discussion

Reclamation identified Water Year 2026 as a Bin 2A year based on the April 90% exceedance forecast. In a Bin 2A year, Shasta Reservoir storage is forecast to be greater than 3.0 million acre-feet (MAF) at the end of April; greater than 2.2 MAF at the end of September; and meet 53.5°F at CCR. Although Shasta storage was forecast greater than 3.7 MAF at the end of April, the CVP's April 90% exceedance forecast of operations estimates 2.2 MAF at end of September which identifies it as a Bin 2A year. For this reason, this Plan proposes to target 53.5°F at CCR during the winter-run spawning and egg incubation period and to shape temperatures through Governance. Reclamation will continue to analyze actual conditions and tradeoffs of establishing alternate temperature locations, increased Shasta Reservoir storage levels and balancing the biological goal of maximizing suitable habitat and the risk of running out of cold water. Operational updates, and any needed changes to the TMP as the season progresses, including changes to the location of temperature targets along the Sacramento River, would be reported and discussed through the Sacramento River Group (SRG), Fish and Water Operations Group (FAWOG), and the SWRCB.

In March, SRG evaluated various spring pulse flow options and Reclamation approved a plan for the potential of multiple pulses from April through May. The purpose of the spring pulse flow is to increase outmigration survival of juvenile Chinook salmon and juvenile steelhead. Based on Reclamation's March 90% exceedance forecast of operations and WTMP modeling, the plan showed the pulse flow action would have minimal effect on temperature management operations. Reclamation deployed approximately 50 TAF of spring pulse flow from April 8 to April 14 to benefit spring-run Chinook salmon and steelhead juveniles.

The Keswick Reservoir release schedule in this Plan, which does not include any additional spring pulse flow actions, was developed by Reclamation as part of the CVP's April 90% exceedance forecast of operations.

The temperature modeling results targeting 53.5°F at CCR for this Plan are presented in Table 3 and Attachment 3. Operating to 53.5°F at CCR provides similar winter-run Chinook temperature mortality estimates as operating to 56.0°F at BSF. For the purposes of WRO 90-5, BSF represents the requirement location to meet a daily average temperature requirement of 56.0°F. Further refinement to the temperature management strategy would occur through coordination with SRG and FAWOG as the temperature management season progresses.

Table 3. Estimated average monthly water temperature in degrees Fahrenheit at Shasta, Keswick, CCR, and BSF based on model run of operations targeting 53.5°F at CCR and April 90% exceedance forecast.

Month	Shasta (°F)	Keswick (°F)	CCR (°F)	BSF (°F)
May	52.6	53.9	54.8	56.1
June	50.1	51.9	53.1	55.0
July	49.7	51.8	53.1	55.2
August	49.9	52.1	53.2	55.0
September	50.2	52.7	53.6	55.1
October	53.4	54.4	54.9	55.7
November	55.8	56.0	55.9	55.4

Water temperature forecasts indicate favorable temperatures for winter-run chinook salmon egg incubation with Temperature Dependent Mortality (TDM) estimates less than 1% and 3% (Table 4) for the scenario targeting 53.5°F at CCR.

The SRG has an interest in better understanding the needs of fall-run chinook and improving the tools to manage conditions for fall run. Maximizing carryover storage and cold water pool can typically improve temperature conditions for fall-run spawning (which historically runs from September through December, peaking in October) and subsequent egg incubation. Minimizing the drop in the stage of the river (from peak summer flows, to fall and winter flows) reduces winter-run redd dewatering, and in turn allows for earlier stabilization of fall flows to minimize fall-run redd dewatering.

Table 4. Fish and water performance metrics from biological modeling (Attachment 4).

Metric/Scenario	53.5°F at CCR (90% Exceedance)
Stage-dependent TDM	0.7%
Stage-independent TDM	2.2%
End of Sept CWP Storage less than 56°F (TAF)	387
First Side Gate Use	August 13
Full Side Gate	August 31
End of September Storage (MAF)	2.2

Footnotes:

TAF = thousand acre-feet
MAF = million acre-feet

Reclamation commits to reporting out on the status of this release outlook, temperature management and overall system operations at the monthly SRG meetings. Reclamation will continue to coordinate through SRG to review these and other model results and may update these TMP and TDM estimates based on those discussions.

References

Bureau of Reclamation. 2025. 2025 Record of Decision to implement the "Action 5" Operations Plan for the Long-Term Operation of the Central Valley Project and State Water Project. U.S. Department of Interior

State Water Resources Control Board. 1990. Water Rights Order 90-5.

Attachment 1 - 2026 Sacramento River Pulse Flows Operations Plan

4/14/2026

Executive Summary

- Reclamation's Shasta Division has been marked by low snow runoff, warmer air temperatures, and above average Shasta reservoir storage during water year 2026. However, forecasted runoff is anticipated to be low and affect End of September storage.
- Reclamation has discussed many spring pulse flow scenarios for April 2026 and identified considerations through the Sacramento Rive Group (SRG) and evaluated a range of scenarios in this operations plan. Based on available tools, SRG feedback from interest holders, agencies, and tribes Reclamation plans the following operation:
    - A 4-day pulse flow starting on April 8, 2026, with an estimated 25% increase in outmigration survival (compared to no pulse) and an estimated water cost of 35 TAF (estimated resulting Keswick release would be 10,000 cfs targeting a flow at Wilkins Slough flow of 11,000 cfs).
- This pulse flow is anticipated to increase outmigration survival for spring-run Chinook in the lower Sacramento River and fall-run chinook salmon released in the Upper Sacramento River from Coleman Fish Hatchery. In addition, Delta water temperatures are approaching unsuitable levels for outmigrating juvenile salmonids; therefore, an earlier season pulse is likely to have better outmigration survival than later season pulse implementation.
- This pulse flow is anticipated to increase temperature dependent mortality, although there remains a high degree of uncertainty about the differences between these values. This pulse flow reduces end of September Shasta storage, although the Shasta Operations Framework year type should remain a Bin 2B. This pulse flow is likely to reduce fall operational flexibility to reduce fall-run Chinook salmon redd dewatering.
- Reclamation will continue to coordinate and evaluate additional Central Valley Project Pulse Flows through the SRG once an April operations forecast and Draft Temperature Management Plan is available.

Background

As part of Action 5 for the Long term Operation of the Central Valley Project and State Water Project (2.11 Central Valley Project Pulse Flows), pulse flows address the outmigration cue stressor on steelhead juveniles and spring-run Chinook salmon juveniles by providing flow cues for outmigration and increasing the outmigration travel rate. Reclamation would release up to 150 thousand acre-feet (TAF) in pulse flow(s) each water year, typically in the spring when the pulse does not interfere with the ability to meet water temperature objectives or other anticipated operations of the reservoir. Reclamation through governance, may discuss the plan and make any appropriate and/or necessary refinements prior to implementation.

Forums are established for the purpose of sharing operational plans via notifications, gathering scientific and commercial data to inform the operation of the CVP and SWP, and for reporting the outcomes of operations. Reclamation would schedule this pulse after coordination through the (SRG) and may include coordinating timing with natural flow events, potential storage management operations and/or pulse flows in tributaries. The timing, magnitude, duration, and frequency of the pulse flows will be refined through the SRG assessment process. The SRG ad hoc pulse flow group convened to discuss pulse flows on 3/17 and 3/24. The SRG convened on 3/26 to discuss, among other items, spring pulse flow. The SRG provided feedback about these conditions and requests included pulse flows in late March. At the March 26 SRG meeting, early observations of coldwater pool stratification were presented and showed very low volumes of coldwater. At the March 31 SRG meeting, a draft of this Operation Plan was shared, and the start date was moved back a day further.

The temperature and flow plans are developed using the best available science including current hydrologic forecasts, CVP operational outlooks, fishery information, and modeling information. Reclamation coordinates through SRG to develop a protocol for agency collaboration regarding temperature and flow models and will strive to create shared understanding of model constraints, uncertainties, limitations, applied assumptions and interpretations; develop management questions and scenarios that may benefit from modeling support; develop and review early season operational scenarios to support temperature management and flow planning. Reclamation, through the Fish and Water Operations Group (FAWOG), will discuss the weekly fish and water outlook operations plan assessment and make any appropriate and/or necessary refinements prior to implementation. SRG meeting notes are posted to Reclamation's webpage.

Forecasted and Current Conditions

Shasta storage is 4.065 MAF as of March 23, 2026, which is 121% of the 15-year average. Total May 1 Shasta Reservoir storage is predicted to be 3.916 MAF based on the preliminary March 90% exceedance forecast and 3.940 MAF based on the preliminary March 50% exceedance forecast. Snowpack levels are 8 percent of average (Figure 1). March Shasta Reservoir temperature profiles as of March 23, consist of low cold-water pool similar to a drought year (Norther CVP Water Temperature Report - May 2026). Water temperatures at Wilkins Slough are approaching 68F (Figure 2).

CVP actual operations do not follow any forecasted operation or outlook; actual operations are based on real-time conditions. CVP operational forecasts or outlooks represent general system-wide dynamics and do not necessarily address specific watershed/tributary details.

CVP releases or export values represent monthly averages. CVP Operations are updated monthly as new hydrology information is made available December through May.

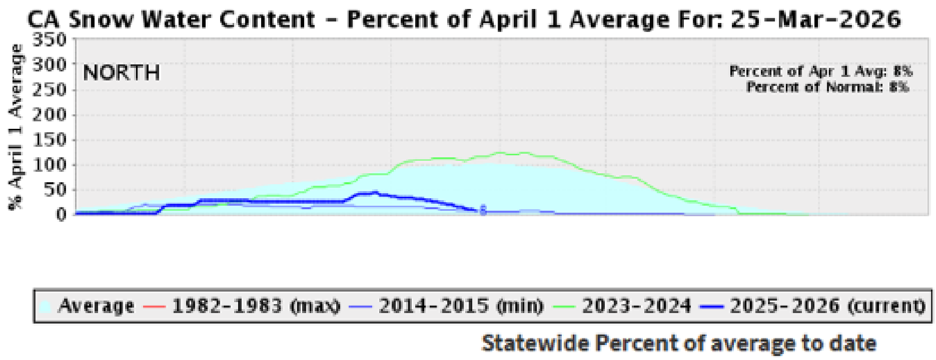

Figure 1. [Snowpack Conditions - Snow Water Content Graph]()

Figure 1 is a line graph showing California northern region snow water content as a percent of the April 1 average through March 25, 2026, compared against historical benchmarks. The current water year 2025–2026 (dark blue) tracks near zero throughout the season, consistent with the 2014–2015 minimum year (dark blue dashed), and well below the long-term average and the 1982–1983 maximum. As of March 25, 2026, the percent of April 1 average is 8% and the percent of normal is 8%.

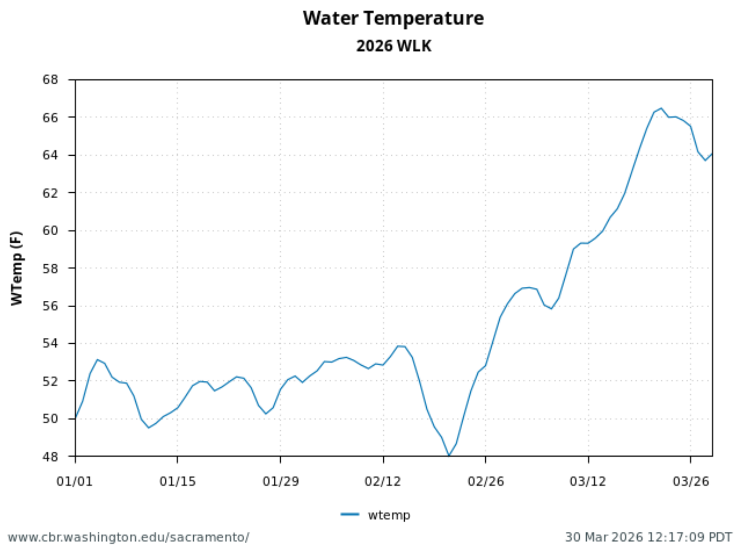

Figure 2. Water temperatures at Wilkins Slough.

Figure 2 is a line graph showing water temperature in degrees Fahrenheit at Wilkins Slough (WLK) for water year 2026 from January 1 through March 30, 2026. Temperatures began around 52°F in early January, dipped to a low near 49°F in mid-January, and remained relatively stable between 50–54°F through mid-February before dropping sharply to approximately 48°F around February 26. Temperatures then rose steeply through March, peaking near 67°F around March 24 before declining slightly to approximately 63°F by March 30.

Scenario Modeling

655 scenarios were modeled to assess outmigration survival benefits (Attachment 1; 2026 Sacramento River Spring Pulse Flow Scenario Evaluation). Note the tool used to develop these scenarios is not peer reviewed and for discussion purposes only. Many of these scenarios are anticipated to interfere with temperature management objectives and even exceed 150 TAF, which are not being considered. There are also concerns with elevated water temperatures impact to outmigration survival and interest in implementing pulse flow action/s earlier in the early than in previous years.

Temperature Dependent Mortality (TDM) modeling compared the NAA, and pulses of 10, 20,30,40, 50 TAF occurring in the month of April based on the March 90% forecast exceedance (Table 1). Water temperature forecasts were contrary to expectations in which pulse scenarios of lower volumes of 50 TAF were warmer and consequently had higher TDM estimates than the 50 TAF scenario. Also unexpected was the 50 TAF pulse in May scenario was forecasted to be warmer than the 50 TAF in April and 50 TAF in May scenario and therefore was estimated to have higher TDM than that scenario. Overall, the scenarios are fairly similar results, and our tools are likely not precise enough for evaluating 10 TAF volume differences. For more information, refer to Attachment 2.

TDM values described in the tradeoff table do not correspond perfectly with the flow scenarios as more precise estimates for water cost are available for the flow scheduling than is practical for temperature modeling. Water costs for scenarios were rounded to the nearest 10 TAF for assigning TDM values.

Table 1. Water and fish management predicted performance measures for considered scenarios. Survival was estimated with the Burford et al (2025) model.

Metric	Scenario description	EOA (MAF)	EOS (MAF)	Bin	TDM% (stage-dependent)	TDM% (stage-independent)	Predicted Estimated Survival (%)	% Change in Survival	Water Cost (TAF)
No Pulse	No pulse flow	3.916	2.105	2B	3	6	3.9	0	0
3.1	1-day pulse 4/7	3.903	2.092	2B	8	13	4.2	7.1	13
3.2	2-day pulse 4/7	3.896	2.085	2B	4	9	4.4	11.1	20.1
3.3	3-day pulse 4/7	3.888	2.077	2B	4	9	4.6	17.5	27.9
3.4	4-day pulse 4/7	3.881	2.07	2B	4	9	4.7	24.5	35.3
4.1	1-day pulse 4/14	3.902	2.091	2B	8	13	4.4	16	14
4.2	2-day pulse 4/14	3.894	2.083	2B	4	9	4.8	27.5	22.4
4.3	3-day pulse 4/14	3.885	2.074	2B	4	9	5.5	41.3	30.8
4.4	4-day pulse 4/14	3.876	2.066	2B	7	12	5.9	52.7	39.3

Anticipated Salmonid Effects

Spring-run young-of-year outmigrate from the upper Sacramento River through the winter and spring. Between 2010-2024, the mean date of passage by these fish at Red Bluff Diversion Dam is March 15, with 95% passing by April 26. Spring-run Chinook salmon from Mill and Deer Creek and other tributaries demonstrate a shorter outmigration period, typically peaking in late April and May. Between 2010-2024, the mean date of passage entering the Delta (e.g. Sacramento Trawl) for spring-run Chinook salmon was April 8, with 95% entering the Delta by April 27. This periodicity suggests spring-run Chinook salmon rearing in the lower Sacramento River through April and May. Fish monitoring is detecting these fish in the lower Sacramento River and Delta, where spring-run Chinook salmon (Feather River lineage) are being salvaged at the CVP and SWP fish collection facilities. Those outmigrating in April and May experience worse outmigration conditions during this later period of their outmigration. In 2023-2025, pulse flows during late April and early May were predicted to have the greatest improvement in riverine outmigration survival.

Steelhead juveniles migrate past Red Bluff Diversion as early as April and throughout the summer, which likely reflects redistribution of these fish into rearing habitat rather than outmigration through the Sacramento River. Between 2011-2025, the median date for steelhead outmigration passing Knights Landing was March 12 and the median last day of May 3 suggesting many steelhead smolts outmigrate prior to May.

Fall-run Chinook salmon are being released from Coleman National Fish Hatchery in March and April 2026. During water year 2025, fall-run Chinook salmon passage by Red Bluff Diversion Dam was greatest in January and early February when high flows occurred in the upper Sacramento River, and currently very few fall-run Chinook salmon are being sampled at Red Bluff Diversion Dam (Figure 3). This year, water temperatures are already approaching unsuitable levels (i.e., above 68°F; Marine and Cech 2004) for outmigrating salmonids. For example, water temperatures were 67.6°F on March 22 at Wilkins Slough. Historically, temperatures at critical migration points in the river and Delta do not exceed 68°F until late April (Figure 4-5).

Increased reservoir releases can improve outmigration conditions resulting in better survival than under lower releases (Notch et al 2020, Michel et al 2021, Burford et al 2025). Due to warm March water temperatures (Figure 4-5), the SRG has shared feedback to pair WY2026 pulse flow releases with water temperature conditions in early April before it is expected to be too hot downstream. There remains uncertainty as to the mechanism resulting in improved outmigration survival and is likely increased flows resulting in some combination of reduced travel times by juvenile salmon, reduced predation effects, and improvement in other environmental conditions favoring successful outmigration (e.g. cooler temperatures, higher turbidity, greater habitat access).

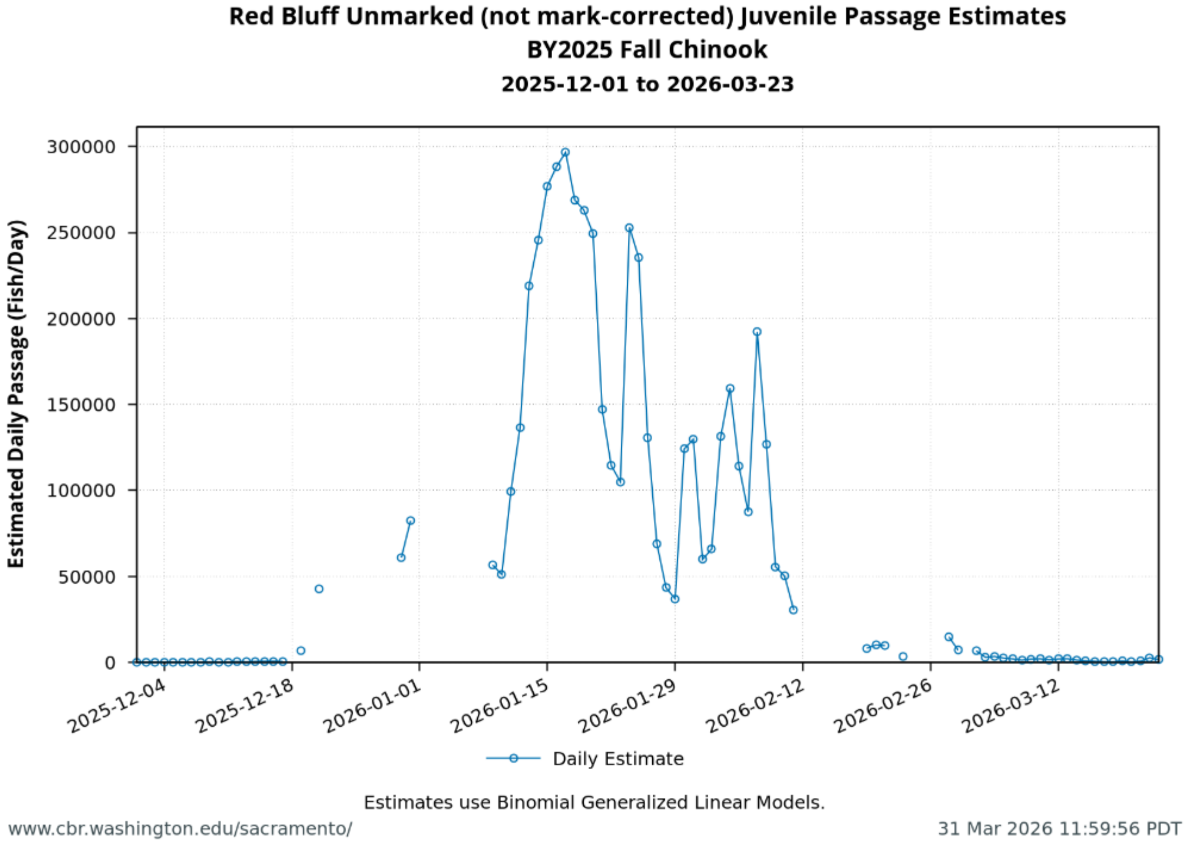

Figure 3. BY25 fall-run chinook salmon median daily passage at Red Bluff Diversion Dam screw traps.

Figure 3 is a line graph showing estimated daily juvenile passage in fish/day from December 1, 2025 through March 23, 2026. Passage remained near zero through late December before rising in early January, peaking near 275,000 fish/day around January 29, 2026. Passage then declined through February with some variability, including a secondary peak near 150,000 fish/day around February 12, before dropping to near zero by early March and remaining there through the end of the period.

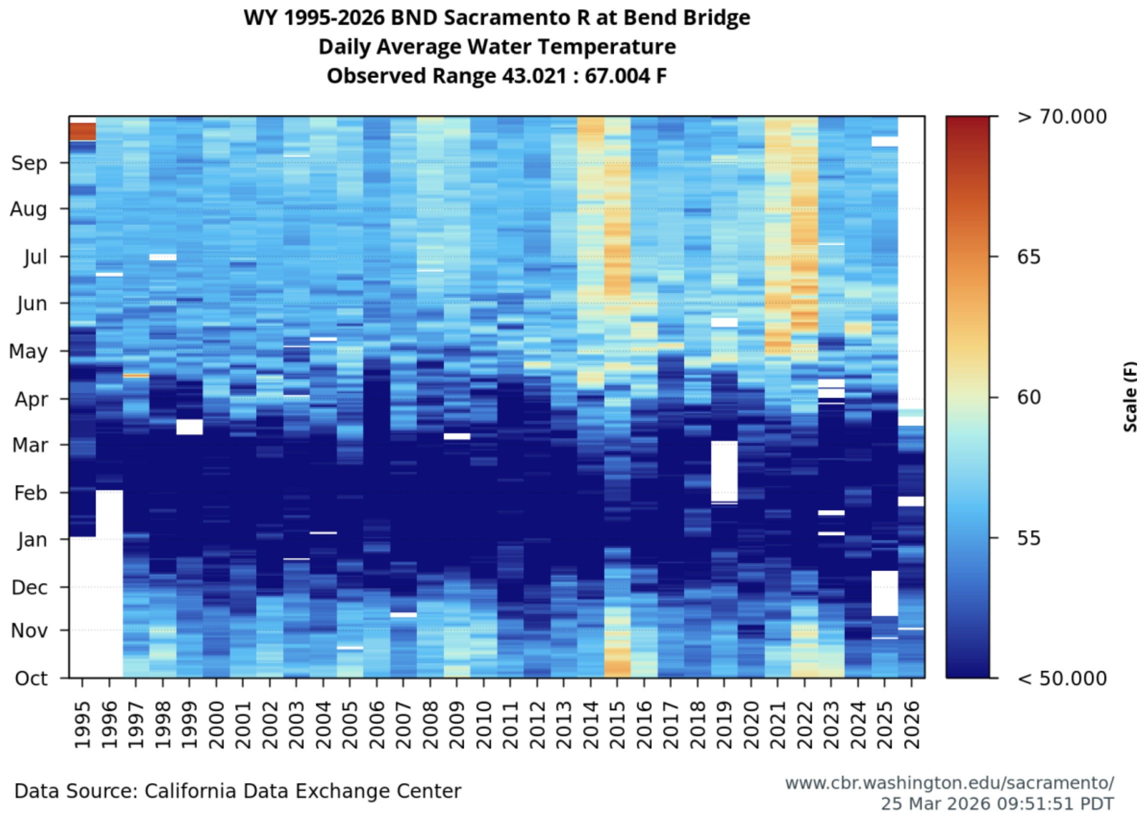

Figure 4. Historical water temperature (degree F) in the Sacramento River at Bend Bridge. This figure demonstrates that in historical wet years water temperatures appear suitable for outmigrating juvenile salmonids in May while in dry years water temperatures are unsuitable.

Figure 4 is a heat map displaying daily average water temperature at Sacramento River at Bend Bridge from water years 1995 through 2026, with the observed range for the current year noted as 43.021–67.004°F. Cooler temperatures (below 50°F, shown in blue) predominate from October through March, while warmer temperatures (above 65°F, shown in orange and red) are concentrated in the summer months of June through September. The figure illustrates interannual variability in spring warming timing, with some years showing notably warmer April and May temperatures than others.

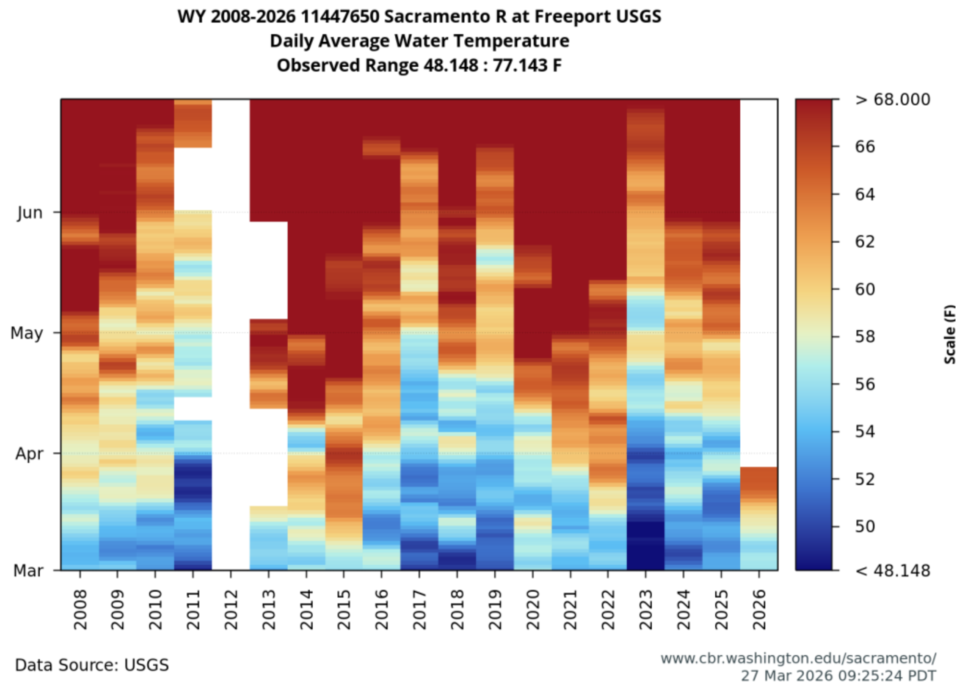

Figure 5. Historical water temperatures in degrees F from 2008 to 2026 at Freeport.

Figure 5 is a heat map displaying daily average water temperature at Sacramento River at Freeport from water years 2008 through 2026, with the observed range for the current year noted as 48.148–77.143°F. Temperatures in March range primarily from below 50°F to around 54°F (blue to light blue), rising through April and May into the mid-50s to low 60s°F (light blue to green), and reaching above 65°F (orange to red) in June and July across most years. Notable data gaps appear in 2010 and 2012. The current year (2026) shows temperatures in the low 50s°F through March, consistent with the cooler end of the historical range for that time of year.

Initial real-time results for this year's Pulse Flow Study as well as previous years are posted to: CalFishTrack. Results will be posted to: Central Valley Enhanced Acoustic Tagging Project (noaa.gov) and will also be reported in the Shasta Winter Storage Rebuilding and Spring Pulse Flow Seasonal Report. In addition, wild *O. mykiss* have been acoustically tagged and released in the Sacramento River to evaluate survival and outmigration rates; however, many of these transmitters may expire before the end of the season CalFishTrack.

Considerations

ACID dam facility

This requires low flow (4,000 to 6,000 cfs) during its installation and cannot sustain high flows greater than 14,000 cfs while fully installed; although flashboards can be removed to adjust flow capacity ACID Dam was installed during the last two weeks of March.

Diversion Schedule

Water Diversions on the Sacramento River are expected to increase mid-April as agricultural water demands begin to ramp up. As these depletions increase, releases from Shasta would increase to meet demands.

Ecological effects

Interested parties have provided observations and described concerns related to reduced insect abundance, juvenile stranding, redd scouring, and other disruptions to spawning events that they believe are associated with pulse/storm flows releases. In 2024, trout guides observed impacts to invertebrate communities following large flood control release that were around 36,000 cfs, which may be three orders of magnitude greater than the spring pulse flows.

Fish Monitoring

Flow fluctuations are anticipated to affect monitoring efforts. For example, efforts for juvenile stranding surveys increase, and effectiveness monitoring for habitat restoration projects is hindered during flow fluctuations. Flows exceeding 20,000 cfs can hinder continuous sampling at Red Bluff rotary screw trap.

GCID Hamilton City Intake Channel Dredging Project

GCID is preparing to start work on Dredging of the Hamilton City Intake Channel pursuant to our permit with CDFW. This is a critical activity to provide sufficient flow through the fish screen and pumping plant to service GCID landowners and the three wildlife refuges served by GCID. Currently, pursuant to the permit, GCID must put in a fish guidance structure 7 days prior to starting dredging activities. Currently, GCID anticipates that occurring on April 2nd and possibly April 3rd to complete. GCID anticipates initiating dredge efforts on April 9th or 10th. There are concerns that the higher river levels associated with a pulse flow could affect dredging work due to high river levels during the pulse flow. GCID prefers if such an action could be complete on or before April 9th. Reclamation updated GCID regarding potential pulse flows on March 30. Continued close coordination with GCID may be able to minimize impacts and ensure their permit condition compliance and complete this important maintenance.

Habitat restoration project implementation

Salmonid rearing habitat project in which 25 to 30 rockwads are being installed upstream of Sundial Bridge during the first week in May. Variable flows could affect barge and stability of craning the rockwads into the river. Higher flows are likely beneficial for building the barge due to deposition at the access site.

Hatchery releases

Coleman National Fish Hatchery fall-run smolts are ready for release early this year. Most of these fish were or are planned to be released in March and early April. Juvenile fall-run Chinook that outmigrate during higher flows and cooler conditions are expected to have better survival.

Hydropower Generation
In terms of power cost impacts, it is generally preferrable to schedule the peak of a pulse flow to occur during the week rather than the weekend, and during warmer periods.

Lunar phase
Outmigration survival is anticipated to increase during a new moon and predation is hypothesized to decrease due to reduced illumination. The new moon is Friday April 17 and May 16.

Recreational and Commercial Fishing
Fishing guides have expressed concerns with variable flows impacting trout behavior and fly hatches, which affect their business.

Redd Dewatering and Juvenile Stranding
WY2026 Spring pulse flows are likely to manage End of September Storage close to the Shasta Framework Bin 2b/3 threshold of 2.0MAF. This may potentially reduce flexibility for higher releases as part of the Wilkins Slough October Maximum Flows and Fall Release Ramp Down (November) actions. Through Governance, Reclamation may determine releases and ramping rates are necessary, that potentially result in higher Chinook salmon stranding and redd dewatering than without pulse flows to maximize the available coldwater pool for water year 2027.

Seepage
Flows exceeding 18,000 cfs at Wilkins Slough have been reported to create seepage problems. Also, weir spills limit the ability for ground preparation and farming within the bypasses, so those thresholds should be considered.

Storage and temperature-dependent mortality
Temperature modeling is unreliable before thermoclines establish in Shasta, typically in late April. In previous years, pulse flow planning occurred simultaneously to temperature management planning during April when temperature stratification allowed for modeling temperature-dependent mortality. Another method is to consider general relationships between Shasta storage and TDM, as shown in Figure 6. In this positional analysis, TDM was estimated using a 53° F, 54°F, and 55° F temperature target at Sacramento at Clear Creek, combining different starting storage levels, hydrology, and meteorology in CalSim2. This produced 100 TDM estimates at individual end-of-April storage values across a range of these storage levels, summarized in boxplots in Figure 4 below. The assumptions for this relationship reflect a deprecated No Action Alternative operations logic, meaning the operational nuances of Action 5 are not reflected. Nonetheless, with few exceptions, TDM remains low when end-of-April Shasta storage is above 3.8 MAF, and end of September Shasta storage exceeds 2.0 MAF. Current forecasts project end-of-April Shasta storage may or may not exceed 3.8 MAF with implementation of full potential pulse flow volume (150,000 acre feet). Pulse flow action implementation could also result in EOS Shasta storage volume below 2.0 MAF.

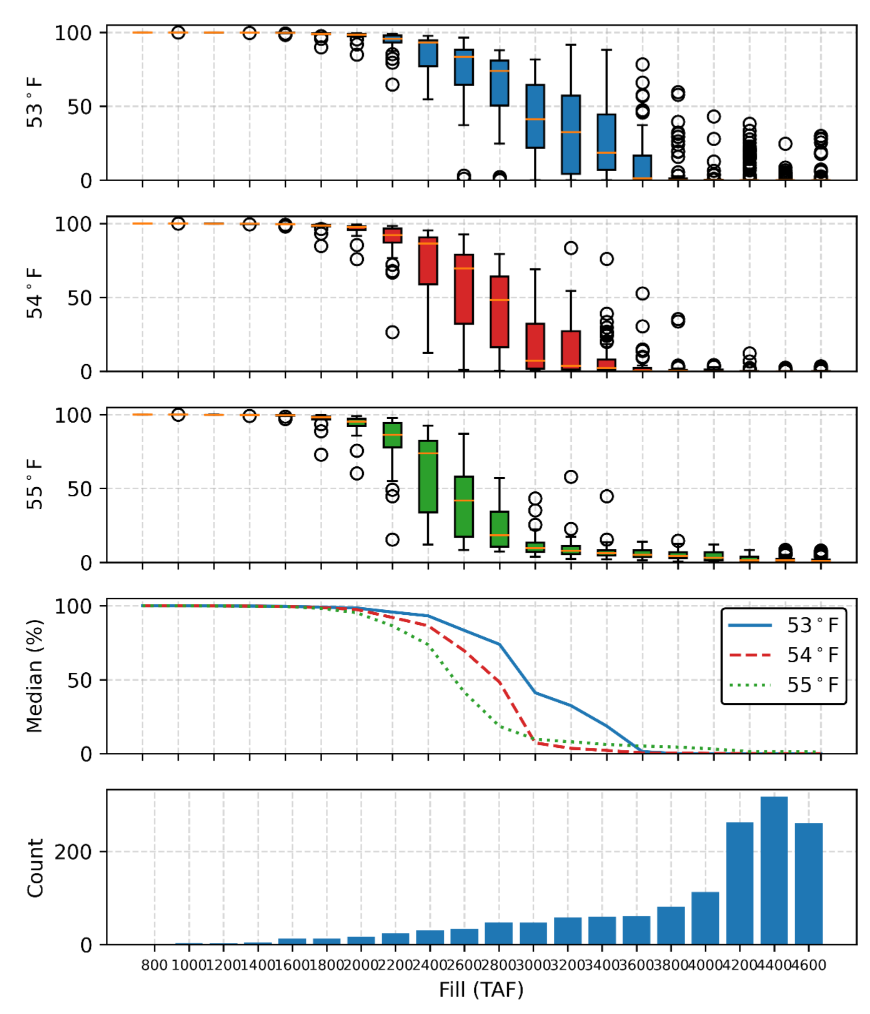

Figure 6. Winter-run Chinook salmon percent temperature dependent mortality (TDM) estimates associated with Shasta fill (e.g., end of April storage; thousand of acre feet (TAF). This figure utilizes the Calsim II model with deprecated No Action Alternative operations logic.

Figure 6 displays four stacked panels showing winter-run Chinook salmon percent temperature dependent mortality (TDM) estimates associated with Shasta fill in thousand acre-feet (TAF). The top three panels are box plots showing TDM distributions at 53°F (blue), 54°F (red), and 55°F (green), with median TDM near 100% at low fill values declining toward zero beyond approximately 3,000–3,500 TAF. The fourth panel overlays the median TDM curves for all three thresholds, and the bottom panel shows a histogram of modeled Shasta fill values concentrated between approximately 3,500 and 4,400 TAF.

Systemwide releases

The American River Group is discussing a spring pulse flow and the possibility of synching with Sacramento River releases. Stanislaus pulse flows are planned April 11-May 9. Tuolumne River pulse flows are planned to start on April 17.

References

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Marine, KR and JJ Cech. 2004. Effects of high water temperature growth, smoltification, and predator avoidance in juvenile Sacramento River Chinook salmon. Fisheries Management 24:198-210.

Michel, CJ, JJ Notch, F Cordoleani, AJ Ammann, EM Danner. 2021. Nonlinear survival of imperiled fish informs managed flows in a highly modified river. Ecosphere. 12:1-20.

Notch, J.J. A.S. McHuron, C.J. Michel, F. Cordoleani, M. Johnson, M.J. Henderson, A.J. Ammann. 2020 Outmigration survival of wild Chinook salmon smolts through the Sacramento River during historic drought and high water conditions. Environmental Biology of Fishes 103: 561-576.

Attachment 1 - Pulse flow scenario evaluation

Pulse flow scenario evaluation

2026 Spring Pulse Flow Survival Simulations for Flow Scenarios

Prepared by Cyril Michel, UC Santa Cruz, cyril.michel@noaa.gov

Using operational forecasts from file: Spring Pulse Flow Mar23 2026.xlsx

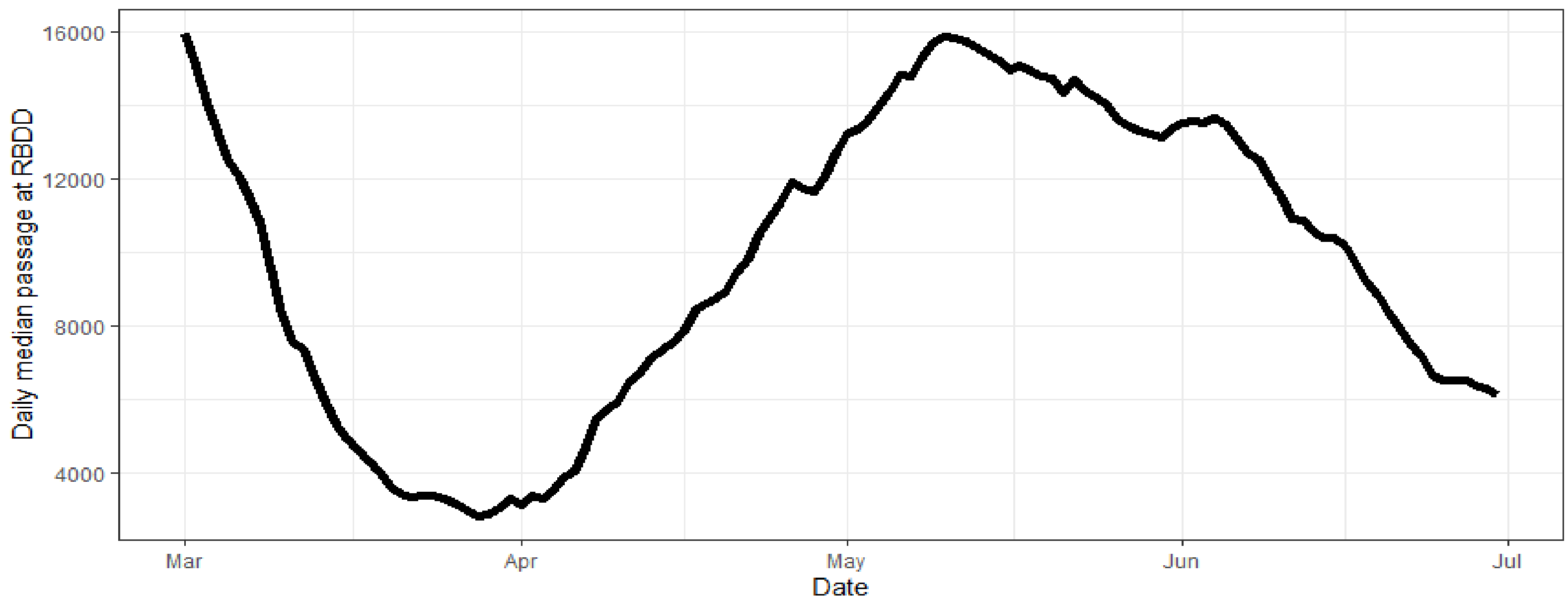

Figure 1. Historic median daily passage (with 20-day moving average smoothing) at Red Bluff Diversion Dam USFWS Screw traps for all years of data (2006-2019)

Figure 1 is a line graph showing historic median daily passage at Red Bluff Diversion Dam from March through July, smoothed with a 20-day moving average. Passage begins near 16,000 fish/day in early March, declines to a low of approximately 3,500 fish/day in early April, then rises steeply to a second peak near 16,000 fish/day in early May before gradually declining to approximately 6,000 fish/day by early July.

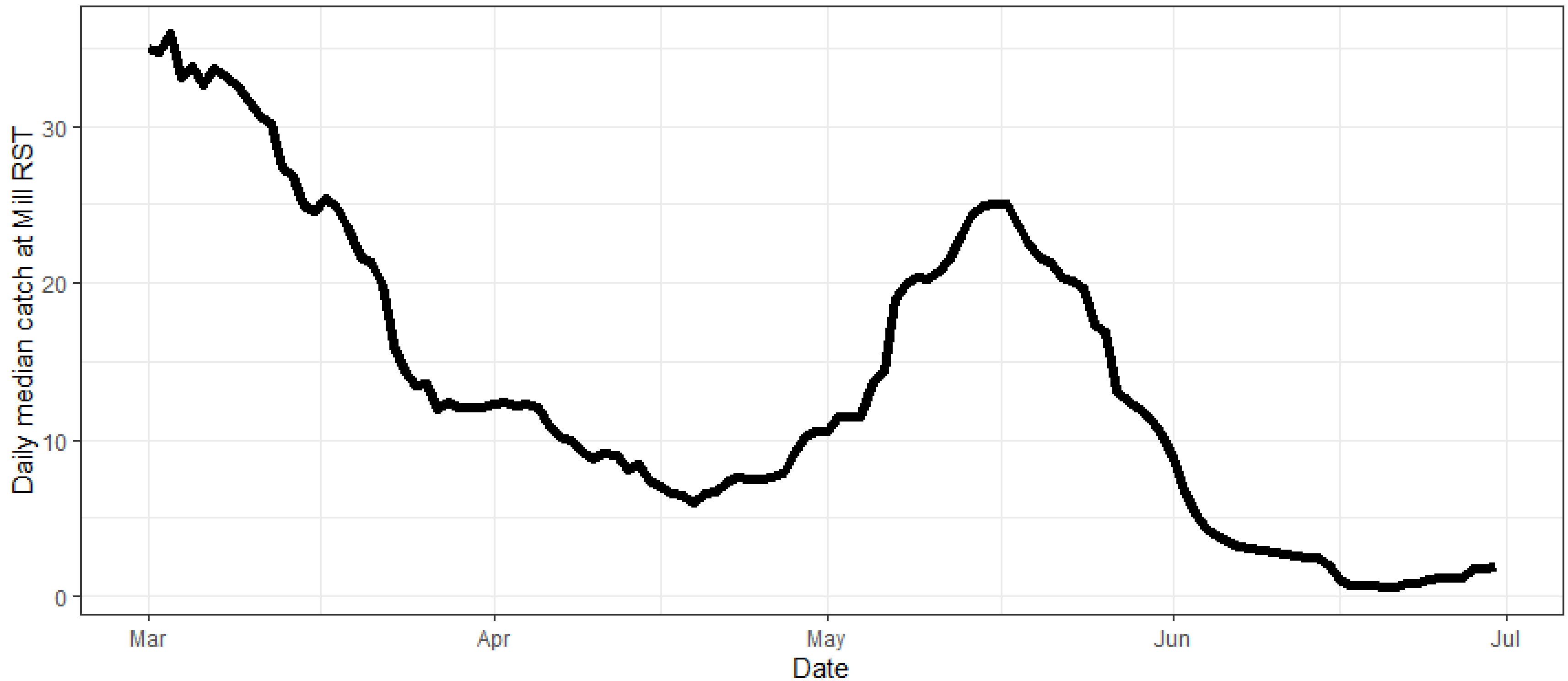

Figure 2. Historic median daily catch (with 20-day moving average smoothing) at Mill Creek CDFW Screw trap for all years of data (1996, 2000, 2001, 2002, 2003, 2007, 2008, 2009, and 2010)

Figure 2 is a line graph showing historic median daily catch at Mill Creek RST from March through July, smoothed with a 20-day moving average. Catch begins near 35 fish/day in early March, declines to a low of approximately 6 fish/day in mid-April, then rises to a secondary peak near 25 fish/day in late May before dropping sharply to near zero by mid-June and remaining there through early July.

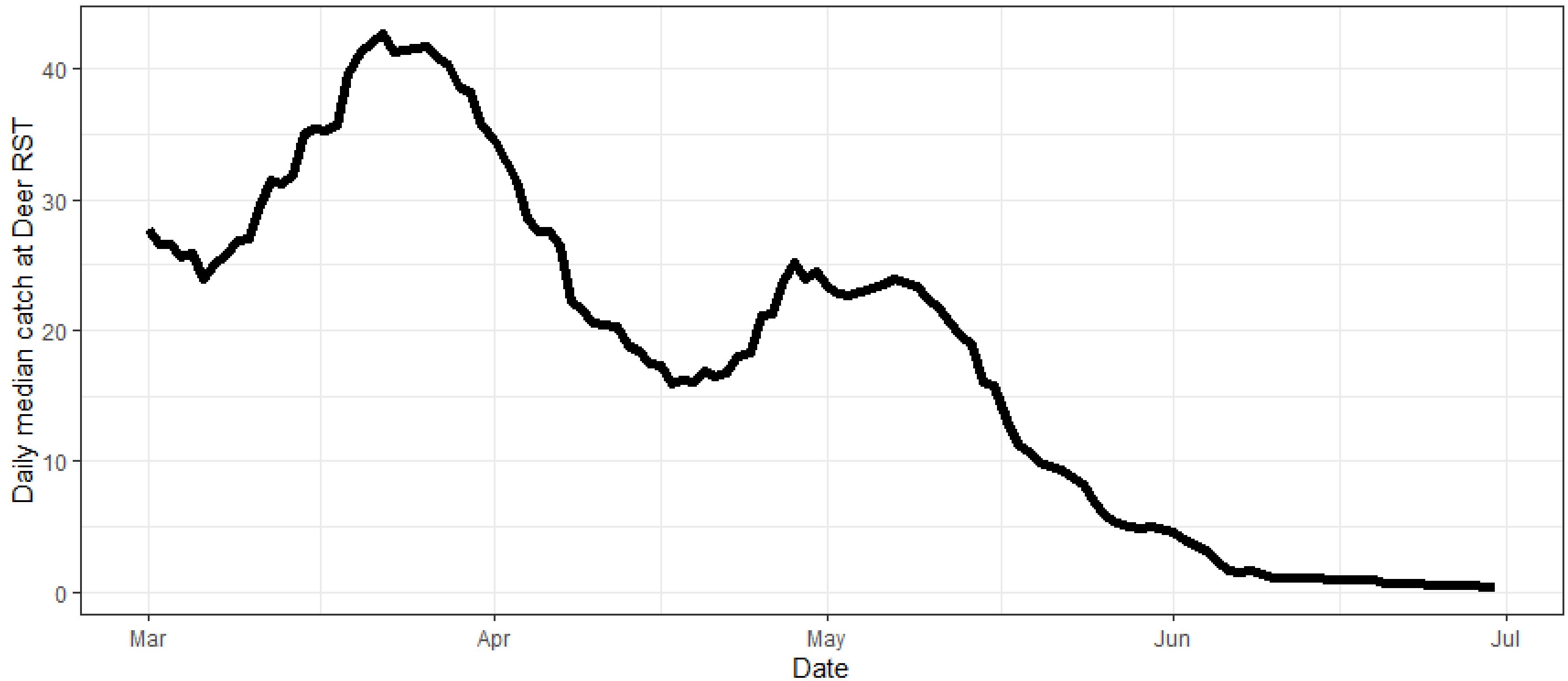

Figure 3. Historic median daily catch (with 20-day moving average smoothing) at Deer Creek CDFW Screw trap for all years of data (1995, 1996, 2000, 2001, 2002, 2003, 2004, 2005, 2007, 2009, and 2010)

Figure 3 is a line graph showing historic median daily catch at Deer Creek RST from March through July, smoothed with a 20-day moving average. Catch begins near 27 fish/day in early March, rises to a peak of approximately 42 fish/day in late March, declines to a low of around 16 fish/day in mid-April, then rises again to a secondary peak near 25 fish/day in early May before declining sharply to near zero by early June and remaining there through July.

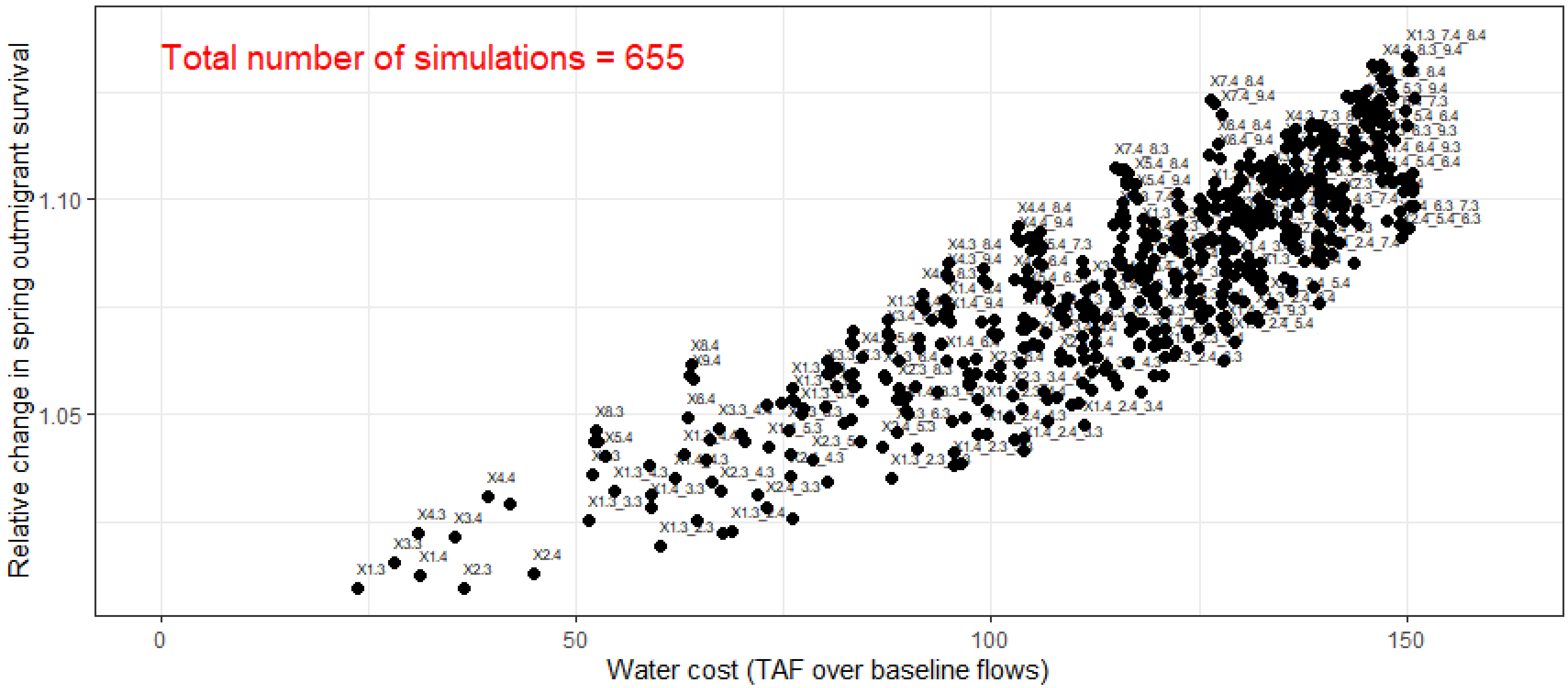

Figure 4. Relative change in spring outmigration survival (over status quo) as a function of water cost (TAF) for all pulse flow scenarios using all years of fish passage data at RBDD (2006-2019), and using the Michel et al. (2021) nonlinear flow:survival relationship

Figure 4 is a scatter plot showing relative change in spring outmigrant survival over status quo as a function of water cost in TAF over baseline flows, across 655 simulations. Points show a positive relationship between water cost and survival benefit, ranging from near 1.00 relative survival at low water costs to approximately 1.15 at water costs around 150 TAF. Individual points are labeled with pulse flow scenario identifiers, and the cluster of points becomes denser at higher water cost values.

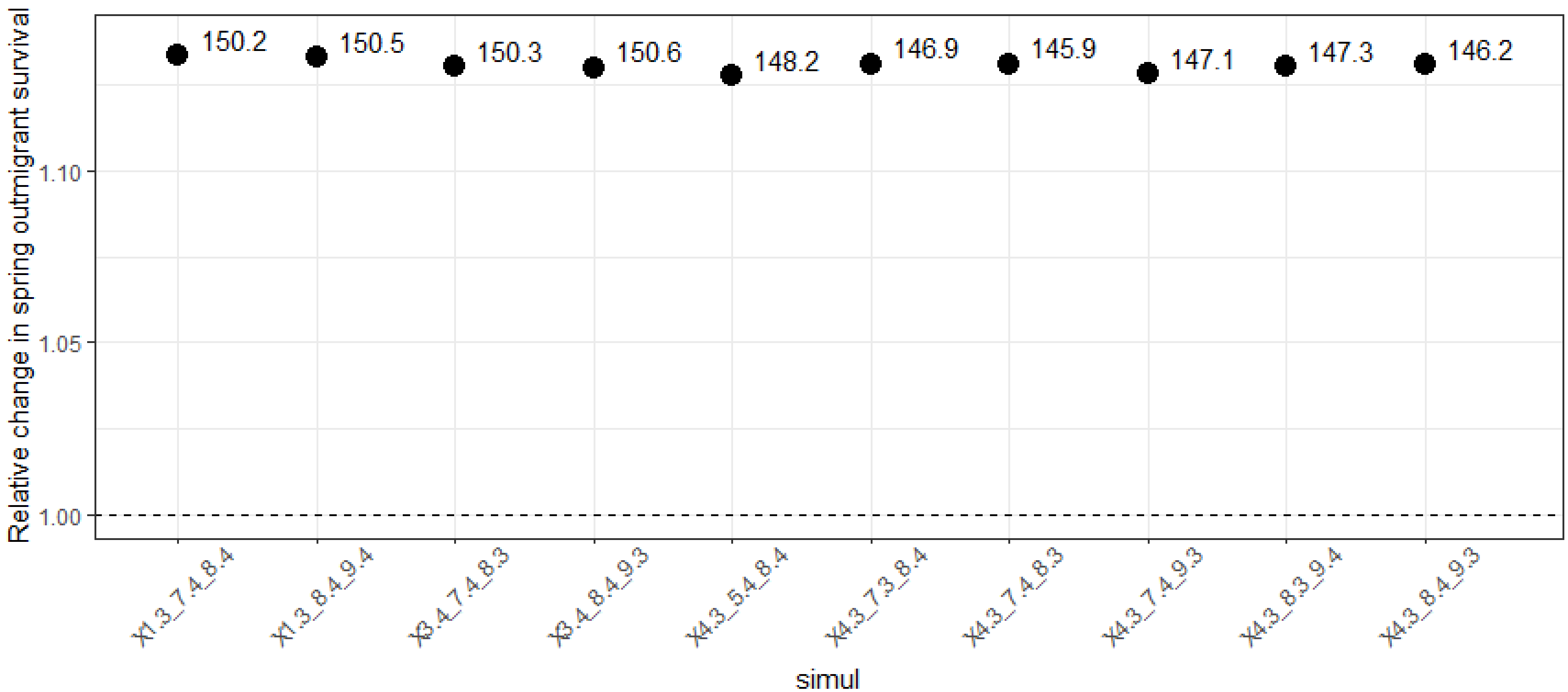

Figure 5. Top 10 pulse flow scenarios as ranked by best spring season survival relative improvement (over status quo), using all years of fish passage data at RBDD (2006-2019), and using the Michel et al. (2021) nonlinear flow:survival relationship. Water cost is shown as point labels (TAF)

Figure 5 is a dot plot showing the top 10 pulse flow scenarios ranked by best spring season survival relative improvement over status quo. All 10 scenarios cluster tightly between approximately 1.13 and 1.14 relative change in spring outmigrant survival, well above the status quo baseline of 1.00 shown as a dashed line. Water costs for the top scenarios range from approximately 145.9 to 150.6 TAF, shown as point labels.

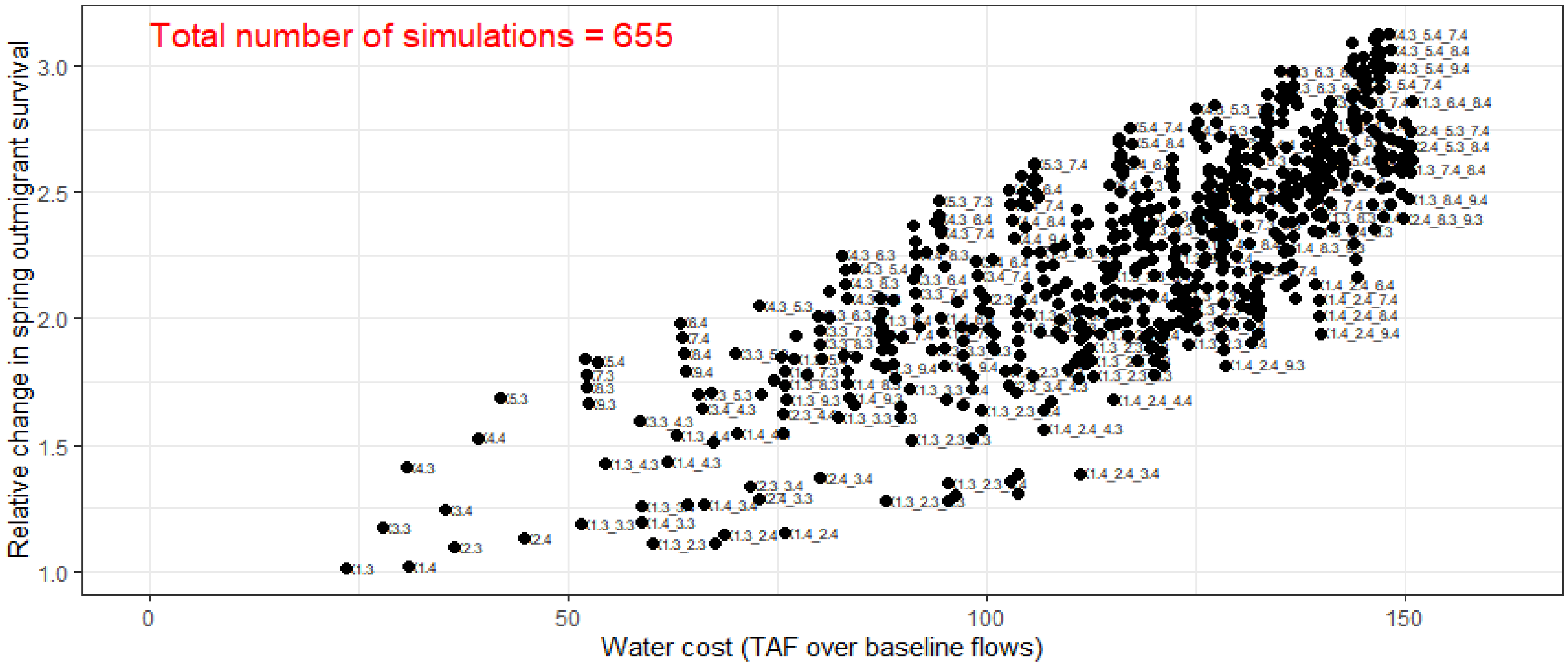

Figure 6. Relative change in spring outmigration survival (over status quo) as a function of water cost (TAF) for all pulse flow scenarios using the Burford et al. (2025) model.

Figure 6 is a scatter plot showing relative change in spring outmigrant survival over status quo as a function of water cost in TAF over baseline flows, across 655 simulations using the Burford et al. (2025) model. Points show a positive relationship between water cost and survival benefit, ranging from near 1.0 relative survival at low water costs to approximately 3.0 at water costs around 150 TAF. The range of outcomes is notably wider than in Figure 4, with greater spread among scenarios at higher water costs.

This model is different from the Michel et al. (2021) model in 4 ways: 1. it uses a continuous, non-linear relationship between flow and survival (i.e., not a threshold), 2. it incorporates a seasonal component in the flow survival relationship (e.g., survival is worse in June vs April for the same flow), 3. it incorporates responses in the number of fish initiating migration as a function of flow changes, and 4. it estimates survival to Benicia Bridge rather than the confluence of the Sacramento and Feather Rivers (as in Michel et al. 2021)

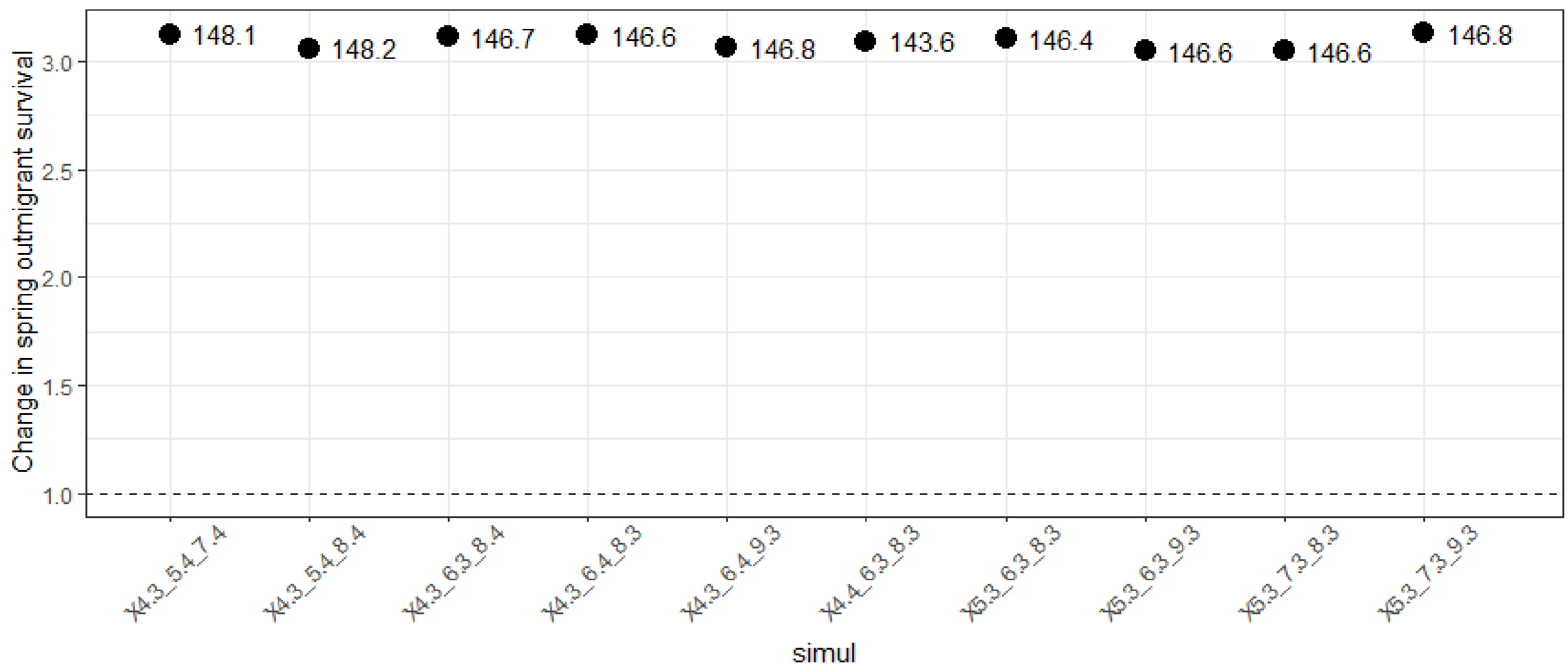

Figure 7. Top 10 pulse flow scenarios as ranked by best spring season survival relative improvement (over status quo) using an adaptation of the Burford et al. (2025) model.

Figure 7 is a dot plot showing the top 10 pulse flow scenarios ranked by best spring season survival relative improvement over status quo using the Burford et al. (2025) model. All 10 scenarios cluster tightly near approximately 3.15 relative change in spring outmigrant survival, well above the status quo baseline of 1.00 shown as a dashed line. Water costs for the top scenarios range from approximately 143.6 to 148.2 TAF, shown as point labels.

This model is different from the Michel et al. (2021) model in 4 ways: 1. it uses a continuous, non-linear relationship between flow and survival (i.e., not a threshold), 2. it incorporates a seasonal component in the flow survival relationship (e.g., survival is worse in June vs April for the same flow), and 3. it incorporates responses in the number of fish initiating migration as a function of flow changes, and 4. it estimates survival to Benicia Bridge rather than the confluence of the Sacramento and Feather Rivers (as in Michel et al. 2021). Water cost is shown as point labels (TAF)

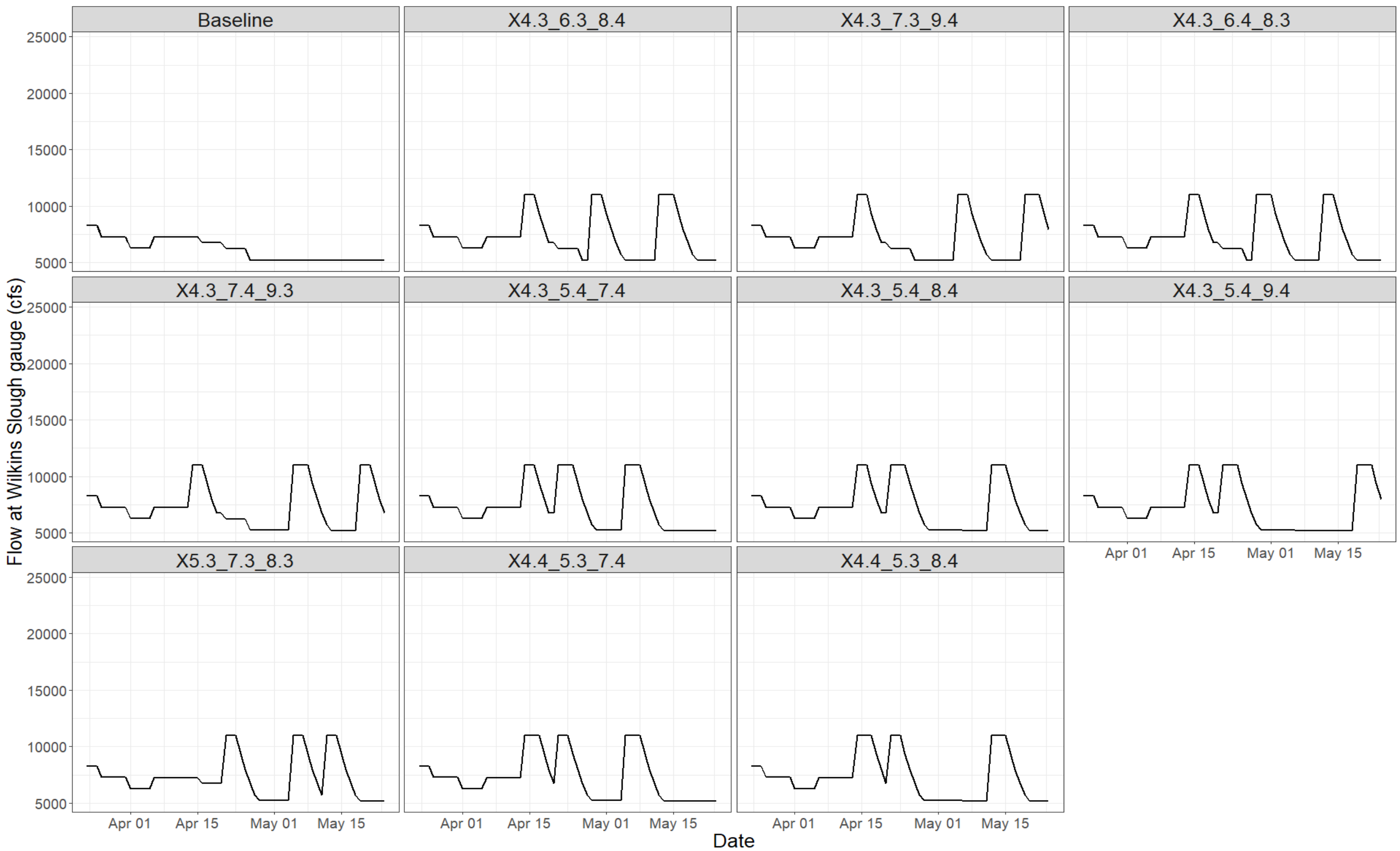

Figure 8. Spring pulse flow hydrographs for the top 10 scenarios as ranked by both Michel et al. and Burford et al. models, and including baseline flows (dashed black line)

Figure 8 is a panel of 11 line graphs showing spring pulse flow hydrographs at Wilkins Slough gauge in cfs from April 1 through May 15, displaying the baseline scenario and the top 10 pulse flow scenarios ranked by both models. The baseline panel shows a relatively flat flow around 7,000–8,000 cfs with a slight decline, while the 10 pulse flow scenarios each show one or two distinct flow pulses rising to approximately 10,000–15,000 cfs above the baseline (shown as a dashed black line), with varying timing and duration across April and May.

Table 1. Spring season survival estimates, survival improvement over baseline, and rank for the top 10 scenarios as ranked by both Michel et al. and Burford et al. models and including baseline flows. PLEASE NOTE: Survival estimates are informed by historical fish abundances and passage timing and should only be used for scenario evaluation and not used at face value.

Scenarios	**TAF**	**Spring Survival Michel**	**Relative Survival Improvement over Baseline Michel**	**Spring Survival Burford**	**Relative Survival Improvement over Baseline Burford**	**Rank Michel**	**Rank Burford**
X4.3_5.4_7.4	148.1	0.247	1.125	0.123	3.125	13	2
X4.3_5.4_8.4	148.2	0.248	1.128	0.121	3.061	10	8
X4.3_6.3_8.4	146.7	0.247	1.123	0.123	3.115	21	4
X4.3_7.4_9.3	147.1	0.248	1.128	0.118	3.007	9	16
X4.3_6.4_8.3	146.6	0.246	1.121	0.123	3.123	29	3
X4.3_5.4_9.4	148.4	0.247	1.124	0.118	2.991	14	18
X4.3_7.3_9.4	147.2	0.248	1.128	0.117	2.985	11	21
X5.3_7.3_8.3	146.6	0.246	1.122	0.120	3.048	24	9
X4.4_5.3_7.4	145.1	0.246	1.122	0.119	3.034	26	13
X4.4_5.3_8.4	145.2	0.247	1.125	0.117	2.971	12	27
Baseline	0.0	0.220	1.000	0.039	1.000	655	655

Table 2. Hydrograph at Wilkins Slough for baseflow, as well as for the top 10 scenarios as ranked by both Michel et al. and Burford et al. models

Date	X4.3_5.4_7.4	X4.3_5.4_8.4	X4.3_6.3_8.4	X4.3_7.4_9.3	X4.3_6.4_8.3	X4.3_5.4_9.4	X4.3_7.3_9.4	X5.3_7.3_8.3	X4.4_5.3_7.4	X4.4_5.3_8.4	Baseline
2026-03-23	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275
2026-03-24	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275
2026-03-25	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275
2026-03-26	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275
2026-03-27	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275
2026-03-28	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275
2026-03-29	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275
2026-03-30	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275
2026-03-31	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275
2026-04-01	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275
2026-04-02	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275
2026-04-03	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275
2026-04-04	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275
2026-04-05	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275
2026-04-06	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-07	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-08	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-09	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-10	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-11	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-12	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-13	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-14	11,000	11,000	11,000	11,000	11,000	11,000	11,000	7,250	11,000	11,000	7,250
2026-04-15	11,000	11,000	11,000	11,000	11,000	11,000	11,000	7,250	11,000	11,000	7,250
2026-04-16	11,000	11,000	11,000	11,000	11,000	11,000	11,000	6,750	11,000	11,000	6,750
2026-04-17	9,350	9,350	9,350	9,350	9,350	9,350	9,350	6,750	11,000	11,000	6,750

Date	X4.3_5.4_7.4	X4.3_5.4_8.4	X4.3_6.3_8.4	X4.3_7.4_9.3	X4.3_6.4_8.3	X4.3_5.4_9.4	X4.3_7.3_9.4	X5.3_7.3_8.3	X4.4_5.3_7.4	X4.4_5.3_8.4	Baseline
2026-04-18	7,948	7,948	7,948	7,948	7,948	7,948	7,948	6,750	9,350	9,350	6,750
2026-04-19	6,756	6,756	6,756	6,756	6,756	6,756	6,756	6,750	7,948	7,948	6,750
2026-04-20	6,750	6,750	6,750	6,750	6,750	6,750	6,750	6,750	6,756	6,756	6,750
2026-04-21	11,000	11,000	6,250	6,250	6,250	11,000	6,250	11,000	11,000	11,000	6,250
2026-04-22	11,000	11,000	6,225	6,225	6,225	11,000	6,225	11,000	11,000	11,000	6,225
2026-04-23	11,000	11,000	6,225	6,225	6,225	11,000	6,225	11,000	11,000	11,000	6,225
2026-04-24	11,000	11,000	6,225	6,225	6,225	11,000	6,225	9,350	9,350	9,350	6,225
2026-04-25	9,350	9,350	6,225	6,225	6,225	9,350	6,225	7,948	7,948	7,948	6,225
2026-04-26	7,948	7,948	5,225	5,225	5,225	7,948	5,225	6,756	6,756	6,756	5,225
2026-04-27	6,756	6,756	5,225	5,225	5,225	6,756	5,225	5,743	5,743	5,743	5,225
2026-04-28	5,743	5,743	11,000	5,225	11,000	5,743	5,225	5,225	5,225	5,225	5,225
2026-04-29	5,225	5,225	11,000	5,225	11,000	5,225	5,225	5,225	5,225	5,225	5,225
2026-04-30	5,225	5,225	11,000	5,225	11,000	5,225	5,225	5,225	5,225	5,225	5,225
2026-05-01	5,225	5,225	9,350	5,225	11,000	5,225	5,225	5,225	5,225	5,225	5,225
2026-05-02	5,225	5,225	7,948	5,225	9,350	5,225	5,225	5,225	5,225	5,225	5,225
2026-05-03	5,225	5,225	6,756	5,225	7,948	5,225	5,225	5,225	5,225	5,225	5,225
2026-05-04	5,225	5,225	5,743	5,225	6,756	5,225	5,225	5,225	5,225	5,225	5,225
2026-05-05	11,000	5,225	5,225	11,000	5,743	5,225	11,000	11,000	11,000	5,225	5,225
2026-05-06	11,000	5,225	5,225	11,000	5,225	5,225	11,000	11,000	11,000	5,225	5,225
2026-05-07	11,000	5,200	5,200	11,000	5,200	5,200	11,000	11,000	11,000	5,200	5,200
2026-05-08	11,000	5,200	5,200	11,000	5,200	5,200	9,350	9,350	11,000	5,200	5,200
2026-05-09	9,350	5,200	5,200	9,350	5,200	5,200	7,948	7,948	9,350	5,200	5,200
2026-05-10	7,948	5,200	5,200	7,948	5,200	5,200	6,756	6,756	7,948	5,200	5,200
2026-05-11	6,756	5,200	5,200	6,756	5,200	5,200	5,743	5,743	6,756	5,200	5,200
2026-05-12	5,743	11,000	11,000	5,743	11,000	5,200	5,200	11,000	5,743	11,000	5,200
2026-05-13	5,200	11,000	11,000	5,200	11,000	5,200	5,200	11,000	5,200	11,000	5,200
2026-05-14	5,200	11,000	11,000	5,200	11,000	5,200	5,200	11,000	5,200	11,000	5,200
2026-05-15	5,200	11,000	11,000	5,200	9,350	5,200	5,200	9,350	5,200	11,000	5,200
2026-05-16	5,200	9,350	9,350	5,200	7,948	5,200	5,200	7,948	5,200	9,350	5,200

Date	X4.3_5.4_7.4	X4.3_5.4_8.4	X4.3_6.3_8.4	X4.3_7.4_9.3	X4.3_6.4_8.3	X4.3_5.4_9.4	X4.3_7.3_9.4	X5.3_7.3_8.3	X4.4_5.3_7.4	X4.4_5.3_8.4	Baseline
2026-05-17	5,200	7,948	7,948	5,200	6,756	5,200	5,200	6,756	5,200	7,948	5,200
2026-05-18	5,200	6,756	6,756	5,200	5,743	5,200	5,200	5,743	5,200	6,756	5,200
2026-05-19	5,200	5,743	5,743	11,000	5,200	11,000	11,000	5,200	5,200	5,743	5,200
2026-05-20	5,200	5,200	5,200	11,000	5,200	11,000	11,000	5,200	5,200	5,200	5,200
2026-05-21	5,200	5,200	5,200	11,000	5,200	11,000	11,000	5,200	5,200	5,200	5,200
2026-05-22	5,175	5,175	5,175	9,350	5,175	11,000	11,000	5,175	5,175	5,175	5,175
2026-05-23	5,175	5,175	5,175	7,948	5,175	9,350	9,350	5,175	5,175	5,175	5,175
2026-05-24	5,175	5,175	5,175	6,756	5,175	7,948	7,948	5,175	5,175	5,175	5,175

Table 3. Hydrograph at Keswick for baseflow, as well as for the top 10 scenarios as ranked by both Michel et al. and Burford et al. models

Date	KES	X4.3_5.4_7.4	X4.3_5.4_8.4	X4.3_6.3_8.4	X4.3_7.4_9.3	X4.3_6.4_8.3	X4.3_5.4_9.4	X4.3_7.3_9.4	X5.3_7.3_8.3	X4.4_5.3_7.4	X4.4_5.3_8.4
2026-03-23	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-24	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-25	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-26	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-27	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-28	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-29	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-30	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-31	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-04-01	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-04-02	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-04-03	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-04-04	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-04-05	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000

Date	KES	X4.3_5.4_7.4	X4.3_5.4_8.4	X4.3_6.3_8.4	X4.3_7.4_9.3	X4.3_6.4_8.3	X4.3_5.4_9.4	X4.3_7.3_9.4	X5.3_7.3_8.3	X4.4_5.3_7.4	X4.4_5.3_8.4
2026-04-06	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
2026-04-07	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
2026-04-08	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
2026-04-09	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
2026-04-10	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
2026-04-11	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
2026-04-12	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
2026-04-13	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
2026-04-14	8,000	11,750	11,750	11,750	11,750	11,750	11,750	11,750	8,000	11,750	11,750
2026-04-15	8,000	11,750	11,750	11,750	11,750	11,750	11,750	11,750	8,000	11,750	11,750
2026-04-16	8,500	12,750	12,750	12,750	12,750	12,750	12,750	12,750	8,500	12,750	12,750
2026-04-17	8,500	11,100	11,100	11,100	11,100	11,100	11,100	11,100	8,500	12,750	12,750
2026-04-18	8,500	9,698	9,698	9,698	9,698	9,698	9,698	9,698	8,500	11,100	11,100
2026-04-19	8,500	8,506	8,506	8,506	8,506	8,506	8,506	8,506	8,500	9,698	9,698
2026-04-20	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,506	8,506
2026-04-21	9,000	13,750	13,750	9,000	9,000	9,000	13,750	9,000	13,750	13,750	13,750
2026-04-22	9,000	13,775	13,775	9,000	9,000	9,000	13,775	9,000	13,775	13,775	13,775
2026-04-23	9,000	13,775	13,775	9,000	9,000	9,000	13,775	9,000	13,775	13,775	13,775
2026-04-24	9,000	13,775	13,775	9,000	9,000	9,000	13,775	9,000	12,125	12,125	12,125
2026-04-25	9,000	12,125	12,125	9,000	9,000	9,000	12,125	9,000	10,723	10,723	10,723
2026-04-26	9,000	11,723	11,723	9,000	9,000	9,000	11,723	9,000	10,531	10,531	10,531
2026-04-27	9,000	10,531	10,531	9,000	9,000	9,000	10,531	9,000	9,518	9,518	9,518
2026-04-28	9,000	9,518	9,518	14,775	9,000	14,775	9,518	9,000	9,000	9,000	9,000
2026-04-29	9,000	9,000	9,000	14,775	9,000	14,775	9,000	9,000	9,000	9,000	9,000
2026-04-30	9,000	9,000	9,000	14,775	9,000	14,775	9,000	9,000	9,000	9,000	9,000
2026-05-01	9,000	9,000	9,000	13,125	9,000	14,775	9,000	9,000	9,000	9,000	9,000
2026-05-02	9,000	9,000	9,000	11,723	9,000	13,125	9,000	9,000	9,000	9,000	9,000
2026-05-03	9,000	9,000	9,000	10,531	9,000	11,723	9,000	9,000	9,000	9,000	9,000
2026-05-04	9,000	9,000	9,000	9,518	9,000	10,531	9,000	9,000	9,000	9,000	9,000

Date	KES	X4.3_5.4_7.4	X4.3_5.4_8.4	X4.3_6.3_8.4	X4.3_7.4_9.3	X4.3_6.4_8.3	X4.3_5.4_9.4	X4.3_7.3_9.4	X5.3_7.3_8.3	X4.4_5.3_7.4	X4.4_5.3_8.4
2026-05-05	9,000	14,775	9,000	9,000	14,775	9,518	9,000	14,775	14,775	14,775	9,000
2026-05-06	9,000	14,775	9,000	9,000	14,775	9,000	9,000	14,775	14,775	14,775	9,000
2026-05-07	9,000	14,800	9,000	9,000	14,800	9,000	9,000	14,800	14,800	14,800	9,000
2026-05-08	9,000	14,800	9,000	9,000	14,800	9,000	9,000	13,150	13,150	14,800	9,000
2026-05-09	9,000	13,150	9,000	9,000	13,150	9,000	9,000	11,748	11,748	13,150	9,000
2026-05-10	9,000	11,748	9,000	9,000	11,748	9,000	9,000	10,556	10,556	11,748	9,000
2026-05-11	9,000	10,556	9,000	9,000	10,556	9,000	9,000	9,543	9,543	10,556	9,000
2026-05-12	9,000	9,543	14,800	14,800	9,543	14,800	9,000	9,000	14,800	9,543	14,800
2026-05-13	9,000	9,000	14,800	14,800	9,000	14,800	9,000	9,000	14,800	9,000	14,800
2026-05-14	9,000	9,000	14,800	14,800	9,000	14,800	9,000	9,000	14,800	9,000	14,800
2026-05-15	9,000	9,000	14,800	14,800	9,000	13,150	9,000	9,000	13,150	9,000	14,800
2026-05-16	9,000	9,000	13,150	13,150	9,000	11,748	9,000	9,000	11,748	9,000	13,150
2026-05-17	9,000	9,000	11,748	11,748	9,000	10,556	9,000	9,000	10,556	9,000	11,748
2026-05-18	9,000	9,000	10,556	10,556	9,000	9,543	9,000	9,000	9,543	9,000	10,556
2026-05-19	9,000	9,000	9,543	9,543	14,800	9,000	14,800	14,800	9,000	9,000	9,543
2026-05-20	9,000	9,000	9,000	9,000	14,800	9,000	14,800	14,800	9,000	9,000	9,000
2026-05-21	9,000	9,000	9,000	9,000	14,800	9,000	14,800	14,800	9,000	9,000	9,000
2026-05-22	9,000	9,000	9,000	9,000	13,175	9,000	14,825	14,825	9,000	9,000	9,000
2026-05-23	9,000	9,000	9,000	9,000	11,773	9,000	13,175	13,175	9,000	9,000	9,000
2026-05-24	9,000	9,000	9,000	9,000	10,581	9,000	11,773	11,773	9,000	9,000	9,000

Table 4. Starting dates for each potential study week of the Spring period, for reference

week	Start date
1	2026-03-23
2	2026-03-30
3	2026-04-06
4	2026-04-13
5	2026-04-20
6	2026-04-27
7	2026-05-04
8	2026-05-11
9	2026-05-18

Attachment 2 - Winter-run Chinook Salmon Temperature Dependent Mortality Estimates

Executive Summary

Water temperature forecasts were contrary to expectations in which pulse scenarios of lower volumes of 50 TAF were warmer and consequently had higher TDM estimates than the 50 TAF scenario. Also unexpected was the 50 TAF pulse in May scenario was forecasted to be warmer than the 50 TAF in April and 50 TAF in May scenario and therefore was estimated to have higher TDM than that scenario. Overall, the scenarios are fairly similar results, and our tools are likely not precise enough for evaluating 10 TAF volume differences.

Temperature modeling described in the tradeoff table do not match up perfectly with the pulse flow scenarios as more precise estimates of water cost are available for the flow scheduling than is practical for temperature modeling. Additionally, information for spring flow forecasts and summer/fall temperature forecasts for informing their associated models are available on different timelines. Water costs for scenarios were rounded to the nearest 10 TAF for assigning TDM values.

Background

To forecast temperature dependent mortality (TDM) of winter-run chinook salmon for the 2026 Sacramento River Spring Pulse Operations Plan, nine scenarios were evaluated. All scenarios targeted 53.5F at Clear Creek (CCR) but consisted of pulse flows in April and/or May of different water volumes described in Table 1.

The modeling framework used spatially explicit, daily average water temperature forecasts from the WTMP model. These forecasts were applied at multiple locations along the Sacramento River, including Keswick Dam and Clear Creek. Observed temperature data were used through March 26, 2026, and modeled forecasts were used thereafter. For locations between these gauges, daily temperatures were estimated by interpolating between nearby model output points. These temperature estimates were then matched to the river mile locations of simulated winter-run Chinook redds constructed based on observed spawning distributions from 2013 to 2022.

TDM was estimated by simulating the thermal history of each redd throughout its incubation period. Mortality was calculated based on cumulative thermal exposure using a degree-day threshold to represent development time, as well as on daily temperature exceedance past critical thresholds known to induce mortality. Two mortality models were applied. The first, based on Martin et al. (2017), assumes stage-independent mortality, using a single temperature threshold (12.14°C) applied consistently from spawning through emergence. The second model, based on Anderson et al. (2022), incorporates stage-dependent mortality, assigning a temperature threshold (11.82°C) and mortality sensitivities across distinct developmental stages. This approach was also applied to all scenarios. Results from the temperature-dependent mortality simulations did not reveal biologically meaningful results among some scenarios and between modeling approaches.

Table 1. Summary of winter-run chinook salmon TDM results for all scenarios developed during the week of March 23, 2026, based on the March 90% exceedance forecast.

Scenario	Stage Dependent (%)	Stage Independent (%)
Baseline/no pulse	3	5.9
50TAFin April	3.5	7.7
50TAF in May	8.2	14.2
50TAFin April and 50TAF in May	4.3	9.2
50TAFin April and 100TAF in May	7.4	13.8
10TAF in April	7.9	12.9
20TAF in April	4.2	8.6
30 TAF in April	4.4	9
40 TAF in April	7.3	12.3

Table 2. Modeling assumptions for TDM estimates for pulse flow scenarios developed during the week of March 23, 2026.

Parameter	Associated Information
Meteorology Source	HIST-2015
Time Period	1/1/2026 – 3/26/2026: Observed temperatures 3/27/2026: Simulated temperatures
Reservoir Model Used	WTMP
River Model Used	WTMP
Shasta Profile Date	3/2/2026
TCD Gate Operations	WTMP
Sacramento Water Temperatures Used	WTMP output at Keswick and Clear Creek
Biological Model Used	SacPAS Fish model (Temperature effect only)
Temperature Mortality Models	Stage-independent mortality Stage-dependent mortality
Egg Emergence Timing Model	Linear. 958 ATUs (degrees C), as indicated for Zeug et al. on SacPAS under Egg to emergence timing model.
TDM Redd Time Distribution	Winter-run chinook salmon carcass surveys 2013-2022
TDM Redd Space Distribution	Winter-run chinook salmon carcass surveys 2013-2022
TDM TCRIT (50^{th} Percentile)	Stage-independent mortality: 12.14°C Stage-dependent mortality: 11.82°C
TDM BT (50^{th} Percentile)	Stage-independent mortality: 0.026°C-1d-1 Stage-dependent mortality: 0.436°C-1d-1
Critical Days	Stage-independent mortality: all Stage-dependent mortality: 4 days

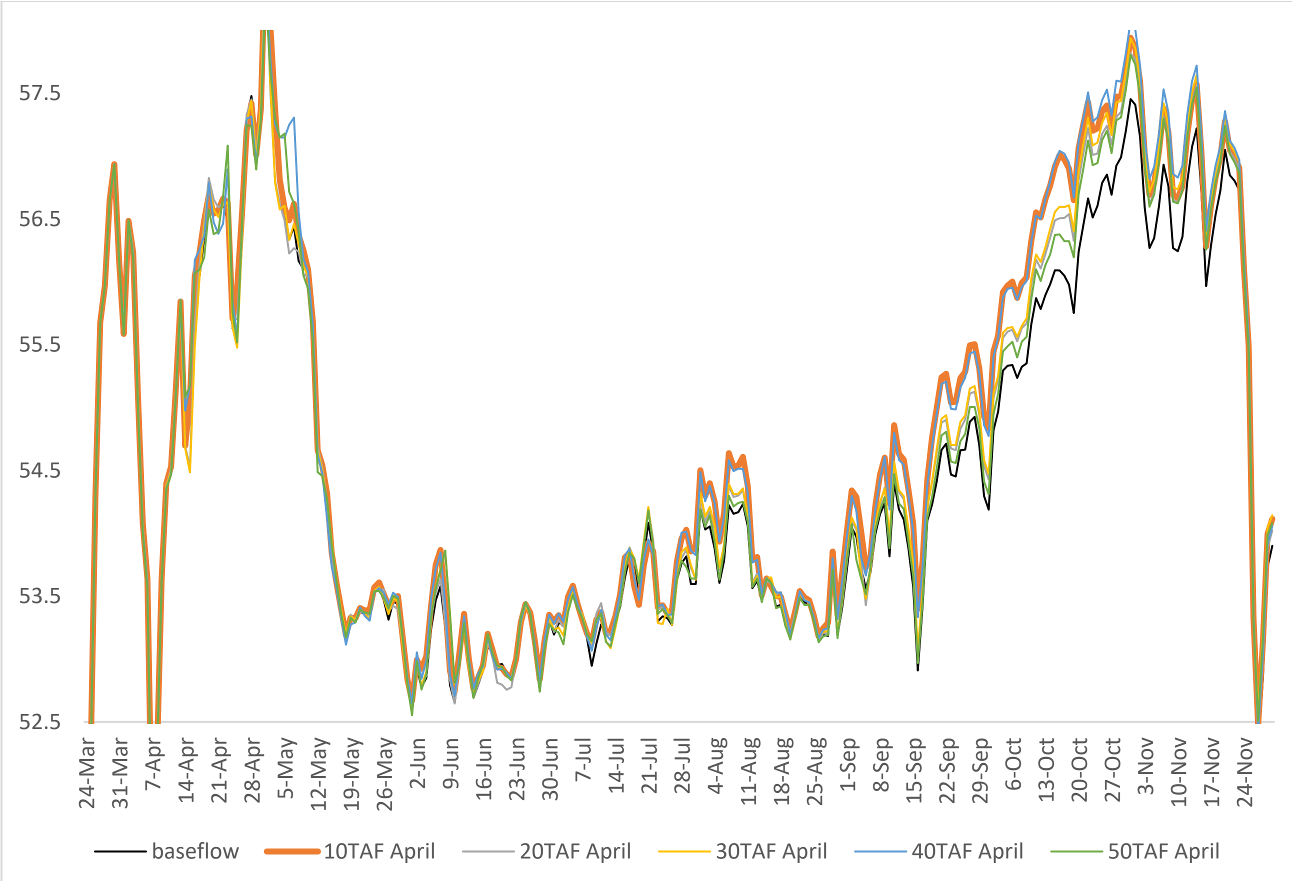

Figure 1. Forecasted daily water temperatures in degrees Fahrenheit at Clear Creek for pulses only occurring in April.

Figure 1 is a line graph showing forecasted daily water temperatures in degrees Fahrenheit at Clear Creek from March 24 through late November, comparing baseline flow against five April pulse scenarios of 10–50 TAF. All scenarios track closely together, ranging from approximately 52.5°F in early April to peaks near 57.5°F in late April and again in October, with a mid-summer low around 53°F. Differences between pulse scenarios and baseline are small throughout the period.

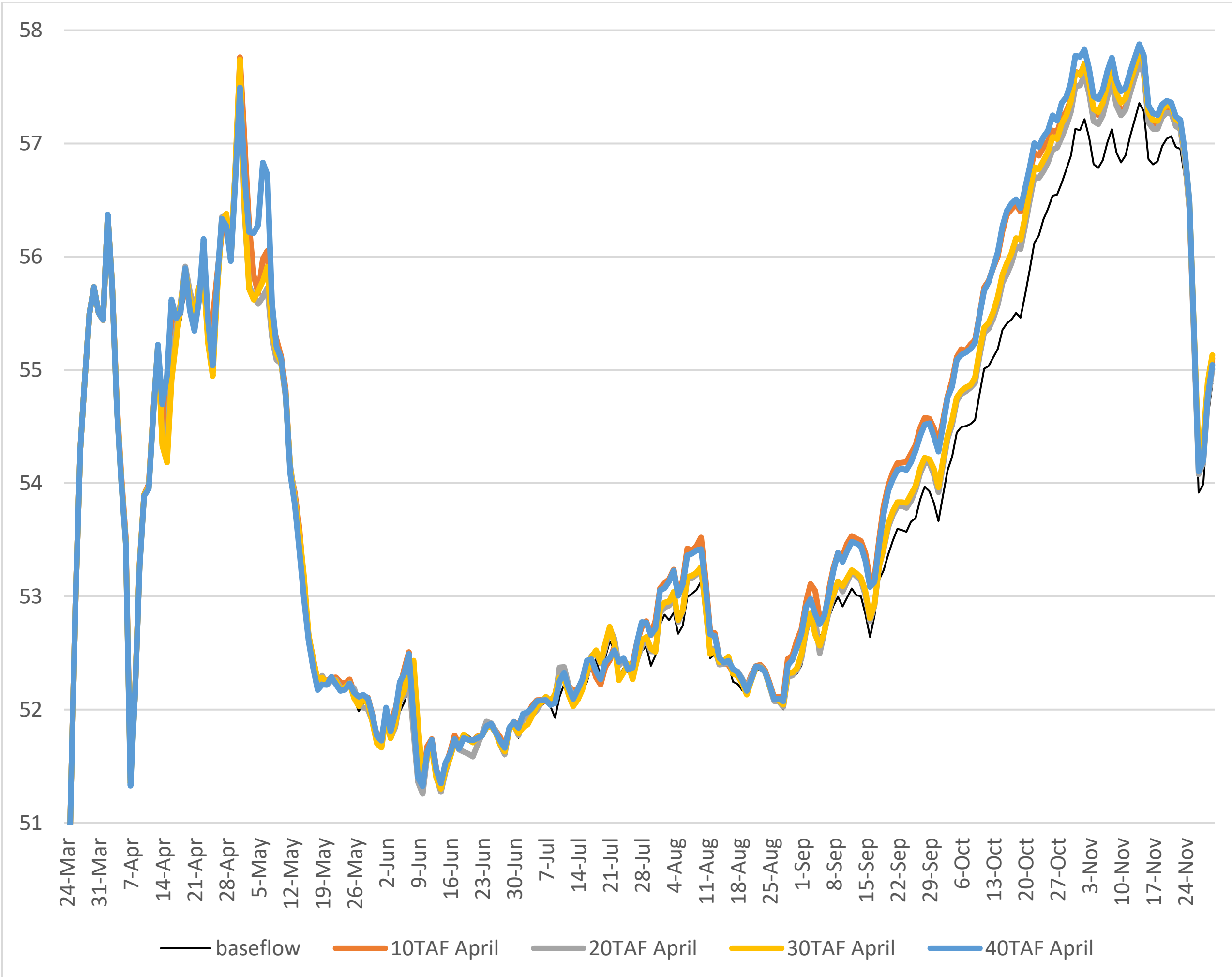

Figure 2. Forecasted daily water temperatures in degrees Fahrenheit at Keswick for pulses only occurring in April.

Figure 2 is a line graph showing forecasted daily water temperatures in degrees Fahrenheit at Keswick from March 24 through late November, comparing baseline flow against four April pulse scenarios of 10–40 TAF. All scenarios track closely together for much of the period, ranging from approximately 51°F in early April to peaks near 57.5°F in late April and again in October. Pulse scenarios diverge most noticeably from baseline during the October warming period, where higher TAF scenarios show slightly elevated temperatures.

Attachment 3 - Estimated CVP Operations 90% Exceedance

Storages

Table 1. Federal End of the Month Storage/Elevation (Thousand Acre-Feet (TAF)/feet)

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Trinity	2232	2228	2033	1878	1727	1545	1369	1291	1234	1165	1167	1139	1167
Trinity Elev.	N/A	2356	2343	2332	2321	2307	2292	2285	2280	2273	2273	2270	2273
Whiskeytown	204	206	238	238	238	238	238	206	206	206	206	206	206
Whiskeytown Elev.	N/A	1199	1209	1209	1209	1209	1209	1199	1199	1199	1199	1199	1199
Shasta	4090	4090	3814	3420	2892	2409	2205	2054	2071	2130	2247	2435	2707
Shasta Elev.	N/A	1051	1041	1025	1003	980	969	960	961	965	971	981	994
Folsom	817	965	897	750	509	358	300	292	287	291	305	364	486
Folsom Elev.	N/A	465	459	444	418	397	387	386	385	386	388	398	415
New Melones	1884	1790	1711	1629	1548	1487	1437	1381	1378	1375	1382	1380	1401
New Melones Elev.	N/A	1033	1025	1017	1008	1002	996	990	990	989	990	990	992
San Luis	814	796	656	407	167	151	209	297	274	312	505	468	416
Total	10041	10075	9350	8321	7081	6189	5758	5520	5451	5480	5812	5992	6383

Table 2. State End of the Month Reservoir Storage (TAF/feet)

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Oroville	3090	3113	2827	2588	2135	1782	1513	1431	1304	1231	1287	1427	1641
Oroville Elev.	N/A	872	852	833	795	761	732	722	707	697	704	722	746
State San Luis	1039	974	845	743	766	812	911	871	942	1043	1043	986	951
Total San Luis (TAF)	1853	1770	1501	1150	932	964	1120	1168	1216	1356	1548	1453	1367
Total San Luis Elev.	N/A	522	499	467	446	449	465	469	473	487	503	495	488

Table 3. Monthly River Releases (TAF/cfs)

Facility	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Trinity (TAF)	74	68	47	28	53	52	23	18	78	18	17	28
Trinity (cfs)	1252	1114	789	455	857	870	373	300	1276	300	300	450

Facility	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Clear Creek (TAF)	15	18	13	7	6	7	10	12	16	18	17	18
Clear Creek (cfs)	247	295	215	113	100	120	157	210	260	293	300	286
Sacramento (TAF)	416	596	654	768	725	446	430	250	200	200	250	277
Sacramento (cfs)	7000	9700	11000	12500	11800	7500	7000	4200	3250	3250	4500	4500
American (TAF)	277	168	204	287	201	95	50	48	49	49	44	50
American (cfs)	4650	2725	3431	4676	3262	1600	807	800	800	800	800	811
Stanislaus (TAF)	60	24	11	9	9	9	35	12	12	12	16	12
Stanislaus (cfs)	1012	391	189	150	150	150	577	200	200	200	293	200
Feather (TAF)	202	166	119	320	264	297	71	74	77	77	58	65
Feather (cfs)	3400	2700	2000	5200	4300	5000	1150	1250	1250	1250	1050	1050

Table 4. Trinity Diversions (TAF)

Facility	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Carr PP	24	159	121	122	122	118	61	51	12	10	65	31
Spring Creek PP	25	115	110	115	115	110	85	40	0	0	60	33

Table 5. Delta Summary (TAF/cfs/%)

Facility	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Tracy	117	109	49	90	260	213	235	63	72	230	47	53
USBR Banks	0	0	0	9	9	39	0	0	0	0	0	0
Contra Costa	12.0	12.0	10.0	11.0	12.0	12.0	14.0	14.0	14.0	14.0	14.0	12.0
Total USBR	129	121	59	110	281	264	249	77	86	244	61	65
State Export	45	37	37	193	195	229	83	161	186	150	60	141
Total Export	175	158	96	303	476	493	332	238	272	394	121	206
COA Balance	24	-76	-76	-76	-76	-76	-77	-76	-77	-77	-76	-76
Vernalis (TAF)	117	84	42	42	37	43	94	74	75	75	86	98
Vernalis (cfs)	1970	1368	710	687	605	722	1537	1242	1225	1225	1554	1599
Old/Middle River calc.	-1,963	-1,956	-1,513	-4,076	-6,280	-6,646	-4,057	-3,112	-3,446	-4,974	-1,569	-2,451
Computed DOI (cfs)	19348	8980	7094	7727	5108	5009	4994	5043	4994	6735	11400	11403
Excess Outflow	7951	0	0	0	0	0	0	0	0	1741	0	0
% Export/ Inflow	12%	17%	12%	28%	45%	51%	44%	38%	42%	50%	15%	22%

Facility	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
% Export/ inflow std.	35%	35%	35%	65%	65%	65%	65%	65%	65%	65%	45%	35%

Hydrology

Table 6. Hydrology

Statistic	Trinity	Shasta	Folsom	New Melones
Water Year Inflow (TAF)	1,024	4,650	2,276	692
Year to Date + Forecasted % of mean	85	84	84	65

CVP actual operations do not follow any forecasted operation or outlook; actual operations are based on real-time conditions.

CVP operational forecasts or outlooks represent general system-wide dynamics and do not necessarily address specific watershed/tributary details.

CVP releases or export values represent monthly averages.

CVP Operations are updated monthly as new hydrology information is made available December through May.

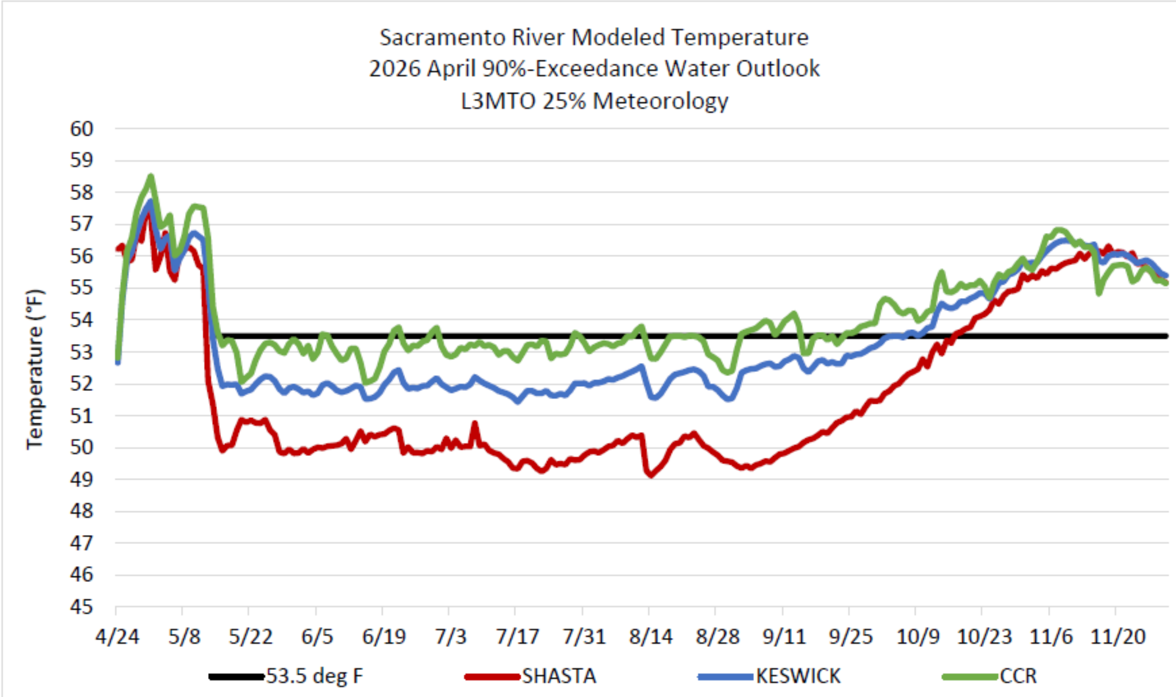

Figure 1. Sacramento River Modeled Temperature – 2026 April 90%-Exceedance Water Outlook, L3MTO 25% Meteorology

Figure 1 is a line graph showing modeled daily water temperatures in degrees Fahrenheit at three Sacramento River locations — Shasta (red), Keswick (blue), and CCR (green) — from April 24 through late November, with a horizontal reference line at 53.5°F. All three locations begin near 56–58°F in late April before diverging: Shasta drops sharply to approximately 49–51°F through the summer, remaining well below the 53.5°F threshold until mid-October before rising to approximately 56°F by late November. Keswick tracks similarly but approximately 2°F warmer than Shasta, crossing the threshold in mid-October. CCR remains near or above the 53.5°F threshold throughout the period, fluctuating between approximately 53–57°F.

Run date: 04/23/2026
EOM Sept storage: 2.20 MAF
Trinity profile date: 04/14/2026
Whiskeytown profile date: 04/15/2026
Shasta profile date: 04/23/2026
Projected Side gates: First Aug 13th Full Aug 31st
End of September Cold-Water-Pool less than 56 deg F: 387 TAF

Table 7. Monthly Average Modeled Temp (°F) by Location, April–November 2026

Month	Shasta deg F	Keswick deg F	CCR deg F
Apr	N/A	N/A	N/A
May	52.6	53.9	54.8
Jun	50.1	51.9	53.1
Jul	49.7	51.8	53.1
Aug	49.9	52.1	53.2
Sep	50.2	52.7	53.6
Oct	53.4	54.4	54.9
Nov	55.8	56.0	55.9

Attachment 4 - Winter-run Chinook Salmon Temperature Dependent Mortality Estimates

Background

To forecast temperature dependent mortality (TDM) of winter-run chinook salmon for the 2026 Sacramento River Temperature Management Plan, a scenario was evaluated that targeted 53.5F at Clear Creek (CCR).

The modeling framework used spatially explicit, daily average water temperature forecasts from the WTMP model. These forecasts were applied at multiple locations along the Sacramento River, including Keswick Dam and Clear Creek. Observed temperature data were used through April 26, 2026, and modeled forecasts were used thereafter. For locations between these gauges, daily temperatures were estimated by interpolating between nearby model output points. These temperature estimates were then matched to the river mile locations of simulated winter-run Chinook redds constructed based on observed spawning distributions from 2013 to 2022.

TDM was estimated by simulating the thermal history of each redd throughout its incubation period. Mortality was calculated based on cumulative thermal exposure using a degree-day threshold to represent development time, as well as on daily temperature exceedance past critical thresholds known to induce mortality. Two mortality models were applied. The first, based on Martin et al. (2017), assumes stage-independent mortality, using a single temperature threshold (12.14°C) applied consistently from spawning through emergence. The second model, based on Anderson et al. (2022), incorporates stage-dependent mortality, assigning a temperature threshold (11.82°C) and mortality sensitivities across distinct developmental stages. This approach was also applied to all scenarios. Results from the temperature-dependent mortality simulations did not reveal biologically meaningful results among some scenarios and between modeling approaches.

Table 1. Summary of winter-run chinook salmon TDM results for all scenarios developed April 28, 2026, based on the April 90% exceedance forecast.

Scenario	**Stage Dependent (%)**	**Stage Independent (%)**
Targeting 53.5F at CCR	0.7	2.2

Table 2. Modeling assumptions for TDM estimates for scenario developed during the week of April 27, 2026.

Parameter	Associated Information
Meteorology Source	25% exceedance L3MTO
Time Period	1/1/2026 – 4/26/2026: Observed temperatures 4/27/2026 – 11/1: Simulated temperatures
Reservoir Model Used	WTMP CE-QUAL-W2
River Model Used	WTMP HEC-ResSim
Shasta Profile Date	4/23/2026
TCD Gate Operations	WTMP CE-QUAL-W2
Sacramento Water Temperatures Used	WTMP output at Keswick and Sacramento River at CCR
Biological Model Used	SacPAS Fish model (Temperature effect only)
Temperature Mortality Models	Stage-independent mortality Stage-dependent mortality
Egg Emergence Timing Model	Linear. 958 ATUs (degrees C), as indicated for Zeug et al. on SacPAS under Egg to emergence timing model.
TDM Redd Time Distribution	Winter-run chinook salmon carcass surveys 2013-2022
TDM Redd Space Distribution	Winter-run chinook salmon carcass surveys 2013-2022
TDM TCRIT (50^{th} Percentile)	Stage-independent mortality: 12.14°C Stage-dependent mortality: 11.82°C
TDM BT (50^{th} Percentile)	Stage-independent mortality: 0.026°C-1d-1 Stage-dependent mortality: 0.436°C-1d-1
Critical Days	Stage-independent mortality: all Stage-dependent mortality: 4 days

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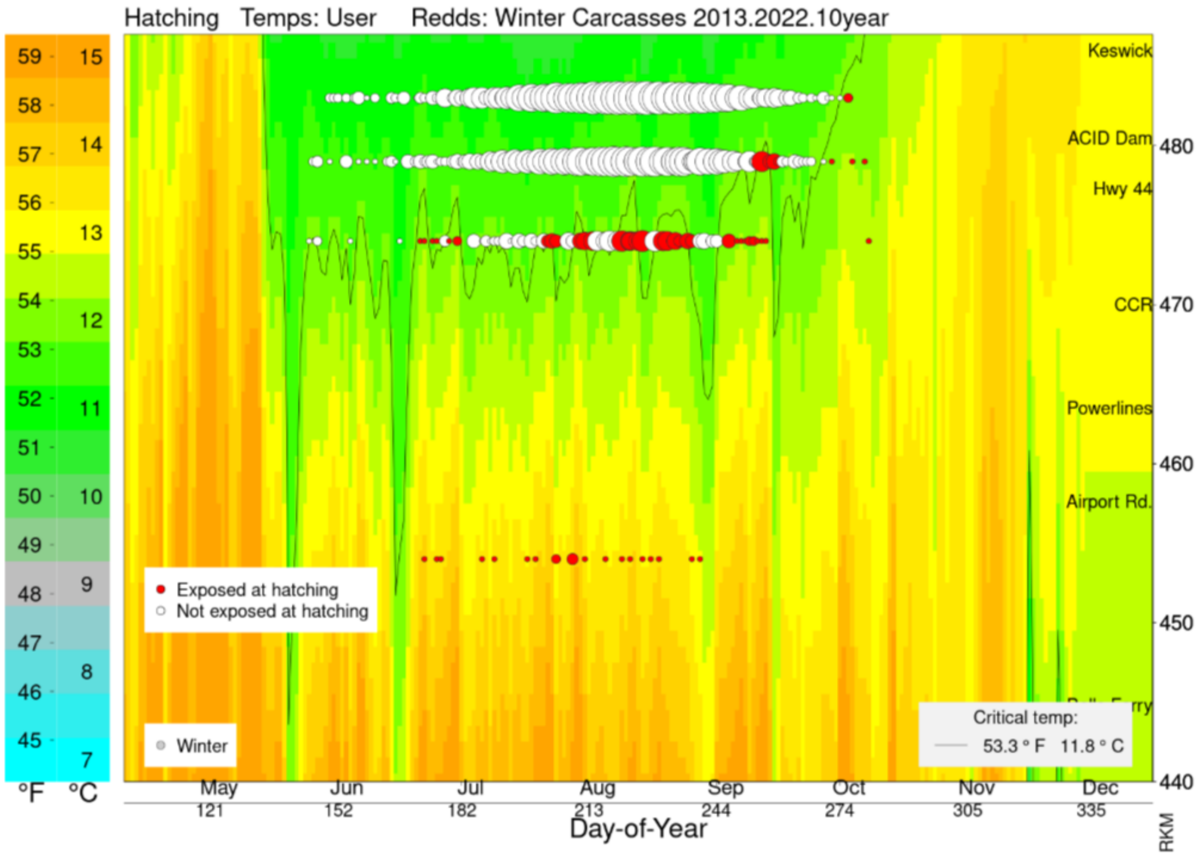

Figure 1. Stage-dependent results for winter-run redds exposed to water temperatures exceeding critical temperature at hatching phase (in red).

Figure 1 is a heat map showing water temperature conditions along the Sacramento River from Keswick to river kilometer 440, spanning May through December (day-of-year 121–335). Background colors represent water temperature, transitioning from cooler blues and greens to warmer yellows and reds as temperatures exceed the critical threshold of 53.3°F (11.8°C). Circles represent winter-run redds based on 2013–2022 ten-year carcass data, with red-filled circles indicating redds exposed to temperatures exceeding the critical threshold at hatching and open white circles indicating redds not exposed. Red dots along the lower portion of the figure indicate additional exposure events at hatching phase.

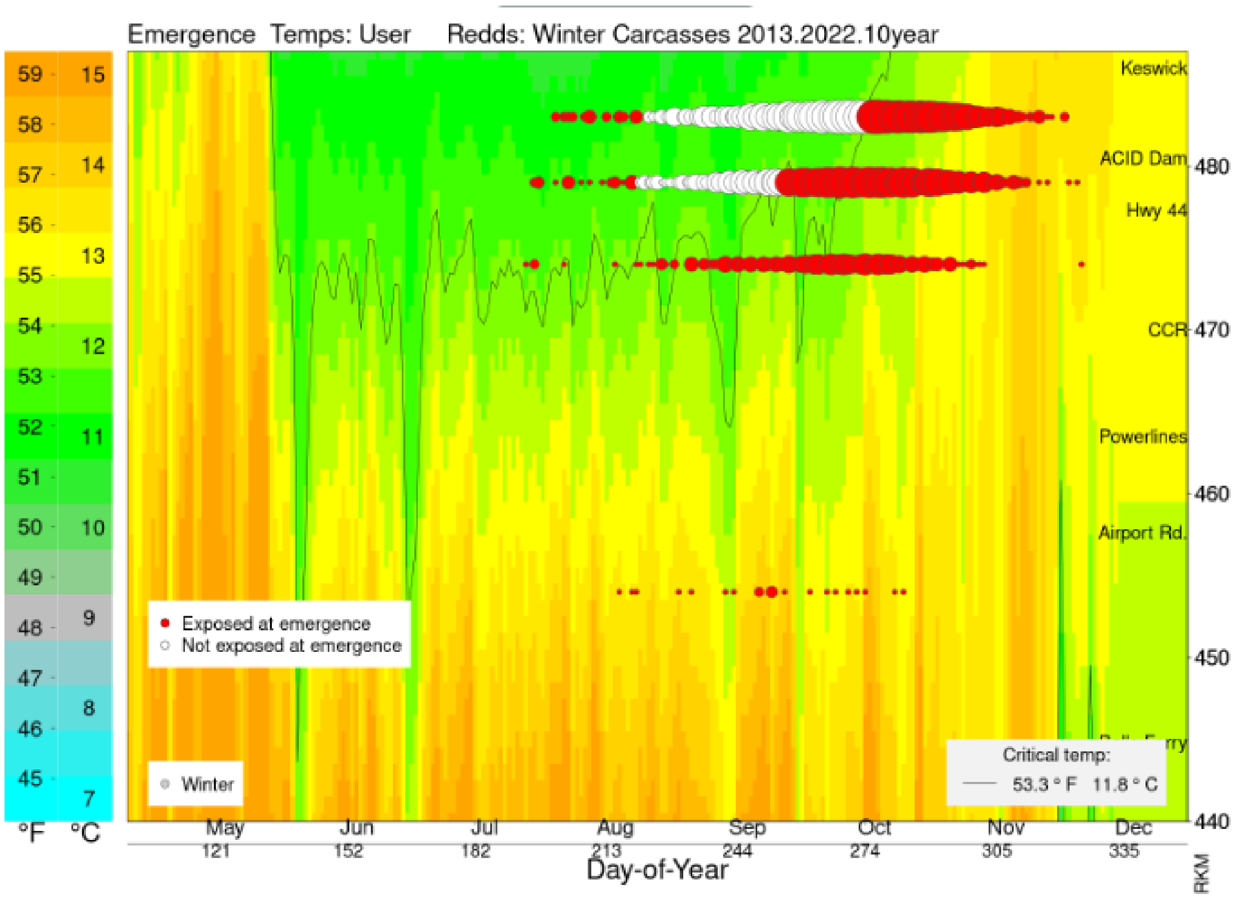

Figure 2. Stage-dependent results for winter-run redds exposed to water temperatures exceeding critical temperature at emergence (in red).

Figure 2 is a heat map showing water temperature conditions along the Sacramento River from Keswick to river kilometer 440, spanning May through December (day-of-year 121–335), with circles representing winter-run redds based on 2013–2022 ten-year carcass data at the emergence phase. Red-filled circles indicate redds exposed to temperatures exceeding the critical threshold of 53.3°F (11.8°C) at emergence, and open white circles indicate redds not exposed. Compared to Figure 1, a greater proportion of redds are shown as exposed at emergence, with red-filled circles concentrated at the upper river locations near Keswick and ACID Dam from July through October.

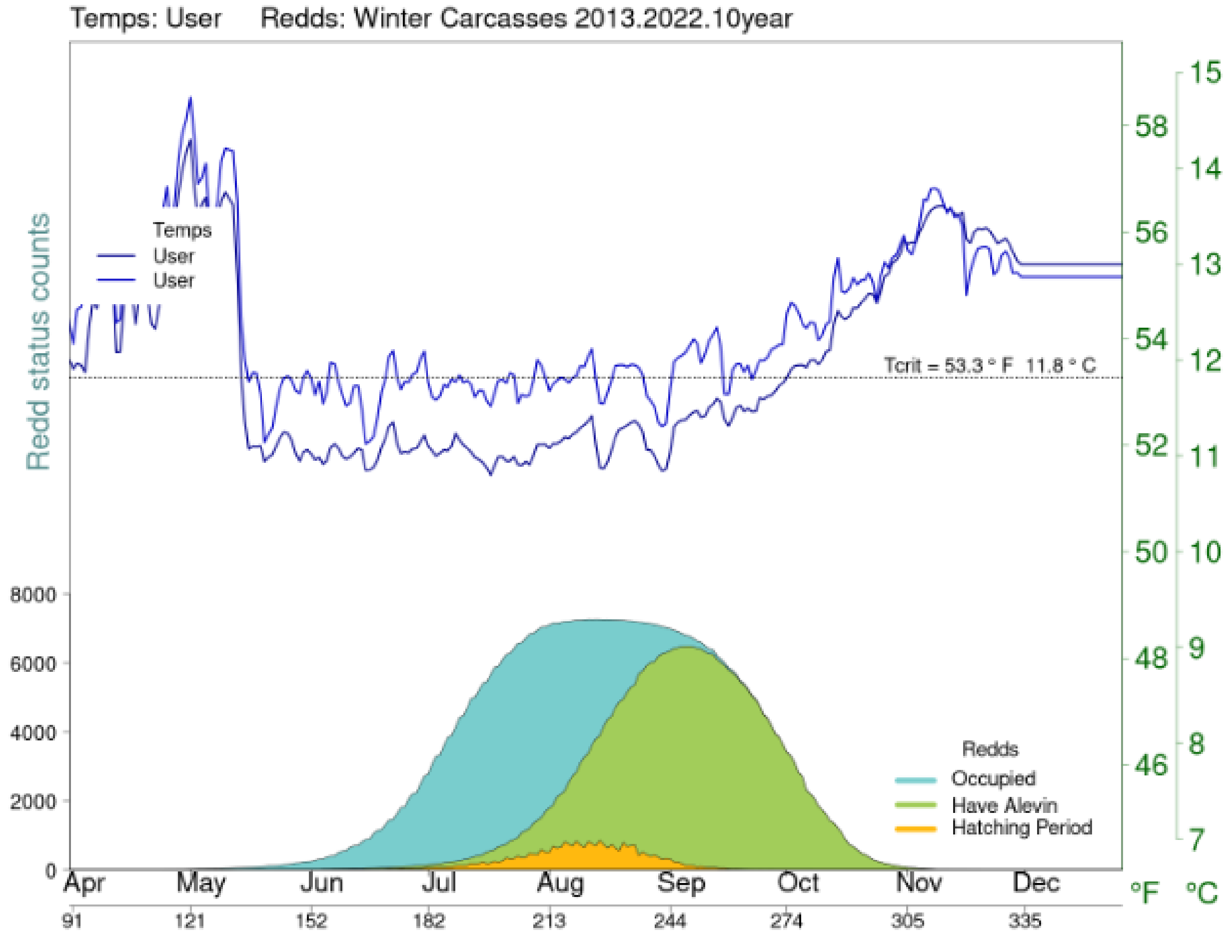

Figure 3. Winter-run redd distribution and water temperatures at Keswick and Clear Creek.

Figure 3 displays two stacked panels showing winter-run redd distribution and water temperatures at Keswick and Clear Creek from April through December. The upper panel shows daily water temperatures in degrees Fahrenheit from two user-specified inputs, tracking closely together and rising from approximately 52°F in spring to above the critical threshold of 53.3°F (11.8°C) through summer and fall, peaking near 57–58°F before stabilizing. The lower panel shows redd status counts over time, with occupied redds (teal) peaking near 7,000 in late August, have alevin redds (green) peaking slightly later in September, and hatching period redds (orange) appearing as a small pulse in late August through September.

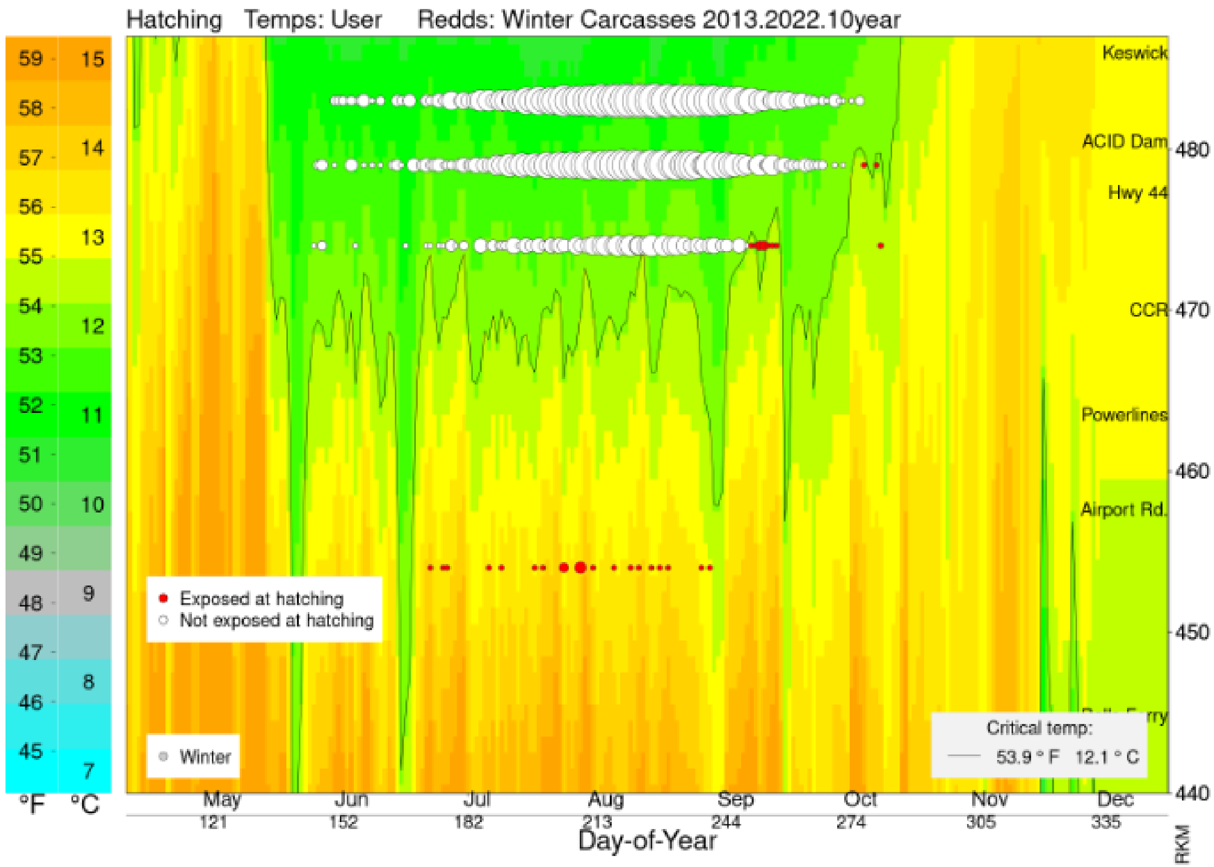

Figure 4. Stage-independent results for winter-run redds exposed to water temperatures exceeding critical temperature at hatching phase (in red).

Figure 4 is a heat map showing water temperature conditions along the Sacramento River from Keswick to river kilometer 440, spanning May through December (day-of-year 121–335). Background colors represent water temperature, transitioning from cooler blues and greens to warmer yellows and reds as temperatures exceed the critical threshold of 53.9°F (12.1°C). Circles represent winter-run redds based on 2013–2022 ten-year carcass data at the hatching phase, with red-filled circles indicating redds exposed to temperatures exceeding the critical threshold and open white circles indicating redds not exposed. The majority of redds appear as open white circles concentrated at upper river locations near Keswick and ACID Dam, with a small number of red-filled circles near CCR 470 in September and scattered red dots along the lower river.

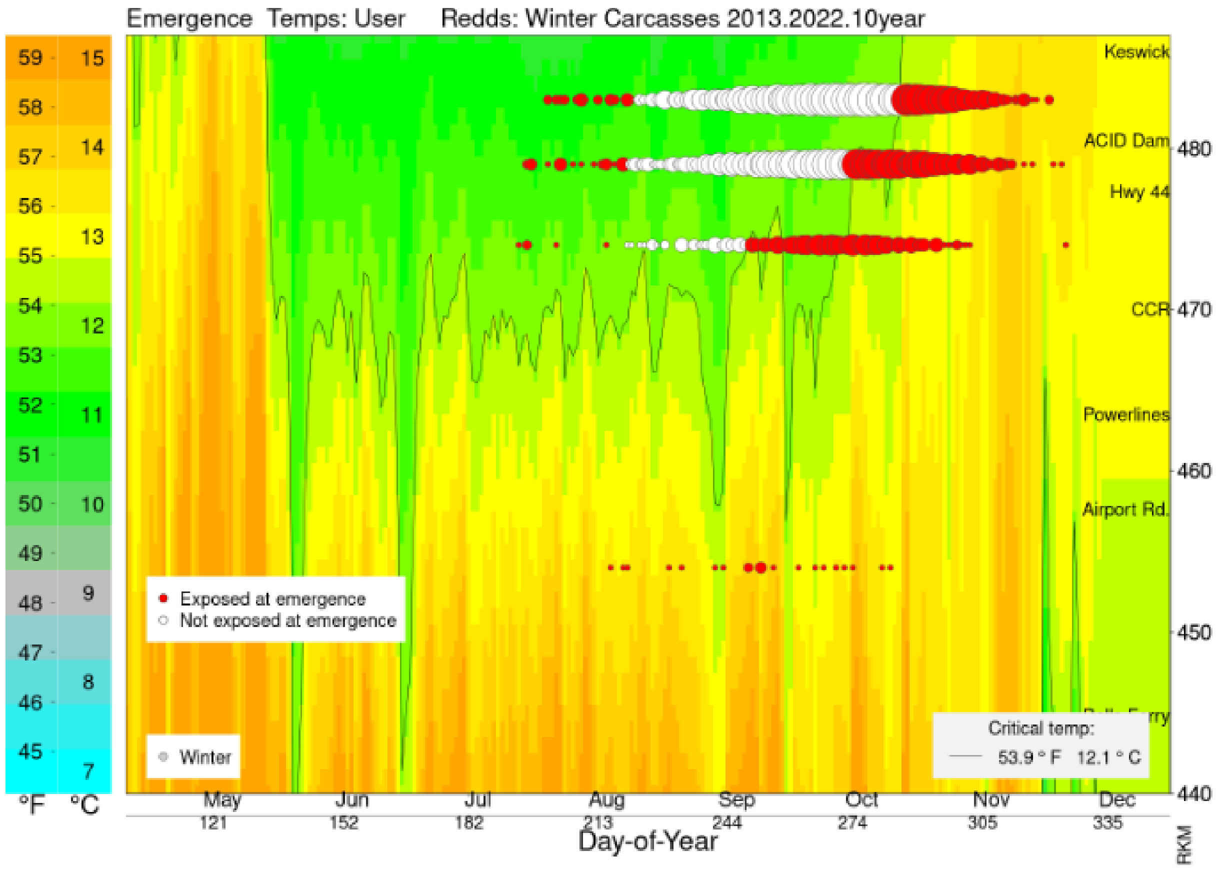

Figure 5. Stage-independent results for winter-run redds exposed to water temperatures exceeding critical temperature in emergence phase (in red).

Figure 5 is a heat map showing water temperature conditions along the Sacramento River from Keswick to river kilometer 440, spanning May through December (day-of-year 121–335). Background colors represent water temperature, transitioning from cooler blues and greens to warmer yellows and reds as temperatures exceed the critical threshold of 53.9°F (12.1°C). Circles represent winter-run redds based on 2013–2022 ten-year carcass data at the emergence phase, with red-filled circles indicating redds exposed to temperatures exceeding the critical threshold and open white circles indicating redds not exposed. Red-filled circles are concentrated at upper river locations near Keswick and ACID Dam from August through October, with a mix of exposed and unexposed redds at Hwy 44, and scattered red dots along the lower river near Airport Rd.