DRAFT
2024 SACRAMENTO RIVER TEMPERATURE MANAGEMENT PLAN

INTRODUCTION

Conditions in the Central Valley this winter season have been cold and wet, and consequently, Shasta temperature management will be similar to last year and much improved over the previous few drought years. The Northern Sierra Precipitation 8-Station Index indicates that this year's hydrologic conditions are very close to average for the last 30 years. In mid-April, Shasta Reservoir's cold water pool used to protect winter-run Chinook salmon was projected to be comparable to other average and wetter years such as 2016 and 2019. This Water Year 2024 Sacramento River Temperature Management Plan (Plan) reflects coordination starting in February 2024 to manage operations of Shasta Reservoir for water temperatures on the Sacramento River using conservative assumptions in modeling, taking advantage of opportunities to increase the cold water pool, and managing to real-time conditions. The Plan describes how the U.S. Bureau of Reclamation (Reclamation) plans to operate Shasta Reservoir and the Temperature Control Device (TCD) on Shasta Dam consistent with the 2020 Record of Decision on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project (LTO) in compliance with:

- RPM 1.a. of the 2019 National Marine Fisheries Service (NMFS) Biological Opinion to, in coordination with the Sacramento River Temperature Task Group (SRTTG), consider technical assistance from NMFS regarding the development of an annual temperature management plan and to submit a final temperature management plan to NMFS by May 20 of each year;
- Order 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; and
- Order 90-5 to provide an operation plan to the State Water Resources Control Board (SWRCB), Chief of the Division of Water Rights, on Reclamation's strategy to meet the temperature requirement at a location upstream of the Red Bluff Diversion Dam.
- The Interim Operations Plan (IOP), ordered by the US District Court on April 2, 2024, which identified priorities and planning efforts for Shasta cold water pool management to meet operational priorities and species needs. This IOP included establishing a six-agency Shasta Planning Group (SPG) to work iteratively with the technical groups (e.g., SRTTG and USST) to solicit operational guidance and risk assessments and provide policy guidance as necessary.

The temperature management strategy provided by the Plan is based on technical review and recommendations received from Sacramento River Temperature Task Group (SRTTG). 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 SRTTG throughout Plan implementation.

Based on the March 90% forecast, Reclamation identified that Water Year 2024 was likely to be a Tier 1 year. In a Tier 1 year, there is more than 2.8 MAF of total storage in Shasta Reservoir at the beginning of

May, and Reclamation can meet 53.5°F at Sacramento River at Clear Creek (CCR). Conditions on April 1 along with modeling based on measured reservoir profiles confirm that WY2024 is a Tier 1 temperature management season.

MODELING ASSUMPTIONS, LIMITATIONS, AND OTHER UNCERTAINTIES

A seasonal water temperature forecast describes future expected downstream water temperature. This forecast, or simulation of expected water temperature performance is based on the targets specified in the TMP. Future water temperature is forecasted using computational tools, 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 in April 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 meteorology) and inherent model error or bias. To better understand the inherent model error or bias, a hindcast evaluation is typically performed. A hindcast, rather than looking forward to forecast, simply uses the actual input/forcing data after it's observed (e.g., hydrology, operations, and meteorology) to determine how well the model reproduced a condition such as actual downstream water temperatures. Reclamation has proposed the use of 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 SRTTG, 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 (e.g., 90% exceedance). In past years, SRTTG has recommended the use of a conservative approach that uses the 25% exceedance L3MTO forecast. Therefore, Reclamation's April model runs utilized historical 25% exceedance meteorology.

RELEASE OUTLOOK

The Shasta Reservoir release strategy included in this plan and temperature modeling is based on the CVP's April 90% exceedence 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 2024 Sacramento River Spring Pulse Operations Plan (Attachment 6) 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. Significant uncertainties exist within the forecast that will require intensive real-time operations management throughout the summer to achieve the various goals and targets throughout the system. Reclamation commits to reporting out on the status of this release outlook, temperature management and overall system operations at the monthly SRTTG meetings. Table 1 describes the monthly forecasted operations for releases and storage targets which were taken from the April 90% CVP forecast of operation (Attachment 1).

Table 1. Monthly forecasted operations for Shasta and Keswick reservoir releases and storage estimates from April 90% exceedance forecast.

Operations Information/Month	April	May	June	July	August	September
Shasta Releases (TAF)	428	615	669	745	575	406
Keswick Releases (cfs)	7,200	10,000	11,250	13,250	10,500	8,000
Keswick Releases (TAF)	428	615	669	815	645	476
Spring Creek Power Plant (TAF)	0	0	0	70	70	70
Shasta End-of-Month Storage (TAF)	4,425	4,195	3,779	3,225	2,800	2,547

KEY AREAS OF UNCERTAINTY

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, forecasted inflows, facility maintenance schedules, 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.

The release forecast and temperature modeling used for this temperature management plan is based on a number of assumptions that each come with a level of uncertainty. A brief list of these uncertainty areas is listed below:

- Inflow hydrology
- Meteorology
- Reservoir stratification
- Accretions and depletions
- Public health and safety demands
- Infrastructure limitations
- Low River flow challenges
- Trinity River imports and Trinity River temperature management
- Low flow river and reservoir thermodynamics
- Delta water quality
- Spring pulse action timing and magnitude

TEMPERATURE STRATEGY

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. Reclamation completed HEC-5Q modeling on April 22, 2024 based on the April 90% exceedance forecast. The temperature modeling is presented here and is reflected in resulting biological and water supply performance metrics as shown in Table 2, Table 4, and Attachment 2. Further refinement to the temperature management strategy will occur through coordination with SRTTG and SPG as the temperature management season progresses.

Table 2. 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). HEC-5Q does not perform well after mid-September. Water temperatures may be warmer than these targets and HEC-5Q results.

Month	Shasta	Keswick	CCR
May	50.0	51.6	52.4
June	50.0	51.8	52.8
July	50.0	52.1	52.9
August	49.0	52.0	53.1
September	51.5	53.6	54.3
October	54.5	55.3	55.7
November	56.2	56.3	56.4

Trinity River and Clear Creek modeled temperatures are included in Attachment 2.

For comparative purposes, Reclamation also completed a forecast of operations that did not include spring pulse flow actions (Attachment 3). Modeling results for this forecast can be found in Table 3, Table 4, and Attachment 4.

Table 3. Estimated average monthly water temperature in degrees Fahrenheit at Shasta, Keswick and CCR based on model run of normal operations without pulse flow action (i.e., baseline scenario described in pulse flow operations plan). HEC-5Q does not perform well after mid-September. Water temperatures may be warmer than these targets and HEC-5Q results.

Month	Shasta	Keswick	CCR
May	50.0	51.9	53.0
June	50.0	51.9	52.8
July	50.0	52.1	52.8
August	48.9	51.9	53.0
September	50.8	53.1	53.8
October	53.5	54.4	54.9
November	55.4	55.5	55.6

In addition to the above temperature management strategy of meeting daily average of 53.5 degrees F at CCR, HEC-5Q modeling will be performed and included in the Final plan to determine the location upstream of the Red Bluff Diversion Dam where a daily average water temperature of 56 degrees F could reasonably be met. The strategy of meeting 53.5 degrees F at CCR will likely result in average daily temperatures at or near 56 degrees F at BSF. Reclamation does not propose to operate the TCD explicitly to meet 56 degrees F at BSF under conditions that may require changes to TCD operations that could risk cold water pool resources for use later in the temperature management season. This would cause an unreasonable risk to other goals and objectives.

Table 4. Fish and water performance metrics from biological modeling (Attachment 5)

Metric	No Pulse Flow Scenario	With Pulse Flow Scenario
Stage-independent TDM	3.4%	9.9%
Stage-dependent TDM	0.4%	0.8%
End of Sept CWP Storage less than 56 deg F (TAF)	502 TAF	381 TAF
First Side Gate Use	July 31	July 31
Full Side Gate	August 26	August 22
End of September Storage (MAF)	2.69 MAF	2.55 MAF

Water temperature forecasts indicate favorable temperatures for winter-run chinook salmon egg incubation with TDM estimates ranging from 0 to 10%. 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.

Reclamation will continue to coordinate through SRTTG to review these and other model results and may update these TDM estimates based on those discussions.

Attachment 1

Estimated CVP Operations 90% Exceedance

Storages

Federal End of the Month Storage/Elevation (TAF/Feet)

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Trinity	**1958**	**1987**	**2031**	**2014**	**1908**	**1786**	**1656**	**1634**	**1630**	**1651**	**1662**	**1699**	**1765**
Elevation		2340	2343	2342	2335	2326	2316	2314	2314	2315	2316	2319	2324
Whiskeytown	**219**	**238**	**238**	**238**	**238**	**238**	**238**	**206**	**206**	**206**	**206**	**206**	**206**
Elevation		1209	1209	1209	1209	1209	1209	1199	1199	1199	1199	1199	1199
Shasta	**4194**	**4425**	**4195**	**3779**	**3225**	**2800**	**2547**	**2452**	**2462**	**2534**	**2605**	**2760**	**3030**
Elevation		1063	1055	1040	1017	999	987	982	982	986	989	997	1009
Folsom	**708**	**830**	**944**	**901**	**653**	**467**	**427**	**375**	**329**	**300**	**286**	**313**	**409**
Elevation		452	463	459	434	412	407	399	392	387	385	389	404
New Melones	**2008**	**1948**	**1933**	**1949**	**1887**	**1828**	**1781**	**1717**	**1724**	**1731**	**1736**	**1738**	**1758**
Elevation		1047	1046	1048	1042	1036	1032	1026	1026	1027	1027	1028	1030
Federal San Luis	**783**	**667**	**525**	**358**	**248**	**204**	**200**	**215**	**285**	**461**	**633**	**594**	**551**
Elevation													
Total	9870	10095	9867	9239	8160	7323	6849	6599	6634	6883	7128	7309	7718

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

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Oroville	**3109**	**3416**	**3492**	**3373**	**2807**	**2290**	**1856**	**1699**	**1583**	**1539**	**1576**	**1664**	**1835**
Elevation		892	897	890	850	809	769	753	740	735	739	749	767
State San Luis	**522**	**444**	**311**	**170**	**365**	**540**	**799**	**782**	**830**	**864**	**893**	**901**	**971**
Elevation													N/A
Total San Luis (TAF)	**1305**	**1111**	**836**	**528**	**614**	**743**	**1000**	**996**	**1114**	**1325**	**1526**	**1495**	**1523**
Elevation		464	436	401	411	426	453	452	464	484	502	499	501

Monthly River Releases (TAF/cfs)

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Trinity		161	215	107	45	53	52	23	18	18	18	17	18
cfs		**2,700**	**3,500**	**1,800**	**735**	**857**	**870**	**373**	**300**	**300**	**300**	**300**	**300**
Clear Creek		12	18	14	9	9	9	12	12	12	12	11	22
cfs		**200**	**291**	**242**	**150**	**150**	**150**	**200**	**200**	**200**	**200**	**200**	**363**
Sacramento		428	615	669	815	645	476	338	238	246	246	222	246
cfs		**7200**	**10000**	**11250**	**13250**	**10500**	**8000**	**5500**	**4000**	**4000**	**4000**	**4000**	**4000**
American		238	184	191	338	272	119	92	89	92	77	76	77
cfs		**4000**	**3000**	**3218**	**5500**	**4432**	**2001**	**1502**	**1500**	**1500**	**1250**	**1370**	**1250**
Stanislaus		91	76	22	15	15	15	48	12	12	14	13	12
cfs		**1537**	**1242**	**363**	**250**	**250**	**250**	**774**	**200**	**200**	**226**	**229**	**200**
Feather		143	172	140	495	464	488	184	104	108	77	111	108
cfs		**2400**	**2800**	**2350**	**8050**	**7550**	**8200**	**3000**	**1750**	**1750**	**1250**	**2000**	**1750**

Trinity Diversions (TAF)

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Carr PP		0	4	12	80	81	80	8	6	1	1	1	1
Spring Crk. PP		**0**	**0**	**0**	**70**	**70**	**70**	**30**	**0**	**0**	**0**	**0**	**0**

Delta Summary (TAF)

Facility/Location/Metric	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Tracy		57	138	194	262	250	202	152	154	230	220	44	55
USBR Banks		0	0	0	15	15	15	0	0	0	0	0	0
Contra Costa		12.0	12.0	10.0	11.0	12.0	13.0	14.0	14.0	14.0	13.0	14.0	12.0
Total USBR		69	150	204	288	277	230	166	168	244	233	58	67
State Export		62	37	49	414	411	395	151	221	160	160	111	183
Total Export		132	187	253	702	688	625	317	389	404	393	169	250
COA Balance		0	0	0	0	0	0	0	0	0	0	1	-1
Vernalis TAF		279	226	82	54	52	57	107	74	75	77	83	98
Vernalis cfs		4698	3683	1372	884	852	956	1734	1242	1225	1251	1489	1599
Old/Middle R. calc. cfs		-179	-1,278	-3,247	-8,985	-8,824	-8,249	-3,780	-5,066	-5,099	-4,950	-2,263	-3,002
Computed DOI cfs		30745	14592	7884	8004	6539	7497	7499	4505	7564	7890	11400	11403
Excess Outflow		15767	4831	0	0	0	0	0	0	3058	1887	0	0
% Export/Inflow		6%	14%	26%	47%	51%	50%	35%	53%	43%	46%	20%	26%
% Export/Inflow std.		35%	35%	35%	65%	65%	65%	65%	65%	65%	65%	45%	35%

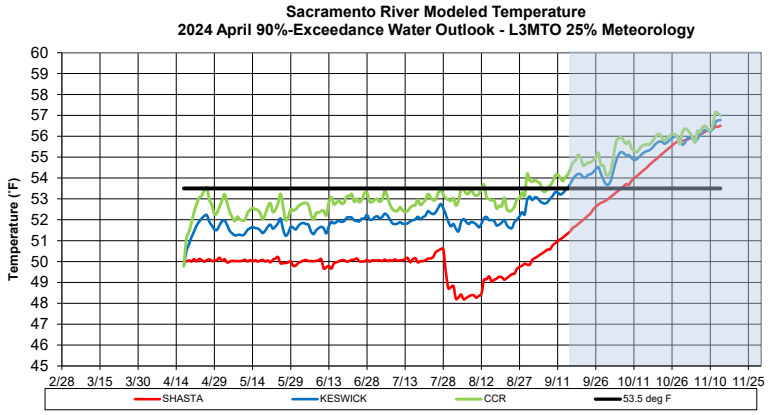
Hydrology

		Trinity		Shasta		Folsom		New Melones	
Water Year Inflow (TAF)		1485		5,616		2,328		1023	
Year to Date + Forecasted	% of mean	123%		101%		86%		97%	

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.

4/22/2024

Attachment 2



	Shasta deg F	Keswick deg F	CCR deg F	Igo deg F	Trinity deg F	Lewiston deg F
May	50.0	51.6	52.4	50.1	44.9	46.5
Jun	50.0	51.8	52.8	51.5	45.2	49.0
Jul	50.0	52.1	52.9	53.4	45.3	48.9
Aug	49.0	52.0	53.1	56.0	45.5	49.3
Sep	51.5	53.6	54.3	56.3	45.5	47.8
Oct	54.5	55.3	55.7	55.0	45.7	48.8
Nov	56.2	56.3	56.4	53.4	45.7	47.7

Run date: 4/22/24

EOM Sept storage: 2.55 MAF (w/pulse)

Trinity profile date: 4/11/24

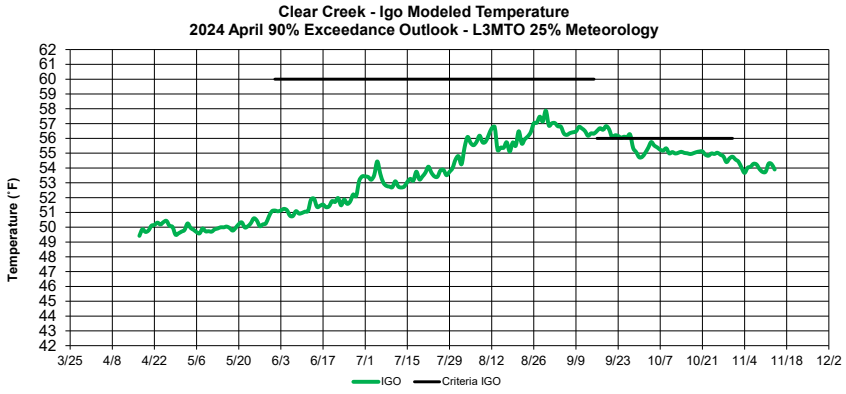
Whiskeytown profile date: 4/10/24

Shasta profile date: 4/17/24

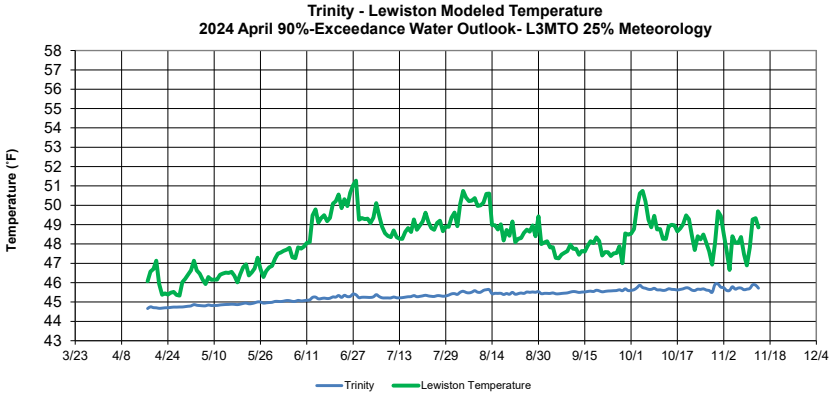
Projected Side gates: First Jul 31 Full Aug 22

Shaded area denotes period of model limitations - see Fall Temperature Index

End of September Cold-Water-Pool less than 56 deg F: 381 TAF



	Igo deg F
May	50.1
Jun	51.5
Jul	53.4
Aug	56.0
Sep	56.3
Oct	55.0
Nov	53.4



	Trinity deg F	Lewiston deg F
May	44.9	46.5
Jun	45.2	49.0
Jul	45.3	48.9
Aug	45.5	49.3
Sep	45.5	47.8
Oct	45.7	48.8
Nov	45.7	47.7

Attachment 3

Estimated CVP Operations 90% Exceedance

Storages

Federal End of the Month Storage/Elevation (TAF/Feet)

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Trinity	**1958**	**1987**	**2031**	**2014**	**1908**	**1786**	**1656**	**1634**	**1630**	**1651**	**1662**	**1699**	**1765**
Elevation		2340	2343	2342	2335	2326	2316	2314	2314	2315	2316	2319	2324
Whiskeytown	**219**	**238**	**238**	**238**	**238**	**238**	**238**	**206**	**206**	**206**	**206**	**206**	**206**
Elevation		1209	1209	1209	1209	1209	1209	1199	1199	1199	1199	1199	1199
Shasta	**4194**	**4449**	**4342**	**3926**	**3371**	**2946**	**2692**	**2597**	**2606**	**2679**	**2749**	**2904**	**3174**
Elevation		1063	1060	1045	1023	1005	994	989	989	993	996	1003	1015
Folsom	**708**	**830**	**944**	**901**	**653**	**467**	**427**	**375**	**329**	**300**	**286**	**313**	**409**
Elevation		452	463	459	434	412	407	399	392	387	385	389	404
New Melones	**2008**	**1948**	**1933**	**1949**	**1887**	**1828**	**1781**	**1717**	**1724**	**1731**	**1736**	**1738**	**1758**
Elevation		1047	1046	1048	1042	1036	1032	1026	1026	1027	1027	1028	1030
Federal San Luis	**783**	**667**	**525**	**358**	**248**	**204**	**200**	**215**	**285**	**461**	**633**	**594**	**551**
Elevation													
Total	9870	10119	10013	9386	8305	7468	6994	6744	6779	7027	7273	7453	7862

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

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Oroville	**3109**	**3416**	**3492**	**3373**	**2807**	**2290**	**1856**	**1699**	**1583**	**1539**	**1576**	**1664**	**1835**
Elevation		892	897	890	850	809	769	753	740	735	739	749	767
State San Luis	**522**	**444**	**311**	**170**	**365**	**540**	**799**	**782**	**830**	**864**	**893**	**901**	**971**
Elevation													N/A
Total San Luis (TAF)	**1305**	**1111**	**836**	**528**	**614**	**743**	**1000**	**996**	**1114**	**1325**	**1526**	**1495**	**1523**
Elevation		464	436	401	411	426	453	452	464	484	502	499	501

Monthly River Releases (TAF/cfs)

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Trinity		161	215	107	45	53	52	23	18	18	18	17	18
cfs		**2,700**	**3,500**	**1,800**	**735**	**857**	**870**	**373**	**300**	**300**	**300**	**300**	**300**
Clear Creek		12	18	14	9	9	9	12	12	12	12	11	22
cfs		**200**	**291**	**242**	**150**	**150**	**150**	**200**	**200**	**200**	**200**	**200**	**363**
Sacramento		405	492	669	815	645	476	338	238	246	246	222	246
cfs		**6800**	**8000**	**11250**	**13250**	**10500**	**8000**	**5500**	**4000**	**4000**	**4000**	**4000**	**4000**
American		238	184	191	338	272	119	92	89	92	77	76	77
cfs		**4000**	**3000**	**3218**	**5500**	**4432**	**2001**	**1502**	**1500**	**1500**	**1250**	**1370**	**1250**
Stanislaus		91	76	22	15	15	15	48	12	12	14	13	12
cfs		**1537**	**1242**	**363**	**250**	**250**	**250**	**774**	**200**	**200**	**226**	**229**	**200**
Feather		143	172	140	495	464	488	184	104	108	77	111	108
cfs		**2400**	**2800**	**2350**	**8050**	**7550**	**8200**	**3000**	**1750**	**1750**	**1250**	**2000**	**1750**

Trinity Diversions (TAF)

Facility	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Carr PP		0	4	12	80	81	80	8	6	1	1	1	1
Spring Crk. PP		**0**	**0**	**0**	**70**	**70**	**70**	**30**	**0**	**0**	**0**	**0**	**0**

Delta Summary (TAF)

Facility/Location/Metric	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Tracy		57	138	194	262	250	202	152	154	230	220	44	55
USBR Banks		0	0	0	15	15	15	0	0	0	0	0	0
Contra Costa		12.0	12.0	10.0	11.0	12.0	13.0	14.0	14.0	14.0	13.0	14.0	12.0
Total USBR		69	150	204	288	277	230	166	168	244	233	58	67
State Export		62	37	49	414	411	395	151	221	160	160	111	183
Total Export		132	187	253	702	688	625	317	389	404	393	169	250
COA Balance		0	0	0	0	0	0	0	0	0	0	1	-1
Vernalis TAF		279	226	82	54	52	57	107	74	75	77	83	98
Vernalis cfs		4698	3683	1372	884	852	956	1734	1242	1225	1251	1489	1599
Old/Middle R. calc. cfs		-179	-1,278	-3,247	-8,985	-8,824	-8,249	-3,780	-5,066	-5,099	-4,950	-2,263	-3,002
Computed DOI cfs		30358	12591	7884	8004	6539	7497	7499	4505	7564	7890	11400	11403
Excess Outflow		15381	2831	0	0	0	0	0	0	3058	1887	0	0
% Export/Inflow		6%	16%	26%	47%	51%	50%	35%	53%	43%	46%	20%	26%
% Export/Inflow std.		35%	35%	35%	65%	65%	65%	65%	65%	65%	65%	45%	35%

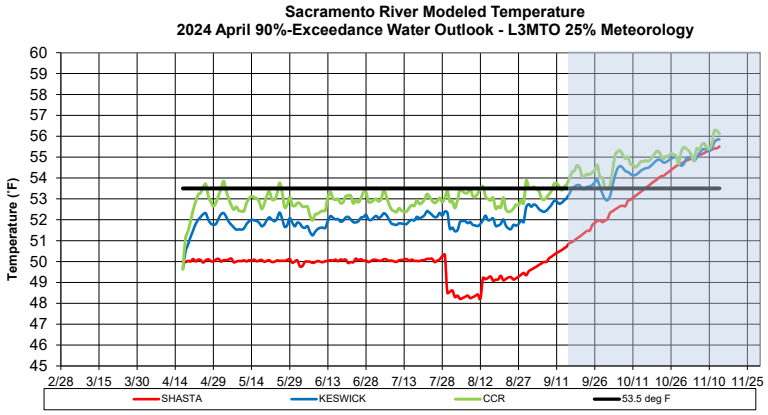
Hydrology

		Trinity		Shasta		Folsom		New Melones	
Water Year Inflow (TAF)		1485		5,616		2,328		1023	
Year to Date + Forecasted	% of mean	123%		101%		86%		97%	

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.

4/19/2024

Attachment 4



	Shasta deg F	Keswick deg F	CCR deg F	Igo deg F	Trinity deg F	Lewiston deg F
May	50.0	51.9	53.0	50.0	44.9	46.5
Jun	50.0	51.9	52.8	51.5	45.2	49.0
Jul	50.0	52.1	52.8	53.4	45.3	48.9
Aug	48.9	51.9	53.0	56.0	45.5	49.3
Sep	50.8	53.1	53.8	56.3	45.5	47.8
Oct	53.5	54.4	54.9	55.0	45.7	48.8
Nov	55.4	55.5	55.6	53.4	45.7	47.7

Run date: 4/19/24

EOM Sept storage: 2.69 MAF

Trinity profile date: 4/11/24

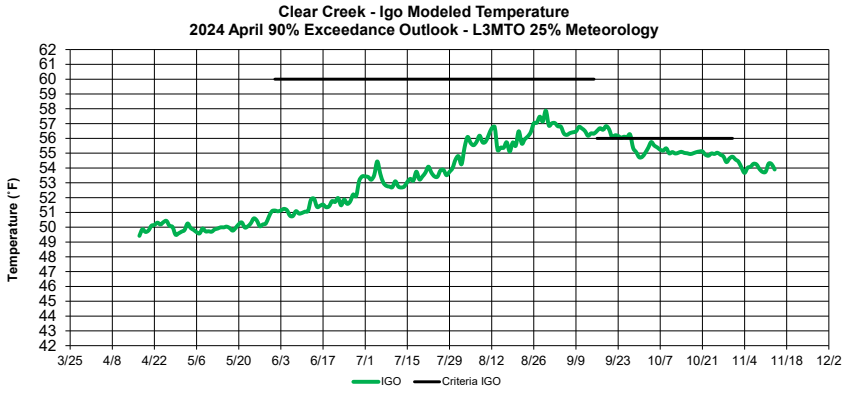
Whiskeytown profile date: 4/10/24

Shasta profile date: 4/17/24

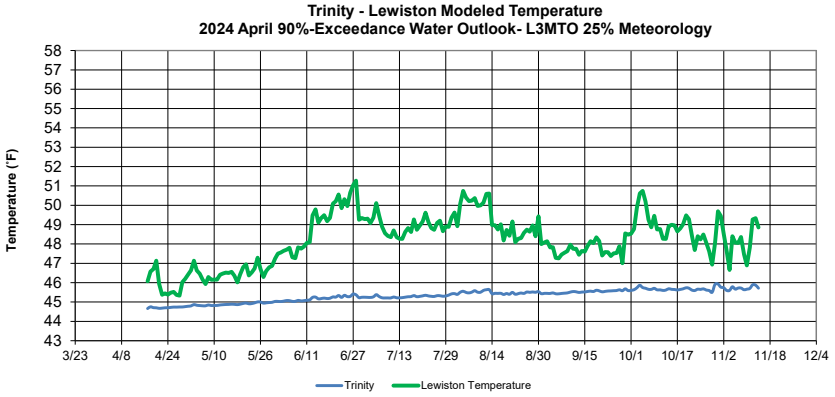
Projected Side gates: First Jul 31 Full Aug 26

Shaded area denotes period of model limitations - see Fall Temperature Index

End of September Cold-Water-Pool less than 56 deg F: 502 TAF



	Igo deg F
May	50.0
Jun	51.5
Jul	53.4
Aug	56.0
Sep	56.3
Oct	55.0
Nov	53.4



	Trinity deg F	Lewiston deg F
May	44.9	46.5
Jun	45.2	49.0
Jul	45.3	48.9
Aug	45.5	49.3
Sep	45.5	47.8
Oct	45.7	48.8
Nov	45.7	47.7

Attachment 5. 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 22, 2024, 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.

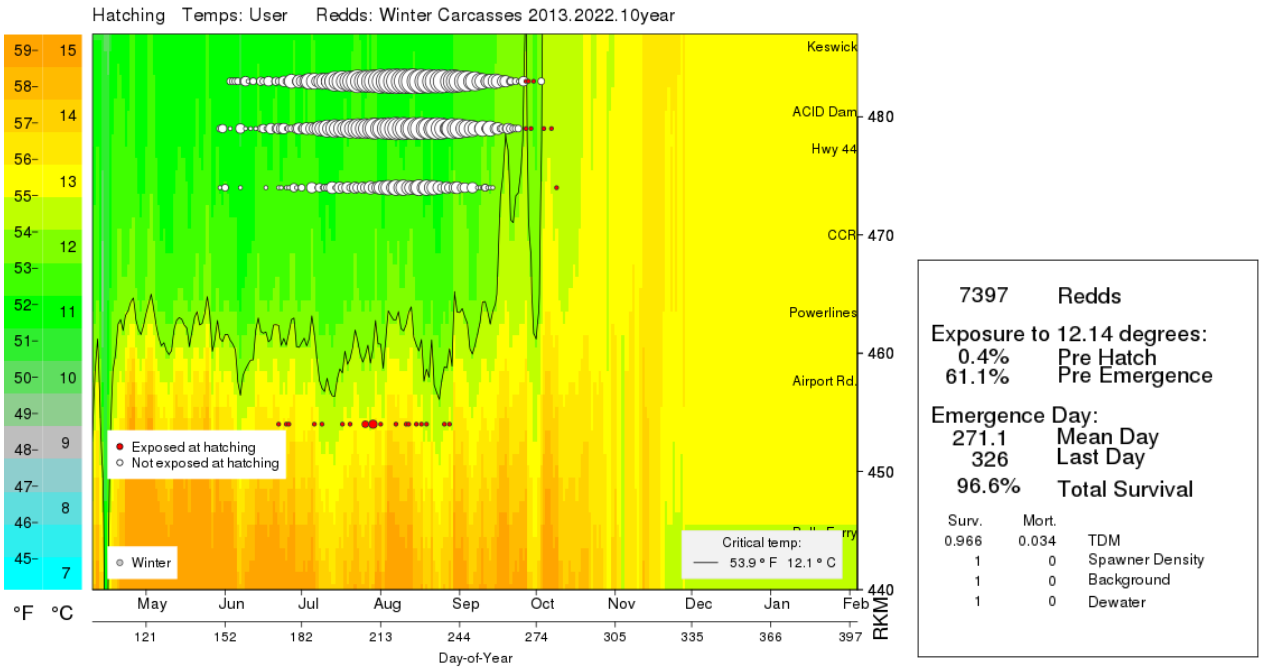


Figure 1. April 23 temperature landscape for no pulse operations with modeled temperatures starting April 23 and using 2013-2022 redd locations and timing (Stage-independent mortality).

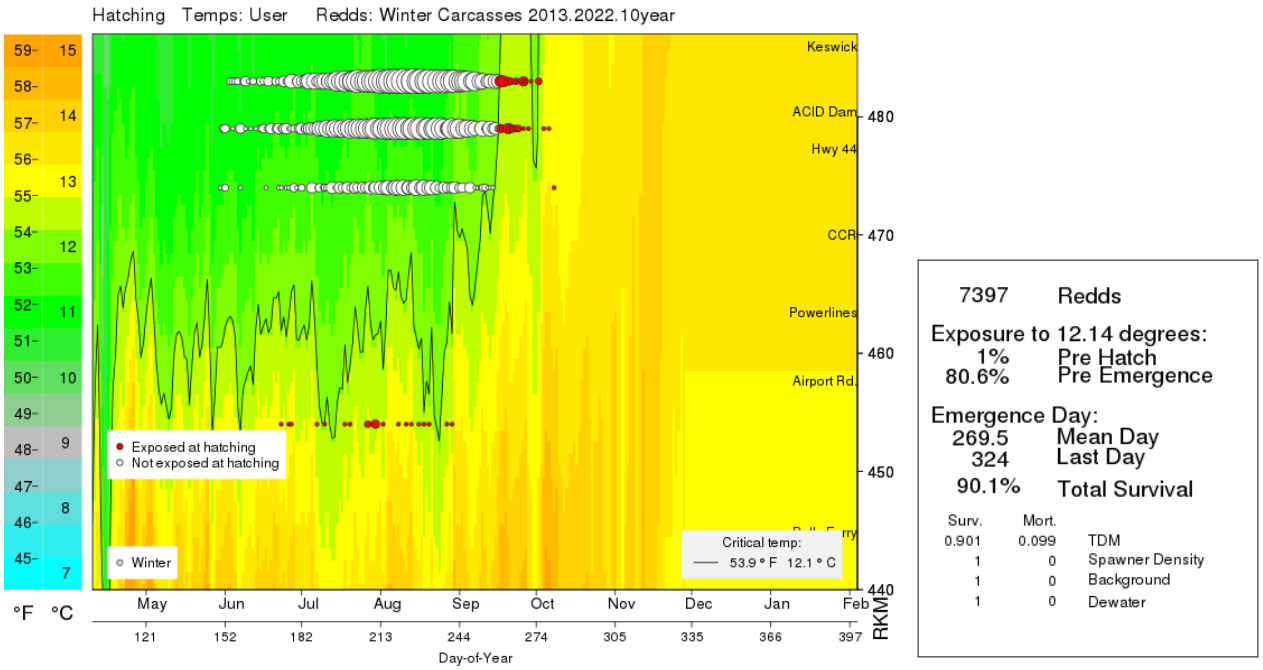


Figure 2. April 23 temperature landscape for Pulse Flow operations with modeled temperatures starting April 23 and using 2013-2022 redd locations and timing (Stage- independent mortality).

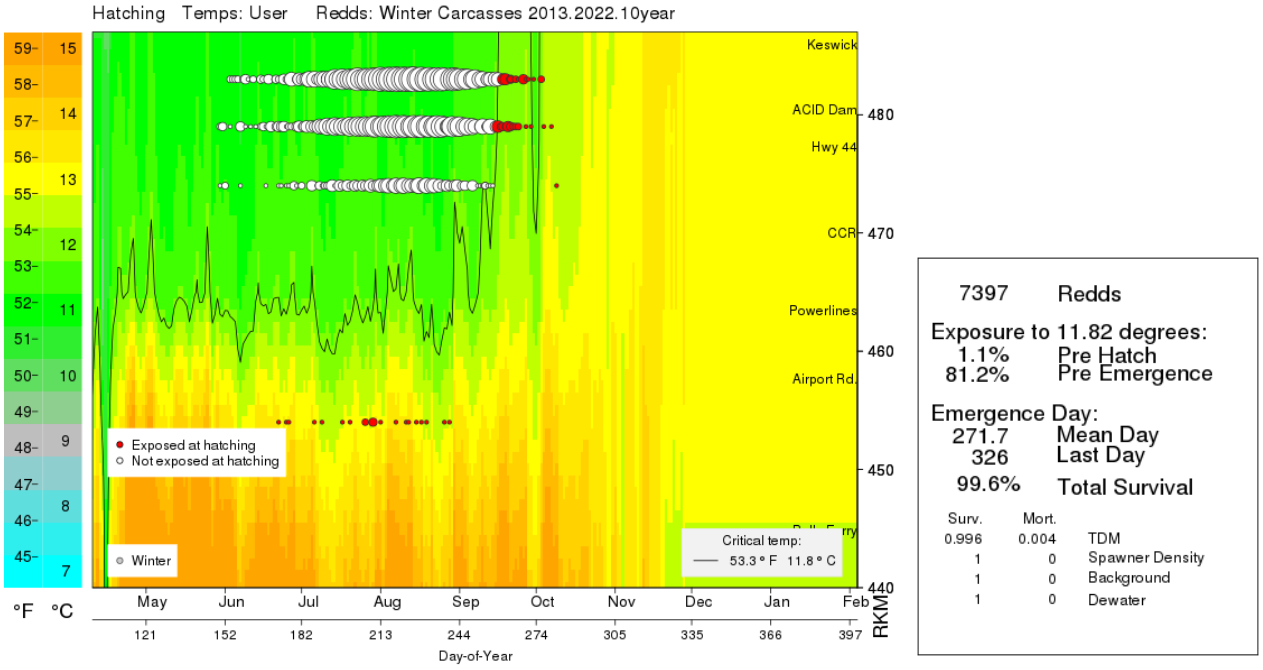


Figure 3. April 23 temperature landscape for no pulse operations with modeled temperatures starting April 23 and using 2013-2022 redd locations and timing (Stage-dependent mortality).

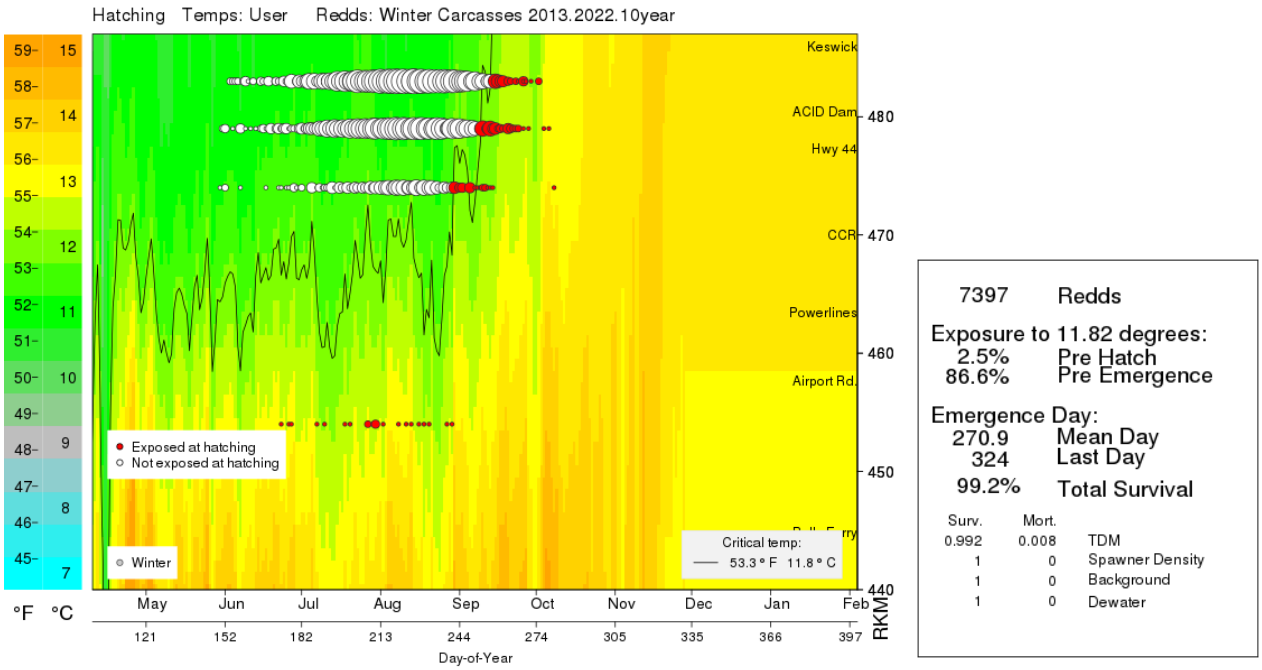


Figure 4. April 23 temperature landscape for Pulse Flow operations with modeled temperatures starting April 23 and using 2013-2022 redd locations and timing (Stage-dependent mortality).

Table 1. Biological modeling parameter information.

Parameter	April 23, 2024 Scenario
Meteorology source	L3MTO Meteorology 25%
Time period	1/1/24-4/22/24: Observed temperature 4/23/24-11/29/24: Simulated
Reservoir Model used	HEC-5Q
River Model used	HEC-5Q
Shasta Profile date	4/17/2024
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	Aerial Surveys 2013-2022 (7,397 redds)
TDM redd space distribution	Aerial Surveys 2013-2022 (7,397 redds)
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 estimate	See Figures 1 and 2

2024 Sacramento River Spring Pulse Operations Plan

April 15, 2024

Background

As part of the Action for the Long term Operation of the Central Valley Project and State Water Project, Reclamation expects to release spring pulse flows of up to 150 thousand acre-feet (TAF) in coordination with the Upper Sacramento Scheduling Team when the projected total May 1 Shasta Reservoir storage indicates a likelihood of sufficient cold water to support summer cold water pool management, and the pulse does not interfere with the ability to meet performance objectives or other anticipated operations of the reservoir. The purpose of the pulse flow is to improve survival rates of outmigrating juvenile spring-run Chinook salmon smolts though the Sacramento River. For more information, refer to Proposed Action 4.10.1.2 Spring Pulse Flows and 4.10.1.4 Cold Water Pool Management which includes information on relationships between Shasta Storage and water temperatures at Clear Creek (CCR).

Reclamation has been coordinating with U.S. Fish and Wildlife Service, National Marine Fisheries Service, California Department of Fish and Wildlife, California Department of Water Resources, Sacramento River Settlement Contractors, Yurok Tribe, Hoopa Valley Tribe, Western Area Power Administration, and the State Water Resource Control Board. During winter 2021, the Upper Sacramento Scheduling Team met to develop a Pulse Flow Study Plan. The Study Plan included the information necessary for considering a seasonal pulse flow and a Fish Monitoring Plan (See Attachment for more information). Following the Guidance Document for the Upper Sacramento River Spring Pulse Flow & Upper Sacramento River Scheduling Team, each year a Pulse Flow Operation Plan will be developed based on the Study Plan and Fish Monitoring Plan and presented to the Sacramento River Temperature Task Group in support of the Proposed Action.

Forecasted and Current Conditions

Reclamation anticipates that a projected May 1 storage greater than 4 million acre feet (MAF) provides sufficient cold water pool management for Tier 1 and may release the spring pulse if it does not impact the ability to meet project objectives. Currently Shasta storage exceeds 4 MAF. Total May 1 Shasta Reservoir storage is predicted to be 4.143 MAF based on the March 90% forecast and 4.290 MAF based on the March 50% exceedance forecast. To date in 2024, actual conditions have more closely followed the 50% forecasts.

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 for implementation of a managed pulse release from Keswick Reservoir to improve outmigration survival of spring-run Chinook salmon smolt, was discussed during the USST meetings. Late April and early May are likely to have the greatest benefits for smolt survival in most years. Factors considered to determine optimal timing were peak period of water deliveries to benefit areas further downstream, attraction pulse flows in Clear Creek, and smolt timing of Delta entry. Based on weekly passage

at the Red Bluff Diversion Dam (RBDD), peak spring-run migration occurs between October and April with the majority of passage occurring by mid-April. Spring-run juveniles from Mill and Deer Creeks generally migrate later than spring-run juveniles observed in the rotary screw traps at RBDD. Spring-run smolts, which outmigrate later in the season, are expected to have a disproportionately large contribution to the returning adult population; yet they also typically experience the worse outmigration conditions due to their later outmigration timing. To support the outmigration success of this year's spring-run smolts, April and May pulse releases may provide the greatest species benefit. In addition, the timing of these pulses may also benefit the approximately 3 million Coleman National Fish Hatchery (CNFH) fall Chinook, which will be released in the next week. 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 (noaa.gov). 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.

Pulse Flow Scenarios

The Upper Sacramento Scheduling Team representatives proposed a set of pulse flow scenarios. All scenarios (with the exception of the no action alternative) have a pulse volume less than 150 TAF, utilize 15% ramping rates, and achieve a pulse magnitude of at least 11,000 cfs at Wilkins Slough. All scenarios have forecasted end of May Shasta storage greater than 4.0 MAF based on the March 50% forecast. A beginning of May Shasta storage of 2.8 MAF is associated with Tier 1 year (2020 ROD Long-term Operations of CVP and SWP). A Tier 1 year is the best temperature management category in which it is suggested that 53.5 degrees F at CCR can be maintained from May 15 to October 31.

On March 28, 2024, Upper Sacramento Scheduling Team representatives reviewed the scenarios described in survival_per_scenario_20240327.pdf and recommended an adaptable approach given the uncertainty with the forecasted conditions. Participants were interested in scenarios that consisted of up to 3 pulses. Participants were interested in continuing to review real-time conditions and provide additional input on flow releases. Ideally, pulse flows would start after flows at Wilkins Slough stabilize in the 5,000 to 10,000 cfs range. Additional constraints and considerations were discussed, including ACID dam needs, power impacts, delta needs (initial estimate is that delta will need 20 days of higher flow in April), and potential effects to Clear Creek Pulse Flow. For more information, see the USST meeting notes.

On April 11, 2024, the agencies in USST met and reviewed the new information. The new information included Scenarios M1 through M9 in the excel file titled *Spring Pulse Flow Apr8 2024* which was developed from the input received during the April 4th, 2024, USST Meeting. Survival estimates benefits using Michel et al. 2021 flow threshold model for these scenarios ranged from 5-15% using all years of passage data (2006-2019; Figure 3) and 3 to 8% using passage estimates for normal and wet years of passage data (2006, 2011, 2017, 2019; Figure 4). Additionally, juvenile chinook salmon survival estimates for ~160 scenarios were simulated using the baseline flows for Keswick and Wilkins Slough described in Spring Pulse Flow Apr8 2024 excel file. The updated modelled juvenile Chinook salmon survival for the top 10 survival scenarios was estimated to be approximately 15 – 17% above the baseline (see *survival_per_scenario_20240410_w_KES.pdf*).

USST and SRTTG representatives expressed support for three pulse flows resembling the M6 scenario from *Spring Pulse Flow Apr8 2024* and X4.4o6.4o8.4 scenario from *survival_per_scenario_20240410_w_KES.pdf*. These scenarios consist of 3, 4-day pulses in Weeks 4 (April 22), Week 6 (May 6), and Week 8 (May 20). Some USST participants were interested in continuing to evaluate the scenarios if conditions change. Although survival estimates for some scenarios were greater than M6, M6 was preferrable to other scenarios as it provides 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. In addition, temperature modelling of planned scenarios will be included in the 2024 Sacramento River Temperature Management Plan.

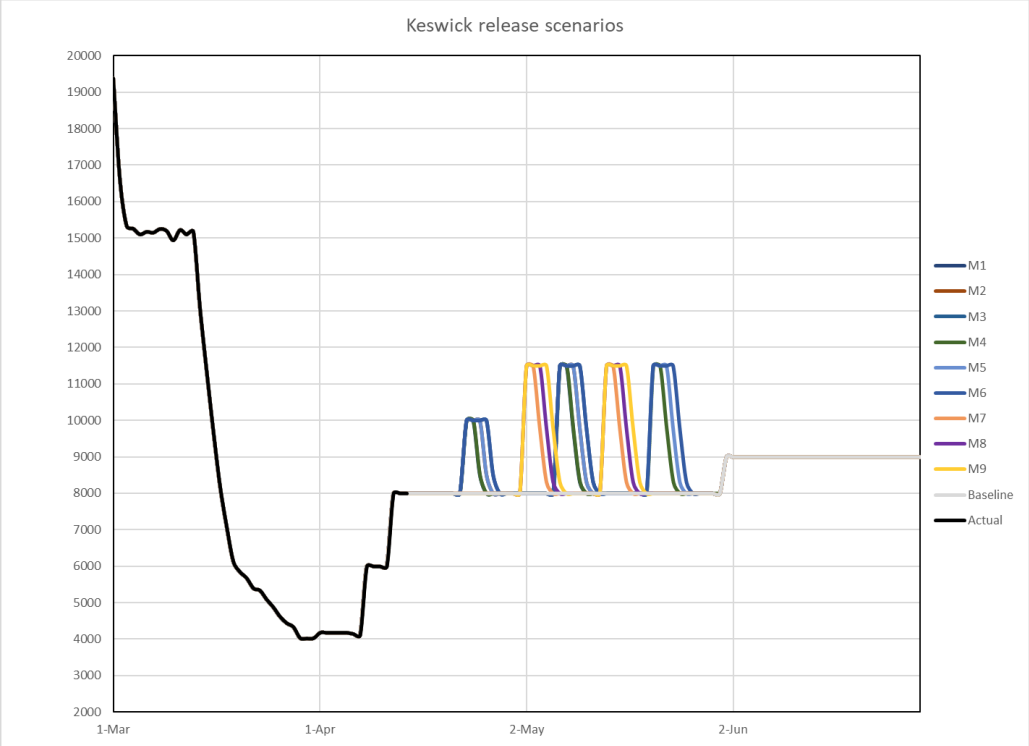


Figure 1. Proposed spring pulse flow scenarios for water year 2024 and associated flow below Keswick in cubic feet per second (cfs).

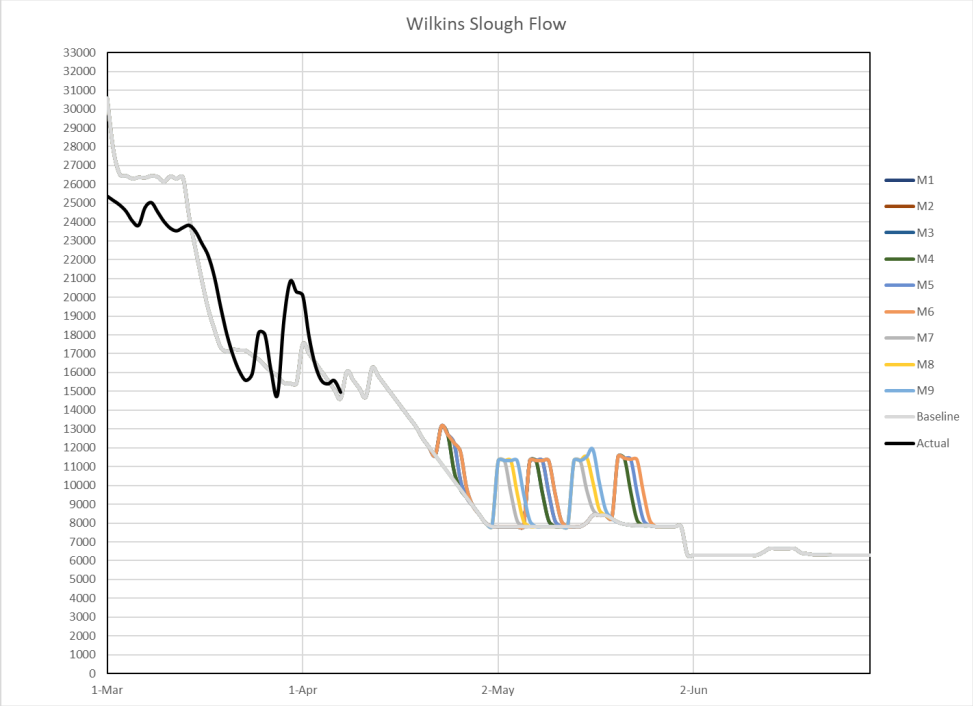


Figure 2. Proposed spring pulse flow scenarios for water year 2024 and associated flow at Wilkins Slough in cubic feet per second (cfs).

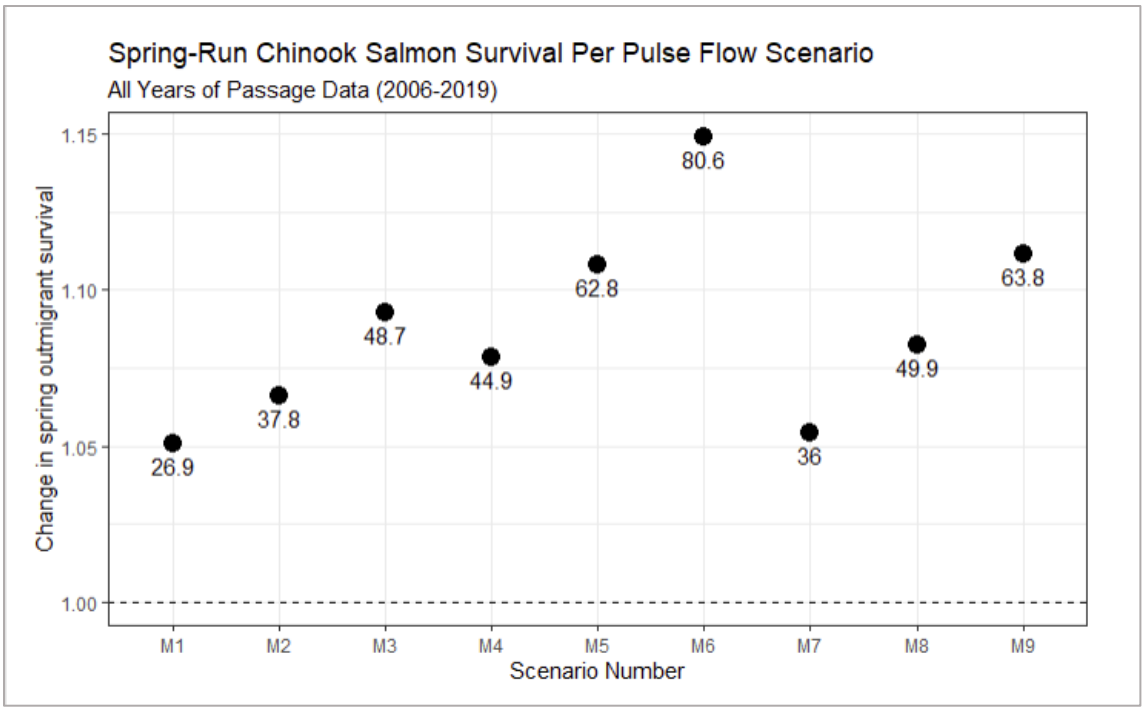


Figure 3. Percent Change in spring Chinook survival per pulse flow scenario with water cost per thousands of acre-feet (TAF; point labels) for all years of passage data (2006-2019).

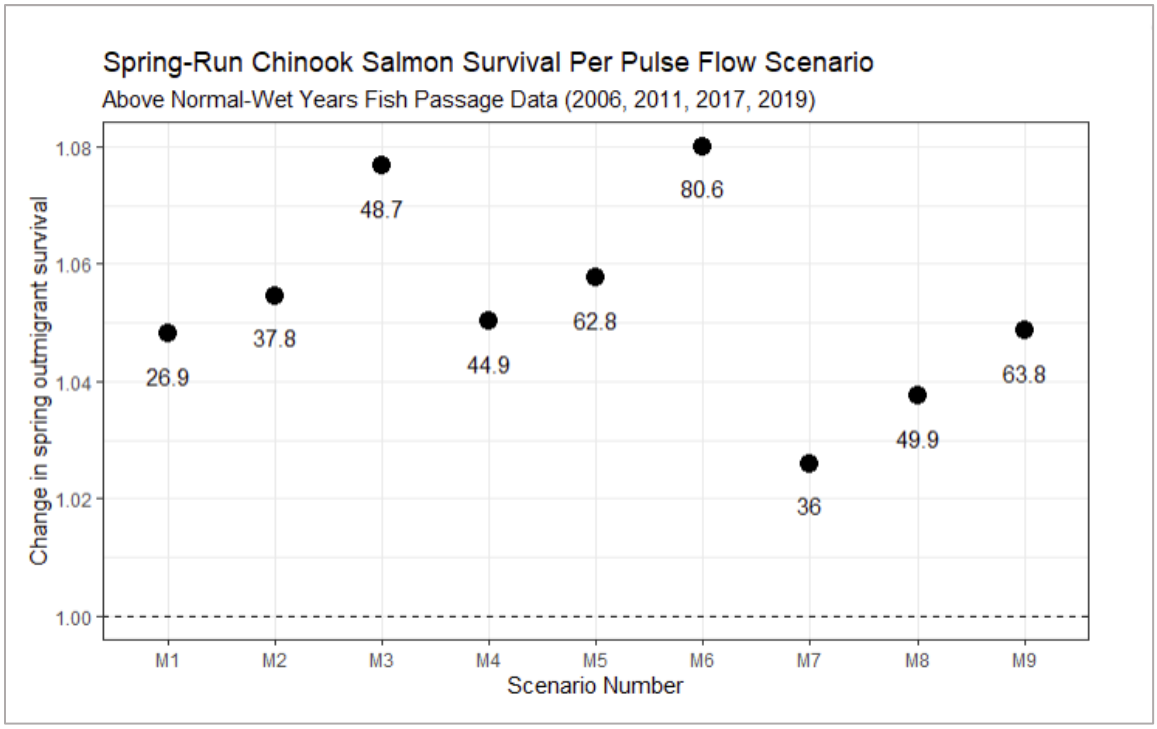


Figure 4. Percent Change in spring Chinook survival per pulse flow scenario with water cost per thousands of acre-feet (TAF; point labels) for above normal and wet years of passage data (2006, 2011, 2017, 2019).