DRAFT 2025 Sacramento River Temperature Management Plan

Executive Summary

This Draft 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 2025 temperature management season. The Plan utilizes data from various sources including Reclamation's April 1 90% exceedance forecast of Central Valley Project (CVP) operations, recent reservoir temperature profiles, seasonal meteorological forecasts, and estimated salmon temperature dependent mortality. The Plan is consistent with the 2024 Record of Decision (ROD) on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project (LTO) (Reclamation 2024) 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 1B in which water temperatures are managed for winter-run spawning habitat downstream from the Sacramento River at Clear Creek (CCR) to a daily average of 53.5°F. Throughout the season, Reclamation will continue to analyze tradeoffs of establishing downstream temperature locations and increased Shasta Reservoir storage levels.

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. Facilities include the Shasta Dam and Powerplant, Keswick Dam and Powerplant and a TCD on the upstream face of Shasta Dam. Shasta Reservoir management considers drought protection actions in nearly every year and identifies actions that would 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. This Plan focuses on the fishery management aspect and attempts to maximize suitable water temperature regimes for the critically 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:

- 2024 ROD on the LTO of the Central Valley Project (Section 3.3.1 Temperature Management Plan) Reclamation will coordinate through the Sacramento River Group (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, and temperature dependent mortality (TDM) estimates for both Martin (2017) and Anderson (2022). Reclamation will finalize the TMP in May or later through coordination with the SRG and Shasta Operations Team (SHOT). Reclamation may update the TMP through coordination with the SRG and SHOT.
- WRO 90-5 to consult with the California Department of Fish and Wildlife (CDFW), U.S. Fish and Wildlife Service (USFWS), 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 recommendations received from SRG. The Plan establishes temperature locations and targets through October 31, 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. 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

As stated above, Shasta Reservoir management considers drought protection actions in nearly every year and identifies actions that would 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 3.2 of Chapter 3 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. The following 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 and less than 3.7	Greater than or equal to 2.2 and less than 2.4	53.5°F at CCR (seasonal shaped if necessary)
Bin 2 (Recover and Maintain)	B	Greater than or equal to 3.0 and less than 3.7	Greater than or equal to 2.0 and less than 2.2	53.5°F at CCR (seasonal shaped if necessary)
Bin 3 (Protect)	A	Less than 3.0	Greater than 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

Northern California has been cold and wet, consequently, Shasta storage and cold water pool volumes will likely be at or near historical maximums. Downstream water temperature performance is expected to be similar to the last few wetter water years (i.e., 2023 and 2024) and 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. In addition, Shasta Reservoir's cold water pool is projected to be comparable to other above average and wetter years such as 2016 and 2018. Coordination and active water temperature management began in February 2025 taking advantage of real-time management opportunities to increase storage and cold water pool. These conditions along with the April 90% forecast and initial temperature model runs supported implementation of a spring pulse operation, described in Attachment 1.

Methodology: Modeling Assumptions, Limitations, and Other Uncertainties

Reclamation uses a physically based simulation model, HEC-5Q, 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 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 and uncertain. Many factors contribute to operational actions including, but not limited to: flood protection operations, forecasted inflows, forecasted meteorology, reservoir stratification, minimum/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. The 2025 Sacramento River Spring Pulse Operations Plan (Attachment 1) was used as a guide for Keswick Dam releases in April and May. Trinity

River releases below Lewiston Dam were based on a forecasted Wet 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 temperature Shasta Lake temperature profile based on 4/22/25 observations. Table 2 describes the monthly forecasted operations for releases and storage targets referenced in the April 90% CVP forecast of operation (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)	626	614	719	584	336
Keswick Releases (cfs)	11,000	11,500	13,000	10,800	7,000
Keswick Releases (TAF)	676	684	799	664	416
Spring Creek Power Plant (TAF)	50	70	80	80	80
Shasta End-of-Month Storage (TAF)	4,326	4,000	3,485	3,067	2,900

Footnotes:

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

Water Temperature Strategy Results and Discussion

Based on the April 90% CVP Operations Outlook (Attachment 2), Reclamation has identified Water Year 2025 as a Bin 1 year. In a Bin 1 year, Shasta Reservoir storage is forecast to be greater than 3.7 million acre-feet (MAF) at the beginning of May; greater than 2.4 MAF at the end of September; and meet 53.5°F downstream of CCR. However, Shasta storage is forecast to be less than 3.0 MAF at end of September and therefore would be categorized as a Bin 1B. For this reason, this Plan proposes to target 53.5°F at CCR. Reclamation, through coordination with SRG and SHOT, would analyze tradeoffs of establishing downstream temperature locations that support the biological goal of maximizing suitable habitat and the risk of running out of cold water. Reclamation would also consider system tradeoffs for supporting higher Shasta storage (up to 3.0 MAF) with minimal impacts to other parts of the system during their monthly forecasting process.

The Keswick Reservoir release schedule, which includes the planned spring pulse flow action, was developed by Reclamation as part of the April forecast of operations (Attachment 2). The purpose of the spring pulse flow is to increase outmigration survival of Chinook salmon. SRG evaluated various pulse flow options and SHOT approved a plan for the potential of three pulses from late April through May. Reclamation completed HEC-5Q modeling on April 22, 2025 based on the April 90% exceedance forecast and most recent Shasta Lake temperature profile. The temperature modeling results are presented here in Table 3 and Attachment 3. Further refinement to the temperature management strategy will occur through coordination with SRG and SHOT as the temperature management season progresses.

Table 3. Estimated average monthly water temperature in degrees Fahrenheit at Shasta, Keswick, and CCR based on model run of operations with pulse flow action (i.e., pulse flow scenario described in pulse flow operations plan) targeting 53.5°F at CCR and 90% exceedance forecast. HEC-5Q does not perform well after mid-September. Water temperatures may be warmer than these targets and HEC-5Q results.

Month	Shasta (°F)	Keswick (°F)	CCR (°F)
June	50.0	51.9	52.8
July	50.0	52.2	52.9
August	50.1	52.4	53.1
September	49.1	52.1	52.9
October	49.4	51.2	51.7
November	52.0	52.2	52.4

Trinity River and Clear Creek modeled temperatures are included in Attachment 3.

For comparative purposes, Reclamation also completed a forecast of operations that did not include spring pulse flow actions (Attachment 4). HEC-5Q water temperature modeling results for this forecast can be found in Table 4 and Attachment 5.

Table 4. Estimated average monthly water temperature in degrees Fahrenheit at Shasta, Keswick, and CCR based on model run of operations without pulse flow action (i.e., baseline scenario described in pulse flow operations plan) targeting 53.5°F at CCR and 90% exceedance forecast. HEC-5Q does not perform well after mid-September. Water temperatures may be warmer than these targets and HEC-5Q results.

Month	Shasta (°F)	Keswick (°F)	CCR (°F)
June	50.0	51.9	52.8
July	50.0	52.1	52.9
August	50.1	52.5	53.2
September	49.1	52.0	52.8
October	49.2	51.0	51.5
November	51.0	51.3	51.6

Water temperature forecasts, with and without the pulse flow, indicate favorable temperatures for winter-run chinook salmon egg incubation with Temperature Dependent Mortality (TDM) estimates less than 1% (Table 5). Modeled water temperature forecasts also indicate suitable temperatures for spring-run and fall-run Chinook salmon incubation; however, temperature models are more uncertain during the fall period (Attachment 6). 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 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 5. Fish and water performance metrics from biological modeling (Attachment 6).

Metric/Scenario	**No Pulse Flow 53.5°F CCR (90% Exceedance)**	**With Pulse Flow 53.5°F CCR (90% Exceedance)**
Stage-independent TDM	0.2%	0.2%
Stage-dependent TDM	0.4%	0.4%
End of Sept CWP Storage less than 56°F (TAF)	893	787
First Side Gate Use	September 4	September 2
Full Side Gate	October 23	October 16
End of September Storage (MAF)	3.02	2.90

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. 2024. Record of Decision on the Coordinated 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

2025 Sacramento River Pulse Flows Operations Plan

Background

As part of the Action for the Long term Operation of the Central Valley Project and State Water Project, Reclamation would release up to 150 thousand acre-feet (TAF) in pulse flow(s) each water year, typically in the spring, to benefit Chinook salmon in the Sacramento River watershed when the pulse does not interfere with the ability to meet temperature objectives or other anticipated operations of the reservoir. Reclamation will schedule this pulse after coordination through the Sacramento River Group (SRG) and the Shasta Operations Team (SHOT) 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 to maximize multi-species benefits, which may include coordinating timing with natural flow events, potential storage management operations, potential Sacramento River Settlement Contractors (SRSC) demands and infrastructure limitations, and/or pulse flows in tributaries or reducing the volume of the pulse flow. The pulse flow volume and schedule will be developed through the SRG and provided to the SHOT. Reclamation, through the SHOT, will discuss the plan and make any appropriate and/or necessary refinements prior to implementation. For more information, refer to Proposed Action "3.1.7 Sacramento River Pulse Flows".

Reclamation has been coordinating pulse flow planning through SRG and SHOT. As described in the Proposed Action 3.13.3.1.2, the SRG develops temperature and flow plans using the best available science including current hydrologic forecasts, operational outlooks, fishery information, and modeling information. Reclamation will coordinate 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. Beginning in March 2025, the technical sub-team of the SRG met to develop a Pulse Flow Operations Plan.

Forecasted and Current Conditions

Shasta storage exceeds 3.9 MAF as of March 26, 2025. Total May 1 Shasta Reservoir storage is predicted to be 4.1 MAF based on the March 90% exceedance forecast and 4.4 MAF based on the March 50% exceedance forecast. Under Bin 2A, hydrologic conditions are more limited than in Bin 1 and adequate water resources are not available to meet all demands. Bin 2A is defined as having an end of September storage between 2.2 and 2.4 MAF. Based on the 90% March forecast, the projected end of September storage projected to be 2.3 MAF. However, there is potential that the year could be reclassified as a Bin 1 category later this season.

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.

Chinook Salmon Benefits and Action Effectiveness

Optimal timing, magnitude, duration, and frequency for implementation of a managed pulse release from Keswick Reservoir to improve outmigration survival of spring-run Chinook salmon smolts, have been discussed during the SRG meetings. Late April and early May are likely to have the greatest benefits for wild smolt survival in most years. Spring-run smolts typically experience the worse outmigration conditions due to their later outmigration timing. For example, historical temperatures at critical migration points in the delta can exceed 68 F as early as late April in some years (see Figure 2). To support the outmigration success of this year's spring-run smolts, April and May pulse releases are predicted provide the greatest species benefit. To evaluate the effectiveness of the spring pulse, juvenile fall chinook salmon from CNFH will be acoustically tagged and tracked as described in the Study Plan. Initial real-time results for this year's Pulse Flow Study as well as previous years are posted to: CalFishTrack. Final 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.

Temperature modeling is unreliable before thermoclines establish in Shasta, typically in late April. As a result, temperature-dependent mortality (TDM) of Chinook salmon was not modeled for specific pulse flow scenarios. However, general relationships between Shasta storage and TDM exist, as shown in Figure 1. In this positional analysis, TDM was estimated using a 53° F, 54°F, and 55° F temperature target 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 1 below. However, it should be noted that this analysis and resulting figure utilizes the Calsim II model with deprecated No Action Alternative operations logic. Nonetheless, with few exceptions, TDM remains low when end-of-April Shasta storage is at or above 3.8 MAF. Current forecasts project end-of-April Shasta storage to exceed 3.8 MAF, thus TDM is unlikely to be significant in WY2025 and would not be influenced by any individual pulse flow scenario. However, in drier years with lower forecasted end-of-April storage, pulse flows may have a more pronounced impact on TDM.

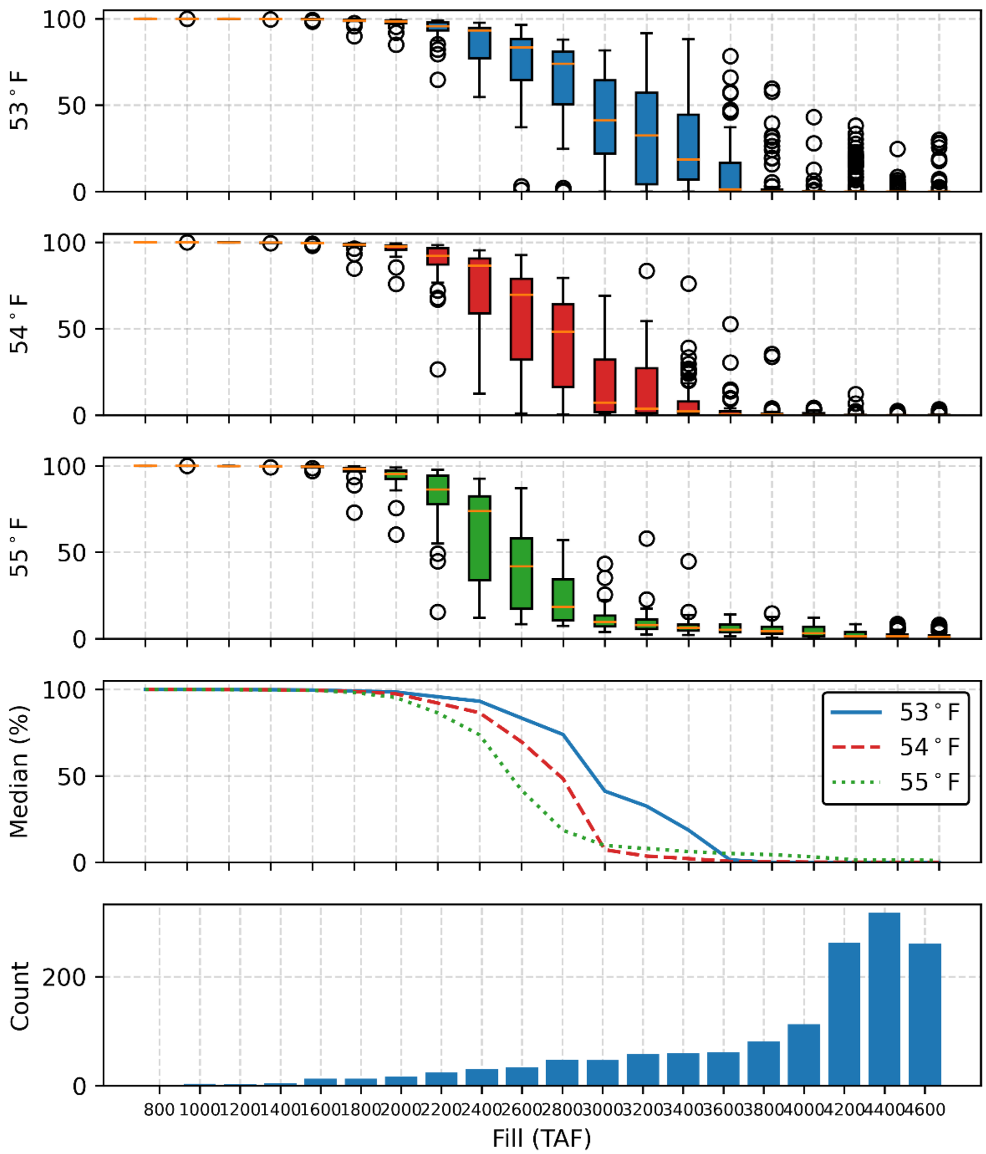

Figure 1. Winter-run Chinook salmon percent TDM estimates associated with Shasta fill (e.g., end of April storage; TAF. This figure utilizes the Calsim II model with deprecated No Action Alternative operations logic.

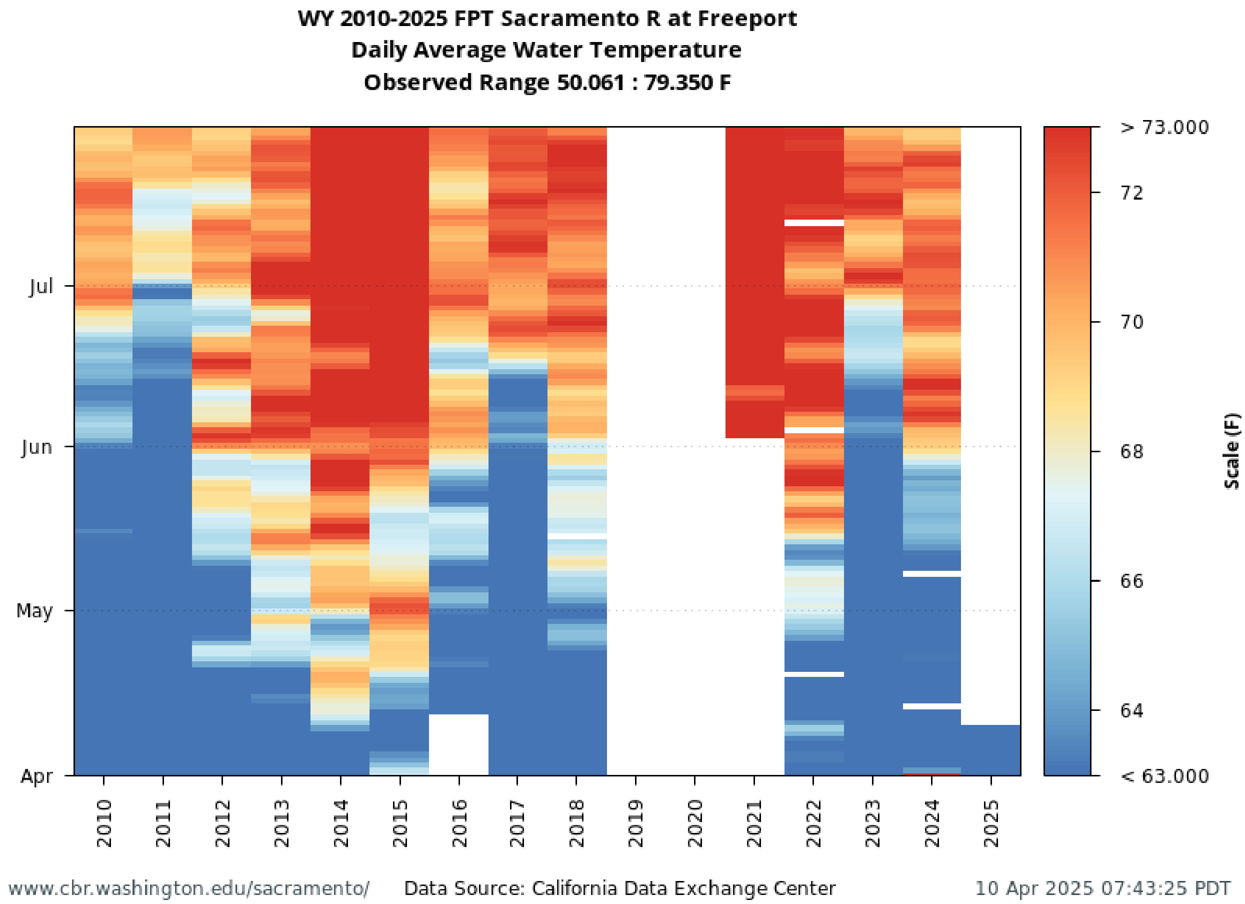

Figure 2. Historical water temperature (degree F) in the Sacramento River at Freeport using a 68 degree F temperature threshold above which is unsuitable for outmigrating juvenile salmonids (Marine and Cech 2004). This figure demonstrates that in historical wet years water temperatures appear suitable for outmigrating juvenile salmonids in May while in dry years water temperatures are unsuitable.

Pulse Flow Alternatives

Reclamation prepared an operational forecast on March 24, 2025, April 1, 2025, and April 15, 2025 that were shared with University of California, Santa Cruz/NOAA Science Center who modelled juvenile chinook salmon outmigration survival for every possible scenario based on this recent operation forecast (see attachment 2025 Spring Pulse Flow Survival Simulations for Flow Scenarios). A similar naming convention was used to describe the pulse scenarios as was used last year. As an example: X5.4o8.4 is a scenario, where 5.4 is the first pulse (5th week of the April/May period, 4 days long), and 8.4 is the second pulse (8th week of the April/May period, 4 days long). The other characters do not have meaning. X5.4 would mean just one pulse the 5th week of the April/May period, 4 days long. X5.4o7.4o8.4 would be 3 pulses, one the 5th week of the period, one the 7th week, and one the 8th week.

- Week 1: week of March 31
- Week 2: week of April 7
- Week 3: week of April 14
- Week 4: week of April 21
- Week 5: week of April 28
- Week 6: week of May 5
- Week 7: week of May 12
- Week 8: week of May 19

UCSC/SWFSC developed a new tool to show predicted improvement in spring outmigration survival over the baseline scenario (i.e., no pulse scenario) as shown in figures 5 and 7 of Attachment 2025 Spring Pulse Flow Survival Simulations for Flow Scenarios. This Burford et al. model is different from the Michel et al. (2021) model (that is used to estimate survival improvement in the other figures) in 3 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 most importantly 3) it incorporates responses in the number of fish initiating migration as a function of flow changes. Pulse flows not only increase survival but also increase the number of fish that initiate migration during those beneficial flows and therefore is an effect multiplier. However, the best scenarios are generally similar between the two models.

Using the April 15 operations information, all scenarios have a pulse volume less than the established 150 TAF water budget, utilize 15% ramping rates, and achieve a pulse magnitude of at least 11,000 cfs at Wilkins Slough. Conditions and water cost will continue to be assessed throughout the season. Ideally, pulse flows would start after flows at Wilkins Slough stabilize in the 5,000 to 10,000 cfs range. Additional constraints and considerations include: ACID dam needs, power impacts, delta needs, SRSC diversions, and timing of other pulse flow actions. Top performing scenarios in terms of greatest estimated outmigration survival have two pulses in weeks 6,7,8 (i.e., May 5-26); however, this timeframe is expected to have greater water cost to reach the 11,000 cfs Wilkins Slough threshold target.

Constraints and Other Considerations:

- ACID dam requires low flows (4,000 to 6,000 cfs) during its installation, and cannot sustain high flows greater than 15,000 cfs while installed. ACID dam was installed in early April in 2025.
- No impacts to construction of Sacramento River habitat restoration projects has been identified as by implementation of pulse flows on the Sacramento River this season.
- Flow fluctuations are anticipated to impact monitoring efforts. For example, efforts for juvenile stranding surveys increase, and effectiveness monitoring for habitat restoration projects (Kapusta Island Side Channel and Shea Island Side Channel) is hindered during flow fluctuations.
- 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.
- Shasta Dam is capacity limited, must provide flood control, and adheres to safe operations. In wet years, (e.g., spring 2023) flows are likely to stay high rather than be shaped into a pulse due to constraints.
- 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.

Uncertainties:

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 community following large flood control release that were around 36,000 cfs—three orders of magnitude greater than the spring pulse flows.

Currently, we do not have many tools to estimate these potential tradeoffs in a quantifiable manner. Michel et al. 2021 describes a few thresholds associated with juvenile chinook salmon outmigration survival. We are targeting a more optimal flow threshold of 11,000 cfs. Michel et al. 2021 described a flow of 22,500 cfs with reduced salmon survival, presumably because these flows contribute to increase in juvenile stranding, food web effect, and negative causal linkages. Adhering to established ramping rates as described in the Proposed Action will also help reduce juvenile stranding. Furthermore, flows exceeding 18,000 cfs at Wilkins Slough have been reported to create seepage problems. Reclamation would plan to avoid flows of this magnitude to avoid stranding, seepage, and other impacts, unless needed for flood control.

USFWS and other interested parties have indicated an interest in releasing hatchery fish during a pulse flow event. As of April 16,2025, Coleman National Fish Hatchery planned on releasing chinook salmon during the week 3 (week of April 14), and in week 5 (late April /early May).

Although survival estimates for some scenarios were greater, other scenarios are likely preferrable to other scenarios, in terms of experimental design, as they provide a week in between pulse flows to better understand the mechanisms behind the pulse flows and juvenile salmonid survival. Another consideration is that the flow threshold survival model does not account for number fish available to migrate, so pulse flows scheduled closer together may not have additive benefits.

On April 16th, SRG developed a schedule for consideration that included three pulses starting Tuesday April 29th, Friday May 9th, and Tuesday May 20. These scenarios consist of a few days in between each pulse and ramp down which allows times for monitoring (e.g., RST and acoustic telemetry) during the non-pulse periods. SHOT should continue to reassess these scenarios, especially mid/late May pulse scenarios, and their associated water cost. There is considerable uncertainty with the forecasts and conditions during this time of year. In addition, temperature modelling of planned scenarios will be included in the 2025 Sacramento River Temperature Management Plan.

References

Marine, K. R., and J. J. Cech Jr. 2004. Effects of high water temperature on the growth, smoltification, and predator avoidance in juvenile Sacramento River Chinook Salmon. North American Journal of 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.

2025 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 Apr 15 2025.xlsx

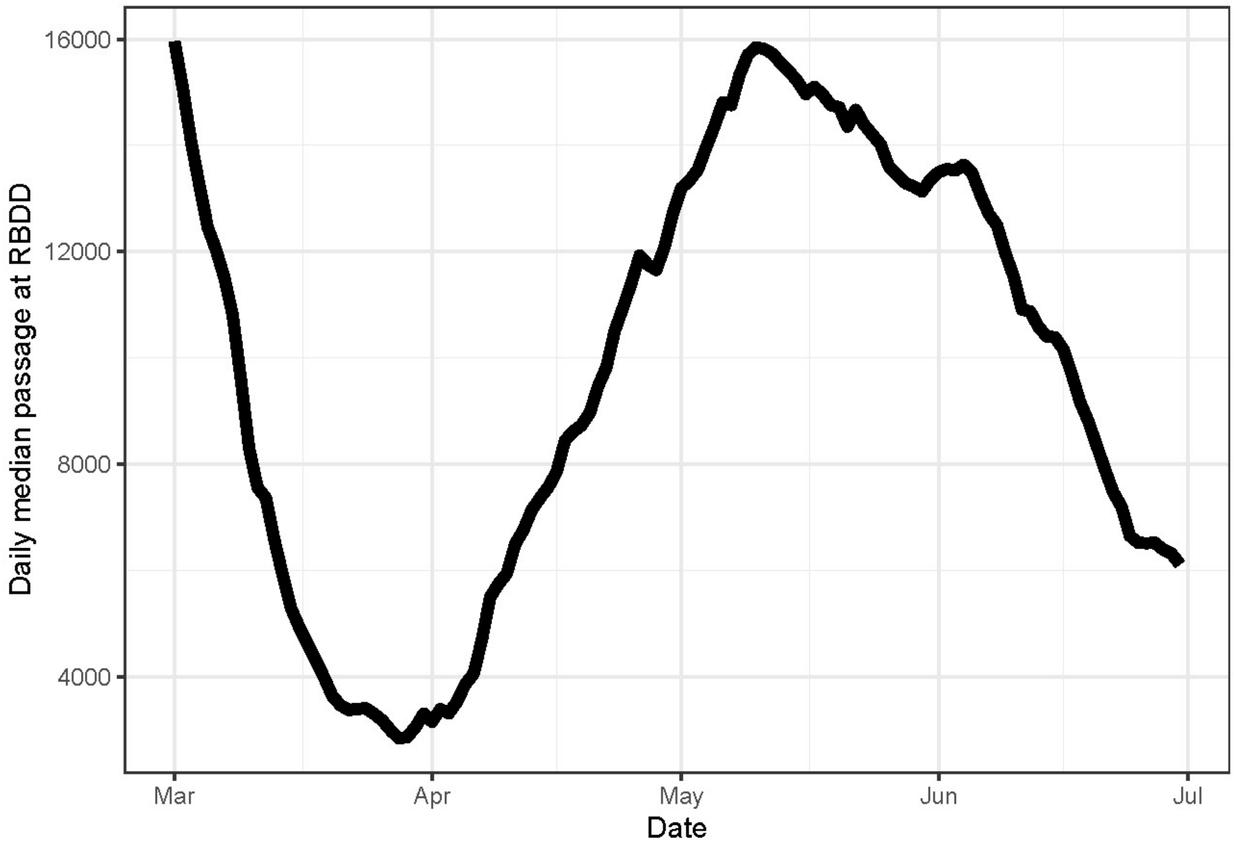

Figure 1. Historic median daily passage (with 20-day moving average smoothing) at Red Bluff Diversion Dam USFWS Screw traps for all years of data (2006-2019).

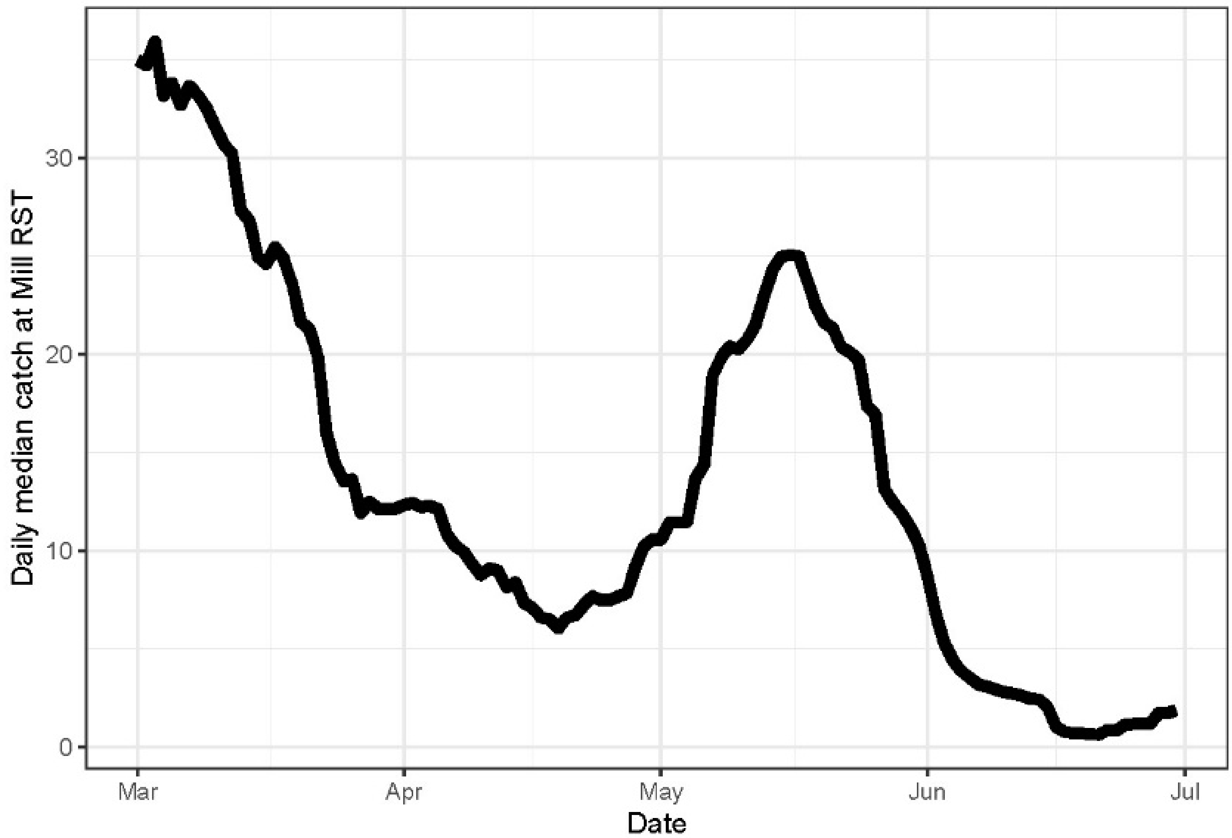

Figure 2. Historic median daily catch (with 20-day moving average smoothing) at Mill Creek CDFW Screw trap for all years of data (1996, 2000, 2001, 2002, 2003, 2007, 2008, 2009, and 2010).

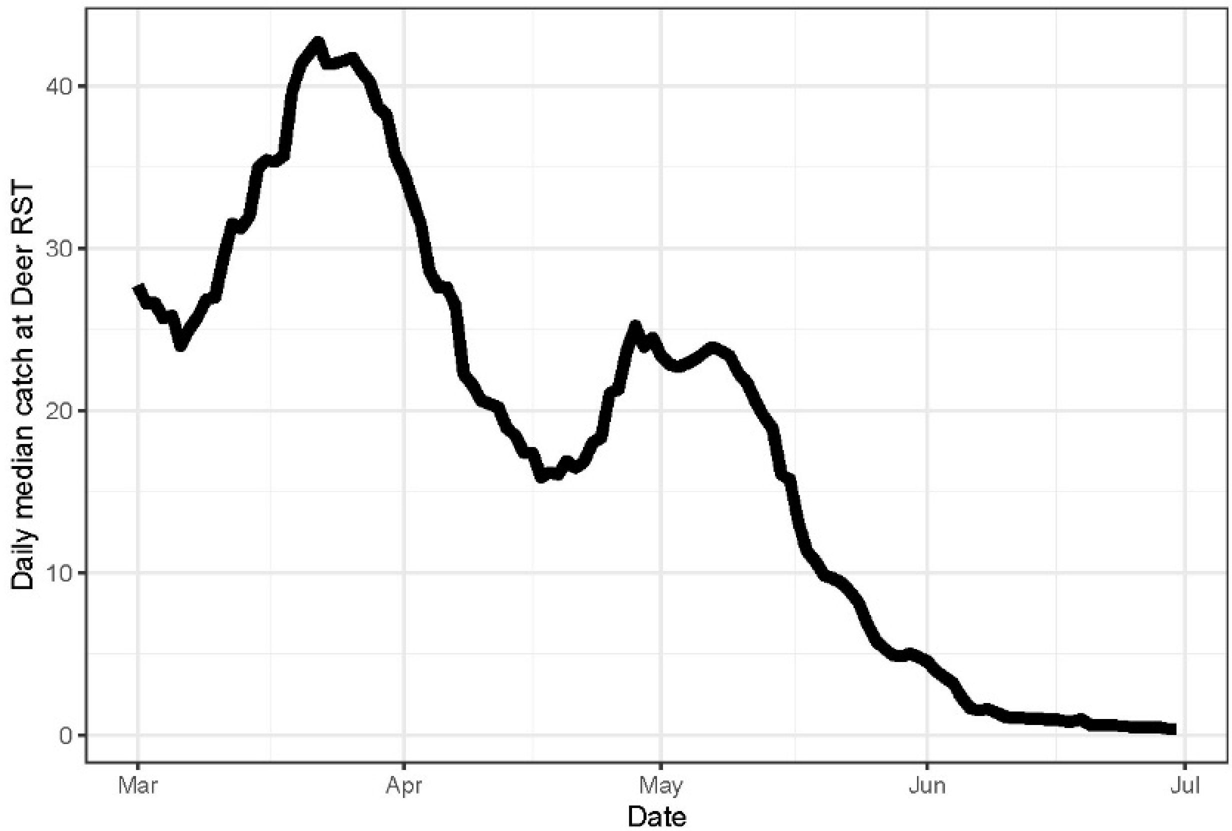

Figure 3. Historic median daily catch (with 20-day moving average smoothing) at Deer Creek CDFW Screw trap for all years of data (1995, 1996, 2000, 2001, 2002, 2003, 2004, 2005, 2007, 2009, and 2010).

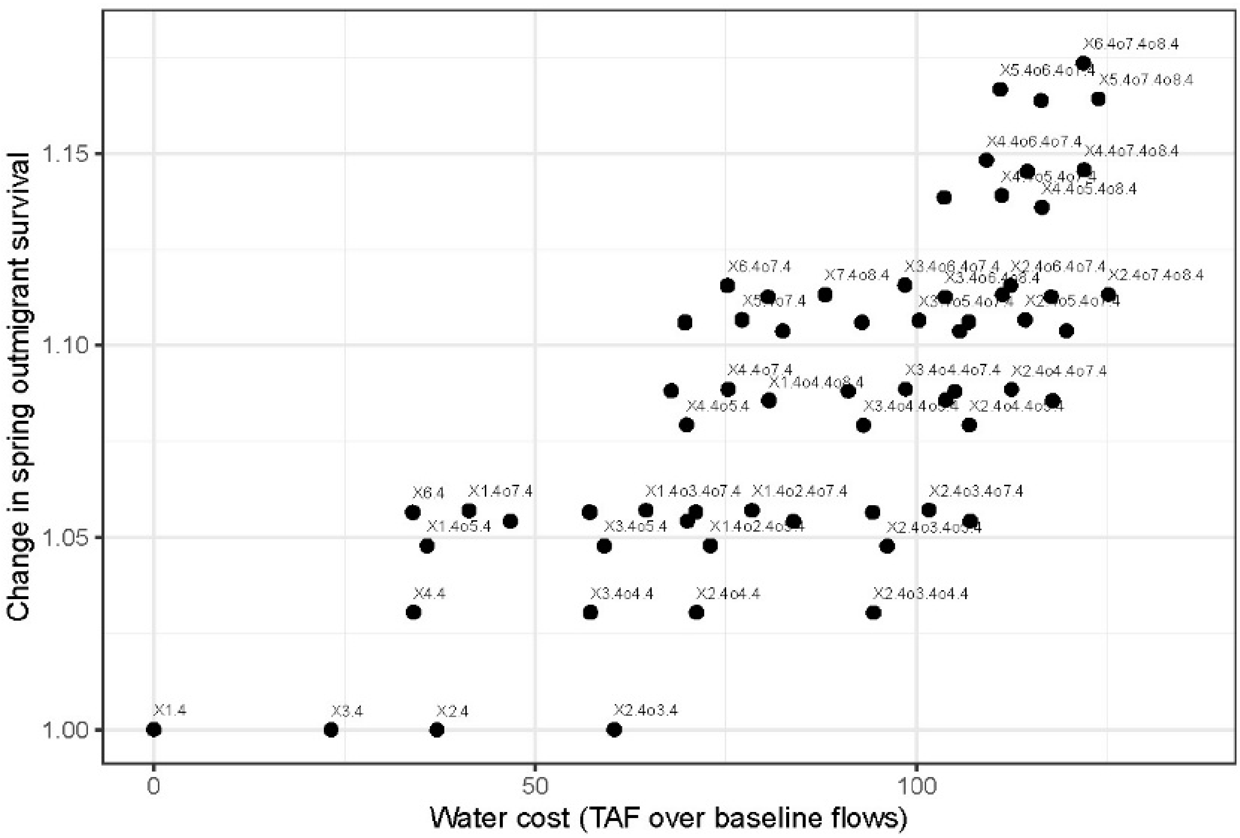

Figure 4. Change in spring outmigration survival (over status quo) as a function of water cost (TAF) for all pulse flow scenarios using all years of fish passage data at RBDD (2006-2019), and using the Michel et al. (2021) nonlinear flow: survival relationship.

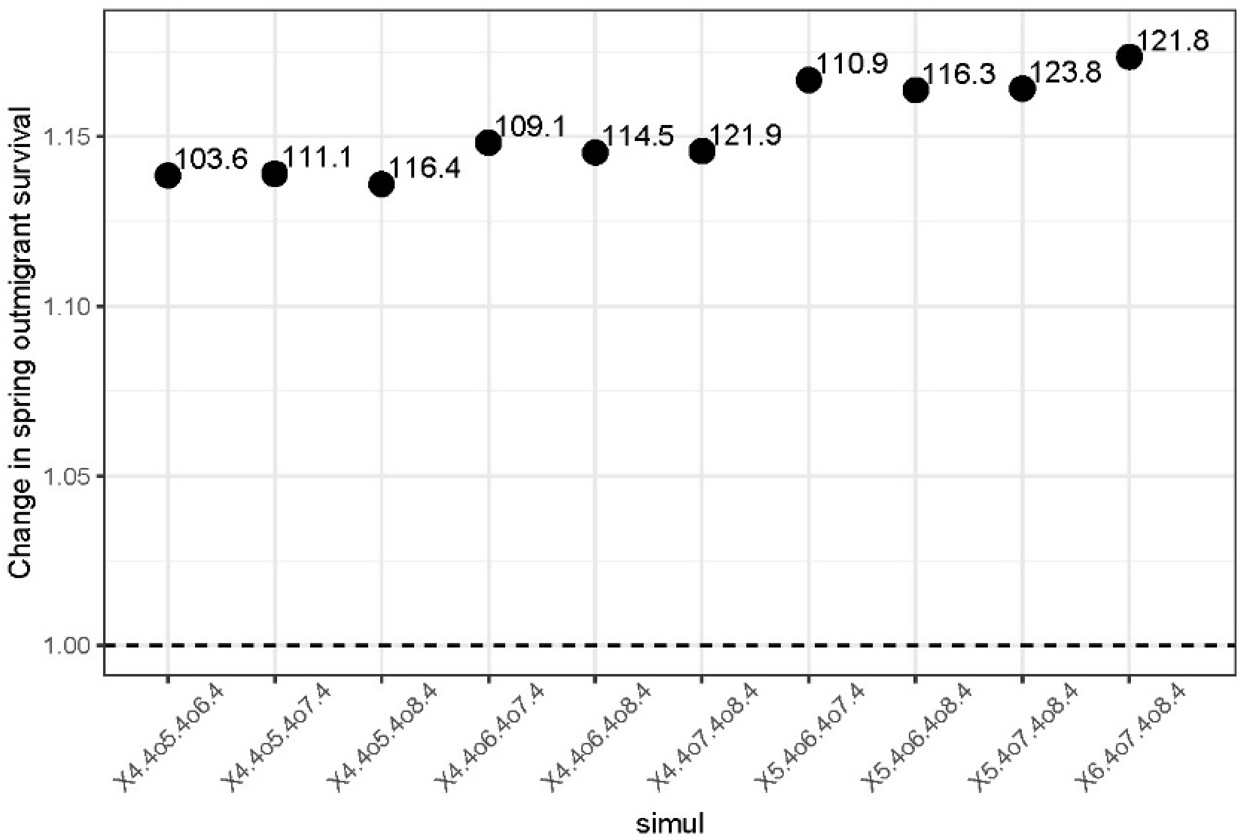

Figure 5. Top 10 pulse flow scenarios as ranked by best spring season survival improvement (over status quo), using all years of fish passage data at RBDD (2006-2019), and using the Michel et al. (2021) nonlinear flow:survival relationship. Water cost is shown as point labels (TAF).

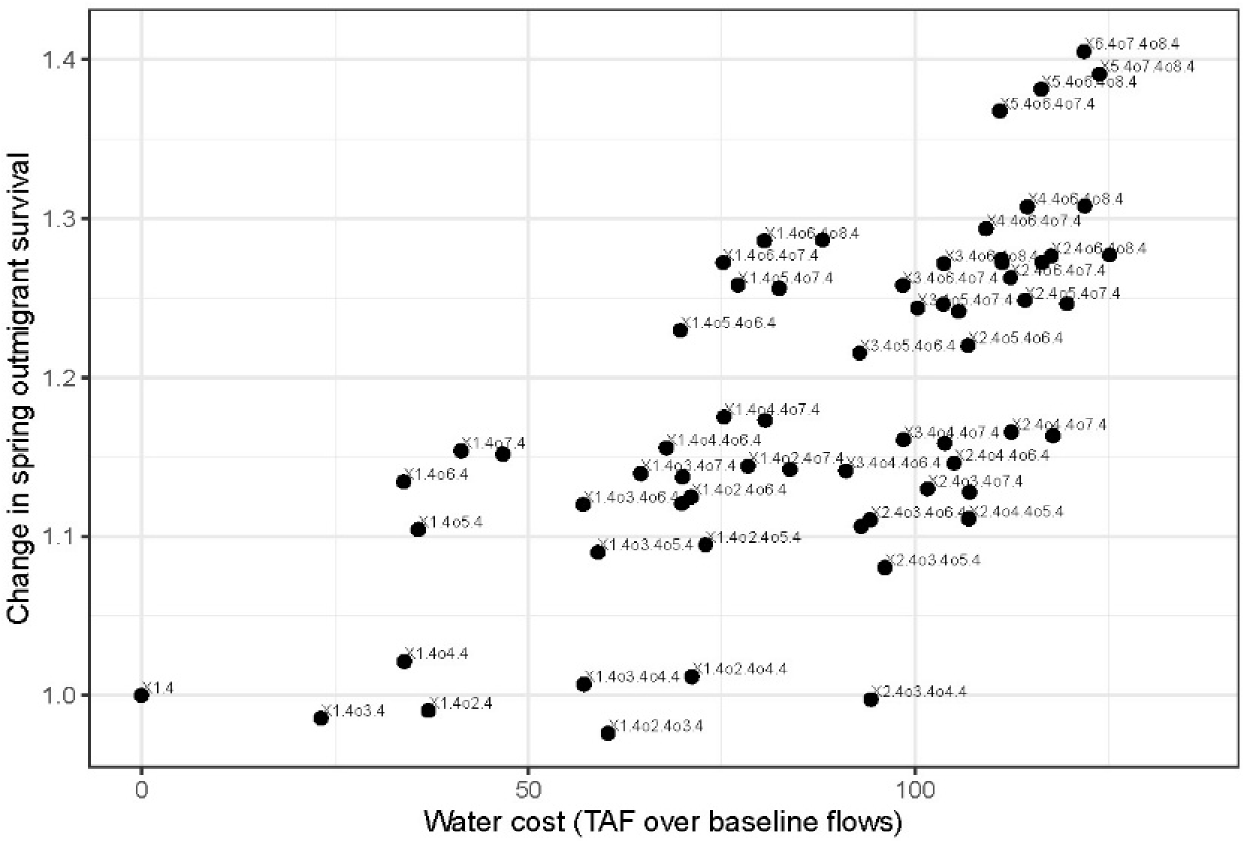

Figure 6. Change in spring outmigration survival (over status quo) as a function of water cost (TAF) for all pulse flow scenarios using the Burford et al. (in review at Ecological Applications) model. This model is different from the Michel et al. (2021) model in 3 ways: 1. it uses a continuous, non-linear 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.

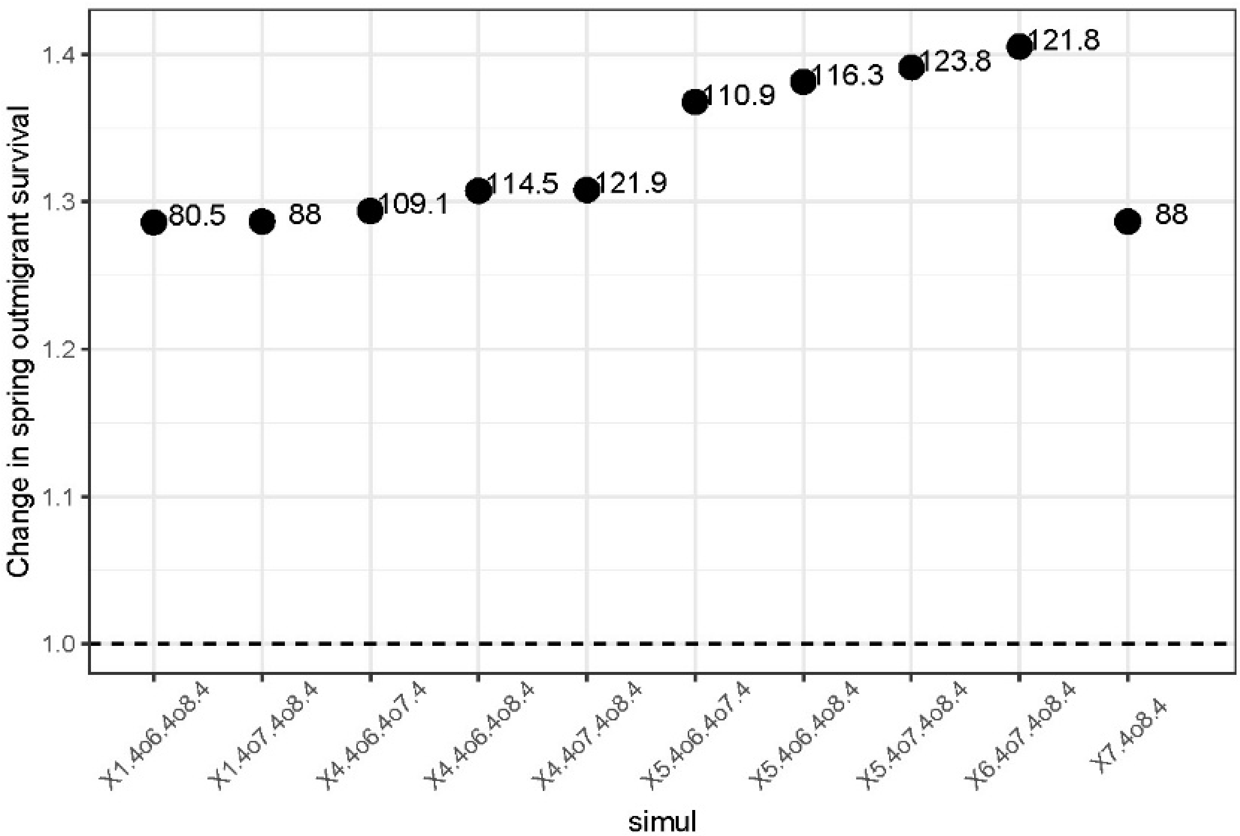

Figure 7. Top 10 pulse flow scenarios as ranked by best spring season survival improvement (over status quo) using the Burford et al. (in review at Ecological Applications) model. This model is different from the Michel et al. (2021) model in 3 ways: 1. it uses a continuous, non-linear relationship between 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 Water cost is shown as point labels (TAF).

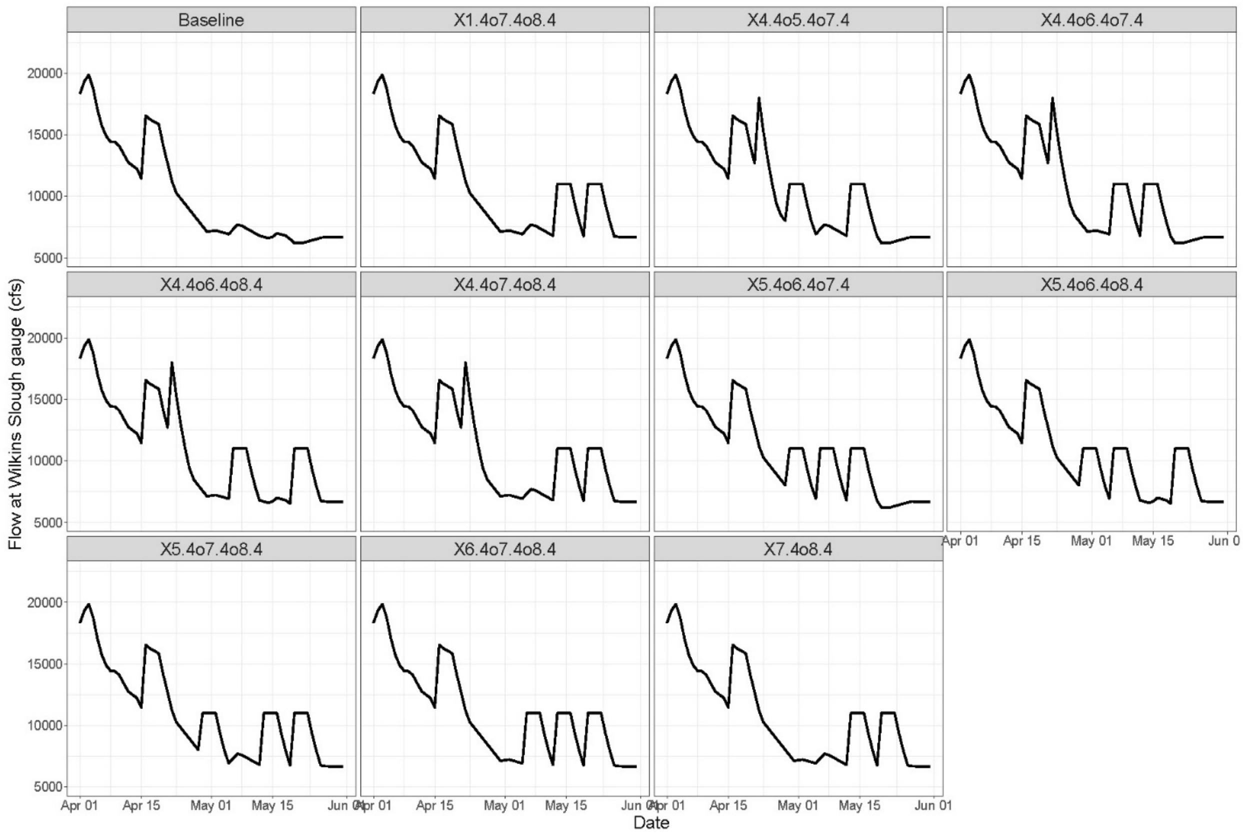

Figure 8. Spring pulse flow hydrographs for the top 10 scenarios as ranked by both Michel et al. and Burford et al. models, and including baseline flows (dashed black line).

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	Survival Improvement over Baseline Michel	Spring Survival Burford	Survival Improvement over Baseline Burford	Rank Michel	Rank Burford
X6.4o7.4o8.4	121.8	0.312	1.173	0.428	1.405	1	1.0
X5.4o7.4o8.4	123.8	0.310	1.164	0.424	1.391	3	2.0
X5.4o6.4o7.4	110.9	0.310	1.167	0.417	1.368	2	4.0
X5.4o6.4o8.4	116.3	0.309	1.164	0.421	1.381	4	3.0
X4.4o7.4o8.4	121.9	0.305	1.146	0.398	1.308	6	5.0
X4.4o6.4o7.4	109.1	0.305	1.148	0.394	1.294	5	7.0
X4.4o6.4o8.4	114.5	0.304	1.145	0.398	1.307	7	6.0
X4.4o5.4o7.4	111.1	0.303	1.139	0.388	1.275	8	14.0
X7.4o8.4	88.0	0.296	1.113	0.392	1.287	15	8.5
X1.4o7.4o8.4	88.0	0.296	1.113	0.392	1.287	18	8.5
Baseline	0.0	0.266	1.000	0.305	1.000	90	85.5

Footnotes:

TAF = thousand acre-feet

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	X6.4o7.4o8.4	X5.4o7.4o8.4	X5.4o6.4o7.4	X5.4o6.4o8.4	X4.4o7.4o8.4	X4.4o6.4o7.4	X4.4o6.4o8.4	X4.4o5.4o7.4	X7.4o8.4	X1.4o7.4o8.4	Baseline
2025-04-01	18342	18342	18342	18342	18342	18342	18342	18342	18342	18342	18342
2025-04-02	19340	19340	19340	19340	19340	19340	19340	19340	19340	19340	19340
2025-04-03	19858	19858	19858	19858	19858	19858	19858	19858	19858	19858	19858
2025-04-04	18762	18762	18762	18762	18762	18762	18762	18762	18762	18762	18762
2025-04-05	17023	17023	17023	17023	17023	17023	17023	17023	17023	17023	17023
2025-04-06	15702	15702	15702	15702	15702	15702	15702	15702	15702	15702	15702
2025-04-07	14877	14877	14877	14877	14877	14877	14877	14877	14877	14877	14877
2025-04-08	14425	14425	14425	14425	14425	14425	14425	14425	14425	14425	14425
2025-04-09	14409	14409	14409	14409	14409	14409	14409	14409	14409	14409	14409
2025-04-10	14075	14075	14075	14075	14075	14075	14075	14075	14075	14075	14075
2025-04-11	13411	13411	13411	13411	13411	13411	13411	13411	13411	13411	13411
2025-04-12	12772	12772	12772	12772	12772	12772	12772	12772	12772	12772	12772
2025-04-13	12490	12490	12490	12490	12490	12490	12490	12490	12490	12490	12490
2025-04-14	12230	12230	12230	12230	12230	12230	12230	12230	12230	12230	12230
2025-04-15	11450	11450	11450	11450	11450	11450	11450	11450	11450	11450	11450
2025-04-16	16550	16550	16550	16550	16550	16550	16550	16550	16550	16550	16550
2025-04-17	16250	16250	16250	16250	16250	16250	16250	16250	16250	16250	16250
2025-04-18	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050
2025-04-19	15850	15850	15850	15850	15850	15850	15850	15850	15850	15850	15850
2025-04-20	14150	14150	14150	14150	14150	14150	14150	14150	14150	14150	14150
2025-04-21	12700	12700	12700	12700	12700	12700	12700	12700	12700	12700	12700
2025-04-22	11225	11225	11225	11225	18000	18000	18000	18000	11225	11225	11225
2025-04-23	10275	10275	10275	10275	15300	15300	15300	15300	10275	10275	10275
2025-04-24	9825	9825	9825	9825	13005	13005	13005	13005	9825	9825	9825
2025-04-25	9375	9375	9375	9375	11054	11054	11054	11054	9375	9375	9375
2025-04-26	8925	8925	8925	8925	9396	9396	9396	9396	8925	8925	8925

Date	X6.4o7.4o8.4	X5.4o7.4o8.4	X5.4o6.4o7.4	X5.4o6.4o8.4	X4.4o7.4o8.4	X4.4o6.4o7.4	X4.4o6.4o8.4	X4.4o5.4o7.4	X7.4o8.4	X1.4o7.4o8.4	Baseline
2025-04-27	8475	8475	8475	8475	8475	8475	8475	8475	8475	8475	8475
2025-04-28	8025	8025	8025	8025	8025	8025	8025	8025	8025	8025	8025
2025-04-29	7575	11000	11000	11000	7575	7575	7575	11000	7575	7575	7575
2025-04-30	7125	11000	11000	11000	7125	7125	7125	11000	7125	7125	7125
2025-05-01	7175	11000	11000	11000	7175	7175	7175	11000	7175	7175	7175
2025-05-02	7225	11000	11000	11000	7225	7225	7225	11000	7225	7225	7225
2025-05-03	7125	9350	9350	9350	7125	7125	7125	9350	7125	7125	7125
2025-05-04	7025	7948	7948	7948	7025	7025	7025	7948	7025	7025	7025
2025-05-05	6925	6925	6925	6925	6925	6925	6925	6925	6925	6925	6925
2025-05-06	11000	7325	11000	11000	7325	11000	11000	7325	7325	7325	7325
2025-05-07	11000	7700	11000	11000	7700	11000	11000	7700	7700	7700	7700
2025-05-08	11000	7600	11000	11000	7600	11000	11000	7600	7600	7600	7600
2025-05-09	11000	7400	11000	11000	7400	11000	11000	7400	7400	7400	7400
2025-05-10	9350	7200	9350	9350	7200	9350	9350	7200	7200	7200	7200
2025-05-11	7948	7000	7948	7948	7000	7948	7948	7000	7000	7000	7000
2025-05-12	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800
2025-05-13	11000	11000	11000	6700	11000	11000	6700	11000	11000	11000	6700
2025-05-14	11000	11000	11000	6600	11000	11000	6600	11000	11000	11000	6600
2025-05-15	11000	11000	11000	6700	11000	11000	6700	11000	11000	11000	6700
2025-05-16	11000	11000	11000	7000	11000	11000	7000	11000	11000	11000	7000
2025-05-17	9350	9350	9350	6900	9350	9350	6900	9350	9350	9350	6900
2025-05-18	7948	7948	7948	6800	7948	7948	6800	7948	7948	7948	6800
2025-05-19	6756	6756	6756	6525	6756	6756	6525	6756	6756	6756	6525
2025-05-20	11000	11000	6200	11000	11000	6200	11000	6200	11000	11000	6200
2025-05-21	11000	11000	6200	11000	11000	6200	11000	6200	11000	11000	6200
2025-05-22	11000	11000	6225	11000	11000	6225	11000	6225	11000	11000	6225
2025-05-23	11000	11000	6325	11000	11000	6325	11000	6325	11000	11000	6325
2025-05-24	9350	9350	6425	9350	9350	6425	9350	6425	9350	9350	6425
2025-05-25	7948	7948	6525	7948	7948	6525	7948	6525	7948	7948	6525

Date	X6.4o7.4o8.4	X5.4o7.4o8.4	X5.4o6.4o7.4	X5.4o6.4o8.4	X4.4o7.4o8.4	X4.4o6.4o7.4	X4.4o6.4o8.4	X4.4o5.4o7.4	X7.4o8.4	X1.4o7.4o8.4	Baseline
2025-05-26	6756	6756	6625	6756	6756	6625	6756	6625	6756	6756	6625
2025-05-27	6700	6700	6700	6700	6700	6700	6700	6700	6700	6700	6700
2025-05-28	6675	6675	6675	6675	6675	6675	6675	6675	6675	6675	6675
2025-05-29	6675	6675	6675	6675	6675	6675	6675	6675	6675	6675	6675
2025-05-30	6675	6675	6675	6675	6675	6675	6675	6675	6675	6675	6675
2025-05-31	6675	6675	6675	6675	6675	6675	6675	6675	6675	6675	6675

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	X5.4o7.4o8.4	X5.4o6.4o7.4	X5.4o6.4o8.4	X4.4o7.4o8.4	X4.4o6.4o7.4	X4.4o6.4o8.4	X4.4o5.4o7.4	X7.4o8.4	X1.4o7.4o8.4	Baseline
2025-04-01	8294	8294	8294	8294	8294	8294	8294	8294	8294	8294	8294
2025-04-02	7503	7503	7503	7503	7503	7503	7503	7503	7503	7503	7503
2025-04-03	6652	6652	6652	6652	6652	6652	6652	6652	6652	6652	6652
2025-04-04	6094	6094	6094	6094	6094	6094	6094	6094	6094	6094	6094
2025-04-05	5852	5852	5852	5852	5852	5852	5852	5852	5852	5852	5852
2025-04-06	5591	5591	5591	5591	5591	5591	5591	5591	5591	5591	5591
2025-04-07	5578	5578	5578	5578	5578	5578	5578	5578	5578	5578	5578
2025-04-08	5361	5361	5361	5361	5361	5361	5361	5361	5361	5361	5361
2025-04-09	5143	5143	5143	5143	5143	5143	5143	5143	5143	5143	5143
2025-04-10	4888	4888	4888	4888	4888	4888	4888	4888	4888	4888	4888
2025-04-11	4738	4738	4738	4738	4738	4738	4738	4738	4738	4738	4738
2025-04-12	4650	4650	4650	4650	4650	4650	4650	4650	4650	4650	4650
2025-04-13	4570	4570	4570	4570	4570	4570	4570	4570	4570	4570	4570
2025-04-14	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600
2025-04-15	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600	4600
2025-04-16	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
2025-04-17	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
2025-04-18	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
2025-04-19	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
2025-04-20	8500	8500	8500	8500	8500	8500	8500	8500	8500	8500	8500
2025-04-21	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500
2025-04-22	6500	6500	6500	6500	13275	13275	13275	13275	6500	6500	6500
2025-04-23	6000	6000	6000	6000	11025	11025	11025	11025	6000	6000	6000
2025-04-24	6000	6000	6000	6000	9180	9180	9180	9180	6000	6000	6000
2025-04-25	6000	6000	6000	6000	7679	7679	7679	7679	6000	6000	6000
2025-04-26	6000	6000	6000	6000	6471	6471	6471	6471	6000	6000	6000

Date	KES	X5.4o7.4o8.4	X5.4o6.4o7.4	X5.4o6.4o8.4	X4.4o7.4o8.4	X4.4o6.4o7.4	X4.4o6.4o8.4	X4.4o5.4o7.4	X7.4o8.4	X1.4o7.4o8.4	Baseline
2025-04-27	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
2025-04-28	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
2025-04-29	6000	9425	9425	9425	6000	6000	6000	9425	6000	6000	6000
2025-04-30	6000	9875	9875	9875	6000	6000	6000	9875	6000	6000	6000
2025-05-01	6500	10325	10325	10325	6500	6500	6500	10325	6500	6500	6500
2025-05-02	7000	10775	10775	10775	7000	7000	7000	10775	7000	7000	7000
2025-05-03	7500	9725	9725	9725	7500	7500	7500	9725	7500	7500	7500
2025-05-04	8000	8923	8923	8923	8000	8000	8000	8923	8000	8000	8000
2025-05-05	8500	8500	8500	8500	8500	8500	8500	8500	8500	8500	8500
2025-05-06	9000	9000	12675	12675	9000	12675	12675	9000	9000	9000	9000
2025-05-07	9500	9500	12800	12800	9500	12800	12800	9500	9500	9500	9500
2025-05-08	9500	9500	12900	12900	9500	12900	12900	9500	9500	9500	9500
2025-05-09	9500	9500	13100	13100	9500	13100	13100	9500	9500	9500	9500
2025-05-10	9500	9500	11650	11650	9500	11650	11650	9500	9500	9500	9500
2025-05-11	9500	9500	10448	10448	9500	10448	10448	9500	9500	9500	9500
2025-05-12	9500	9500	9500	9500	9500	9500	9500	9500	9500	9500	9500
2025-05-13	9500	13800	13800	9500	13800	13800	9500	13800	13800	13800	9500
2025-05-14	9500	13900	13900	9500	13900	13900	9500	13900	13900	13900	9500
2025-05-15	9500	13800	13800	9500	13800	13800	9500	13800	13800	13800	9500
2025-05-16	9500	13500	13500	9500	13500	13500	9500	13500	13500	13500	9500
2025-05-17	9500	11950	11950	9500	11950	11950	9500	11950	11950	11950	9500
2025-05-18	9500	10648	10648	9500	10648	10648	9500	10648	10648	10648	9500
2025-05-19	9500	9731	9731	9500	9731	9731	9500	9731	9731	9731	9500
2025-05-20	9500	14300	9500	14300	14300	9500	14300	9500	14300	14300	9500
2025-05-21	9500	14300	9500	14300	14300	9500	14300	9500	14300	14300	9500
2025-05-22	9500	14275	9500	14275	14275	9500	14275	9500	14275	14275	9500
2025-05-23	9500	14175	9500	14175	14175	9500	14175	9500	14175	14175	9500
2025-05-24	9500	12425	9500	12425	12425	9500	12425	9500	12425	12425	9500
2025-05-25	9500	10923	9500	10923	10923	9500	10923	9500	10923	10923	9500

Date	KES	X5.4o7.4o8.4	X5.4o6.4o7.4	X5.4o6.4o8.4	X4.4o7.4o8.4	X4.4o6.4o7.4	X4.4o6.4o8.4	X4.4o5.4o7.4	X7.4o8.4	X1.4o7.4o8.4	Baseline
2025-05-26	9500	9631	9500	9631	9631	9500	9631	9500	9631	9631	9500
2025-05-27	9500	9500	9500	9500	9500	9500	9500	9500	9500	9500	9500
2025-05-28	9500	9500	9500	9500	9500	9500	9500	9500	9500	9500	9500
2025-05-29	9500	9500	9500	9500	9500	9500	9500	9500	9500	9500	9500
2025-05-30	9500	9500	9500	9500	9500	9500	9500	9500	9500	9500	9500
2025-05-31	9500	9500	9500	9500	9500	9500	9500	9500	9500	9500	9500

Table 4. Starting dates for each week of the April/May period

Week 1: week of March 31

Week 2: week of April 7

Week 3: week of April 14

Week 4: week of April 21

Week 5: week of April 28

Week 6: week of May 5

Week 7: week of May 12

Week 8: week of May 19

Attachment 2

Estimated CVP Operations 90% Exceedance (Pulse Flows)

Storages

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 (TAF)	2112	2203	2312	2342	2238	2098	1959	1899	1884	1842	1844	1876	1918
Trinity Elevation (feet)	N/A	2355	2362	2363	2357	2348	2338	2334	2333	2330	2330	2332	2335
Whiskeytown (TAF)	231	232	238	238	238	238	238	206	206	206	206	206	232
Whiskeytown Elevation (feet)	N/A	1207	1209	1209	1209	1209	1209	1199	1199	1199	1199	1199	1207
Shasta (TAF)	4067	4472	4326	4000	3485	3067	2900	2784	2743	2785	2824	2952	3221
Shasta Elevation (feet)	N/A	1064	1059	1048	1028	1011	1003	998	996	998	1000	1006	1017
Folsom (TAF)	817	923	933	890	634	516	478	411	350	305	291	325	420
Folsom Elevation (feet)	N/A	461	462	458	432	419	414	405	395	388	386	391	406
New Melones (TAF)	1984	1948	1891	1756	1685	1627	1580	1525	1531	1539	1545	1503	1481
New Melones Elevation (feet)	N/A	1048	1042	1029	1022	1016	1012	1006	1006	1007	1008	1003	1001
Federal San Luis (TAF)	819	784	627	489	318	236	193	216	307	481	651	623	677
Federal San Luis Elevation (feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Storage (TAF)	10030	10561	10326	9715	8598	7783	7347	7040	7021	7158	7362	7484	7949

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

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Oroville (TAF)	3024	3262	3268	3186	2691	2211	1836	1637	1520	1476	1494	1595	1766
Oroville Elevation (feet)	N/A	882	883	877	841	802	767	746	733	728	730	741	760
State San Luis (TAF)	999	891	678	410	449	474	563	473	491	494	648	651	592
State San Luis Elevation (feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total San Luis (TAF)	1818	1675	1304	900	767	710	756	689	798	975	1299	1274	1268
Total San Luis Elevation (feet)	N/A	514	482	443	428	422	427	420	432	450	481	479	479

Monthly River Releases (TAF/(cubic feet per second (cfs))

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Trinity (TAF)	N/A	193	105	50	44	53	52	23	18	78	18	17	18
Trinity (cfs)	N/A	3,245	1,710	848	723	857	870	373	300	1,276	300	300	300
Clear Creek (TAF)	N/A	15	18	13	7	6	7	10	12	16	18	17	18
Clear Creek (cfs)	N/A	247	295	215	113	100	120	157	210	260	293	300	286
Sacramento (TAF)	N/A	416	676	684	799	664	416	400	297	277	277	250	246
Sacramento (cfs)	N/A	7000	11000	11500	13000	10800	7000	6500	5000	4500	4500	4500	4000
American (TAF)	N/A	339	221	166	338	198	104	108	104	108	77	70	77
American (cfs)	N/A	5700	3600	2798	5500	3220	1750	1750	1750	1750	1250	1255	1250
Stanislaus (TAF)	N/A	45	74	107	12	12	12	39	12	12	12	57	55
Stanislaus (cfs)	N/A	752	1212	1800	200	200	200	635	200	200	200	1020	900
Feather (TAF)	N/A	428	283	113	430	430	428	227	104	108	108	97	108
Feather (cfs)	N/A	7200	4600	1900	7000	7000	7200	3700	1750	1750	1750	1750	1750

Trinity Diversions (TAF)

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Carr Powerplant (TAF)	N/A	1	68	81	87	87	88	45	17	3	10	5	24
Spring Creek Powerplant (TAF)	N/A	22	50	70	80	80	80	70	10	0	0	0	0

Delta Summary (TAF/cfs/%)

Facility/Location/Metric	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Tracy (TAF)	N/A	138	154	250	260	256	208	215	196	230	230	95	180
USBR Banks (TAF)	N/A	0	0	0	22	22	22	0	0	0	0	0	0
Contra Costa (TAF)	N/A	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 (TAF)	N/A	150	166	260	293	290	242	229	210	244	244	109	192
State Export (TAF)	N/A	65	37	32	378	360	314	134	194	155	155	117	96
Total Export (TAF)	N/A	215	203	292	671	650	556	363	404	399	399	226	288
COA Balance (TAF)	N/A	0	0	0	22	-5	-5	-5	-5	-5	-5	-5	-112
Vernalis (TAF)	N/A	139	146	138	45	40	46	98	74	75	75	127	141
Vernalis (cfs)	N/A	2341	2374	2321	737	655	772	1595	1242	1225	1225	2281	2299
Old/Middle River (cfs)	N/A	-2,323	-2,065	-3,325	-8,663	-8,437	-7,439	-4,419	-5,260	-5,037	-5,037	-2,698	-3,163
Computed Delta Outflow (cfs)	N/A	37906	16430	7699	8004	5450	6354	7548	4505	5628	8849	11400	11403
Excess Outflow (cfs)	N/A	17011	4506	0	0	0	3345	3546	0	1122	2847	0	0
% Export/Inflow	N/A	8%	14%	29%	46%	52%	50%	38%	54%	50%	43%	25%	29%
% Export/Inflow standard	N/A	35%	35%	35%	65%	65%	65%	65%	65%	65%	65%	45%	35%

Hydrology

Statistic	Trinity	Shasta	Folsom	New Melones
Water Year Inflow (TAF)	1,785	6,873	2,445	735
Year to Date + Forecasted (% of mean)	148	124	90	70

Footnotes:

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.

Attachment 3

Temperature Modeling (Pulse Flows)

Facility Temperature Outlook in Degrees Fahrenheit (°F)

Month	Shasta (°F)	Keswick (°F)	CCR (°F)	Igo (°F)	Trinity (°F)	Lewiston (°F)
April						
May	50.1	51.6	52.5	49.5	44.2	46.3
June	50.0	51.9	52.8	52.2	44.5	47.7
July	50.0	52.2	52.9	55.5	44.7	48.1
August	50.1	52.4	53.1	56.8	44.8	47.6
September	49.1	52.1	52.9	55.7	45.1	47.0
October	49.4	51.2	51.7	53.6	45.3	47.2
November	52.0	52.2	52.4	51.9	45.4	46.7

Footnotes:

Run Date: 4/22/2025

EOM September Storage: 2.90 million acre-feet (MAF)

Trinity Profile Date: 4/3/2025

Whiskeytown Profile Date: 4/2/2025

Shasta Profile Date: 4/22/2025

Projected Side Gates: First 9/2/2025, Full 10/16/2025

Shaded area (September, October, and November) denotes period of model limitations – see Fall Temperature Index

End of September Cold-Water-Pool less than 56°F: 787 thousand acre-feet (TAF)

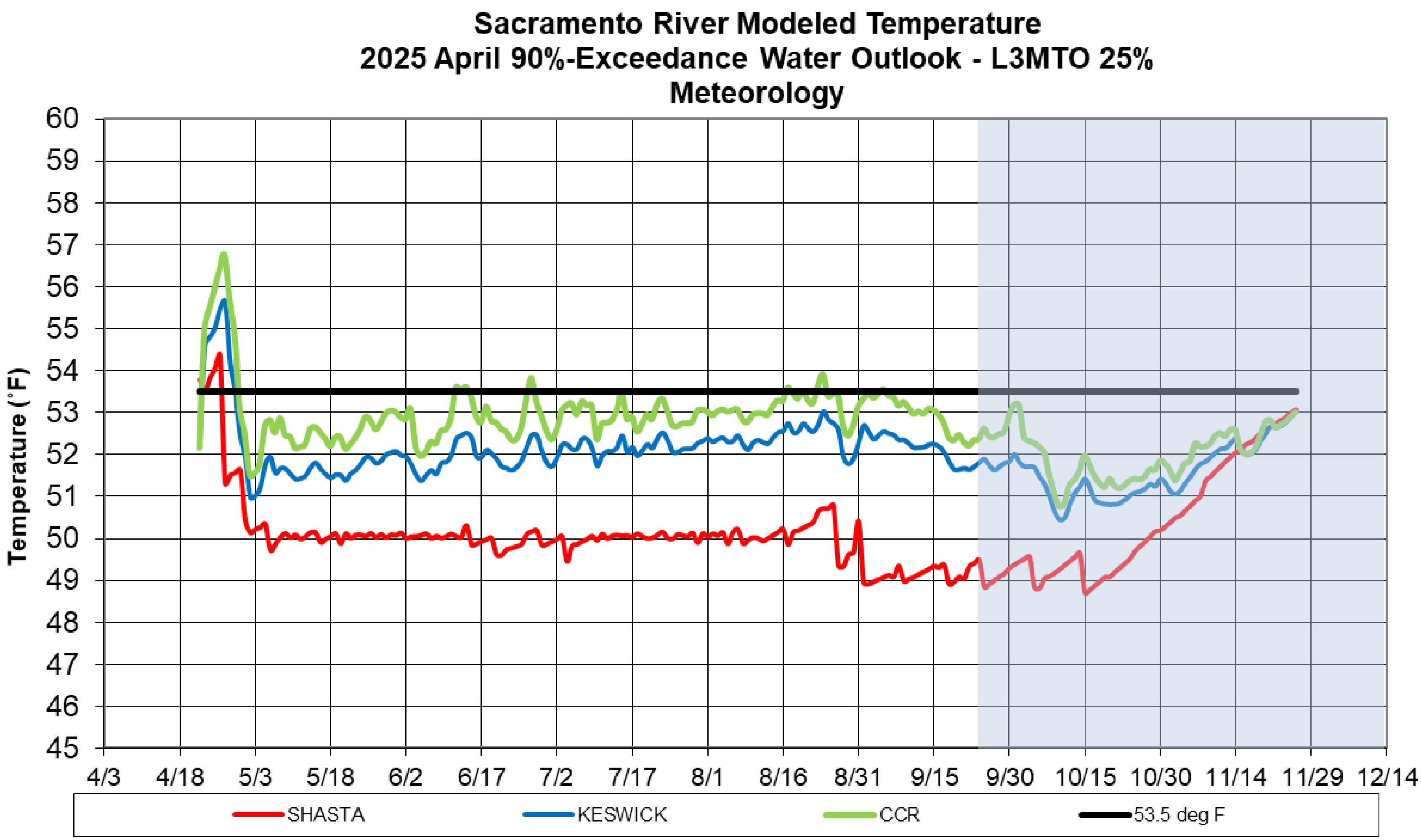

Figure: Sacramento River Modeled Temperature – April 2025 90%-Exceedance Water Outlook – L3MTO 25% Meteorology

This figure shows Sacramento River modeled temperature in degrees Fahrenheit at Shasta and Keswick Dams, and above Clear Creek from 4/22 to 11/26 in percent exceedances. It also shows the desired degree of 53.5 degrees Fahrenheit.

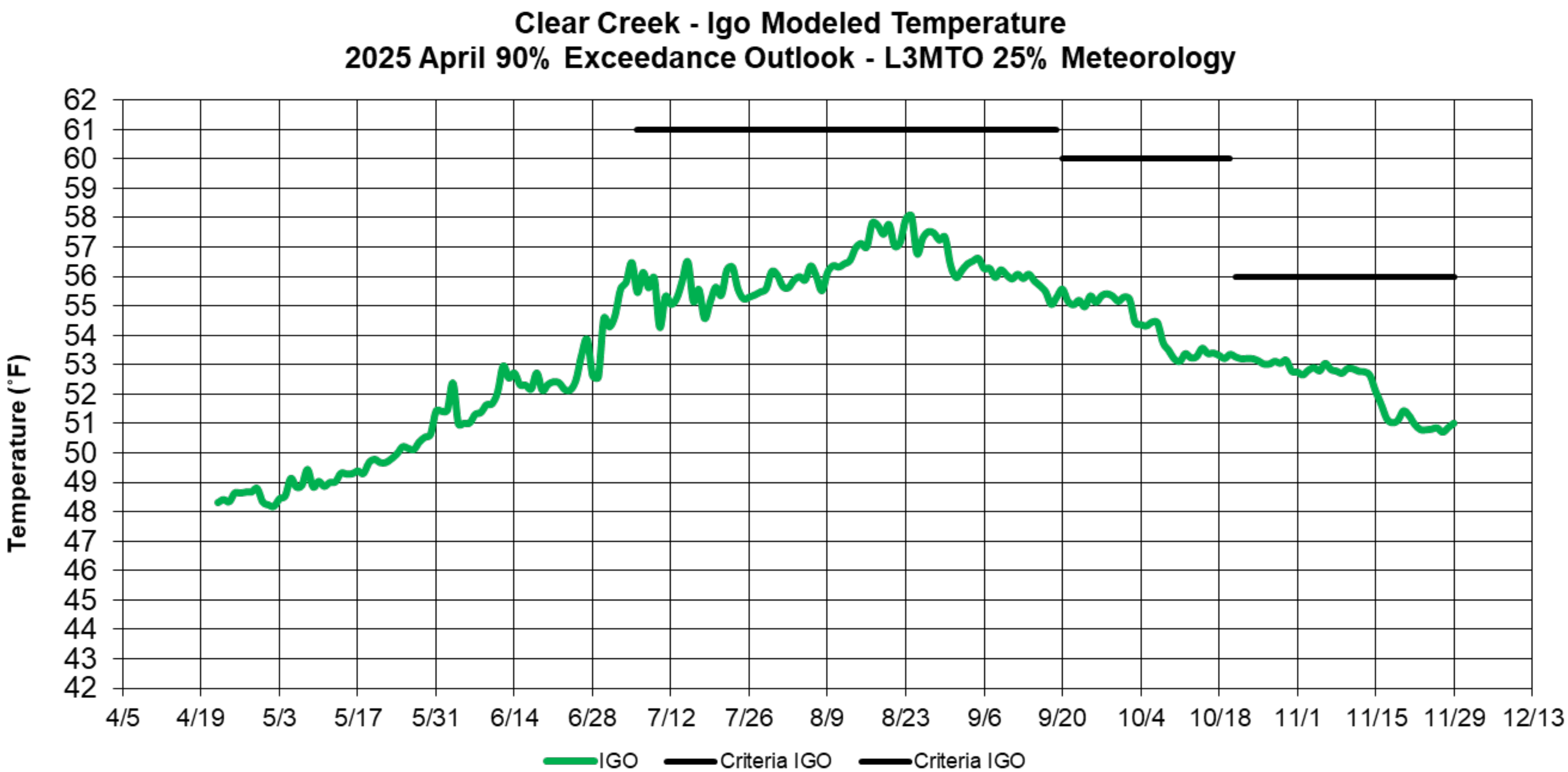

Figure: Clear Creek Igo Modeled Temperature – April 2025 90%-Exceedance Water Outlook – L3MTO 25% Meteorology

This figure shows Igo modeled temperature in degrees Fahrenheit at Clear Creek from 4/22 to 11/29 in percent exceedances.

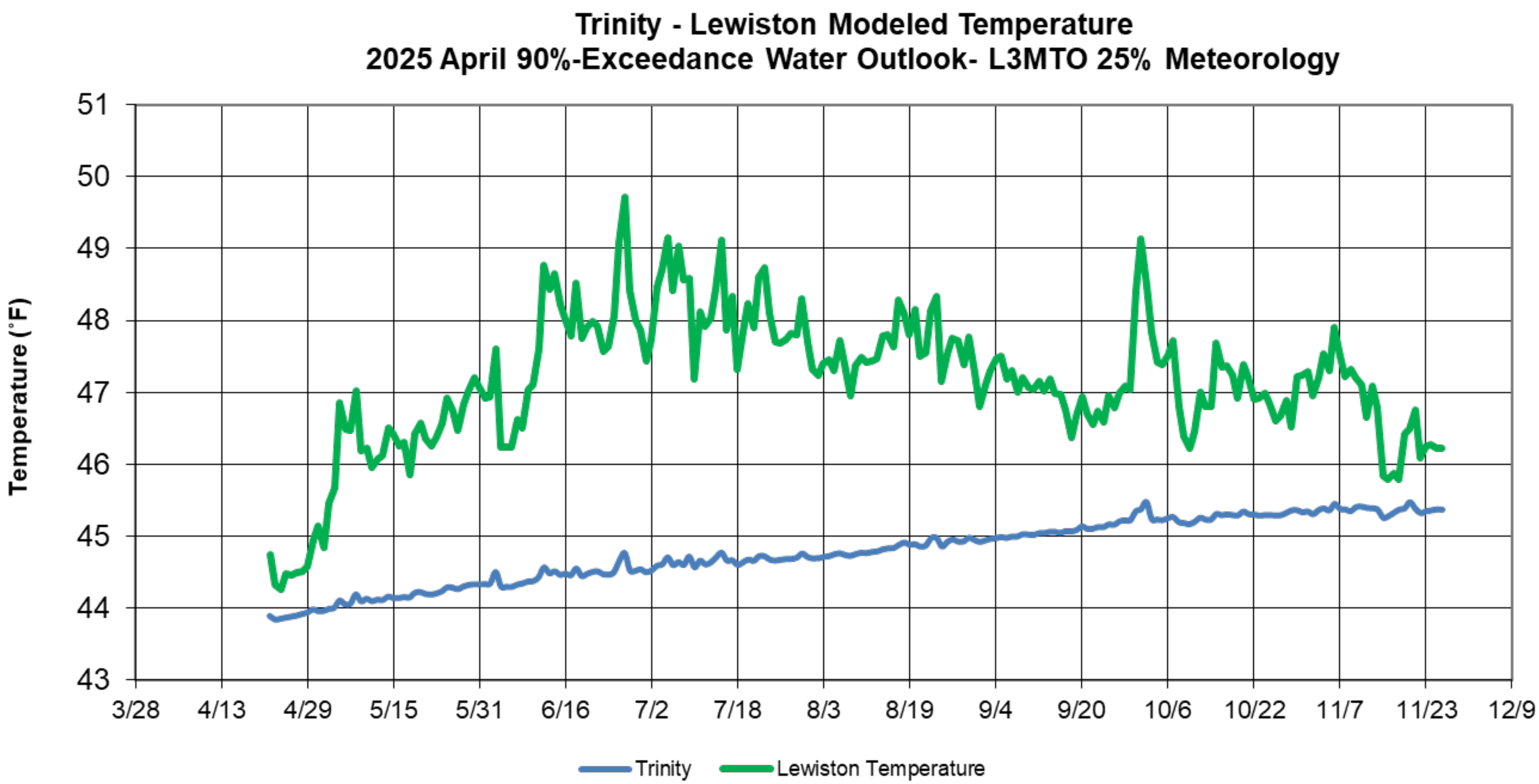

Figure: Trinity-Lewiston Modeled Temperature – April 2025 90%-Exceedance Water Outlook – L3MTO 25% Meteorology

This figure shows Trinity and Lewiston modeled temperature in degrees Fahrenheit from 4/22 to 11/26 in percent exceedances.

Attachment 4

Estimated CVP Operations 90% Exceedance (No Pulse Flows - Baseline)

Storages

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 (TAF)	2112	2203	2312	2342	2238	2098	1959	1899	1884	1842	1844	1876	1918
Trinity Elevation (feet)	N/A	2355	2362	2363	2357	2348	2338	2334	2333	2330	2330	2332	2335
Whiskeytown (TAF)	231	232	238	238	238	238	238	206	206	206	206	206	232
Whiskeytown Elevation (feet)	N/A	1207	1209	1209	1209	1209	1209	1199	1199	1199	1199	1199	1207
Shasta (TAF)	4067	4472	4449	4122	3607	3189	3021	2905	2864	2906	2945	3073	3342
Shasta Elevation (feet)	N/A	1064	1064	1052	1033	1016	1009	1003	1002	1004	1005	1011	1022
Folsom (TAF)	817	923	933	890	634	516	478	411	350	305	291	325	420
Folsom Elevation (feet)	N/A	461	462	458	432	419	414	405	395	388	386	391	406
New Melones (TAF)	1984	1948	1891	1756	1685	1627	1580	1525	1531	1539	1545	1503	1481
New Melones Elevation (feet)	N/A	1048	1042	1029	1022	1016	1012	1006	1006	1007	1008	1003	1001
Federal San Luis (TAF)	819	784	627	489	318	236	193	216	307	481	651	623	677
Federal San Luis Elevation (feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Storage (TAF)	10030	10561	10449	9838	8721	7904	7469	7161	7142	7279	7483	7605	8070

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

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Oroville (TAF)	3024	3262	3268	3186	2691	2211	1836	1637	1520	1476	1494	1595	1766
Oroville Elevation (feet)	N/A	882	883	877	841	802	767	746	733	728	730	741	760
State San Luis (TAF)	999	891	678	410	449	474	563	473	491	494	648	651	592
State San Luis Elevation (feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total San Luis (TAF)	1818	1675	1304	900	767	710	756	689	798	975	1299	1274	1268
Total San Luis Elevation (feet)	N/A	514	482	443	428	422	427	420	432	450	481	479	479

Monthly River Releases (TAF/(cubic feet per second (cfs))

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Trinity (TAF)	N/A	193	105	50	44	53	52	23	18	78	18	17	18
Trinity (cfs)	N/A	3,245	1,710	848	723	857	870	373	300	1,276	300	300	300
Clear Creek (TAF)	N/A	15	18	13	7	6	7	10	12	16	18	17	18
Clear Creek (cfs)	N/A	247	295	215	113	100	120	157	210	260	293	300	286
Sacramento (TAF)	N/A	416	553	684	799	664	416	400	297	277	277	250	246
Sacramento (cfs)	N/A	7000	9000	11500	13000	10800	7000	6500	5000	4500	4500	4500	4000
American (TAF)	N/A	339	221	166	338	198	104	108	104	108	77	70	77
American (cfs)	N/A	5700	3600	2798	5500	3220	1750	1750	1750	1750	1250	1255	1250
Stanislaus (TAF)	N/A	45	74	107	12	12	12	39	12	12	12	57	55
Stanislaus (cfs)	N/A	752	1212	1800	200	200	200	635	200	200	200	1020	900
Feather (TAF)	N/A	428	283	113	430	430	428	227	104	108	108	97	108
Feather (cfs)	N/A	7200	4600	1900	7000	7000	7200	3700	1750	1750	1750	1750	1750

Trinity Diversions (TAF)

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Carr Powerplant (TAF)	N/A	1	68	81	87	87	88	45	17	3	10	5	24
Spring Creek Powerplant (TAF)	N/A	22	50	70	80	80	80	70	10	0	0	0	0

Delta Summary (TAF/cfs/%)

Facility/Location/Metric	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Tracy (TAF)	N/A	138	154	250	260	256	208	215	196	230	230	95	180
USBR Banks (TAF)	N/A	0	0	0	22	22	22	0	0	0	0	0	0
Contra Costa (TAF)	N/A	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 (TAF)	N/A	150	166	260	293	290	242	229	210	244	244	109	192
State Export (TAF)	N/A	65	37	32	378	360	314	134	194	155	155	117	96
Total Export (TAF)	N/A	215	203	292	671	650	556	363	404	399	399	226	288
COA Balance (TAF)	N/A	0	0	0	22	-5	-5	-5	-5	-5	-5	-5	-112
Vernalis (TAF)	N/A	139	146	138	45	40	46	98	74	75	75	127	141
Vernalis (cfs)	N/A	2341	2374	2321	737	655	772	1595	1242	1225	1225	2281	2299
Old/Middle River (cfs)	N/A	-2,323	-2,065	-3,325	-8,663	-8,437	-7,439	-4,419	-5,260	-5,037	-5,037	-2,698	-3,163
Computed Delta Outflow (cfs)	N/A	37906	14429	7699	8004	5450	6354	7548	4505	5628	8849	11400	11403
Excess Outflow (cfs)	N/A	17011	2505	0	0	0	3345	3546	0	1122	2847	0	0
% Export/Inflow	N/A	8%	16%	29%	46%	52%	50%	38%	54%	50%	43%	25%	29%
% Export/Inflow standard	N/A	35%	35%	35%	65%	65%	65%	65%	65%	65%	65%	45%	35%

Hydrology

Statistic	Trinity	Shasta	Folsom	New Melones
Water Year Inflow (TAF)	1,785	6,873	2,445	735
Year to Date + Forecasted (% of mean)	148	124	90	70

Footnotes:

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

Attachment 5

Temperature Modeling (No Pulse Flows - Baseline)

Facility Temperature Outlook in Degrees Fahrenheit (°F)

Month	Shasta (°F)	Keswick (°F)	CCR (°F)	Igo (°F)	Trinity (°F)	Lewiston (°F)
April						
May	50.0	51.9	52.9	49.5	44.2	46.3
June	50.0	51.9	52.8	52.2	44.5	47.7
July	50.0	52.1	52.9	55.5	44.7	48.1
August	50.1	52.5	53.2	56.8	44.8	47.6
September	49.1	52.0	52.8	55.7	45.1	47.0
October	49.2	51.0	51.5	53.6	45.3	47.2
November	51.0	51.3	51.6	51.9	45.4	46.7

Footnotes:

Run Date: 4/25/2025

EOM September Storage: 3.02 million acre-feet (MAF)

Trinity Profile Date: 4/3/2025

Whiskeytown Profile Date: 4/2/2025

Shasta Profile Date: 4/22/2025

Projected Side Gates: First 9/4/2025, Full 10/23/2025

Shaded area (September, October, and November) denotes period of model limitations – see Fall Temperature Index

End of September Cold-Water-Pool less than 56°F: 893 thousand acre-feet (TAF)

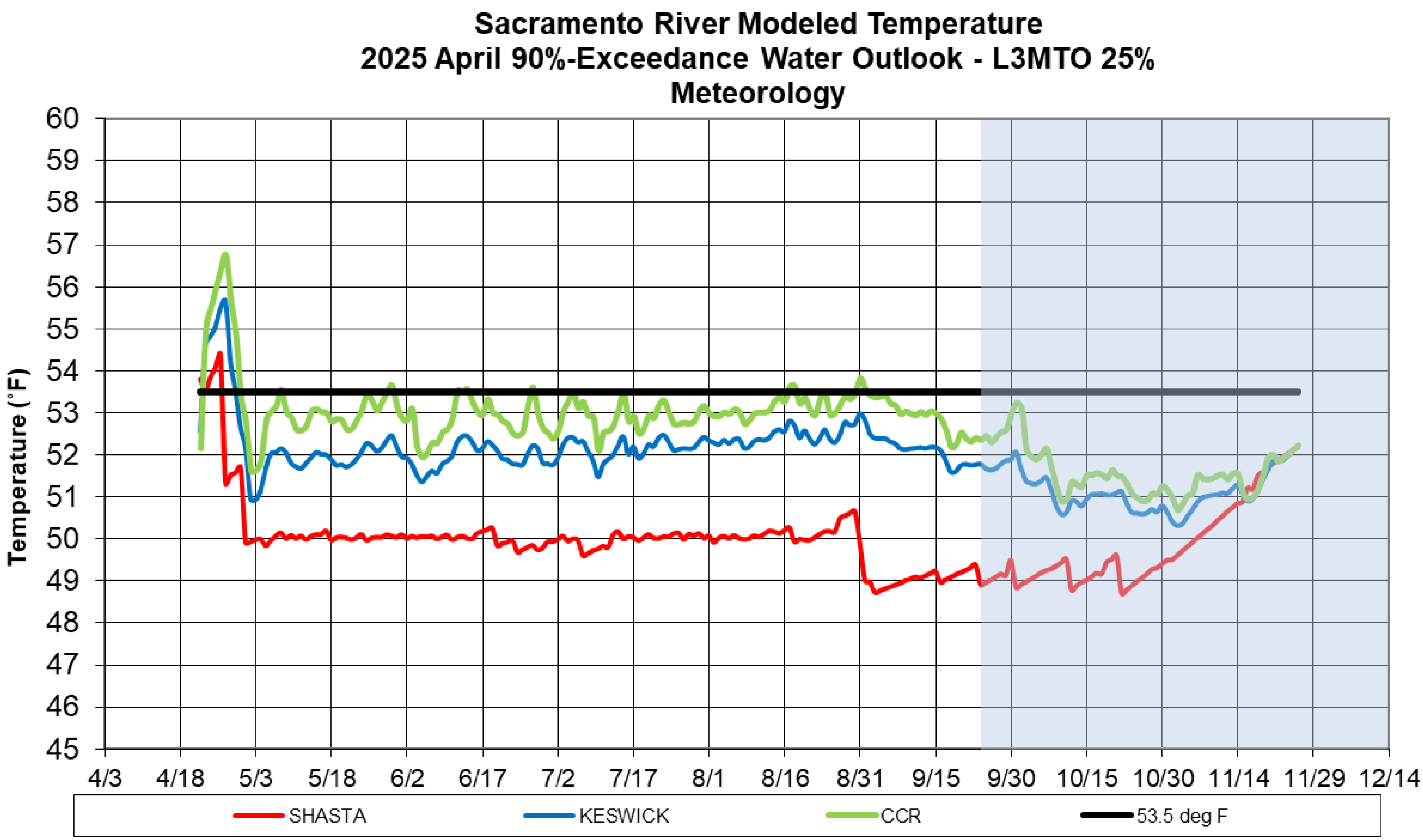

Figure: Sacramento River Modeled Temperature – April 2025 90%-Exceedance Water Outlook – L3MTO 25% Meteorology

This figure shows Sacramento River modeled temperature in degrees Fahrenheit at Shasta and Keswick Dams, and above Clear Creek from 4/22/2025 to 11/26/2025 in percent exceedances. It also shows the desired degree of 53.5 degrees Fahrenheit.

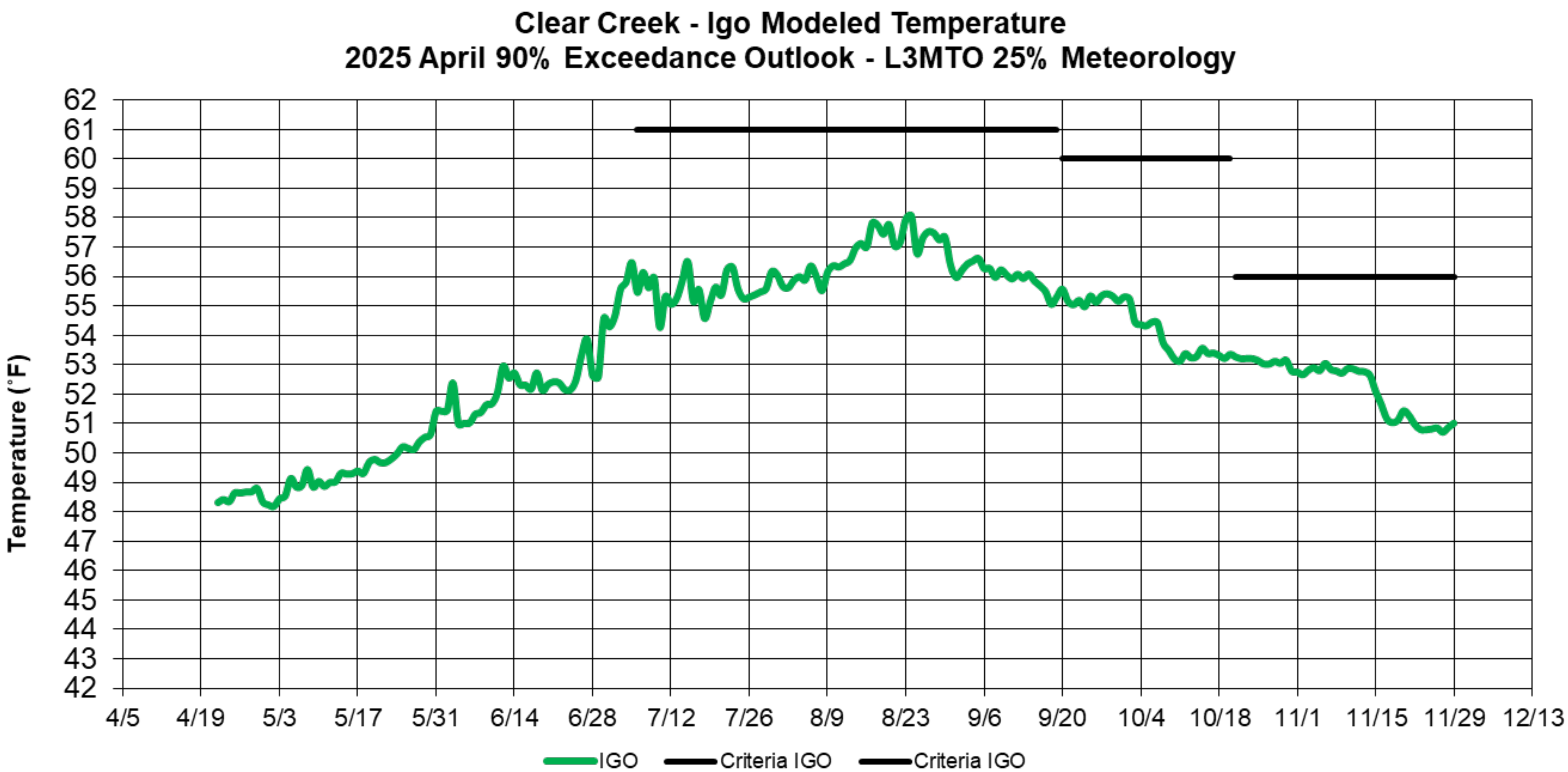

Figure: Clear Creek Igo Modeled Temperature – April 2025 90%-Exceedance Water Outlook – L3MTO 25% Meteorology

This figure shows Igo modeled temperature in degrees Fahrenheit at Clear Creek from 4/22/2025 to 11/29/2025 in percent exceedances.

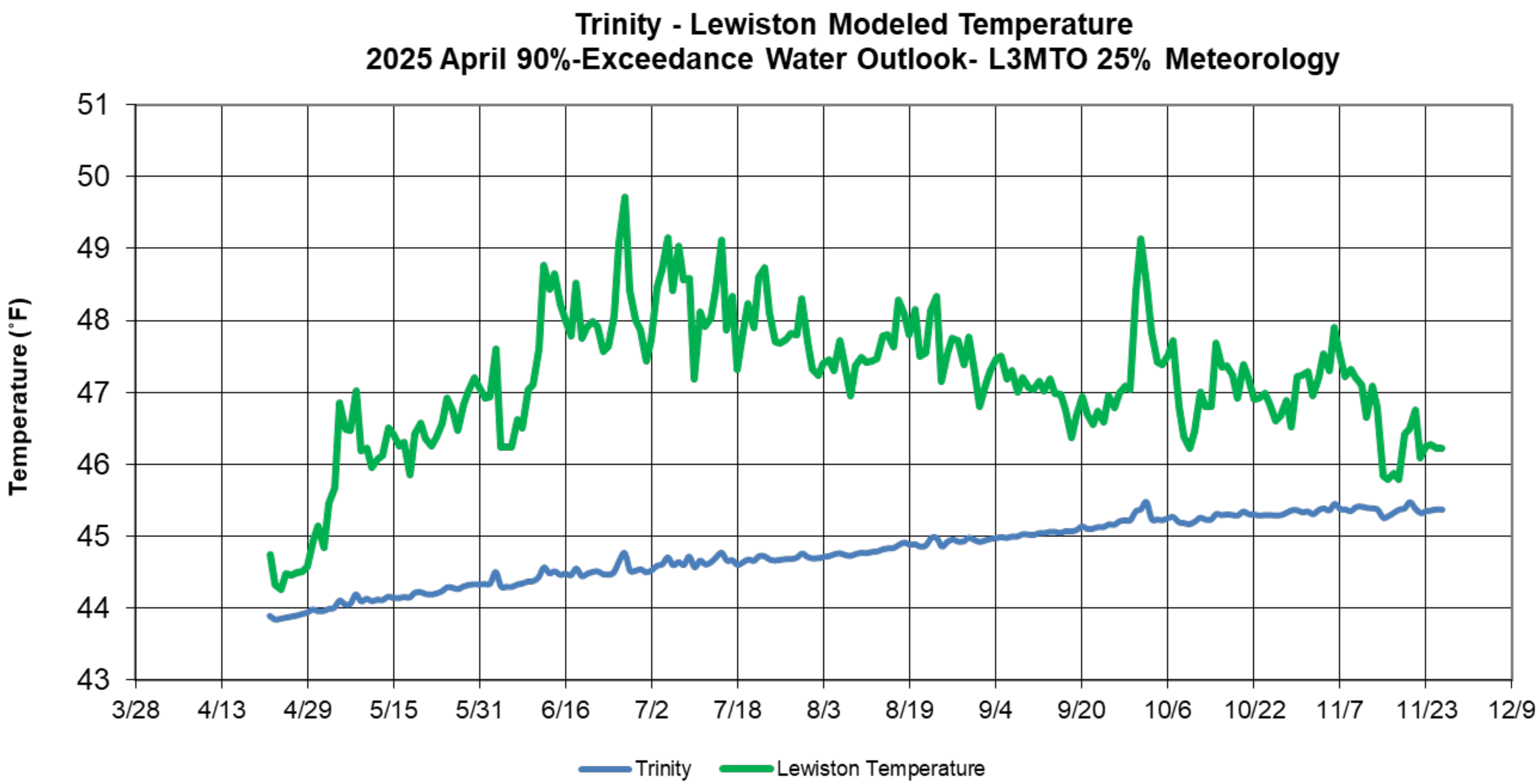

Figure: Trinity-Lewiston Modeled Temperature – April 2025 90%-Exceedance Water Outlook – L3MTO 25% Meteorology

This figure shows Trinity and Lewiston modeled temperature in degrees Fahrenheit from 4/22/2025 to 11/26/2025 in percent exceedances.

Attachment 6

Biological Modeling

Spatially-explicit daily average Sacramento River water temperatures forecasts from the HEC-5Q model results are used as inputs to generate temperature-dependent egg mortality estimates. For this period, actual temperatures until April 23, 2025, and modeled temperatures after that, on the Sacramento River at Keswick Dam, above Highway 44, above Clear Creek, and Balls Ferry bridge, and interpolated temperatures at other locations are used to estimate temperatures at river miles where simulated winter-run redds were located.

Temperature-dependent egg mortality estimates are calculated by modeling a redd's lifetime based on the days required to cross a known cumulative degree-day threshold and estimating mortality as an increasing function of temperature past a temperature threshold. Martin et al (2017) was used to estimate stage-independent mortality whereby a single temperature threshold is used from spawning and incubation through emergence for normal operations (Figure 1) and Pulse Flow operations (Figure 2). Anderson et al. (2021) was used to estimate stage-dependent mortality targeting different temperatures before, during, and after the most sensitive stages during egg incubation for normal operations (Figure 3) and Pulse Flow operations (Figure 4). The methods are applied to a set of simulated redds representative of redd construction timing and location from 2013-2022 and the results summarized on a population level for comparison. Further information about the model's assumptions are documented in Table 1 below.

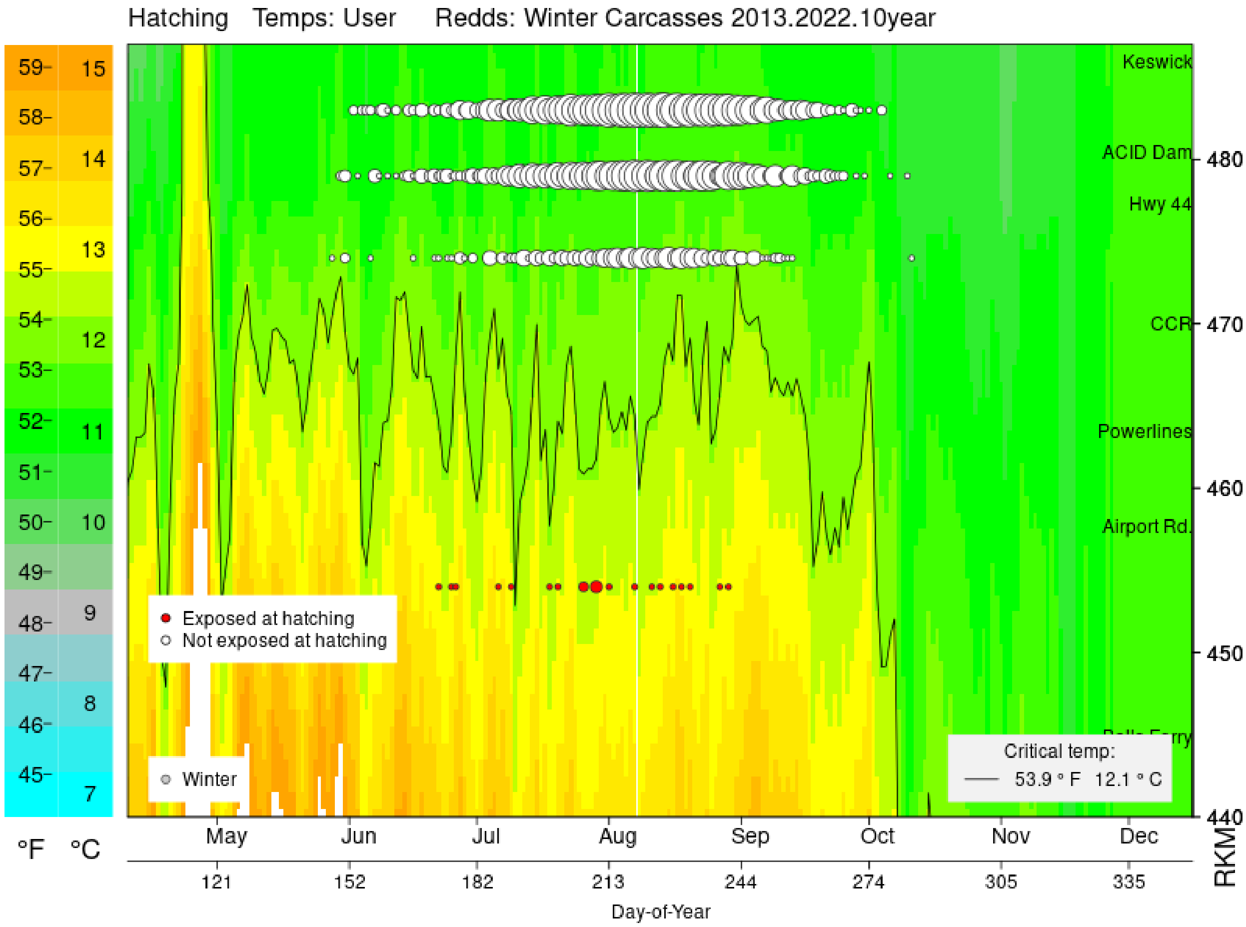

Figure 1. April 23, 2025 forecast temperature landscape (i.e. heatmap) for **no pulse** operations with modeled temperatures between April 2025 and December 2025, using 2013-2022 redd locations and timing (Stage-**independent** mortality). It shows redds exposed at hatching and not exposed at hatching with red and white dots.

Footnotes:

7397 Redds
Exposure to 12.14 degrees = 0.3% Pre Hatch, 0.5% Pre Emergence
Emergence Day = 272.9 Mean Day, 336 Last Day
99.8% Total Survival

Figure 1 Summary Table.

Factor	Survival %	Mortality %
Temperature Dependent Mortality	99.8	0.2
Spawner Density	100	0
Background	100	0
Dewater	100	0

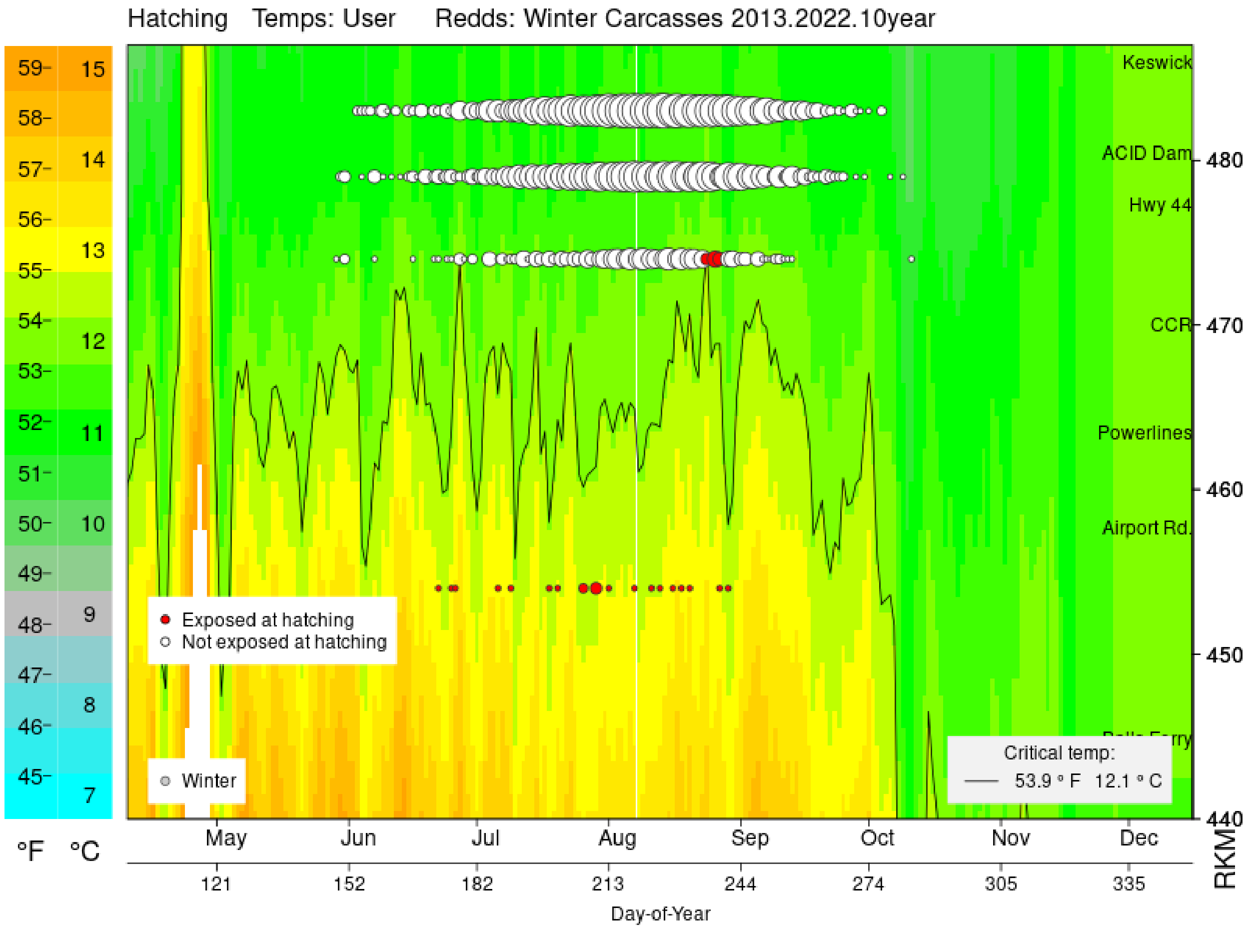

Figure 2. April 23, 2025 temperature landscape (i.e. heatmap) for **Pulse Flow** operations with modeled temperatures between April 2025 and December 2025, using 2013-2022 redd locations and timing (Stage- **independent** mortality). It shows redds exposed at hatching and not exposed at hatching with red and white dots.

Footnotes:

7397 Redds
Exposure to 12.14 degrees = 0.5% Pre Hatch, 5.2% Pre Emergence
Emergence Day = 272.8 Mean Day, 335 Last Day
99.8% Total Survival

Figure 2 Summary Table.

Factor	Survival %	Mortality %
Temperature Dependent Mortality	99.8	0.2
Spawner Density	100	0
Background	100	0
Dewater	100	0

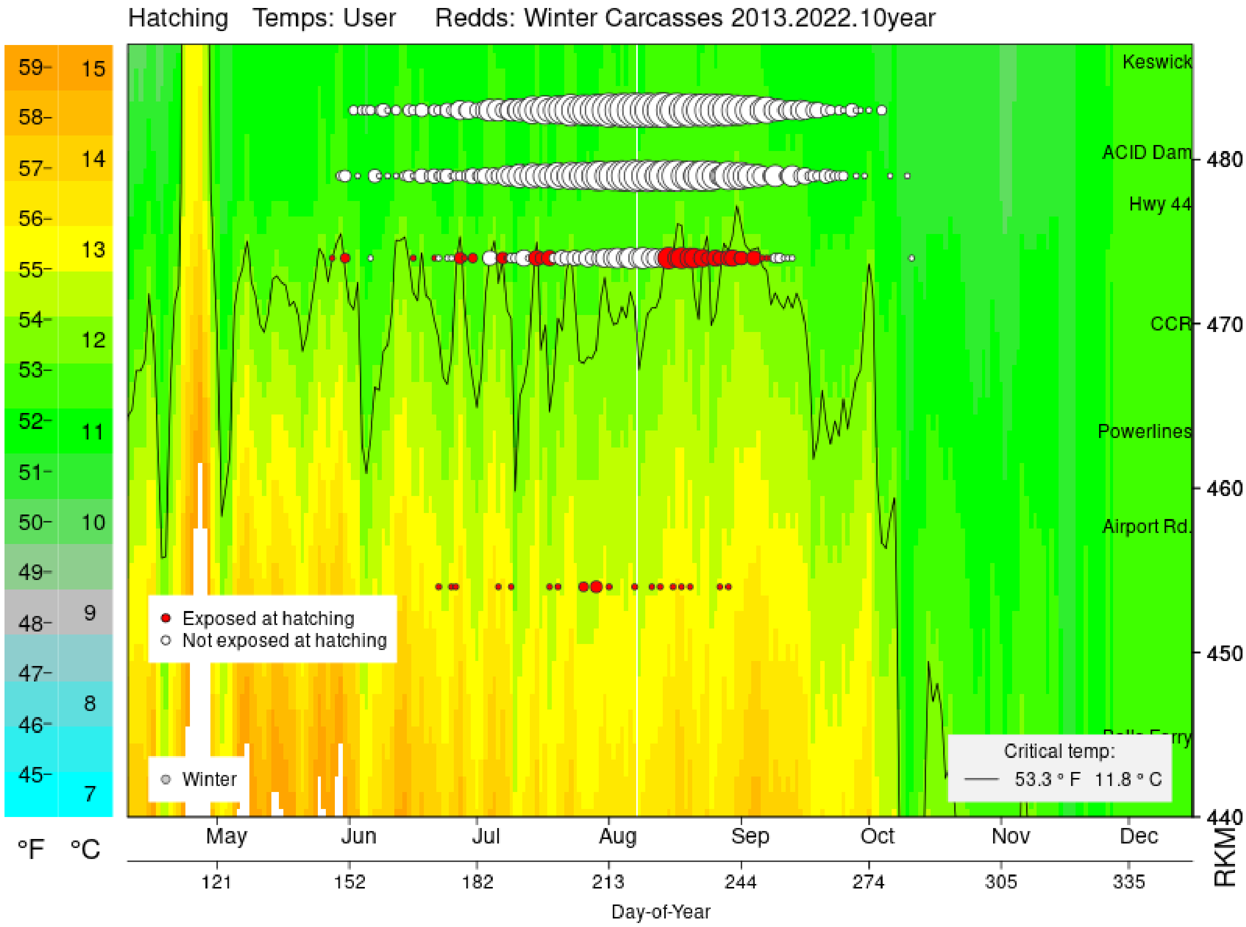

Figure 3. April 23, 2025 temperature landscape (i.e. heatmap) for **no pulse** operations with modeled temperatures between April 2025 and December 2025, using 2013-2022 redd locations and timing (Stage-**dependent** mortality). It shows redds exposed at hatching and not exposed at hatching with red and white dots.

Footnotes:

7397 Redds
Exposure to 11.82 degrees = 2.5% Pre Hatch, 5.4% Pre Emergence
Emergence Day = 272.9 Mean Day, 336 Last Day
99.6% Total Survival

Figure 3 Summary Table.

Factor	Survival %	Mortality %
Temperature Dependent Mortality	99.6	0.4
Spawner Density	100	0
Background	100	0
Dewater	100	0

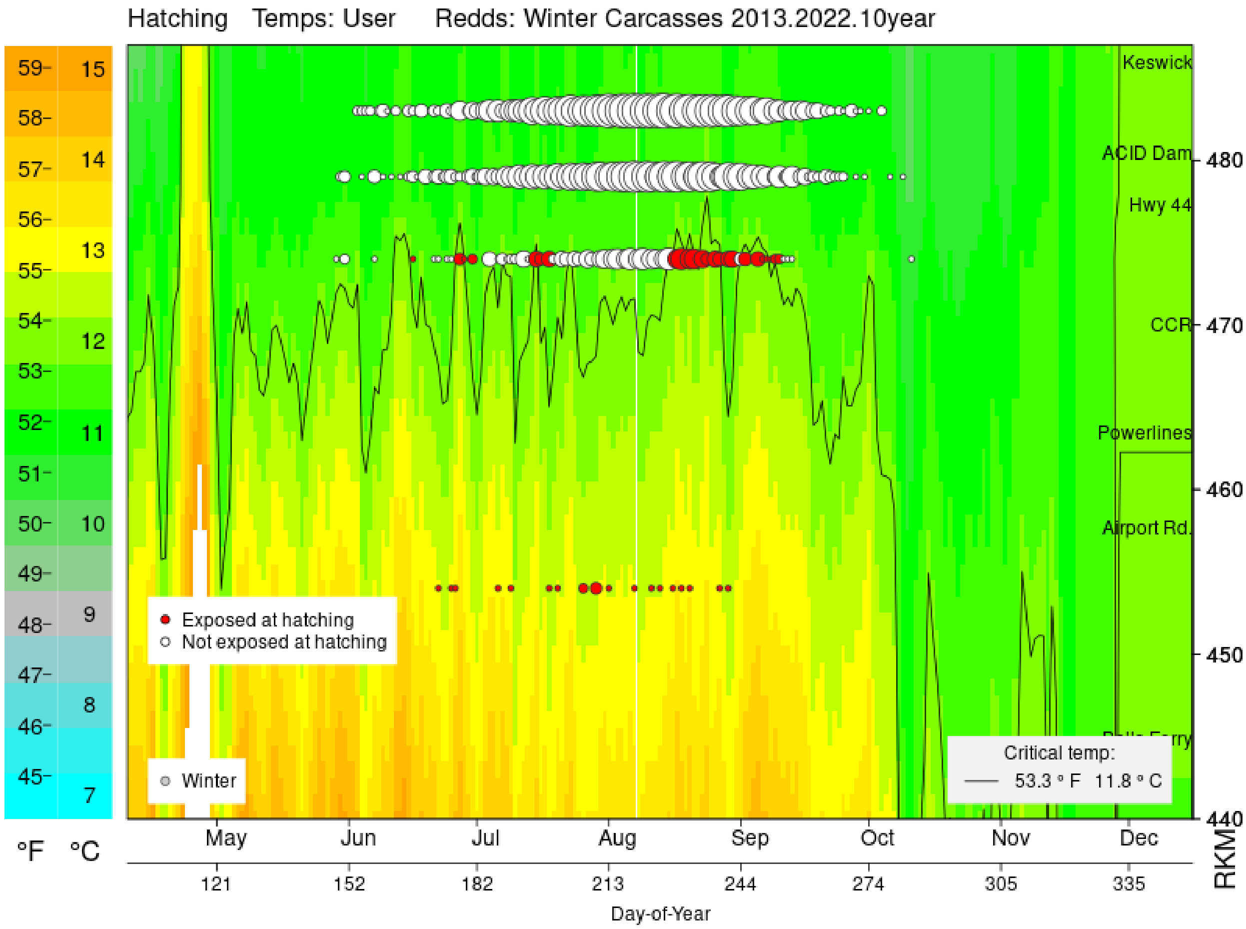

Figure 4. April 23, 2025 temperature landscape (i.e. heatmap) for **Pulse Flow** operations with modeled temperatures between April 2025 and December 2025, using 2013-2022 redd locations and timing (Stage-**dependent** mortality). It shows redds exposed at hatching and not exposed at hatching with red and white dots.

Footnotes:

7397 Redds
Exposure to 11.82 degrees = 2.1% Pre Hatch, 5.4% Pre Emergence
Emergence Day = 272.8 Mean Day, 335 Last Day
99.6% Total Survival

Figure 4 Summary Table.

Factor	Survival %	Mortality %
Temperature Dependent Mortality	99.6	0.4
Spawner Density	100	0
Background	100	0
Dewater	100	0

Table 1. Biological modeling parameter information.

Parameter	April 23, 2025 Scenarios
Meteorology source	L3MTO Meteorology 25%
Time period	1/1/2025-4/22/20225: Observed temperature 4/23/2025-11/29/2025: Simulated
Reservoir Model used	HEC-5Q
River Model used	HEC-5Q
Shasta Profile date	4/22/2025
TCD Gate operations	HEC-5Q
Sacramento water temperatures used	HEC-5Q output at Keswick, Highway 44, Clear Creek, and Balls Ferry
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	Carcass Surveys 2013-2022
TDM redd space distribution	Carcass Surveys 2013-2022
TDM Tcrit (50th percentile)	Stage-independent mortality: 12.14°C Stage-dependent mortality: 11.82°C
TDM bT (50th percentile)	Stage-independent mortality: 0.026$°C^{-1}d^{-1}$ Stage-dependent mortality: 0.436$°C^{-1}d^{-1}$
Critical Days	Stage-independent mortality: All Stage-dependent mortality: 4 days
TDM estimates	See Figures 1, 2, 3 and 4

Footnotes:

ATUs = accumulated thermal units
HEC-5Q = water quality modeling software
L3MTO = Local Three-Month Temperature Outlooks
SacPAS = Sacramento Prediction and Assessment of Salmon
TCD = Temperature Control Device
TDM = Temperature Dependent Mortality
$C^{-1}d^{-1}$ = per degree Celsius days