American River Group Summary of Activities for Water Year 2021

Central California Area Office, Folsom, CA
Interior Region 10- California-Great Basin

Distant view of Folsom Dam during morning quagga survey on Folsom Lake. Photo credit: Spencer Marshall, USBR.

U.S. Department of the Interior November 2021

Mission Statements

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

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

American River Group Summary of Activities for Water Year 2021

Folsom Dam, CA
Interior Region 10- California-Great Basin

prepared by

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Acronyms and Abbreviations

ARG	American River Group
BiOp	Biological Opinion
cfs	Cubic Feet Per Second
CFS	Cramer Fish Sciences
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CDFW	California Department of Fish & Wildlife
DWR	Department of Water Resources
CWP	Cold Water Pool
FMS	Flow Management Standard
LAR	Lower American River
MRR	Minimum Release Requirement
NMFS	National Marine Fisheries Service
CNRFC	California Nevada River Forecast Center
Reclamation	U.S. Bureau of Reclamation
RM	River Mile
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	Thousand Acre-Feet
USFWS	U.S. Fish & Wildlife Service
WOMT	Water Operations Management Team
WY	Water-Year

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Chapter 1 – Introduction and Background

1.1 Introduction

The Water Year (WY) 2021 Summary of Activities serves to summarize biological information, and operational discussions and decisions for the lower American River (LAR). Additionally, it serves to document implementation of Alternative 1 (Preferred Alternative) as described in the Final Environmental Impact Study and as analyzed in the 2019 National Marine Fisheries Service (NMFS) Biological Opinion (BiOp) (NMFS 2019), adopted in the February 2020 Record of Decision (ROD) for the Coordinated Long-Term Operations of the Central Valley Project (CVP) and State Water Project (SWP) during WY 2021 (October 1, 2020 – September 30, 2021).

1.2 American River Geographic Orientation

The American River is located in California's Central Valley. It is the second largest tributary to the Sacramento River below Shasta Dam. The North, Middle, and South forks of the American River originate in the Sierra Nevada range and flow into Folsom Reservoir, approximately 25 miles east of the City of Sacramento, California. Folsom Dam and Reservoir, as well as Nimbus Dam, and Lake Natoma are features of the CVP operated by Reclamation. The LAR reach begins at Nimbus Dam, approximately river mile (RM) 23, and continues downstream until its confluence with the Sacramento River. Figure 1 illustrates the LAR and surrounding features.

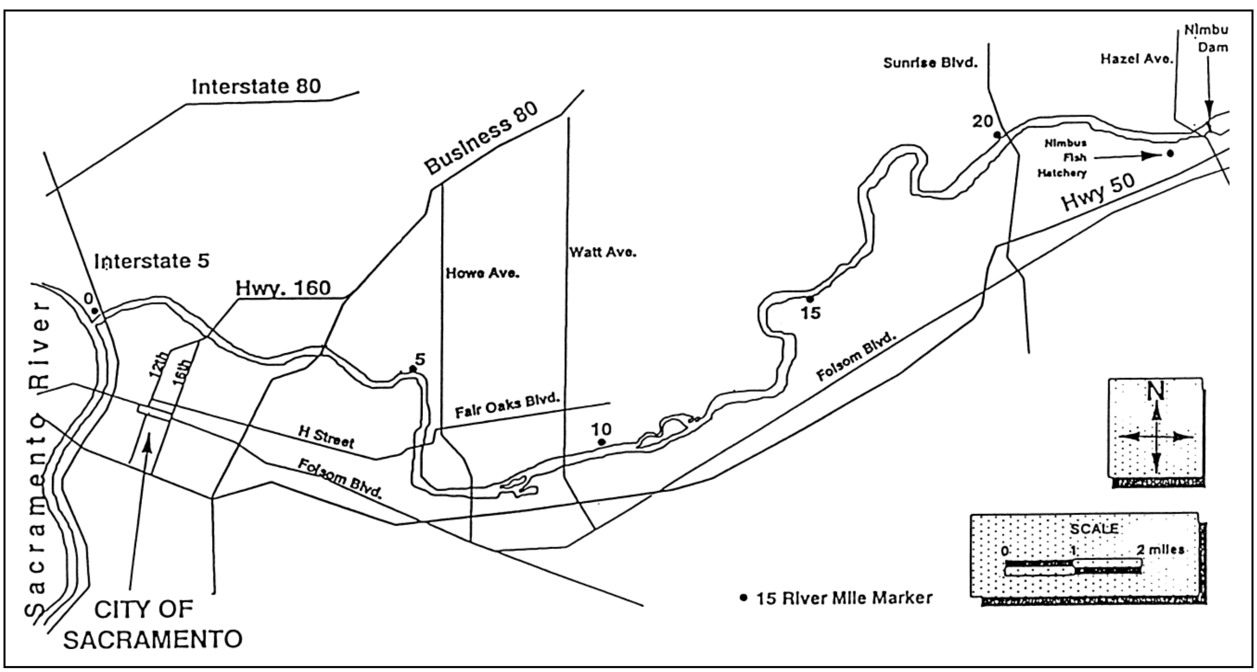

Figure 1. The Lower American River between Nimbus Dam and the Sacramento River

1.3 Lower American River Historical Background

The LAR provides water supply for urban and agricultural uses, flood control, fish and wildlife protection, recreational opportunities, hydroelectric power generation, and contributes to water quality conditions in the Sacramento-San Joaquin Delta. Reclamation is responsible for operating the Folsom/Nimbus Dam complex to meet local and downstream water demands, regulatory requirements, and fish habitat needs. The regulating facilities of the Folsom/Nimbus Dam complex include Folsom Dam, Reservoir and Powerplant; Nimbus Dam and Powerplant, and Lake Natoma. Releases from Folsom Dam are re-regulated approximately seven miles downstream by Nimbus Dam. Nimbus Dam creates Lake Natoma, which serves as a forebay for the diversions to the Folsom South Canal. Additional facilities at Nimbus Dam include the Nimbus Fish Hatchery, which is owned by Reclamation and operated by the California Department of Fish and Wildlife (CDFW).

Reclamation operates Folsom and Nimbus dams under a state water right permit and fish protection requirements that were adopted in 1958 as the State Water Resources Control Board (SWRCB) Decision 893 (D-893). This decision allows flows at the mouth of the American River to fall as low as 250 cubic feet per second (cfs) from January through mid-September, with a minimum of 500 cfs required between mid-September through December 31. The flow operations based on D-893 may not optimize habitat protection given current water rights and fishery conditions. Since 1958, additional SWRCB Decisions and Congressional Acts [i.e. Central Valley Project Improvement Act (CVPIA)], and Endangered Species Act (ESA) requirements have changed the regulatory landscape for the State and Federal Water Projects, including operations on the LAR.

In 1996, Reclamation established a working group to coordinate fishery and operational requirements for the LAR, known as the American River Group (ARG). The ARG brings together stakeholders who have either a legislated or resources-specific interest in the operation of Folsom Dam and Reservoir and the LAR. Reclamation is the lead coordinator of the ARG. The formal members include agencies with trust responsibilities for fisheries resources in the LAR: Reclamation, the U.S. Fish and Wildlife Service (USFWS), NMFS, CDFW and Sacramento Water Forum (Water Forum). Members of the public and other agencies may attend ARG meetings and comment on matters under consideration by the ARG. The ARG convenes monthly or more frequently, if needed, to discuss water operations, fisheries, and other environmental factors. Reclamation considers the information provided by the ARG when making management decisions regarding temperatures and flows necessary to sustain LAR fish resources.

The Water Forum, comprised of local American River stakeholders, has successfully joined together water purveyors, environmentalists, agriculturalists, business leaders, along with city and county governments in Sacramento, El Dorado and Placer counties in an agreement to secure Sacramento region water supply through the year 2030. The Water Forum has promoted operational changes with coequal objectives*: "to provide a reliable supply for planned development to the year 2030, and to preserve the Sacramento region's environmental crown jewel, the lower American River."* The Water Forum, in cooperation with Reclamation, NMFS, USFWS, and CDFW, developed a draft Flow Management Standard (FMS) for the LAR to potentially improve the conditions of aquatic resources in the LAR. The FMS was designed to improve habitat conditions for fall-run Chinook salmon and steelhead in the LAR by enhancing minimum flows and water temperature, establishing a formal management process, and facilitating coordinated monitoring, and evaluation and reporting (Water Forum 2006).

The FMS was designed to integrate water temperature performance capability for management of the downstream habitat. The NMFS 2009 BiOp (NMFS 2009) also adopted components of the FMS temperature management process. Action II.2 of the NMFS 2009 BiOp states that "The priority for use of the lowest water temperature control shutters at Folsom Dam shall be to achieve the water temperature requirement for steelhead, and thereafter may also be used to provide cold water for fall-run Chinook salmon spawning." While NMFS's priority was temperature management for steelhead due to federal listing status, temperature management for fall-run Chinook salmon was also important. Because water temperature control operations in the LAR are affected by many factors and operational tradeoffs, ideal downstream temperature targets are sometimes infeasible (particularly with multiple years of below normal or dry water year type conditions). These factors include available cold-water resources, Nimbus Dam release schedules, annual hydrology/snowpack, Folsom power penstock shutter management flexibility, power generation, Nimbus Fish Hatchery operations and maintenance, and Delta needs.

The Folsom temperature shutters are structural devices at the Folsom Dam power unit intakes that provide downstream temperature management control. These devices help control the desired downstream temperature by selecting the elevation where water is withdrawn from the reservoir. The Folsom Shutters can be operated such that water from different reservoir elevations is accessed and blended, providing additional temperature management control. Lastly, when temperature operations exhaust the reservoir's cold water pool (CWP) at the lowest shutter locations, Reclamation has the operational ability to release the coolest water from the river outlets at the lowest elevation outfall in Folsom Dam in effort to achieve targeted temperatures in the LAR to the extent physically controllable. Releases from the river outlets cannot be used to generate power and thus this operation is referred to as a "power bypass".

1.4 Transition to February 2020 ROD

In 2009, NOAA Fisheries issued a BiOp to Reclamation that included an RPA to address the effects of the proposed action considered in the 2009 BiOp and how that action could be implemented in a manner that would avoid the likelihood of jeopardy to listed species or adverse modification of critical habitat. On April 7, 2011, NOAA Fisheries provided an RPA amendment (NMFS 2011), which, consistent with the Delta Stewardship Council's Independent Review Panel (DSC 2010), corrected errors in the 2009 RPA and provided clarification.

On August 2, 2016, Reclamation, the federal action agency, and the California Department of Water Resources (DWR), the applicant, jointly requested the reinitiation of ESA consultation with the USFWS and NOAA Fisheries on the coordinated long-term operation of the CVP and SWP. NOAA Fisheries accepted the reinitiation request on August 17, 2016. On January 31, 2019, Reclamation transmitted their Biological Assessment (BA) to NOAA Fisheries and a revised BA (Reclamation 2019b) was submitted on October 21, 2019.

NOAA Fisheries finalized and issued its BiOp on the coordinated operations of the CVP and SWP on October 21, 2019. NOAA Fisheries concluded that Reclamation's proposed operations will not jeopardize threatened or endangered species, or destroy or adversely modify designated critical habitats.

The Bureau of Reclamation signed a ROD on February 18, 2020 to implement the preferred alternative as described in the Final EIS for the Reinitiation of Consultation on the Coordinated Long-Term Operation (ROC on LTO) of the CVP and SWP and evaluated in the 2019 USFWS and NMFS BiOps (Reclamation 2020; USFWS 2019).

Chapter 2 – February 2020 ROD

2.1 Summary of February 2020 ROD

Implementation of the February 2020 ROD began on February 19, 2020. The February 2020 ROD for American River operations includes commitments regarding flows and water temperature objectives, with some conservation measures related to habitat restoration and hatchery management (Table 1). Reclamation proposed to adopt the minimum flow schedule or Minimum Release Requirement (MRR) and approach developed by the Water Forum in 2017-2018 (Water Forum 2017). This approach also includes implementation of redd dewatering protective adjustments that restrict changes in the MRR between December and June and, under certain conditions, a spring pulse flow. Reclamation also proposed to continue summer and fall temperature management for the LAR.

Table 1. Components of the Proposed Action related to the American River system per Table 4-7 in Chapter 4 of the 2019 Biological Assessment.

Component
Seasonal Operations
2017 Flow Management Standard Releases and "Planning Minimum"
American River Pulse Flows
Spawning and Rearing Habitat Restoration
Nimbus Hatchery Genetic Management Plans
Drought Temperature Management
Yellow-billed Cuckoo Surveys

An overview of American River operations under the February 2020 ROD specific to the 2017 FMS planning minimum and spring pulse flow is provided in Attachment A. An overview of American River operations under the February 2020 ROD specific to water temperature management is provided in Attachment B. American River operations under the 2020 ROD continue to be coordinated through the ARG.

The following non-flow components of the February 2020 ROD are not discussed in this report as they have not been standing topics of discussion at ARG meetings during WY 2021.

- *Spawning and Rearing Habitat Restoration*
- *Hatchery Genetics Management Plans (HGMPs)*

- *Drought Temperature Management*
    - *Reclamation did degang the shutters of the Temperature Control Device during WY 2021, which allowed for the alternative shutter configurations proposed in this component of the 2020 ROD. Shutter configurations were reported out at the monthly ARG meetings.*
- *Yellow-billed Cuckoo Surveys*

Chapter 3 – ARG Discussion Topics

The following section outlines ARG discussion topics from the October 2020 through September 2021 monthly meetings. Meeting notes and supplemental ARG documents were made available to the ARG members and posted to the ARG Technical Group website[1]. The ARG distribution list is maintained by the Central California Area Office (CCAO) Resources Management Division.

3.1 Monthly Discussion Topics

- **Lower American River Fisheries Monitoring**
  - The status of current and future fisheries monitoring activities were provided by Reclamation, NMFS, USFWS, CDFW, Cramer Fish Sciences (Cramer), and Pacific States Marine Fisheries Commission (PSMFC) (see Chapter 5).
- **American River System Reservoir Operations**
  - Monthly reservoir operations and hydraulic forecast updates provided by Central Valley Operations (CVO), Sacramento Municipal Utility District (SMUD), and Placer County Water Agency (PCWA).
- **Water Operations and Water Quality**
  - Reservoir storage, CWP volume, flows measured at Fair Oaks gage on the LAR, current temperature modeling results and water temperatures measured at Nimbus Dam, Fair Oaks gage, and Watt Avenue (see Chapter 4).
  - February 2020 ROD *2017 Flow Management Standard Releases and Folsom Planning Minimum*

    The 2017 FMS in the February 2020 ROD was finalized in December 2018 and incorporated into the Proposed Action for ROC on LTO of the CVP and SWP. The 2017 FMS in the February 2020 ROD includes a minimum release requirement (MRR) with flows ranging from 500 to 2,000 cfs based on time of year and annual hydrology. The flow schedule is intended to improve CWP and habitat conditions for steelhead and fall-run Chinook salmon. Specific flows are determined using the American River and Sacramento River indices intended to define the current and recent hydrology.

    The 2017 FMS in the February 2020 ROD includes an end-of-December storage planning minimum that aims to improve water supply reliability and help manage water temperatures in the LAR. The objective of incorporating the planning minimum into the forecasting process is to provide releases of salmonid-suitable temperatures to the LAR and reliable deliveries to American River water agencies that are

[1] The ARG Technical Team webpage can be found here: https://www.usbr.gov/mp/bdo/american-river-group.html

dependent on deliveries or releases from Folsom Reservoir.

- *Spring Pulse Flows*

  The 2017 FMS in the February 2020 ROD includes a pulse flow component of about a four-week duration during March and April. This requires supplementing normal operational releases from Folsom Dam under certain conditions. Accommodations may be made for additional requests for spring pulse flows by re-shaping previously planned releases. The intent of the spring pulse flow is to provide a juvenile salmonid emigration cue before relatively low flow conditions and unsuitable thermal conditions occur later in spring.

- *Temperature Management Plan*

  Reclamation will prepare a draft Temperature Management Plan by May 15 for the summer through fall water temperature management season using the best available information and decision support tools. The draft plan will contain: (1) forecasts of hydrology and storage; and (2) a modeling run or runs, using these forecasts, demonstrating what temperature compliance schedule can be attained. Reclamation will use an iterative approach, varying shutter configurations, with the objective to attain the best possible water temperature schedule for the compliance point at Watt Avenue Bridge (AWB[2]).

3.2 Other Discussion Topics

- **Central Valley Project Improvement Act (CVPIA)**

  Reclamation's most recently completed restoration project took place in the fall of 2021 at Ancil Hoffman Park, adjacent to the Effie Yeaw Nature Center in Carmichael, California. Mobilization of construction equipment for the Ancil Hoffman Salmonid Restoration Project started on August 30, 2021. The construction was completed on October 1, 2021. The Ancil Hoffman Project focused on gravel sorting and placement for spawning adults; and floodplain rearing habitat for juveniles. Over 15,000 cubic tons of gravel was sorted and placed in the mainstem river. Gravel for the Ancil Hoffman restoration project was extracted from the Project site. Gravel was processed (sorted and cleaned) and stockpiled at the Project site before being delivered via dump truck to short-term areas adjacent to gravel augmentation sites within the Ancil Hoffman portion of the mainstem American River (Figure 2). The sorted gravel is ideal size for spawning fall-run Chinook and Steelhead. Floodplain habitat was created by creating a 1,000 ft alcove feature (Figure 3). Inundation of the rearing habitat can occur at flows of 800 cfs and greater.

  Reclamation is working on permitting for additional habitat improvement sites at Lower Sailor Bar (Figure 4), including upper Sunrise Side Channel (Figure 5).

[2] Temperature data for the compliance point at Watt Avenue Bridge (AWB) can be found here: https://cdec.water.ca.gov/webgis/?appid=cdecstation&sta=AWB

Habitat improvement projects in the LAR are often led by or coordinated with the Water Forum.

Figure 2. A dump truck placing sorted gravel into the mainstem American River.

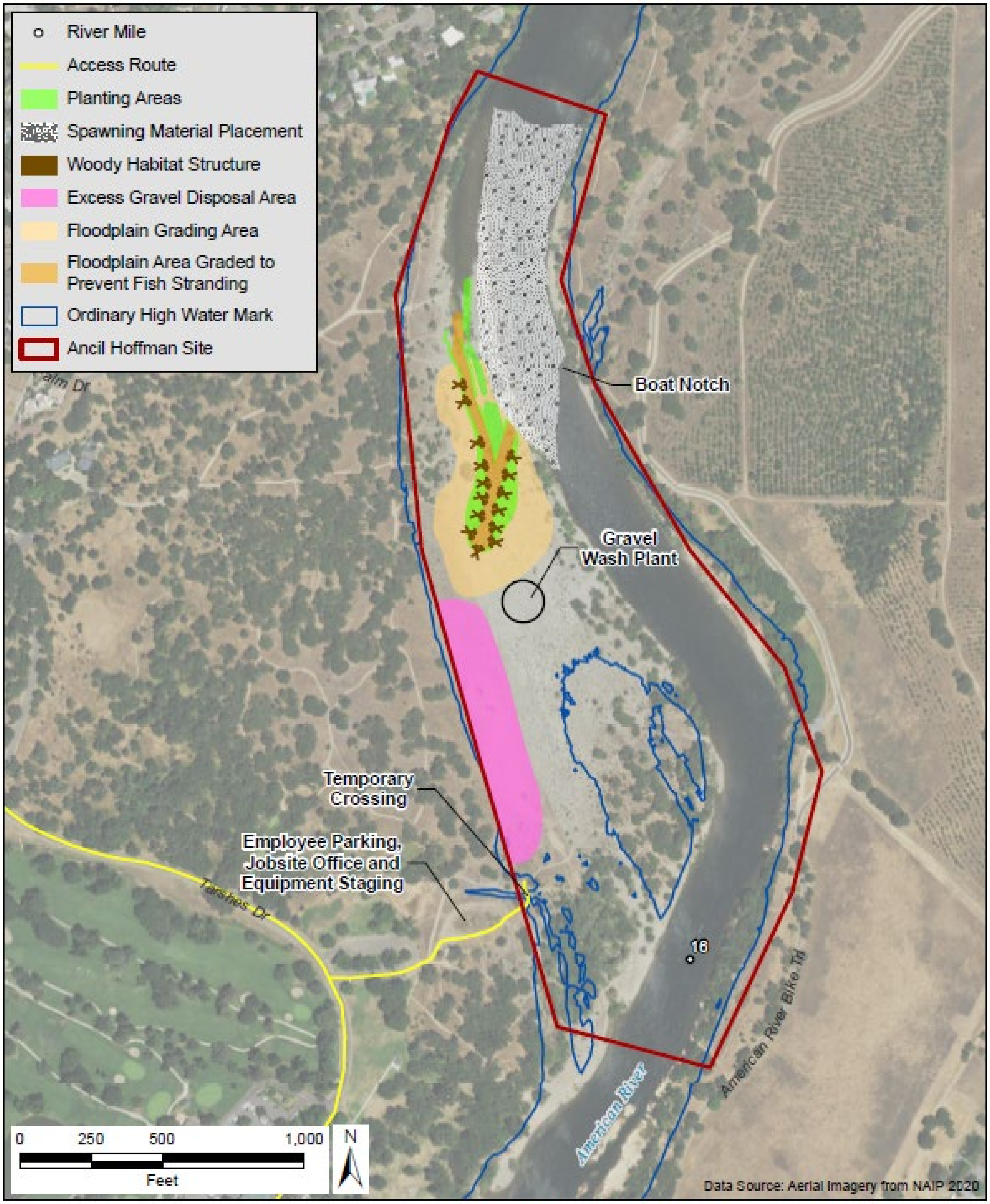

Figure Source: GEI Consultants, Inc. 2021.

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Figure 3. Project design of the Ancil Hoffman Salmonid Restoration in the Lower American River. Project completed on October 1, 2021.

Figure 4. Future restoration site at Lower Sailor Bar (extent of project site, gravel augmentation and side channel area may not be current).

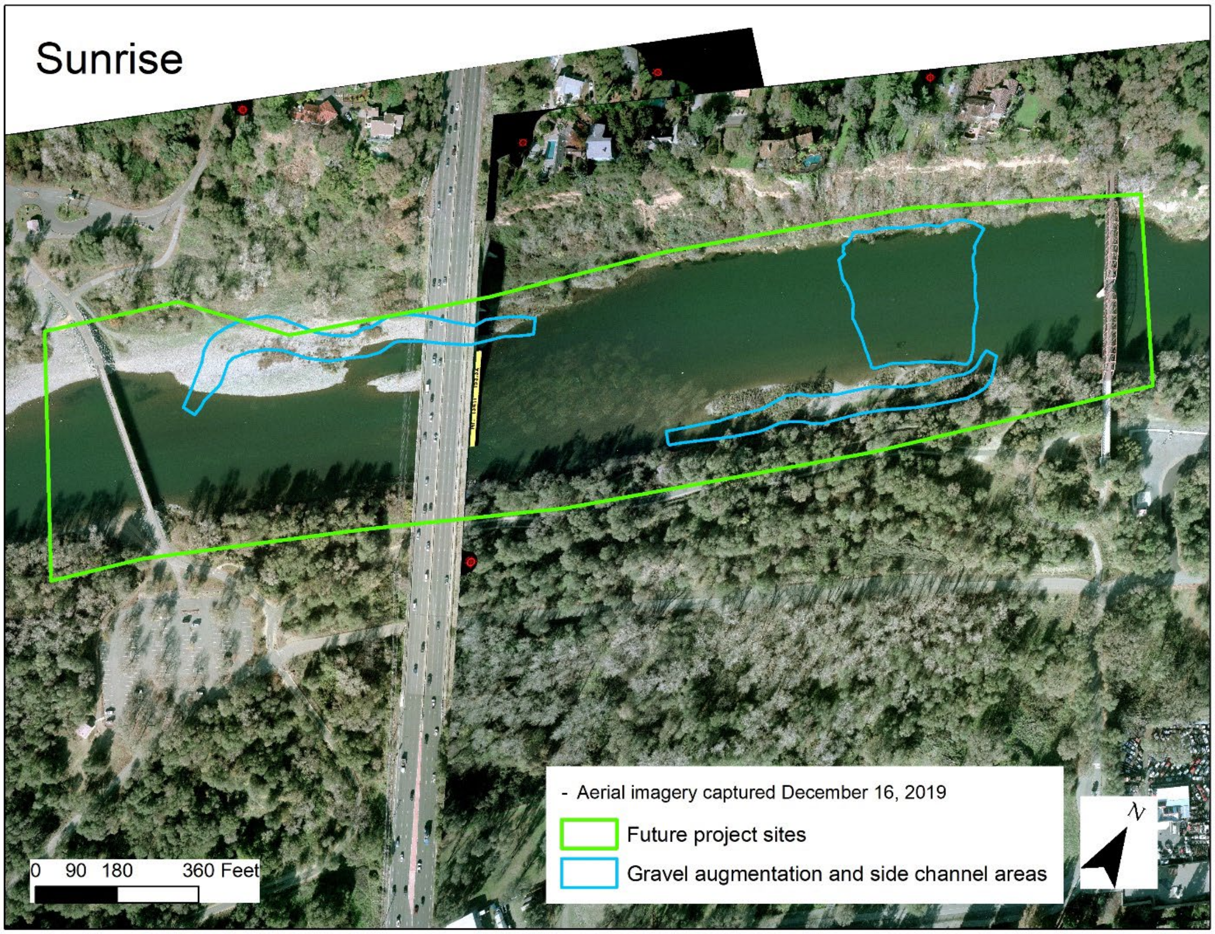

Figure 5. Future restoration site at Sunrise Side Channel (extent of project site, gravel augmentation and side channel area may not be current).

- **Power Bypass proposals**
  - Group discussed power bypass options to achieve cooler fall temperatures for spawning fall-run Chinook salmon. A power bypass was approved by Reclamation for implementation during fall 2020. Another power bypass was discussed and proposed for fall 2021 and was also approved by Reclamation. The implementation of that power bypass began in October 2021 and thus occurred during WY 2022 (see Attachment D).
- **ARG Presentations**
  - **Nimbus Fish Ladder (12/17/2020)** - John Hannon, Fish Biologist, Bay-Delta Office, Reclamation; shared photos of the new fish ladder in the Nimbus Basin.
  - **Shining a Light on Harvest Management (1/21/2021) –** Dana Lee, Fisheries Biologist, FISHBIO; fall-run harvest management in the CV, importance of forecasts, harvest and escapement during the drought, status of hatcheries, possible

improvements to harvest management.

- **2017 FMS Refresher (2/18/2021)** - Jeff Weaver, HDR; summary of 2017 Flow Management Standard Minimum Releases Requirement (FMS calculation and application).
- **Sailor Bar: Tested Techniques & Innovative Ideas (3/18/2021)** - Avery Scherer, Cramer; results of monitoring at Sailor Bar restoration site following gravel augmentation and side channel construction.
- **Pre-spawn Mortality of Female Fall-run Chinook on the Lower American River (4/15/2021)** – Tracy Grimes, CDFW; presented data on prespawn mortality of Chinook salmon in the lower American River from carcass surveys between 2011-2020.
- **LAR RST Salmonid Data Analysis (7/15/2021)** - Olivia Mihok, a NOAA Hollings Scholar; presented her findings related to Lower American Rotary Screw Trap Data for Steelhead & Chinook salmon. Her research focused on analyzing catch patterns to better understand the cause and impacts of data gaps.

Chapter 4 – Water Operations Summary

4.1 General Water Year Conditions and Operations

The 40-30-30 index for the Sacramento Valley was ultimately characterized as “critical” for WY 2021, based on the May 50% exceedance forecast. American River operations were dominated by storage conservation operations from late December 2020 through September 2021.

4.2 Hydrologic Conditions – American River

Watershed runoff in California is typically driven by winter precipitation and spring snow-melt runoff and quantified as a late spring through summer inflow volume (April through July volume, in addition to a water year total volume). The American River watershed spring/summer forecasted inflow volume is fundamental in operational planning. This runoff forecast is updated routinely by the DWR and the National Weather Service California Nevada River Forecast Center (CNRFC), where uncertainty is represented by percent runoff exceedances. The February 2021 initial unimpaired runoff 90% exceedance (conservative) forecast volume for April – July 2021 by DWR in their Bulletin 120 was 350 thousand Acre-Feet (TAF), or 50.0% of the average 370 TAF[3]. The actual full natural flow volume April –July in 2021 was 745 TAF, or 33% of the 15 year average (final WY 2021 actual inflow to Folsom volume October – September was 718.37 TAF).[4] Table 2 provides precipitation data and characteristics for November to May of WY 2021. Because operational planning is significantly influenced by future forecasts, these uncertainties and eventually modified decisions are translated into the performance and efficiency of the system-wide operation.

Table 2. 2021 Water Year Northern Sierra precipitation, American River Basin snowpack, and Sacramento Valley Index statistics by November 2020 through May 2021 (DWR Bulletin 120).

Water Year 2021	Northern Sierra 8- Station Precipitation (Cumulative inches through month)[5]	Sacramento Valley Index (40-30-30 Index 50% Exceedance; year type)[6]
November	3.49	N/A
December	7.11	5.9; Dry
January	13.98	5.3; Critical
February	18.02	5.0; Critical
March	22.08	4.6; Critical
April	22.83	4.4; Critical
May	23.01	4.0; Critical

[3] https://cdec.water.ca.gov/reportapp/javareports?name=b120feb21.pdf
[4] https://cdec.water.ca.gov/dynamicapp/QueryMonthly?&s=AMF
[5] https://cdec.water.ca.gov/reportapp/javareports?name=8STATIONHIST
[6] http://cdec4gov.water.ca.gov/reportapp/javareports?name=WSI

4.3 Operations – Lower American River

Operational decisions on the LAR are balanced with local, CVP and SWP system-wide multi-purpose objectives including those that are planned and unplanned. 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, downstream Delta regulatory requirements, Delta exports, power generation, recreation, fish hatchery accommodations, water temperature management capabilities and others. In addition, uncertain, or unplanned, events may also influence real-time operation decisions (e.g. additional flow reduction for debris removal prior to fish weir and picket installation for the Nimbus Fish Hatchery). Planned operational targets are regularly updated in late winter through early summer (depending on hydrologic conditions) on Reclamation's website (http://www.usbr.gov/mp/cvo/).

Key factors that influenced WY 2021 LAR operations:

- Minimum flow rate/FMS: WY 2021 was a critical water year and there were no flood control releases required.
- LAR Flow Reduction Discussions: In addition to the monthly ARG meetings, several ARG calls were scheduled to discuss specifically the potential reduction of LAR flows due to current hydrologic conditions and poor outlooks. ARG members provided redd dewatering information to help understand potential redd dewatering impacts with LAR flow reductions. These discussions weighed the risk of reducing flows to increase storage and minimizing risk of redd impacts due to increased or fluctuating flows needed for flood management.
- Reservoir Storage: Reservoir storage peaked on May 15, 2021 at 398.78 TAF.
- Cold Water Pool (CWP): The CWP volume was lower than desirable by the end of May this water year (see historical end of May CWP volumes in Table 3). This was due to the lower reservoir storage that resulted from critical year hydrology.
- Temperature Management Plan (TMP): Based on various iCPMM and CE-QUAL-W2 modelling runs and given the current number of uncertainties with potential drought actions, inflow projections and operations forecasts, the LAR TMP goal was to target 71°F at Hazel (as measured at the American River at Fair Oaks - AFO gauge; see Figure 6) from June 6, 2021 to October 31, 2021 and target 58°F from November 1, 2021 until winter. Diminishing levels of precipitation and runoff in California resulted in the driest Water Year in a century. Extreme heat compounded the difficulty of meeting water temperature objectives over the summer months. Reclamation operated to 71°F at Hazel Avenue thru October 31, 2021. This decision, with agreement from the ARG, was made to conserve CWP resources to attempt to meet more suitable water temperatures in November than the temperature plan objective of 59°F° at Hazel Ave. See Section 4.4.3 Temperature Management Plan for more details.
- October 2020 Hatchery Conditions: The water for the fish ladder was turned on October 30, 2020 to allow Chinook salmon to begin entering the ladder. Flows into the ladder

were set at 20 cfs for the entirety of the season. Flow was set using two staff gauges, one located within the fish ladder and the other located just downstream. Fall-run Chinook salmon brood stock collection began on November 2, 2020 and continued until January 26, 2021. In early October 2020, CDFW reported approximately 25,000 steelhead deaths in the Nimbus raceways, thought to be due to conditions (low dissolved oxygen and disease) exacerbated by very warm water temperatures. CDFW installed aerators and sourced medicated feed, which reduced deaths into the single digits daily. The Nimbus Dam Gate 18 was opened in November 2019 to address stagnant warmer water at the hatchery intake, but that was not possible in fall 2020 because of construction on the hatchery fish ladder directly downstream of the gate.

- October-November 2021 Folsom Power Bypass: On October 1, 2021, Reclamation received a Folsom Power Bypass proposal from CDFW on behalf of the state and federal fisheries agencies (see Attachment D). The proposal contains three bypass scenarios that would access Folsom's CWP below the power unit penstocks to reduce LAR water temperatures to benefit rearing steelhead and spawning fall-run Chinook salmon. Prior to submittal to USBR, this proposal was provided in Draft form to the ARG for review and comment. The proposal draws upon numerous Folsom power bypass and LAR temperature management discussions held at the monthly and ad hoc ARG meetings over the previous several months. The proposal was presented and discussed at the September 24, 2021 ARG ad-hoc meeting:

    - Scenario A: power bypass starting October 18 at 150 cfs and then increasing to 350 cfs on October 25 and continuing at 350 cfs until November 25 or a bypass is no longer needed
    - Scenario B: power bypass starting October 18 at 350 cfs and then continuing at 350 cfs until November 25 or a bypass is no longer needed
    - Scenario C: power bypass starting October 11 at 150 cfs and then increasing to 350 cfs on October 18 and continuing until November 25 or a bypass is no longer needed

  On October 7, the Regional Director approved Scenario C but with the following characteristics:

    - Start date of October 11 with 50 cfs and adding approximately 50 cfs per day for 3 days up to approximately 150 cfs (to avoid cold water shock to fish in Lake Natoma) with the goal of reaching a LAR daily average water temperature of 62° F measured at Hazel Avenue to limit pre-spawn mortality and limit induction of spawning
    - Hold the approximately 62° F LAR daily average water temperature measured at Hazel Avenue (approximately 150 cfs and not to exceed 350 cfs of power bypass) through the month of October
    - For comparison, Scenario C requested a power bypass volume and modeled temperatures resulting from that volume. The power bypass proposal did not target a particular temperature, but instead focused on a volume aimed to achieve the coldest temperature possible given the limited CWP.

- Starting around October 25 increase the bypass to no more than 350 cfs to target 56° F LAR daily average water temperature measured at Hazel Avenue (via approximately 100 cfs/day increments) by November 1.
- Continue with the maximum 350 cfs power bypass until ambient air temperatures make power bypass no longer necessary to maintain LAR daily average water temperature of 56° F measured at Hazel Avenue.

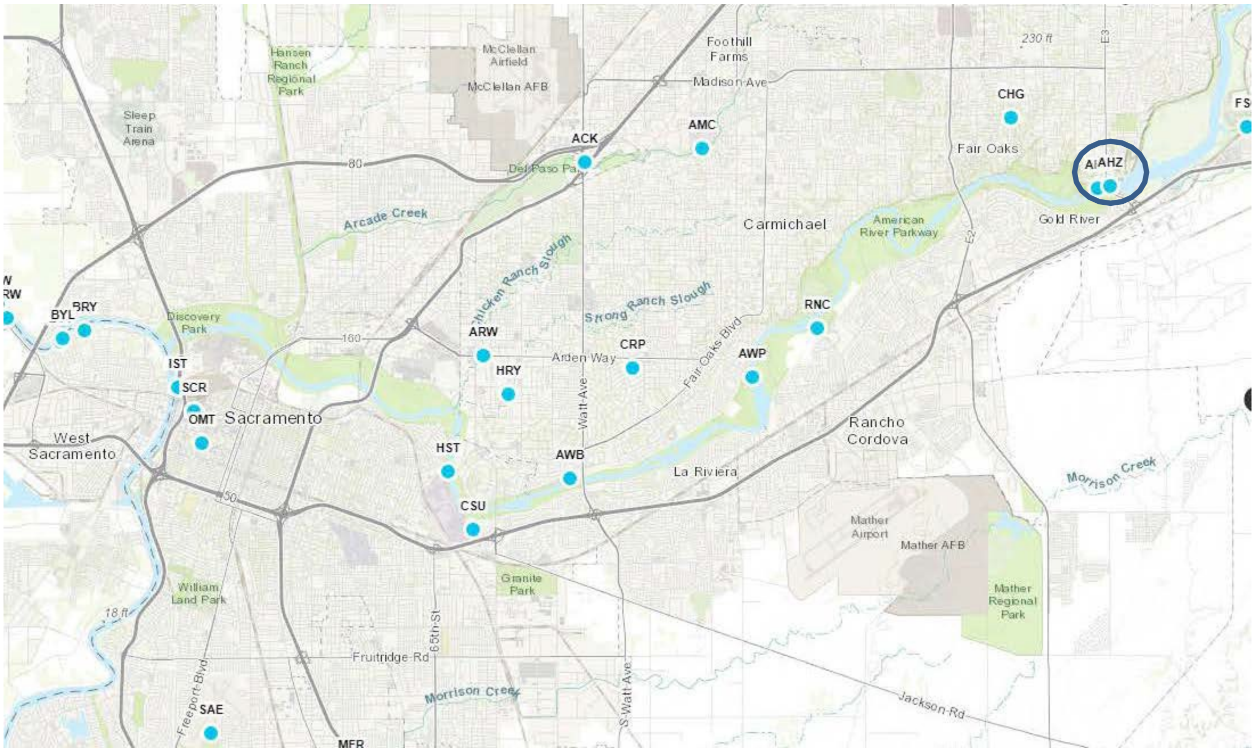

Figure 6. Location of water temperature monitoring station (AFO) at American River at Fair Oaks.

Table 3. Historical Conditions (2001-2021) Folsom Reservoir Cold Water Pool dynamics.

Year	End of May Storage (TAF)	End of May CWP Volume < 58˚F (TAF)	All Upper Shutters Lowered by	End of September Storage (TAF)	End of September CWP Volume < 60˚F (TAF)	Watt Avenue Target (˚F)
2001	696	275	30 Mar	368	30	65-71
2002	822	455	04 Mar	510	50	65-69
2003	962	640	02 Apr	658	135	65-67
2004	635	300	05 Mar	376	30	69
2005	959	705	15 Mar	652	140	65

Year	End of May Storage (TAF)	End of May CWP Volume < 58˚F (TAF)	All Upper Shutters Lowered by	End of September Storage (TAF)	End of September CWP Volume < 60˚F (TAF)	Watt Avenue Target (˚F)
2006	928	670	29 Mar	639	125	65
2007	787	355	21 Mar	323	30	68
2008	617	250	None Lowered	270	25	69-70
2009	933	550	12 Mar	412	60	67
2010	905	580	14 Apr	624	130	66
2011	880 (960-July)	590	28 Mar	740	180	65
2012	926	536	29 Mar	450	60	65-66
2013	734	277	15 Apr	361	50	69
2014	548	200	None Lowered	345	35	70
2015	576	256	None Lowered	174	39	75
2016	826	421	23 Mar	306	27	68
2017	937	558	2 June	664	85	65
2018	955	622	28 Mar	467	56	66
2019	935	605	26 Mar 5 Jun (unit 1 returned to service)	714	89	65
2020	790	366	21 Apr	423	60	68
2021	361	117	None Lowered	230	34	71 *(at AFO)*

From April through November, Reclamation collects temperature profile data in Folsom Reservoir twice a month (essentially every two weeks). For December through March, temperature profiles are taken one time per month at all six locations. The temperature profile data are used to model reservoir and downstream temperatures throughout the temperature control season. This allows Reclamation to determine feasible temperature objectives on the Lower American River. The temperature model is run for every new profile to be able to either confirm that the temperature objectives are still feasible or determine that a change to the temperature plan needs to be made. The temperature compliance location is at Watt Ave for May through October and shifts to the Hazel Ave Bridge location for November. However, during this critical year, the compliance location was moved to Hazel Ave Bridge.

4.4 WY 2021 Operations Under February 2020 ROD

4.4.1 2017 Flow Management Standard Releases and Planning Minimum

The February 2020 ROD is designed to provide minimum required flows for all steelhead life stages, as specified by the 2017 FMS Minimum Release Requirement (MRR). These MRRs are measured as total releases at Nimbus Dam. The 2017 FMS uses two hydrological indices to determine the MRR: American River Index (ARI) and Sacramento Index (SRI). The prescribed flows are minimums only, and do not preclude Reclamation from making higher releases.

Storage and flood control conditions for Folsom Lake are illustrated in Figure 7, which also includes inflow to Folsom Lake and releases at Nimbus Dam for October 2020 through October 2021. Folsom storage at the end of September was 230 TAF.

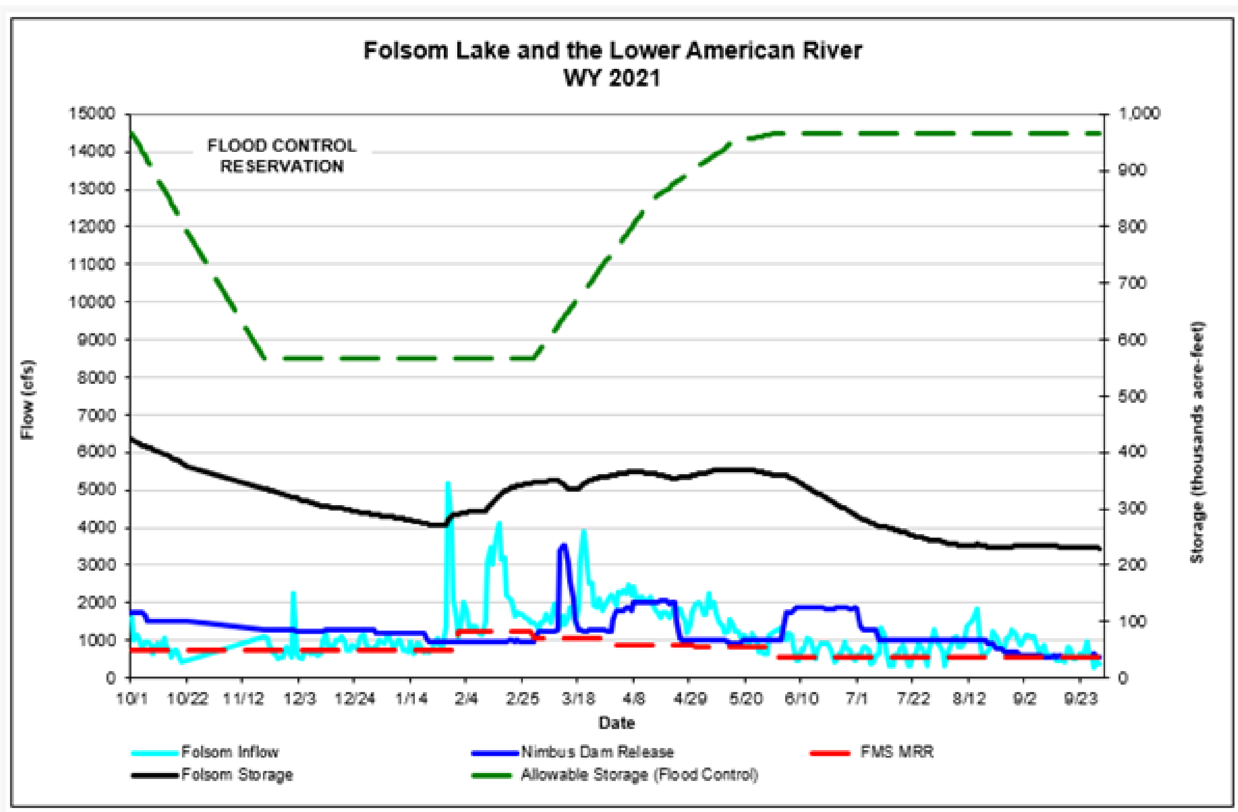

Figure 7. Summary of WY 2020 Folsom Reservoir Storage and Flow Releases from Nimbus Dam to the Lower American River.

The Nimbus Dam releases to the LAR and the prescribed MRRs for WY 2021 are shown in Figure 8.

Table 4 contains a summary of operational release changes from Nimbus Dam. Factors in making flow management adjustments included flood control, storage conservation, fall-run Chinook salmon spawning needs, Delta needs and salinity management and picket installation below Nimbus Dam. Because of concerns about dry hydrology, Reclamation operated to a February 2021 Nimbus release of 950 cfs rather than the MRR of 1,246 cfs, as shown below in Figure 8.

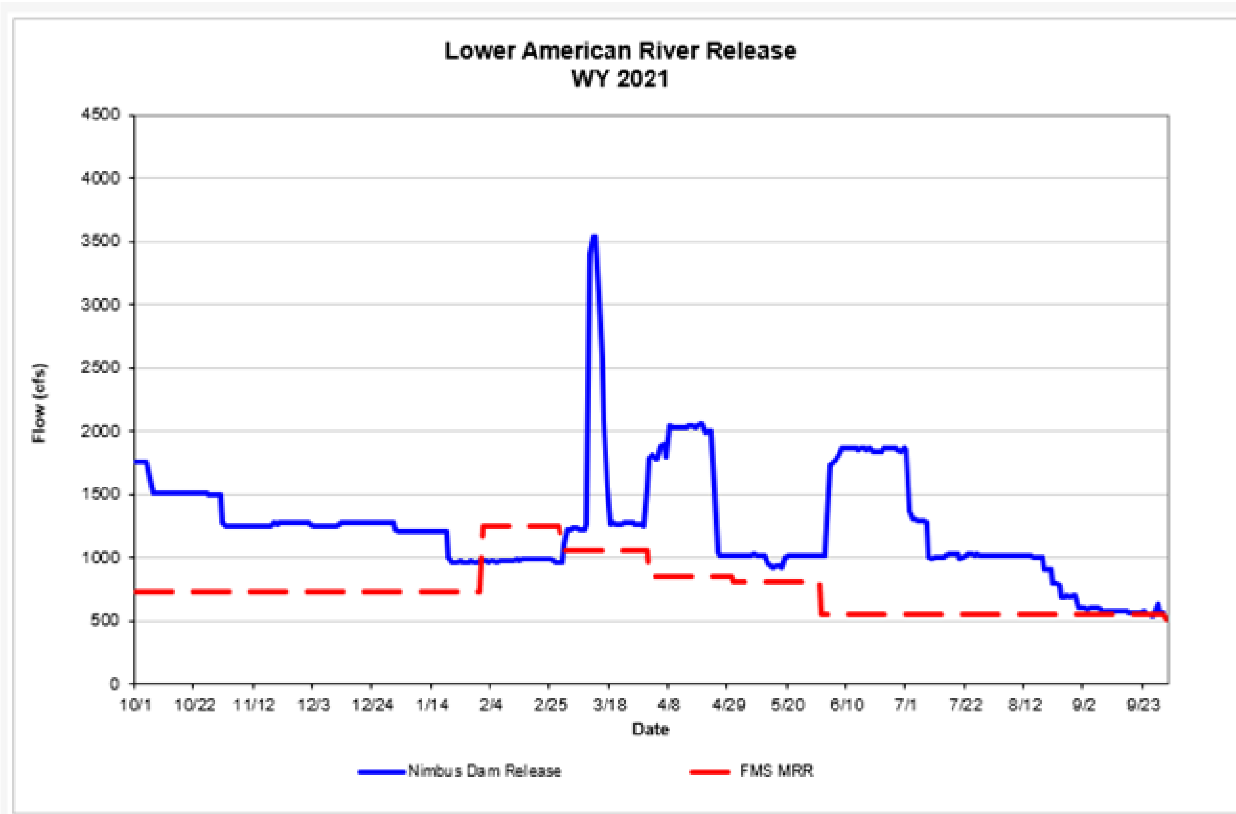

Figure 8. Summary of WY 2021 Nimbus Dam Releases to the Lower American River Releases.

Table 4. Reclamation's WY 2021 Release Changes at Nimbus Dam

Start Date	Release	To (cfs)	Comment
11/1/2020	Decrease	1,250	Fall spawning flows
1/1/2021	Decrease	950	Storage Conservation
3/2/2021	Increase	1,200	Delta Needs
3/11/2021	Increase	3,500	SWRCB D-1461
3/14/2021	Decrease	3,000	SWRCB D-1461
3/15/2021	Decrease	2,500	SWRCB D-1461
3/16/2021	Decrease	2,000	SWRCB D-1461
3/17/2021	Decrease	1,500	SWRCB D-1461
3/18/2021	Decrease	1,200	SWRCB D-1461
3/31/2021	Increase	1,500	SWRCB D-1461 -- Delta Outflow
4/1/2021	Increase	1,750	SWRCB D-1461 -- Delta Outflow
4/8/2021	Increase	2,000	SWRCB D-1461 -- Delta Outflow
4/24/2021	Decrease	1,500	Conserve Storage
4/25/2021	Decrease	1,000	Conserve Storage
5/13/2021	Decrease	900	Conserve Storage

Start Date	Release	To (cfs)	Comment
5/19/2021	Increase	1,000	D-1641 Salinity
6/3/2021	Increase	1,250	Delta Outflow
6/4/2021	Increase	1,750	Delta Outflow
6/7/2021	Increase	1,850	Delta Outflow
7/2/2021	Decrease	1,300	Conserve Storage
7/9/2021	Decrease	1,000	Conserve Storage
8/19/2021	Decrease	900	Conserve Storage
8/22/2021	Decrease	800	Conserve Storage
8/25/2021	Decrease	700	Conserve Storage
8/31/2021	Decrease	600	Conserve Storage
9/9/2021	Decrease	550	Conserve Storage
*10/24/2021	Increase	2,500	Lake Natoma Reservoir Management
*10/25/2021	Decrease	550	Lake Natoma Reservoir Management

*Denotes release changes that occurred after WY 2021 for continuity of operations

4.4.2 Spring Pulse Flows

Spring pulse flows were not required or implemented in Water Year 2021 as part of the February 2020 ROD. Because this was an off-ramp year (i.e., Nimbus releases exceeded the spring pulse flow for more than two days between Feb 1 and March 15) there was no requirement for a separate pulse flow.

4.4.3 Temperature Management Plan

The temperature management plan component in the February 2020 ROD is designed to provide suitable temperatures to support over-summer rearing steelhead in the LAR from May 15 through October 31. Figure 9 is a summary of Reclamation's water temperature operations, from October 2020 through November 2021, at the Watt Avenue Bridge (~RM 9) temperature compliance point. Each year, available water resources and conditions are assessed to develop a temperature management plan. The iCPMM tool is used to generate temperature modeling results which are one component that guides the decision making for the Temperature Management Plan. Model runs incorporate the latest operation's forecast (inflow, outflow and storage) and iteratively select a temperature target based on available resources and a pre-determined habitat balance between steelhead and fall-run Chinook salmon. The selected plan is provided to ARG for comments and recommendations. After the ARG review of the Water Temperature Plan, Reclamation reviews the comments and determines the final plan. The plan is reviewed for potential updates every month based on the latest hydrology and CWP conditions.

Reclamation presented a draft Temperature Management Plan to ARG in May of 2021. On June 30, 2021, Reclamation finalized the WY 2021 Temperature Management Plan which included an iCPMM temperature model run with the objective to achieve a maximum temperature (mean daily) target at Hazel of 71°F. The temperature target of 71°F at Hazel was exceeded on two consecutive days in July. Extreme heat in July complicated efforts to control LAR temperatures. the heat waves were more durable and long lasting than the weather forecasts were able to accurately predict. As a result, multiple changes to river releases (temperature blending) were made until control was re-gained of the LAR in-stream temperatures. As a result, multiple changes in TCD operations were made to regain LAR in-stream temperatures.

The 2017 FMS under the February 2020 ROD includes a temperature management strategy that acknowledges resource needs for the protection of fall-run Chinook salmon spawning. The goal is to achieve cooler water temperatures in October, depending on the availability of remaining CWP resources, and continue through November until active water temperature management is no longer necessary. The onset of seasonal fall cooling in most years occurs in mid-November due to ambient air temperature cooling and decreased day length. As a result, in many years, active temperature management continues after the October 31 end date of the juvenile steelhead temperature management period. After November, cooling the river to temperatures suitable for fall-run Chinook salmon spawning is typically accomplished by raising the lower shutter and releasing water through Folsom Dam's power units. In some years, Reclamation may release water from the lower river outlet gates at a cost to power generation for additional river cooling. A summary of WY 2021 temperature shutter and power penstock blending operations, including power bypass, is provided in Table 5.

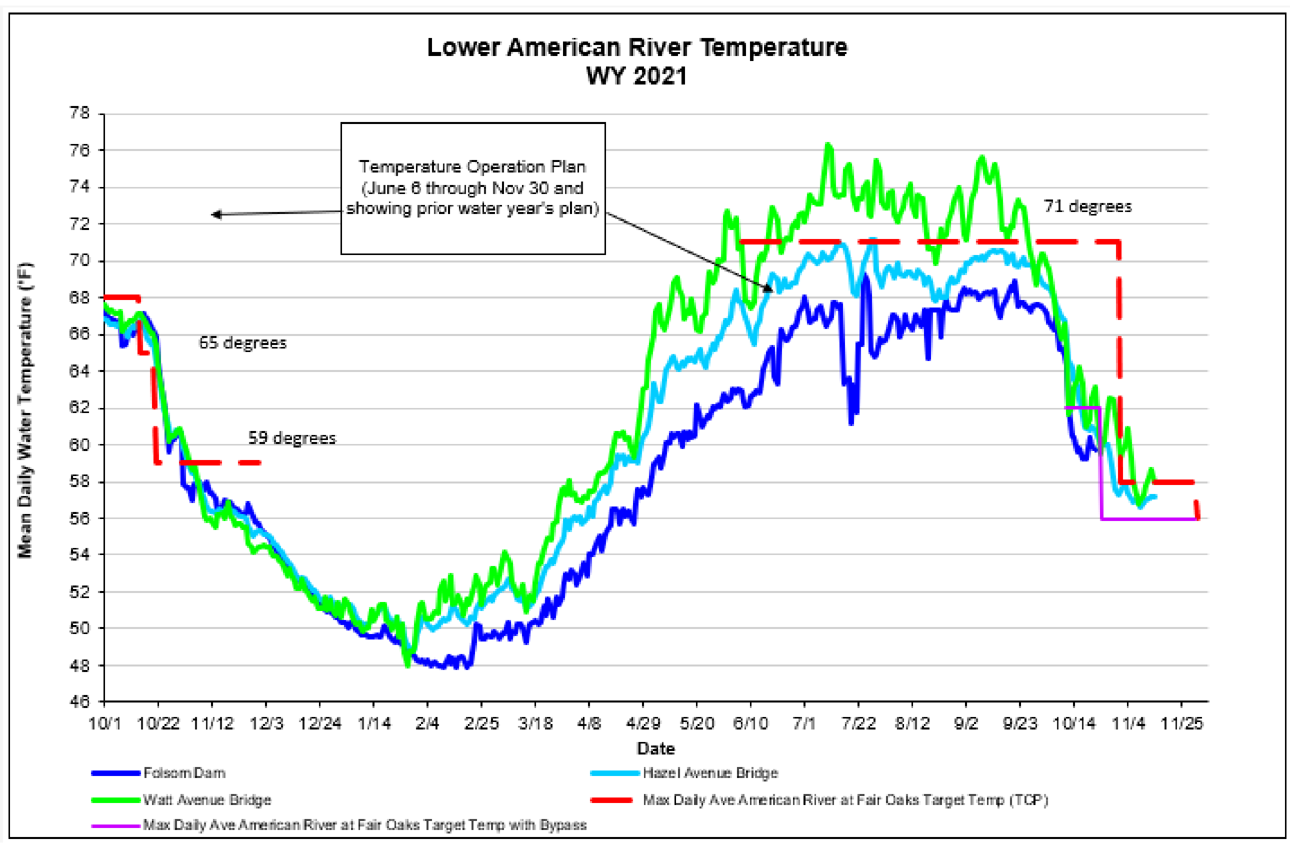

Figure 9. Summary of WY 2021 Water Temperatures in the Lower American River.

Table 5. List of Folsom Dam temperature shutter and power penstock blending operations taken to meet downstream temperature requirements.

Date	Operation
10/13/2020	Effective ASAP please maximize Unit 2 (minimize Unit 1). Note: Temperature control at Watt Ave (decreasing from 68 degrees F to 65 degrees F on Thursday October 15, 2020).
10/14/20	Please schedule the following Shutter Pulls at Folsom Dam: On Wednesday October 14, 2020, please pull the middle shutter on Unit 1 putting it in Configuration 3. After this shutter pull is complete, all blending requirements are canceled. Shutter positions after change: Uppers: all up Middles: all up Bottom: all down Note: Temperature control at Watt Ave
10/19/20	Effective ASAP Monday October 19, 2020, please utilize Unit 1 at 50%. Note: Temperature control at Watt Ave.
10/21/20	Effective ASAP Wednesday Oct 21, 2020 please run Unit 1 at 75% blend. Note: Target 59 degrees F at Watt Ave per revised Temperature Control Plan
10/21/20	Please schedule the following Shutter Pull at Folsom Dam: On Wednesday October 21, 2020 at approximately 0700, please pull the bottom shutter on Unit 2 putting it in Configuration 4. Shutter positions after change: Uppers: all up Middles: all up Bottom: all up Note: Temperature control at Watt Ave, targeting 59 degrees F based on revised Temperature Control Plan.
10/21/20	Effective ASAP Thursday Oct 22, 2020 remove all blending requirements. Note: Target 59 degrees F at Watt Ave per revised Temperature Control Plan
10/28/20 0100 hr	Please make the following power bypass releases from the lower outlet tubes: 100 cfs
10/28/20 1300 hr	Please make the following power bypass releases from the lower outlet tubes: 200 cfs
10/29/20 0100 hr	Please make the following power bypass releases from the lower outlet tubes: 300 cfs
10/29/20 1300 hr	Please make the following power bypass releases from the lower outlet tubes: 400 cfs

Date	Operation
10/30/20 1300 hr	Please make the following power bypass releases from the lower outlet tubes: 500 cfs
10/30/20 0100 hr	Please maintain 500 cfs power bypass until further notice. Note: Implement Power Bypass Temperature Control Plan approved by RD
11/25/20 0100 hr	Please make the following power bypass reduction from the lower outlet tube: From (cfs) To (cfs) 500 250
11/26/20 0100 hr	Please make the following power bypass reduction from the lower outlet tubes: From 250 cfs to 0 cfs Note: Power Bypass Temperature Control Plan ends
2/22/21	On Monday, 02/22/2021, please lower all the Bottom and Middle set of temperature shutters on Penstock Units 1, 2, and 3. Folsom shutter status after changes: Top Shutters: Units 1, 2, & 3 - raised Middle Shutters: Units 1, 2, & 3 - lowered Bottom Shutters: Units 1, 2, & 3 - lowered Comment: Temperature Management
6/18/21	Unit 2 and 3 are deganged and top of the middle are out. Unit 3 has the uppers lifted up. • Unit 3 deganged and top of the middle out on June 18th
6/21/21	Unit 2 and 3 are deganged and top of the middle are out. Unit 3 has the uppers lifted up. • Unit 2 deganged and top of the middle out on the June 21st
6/22/21	Effective ASAP today, June 22, 2021, please run Unit 1 at 50% blend. Note: Target 71 degrees F at Hazel per Temperature Control Plan
6/23/2021	On Wednesday June 23, 2021, please raise the middle shutter on Unit 1. This will put Unit 1 in Configuration 3. Status after change: Upper gates - all up Middle Gates - Units 2 and 3 (Deganged): top panel up, lower panel down, Unit 1 up Lower Gates - all down Note: Elevation requirement
6/23/21	Effective ASAP Wednesday June 23, 2021 please minimize Unit 1 as much as possible. Note: conserving the coldest water by minimizing the coldest unit.
7/2/21	Effective ASAP Friday, July 2, 2021 please run Unit 1 at 20% blend. Note: Target 71 degrees F at Hazel Ave
7/3/21	On Saturday July 3, 2021, a call was made into the CVO control room to please run Unit 1 at a 50% blend. Note: conserving the coldest water by minimizing the coldest unit.

Date	Operation
7/8/21	On Thursday July 8, 2021, please raise the middle lower shutter on Unit 2. This will put Unit 2 in Configuration 3. Status after change: Upper gates - all up Middle Gates - Units 3 (Deganged): top panel up, lower panel down, Unit 1 and Unit 2 up Lower Gates - all down Note: Temperature management
7/8/21	Effective ASAP Thursday, July 8, 2021 please run Unit 1 at 75% blend. Note: Target 71 degrees F at Hazel Ave
7/9/21	This order supersedes the last Folsom Blending order sent yesterday. Effective ASAP Friday, July 9, 2021 please run Unit 1 at 75% and Unit 2 at 25% blend. Note: Target 71 degrees F at Hazel Ave
7/14/21	Effective ASAP Wednesday, July 14, 2021 please run Unit 1 at 50% and Unit 2 at 10% blend. Note: Target 71 degrees F at Hazel Ave
7/14/21	Effective ASAP today, July 14, 2021, please minimize Unit 3 blending. Note: Target 71 degrees F at Hazel Ave
7/16/21	On Friday July 16, 2021, please raise the lower shutters on Unit 1. This will put Unit 1 in Configuration 4. Status after change: Upper gates - all up Middle Gates - Units 3 (Deganged): top panel up, lower panel down, Unit 1 and Unit 2 up Lower Gates - Unit 1 up, and Unit 2 and 3 down Note: Temperature management
7/19/21	On Monday July 19, 2021, please degange Unit 2 bottom shutters and remove the top 1 panel of the bottom shutters. Status after change: Upper gates - all up Middle Gates - Units 3 (Deganged): top panel up, lower panel down, Unit 1 and Unit 2 up Lower Gates - Unit 1 up, and Unit 2 (Deganged): top panel 1 up, lower 2,3,4 panels down, and Unit 3 down Note: Temperature management
7/21/21	On Wednesday July 21, 2021, please lower Unit 1 bottom shutters to configuration 3. Status after change: Upper gates - all up Middle Gates - Units 3 (Deganged): top panel up, lower panel down, Unit 1 and Unit 2 up Lower Gates - Unit 1 down, and Unit 2 (Deganged): top panel 1 up, lower 2,3,4 panels down, and Unit 3 down Note: Temperature management

Date	Operation
7/22/21	Starting on Thursday, July 22, 2021, please run the Folsom units to this daily blending schedule: Unit 1 at 40% Unit 2 at 30% Unit 3 at 30% Note: Target 71 degrees F at Hazel Ave
7/26/21	On Tuesday July 26, 2021, please lift bottom shutters on Unit 1 to configuration 4. Also please lift Middle shutters on Unit 3. Status after change: Upper gates - all up Middle Gates - all up Lower Gates - Unit 1 up (configuration 4), and Unit 2 (Deganged): top panel 1 up, lower 2,3,4 panels down, and Unit 3 down Note: Temperature management
7/27/21	Starting on Tuesday, July 27, 2021, please run the Folsom units to this daily blending schedule: Unit 1 at 20% Unit 2 at 50% Unit 3 at 30% Note: Target 71 degrees F at Hazel Ave
8/8/21	Starting on Sunday, Aug 8, 2021, please run the Folsom units to this daily blending schedule: Unit 1 at 25% Unit 2 at 60% Unit 3 at 15% Note: Target 71 degrees F at Hazel Ave
8/24/21	Starting ASAP on Saturday, Aug 24, 2021, please run the Folsom units to this daily blending schedule: Unit 1 at 60% Unit 2 at 0% Unit 3 at 40% Note: Target 71 degrees F at Hazel Ave, Unit 2 minimized while exciter diagnosis/repair work is completed.
9/7/21	Starting on Tuesday, September 7, 2021, please run the Folsom units to this daily blending schedule: Unit 1 at 10% Unit 2 at 40% Unit 3 at 50% Note: Target 71 degrees F at Hazel Ave
10/11/21	Please make the following power bypass releases from the lower outlet tubes: Date Time cfs 10/11/21 0100 50 10/12/21 0100 100 10/13/21 0100 150 Please maintain 150 cfs power bypass until further notice. Also, starting on October 11, 2021, please prioritize Unit 1 first, then Unit 3 second, and Unit 2 at last priority. Note: Implement Power Bypass approved by RD

Date	Operation
10/13/21	On Wednesday October 13, 2021, please lift Bottom shutters on Unit 3 to configuration 4. Also please lift Bottom shutters on Unit 2 to configuration 4 if time permit. Status after change: Upper Gates - all up Middle Gates - all up Lower Gates - all up Note: Temperature management
10/25/21	Please make the following power bypass releases from the lower outlet tubes: Date Time cfs 10/25/21 0100 250 10/26/21 0100 350 Please maintain 350 cfs power bypass until further notice.

4.5 Summary of American River Operations to Meet Delta Requirements

In the spring, Nimbus Dam (as measured at the AFO[7] gauge on the LAR) releases are held steady (unless Shasta Reservoir is in flood control operations and thus can result in fluctuating demand on Folsom Reservoir) until flows are needed to support instream demands on the mainstem Sacramento River, Delta Outflow and other requirements (refer to Table 4 for Reclamation's WY 2021 Release Changes at Nimbus Dam). CVP releases for Delta Outflow requirements are balanced between Shasta Reservoir and Folsom Reservoir. Shasta Reservoir and Folsom Reservoir are relied upon to meet in-river water temperature control requirements below Keswick Dam and Nimbus Dam later in the season, and both reservoirs need to substantially fill in the spring to fully meet these requirements. Therefore, releases must be carefully balanced to manage storage in each reservoir. An overarching goal for Reclamation when operating the CVP is to fill both reservoirs as much as possible by the end of the flood control season (end of May) while meeting all other authorized project purposes.

[7] Temperature data for the Fair Oaks (AFO) gage can be found here: https://cdec.water.ca.gov/webgis/?appid=cdecstation&sta=AFO

Chapter 5 – Lower American River Biological Monitoring

The monitoring activities described below are currently being implemented on the LAR and include actions which: represent requirements in the NMFS 2009 BiOp, NMFS 2019 BiOp, or 2020 ROD; assist Reclamation in implementing operations pursuant to the NMFS 2009 BiOp, NMFS 2019 BiOp, or 2020 ROD; provide supplemental information; or meet CVPIA specific requirements.

5.1 Monitoring Activities

5.1.1 Steelhead Spawning Surveys

Reclamation contracted with Cramer to conduct bi-weekly steelhead redd surveys. Redd surveys were conducted from Nimbus Dam to Watt Avenue, with the addition of surveys at Paradise Beach every other survey period, covering 18 river miles (Figure 10) (CFS 2021). Surveys began on January 6, 2021 and continued through April 15, 2021. No steelhead redds were observed on the final three surveys. From January 6 to April 15, 2021, a total of 101 new, clear salmonid and Pacific lamprey (*Entosphenus tridentatus)* redds were observed. When possible, redds were assigned to species based on observations of adults of these species within proximity of the redds. Of the 101 new redds, 10 were positively identified in the field as steelhead, and five as Chinook salmon. Of the remaining redds, 86 redds were initially classified as “unknown” because no fish were observed on the redd. Categorization by Discriminant Function Analysis (DFA) led to designation of 46 unknown redds as steelhead, for a total of 56 steelhead redds. Of the remaining 40 unknown redds, four were classified as Chinook salmon and 36 as Pacific lamprey.

Figure 11 shows the 2021 steelhead redd locations (following DFA) and their corresponding discovery dates by survey week. Overall, 11% of steelhead redds during the 2020 surveys were observed at gravel augmentation sites, which is the lowest percentage observed since Cramer began performing surveys in 2015. The percentage of steelhead redds observed at gravel augmentation sites had previously ranged from 27.2% to 50% since 2015. Surveyed redds were recorded from a cataraft, raft, or on foot and plotted using geographic positioning system (GPS) and biometric equipment. Bi-weekly reports summarizing the findings of the steelhead spawning survey were sent to NMFS and survey data were also reported at the monthly ARG meeting.

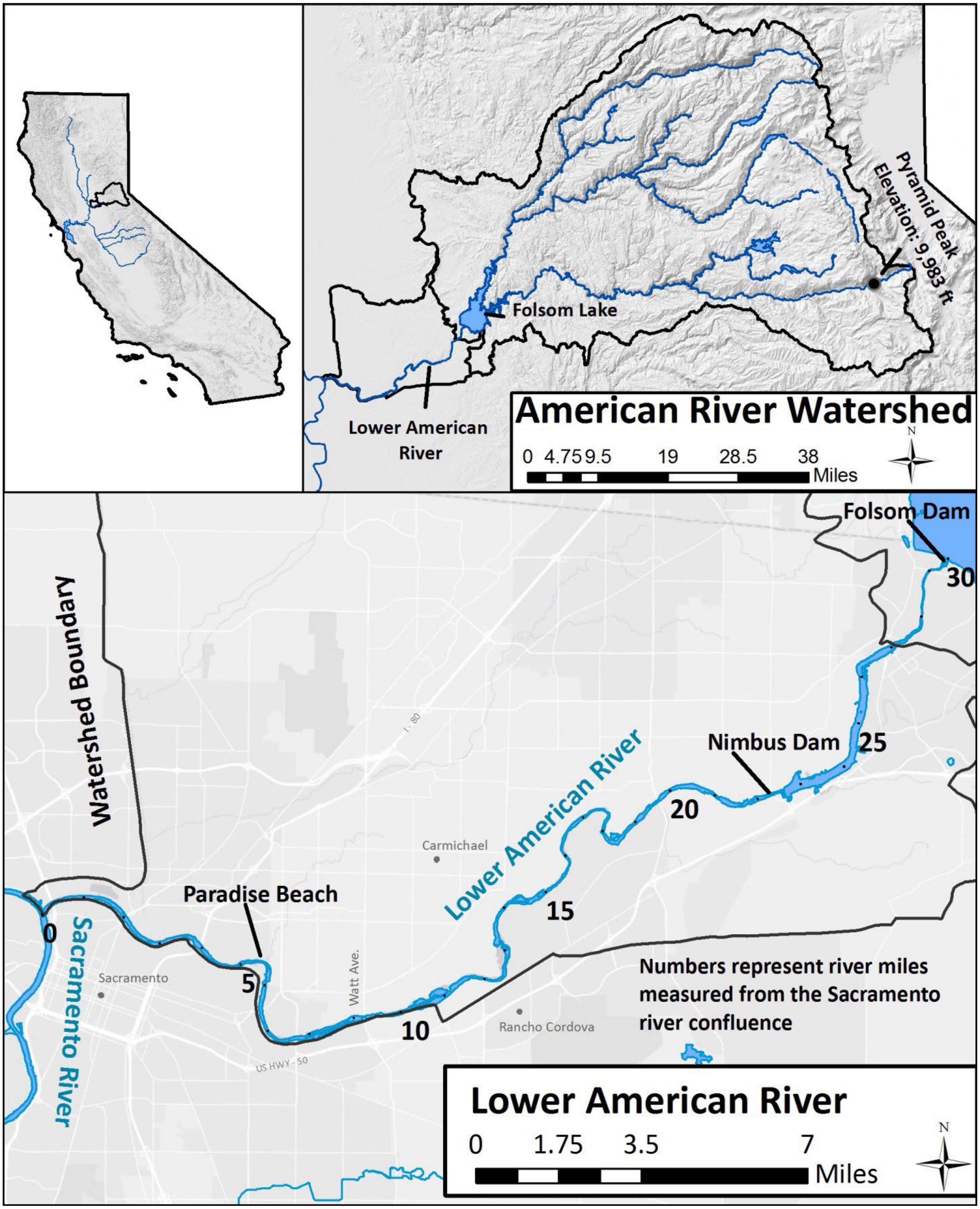

Figure 10. American River steelhead spawning survey reach.

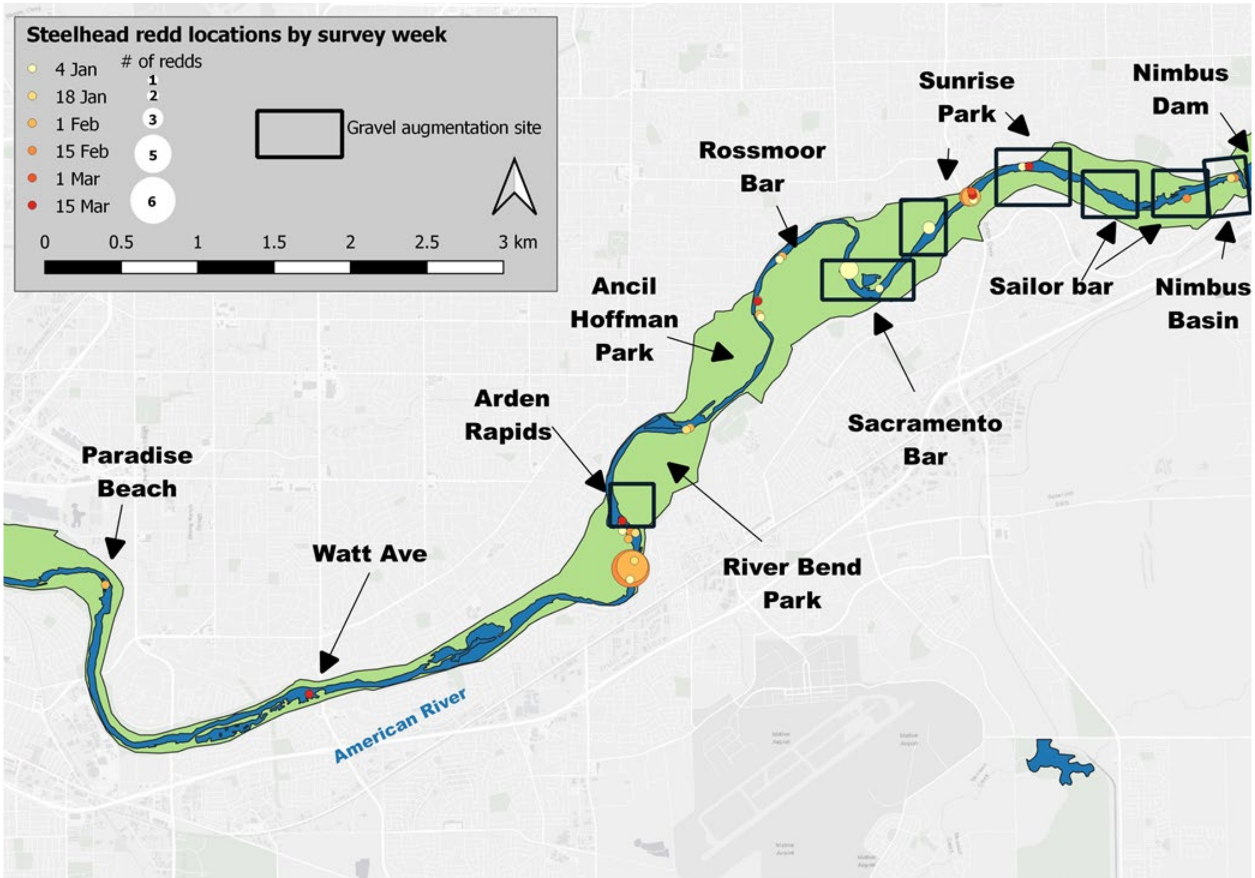

Figure 11. American River steelhead redd distribution and timing in 2021.

5.1.2 Stranding and Isolation Pool Monitoring

Reclamation monitors flow fluctuations in the LAR to assess and reduce dewatering of salmonid redds, and stranding and isolation of juvenile salmonids. Typically, stranding surveys occur under the following conditions: 1) when there is a flow reduction of more than 1,000 cfs when the initial flow is greater than 2,000 cfs or 2) when there is a flow reduction of 250 cfs if the final flow will be below 1,000 cfs. Stranding surveys may also be performed for smaller flow reductions, following discussion with Reclamation and other resource agencies. The purpose of each survey was to determine if steelhead redds and/or juvenile salmonids were stranded in disconnected pools as a result of the flow reduction. Habitat evaluations have identified several locations where isolation of salmonids and other fish species have been observed in the past coinciding with the reduction or fluctuation of flows.

LAR stranding surveys were performed on 20 - 22 January, 18 - 19 March, and 26 - 27 April 2021 between Nimbus Dam and Paradise Beach (Figure 12). When juvenile salmonids were observed, the approximate number and size of fish in the isolated pool were recorded, along with species identification, when possible. Water temperature, dissolved oxygen (DO), and turbidity were recorded in isolated pools that contained stranded juvenile salmonids. A GPS polygon outlining the stranding pool was also recorded to estimate pool area. Survey crews looked for new stranding pools and revisited previous stranding locations during each survey. All fish were captured with a beach seine. All fish captured in the isolated pools were released back into the main channel with assistance from

CDFW. Occasionally some juveniles could not be captured due to dense vegetation, etc. In these cases, fish numbers were estimated visually. If the salmonids were captured with a beach seine they were identified to species. Table 6 summarizes salmonids captured, with steelhead numbers in parentheses. In cases where fish were observed but could not be captured by seine net they generally could not be accurately identified to species.

Table 6. Summary of stranded juvenile salmonids on the Lower American River observed during stranding surveys that occurred March 18-19 and April 26-27 2021. Values reported below are total salmonids; numbers in parentheses below salmonid counts are fish that were positively identified as steelhead.

Date	Categories	Nimbus, above hatchery weir (22)	Upper Sunrise above side channel (21)	Upper Sunrise side channel (21)	Lower Sunrise side channel (19)	Lower Riverbend Side Channel (13)	Below River Bend side channel (13)
18 - 19 March	**# pools**	0	1	1	1	2	0
18 - 19 March	**total area (m²)**	0	466	2,332	16	564	0
18 - 19 March	**total stranded salmonids (steelhead)**	0	199 (18)	373	N/A[1]	327	0
26 - 27 April	**# pools**	1	1[2]	1[2]	0	1[2]	1
26 - 27 April	**total area (m²)**	50	420	60	0	208	161
26 - 27 April	**total stranded salmonids (steelhead)**	1	7 (3)	548 (20)	0	31 (2)	5

Following flow reductions between January 16 and April 27, 2021, isolated pools were observed at six unique locations adjacent to the LAR, covering an estimated area of 3,636 m^2. Within these pools, 1,534 juvenile salmonids were observed; 43 of these were steelhead. Other fish species observed in pools included Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento Sucker (*Catostomus occidentalis*), Three-spined Stickleback (*Gasterosteus aculeatus*), Golden Shiner (*Notemigonus crysoleucas*), Western Mosquitofish (*Gambusia affinis*), Bluegill (*Lepomis macrochirus*), sculpin (*Cottus* sp.), bass (*Micropterus* sp.) and small unidentified Cyprinidae. CDFW staff accompanied Cramer during stranding surveys conducted on March 18-19 and April 26-27 and assisted Cramer with returning stranded salmonids to the LAR main channel on those survey dates. No stranded salmonids were observed during the January 20-22 surveys.

The majority of juvenile salmonid stranding occurred following a flow reduction of 2,550 cfs between 13 – 19 March (Table 6). The flow reduction in March accounted for 60% of all stranded salmonids observed in 2021 (42% of stranded steelhead; 18 total). The remaining 40% of the juvenile salmonid stranding in 2021 occurred in late April following a flow reduction of 1,058 cfs, and 58% of all confirmed steelhead were stranded after this flow reduction.

In March, none of the observed stranding pools reached water temperatures considered to be stressful for juvenile salmonids (above 60.8°F, USEPA 2003; Table 7). However, in April, three stranding pools had stressful temperatures exceeding 60.8°F (Table 7). Two pools containing stranded salmonids were measured between 74.48°F and 79.88°F. Both of these pools were relatively small, shallow, and in an area exposed to direct sunlight for most of the day (Table 7). Additionally, in April one relatively small pool (60 m^2) in the Upper Sunrise Side Channel had low DO conditions (3.02 mg/l), although water temperatures were not at stressful levels (14.1°C; Table 7). A total of 568 salmonids and high numbers of numerous other species were rescued from that pool; the low DO conditions were likely the result of crowded conditions in a small water body. No additional stranding surveys were conducted after April 27 because flows on the lower American River remained stable through the end of May.

Table 7. Summary of environmental data in the observed stranding pools containing stranded juvenile salmonids March 18-19 and April 26-27 2021. Numbers reported are averages across the pools observed within each location. Bolded numbers indicate stressful conditions for juvenile salmonids (USEPA 2003).

Date	Categories	Nimbus, above hatchery weir (22)	Upper Sunrise above side channel (21)	Upper Sunrise side channel (21)	Lower Sunrise side channel (19)	Lower Riverbend Side Channel (13)	Below River Bend side channel (13)
18 - 19 March	**Temperature (°C)**	N/A	12.7	13.8	14.8	12.05	N/A
18 - 19 March	**Dissolved oxygen (mg/l)**	N/A	10.79	11.26	9.06	11.43	N/A
18 - 19 March	**Turbidity (ntu)**	N/A	2.26	2.45	0.56	3.75	N/A
26 - 27 April	**Temperature (°C)**	26.6	17.3	14.1	N/A	14.1	23.6
26 - 27 April	**Dissolved oxygen (mg/l)**	12.9	9.36	3.02	N/A	8.43	9.05
26 - 27 April	**Turbidity (ntu)**	4.64	0.92	2.33	N/A	2.28	0.56

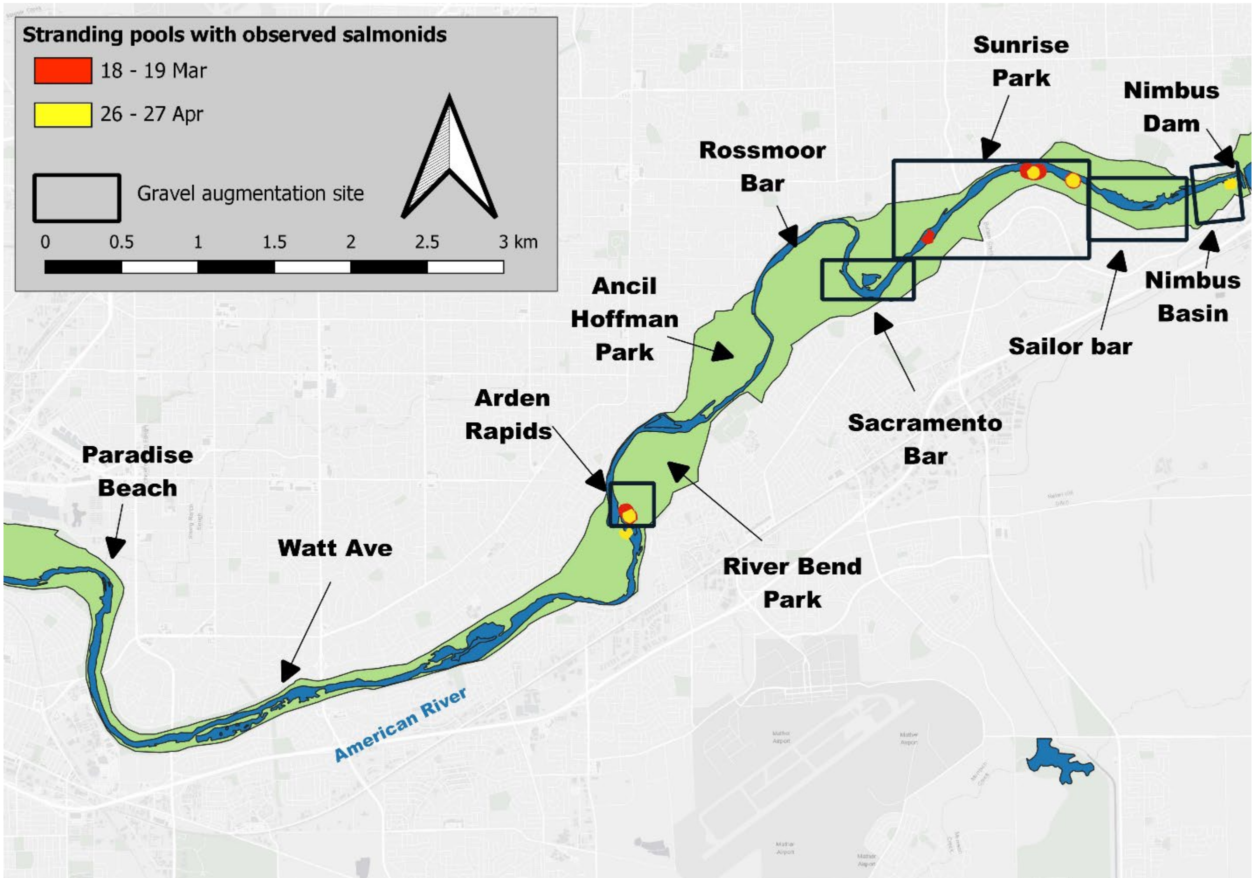

Figure 12. Locations of stranding areas on the Lower American identified March 18-19 and April 26-27, 2021. Stranded salmonids were not observed during the 20-22 January stranding surveys.

5.1.3 Steelhead Redd Dewatering

During stranding surveys, steelhead redds were monitored for dewatering. No steelhead redds were dewatered during 2021 flow reductions.

5.2 Other Monitoring Activities

5.2.1 Rotary Screw Trap

LAR rotary screw trap (RST) operations in 2021 were part of a collaborative effort by the USFWS' Comprehensive Assessment and Monitoring Program (CAMP), PSMFC, and CDFW, and results are reported annually. The primary objectives of the trapping operations are:

1. To collect fork length and weight data for juvenile salmonids;
2. To collect data that can be used to estimate the passage of juvenile fall-run Chinook

salmon; [8] and

3. To quantify raw catch of winter-, spring-, and fall-runs of Chinook salmon and steelhead/rainbow trout.

Sampling for the 2021 survey season began on January 12 and ended on June 4 with 124 days of successful sampling during the 144 day season. Two 8-foot diameter RSTs were deployed into the north channel of the Watt Avenue trapping site in a side-by-side configuration for the 2021 sampling season. Natural origin fall-run Chinook salmon encompassed the majority of all natural origin fish captured (88.62%) with a total of 35,433 determined to be fall-run based on the genetic analysis results. According to the CAMP platform "run_passage" report, which is used to expand catch into a passage estimate, 347,100 [95% CI: 324,000 – 372,800] natural origin fall-run Chinook salmon were estimated to have migrated past the Watt Ave rotary screw traps during the 2021 survey season (Figure 13**).** Daily catch peaked on February 28 when 3,292 natural origin fall-run Chinook salmon were captured. Daily passage estimate peak on February 26 when 27,131 natural origin fall-run Chinook Salmon were estimated to migrate past the rotary screw traps.

In total, 283 natural origin steelhead, 3 natural origin winter-run Chinook salmon and 4 natural origin spring-run Chinook salmon were captured during the 2021 survey season. No genetic analysis was performed on steelhead; however, spring-run Chinook salmon and winter-run Chinook salmon were identified through genetic analysis.

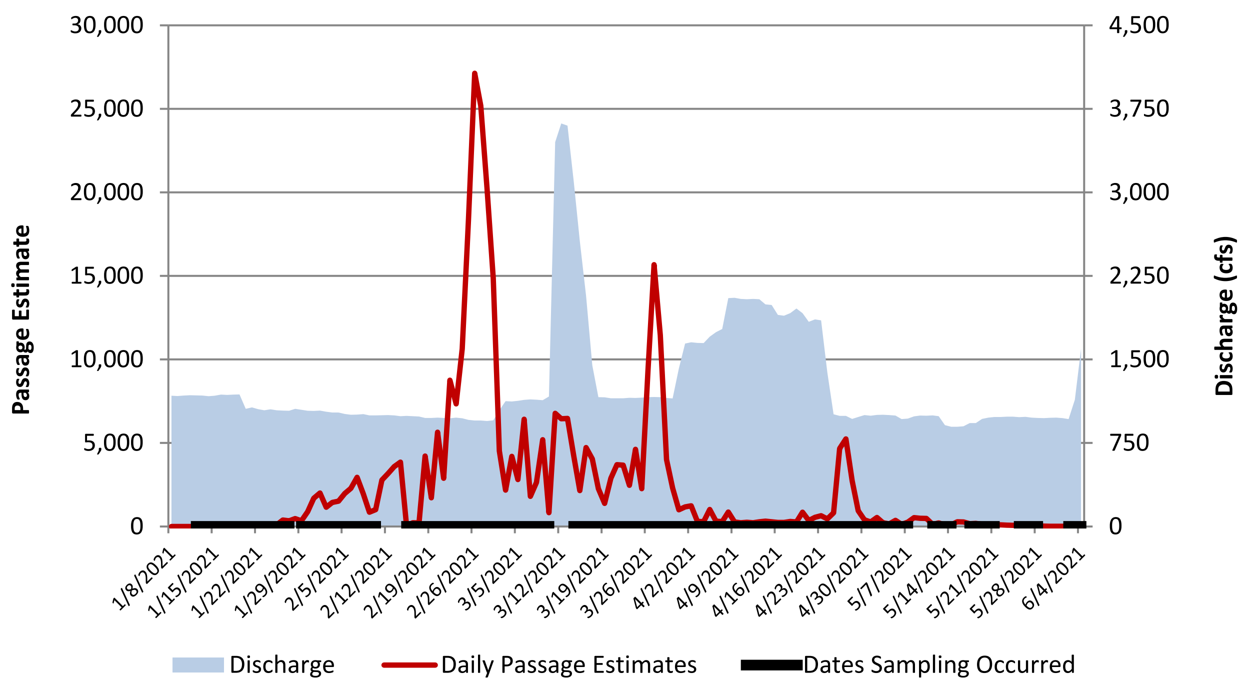

Figure 13: Daily passage estimate of natural origin fall-run Chinook salmon and daily average discharge at Fair Oaks during the 2021 lower American River rotary screw trap survey season.

[8] Passage estimates were created using a mark-recapture spline model in the CAMP RST database platform.

5.2.2 Chinook Escapement Survey

CDFW conducted the Brood Year 2020 LAR fall-run Chinook salmon Escapement Survey over 15 survey periods from October 13, 2020, to January 22, 2021 (CDFW 2021). [9] The 13.5-mile stretch of river from the Nimbus Dam, including Nimbus Weir downstream to Watt Avenue, was divided into six sections and surveyed once during each survey week for salmon carcasses. The objectives of the escapement survey are to:

1. Estimate the size of the fall-run Chinook salmon escapement in the LAR;
2. Determine the ratio of adults to grilse, as well as the sex ratios of adults and grilse;
3. Determine the degree of female pre-spawn mortality; and
4. Collect coded-wire tags (CWT) to investigate the number and origin of hatchery-reared fall-run Chinook salmon using spawning habitat in the LAR.

The 2020 LAR fall-run Chinook salmon in-river escapement estimate is 22,456. In addition to the in-river estimate, 6,264 salmon were trapped at the Nimbus Fish Hatchery for spawning purposes but were not included in the in-river escapement estimate. The carcass crew processed 4,532 carcasses in Nimbus Basin, 986 carcasses on the Nimbus Hatchery Weir, 6,927 carcasses in the area from below Nimbus Hatchery Weir to El Manto Dr access, 535 carcasses in the area extending from El Manto Dr access to River Bend Park, and finally, 52 carcasses in the area from River Bend Park to Watt Ave access.

Coded wire tagged carcasses (adipose fin clipped) comprised 25.5% of the total carcasses observed. Preliminary coded wire tag data revealed that approximately 52% originated from the Nimbus Fish Hatchery, 31% were from the Mokelumne River Fish Hatchery, 6% were from the Feather River Fish Hatchery, and 4% were from the Merced River Hatchery. Coded wire tags were either not recovered or unreadable for 239 (7%) of the adipose fin-clipped carcasses processed.

After carcasses were counted and processed by CDFW, Cramer collected genetic samples and otoliths from approximately 1,450 Chinook salmon carcasses to gather migratory information and to assess spawning success at gravel augmentation sites.

5.2.3 Other Monitoring

Additional project specific fisheries monitoring is being conducted to evaluate spawning and rearing habitat restoration projects. This monitoring includes river-wide Chinook salmon redd surveys, ground-based redd surveys at project sites, an assessment of juvenile use of various types of habitat structure, environmental DNA and video monitoring to assess presence and distribution of Chinook salmon and steelhead under 2021 late summer drought conditions, temperature monitoring, and comparisons of habitat availability before and after restoration implementation projects. A structured decision-making process is being used to determine future project types and identify monitoring needs.

[9] Lower American River Fall-run Chinook Salmon Escapement Survey October 2020-January 2021 can be found here: https://www.calfish.org/portals/2/Programs/CentralValley/LAR/docs/2020_LARC_Report.pdf

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Attachment A

American River 2017 Flow Management Standard, Planning Minimum & Spring Pulse Flow Guidance Documents

GUIDANCE DOCUMENT
LTO 013
American River 2017 Flow Management Standard, Planning Minimum & Spring Pulse Flow
LTO Implementation
October 7, 2021

I. PURPOSE

This document provides implementation guidance on the American River 2017 Flow Management Standard (FMS) approach proposed by the Water Forum in 2017 as identified in the document titled "Lower American River – Standards for Minimum Flows" dated December 2018, and further modified in the document titled "The 2017 Flow Management Standard Minimum Release Requirement" dated March 2020 (Attachment 1). The scope of guidance includes the deliverables, schedule, and processes of the American River Group (ARG) Technical Team to implement the FMS as analyzed in the Proposed Action; develop and implement the Planning Minimum; and implement the Spring Pulse Flow when applicable. The primary deliverables are ARG meeting notes and handouts that include a monthly summary, and more frequent summary if needed, of the system-wide hydrologic, operational, regulatory requirement compliance, flood control, and temperature data related to the implementation and objectives of the FMS, Planning Minimum and Spring Pulse Flow and associated implementation plans. ARG feedback on these topics will be solicited, discussed and considered by Reclamation. Reclamation intends to work with the Water Forum in collaboration on determining and implementing an appropriate planning minimum and will confer with the California Department of Fish and Wildlife (CDFW), the US Fish and Wildlife Service (USFWS), and NMFS on planning minimum discussions.

II. 2017 FMS, Planning Minimum & Spring Pulse Flow

This section provides the applicable verbatim language for American River Division 2017 FMS, Planning Minimum and Spring Pulse Flow.

Erratum:

- Section: "4.10.4.1 Seasonal Operations" of the BA
  - *Corrected language:* Reclamation proposes to follow the 2017 Flow Management Standard, which includes a pulse flow event at some time during the period extending from March 15 to April 15 by supplementing normal operational releases from Folsom Dam under certain conditions when no such flow event has occurred between the preceding February 1 and March 15 timeframe.

Proposed Action:

4.10.2 American River Division

[…] Reclamation proposes to meet water rights, contracts and agreements that are both specific to the American River Division as well as those that apply to the entire CVP, including the Delta Division. For lower American River flows (below Nimbus Dam), Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in 2017 in the document titled "Lower American River – Standards for Minimum Flows" dated December 2018. Flows range from 500 to 2000 cfs based on time of year and annual hydrology. The flow schedule is intended to improve cold water pool and habitat conditions for Steelhead and Fall-

Run Chinook Salmon. Specific flows are determined using an index intended to define the current and recent hydrology. Although Reclamation has assumed the index proposed by the Water Forum in 2017 for the purposes of modeling and analysis within this biological assessment, Reclamation intends to continue discussions with the Water Forum to ensure the index used for implementation is appropriate to meet the intended objectives under continuously changing hydrology.

Reclamation proposes to work together with the American River water agencies to define an appropriate amount of storage in Folsom Reservoir that represents the lower bound for typical forecasting processes at the end of calendar year (the "planning minimum"). The planning minimum brings Reclamation's forecasting process together with potential local actions that either increase Folsom storage or reduce demand out of Folsom Reservoir. The implementation of a planning minimum allows Reclamation to work with the American River Group to identify conditions when local water actions may be necessary to ensure storage is adequate for diversion from the municipal water intake at Folsom Dam and/or the extreme hydrology presents a risk that needs to be properly communicated to the public and surrounding communities. This planning minimum will be a single value (or potentially a series of values for different hydrologic year types) to be used for each year's forecasting process into the future. The objective of incorporating the planning minimum into the forecasting process is to provide releases of salmonid-suitable temperatures to the lower American River and reliable deliveries (using the existing water supply intakes and conveyance systems) to American River water agencies that are dependent on deliveries or releases from Folsom Reservoir.
This planning minimum was defined in 2019 and will be continuously evaluated between Reclamation and the Water Forum throughout implementation.

Reclamation expects infrequent scenarios where the forecasted storage may fall below the "planning minimum" due to a variety of circumstances and causes. In those instances, Reclamation and the American River water agencies will develop a list of potential off-ramp actions that may be taken to either improve forecasted storage or decrease demand on Folsom Reservoir. In its forecasting process for guiding seasonal operations, Reclamation will plan to maintain or exceed the planning minimum at the end of the calendar year. Reclamation has no legal liability should it fall below the planning minimum. When Reclamation estimates, using the forecasting process, that it would not be able to maintain Folsom Reservoir storage at or above the planning minimum for that year type (such as in extreme hydrologic conditions) or unexpected events cause the storage level to be at risk, American River water agencies would coordinate with Reclamation to identify and implement appropriate actions to improve forecasted storage conditions, and the American River water agencies would work together to educate the public on the actions that have been agreed upon and implemented and the reasons and basis for them. If potential changes to Folsom Dam operations would have impacts on other aspects of the CVP and SWP or the entire integrated system, Reclamation will meet and discuss these potential changes and impacts with water contractors.

Reclamation will continue to work with the American River Group, a group that includes federal, state, and local agencies, water users, and NGOs, to coordinate spring pulse flow timing and communicate upcoming releases.

Reclamation would ramp down to the revised minimum flows from Folsom Reservoir as soon as possible in the fall and maintain these flows, where possible.

4.10.4.1 Seasonal Operations

In the winter and spring, flood control releases typically dominate the flow regime in the American River Division. Flood control operations occur to safely pass large storm events without exceeding the identified downstream levee capacity. This includes making dry-weather releases to ensure that the maximum storage adheres to the flood control elevation identified in the applicable Water Control Manual.

As part of implementing the 2017 Flow Management Standard, Reclamation proposes redd dewatering protective adjustments to limit potential redd dewatering due to reductions in the minimum release during the January through May period. Redd dewatering protective adjustments should limit the amount of dewatering due to a reduction of the minimum release, not the actual river release, and, as such, would not always minimize dewatering impacts to the same extent. In January and February, there is a Chinook Salmon redd dewatering protective adjustment, and in February through May there is a Steelhead redd dewatering protective adjustment.

During non-flood control operations within the fall and winter months, Reclamation proposes to operate to build storage by making minimum releases and capturing inflows, although drier conditions may also require releases for Delta requirements. To the extent possible, releases will be held relatively consistent to minimize potential redd dewatering.

Spring releases will be controlled by flood control requirements or, in drier hydrology, Delta requirements and water supply. Reclamation proposes to operate Folsom Dam in a manner designed to maximize capture of the spring runoff to fill as close to full as possible. Reclamation proposes to follow the 2017 Flow Management Standard, which includes a pulse flow event at some time during the period extending from March 15 to April 15 by supplementing normal operational releases from Folsom Dam under certain conditions when no such flow event has occurred between the preceding February 1 and March 1 timeframe. In addition to the pulse flow under the 2017 Flow Management Standard, to the extent feasible, Reclamation proposes to accommodate additional requests for spring pulse flows by re-shaping previously planned releases; however, these requests will not be accommodated in times when they may compromise temperature operations later in the year. This spring pulse flow provides a juvenile salmonid emigration cue before relatively low flow conditions and associated unsuitable thermal conditions later in the spring, and downstream in the lower Sacramento River.

Reclamation proposes to continue to make summer releases for instream temperature control, Delta outflow, and exports, typically above the planning minimum flows. By late October, it is typical for Folsom Reservoir to have depleted the cold water pool. The primary way to provide additional instream cooling is to release water from the lower outlet works. This operation bypasses the power penstocks and has a significant impact on power generation. In order to optimize power generation, Reclamation proposes to limit power bypass operations solely to respond to emergency or unexpected events or during extreme drought years when a drought emergency has been declared by the Governor of California.

Reclamation will ramp down releases in the American River below Nimbus Dam as follows in Table 4-12 below.

Table 4-12: American River Ramping Rates

Lower American River Daily Rate of Change (cfs)	Amount of decrease in 24 hrs (cfs)	Maximum change per step (cfs)
20,000 to 16,000	4,000	1,350
16,000 to 13,000	3,000	1,000
13,000 to 11,000	2,000	700
11,000 to 9,500	1,500	500
9,500 to 8,300	1,200	400
8,300 to 7,300	1,000	350
7,300 to 6,400	900	300
6,400 to 5,650	750	250
5,650 to 5,000	650	250
<5,000	500	100

Ramping rates do not apply during flood control or if needed for facility operational concerns. The working groups may also determine a need for a variance.

Appendix C –

C.7 DECISION MAKING

Nothing in this Charter modifies the rights and responsibilities of the Participants. Decisions shall be made consistent with the authorizing legislation and the regulations and policies under the federal and state Endangered Species Acts, as appropriate.

Reclamation and DWR shall retain sole discretion for:

- Water Operations of the CVP and SWP, including Allocations, under Reclamation Law and the State Water Project, as appropriate
- Agency Appropriations (budget requests, fund alignment, contracting, etc.)
- Section 7 Action Agency and Applicant (consultation)
- Coordination and cooperation with PWAs as required by Contracts and Agreements

CDFW, FWS, and NMFS shall retain sole discretion for:

- Consultation under Section 7 of the federal ESA and California Fish and Game Code, as appropriate and the associated Incidental Take Statements/Permits
- Agency Appropriations

NMFS ITS:

13.3.3.2 Take Anticipated from Flow Management

Flow fluctuations in the lower American River may result in steelhead redd dewatering and isolation. Redd dewatering can affect salmonid eggs and alevins by impairing development and causing direct mortality due to desiccation, insufficient oxygen levels, waste metabolite toxicity, and thermal stress. Flow fluctuations are also reasonably expected to result in the stranding of juvenile CCV steelhead in isolated pools where desiccation, insufficient oxygen levels, thermal stress, or predation would lead to mortality.

The flow regime of a water body is defined by its flow magnitude, timing, duration, frequency, and rate of change. Literature reviews have shown that useable habitat and fish abundance, diversity, and demographic rates can decline in response to both elevated and reduced flow magnitude. Because of the causal relationship of flow magnitude, timing, duration, frequency, and rate of change to survival within and between life stages, flow may be used as a surrogate for the amount or extent of take for listed salmonids.

The ecological surrogate to define the amount or extent of take for CCV steelhead egg-to-fry is the extent of egg habitat that is dewatered and exposed to the stressors from lower flows from January through May.

The ecological surrogate to define the amount or extent of take of CCV steelhead juvenile life stages is the ramping rate that results in isolation. Take will be exceeded if flow decreases occur at a rate greater than the ramping rates described in the proposed action, with the exception of flood control or emergency conditions.

The ecological surrogate to define the amount or extent of take of CCV steelhead egg-to-fry life stage from redd scouring is flow magnitude and rate created by releases from Nimbus Dam during egg incubation (i.e., January through May). Take will be exceeded if flows are higher than 50,000 cfs in the American River during January to May with the exception of flood control or emergency conditions.

RPM 3: Reclamation shall minimize the impact of the amount or extent of incidental take of listed species during operations of the American Division.

a. Seasonal operational decisions that affect water temperature and river flows shall be coordinated through the American River Group.

III. DELIVERABLES

Deliverables resulting from this effort follow the coordination described in Appendix C of the Proposed Action and include regularly scheduled and ad hoc ARG meeting notes and handouts that include a summaries of the system-wide fisheries, hydrologic, operational, regulatory requirement compliance, flood control, and temperature-related data that may affect implementation of the FMS as analyzed in the Proposed Action, planning minimum and spring pulse flow. Additional items will be included as needed related to any ad hoc ARG meeting. A sample ARG monthly and ad hoc meeting agenda (BOX 1) is attached that describes the expected meeting topics and contents for the meeting notes. Section IV A and B herein describe the processes to achieve the deliverables.

IV. PROCESS

A. American River Group

Reclamation will convene and facilitate ARG monthly meetings and ad hoc meetings, as needed, to include:

- meeting scheduling and coordination,
- agenda development and distribution,
- coordinate preparation of monthly meeting handout materials,
- take notes, and
- posting notes and reports (including annual reports) online

Reclamation established a working group to coordinate fishery and operational requirements for the lower American River (LAR), known as the ARG, in 1996. Reclamation is the lead coordinator of the ARG, bringing together those who have either a legislated or resources-specific interest in the operation of Folsom Dam and Reservoir, and the LAR. The formal members include Reclamation which has responsibility for water operations of the Central Valley Project, the Water Forum which has interests in Folsom Reservoir water operations, and agencies with public trust responsibilities for fisheries resources in the LAR which include USFWS, NMFS, and CDFW. Members of the public and other agencies may attend ARG meetings and comment on matters under consideration by the ARG. The ARG meetings include discussion of water operations, fisheries, and other environmental concerns and to share operational and biological information with the goal of improving the technical understanding of LAR temperature needs and operational constraints and considerations. Reclamation considers the provided information when making operational and management decisions regarding temperatures and flows necessary to sustain fish resources in the LAR. In addition, temperature is a factor that may impact FMS implementation, the planning minimum and spring pulse flow. Temperature Management is acknowledged here and will be developed in a separate guidance document.

The ARG will provide input on, among other items, Reclamation's monthly forecasting and outlooks, projected end-of-year Folsom storage compared to the planning minimum, ramping rates, monthly minimum release requirements (MRR), spring pulse flow, proposed monthly operations and potential impacts. Release discussions are expected to consider both near-term and long-term perspectives, risks, and tradeoffs. MRR provides a minimum flow value, not a maximum, and real-time conditions will dictate operations. The general steps of this process are as follows:

1. Prior to the ARG meetings, Reclamation will send to ARG a meeting agenda along with other supporting meeting materials (including temperature management updates, potential spring pulse flow and exceedance outlooks).
2. At the ARG meetings, ARG will review available hydrological and biological information along with exceedance outlooks and the details associated with the

calculations of the MRR (adjusted MRR, if applicable) and potential spring pulse flow for FMS implementation.[1]

3. ARG feedback will be solicited, discussed, and considered by Reclamation.
4. ARG Meeting notes will be generated, and a draft distributed to the ARG for review and comment before final notes are posted online along with pertinent meeting materials.
5. Reclamation, at monthly meetings, will provide updates on previous monthly FMS implementation for monthly operations (and how it relates to the planning minimum, redd dewatering[2], temperature management, ramping rates, spring pulse flows, etc.). ARG meeting notes will be made available to the Water Operations Management Team (WOMT).

B. ARG Ad-hoc meetings.

The formal members of the ARG conduct ad hoc meetings to discuss regularly occurring Folsom Reservoir operations that do not conform to the time step of the monthly ARG meeting or require discussion beyond the time allotted for the monthly ARG meeting. The purpose of these meetings is the same as the monthly ARG meetings. This information is then used to make recommendations to avoid and minimize impacts to fisheries resources based on real-time operations, consistent with Reclamation's need to balance other project purposes. Annual Folsom Reservoir operations identified in the USBR PA Section 4.10.4.1 Seasonal Operations that may require additional meetings and associated meeting timeframes include but are not limited to the following:

1. Flood Control Operations, August – May: Dry weather releases to ensure that the maximum storage adheres to the flood control elevation identified in the applicable Water Control Manual. Although, 2017 FMS redd dewatering protective adjustments would theoretically limit the amount of dewatering due to a reduction of the minimum release, the impact of flow reduction from actual river releases for flood control elevation or other purposes would not result in reduction of dewatering impacts to the same extent. These changes in releases for flood control regularly occur between monthly ARG meetings and may require discussion to develop releases strategies, to the extent possible, to releases to minimize redd dewatering, fish stranding, and other flow related fisheries impacts while meeting other Folsom Reservoir purposes.

2. Downstream Regulatory Requirements, September – June: Folsom Reservoir operations require releases for Delta regulatory requirements and other downstream needs that are above the 2017 FMS as analyzed in the Proposed Action. These changes in releases regularly occur between monthly ARG meetings and may require discussion to develop

[1] Reclamation proposes to use the combined Sacramento Index (in the month of January) and American River Index (all other months) approach specified in the 2017 FMS. The Planning Minimum for WY21-WY23 is 300 TAF.
[2] Reclamation intends to implement redd dewatering protective adjustments. These adjustments are modifications to the MRRs based on hydrology and potential dewatering impacts to Chinook salmon redds in January – February and steelhead redds in February – March. These protective adjustments are built into the 2017 FMS.

releases strategies, to the extent possible, to minimize redd dewatering, fish stranding, and other flow related fisheries impacts while meeting other Folsom Reservoir purposes.

3. Spring Pulse Planning, February – May: Spring pulses under the 2017 FMS as analyzed in the Proposed Action may require discussion and planning outside of the time allotted for monthly ARG meetings. Spring pulse planning should prioritize real-time empirical fisheries data and account for real time Folsom Reservoir operations to meet system-wide regulatory requirements to optimize benefits of spring pulse flows while also considering modeled or other information. This planning should be initiated in February and continue through May in conjunction with other potential ARG ad-hoc discussions.

4. Temperature Management, April – November: Temperature management for juvenile steelhead rearing and fall-run Chinook salmon spawning, egg incubation and fry emergence affects Folsom Reservoir release operations. Further discussion of temperature management implementation is contained in the ARG Temperature Management Guidance Document.

C. Folsom Planning Minimum

Reclamation and the Water Forum worked to develop an initial planning minimum (end of December Folsom Storage) of 300 TAF for Water Years 2021-2023 that is considered by Reclamation for monthly forecasting purposes. The Water Forum will provide input on, among other items, Reclamation's monthly forecasting and outlooks, projected end of year Folsom storage compared to the planning minimum and potential local actions that either increase forecasted Folsom storage or reduce demand out of Folsom Reservoir, if needed. Reclamation/Water Forum coordination and communication is detailed in the March 2021 MOU for Coordination of Communication and Information-Sharing Activities Related to the Lower American River Operations.

D. Change Orders

Reclamation operators coordinate the daily operation of Folsom and Nimbus Dams. Changes to releases in LAR operations require at least 48 hours prior notice to any desired releases. However, under conditions of urgent need with appropriate coordination with ARG and the fisheries agencies, Reclamation may make release changes as quickly as real-time. Reclamation intends to continue to provide change order information via email to the ARG.

E. Water Operations Management Team

After the ARG provides input on Reclamation operations under the FMS, at monthly ARG meetings or otherwise, and Reclamation has captured previous months operations, Reclamation will provide this information to WOMT and make notes and other pertinent material available from the corresponding ARG monthly meetings.

E. Updates to Guidance Document

In addition, it is expected that as this guidance is being implemented there will be necessary revisions to the document to provide further clarification and refinement. Reclamation and DWR, with technical assistance from the USFWS, NMFS, and CDFW, commit to reviewing this implementation guidance following each water year, at a minimum, to identify and incorporate any necessary revisions.

BOX 1: AMERICAN RIVER GROUP AGENDA

Date

Roster

Agency, Office, Name, Alternate(s)

Topics

1. Introductions
2. Presentation (if applicable)
3. Housekeeping
4. Fisheries Update
    a. CDFW
    b. CFS
    c. PSMFC
5. Operations Forecast
    a. SMUD
    b. PCWA
6. Central Valley Operations
    a. Operations review and outlook (storage conditions and releases)
    b. Temperature management
7. Discussion
8. Recommendation(s)
9. Decision(s)
10. Review Action Items
11. Next Meeting Scheduling

ATTACHMENT 1

The 2017 Flow Management Standard Minimum Release Requirement

MARCH 2020 (as amended)

The 2017 Flow Management Standard Minimum Release Requirement

In response to the 2012-2016 drought, uncertainty about Reclamation operations with the implementation of the Water Fix, observations during operations for the 2007 Flow Management Standard (FMS), and NMFS's directive for improved American River water temperature management in its 2009 Biological Opinion, and 2011 amendments, for the CVP's operations, the Water Forum developed the 2017 FMS to provide improved American River water supply reliability and water temperature management for fisheries. Among the elements of the 2017 FMS was a revised approach for determining the Minimum Release Requirement (MRR) from Nimbus Dam. This document summarizes the determination of the MRR.

1 Hydrological Indices

The 2017 FMS uses two hydrological indices to determine the MRR. Those two indices are described below.

1.1 Sacramento River Index

The Sacramento River Index (SRI), published by DWR at the start of each month from December through May, is a forecast of total water year unimpaired flow volume from the Sacramento River above Bend Bridge, Feather River at Oroville, Yuba River near Smartsville, and the American River below Folsom. Forecasted 99%, 90%, 75%, 50%, 25%, and 10% exceedance probability volumes are computed for each forecast. The 2006 FMS used the 75% exceedance SRI to determine January and February minimum release requirements; the 75% exceedance SRI has been retained for use under the 2017 FMS for determining the January MRR. The SRI can be found at Department of Water Resources California Data Exchange Center. Historical SRI values can be found in the MRR Calculator on the "Hist_SRI" worksheet.

1.2 American River Index

To determine the February through December MRRs, the Water Forum wanted to use a water supply index that was publicly available, published each year, updated monthly, and that would reflect the overall water availability of the American River watershed. After considering other available indices, the Water Forum developed the American River Index (ARI), based on the B120 unimpaired water year forecasts. Historical Bulletin 120s for the American River at Folsom can be found in the MRR Calculator on the "Hist_B120" worksheet. DWR also publishes the Bulletin 120 at Department of Water Resources California Cooperative Snow Survey.

The ARI is a measure of the unimpaired inflow to Folsom Reservoir minus the amount of "spill" water that could not be captured at Folsom Reservoir (unimpaired runoff minus spill flows). The ARI is based on the median B120 forecasted unimpaired American River flow at Folsom for the water year, published on February 1, March 1, April 1, and May 1. Flood releases for the water year prior to the B120 publication are subtracted from the water year forecast; winter and spring storage is typically restricted by the flood reservation space, and any water that is released for flood management purposes is not available for use in meeting either water supply or flow requirements.

For purposes of determining spill volume, releases from the spillway and from the river gates between October 1 and the forecast data are added up. Note that only releases from the river gates for avoiding reservoir spills, not releases used for temperature control in the fall or other discretionary releases should be considered. The CDEC timeseries for Folsom Reservoir sensor 85 (Discharge, Control Regulating) and 71 (Discharge, Spillway) are used to characterize the flood releases, when storage is within 50,000 acre-feet of the top of conservation (determined by CDEC sensor 94 – Reservoir, Top of Conservation Storage). Historical CDEC data for Folsom Reservoir storage, spillway releases, river outlet releases, and the top of conservation can be found in the MRR Calculator on the "CDEC Data" worksheet.

The MRR Calculator includes the ARI calculation on the “ARI Calculation” worksheet.

2 Minimum Release Requirements

As indicated above, the two hydrologic indices are used to compute the MRR from Nimbus Dam. The inflection points and corresponding index values for the MRR curves were developed through iteration; while the target flows were identified based on biological effects. Each of the curves are described below.

With the release of the first Bulletin 120 in February and each subsequent update, a calculation of the MRRs through the end of December can be made. The final calculation of MRRs for the remainder of the year would be made in May. The MRR Calculator includes calculation of MRRs through the end of the year on the “MRR Forecast” worksheet, with the intent that they are used for operations planning purposes.

2.1 January

As described above, determination of the January MRR uses the 75% exceedance January 1 SRI forecast value. Figure 2-1 shows the January MRR curve.

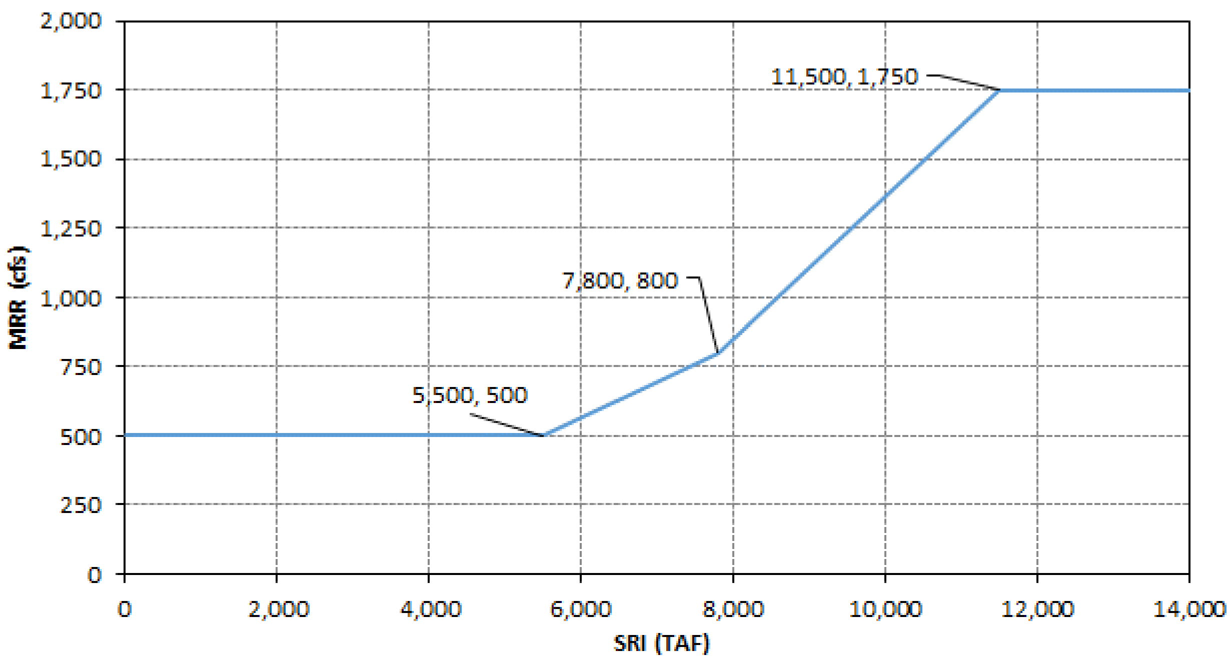


Figure 2-1. January Relationship Between SRI and MRR

Januarys with an SRI of less than 5.5 MAF would have an MRR of 500 cfs, and those with a SRI greater than 11.5 MAF would have an MRR of 1,750 cfs. SRIs between 5.5 MAF and 11.5 MAF would be linearly interpolated as shown in Figure 2-1.

The MRR for January can also be determined by the following formula based on the SRI:

- If SRI <= 5,500 TAF, then MRR = 500
- If 5,500 TAF < SRI <= 7,800 TAF, then MRR = 0.1304 * SRI -217
- If 7,800 TAF < SRI <= 11,500 TAF, then MRR = 0.2568 * SRI -1,203
- If SRI > 11,500 TAF, then MRR = 1,750

2.2 February through March

Calculation of the MRR for February through March uses the same relationship between ARI and MRR for both months. The MRR for this period uses the February and March B120 forecast values to determine the ARI. Figure 2-2 shows the February through March MRR curve.

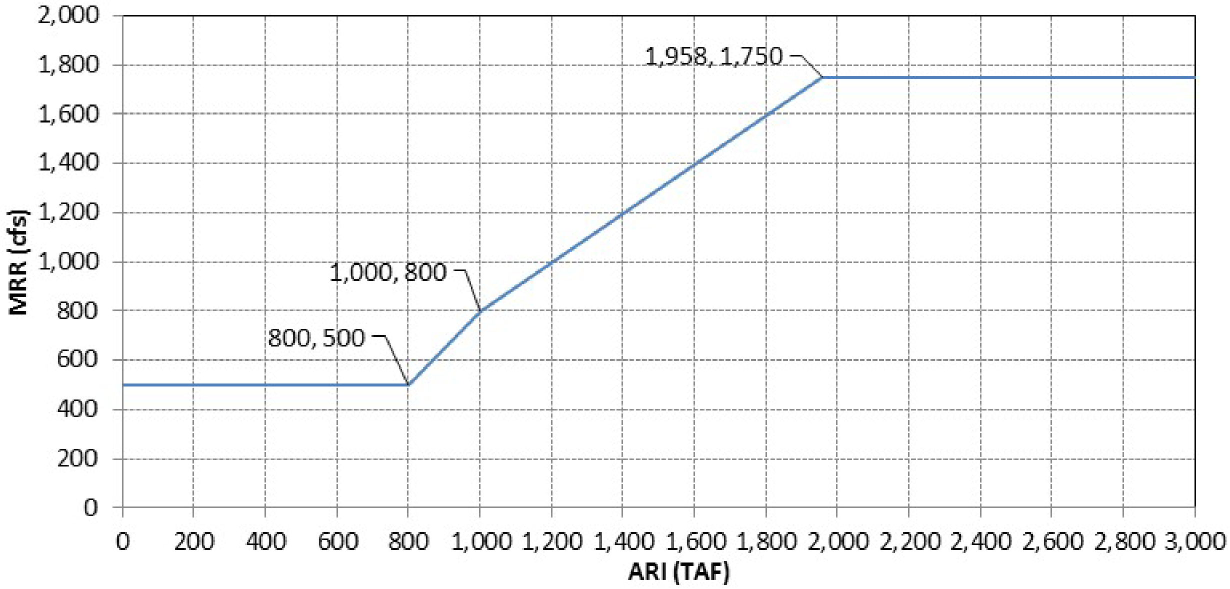


Figure 2-2. February through March Relationship Between ARI and MRR

Years with a February or March ARI less than 800 TAF would have an MRR of 500 cfs, and years with a February or March ARI greater than 1,958 TAF would have an MRR of 1,750 cfs. An ARI of 1,000 TAF would correspond to 800 cfs, and MRRs for years with an ARI between 800 and 1,000 TAF, or between 1,000 and 1,958 TAF, would be linearly interpolated between points, as shown in Figure 2-2.

The MRR for February 1 through March 31 can also be determined by the following formula based on the ARI:

- If ARI <= 800 TAF, then MRR = 500
- If 800 TAF < ARI <= 1,000 TAF, then MRR = 1.500 * ARI -700
- If 1,000 TAF < ARI <= 1,958 TAF, then MRR = 0.9918 * ARI -192
- If ARI > 1,958 TAF, then MRR = 1,750

2.3 April through June

Calculation of the MRR for April through June uses the same relationship between ARI and MRR for all three months. The MRR for this period uses the April and May B120 forecast value to determine the ARI. Since the last B120 forecast is made in early May, the May B120-based ARI would also be used for June. Figure 2-3 shows the April through June MRR curve.

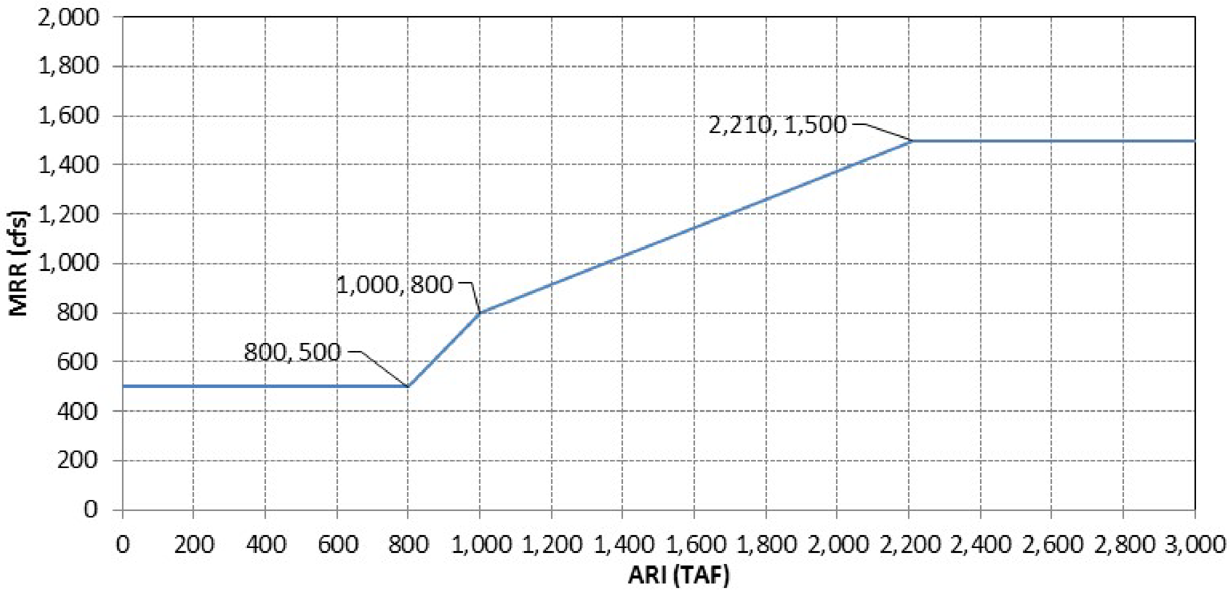


Figure 2-3. April through June Relationship Between ARI and MRR

Years with an April or May ARI less than 800 TAF would have an MRR of 500 cfs, and years with an April or May ARI greater than 2,210 TAF would have an MRR of 1,500 cfs. An ARI of 1,000 TAF would correspond to 800 cfs, and MRRs for years with an ARI between 800 and 1,000 TAF, or between 1,000 and 2,210 TAF, would be linearly interpolated between points, as shown in Figure 2-3.

The MRR for April 1 through June 30 can also be determined by the following formula based on the ARI:

- If ARI <= 800 TAF, then MRR = 500
- If 800 TAF < ARI <= 1,000 TAF, then MRR = 1.500 * ARI -700
- If 1,000 TAF < ARI <= 2,210 TAF, then MRR = 0.579 * ARI + 221
- If ARI > 2,210 TAF, then MRR = 1,500

2.4 July through September

Calculation of the MRR for July through September uses the same relationship between ARI and MRR for all three months. The MRR for this period uses the ARI computed in early May (or potentially an updated ARI if the B120 is updated after the May forecast). Figure 2-4 shows the July through September MRR curve.

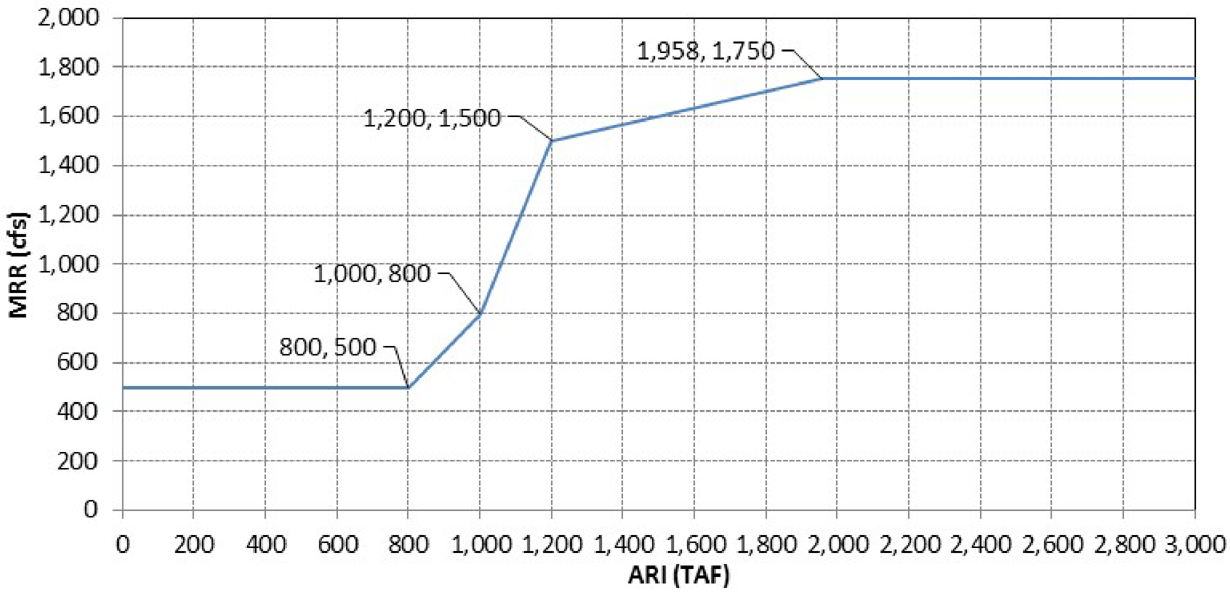


Figure 2-4. July through September Relationship Between ARI and MRR

The MRR for July 1 through September 30 can also be determined by the following formula based on the ARI:

- If ARI <= 800 TAF, then MRR = 500
- If 800 TAF < ARI <= 1,000 TAF, then MRR = 1.500 * ARI -700
- If 1,000 TAF < ARI <= 1,200 TAF, then MRR = 3.5 * ARI -2,700
- If 1,200 TAF < ARI <= 1,958 TAF, then MRR = 0.330 * ARI + 1,104
- If ARI > 1,958 TAF, then MRR = 1,750

2.5 October

The October MRR is also based on the May ARI value (or potentially an updated ARI if the B120 is updated after the May forecast). The October ARI-MRR relationship is almost identical to the November through December relationship (see below), except the MRR is capped at 1,500 cfs rather than 2,000 cfs. Figure 2-5 shows the October ARI-MRR relationship.

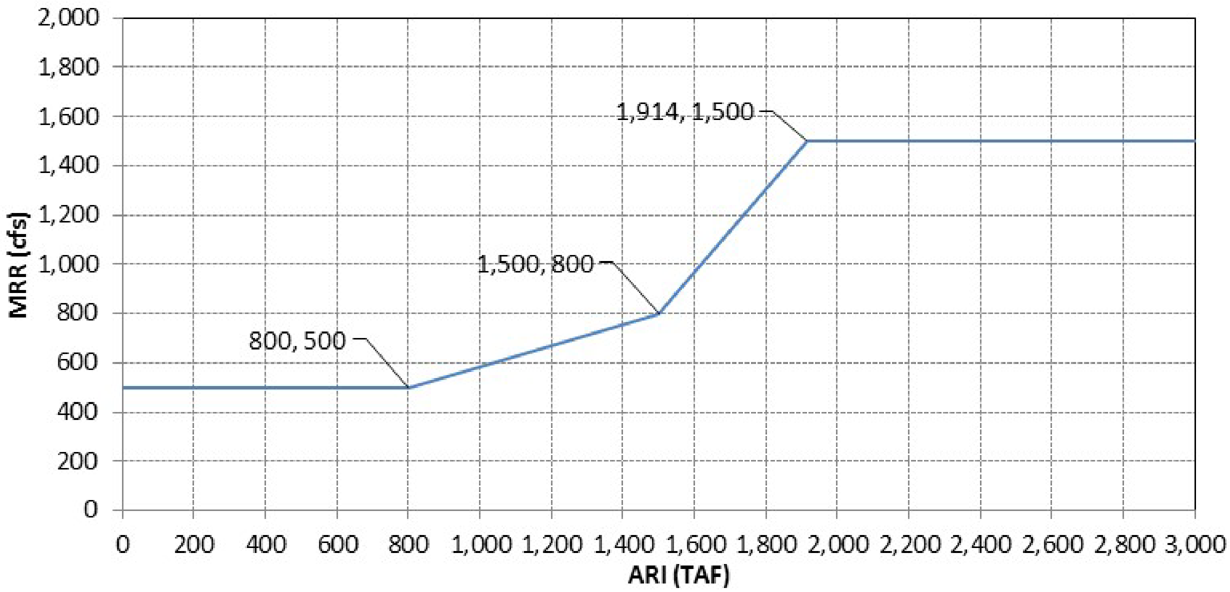


Figure 3.2-5. October Relationship Between ARI and MRR

The MRR for October 1 through October 30 can also be determined by the following formula based on the ARI:

- If ARI <= 800 TAF, then MRR = 500
- If 800 TAF < ARI <= 1,500 TAF, then MRR = 0.429 * ARI +157
- If 1,500 TAF < ARI <= 1,914 TAF, then MRR = 1.690 * ARI -1,735
- If ARI > 1,705 TAF, then MRR = 1,500

2.6 November through December

Calculation of the MRR for November through December uses the same relationship between ARI and MRR for both months. The MRR for this period uses the ARI computed in early May (or potentially an updated ARI if the B120 is updated after the May forecast). Figure 2-6 shows the November through December MRR curve.

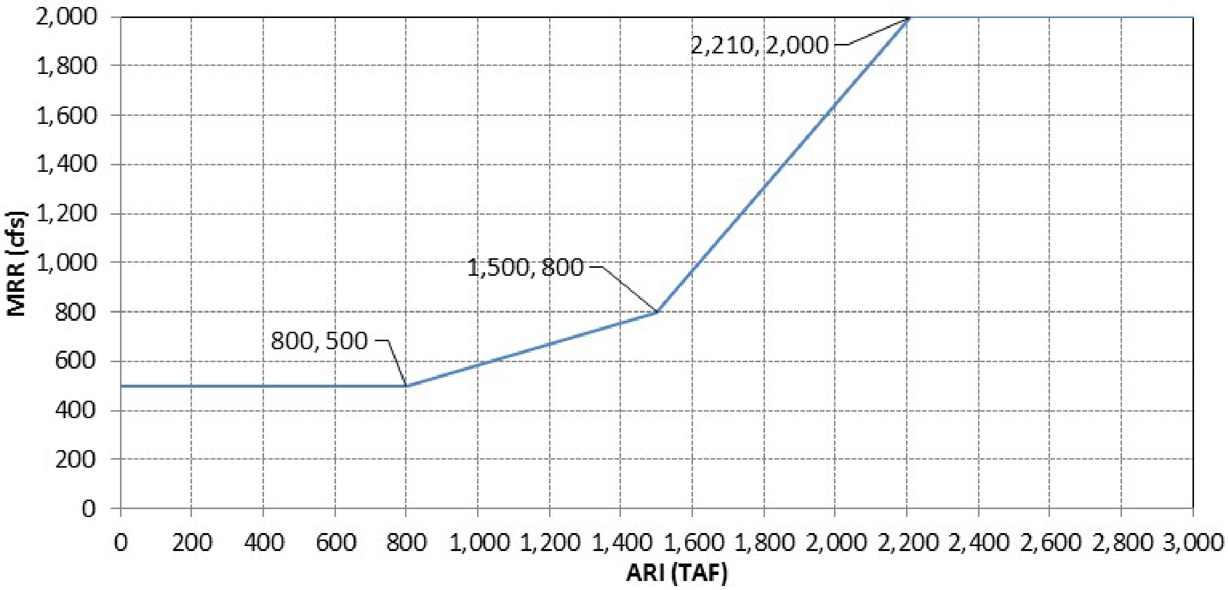


Figure 2-6. November through December Relationship Between ARI and MRR

The MRR for November 1 through December 31 can also be determined by the following formula based on the ARI:

- If ARI <= 800 TAF, then MRR = 500
- If 800 TAF < ARI <= 1,500 TAF, then MRR = 0.429 * ARI +157
- If 1,500 TAF < ARI <= 2,210 TAF, then MRR = 1.690 * ARI -1,735
- If ARI > 2,210 TAF, then MRR = 2,000

3 Redd Dewatering Protective Adjustments

The 2017 FMS also includes Redd Dewatering Protective Adjustments (RDPA) to ensure reductions in MRR do not result in dewatering of fall-run Chinook salmon or steelhead redds. The RDPA would restrict changes in the MRR between December and June, but would not affect releases above the MRR.

3.1 Fall-Run Chinook Salmon

The fall-run Chinook salmon RDPA affect winter MRRs in two ways: there is a restriction on increases in MRR for January, and in decreases in MRR for January and February.

3.1.1 Restriction on Increasing the January MRR from the December MRR

In recognition of the uncertainty of the January SRI forecast, the 2017 FMS precludes increases in MRR from December to January. Fall-run Chinook redds are constructed in October through December, and the fall-run Chinook fry emerge through February. Rather than have a condition where a January-forecasted SRI resulted in an increase in MRR, only to see a decrease in MRR with the February B120 forecast, the 2017 FMS only allows for reductions in the January MRR from the December MRR. The fall-run Chinook salmon RDPA limiting flow increases is included in the MRR calculator on the MRR Forecast worksheet as part of the January calculation.

3.1.2 Restrictions on Reductions in the January and February MRR from December MRR

The fall-run Chinook salmon RDPA would restrict MRR reductions from the December MRR for January and February. If the SRI-based MRR for January, or the ARI-based MRR for February was less than 70%

of the December MRR, the January or February MRR could not be less than 70% of the December MRR. If the SRI- or ARI-based MRR was higher, then it would be used. The fall-run Chinook salmon RDPA limiting flow reductions is included in the MRR calculator on the MRR Forecast worksheet as part of the January and February calculations.

3.2 Steelhead

The steelhead RDPA restrict MRR reductions from February and March, through the end of June. Table 3-1 shows the steelhead RDPA-based MRR for February through May.

Table 3-1. Steelhead RDPA-based MRR for February through May

MRR_{Jan} or MRR_{Feb} (cfs)	Steelhead RDPA-Based MRR for February-May (cfs)
≤700	500
800	520
900	580
1,000	640
1,100	710
1,200	780
1,300	840
1,400	950
1,500	1,030
1,600	1,100
1,700	1,180
1,800	1,250

The ARI- and fall-run Chinook RDPA-based MRR for February and March are compared to the steelhead RDPA-based MRR in Table 3-1, using the final, RDPA-based January or February MRR as a basis. Steelhead RDPA for January and February MRR values between those in the table would be linearly interpolated. The maximum MRR in January through May is 1,750 cfs, but 1,800 cfs is included in the table as a maximum value. If the ARI-based MRR is less than the steelhead-RDPA-based MRR, the RDPA-based MRR controls operations. Otherwise, the ARI-based MRR remains in effect. This procedure would be repeated in March, but after March, the RDPA-based MRR determined in March would remain the minimum MRR through the end of May.

The Steelhead RDPA calculation is included in the MRR Calculator on the “MRR Forecast” worksheet as part of the February, March, April, and May calculations.

4 Spring Pulse Flow

The 2017 FMS includes a spring pulse flow intended to provide an outmigration cue for juvenile salmonid emigration before relatively low water flow and associated challenging thermal conditions occur later in the spring, and downstream in the lower Sacramento River.

The spring pulse would occur in years that the MRR for March (determined by the March Bulletin 120) was between 1,000 cfs and 1,500 cfs, and Nimbus releases had not exceeded the maximum pulse flow rate for at least two consecutive days between February 1 and March 15.

A pulse flow would occur between March 15 and April 15. The peak flow of the pulse flow would be 3 times the current MRR, but no higher than 4,000 cfs, and would last for two days. Following two days at the peak flow, Nimbus releases would be decreased at no more than 500 cfs per day and no more than 100 cfs per hour. Changes in Nimbus releases would occur at night, if possible.

In years with a pulse flow, the daily MRR for April 1 through June 30 would be reduced evenly by the volume of the pulse flow and downramp. The MRR calculator includes a calculation of maximum pulse flow as part of the March calculation.

Attachment B

American River Temperature Management Plan Guidance Document

GUIDANCE DOCUMENT
American River Temperature Management Plan
LTO Implementation
March 23, 2020

I. PURPOSE

This document provides implementation guidance on the American River Temperature Management Plan pursuant to 4.10.4.2 and 4.10.4.3 of the U.S. Bureau of Reclamation's (Reclamation) Proposed Action and NOAA's National Marine Fisheries Service's (NMFS) Biological Opinion and Incidental Take Statements (ITS). The scope of guidance includes the deliverables, schedule, and processes to develop and implement the Temperature Management Plan. The primary deliverables are American River Group (ARG) meeting notes and handouts that include a monthly summary of the hydrologic, operational, and temperature data related to Folsom cold water pool management; and draft/final Temperature Management Plans.

II. Temperature Management

This section provides the applicable verbatim language for American River Division Temperature Management

Proposed Action:

4.10.4.1 Seasonal Operations

[…]

Reclamation proposes to continue to make summer releases for instream temperature control, Delta outflow, and exports, typically above the planning minimum flows. By late October, it is typical for Folsom Reservoir to have depleted the cold water pool. The primary way to provide additional instream cooling is to release water from the lower outlet works. This operation bypasses the power penstocks and has a significant impact on power generation. In order to optimize power generation, Reclamation proposes to limit power bypass operations solely to respond to emergency or unexpected events or during extreme drought years when a drought emergency has been declared by the Governor of California.

4.10.4.2 Temperature Management

Reclamation proposes to prepare a draft Temperature Management Plan by May 15 for the summer through fall temperature management season using the best available (as determined by Reclamation) decision support tools. The information provided by the Operations Forecast will be used in the development of the Temperature Plan. The draft plan will contain: (1) forecasts of hydrology and storage; and (2) a modeling run or runs, using these forecasts, demonstrating what temperature compliance schedule can be attained. Reclamation will use an iterative approach, varying shutter configurations, with the objective to attain the best possible temperature schedule for the compliance point at Watt Avenue Bridge. The draft plan will be shared with the American River Group before finalization and may be updated monthly based on system conditions.

Reclamation proposes to manage the Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam to maintain a daily average water temperature of 65°F (or other temperature as determined by the temperature modeling) or lower at Watt Avenue Bridge from May 15 through October 31, to provide suitable conditions for juvenile Steelhead rearing in the lower American River. If the temperature is exceeded for 3 consecutive days, Reclamation will notify NMFS and outline steps being taken to bring the water temperature back into compliance. During the May 15 to October 31 period, if the Temperature Plan defined temperature requirement cannot be met because of limited cold water availability in Folsom Reservoir, then the target daily average water temperature at Watt Avenue may be increased incrementally (i.e., no more than 1°F every 12 hours) to as high as 68°F. The priority for use of the lowest water temperature control shutters at Folsom Dam shall be to achieve the water temperature requirement for listed species (i.e., Steelhead), and thereafter may also be used to provide cold water for Fall-Run Chinook salmon spawning.

4.10.4.3 Conservation Measures

Reclamation and DWR are proposing conservation measures to avoid and minimize or compensate for CVP and SWP project effects, including take, on the species under review in this biological assessment as well as contribute to the recovery and enhancement of species and their habitats. These conservation measures include non-flow actions that benefit listed species without impacting water supply or other beneficial uses. Actions could be implemented in part or fully through agreements and cost share with the State of California and potentially under the Voluntary Agreement alternative under the State Water Resources Control Board update to the Bay-Delta Water Quality Control Plan. […]

- Drought Temperature Management: In severe or worse droughts, Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility. […]

NMFS ITS:

13.3.3 American River Division

Reclamation's proposed action in the American River Division will create stressors of water temperature and flow that is reasonably expected to result in take of CCV steelhead.

Surrogates are used for this Division because, as described in the Opinion, it is not practical to accurately quantify and monitor the amount of individuals that are expected to be taken due to the co-occurrence of non-listed steelhead from the Nimbus Hatchery Program in the American River. Surrogates may also be used due to the variability in the population size at any given time of exposure to the stressors of water temperatures outside of the optimal temperature range of the species, lack of quantification for what optimal water flow are for the species in the American River, the annual variations in the timing of various parts of the species' life cycle, and variation in how individual fish use habitat within the American River. Because of the causal relationship of flow magnitude, timing, duration, frequency, and rate of change to survival within and between life stages, flow can be used as a surrogate for the amount or extent of take for salmonids.

13.3.3.1 Take Anticipated from Water Temperature Effects

Suboptimal water temperatures in the American River are expected to result in reduced survival during egg-to-fry life stage and reduced growth for the juvenile rearing and smolt emigration life stages for CCV steelhead as described in the Opinion.

The ecological surrogate to define the amount or extent of take in the American River is both the magnitude and frequency of suboptimal water temperature in the reach from Nimbus Dam to Watt Avenue.

The CCV steelhead egg-to-fry life stage occurs December through May, and temperatures above 54°F create suboptimal conditions for this life stage. A small proportion of CCV steelhead eggs will still be in redds during May and potentially exposed to water temperatures that will reasonably be expected to result in egg mortality. The extent of take is all redds exposed to temperatures above 54°F in the vicinity of Watt Avenue December 1 through May 31. Take of CCV steelhead during the egg-to-fry life stage during these months is expected to be minimal because of the small proportion of eggs or alevins still incubating in the month of May.

CCV steelhead juveniles can survive and grow at water temperatures of 45 to 66°F. Reduced survival is anticipated at temperatures at or above 68°F. The ecological surrogate to define the amount or extent of take of CCV steelhead juvenile life stage is daily average temperature at Watt Avenue May 15 to October 31. The anticipated level of take will be exceeded if temperatures at Watt Avenue exceed 68°F from May 15 to October 31 for more than seven consecutive days unless it is a critical year based on the Sacramento Valley index or a year following one or more critical years[31]. In critical years, and years immediately after a critical year, anticipated level of take is exceeded if temperature exceeds 68°F at Hazel Avenue.

31 In a critical year, or year following critical year, Reclamation will meet with NMFS, FWS, CDFW, and the SWRCB to discuss and determine the best use of the limited cold water pool for that year.

RPM 3: Reclamation shall minimize the impact of the amount or extent of incidental take of listed species during operations of the American Division.

a. Seasonal operational decisions that affect water temperature and river flows shall be coordinated through the American River Group.

III. DELIVERABLES

Deliverables resulting from this effort follow the coordination described in Appendix C of the Proposed Action and include ARG meeting notes and handouts that include a monthly summary of the hydrologic, operational, and temperature data related to Folsom cold water pool management; and draft/final Temperature Management Plans. A sample ARG monthly meeting agenda (BOX 1) is attached that describes the expected meeting topics and contents for the meeting notes. Section IV herein describes the processes to achieve the deliverables:

IV. PROCESS

Reclamation will convene and facilitate ARG monthly meetings or more frequently, as needed, to include:

- meeting scheduling and coordination,

- agenda development and distribution,
- coordinate preparation of monthly meeting handout materials,
- take notes, and
- posting notes and reports (including annual reports) online

A. American River Group

Reclamation established a working group to coordinate fishery and operational requirements for the lower American River (LAR), known as the American River Group (ARG), in 1996. Reclamation is the lead coordinator of the ARG, bringing together those who have either a legislated or resources-specific interest in the operation of Folsom Dam and Reservoir, and the LAR. The formal members include agencies with responsibilities for fisheries resources in the LAR: Reclamation, the U.S. Fish and Wildlife Service (USFWS), NMFS, CDFW, and Sacramento Area Water Forum (Water Forum). Members of the public and other agencies may attend ARG meetings and comment on matters under consideration by the ARG. The ARG convenes monthly or more frequently, if needed, to discuss water operations, fisheries, and other environmental concerns and to share operational and biological information with the goal of improving the technical understanding of LAR temperature needs and operational constraints and considerations. Reclamation considers the provided information when making management decisions regarding temperatures and flows necessary to sustain fish resources in the LAR. In addition, the Flow Management Standard (FMS) and Spring pulse flow shaping are factors that may impact temperature management. FMS and Spring pulse flow shaping are acknowledged here and will be developed in separate guidance document.

The ARG will provide input on the draft Temperature Management Plan, which Reclamation will provide by May 15 of each year. Temperature Management Plans are to be developed with the best available decision making support tools, currently, currently ATSP and iCPMM models. The ARG will also provide input on monthly updates to the temperature management plan developed by Reclamation throughout the temperature management season. The general steps of this process are as follows:

1. Beginning with the May ARG meeting, Reclamation will provide the draft Temperature Management Plan (May) or updated Temperature Management Plans depending on conditions (June – October) along with other supporting monthly meeting materials.

2. At the ARG meeting, ARG will review available hydrologic and biological information along with the draft or updated Temperature Management Plans and provide feedback to Reclamation.

3. ARG Meeting notes will be generated, and a draft distributed to the ARG for review and comment before final notes are posted online along with pertinent meeting materials.

4. Reclamation will develop a Final Temperature Management Plan considering ARG feedback from the May ARG meeting or provided shortly after the meeting, distribute to the ARG and make available to the Water Operations Management Team (WOMT).

B. Change Orders

Reclamation operators coordinate the daily operation of Folsom and Nimbus Dams. Changes to releases in LAR operations require at least 48 hours prior notice to any desired releases.

However, under conditions of urgent need with appropriate coordination with ARG and the fisheries agencies, Reclamation may make release changes as quickly as real time changes. Reclamation intends to continue to provide change order information via email to the ARG.

C. Folsom Temperature Shutter Operations

Reclamation operators work with CCAO Reclamation staff to order changes in Folsom Temperature Shutter Configuration to control the blending of water of different temperatures to ensure certain temperature requirements in the LAR. Changes to the temperature shutter configuration typically require 3-5 days of planning. Temperature shutter operations will be dictated by the Temperature Management Plan and subsequent updates that have been reviewed and commented on by the ARG. In severe or worse droughts, Reclamation will evaluate and consider implementing alternative shutter configurations at Folsom Dam to allow temperature flexibility.

D. Water Operations Management Team

After the ARG provides input on the draft Temperature Management Plan, Reclamation will prepare the Final Temperature Management Plan in May and provide to WOMT and make notes available from the corresponding ARG monthly meetings (April and May). The Temperature Management Plan will be updated monthly, based on system conditions, and in this event, Reclamation will request feedback from ARG and provide any monthly plan updates to the WOMT and make notes available from the corresponding ARG meetings.

E. Updates to Guidance Document

In addition, it is expected that as this guidance is being implemented there will be necessary revisions to the document to provide further clarification and refinement. Reclamation and DWR, with technical assistance from the USFWS, NMFS, and CDFW, commit to reviewing this implementation guidance following each water year, at a minimum, to identify and incorporate any necessary revisions.

BOX 1: AMERICAN RIVER GROUP AGENDA

Date

Roster

Agency, Office, Name, Alternate(s)

Topics

1. Introductions
2. Presentation (if applicable)
3. Fisheries Update
    a. CDFW
    b. CFS
    c. PSMFC
4. Operations Forecast
    a. SMUD
    b. PCWA
    c. Central Valley Operations
5. Central Valley Operations
    a. Recap of Previous Month's Operations
    b. Temperature Management
    c. Exceedance Forecast
6. Discussion
7. Review Action Items
8. Next Meeting Scheduling

Materials

Attachment C

Water Year 2021 Temperature Management Plan for the Lower American River

— BUREAU OF —
RECLAMATION

Water Year 2021 Temperature Management Plan for the Lower American River - Final

U.S. Bureau of Reclamation

June 30, 2021

The following Water Year (WY) 2021 Temperature Management Plan (TMP) for the Lower American River (LAR) has been developed according to the 2020 Record of Decision (ROD) on the Coordinated Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP). The ROD implements Alternative 1 (the Preferred Alternative) as described in the associated Environmental Impact Statement. Alternative 1 was the Proposed Action consulted upon and analyzed in the Biological Opinions issued in October 2019 by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). A Draft TMP was developed by Reclamation and distributed to the American River Group (ARG) for feedback. Comments received on the Draft TMP are attached to this Final Plan.

After reviewing the current hydrological conditions, operations forecast, and Folsom temperature profile, Reclamation, with support from the Water Forum (cbec eco Engineering), ran numerous iCPMM models with varying inputs (inflow, air temperature, shutter deganging at Folsom, etc). The iCPMM temperature results were corroborated, with support from Placer County Water Agency (Cardno), with CE-QUAL-W2 modeling. Based on these various model runs, and given the current number of uncertainties with potential drought actions, inflow projections and operations forecasts, the LAR TMP Goal is to target 71°F at Hazel from June 6, 2021 to October 31, 2021 and target 58°F from November 1, 2021 until winter.

The summer target of 71°F at Hazel (as measured at the American River at Fair Oaks - AFO gage) is what Reclamation expects to be the lowest achievable and sustainable temperature possible this summer. Numerous temperature modeling runs were presented and discussed at the ARG. These discussions are captured in ARG meeting notes which can be accessed here: [Bureau of Reclamation: American River Group]

The TMP includes deganging of the temperature shutters at Folsom Dam, but does not currently included a potential fall Power Bypass, which Reclamation expects to evaluate later in the summer. Reclamation will continue to review the hydrology and Folsom cold water pool on a bi-weekly timeframe and update this TMP accordingly. LAR TMP updates will be shared with ARG to seek feedback from the group.

Reclamation recognizes that given the hydrology and Folsom storage conditions for WY 2021, water temperatures are expected to exceed 68°F at Hazel Avenue for most of the summer, and therefore would exceed the water temperature-threshold described in the 2019 NMFS Biological Opinion on Long-Term Operations of the CVP and SWP. These higher water temperatures are expected to adversely affect oversummering juvenile *O. mykiss* and fall-run Chinook in the Lower American River below Nimbus Dam. The 2019 NMFS Biological Opinion specifies that "In a critical year, or year following critical year, Reclamation will meet with NMFS, FWS, CDFW, and the SWRCB to discuss and determine the best use of the limited cold water pool for that year" (2019 NMFS, p 806). The TMP temperature target of 71°F at Hazel is consistent with discussions with the ARG including at the June 3, 2021 ARG ad hoc meeting, where NMFS supported this TMP target.

Reclamation coordinates with USFWS, NMFS, DWR, CDFW, State Board (Agencies) and other American River stakeholders monthly through the ARG. The coordination includes monthly assessments of conditions and potential actions and allows each agency to collaborate on water operations, identify disagreements, and elevate issues to the Directors of the Agencies for resolution.

BUREAU OF RECLAMATION

ATTACHMENTS

NMFS Feedback on Draft Temperature Management Plan for the Lower American River

June 16, 2021

DRAFT May iCPMM Temperature Modeling Summary – Preliminary Results for Discussion Purposes
5/7/21

Inputs
The standard inputs for iCPMM have been updated to reflect more recent conditions and are summarized below:

- Folsom Reservoir Temperature Profile collected on 5/5/21
- Unofficial 90% release projection as discussed with Reclamation on 5/3/21
- 90% Inflow Projections as provided by SMUD (4/26) and PCWA (5/6)
- Air Temperatures – 2014 actual air temperatures used, not the warmest recorded but warmer than the standard air temperature time series typically used in iCPMM
- Inflow Water Temperatures – 2014 actual inflow temperatures used. 2014 chosen due to a similar volume/magnitude of projected inflow. 2015 inflow temperatures are significantly warmer, but 2015 has a much lower volume/magnitude of inflow, so not as representative.
- Different inputs will change the model results, but these are reasonably representative for planning purposes.

Temperature Targets
Due to low storage, low volume of anticipated runoff, and low Folsom release rates, water temperatures are projected to be MUCH higher than typical. In fact, the expected temperatures are well above those represented by the standard Automated Temperature Selection Procedure (ATSP). The standard ATSP schedules max out at temperature schedule 78 which represents 72F throughout the summer and fall. As a reminder, the iCPMM model tries to achieve the prescribed temperature target for the reach extending from Nimbus Dam to Watt Ave. In addition, a 1F temperature buffer is included in the scenarios, for example if a temperature of 75F is requested, the model will try to provide a temperature of 74F. This has been the standard practice for the last decade to account for the differences between daily average and weekly average water temperature values.

Custom temperature schedules (TS) were developed for this preliminary analysis.

- TS 79 – no temperature target provided through the summer, 60F second half of October, 56F November and December. Prior to the fall, shutters are only pulled due to hydraulic constraints.
- TS 80 – 74F through the summer, 60F second half of October, 56F November and December
- TS 81 – 75F through the summer, 60F second half of October, 56F November and December
- TS 82 – 76F through the summer, 60F second half of October, 56F November and December
- TS 83 – 77F through the summer, 60F second half of October, 56F November and December

Power Bypass
For each of the runs aside from TS 79, a 500 cfs of power bypass (aka river gates or RG) was applied for 4 weeks (10/15-11/11). These results are provided after each of the individual non-power bypass results.

Results Summary
Summary plots for each of the runs are provided below. The Nimbus Dam (aka Hazel Ave.) water temperature representation has been changed to a dotted green line in order to make the plots more visually digestible. When power bypass (aka river gates) is applied it is shown in green to aid in graphical interpretation.

NMFS Feedback on Draft Temperature Management Plan for the Lower American River
June 16, 2021

At this time, given the many uncertainties in system-wide operations and meteorology, NMFS offers only very preliminary comments regarding temperature management in October and beyond.

- NMFS encourages further discussion with the American River Group about how to transition to fall temperature management.
- Water temperatures in the 60's and even low 70's in October is expected to cause significant pre-spawn mortality for fall-run Chinook salmon, a key prey item for endangered Southern Resident killer whales.
- Shifting the target by 13 degrees (from 71°F to 58°F) in one day is likely not operationally practicable.
- NMFS urges Reclamation to implement power bypass operations for 4-6 weeks in the fall, potentially to start as early as mid-October. Power bypass may be necessary sooner than mid-October to maintain the 71°F target if, for example, the reservoir layers accessible by the TCD warm faster than modeled.
- The 2019 Proposed Action notes that "Reclamation proposes to limit power bypass operations solely to respond to emergency or unexpected events or during extreme drought years when a drought emergency has declared by the Governor of California". Drought emergency (for counties in the American River basin) was declared by the Governor on May 10, 2021[1].

[1] *https://www.gov.ca.gov/wp-content/uploads/2021/05/5/10/2021-Drought-Proclamation.pdf*

NMFS Feedback on Draft Temperature Management Plan for the Lower American River
June 16, 2021

NMFS appreciates the extensive work done (by Reclamation and by consultants to the Water Forum or Placer County Water Agency) to explore temperature management options for the Water Year (WY) 2021 summer/fall temperature management season. Model variations were run to accommodate changing operations outlooks, alternative temperature targets, and also scenarios with and without a power bypass, and with and without deganging the shutters of the Temperature Control Device (TCD) at Folsom Dam. Key modeling outputs reviewed by NMFS are summarized in Table 1.

Table 1. Overview of key "model packets" for summer 2021 temperature management planning. Each packet includes results from multiple scenarios.

Date	**5/7/21**	**5/25/21**	**6/3/21**	**6/4/21**
Results	Attachment A	Attachment B	Attachment C	Attachment D
Model (Modeler)	iCPMM[1] (Chris Hammersmark, CBEC, for Water Forum)	iCPMM[1] (Chris Hammersmark, CBEC, for Water Forum)	CE-QUAL-W2 (Vanessa Martinez, Cardno, for Placer County Water Agency)	iCPMM[1] (Chris Hammersmark, CBEC, for Water Forum)
Location of water temperature target	Watt	Hazel	Hazel	Hazel
Date of reservoir profile	5/5/21	5/18/21	6/1/21	6/1/21
Release assumptions	Unofficial 90% release projection as discussed with Reclamation on 5/3/21	Unofficial 90% release projection as discussed with Reclamation on 5/25/21	Updated projections provided by Reclamation on 6/1/21	Updated projections provided by Reclamation on 6/1/21
Inflow assumptions (flow)	90% Inflow Projections as provided by SMUD (4/26) and PCWA (5/6)	90% Inflow Projections as provided by SMUD (4/26) and PCWA (5/6)	Updated projections provided by SMUD/PCWA on 6/1/21	Updated projections provided by SMUD/PCWA on 6/1/21

Date	**5/7/21**	**5/25/21**	**6/3/21**	**6/4/21**
Results	Attachment A	Attachment B	Attachment C	Attachment D
Inflow assumptions (water temperatures)	2014 actual inflow water temperatures	Modeled inflow water temperatures based on 2014 air temperatures and projected 2021 inflows	Modeled inflow water temperatures based on 2014 air temperatures and projected 2021 inflows	Modeled inflow water temperatures based on 2014 air temperatures and projected 2021 inflows
Air temperature assumptions	2014 actual air temperatures	2014 actual air temperatures	2014 actual air temperatures	2014 actual air temperatures
Comments *(see attachments for full scenario details)*	Documents first instance of "custom" ATSP[2] schedules. Summer Watt targets of 74°F, 75°F, 76°F, and 77°F; with and without power bypass in the fall.	Summer Hazel targets of 69°F and 70°F; with and without power bypass in the fall.	Summer Hazel targets of 69°F to 71°F; with and without deganged middle shutters of Folsom TCD.	Summer Hazel target of 71°F; Fall Hazel target of 58°F; with deganged middle shutters of Folsom TCD; with and without power bypass in the fall.

[1] Iterative Coldwater Pool Management Model
[2] Automated Temperature Selection Procedure

Reclamation's Draft Water Year (WY) 2021 Temperature Management Plan (TMP) for the Lower American River (LAR) (LAR TMP) proposes:

> *Based on these various model runs, and given the current number of uncertainties with potential drought actions, inflow projections and operations forecasts, the LAR TMP Goal is to target 71°F at Hazel from June 6, 2021 to October 31, 2021 and target 58°F from November 1, 2021 until winter.*

NMFS acknowledges that given the hydrology and Folsom storage conditions for WY 2021, water temperatures are expected to exceed 68°F at Hazel Avenue for most of the summer, which exceeds the water-temperature-related incidental take limit for the American River in the 2019 NMFS Biological Opinion on Long-term Operations of the CVP and SWP (2019 NMFS BiOp). These higher water temperatures will further impact oversummering juvenile O. mykiss in the Lower American River below Nimbus Dam. The 2019 Proposed Action notes "The priority for use of the lowest water temperature control shutters at Folsom Dam shall be to achieve the water temperature requirement for listed species (i.e., Steelhead), and thereafter may also be used to provide cold water for Fall-Run Chinook Salmon spawning."

Given the constraints of the current water year, NMFS supports a temperature management approach that provides the coolest possible water temperature that can be sustained until at least mid-October, at which point seasonal meteorology and (if approved by Reclamation) a power bypass will support cooler water temperatures. Based on the temperature model results reviewed to date (see Attachments A-D), NMFS supports 71°F as the summer 2021target temperature at Hazel Avenue. Additionally, in order to add flexibility to temperature blending of releases at Folsom Dam, NMFS appreciates and supports Reclamation's commitment to degang the middle and bottom shutters of the TCD. NMFS agrees that Reclamation should (in coordination with the American River Group) "continue to review the hydrology and Folsom cold water pool on a bi-weekly timeframe and update this TMP accordingly".

At this time, given the many uncertainties in system-wide operations and meteorology, NMFS offers only very preliminary comments regarding temperature management in October and beyond.

- NMFS encourages further discussion with the American River Group about how to transition to fall temperature management.
- Water temperatures in the 60's and even low 70's in October is expected to cause significant pre-spawn mortality for fall-run Chinook salmon, a key prey item for endangered Southern Resident killer whale.
- Shifting the target by 13 degrees (from 71°F to 58°F) in one day is likely not operationally practicable.
- NMFS urges Reclamation to implement power bypass operations for 4-6 weeks in the fall, potentially to start as early as mid-October. Power bypass may be necessary sooner than mid-October to maintain the 71°F target if, for example, the reservoir layers accessible by the TCD warm faster than modeled.
- The 2019 Proposed Action notes that "Reclamation proposes to limit power bypass operations solely to respond to emergency or unexpected events or during extreme drought years when a drought emergency has declared by the Governor of California". Drought emergency (for counties in the American River basin) was declared by the Governor on May 10, 2021[1].

[1] *https://www.gov.ca.gov/wp-content/uploads/2021/05/5.10.2021-Drought-Proclamation.pdf*

DRAFT May iCPMM Temperature Modeling Summary – Preliminary Results for Discussion Purposes
5/7/21

Inputs
The standard inputs for iCPMM have been updated to reflect more recent conditions and are summarized below:

- Folsom Reservoir Temperature Profile collected on 5/5/21
- Unofficial 90% release projection as discussed with Reclamation on 5/3/21
- 90% Inflow Projections as provided by SMUD (4/26) and PCWA (5/6)
- Air Temperatures – 2014 actual air temperatures used, not the warmest recorded but warmer than the standard air temperature time series typically used in iCPMM
- Inflow Water Temperatures – 2014 actual inflow temperatures used. 2014 chosen due to a similar volume/magnitude of projected inflow. 2015 inflow temperatures are significantly warmer, but 2015 has a much lower volume/magnitude of inflow, so not as representative.
- Different inputs will change the model results, but these are reasonably representative for planning purposes.

Temperature Targets
Due to low storage, low volume of anticipated runoff, and low Folsom release rates, water temperatures are projected to be MUCH higher than typical. In fact, the expected temperatures are well above those represented by the standard Automated Temperature Selection Procedure (ATSP). The standard ATSP schedules max out at temperature schedule 78 which represents 72F throughout the summer and fall. As a reminder, the iCPMM model tries to achieve the prescribed temperature target for the reach extending from Nimbus Dam to Watt Ave. In addition, a 1F temperature buffer is included in the scenarios, for example if a temperature of 75F is requested, the model will try to provide a temperature of 74F. This has been the standard practice for the last decade to account for the differences between daily average and weekly average water temperature values.

Custom temperature schedules (TS) were developed for this preliminary analysis.

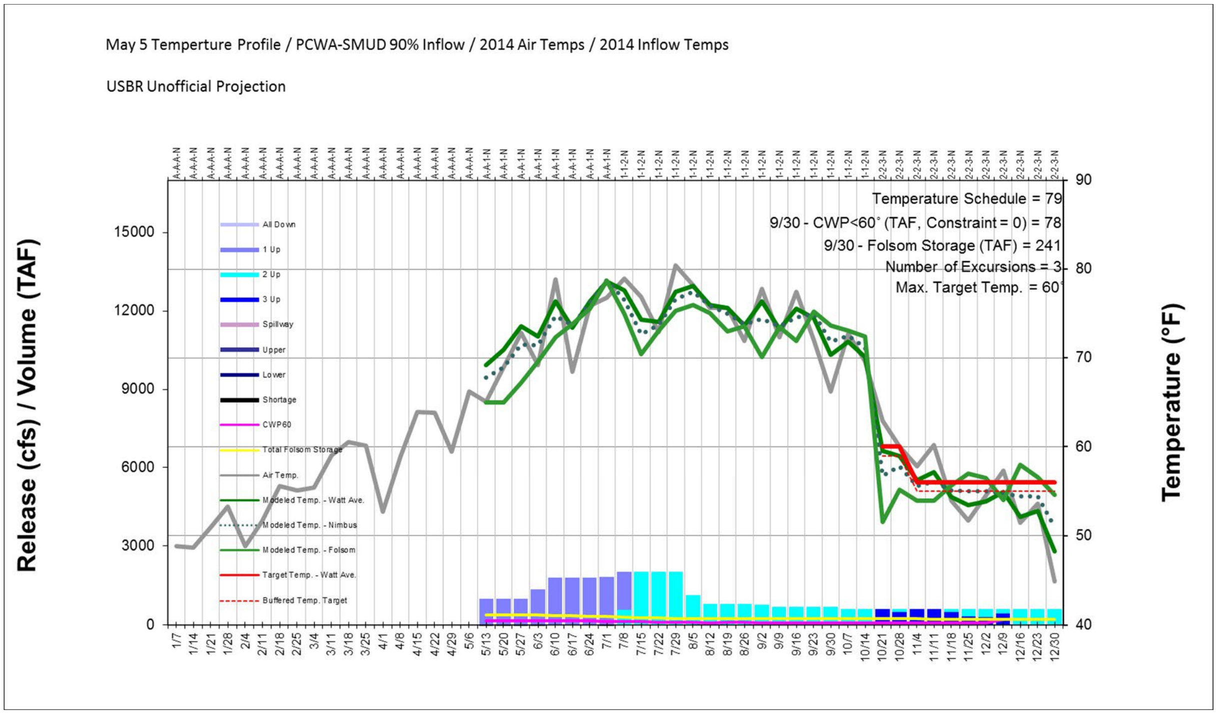
- TS 79 – no temperature target provided through the summer, 60F second half of October, 56F November and December. Prior to the fall, shutters are only pulled due to hydraulic constraints.
- TS 80 – 74F through the summer, 60F second half of October, 56F November and December
- TS 81 – 75F through the summer, 60F second half of October, 56F November and December
- TS 82 – 76F through the summer, 60F second half of October, 56F November and December
- TS 83 – 77F through the summer, 60F second half of October, 56F November and December

Power Bypass
For each of the runs aside from TS 79, a 500 cfs of power bypass (aka river gates or RG) was applied for 4 weeks (10/15-11/11). These results are provided after each of the individual non-power bypass results.

Results Summary
Summary plots for each of the runs are provided below. The Nimbus Dam (aka Hazel Ave.) water temperature representation has been changed to a dotted green line in order to make the plots more visually digestible. When power bypass (aka river gates) is applied it is shown in green to aid in graphical interpretation.

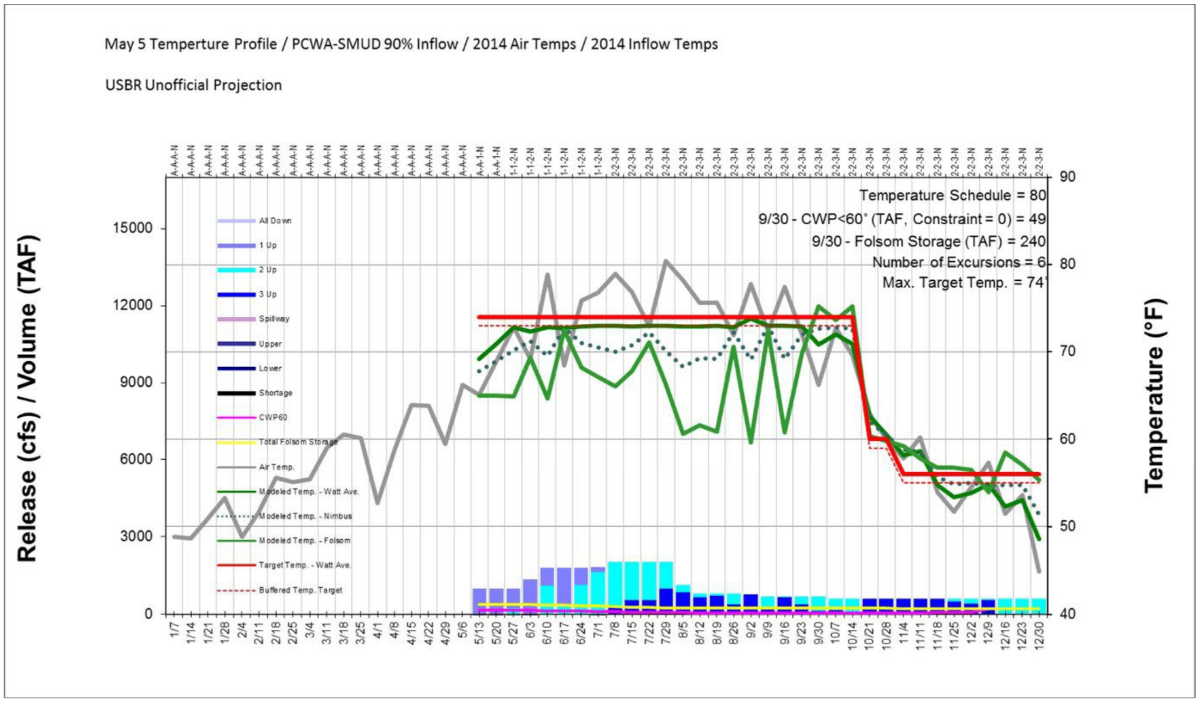
TS 79 – No summer temperature target / 60F 2nd half October / 56F Nov+Dec

- Summer temperatures range from 72-79F.
- Lowest shutters pulled 10/15.
- October target not met at Watt Ave.
- November water temperatures exceed 56F at Watt and Hazel for the first two weeks of November.



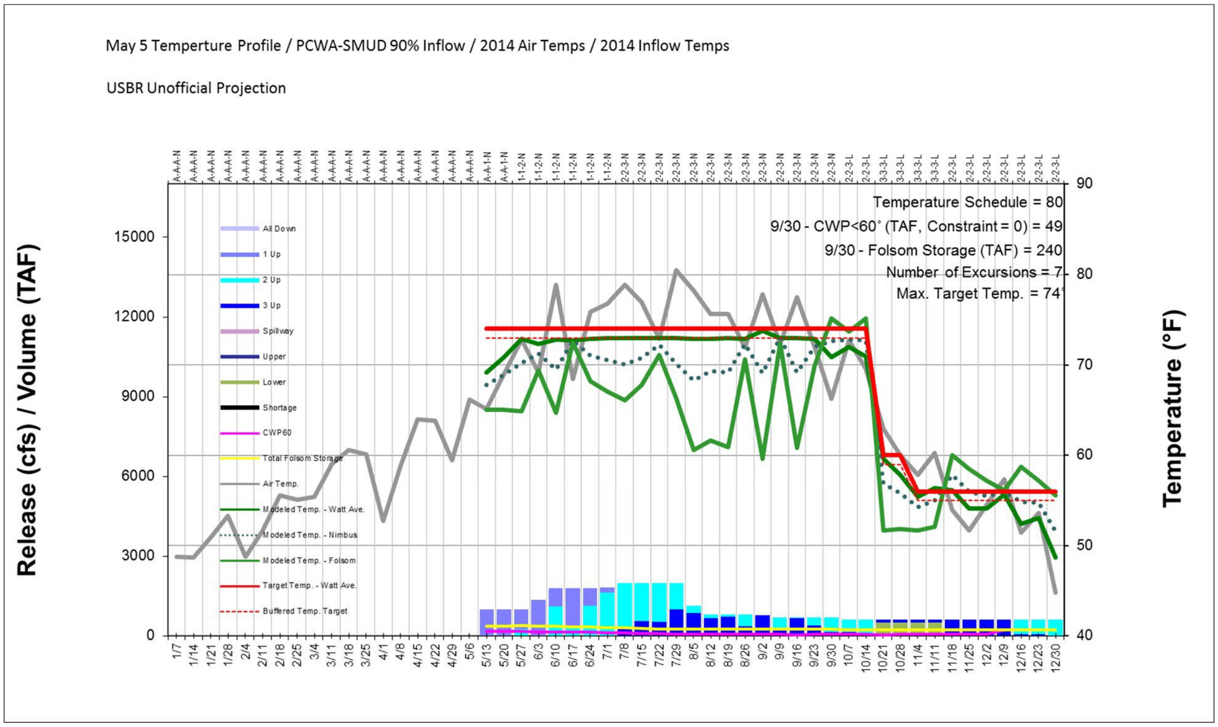
TS 80 – 74F summer / 60F 2nd half October / 56F Nov+Dec

- Able to *almost* meet 74F during summer at Watt Ave. with use of lowest shutter water(starting 7/2). Target is slightly exceeded during one week of summer (9/2).
- Not able to meet Fall temp targets. Hazel meets 56F second half of November.



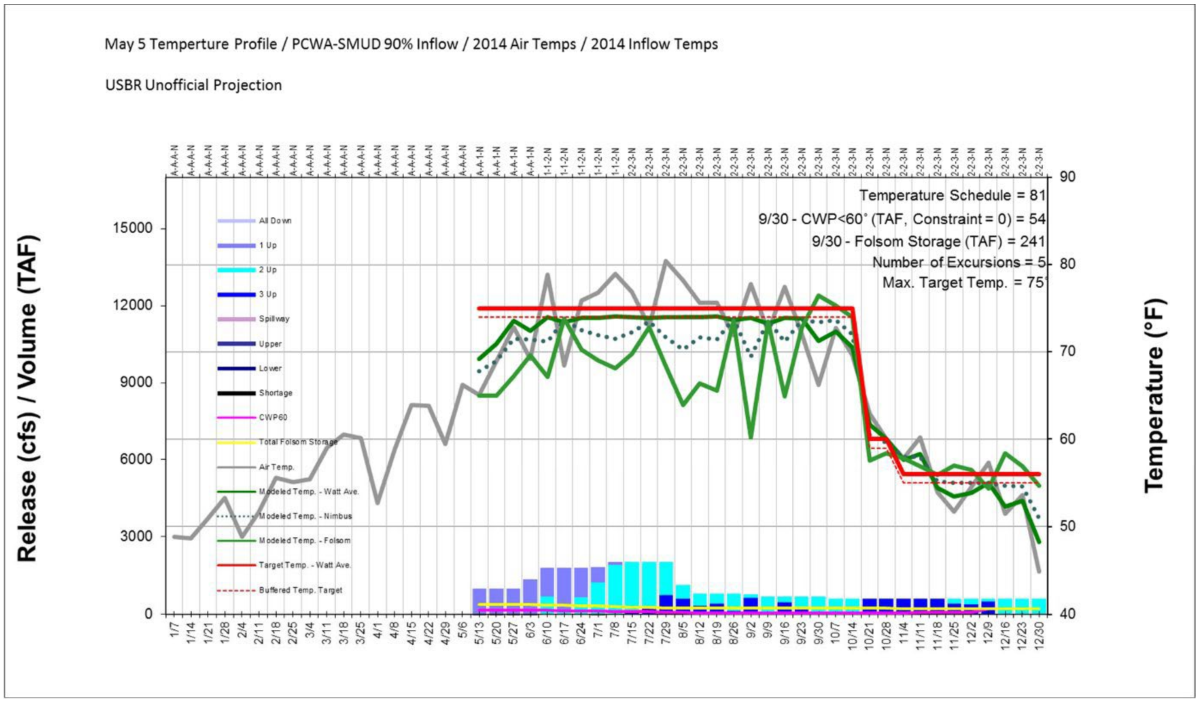
TS 80-PB – 74F summer / 60F 2nd half October / 56F Nov+Dec

- **Power bypass** is applied for 4 weeks (10/15-11/11).
- Able to almost meet 74F during summer at Watt Ave. with use of lowest shutter water(starting 7/2). Target is slightly exceeded during one week of summer.
- Not able to meet Fall temp targets at Watt and Hazel. Cooler October and early November results in warmer temps once bypass is terminated.



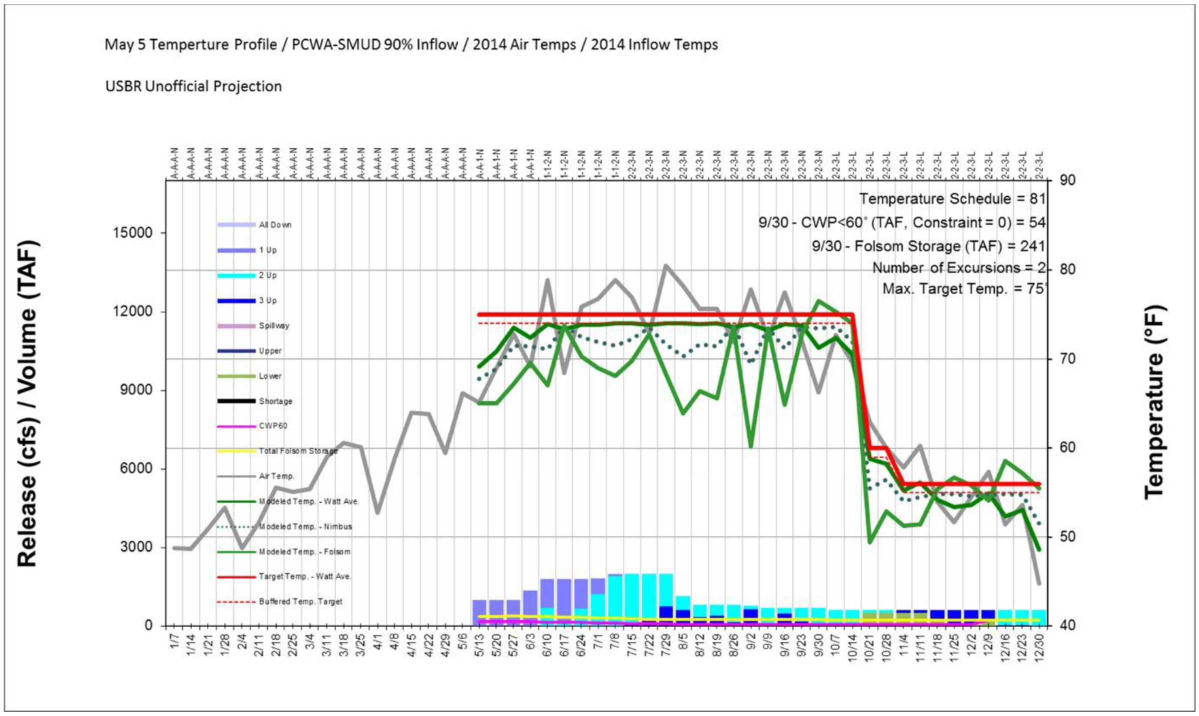
TS 81 – 75F summer / 60F 2nd half October / 56F Nov+Dec

- Able to meet 75F during summer at Watt Ave. with use of lowest shutter water (starting 7/16)
- Not able to meet Fall temp targets. Hazel meets 56F 11/12 and after.



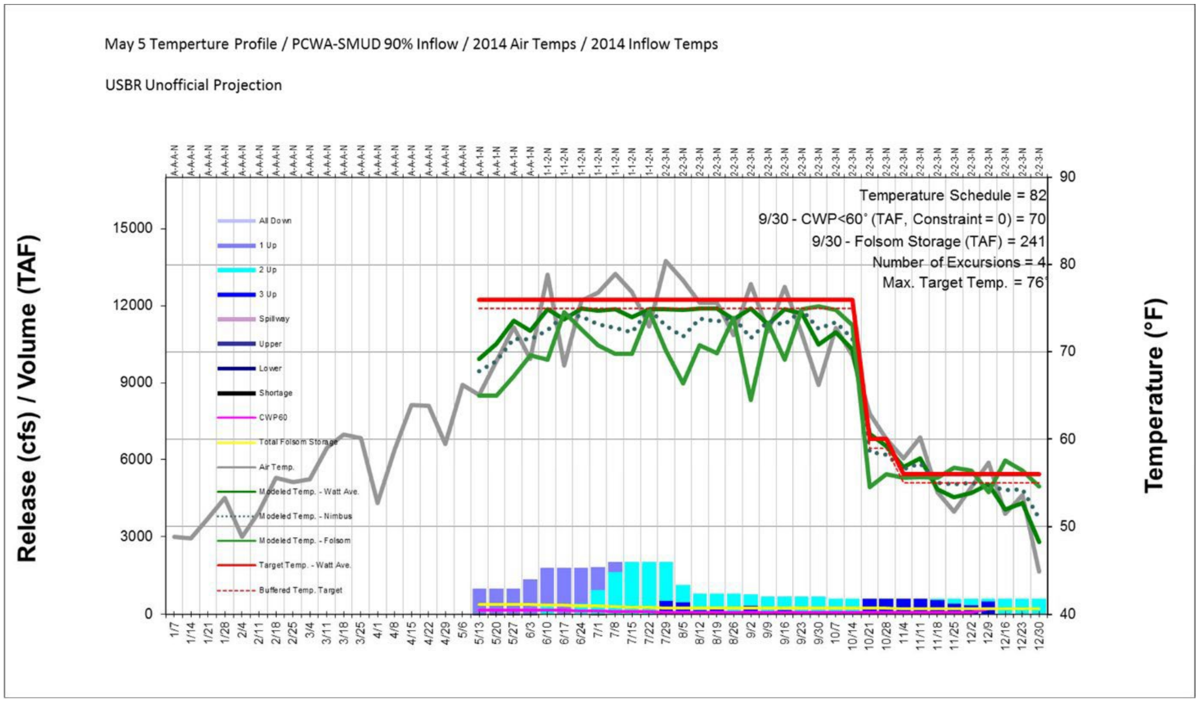
TS 81-PB – 75F summer / 60F 2nd half October / 56F Nov+Dec

- **Power bypass** is applied for 4 weeks (10/15-11/11).
- Able to meet 75F during summer at Watt Ave. with use of lowest shutter water (starting 7/16)
- Fall temp targets met at Hazel Ave., but not at Watt Ave.



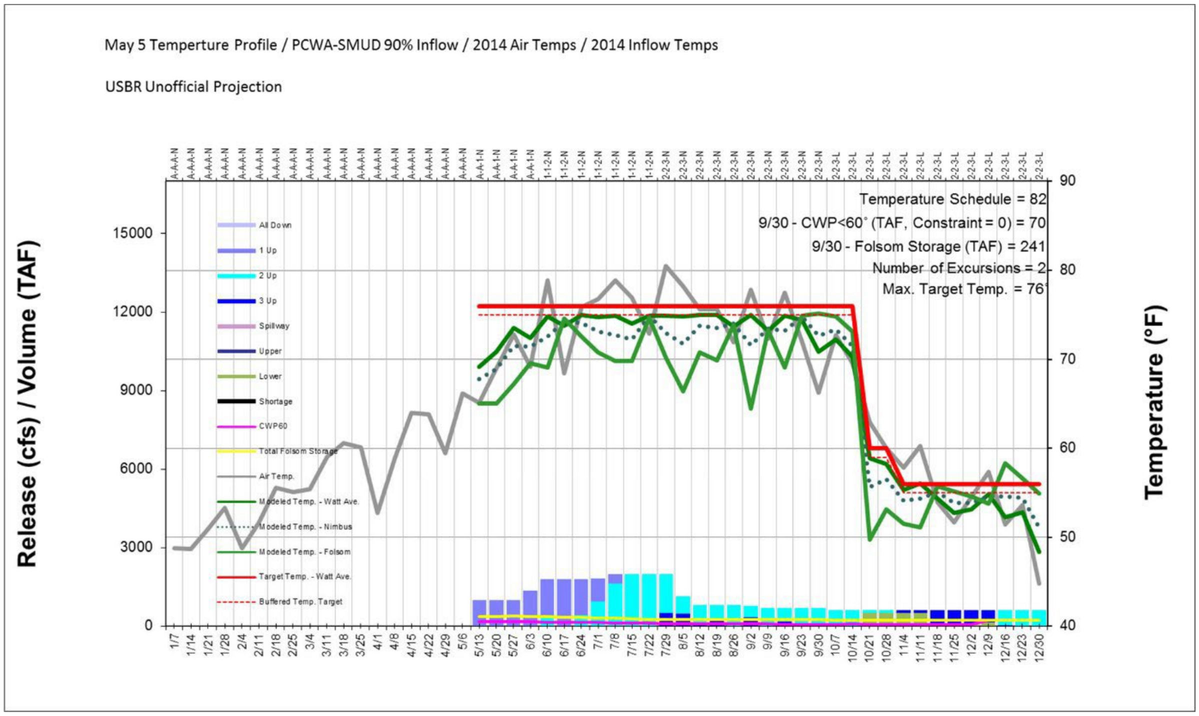
TS 82 – 76F summer / 60F 2nd half October / 56F Nov+Dec

- Able to meet 76F during summer at Watt with limited use of lowest shutter water(starting 7/23),
- Not able to meet Fall temp targets. Hazel meets 56F 11/12 and after.



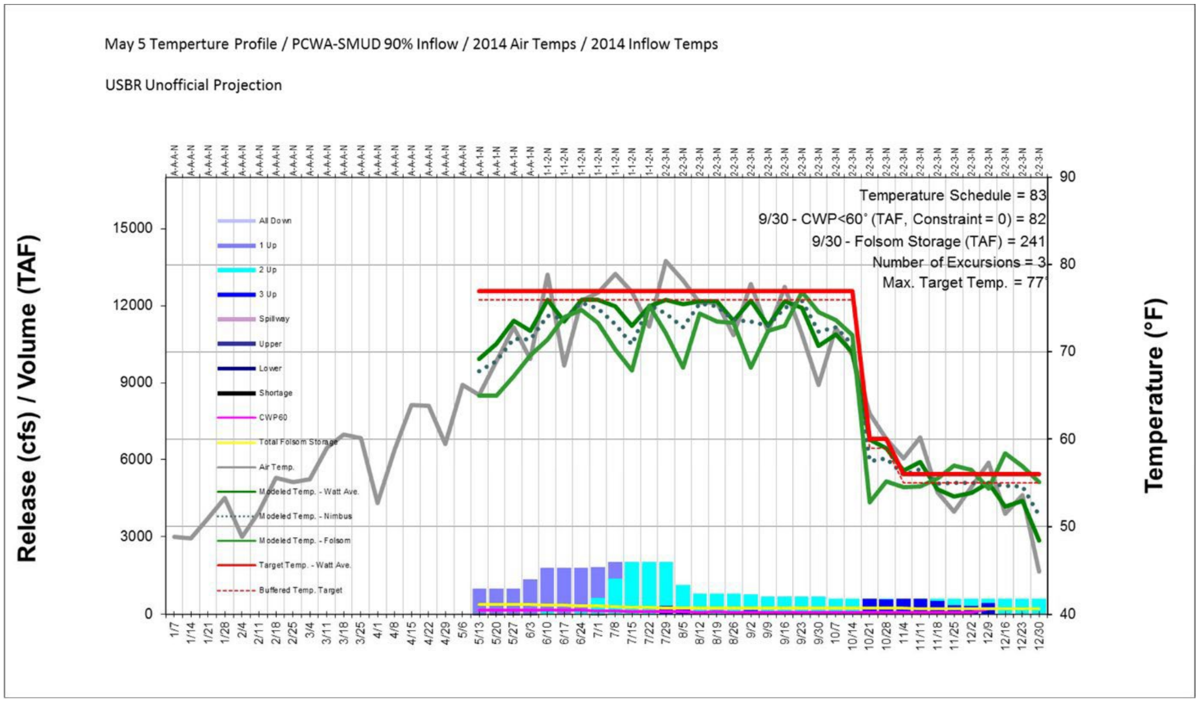
TS 82-PB – 76F summer / 60F 2nd half October / 56F Nov+Dec

- **Power bypass** is applied for 4 weeks (10/15-11/11).
- Able to meet 76F during summer at Watt with limited use of lowest shutter water(starting 7/23),
- Fall temp targets met at Hazel Ave., but not at Watt Ave.



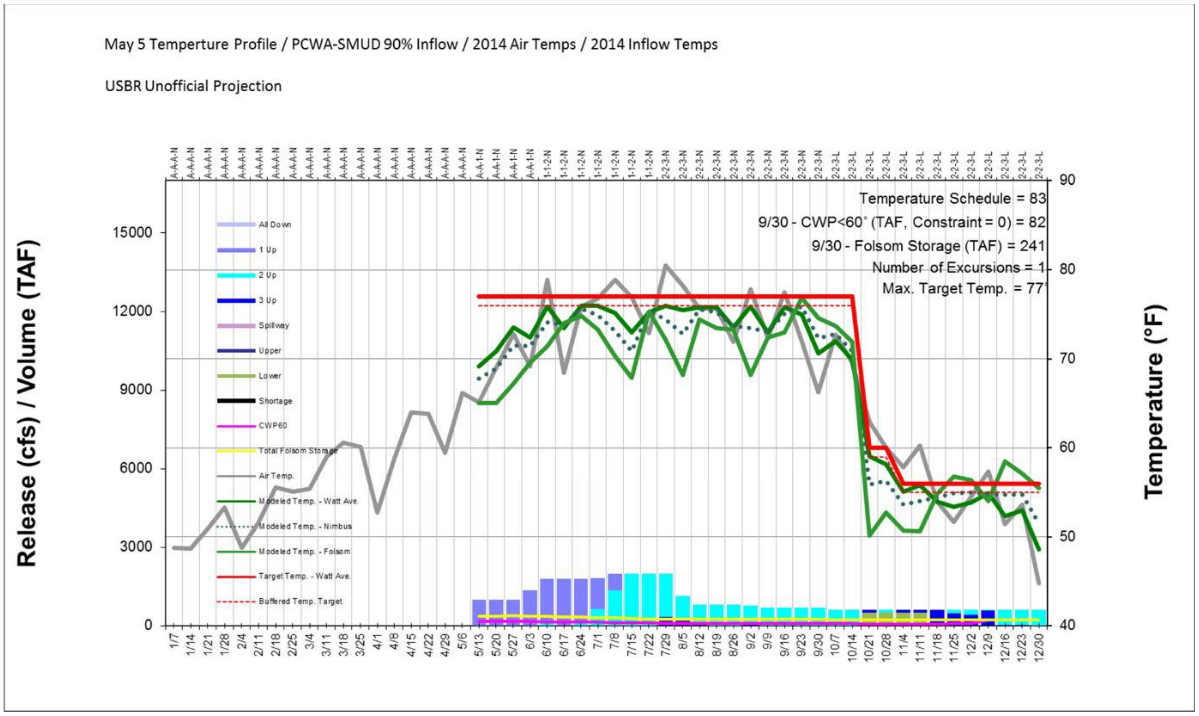
TS 83 – 77F summer / 60F 2nd half October / 56F Nov+Dec

- Able to meet 77F during summer at Watt with limited use of lowest shutter water (as early as 7/23)
- Not able to meet Fall temp targets



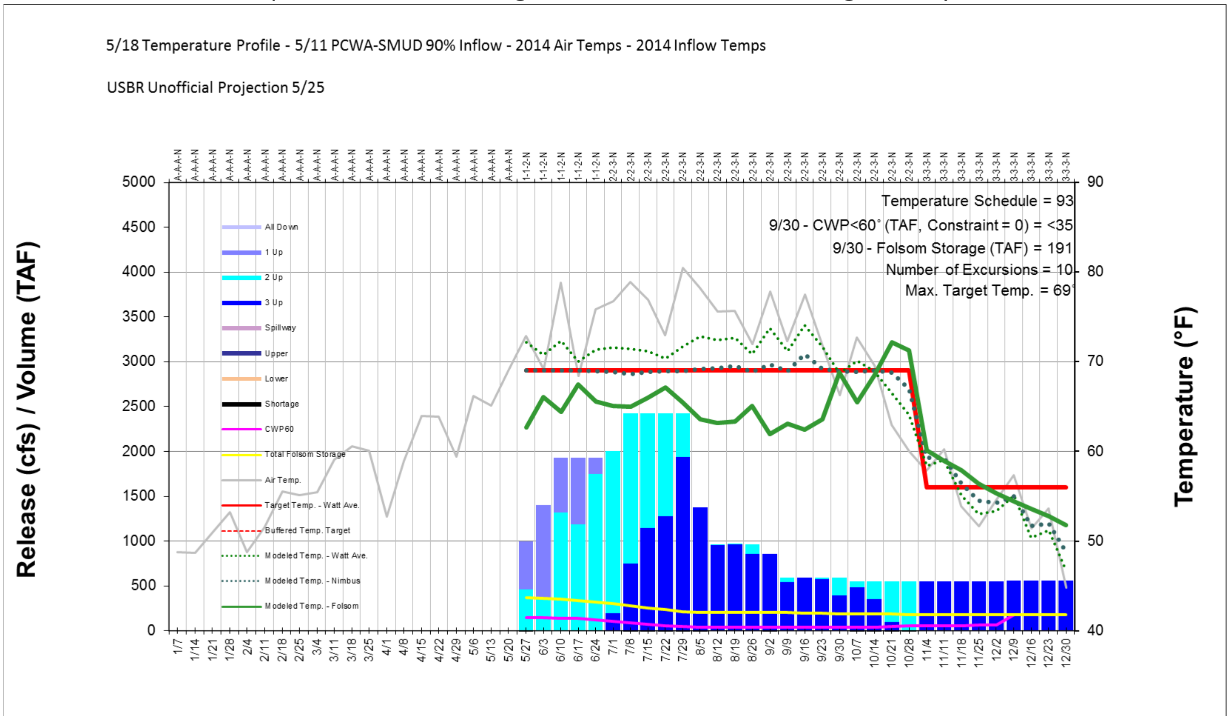
TS 83-PB – 77F summer / 60F 2nd half October / 56F Nov+Dec

- **Power bypass** is applied for 4 weeks (10/15-11/11).
- Able to meet 77F during summer at Watt with limited use of lowest shutter water (7/23-8/5)
- Fall temp targets met at Hazel Ave., but not at Watt Ave.



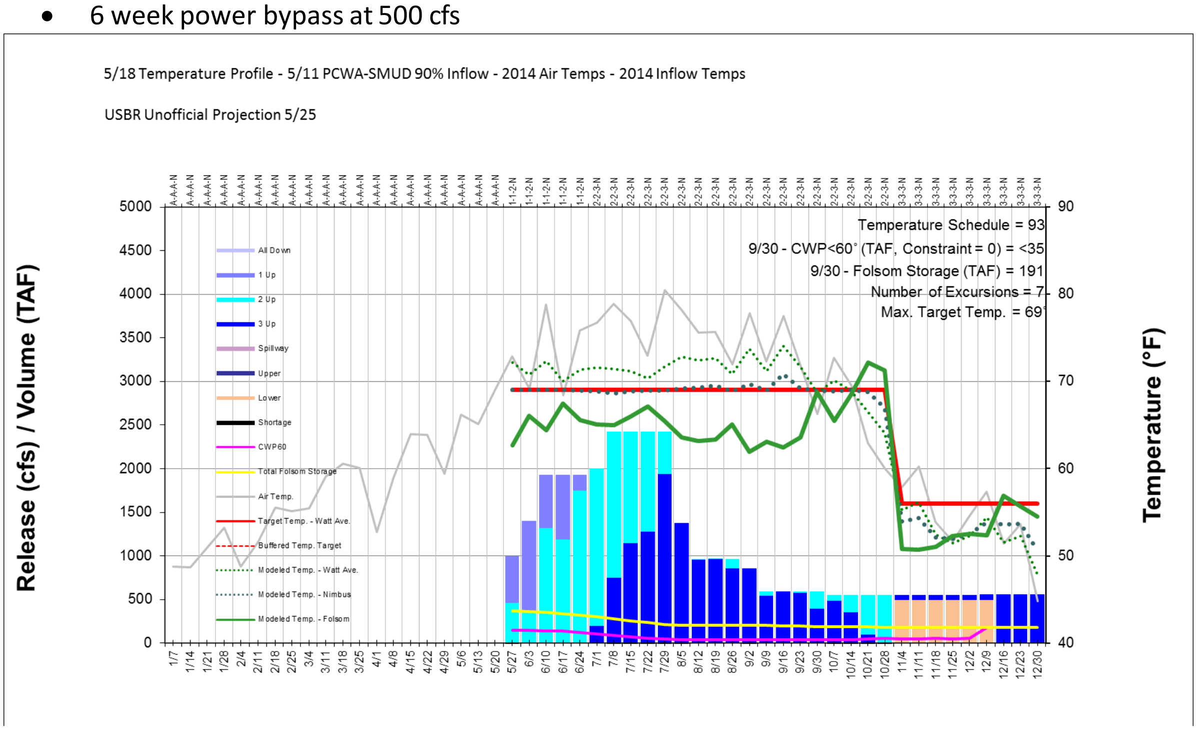
TS 93 – 69F Target through 10/28, then 56F

- Summer temperatures at Hazel met not throughout summer
- November temperatures exceed target for three weeks, reaching ~56F by 11/19



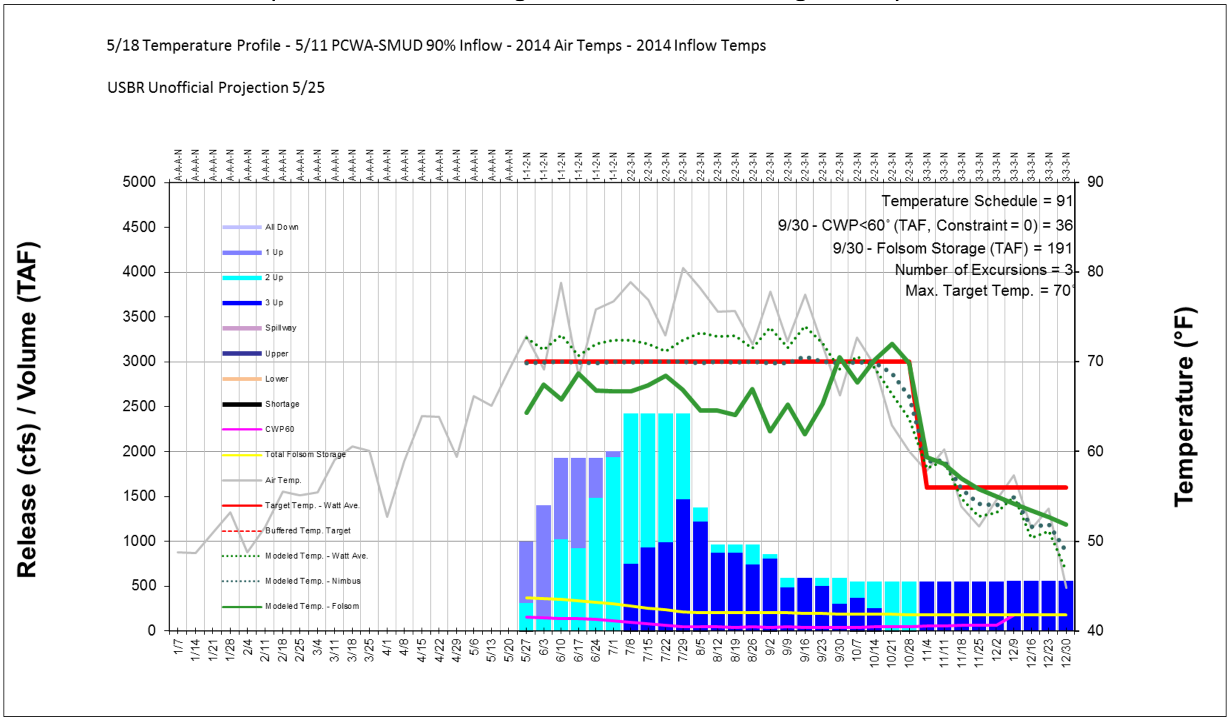
TS 93-PB6 – 69F Target through 10/28, then 56F

- 6 week power bypass at 500 cfs



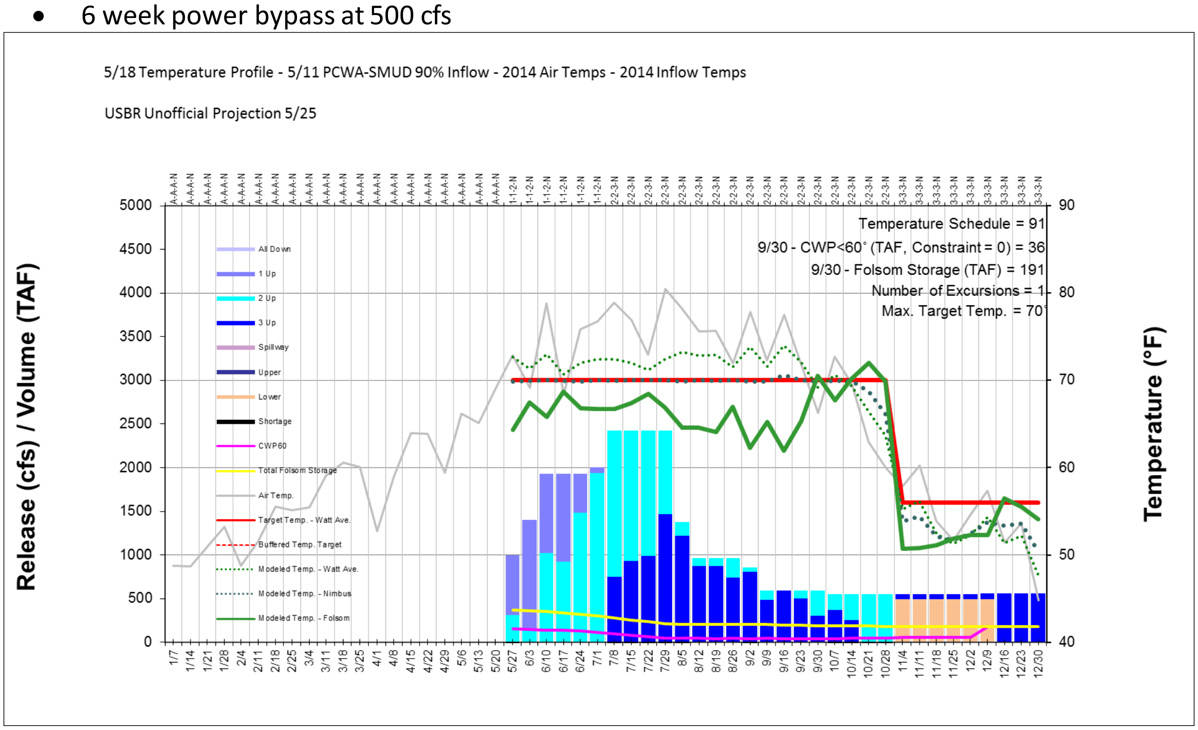
TS 91 – 70F Target through 10/28, then 56F

- Summer temperatures at Hazel met throughout summer, except for 1 minor excursion on 9/16
- November temperatures exceed target for 2 weeks, reaching ~56F by 11/12



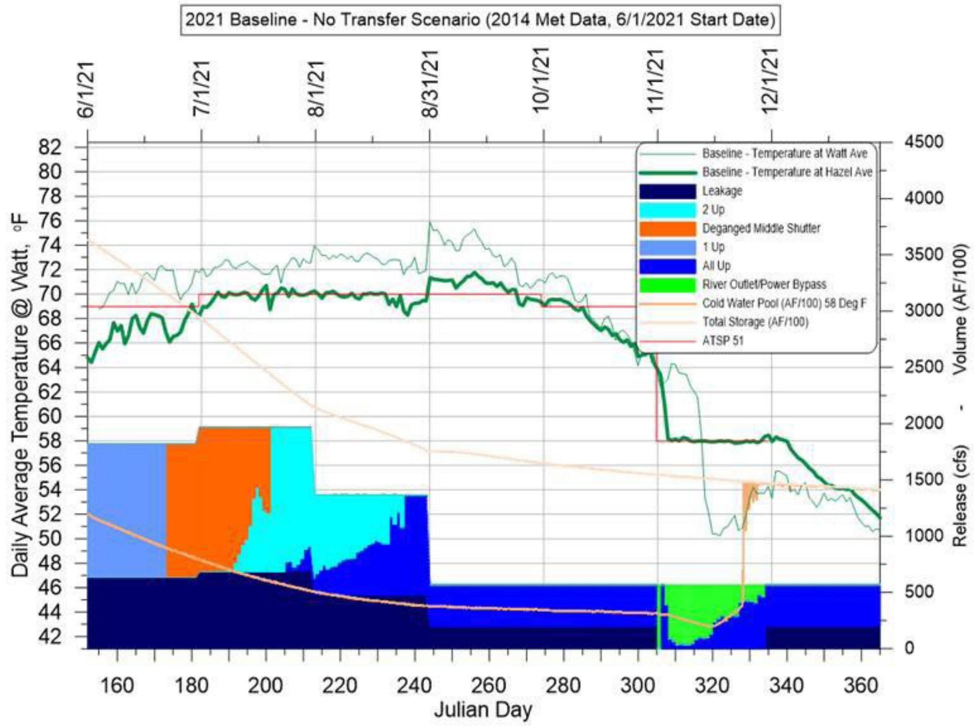
TS 91-PB6 – 70F Target through 10/28, then 56F

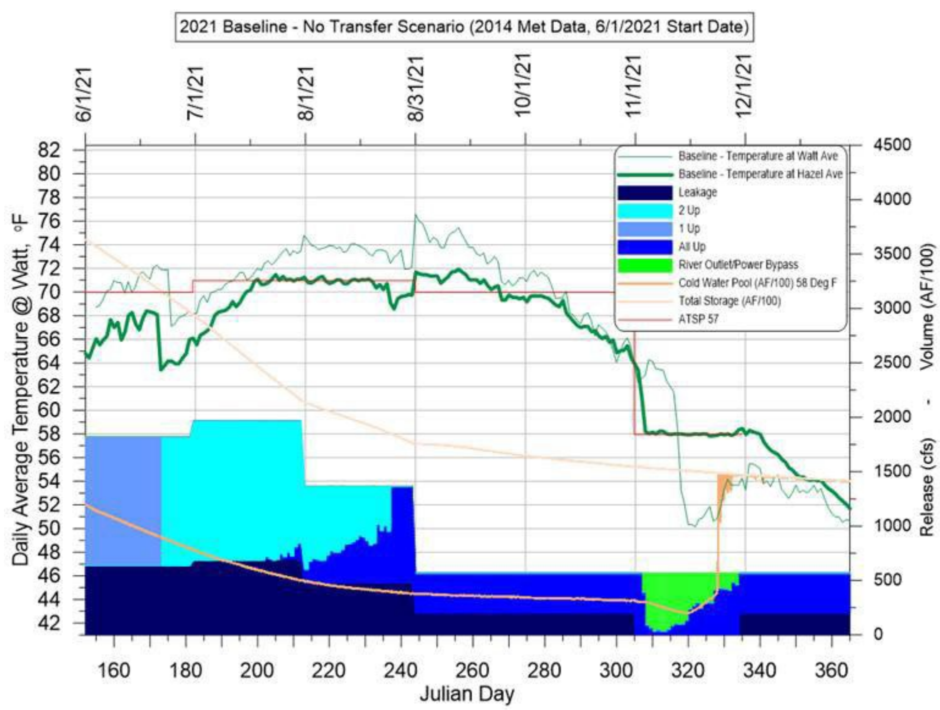
- 6 week power bypass at 500 cfs



6/3/2021 CE-QUAL-W2 Temperature Model Runs for LAR water temperatures
From Vanessa Martinez, Cardno

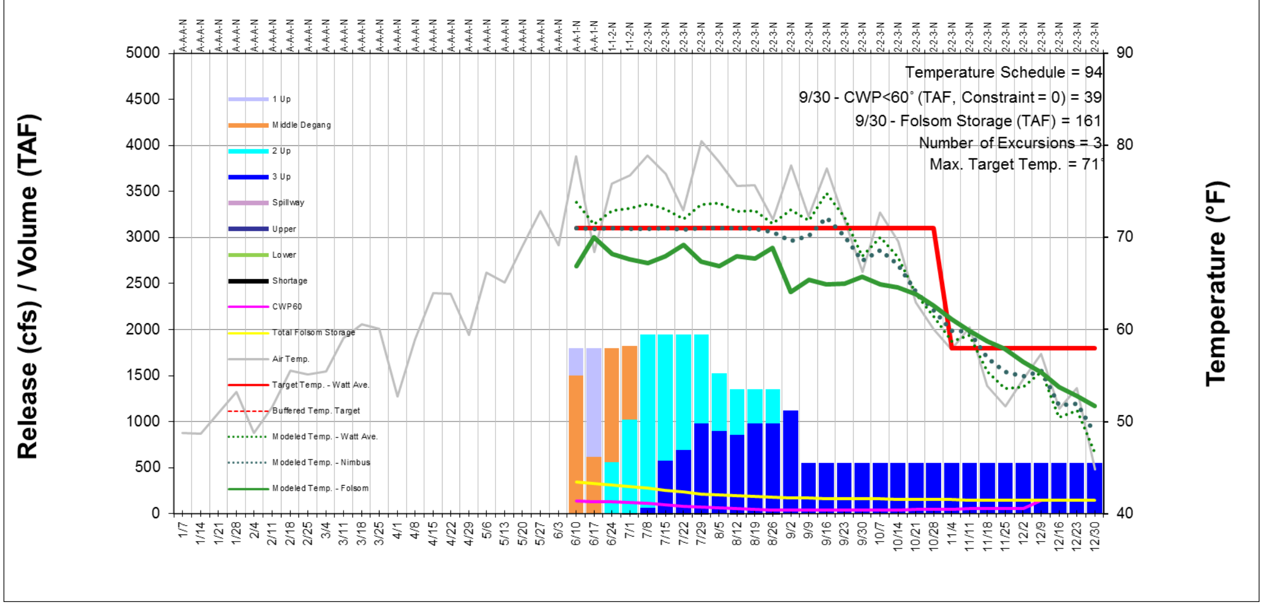
TOP=Model output assuming deganged middle shutter (likely operation)
BOTTOM= Model output assuming non-deganged middle shutter





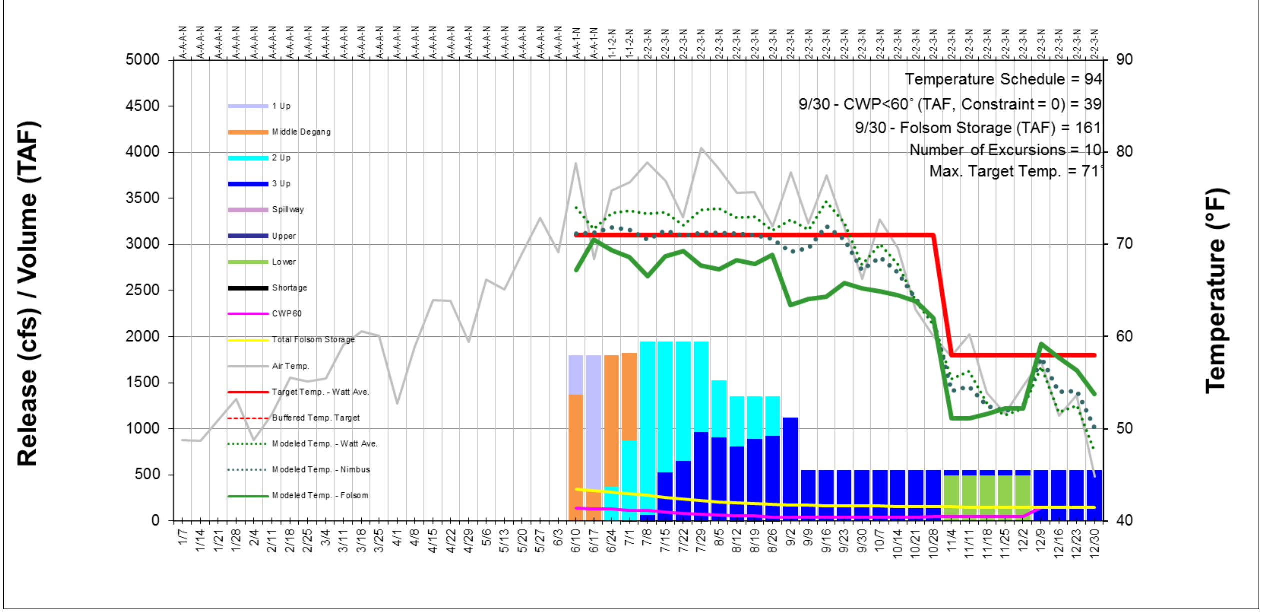
6/1 Temperature Profile - 6/1 PCWA-SMUD 90% Inflow - 2014 Air Temps - PCWA Regression Based Inflow Temps - Middle Shutter Deganged

USBR 6/1 Release Projection



6/1 Temperature Profile - 6/1 PCWA-SMUD 90% Inflow - 2014 Air Temps - PCWA Regression Based Inflow Temps - Middle Shutter Deganged - 5 week 500 cfs Power Bypass

USBR 6/1 Release Projection



Water Forum Comments on Draft Temperature Management Plan

June 17, 2021

[EXTERNAL] Water Forum - Comments on Draft Temperature Management Plan

Jessica Law <JLaw@waterforum.org>
Thu 6/17/2021 9:05 AM
To: WASHBURN, THUYT <TWashbum@usbr.gov>
Cc: Johnson, Levi E <lejohnson@usbr.gov>;White, Kristin N <knwhite@usbr.gov>; Hammersmark, Chris <c.hammersmark@cbecoeng.com>; Rafael Silberblatt <rsilberblatt@keamswest.com>

® 2 attachments (1 MB)
Water Forum 2021 Temperature Planning Tech Memo 5-25-21.pdf; 2021 LAR Draft Temp Plan_06102021_CTH.pdt,

Hi Thuy-

Thank you for the opportunity to comment on the draft temperature management plan. Please see below and attached for our feedback.

We appreciate efforts by Reclamation to collaborate with Water Forum, NMFS, CDFW, SWRCB, and other interested parties to discuss and determine the best use of the limited cold-water pool in this Critical water year, consistent with Section 13.3.3.1of the 2019 NMFS BiOp. As discussed at the ARG meetings, the best science currently available suggests Reclamation should pursue the following management actions to maintain best possible conditions for fish and maintain adequate water supplies:

- **Summer/Early Fall (June 1- October 15):** Operate to a temperature target not to exceed 71 degrees at Hazel. Since maintaining a consistent temperature is important for fish health, Reclamation should aim for what is achievable based on changes in ambient temperatures and hold the lowest temperature that it is possible to maintain. Reclamation should degang (that is, separate) the middle shutters in June, which will allow for more control over temperature of releases. Reclamation should also evaluate the potential benefits that could be achieved by deganging the lower shutter as well. During this time, Reclamation should also strive to maintain sufficient storage in Folsom to preserve a cold-water pool adequate to support Fall releases as set forth below, and protect water supply for this year and next.
- **Fall (October 15 - November 1):** Operate to reduce ternperatures to 60 degrees at Hazel in order to reduce pre-spawn mortality. This may have to be revisited based on conditions and available cold-water pool.
- **Fall/Winter (November 1- December 31):** Implement a power bypass for 4-6 weeks in the Fall to maintain 56 degrees if possible, but not to exceed 58 degrees, for Fall-Run chinook spawning. Power Bypass will need to be initiated prior to November 1 to account for travel time through Lake Natoma.

As conditions continue to change, Reclamation must take deliberate action to carefully adjust flows to balance storage and maximize benefits for fish. **All releases should be considered for Folsom reservoir storage and lower American River temperatures as the top priority.** Each time the Reclamation issues a new operations outlook and flow pattern, it needs evaluated for temperature impacts. Reclamation provided an updated forecast yesterday afternoon, and given the update, we will review the temperature implications and look forward to discussing at the ARG meetingthis afternoon.

Best, Jessica

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Water Forum
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Attachment D

American River Power Bypass Proposal, October 1, 2021

Proposal for Power Bypass at Folsom Dam
October 1, 2021

Proposed Power Bypass and Executive Summary: To improve conditions in the Lower American River, the California Department of Fish and Wildlife (CDFW), the National Marine Fisheries Service, and United States Fish and Wildlife Service jointly request implementation of Bypass Scenario C, which is a 150 cfs power bypass at Folsom Dam from October 11, 2021 through October 18, 2021 and a 350 cfs power bypass at Folsom Dam from October 18, 2021 through November 25, 2021, or until a target temperature of 56°Fahrenheit (F) at Hazel Avenue Bridge can be achieved and maintained without a power bypass. This proposal was presented to the American River Group (ARG) at the September 24th, 2021, ad hoc meeting on and was supported by all members present. Power bypass is an established tool regularly utilized on large Central Valley Project reservoirs to improve spawning and egg incubation temperatures for Chinook Salmon spawning. Power bypass was utilized in twelve of the previous twenty years on the Lower American River (LAR) (Appendix A). Folsom Reservoir power bypasses averaged from 172 to 516 cfs during 2001-2020 (Appendix A). Drought conditions this year and associated low reservoir storage in Folsom Reservoir and diminished cold-water pool make this action particularly important in trying to achieve suitable spawning temperatures for fall-run Chinook Salmon in the Lower American River.

The United States Bureau of Reclamation (USBR) is currently operating to a Summer-Fall Temperature Management Plan which targets water temperatures not to exceed 71° F through October 31, and 58°F beginning November 1 at Hazel Avenue. That Management Plan did not include a power bypass at Folsom Dam but did acknowledge that Reclamation would evaluate a power bypass later in the summer. The temperature modeling (Appendix B) shows that the No Power Bypass scenario gradually decreases water temperatures through October but doesn't achieve 58° F until the second half of November. Flows on the American River are currently at 550 cfs and are projected to remain at 550 cfs through the month of November. CE-QUAL-W2 modeling results indicate that a 150 cfs power bypass followed by a 350 cfs of power bypass provides a significant temperature benefit, with minimal risk of premature cold-water pool depletion. A power bypass greater than 350 cfs was not explored as USBR has noted that it needs to maintain 30% of the total reservoir release for power generation to maintain grid viability (T. Washburn personal communication[1]).

As previously presented to the ARG and as recognized in the Water Quality Control Plan for the Central Valley Region, 56° F or less supports Chinook Salmon spawning and egg incubation in the LAR and at the Nimbus Fish Hatchery (NIM). This is consistent with operating criteria on other Central Valley Project reservoirs. Using the modeling results from three different models (SALMOD, Water Forum 2020, and Martin 2016), the anticipated increase in cohort-level egg survival for Bypass Scenario C compared to the No Bypass Scenario is between 2% and 13% (Table 3). At the daily level, for early-season redds, the anticipated increase in egg survival can be as high as 85% (see, for example, the relative survivals on October 22 in Table 4). It is important to note this is strictly an egg survival estimate, which underestimates total impacts to spawning because of elevated temperature. In 2019, prespawn mortality for the weeks between October 14 - November 15 was 46%; with corresponding water temperatures exceeding 58° F. In 2020, prespawn mortality for these same weeks (October 13 – November 13) was 77% with corresponding water temperatures exceeding 56° F. This is important to note as Sacramento Valley fall-run Chinook Salmon support the states multimillion dollar sport and commercial fishery and providing suitable conditions for spawning is a public trust responsibility.

Fiscal impacts to California from lost salmon production as well as to USBR from lost power production were evaluated. CDFW calculated the power bypass costs using the anticipated flow schedule for the LAR and publicly- available CAISO hourly pricing data for recent days, recent headwater and tailwater elevations, and assuming a hydropower efficiency factor of 86%. Power bypass costs for this proposal (Bypass Scenario C) are estimated to be up to $400,000 if the bypass is

[1] T. Washburn personal communication. August 19, 2021. American River Group Meeting Notes. United States Bureau of Reclamation. Email to M. Kilgour on September 23, 2021.

used for the full seven-week period. This is comparable to the USBR estimate of $412,000. The Bureau's total generation revenue through the Folsom units during this time, was estimated to still be about $419,000. These values are provided only for comparison as they were developed not with the actual power prices that will occur during the bypass. As more water can still be run through the powerhouse during peak hours, 50% of the revenue generation potential at Folsom should still be available to the USBR in addition to full power generation at Nimbus Dam. In contrast, and not accounting for losses in the ocean sport or commercial fishery, a reduction of only 500 adult salmon available for harvest in the Sacramento Valley due to decreased juvenile production represents an economic loss of $618,000 (2015 dollars) based on values developed by Fish Bio.

Issue: In 2020, adult fall-run Chinook salmon returns to the Sacramento Valley were considered rebuilt and not overfished nor undergoing overfishing. However, this status is based on the three-year geometric mean of adult spawning escapement and is subject to change. Conservation targets are set by the Pacific Fisheries Management Council (PFMC), a multi-agency governing body to which the CDFW and the NMFS are members, and stock status is evaluated annually. Fall-run on the American River have historically contributed significantly to the ocean sport and commercial fishery. To increase in-river production of fall-run Chinook salmon on the LAR water temperature management and management of the Folsom Lake's cold-water pool needs to improve, and annual operational planning should incorporate fall-run spawning temperature and flow needs. Drought conditions in 2021 and associated low reservoir storage in Folsom Reservoir and diminished cold-water pool have highlighted this need.

Temperatures in the LAR and at NIM were projected to be 71° F during the summer months, well beyond temperatures suitable for maintaining health and growth of steelhead in a hatchery setting. As a result, NIM steelhead were temporarily relocated to the Mokelumne Fish Hatchery to help ensure USBR meets steelhead mitigation goals for the loss of spawning and rearing habitat with the creation of the Nimbus Dam. To minimize impacts to the Mokelumne Fish Hatchery operations, it is critical that these fish are returned to NIM as soon as possible. To avoid additional losses, NIM steelhead cannot be returned to the Nimbus Fish Hatchery until temperatures of 60° F or lower can reliably be maintained at the hatchery. Without a power bypass, successful return to the hatchery will be further delayed.

The USBR is required to address American River temperature management as per the USBR 2019 Biological Assessment which also states that USBR will attempt a target temperature of 56° F starting November 1 if cold water pool allows. Furthermore, it states that USBR will limit power bypass operations solely to respond to emergency or unexpected events or during extreme drought years when a drought emergency has been declared by the Governor of California. On April 21, 2021, Governor Newsom declared a Drought Emergency Proclamation due to dry conditions as of that date which included the Sacramento-San Joaquin Delta Watershed Counties. Elevated water temperatures are a major stressor for Sacramento River fall-run Chinook salmon, a stock managed under the federal Magnuson-Stevens Fishery Conservation and Management Act (MSA). In 1992, the Central Valley Project Improvement Act (CVPIA) modified the Central Valley Project purpose to include mitigation, protection, and restoration of fish and wildlife, including fall-run Chinook salmon.
As stated in Title 34 Public Law 102-575, CVPIA Section 3402 Purposes:

The purpose of this title shall be:

- *(a) To protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California;*
- *(b) To address impacts of the Central Valley Project on fish, wildlife and associated habitats;*
- *(c) To improve the operational flexibility of the Central Valley Project;*
- *(d) To increase water-related benefits provided by the Central Valley Project to the State of California through expanded use of voluntary water transfers and improved water conservation;*

(e) To contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary;

(f) To achieve a reasonable balance among competing demands for use of Central Valley Project water, including the requirements of fish and wildlife, agricultural, municipal and industrial and power contractors

Biological Justification: During summer months, warm surface water and cooler water below the surface in the reservoir (cold-water pool) are blended during dam releases to meet the LAR summer temperature limit for juvenile steelhead while releasing stored water from Folsom Lake for exports and Bay-Delta water quality. These operations reduce cold- water pool storage prior to fall-run Chinook salmon spawning, making it difficult to achieve suitable spawning temperatures using only releases through the Temperature Control Device (TCD) at Folsom Dam. As demonstrated by the CE-QUAL-W2 modeling results, water temperatures can be reduced through utilizing power bypass (Appendix B) which results in improved fall-run Chinook Salmon spawning and egg incubation success (Table 3 and Table 4). A general discussion of the relationship between water temperature and spawning success, and a summary of mortality modeling results, is provided below.

On the LAR, fall-run Chinook salmon initiate spawning toward the latter end of October with most of spawning occurring during the month of November. Temperatures in late October and early November have frequently been observed to be over 60° F and result in temperature-caused egg loss during these periods (Snider et. al 1995). Water temperatures in the early part of spawning frequently exceed 62° F, which is expected to cause 100% temperature related mortality to these eggs. The thermal requirements for Chinook Salmon in the Central Valley have been evaluated in thermal physiological studies. In 1997 A.A. Rich reported to the California State Water Resource Control Board that thermal stress for migrating adult salmon had been reported at temperatures beginning at 59° F, and lethal temperatures began at 62.6° F. Incubating eggs were even more sensitive; temperatures lethal to incubating eggs began at 55° F (Rich, A.A. 1997). Rich based her testimony on results of thermal studies both within the Sacramento-San Joaquin River system and elsewhere indicating that constant exposure of salmonid eggs to temperatures above 55-56° F will result in some egg mortality. The Bureau's egg mortality model (as used for the 2009 Biological Assessment) assumed non-zero egg mortality at 57°F and higher (Table 1).

Table 1. Relationship between water temperature and mortality of Chinook salmon eggs and preemergent fry used in the Reclamation egg mortality model (reproduced from the CVP/SWP operations BA table 6-2).

Water Temperature (°F)[a]	Egg Mortality[b]	Instantaneous Daily Mortality Rate (%)	Pre-Emergent Fry Mortality[b]	Instantaneous Daily Mortality Rate (%)
41-56	Thermal optimum	0	Thermal optimum	0
57	8% @ 24d	0.35	Thermal optimum	0
58	15% @ 22d	0.74	Thermal optimum	0
59	25% @ 20d	1.40	10% @ 14d	0.75
60	50% @ 12d	5.80	25% @ 14d	2.05
61	80% @ 15d	10.70	50% @ 14d	4.95
62	100% @12d	38.40	75% @ 14d	9.90
63	100% @11d	41.90	100% @ 14d	32.89
64	100% @ 7d	65.80	100% @10d[c]	46.05

[a] This mortality schedule was compiled from a variety of studies each using different levels of precision in temperature measurement, the lowest of which was whole degrees Fahrenheit (+0.5°F). Therefore, the level of precision for temperature inputs to this model is limited to whole degrees Fahrenheit.

[b] These mortality schedules were developed by the USFWS and CDFG for use in evaluation of Shasta Dam temperature control alternatives in June 1990 (Richardson *et al*. 1990)

[c] This value was estimated similarly to the preceding values but was not included in the biological assumptions for Shasta outflow temperature control FES (Reclamation 1991b)

In the LAR, Chinook Salmon eggs incubated in water temperatures above 62° F resulted in 100% mortality; eggs incubated in water at 60-62° F had a 50% mortality to the eyed stage, and eggs incubated in 55-59° F experienced 20% mortality (Hinze 1959[2]). Furthermore, when eggs were taken at water temperatures of 60-62° F and incubated at cooler temperatures of 55-56° F there was still a 30% loss to the eyed-egg stage. Sacramento River-strain Chinook salmon eggs and fry exposed to water temperatures ranging from 43.5-63° F showed similar results. Mortalities of 80% or more were experienced during fingerling development of fry when incubated in water temperatures of 60-61° F; egg and fry mortalities decreased as temperatures decreased below 60° F and were abnormally high when temperatures exceeded 57.5° F (Healey 1979[3]).

The SacPAS website includes an "Egg Growth Model" tool (SacPAS: Egg Growth Model website) that allows the user to apply a variety of egg mortality and emergence timing models to historical (or user-defined) water temperature and spawning data to estimate outputs such as timing to hatch, emergence, and overall egg-to-fry mortality. The survival functions available (with default parameters) are summarized in Figure 1.

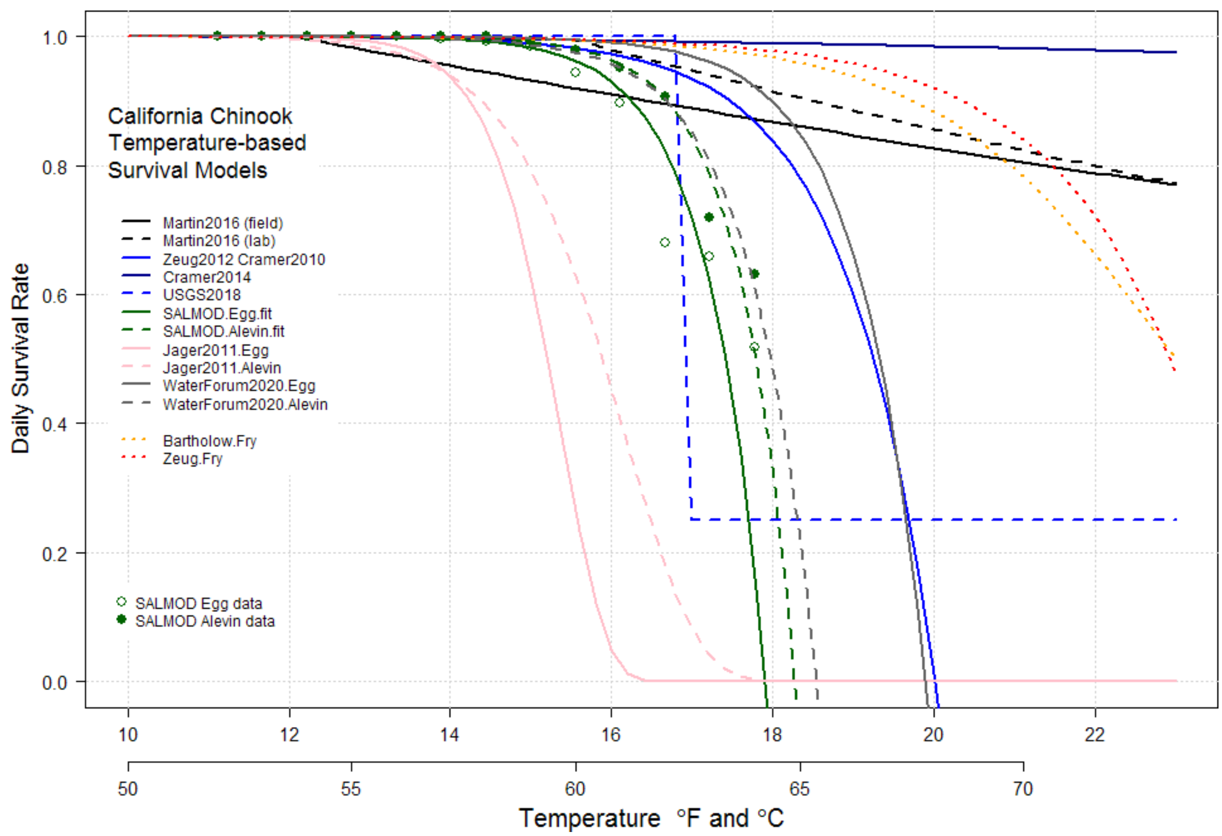


Figure 1: Temperature-dependent survival models available for use in the SacPAS Egg Growth Model tool. Each curve shows daily survival rate as a function of water temperature. Figure downloaded from SacPAS: Egg Growth Model website on September 24, 2021.

2 Hinze, J.A. 1959. Annual Report Nimbus Salmon and Steelhead Hatchery Fiscal Year of 1957-58. California Department of Fish and Game, Inland Fisheries Administrative Report 59-4. 21 p.
3 Healey, T.P. 1979. The Effect of High Temperature on the Survival of Sacramento River Chinook (King) Salmon, Oncorhynchus tshawytscha, Eggs and Fry. California Department of Fish and Game Inland Fisheries Administrative Report 79-10. 7 p.

Several methods were used to compare the expected egg-to-fry survival under the four scenarios (three bypass scenarios and the No Bypass Scenario), as summarized in Table 2. The water temperature modeling was done by Cardno using a CE-QUAL-W2 model for Folsom, a CE-QUAL-W2 model for Lake Natoma, and regression-based estimates for water temperatures below Nimbus dam (based on data from 2001-2019). Before being used as the water temperature inputs to the egg mortality model, the outputs from the CE-QUAL-W2 modeling (see summary in Appendix B) were modified in two ways. First, the date range of the water temperature files was extended through the end of April to allow the estimation of egg mortality through emergence of all redds. Second, water temperatures were set to a steady 56° F once modeled water temperatures fell consistently below 56° F; this occurred November 22 in the No Bypass scenario, November 12 in Bypass Scenario A, November 14 in Bypass Scenario B, and November 16 in Bypass Scenario C (see modified data series in Appendix C). This approach is consistent with the proposal to implement a power bypass *only until a target temperature of 56°F at Hazel Avenue Bridge can be achieved and sustained without power bypass*. When the temperature achieved is lower than the proposed temperature, power bypass will be gradually reduced to a level that allows us to maintain temperatures at the proposed level. While actual late fall and winter water temperatures may be cooler than 56°F (which might affect emergence timing and mortality), the egg-to-fry survival estimates from the modified temperature datasets are comparable across scenarios, since all scenarios make this simplifying assumption. For convenience, a calendar of Julian days is provided in Appendix D to help interpret the SacPAS output which lists only Julian days.

The spawning data used for the egg growth model was from Brood Years 2014, 2015, and 2016. A multi-year selection is a new option in the SacPAS tool and was chosen to get a more generalized spawn-timing distribution by including multiple years. The specific years of 2014, 2015, and 2016 were chosen as representative years from the recent drought period. When multiple years of spawning data are selected, the SacPAS Egg Growth Model tool implements the selection by creating a “super-cohort” time series that, for each date, has a carcass count (offset to 12 days earlier to represent the date eggs were laid in a redd) that is the sum of the carcasses observed on that date across all selected years. This summation approach results in better coverage of dates during October, when carcasses (and offset redd numbers) in any single year are relatively sparse. The summation approach does mean that the number of redds, eggs, and juveniles in the output data should be disregarded (because they are not representative of single-year abundance), but the egg-to-fry survival estimates that are the focus of this evaluation are still relevant and unaffected by the summation approach.

Next, egg-to-fry survival estimates were generated using the SacPAS Egg Growth Model tool, with inputs described in Table 2.

Table 2: Description of runs using the SacPAS Egg Growth Model tool. All options for user defined values were left at default settings except that “Smooth redd or carcass values” was selected in the “Analysis and Results Display” box; temperature data was specified “Celsius”, and Celsius-based parameters were selected. Three sets of results are provided for each scenario – one for each of the temperature-dependent mortality models used.

Scenario	Options and Input Data
Temperature Data	Water temperature dataset for each of four scenarios (through “Upload File” option)
Spawning Data	American River Fall Chinook carcasses in 2014, 2015, and 2016 (spawned females; smoothed)
Mortality models (temperature)	• Exponential: Water Forum 2020 • Exponential: SALMOD 2006, USBR 2008, HCI 1996 • Linear: Martin 2016
Mortality model (density)	No density dependence
Egg Development model	Chinook linear

Results for cohort-level egg-to-fry survival from the SacPAS Egg Growth Model tool are summarized in Table 3, for all twelve runs (four scenarios run using three mortality models). These results summarize egg-to-fry survival for all redds in a season, including those spawned after the bypass period during which a common temperature of 56°F is assumed for all incubating eggs. Differences in survival rate between the scenarios are driven by the differential survival of the eggs in the redds spawned during the bypass period (when water temperatures are cooler in the bypass scenarios compared to the no bypass scenario). Daily-level egg-to-fry survival results (survival through emergence for eggs spawned on a particular day during the bypass period) are summarized in Table 4.

Table 3: Cohort-level Egg-to-fry survival reported out from the SacPAS Egg Growth Model tool.

Growth Model	Egg-to-fry survival (%)	Egg-to-fry survival (%)	Egg-to-fry survival (%)	Egg-to-fry survival (%)
N/A	No Bypass	Bypass A	Bypass B	Bypass C
Water Forum 2020	88.20	90.89	91.21	91.63
SALMOD 2006, USBR 2008, HCI 199	76.38	88.39	89.46	89.81
Martin 2016	8.64	10.63	10.69	10.65

A summary of estimated daily-level overall egg-to-fry survivals for each scenario from October 2 (date of the first redd) through November 22 (the date at which the water temperature inputs for all four scenarios converge at a steady 56° F) is provided in Table 4; missing dates October 7 through October 12 represent dates for which no redds were present in the selected spawning input file. The SALMOD model appears to be the most sensitive to the temperature differences modeled; those outputs represent the greatest differential between scenarios and are the basis for the comparisons below.

- During the third week of October (orange-highlighted cells), there is 0% egg-to-fry survival in the no bypass scenario, with improvements in survival observed by late in that week for the three bypass scenarios, reaching 25% survival for Bypass Scenario A, 79% survival for Bypass Scenario B, and 81% survival for Bypass Scenario C.
- During the fourth week of October (green-highlighted cells), egg-to-fry survival is still very poor in the No Bypass scenario (0% to 27%), intermediate in Bypass Scenario A (44% to 89%) and highest in Bypass Scenario B and Bypass Scenario C (85% to 90%).
- By the first week of November (blue-highlighted cells), when the full 350 cfs bypass is being implemented in the three bypass scenarios and spawning is more likely, egg-to-fry survival is 91% in the three bypass scenarios compared to 55% to 70% in the No Bypass Scenario.
- The yellow-highlighted cells show when, for each egg growth model and scenario, egg-to-fry survival reaches the maximum modeled value. The timing of peak survival is related to the time by which the scenario's water temperature input reaches 56°F and occurs earlier in all three bypass scenarios compared to the No Bypass scenario.
- The largest differences in egg-to-fry survival are observed for early-season redds. While these early-season redds represent a small portion of overall egg production for the brood year, they are important in providing life-history diversity.

While few eggs are spawned in late October, temperatures at this time of year could also affect pre-spawn mortality and or the viability of eggs *in vivo* (but those impacts are not evaluated by the SacPAS egg models).

Table 4: Estimated overall egg-to-fry survival for eggs spawned from early October to late November from the SacPAS results.

Calendar Day	Julian Day	No Bypass-WaterFor	No Bypass-SALMOD	No Bypass-Linear	Bypass Scenario A: WaterFor	Bypass Scenario A: SALMOD	Bypass Scenario A: Linear	Bypass Scenario B: WaterFor	Bypass Scenario B: SALMOD	Bypass Scenario B: Linear	Bypass Scenario C: WaterFor	Bypass Scenario C: SALMOD	Bypass Scenario C: Linear
10/2/2021	275	0	0	0	0	0	0	0	0	0	0	0	0
10/3/2021	276	0	0	0	0	0	0	0	0	0	0	0	0
10/4/2021	277	0	0	0	0	0	0	0	0	0	0	0	0
10/5/2021	278	0	0	0	0	0	0	0	0	0	0	0	0.01
10/6/2021	279	0	0	0	0	0	0	0	0	0.01	0	0	0.01
10/7/2021	280	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/8/2021	281	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/9/2021	282	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/10/2021	283	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/11/2021	284	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/12/2021	285	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/13/2021	286	0.08	0	0	0.14	0	0.02	0.18	0	0.03	0.56	0	0.03
10/14/2021	287	0.13	0	0	0.22	0	0.02	0.27	0	0.03	0.68	0.01	0.04
10/15/2021	288	0.18	0	0.01	0.31	0	0.03	0.37	0	0.04	0.74	0.06	0.04
10/16/2021	289	0.23	0	0.01	0.39	0	0.03	0.48	0	0.04	0.78	0.13	0.05
10/17/2021	290	0.3	0	0.01	0.48	0	0.04	0.58	0	0.05	0.81	0.22	0.05
10/18/2021	291	0.36	0	0.01	0.57	0	0.04	0.69	0	0.06	0.85	0.41	0.06
10/19/2021	292	0.44	0	0.01	0.68	0	0.04	0.83	0.18	0.06	0.88	0.65	0.06
10/20/2021	293	0.5	0	0.01	0.77	0.1	0.05	0.89	0.68	0.07	0.9	0.76	0.07
10/21/2021	294	0.55	0	0.01	0.81	0.25	0.06	0.9	0.79	0.07	0.91	0.81	0.07
10/22/2021	295	0.61	0	0.02	0.85	0.44	0.06	0.91	0.85	0.08	0.91	0.85	0.08
10/23/2021	296	0.65	0.02	0.02	0.87	0.55	0.07	0.91	0.86	0.08	0.91	0.86	0.08
10/24/2021	297	0.69	0.04	0.02	0.88	0.64	0.07	0.91	0.87	0.08	0.91	0.87	0.08
10/25/2021	298	0.72	0.08	0.03	0.89	0.72	0.08	0.91	0.88	0.09	0.91	0.88	0.08
10/26/2021	299	0.76	0.14	0.03	0.9	0.79	0.08	0.92	0.89	0.09	0.92	0.89	0.09
10/27/2021	300	0.78	0.21	0.03	0.91	0.86	0.09	0.92	0.9	0.09	0.92	0.89	0.09
10/28/2021	301	0.8	0.27	0.03	0.92	0.89	0.09	0.92	0.9	0.1	0.92	0.9	0.09

Calendar Day	Julian Day	No Bypass-WaterFor	No Bypass-SALMOD	No Bypass-Linear	Bypass Scenario A: WaterFor	Bypass Scenario A: SALMOD	Bypass Scenario A: Linear	Bypass Scenario B: WaterFor	Bypass Scenario B: SALMOD	Bypass Scenario B: Linear	Bypass Scenario C: WaterFor	Bypass Scenario C: SALMOD	Bypass Scenario C: Linear
10/29/2021	302	0.82	0.33	0.04	0.92	0.9	0.09	0.92	0.9	0.1	0.92	0.9	0.09
10/30/2021	303	0.84	0.41	0.04	0.92	0.91	0.1	0.92	0.91	0.1	0.92	0.9	0.1
10/31/2021	304	0.85	0.49	0.04	0.92	0.91	0.1	0.92	0.91	0.1	0.92	0.91	0.1
11/1/2021	305	0.86	0.55	0.05	0.92	0.91	0.1	0.92	0.91	0.1	0.92	0.91	0.1
11/2/2021	306	0.87	0.6	0.05	0.92	0.91	0.1	0.92	0.91	0.1	0.92	0.91	0.1
11/3/2021	307	0.87	0.62	0.05	0.92	0.91	0.1	0.92	0.91	0.1	0.92	0.91	0.1
11/4/2021	308	0.88	0.65	0.06	0.92	0.91	0.1	0.92	0.91	0.1	0.92	0.91	0.1
11/5/2021	309	0.88	0.66	0.06	0.92	0.91	0.1	0.92	0.91	0.1	0.92	0.91	0.1
11/6/2021	310	0.88	0.68	0.06	0.92	0.91	0.1	0.92	0.91	0.1	0.92	0.91	0.1
11/7/2021	311	0.89	0.7	0.06	0.92	0.91	0.1	0.92	0.91	0.1	0.92	0.91	0.1
11/8/2021	312	0.89	0.73	0.07	0.92	0.91	0.1	0.92	0.91	0.1	0.92	0.91	0.1
11/9/2021	313	0.9	0.76	0.07	0.92	0.91	0.1	0.92	0.91	0.1	0.92	0.91	0.1
11/10/2021	314	0.9	0.79	0.08	0.92	0.92	0.11	0.92	0.91	0.11	0.92	0.91	0.1
11/11/2021	315	0.91	0.82	0.08	0.92	0.92	0.11	0.92	0.91	0.11	0.92	0.91	0.11
11/12/2021	316	0.91	0.85	0.08	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11
11/13/2021	317	0.91	0.87	0.09	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11
11/14/2021	318	0.92	0.88	0.09	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11
11/15/2021	319	0.92	0.89	0.09	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11
11/16/2021	320	0.92	0.9	0.1	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11
11/17/2021	321	0.92	0.91	0.1	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11
11/18/2021	322	0.92	0.91	0.1	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11
11/19/2021	323	0.92	0.91	0.1	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11
11/20/2021	324	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11
11/21/2021	325	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11
11/22/2021	326	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11	0.92	0.92	0.11

Conclusion: To improve temperature management and help with fall-run Chinook salmon stock rebuilding, the California Department of Fish and Wildlife (CDFW), the National Marine Fisheries Service and United States Fish and Wildlife Service request implementation of Bypass Scenario C, which includes a 150 cfs power bypass at Folsom Dam from October 11, 2021 through October 18, 2021 and a 350 cfs power bypass at Folsom Dam from October 18, 2021 through November 25, 2021, or until a target temperature of 56°Fahrenheit (F) at Hazel Avenue Bridge can be achieved and maintained without a power bypass.

Based on discussions initiated during the 2020 and 2021 ARG meetings, USBR requested formal documentation to support a power bypass request. This proposal includes biological justification, modeling results outlining there is sufficient cold-water pool, and economic forecasting on the anticipated foregone yield of power based on market rates and the requested bypass proposal. It should be noted that the actual 'costs' to the USBR for foregone power generation may differ from the as forecasting used market rates and not the actual rates that will be in effect during a power bypass. The current cost estimate is based on an assumption that the bypass will continue through November; however, power bypass is only requested until 56° F can be achieved and maintained at Hazel. If water temperatures of 56° F can be achieved without a power bypass sooner than November 25, 2021 (the modeling for Bypass Scenario C shows that water temperatures drop below 56° F on November 16, 2021), the actual costs of the power bypass may be lower than estimated.

The CE-QUAL-W2 temperature modeling runs provided to ARG from the Water Forum on September 24, 2021, indicated a temperature target of 56°F is not achievable until November 22 without the use of power bypass and results in temperatures exceeding 60°F throughout the month of October and until at least the first week of November. Recent events resulted in the loss of approximately 10% of the hatchery-produced NIM steelhead from temperature induced stress and increased prevalence of disease. The recommendation from CDFW, NMFS, and USBR staff to return NIM hatchery steelhead to NIM at the soonest possible date highlights the immediate need of temperature appropriate water. Temperature appropriate water is also required for successful NIM fall-run egg collation and incubation to meet USBR's fall-run Chinook salmon mitigation production requirement, and highlights that these cooler temperatures need to be achieved sooner. At the request of the ARG, the Water Forum provided model runs to aid in understanding the thermal impacts of various power bypass scenarios to evaluate the outcomes and the resulting temperature that would be achievable through November 2021. These modeling results indicate that usage of the power bypass results in the ability to lower temperatures to 58°F beginning November 1 in all power bypass operational scenarios, but not all result in tolerable in river temperatures during October (Appendix B).

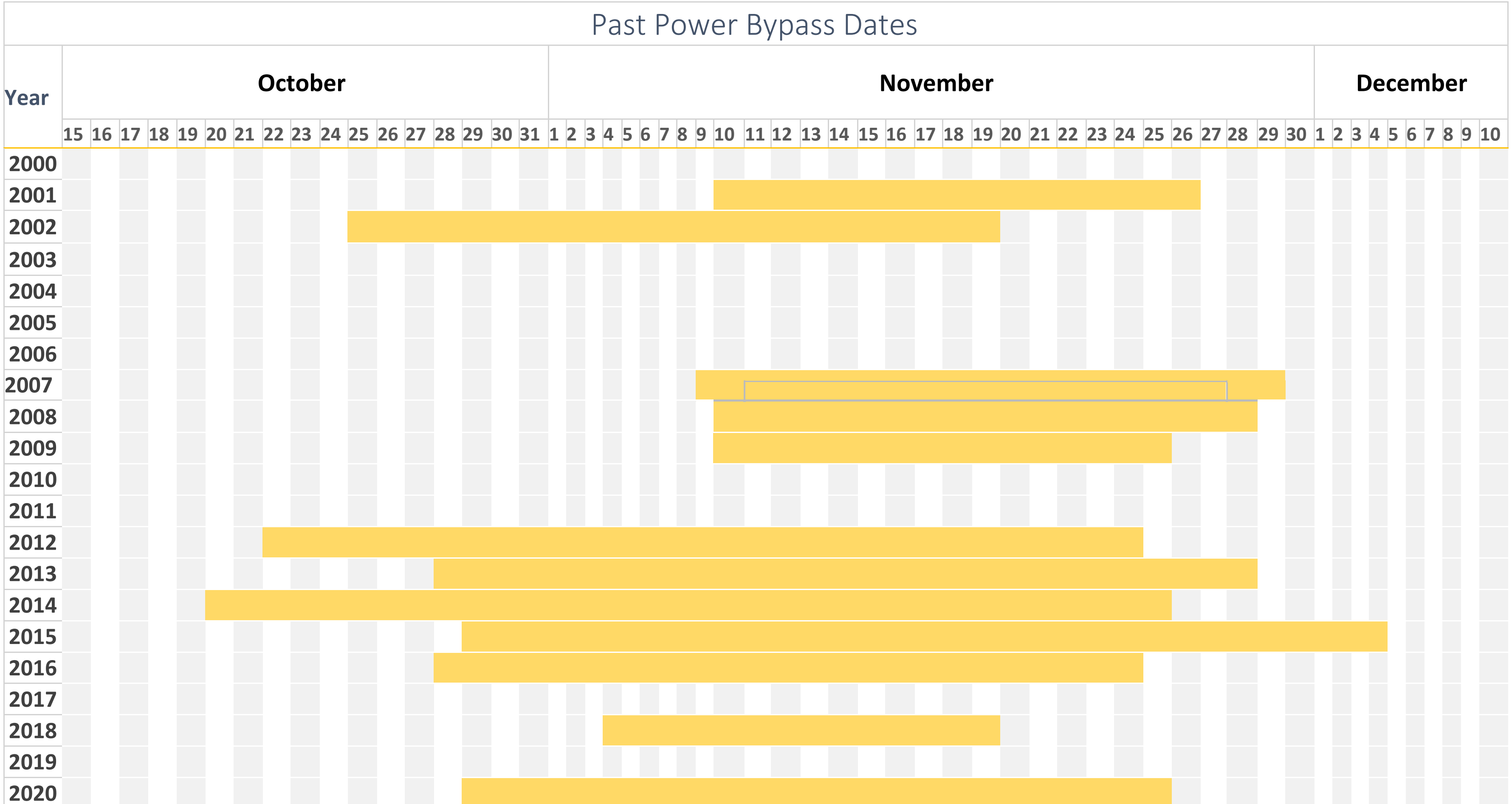
Logistical considerations to maximize temperature reduction benefits were discussed at the September 24, 2021, ad hoc ARG meeting and included discussion on the information presented in this power bypass proposal, including the water temperature modeling based on the most recent Folsom Lake temperature profile data, timing and magnitude and costs of power bypass, fall-run Chinook salmon presence and spawning maturity information, and the egg-to-fry survival results. Bypass Scenario C provided the greatest fish benefits and the proposal to request that Reclamation implement Bypass Scenario C was supported by all ARG members attending the Ad Hoc ARG meeting held on September 24, 2021.

Appendix A

Folsom Dam Power Bypass for Temperature Management

2000-2020

Year	Start	End	Total Days of Bypass (TAF)
2000	N/A	N/A	N/A
2001	11/10/2001	11/26/2001	17
2002	10/25/2002	11/19/2002	26
2003	N/A	N/A	N/A
2004	N/A	N/A	N/A
2005	N/A	N/A	N/A
2006	N/A	N/A	N/A
2007	11/09/2007	11/29/2007	21
2008	11/10/2008	11/28/2008	19
2009	11/10/2009	11/25/2009	16
2010	N/A	N/A	N/A
2011	N/A	N/A	N/A
2012	10/22/2012	11/24/2012	34
2013	10/28/2013	10/28/2013	31
2014	10/20/2014	11/25/2014	37
2015	10/29/2015	12/04/2015	37
2016	10/28/2016	11/24/2016	28
2017	N/A	N/A	N/A
2018	11/04/2018	11/19/2018	16
2019	N/A	N/A	N/A
2020	10/29/2020	11/25/2020	28


Past Power Bypass Dates
Year
October
November
December
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

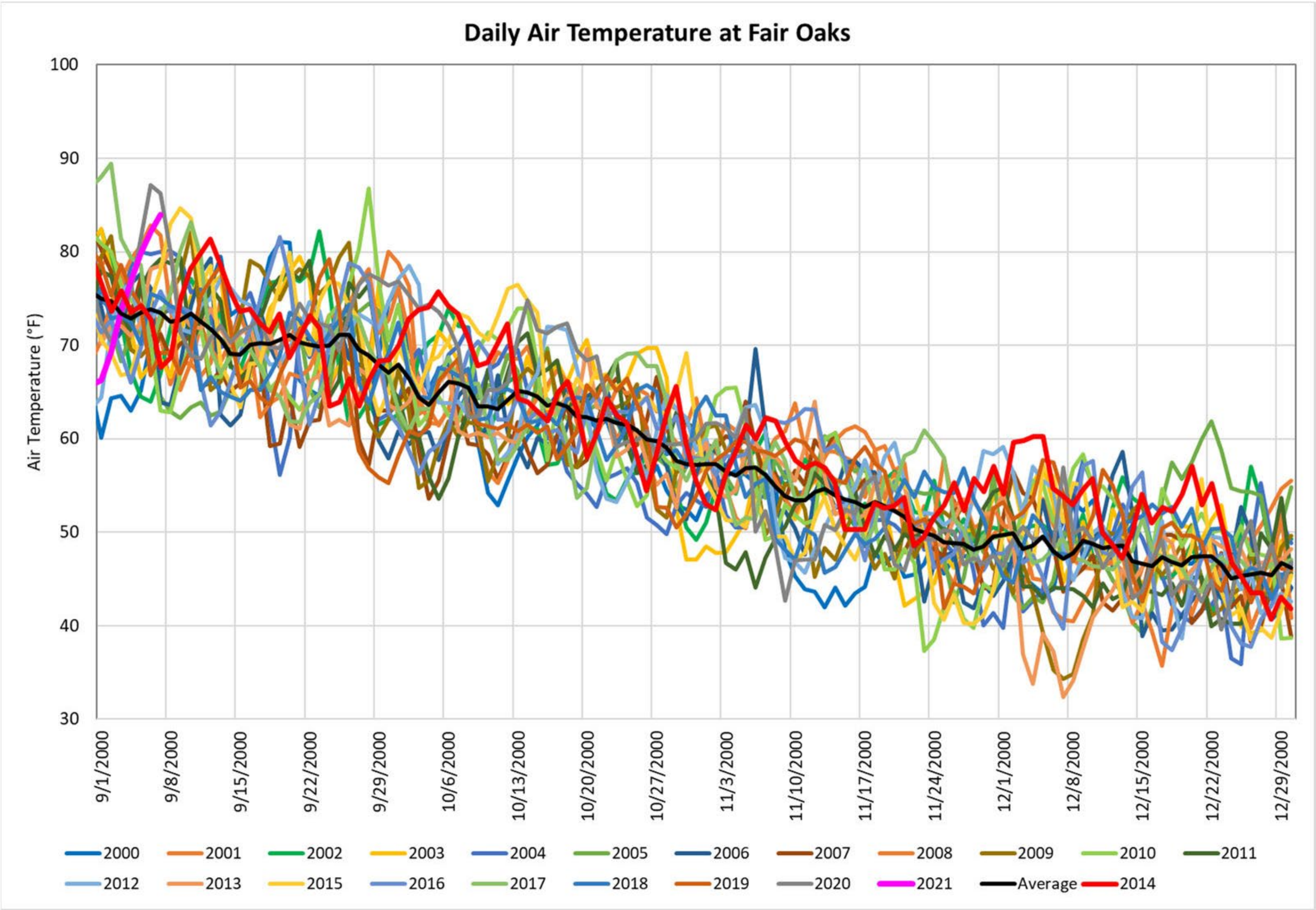
2021 Power Bypass Scenarios Simulated with Conservative (warm) 2014 Meteorological Conditions

Start of bypass at Folsom Dam	No Bypass	Bypass A	Bypass B	Bypass C
N/A	No bypass	No bypass	No bypass	No bypass
11-Oct	No bypass	No bypass	No bypass	150 cfs bypass
18-Oct	No bypass	150 cfs bypass	350 cfs bypass	350 cfs bypass
25-Oct	No bypass	350 cfs bypass	350 cfs bypass	350 cfs bypass
November	No bypass	350 cfs bypass	350 cfs bypass	350 cfs bypass

Scenarios were simulated with:

- Folsom Reservoir CE-QUAL-W2 model to simulate Folsom Res. release temperatures,
- Lake Natoma CE-QUAL-W2 model to simulate Hazel Ave temperatures and to get more precise estimates of travel time through Lake Natoma, and
- monthly regression equations to simulate water temperature at downstream locations (e.g., Watt Ave.)

2014 Meteorological Conditions Compared to Other Years



2014 Meteorological Conditions Compared to Other Years

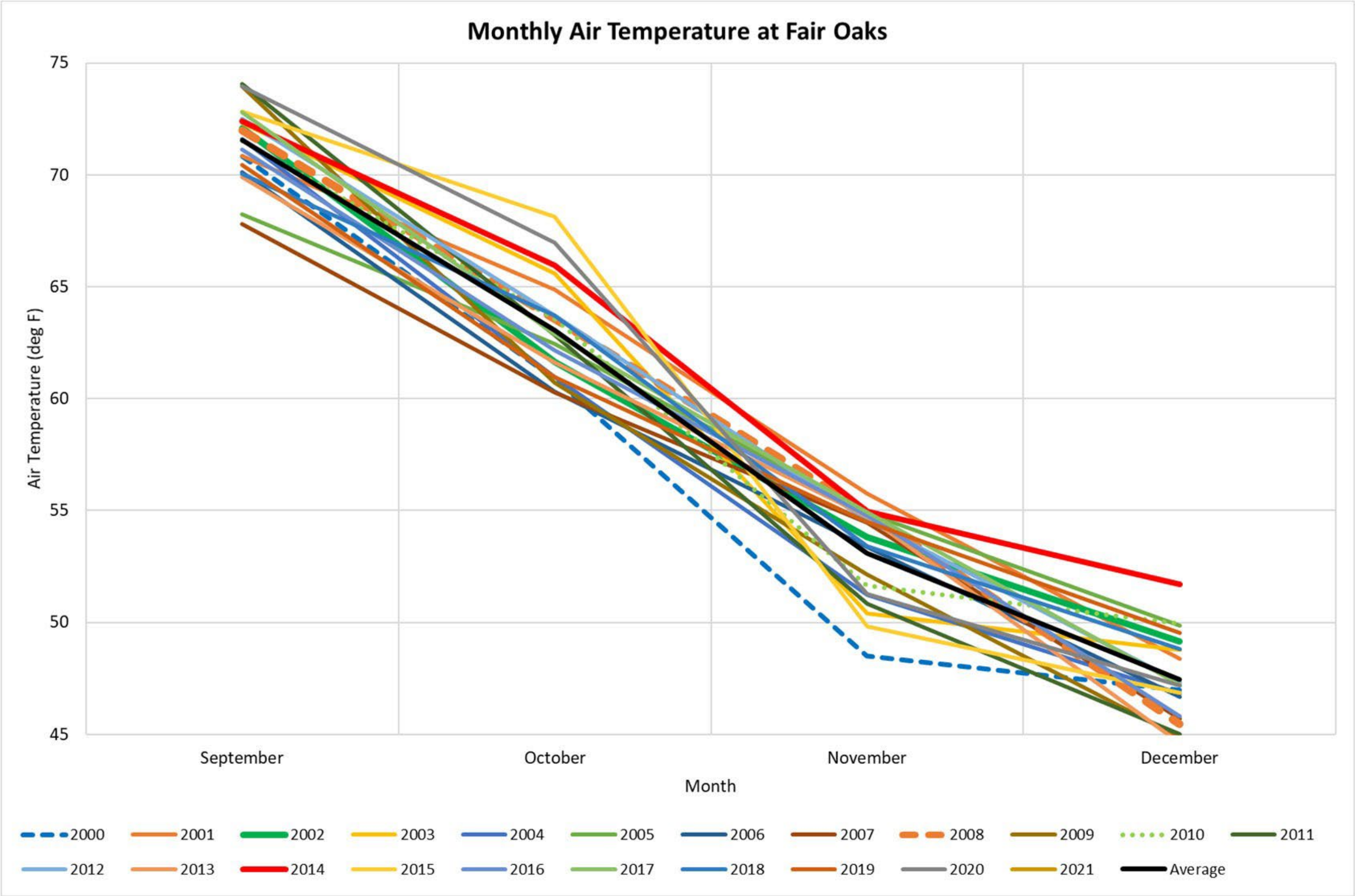
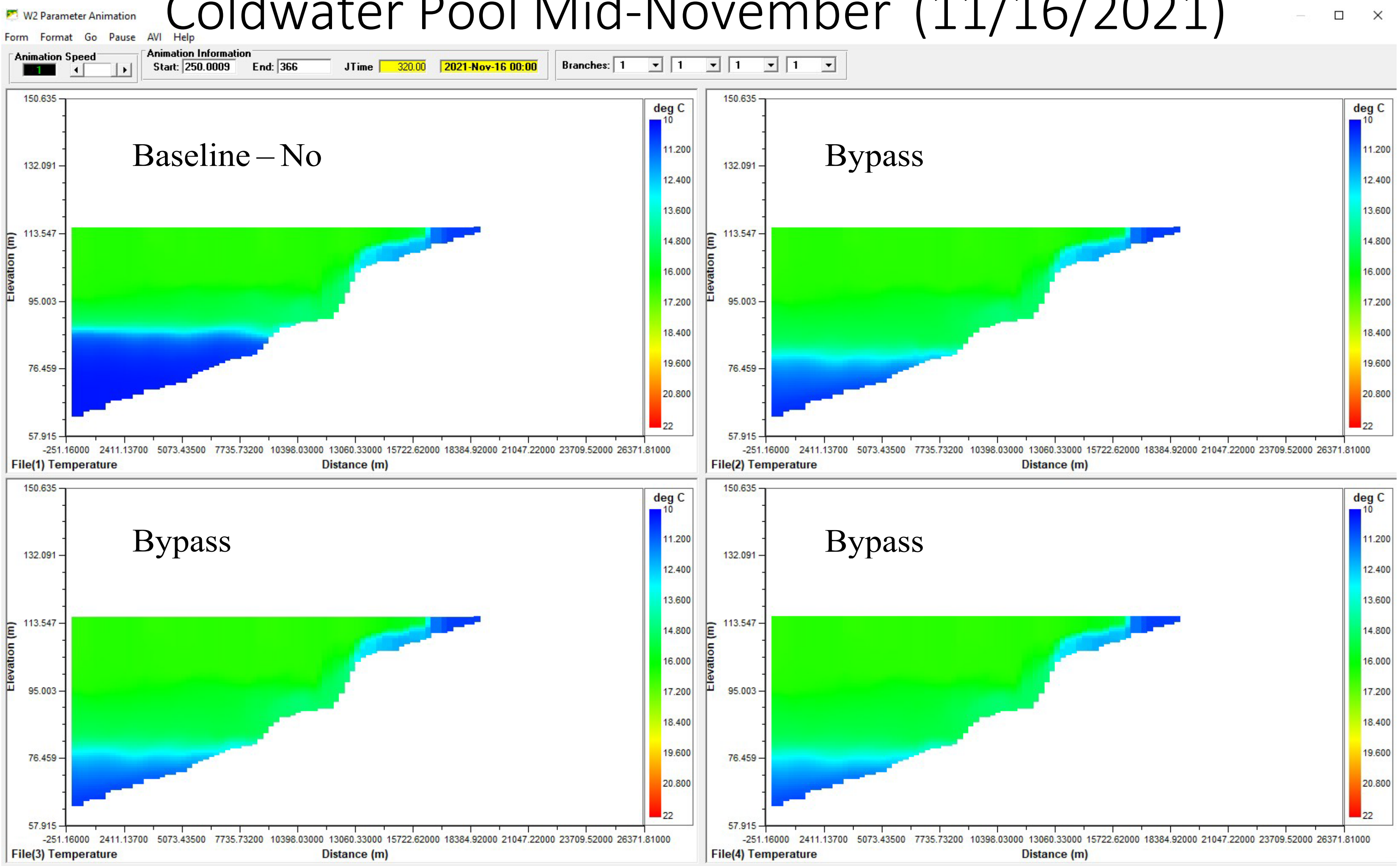
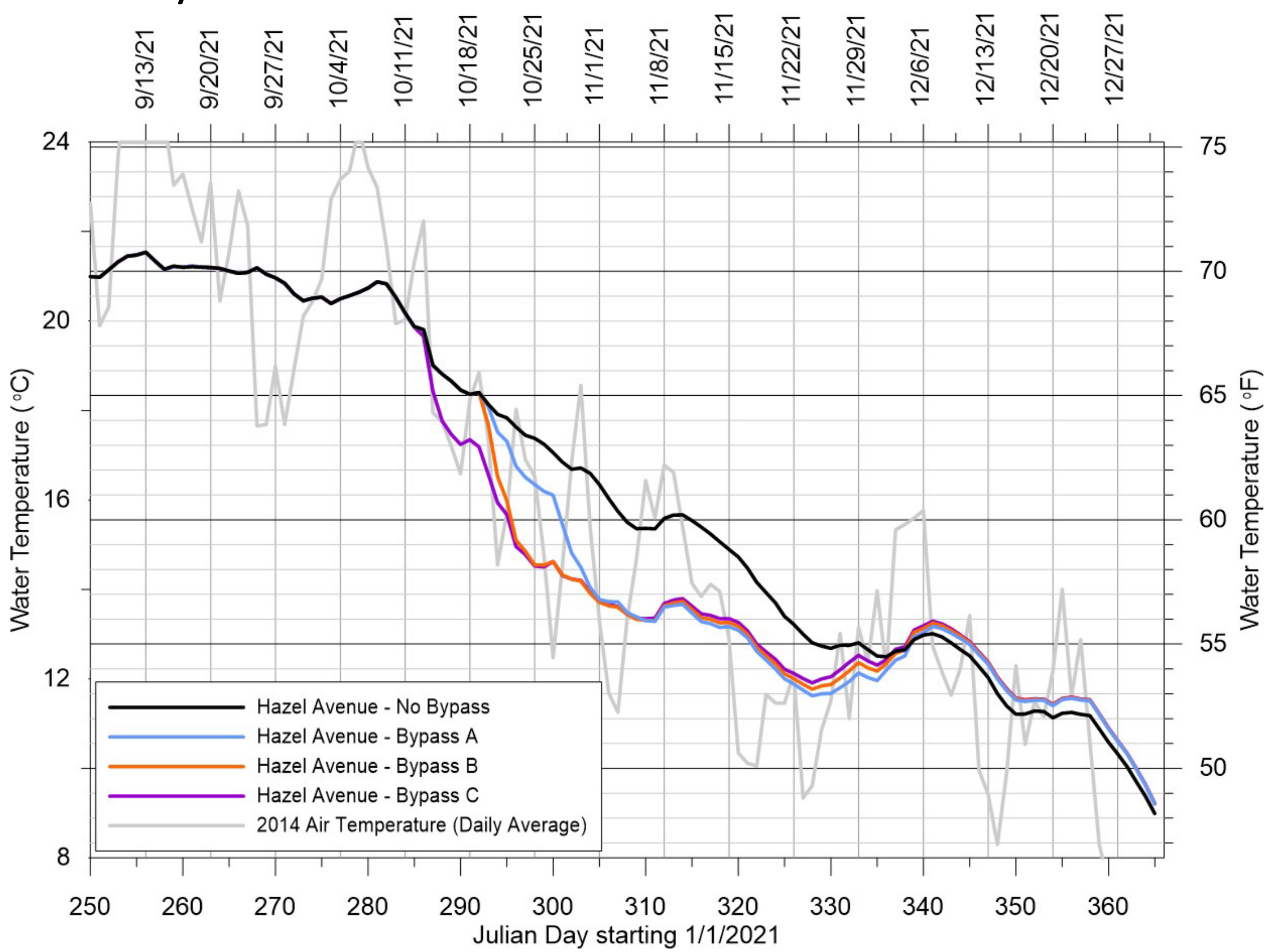


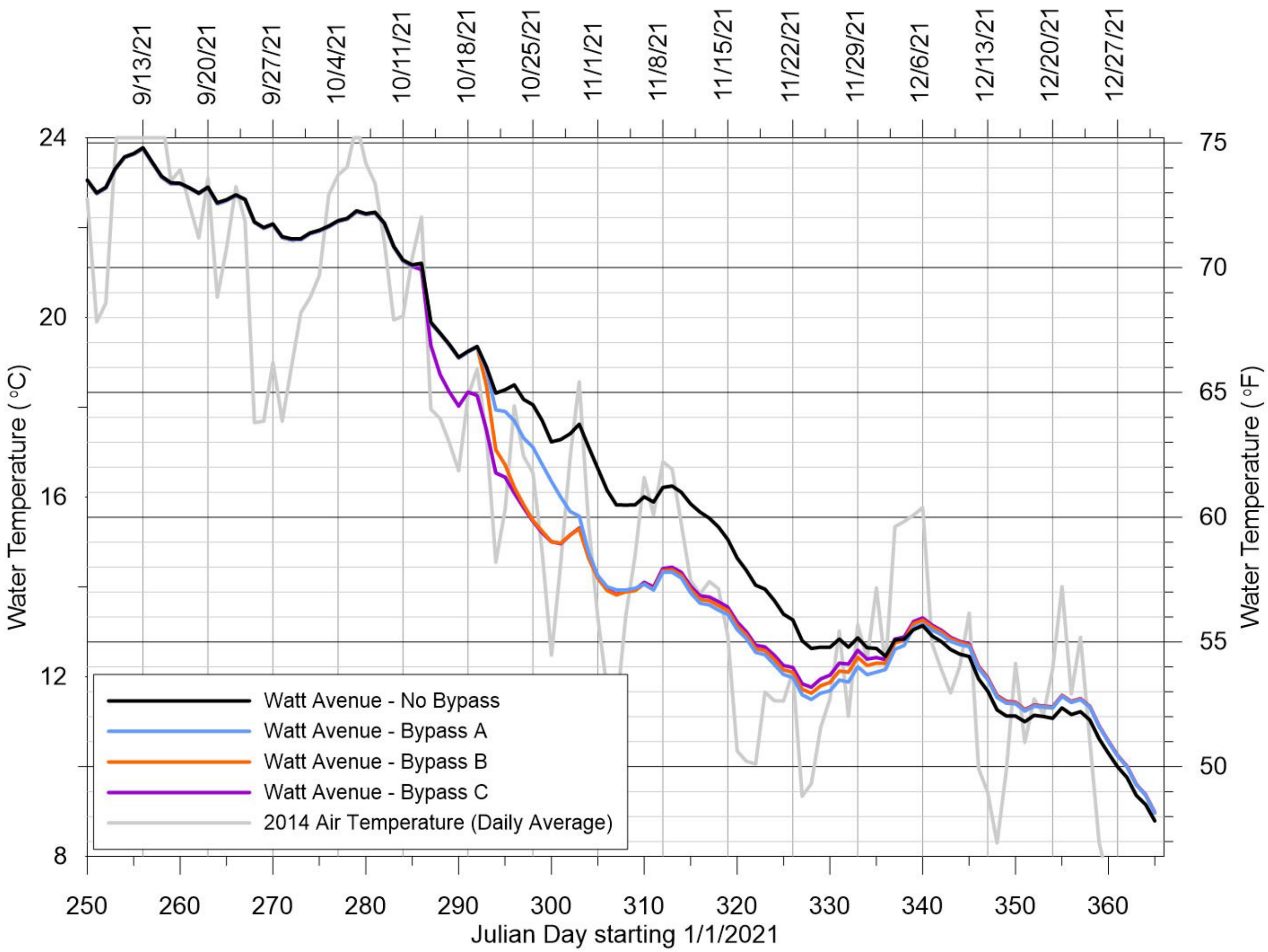
Illustration of Predicted Remaining Folsom Reservoir Coldwater Pool Mid-November (11/16/2021)



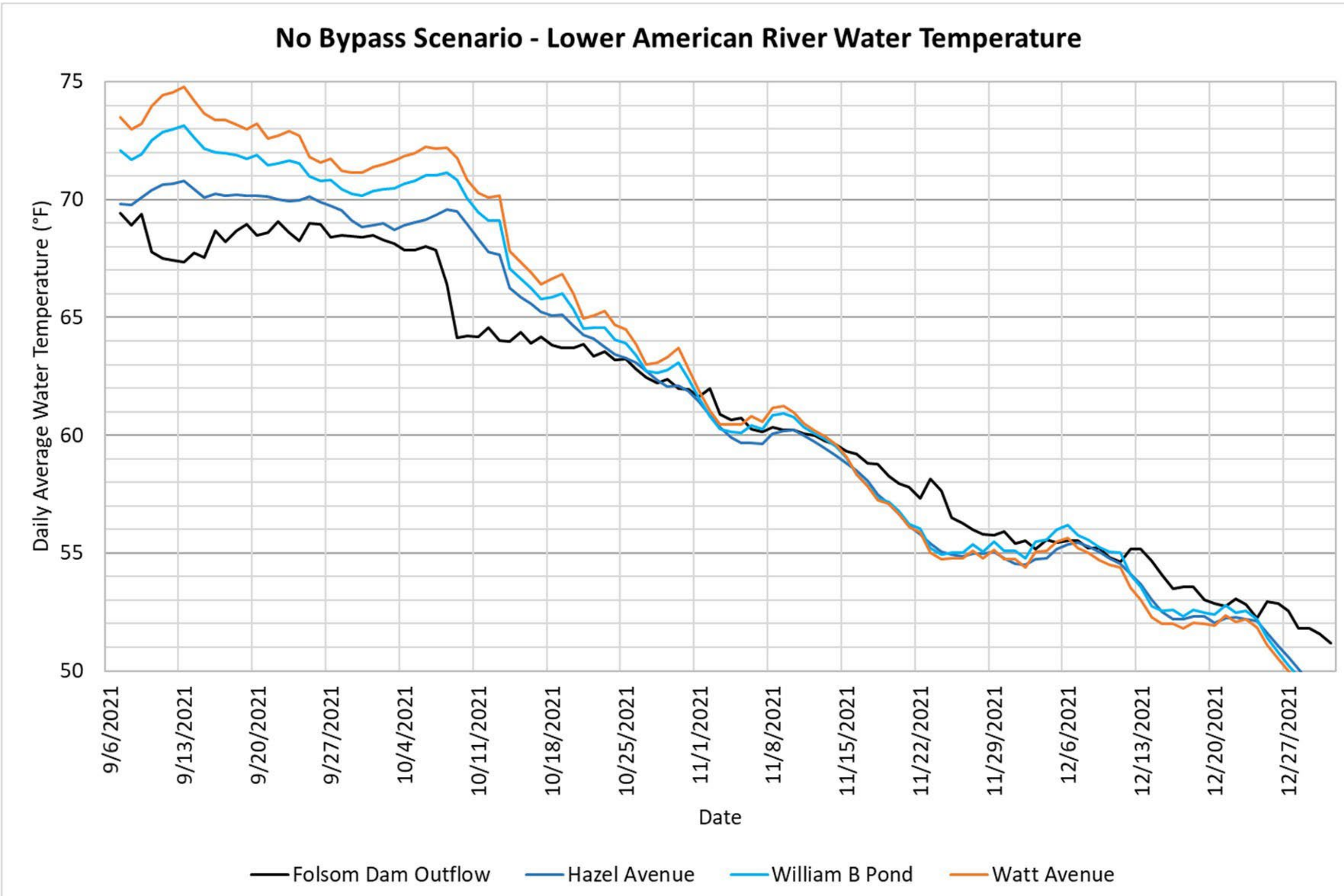
Summary Results For Scenarios at Hazel Avenue



Summary Results For Scenarios at Watt Avenue

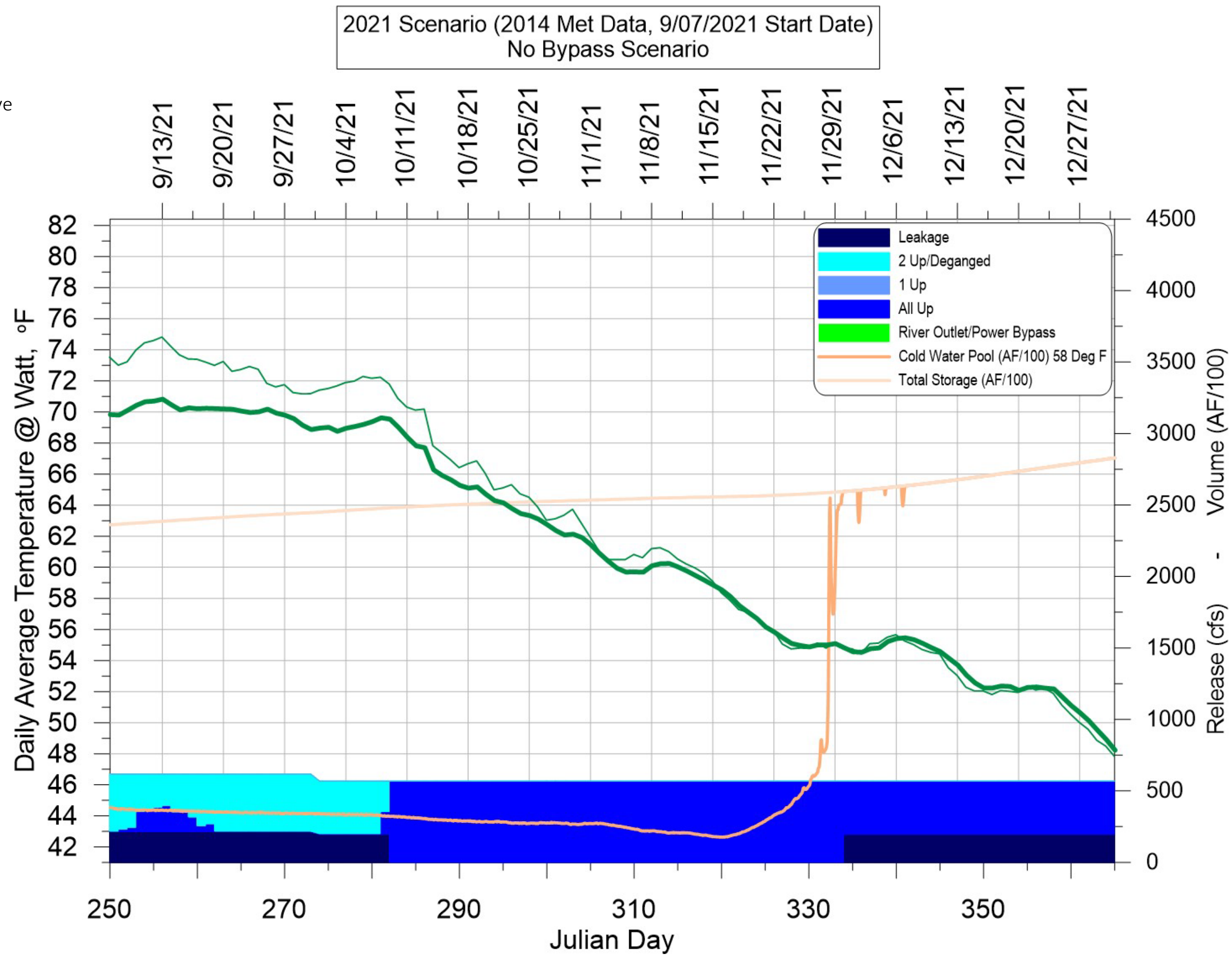


No Bypass Scenario – Modeled Temperature at Various Locations on LAR

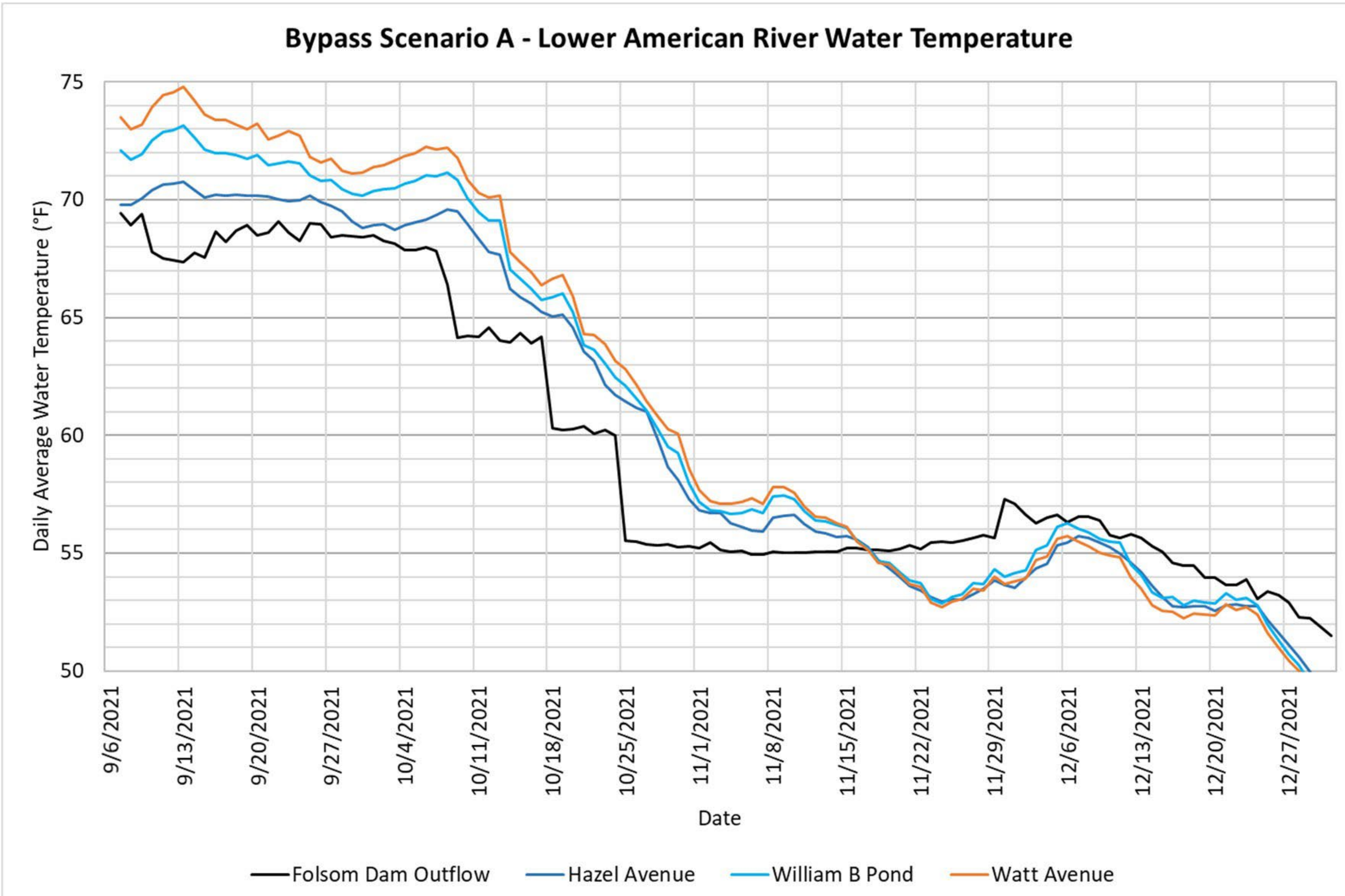


No Bypass Scenario

Thin green line is water temperature at Watt Ave
Thicker green line is water temperature at Hazel Ave

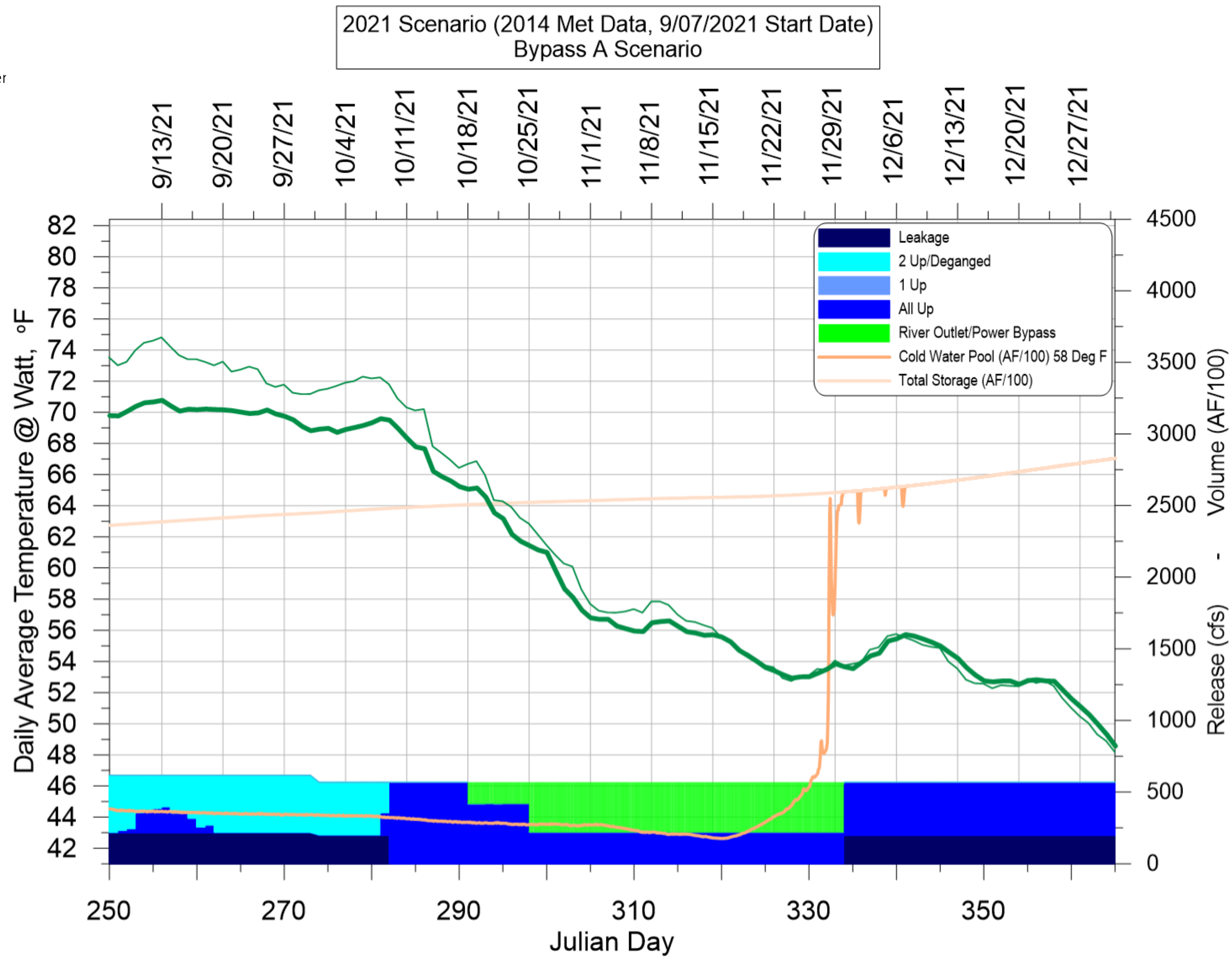


Bypass A Scenario – Modeled Temperature at Various Locations on LAR

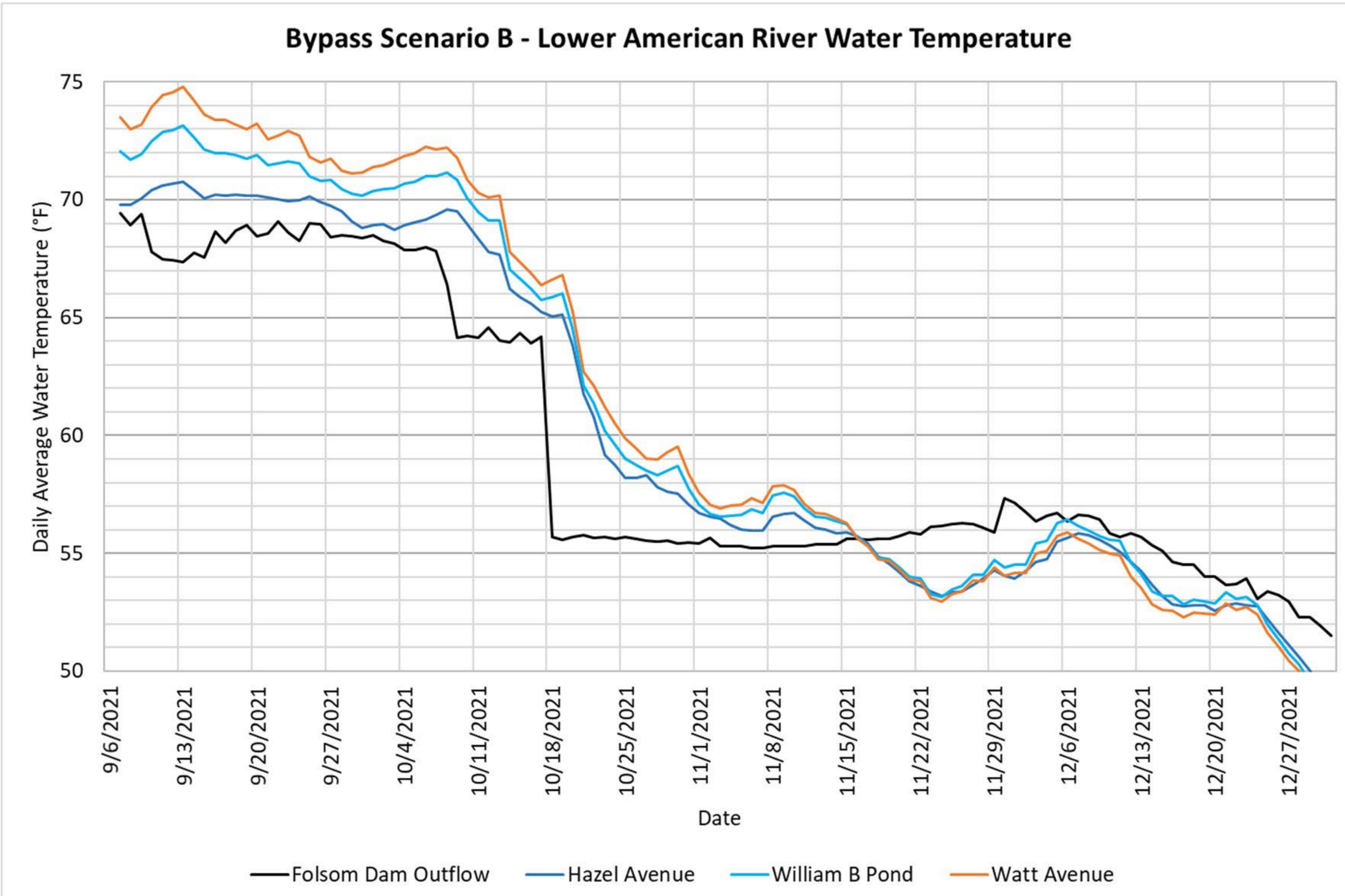


Bypass A Scenario

Thin green line is water temperature at Watt Ave Thicker green line is water temperature at Hazel Ave

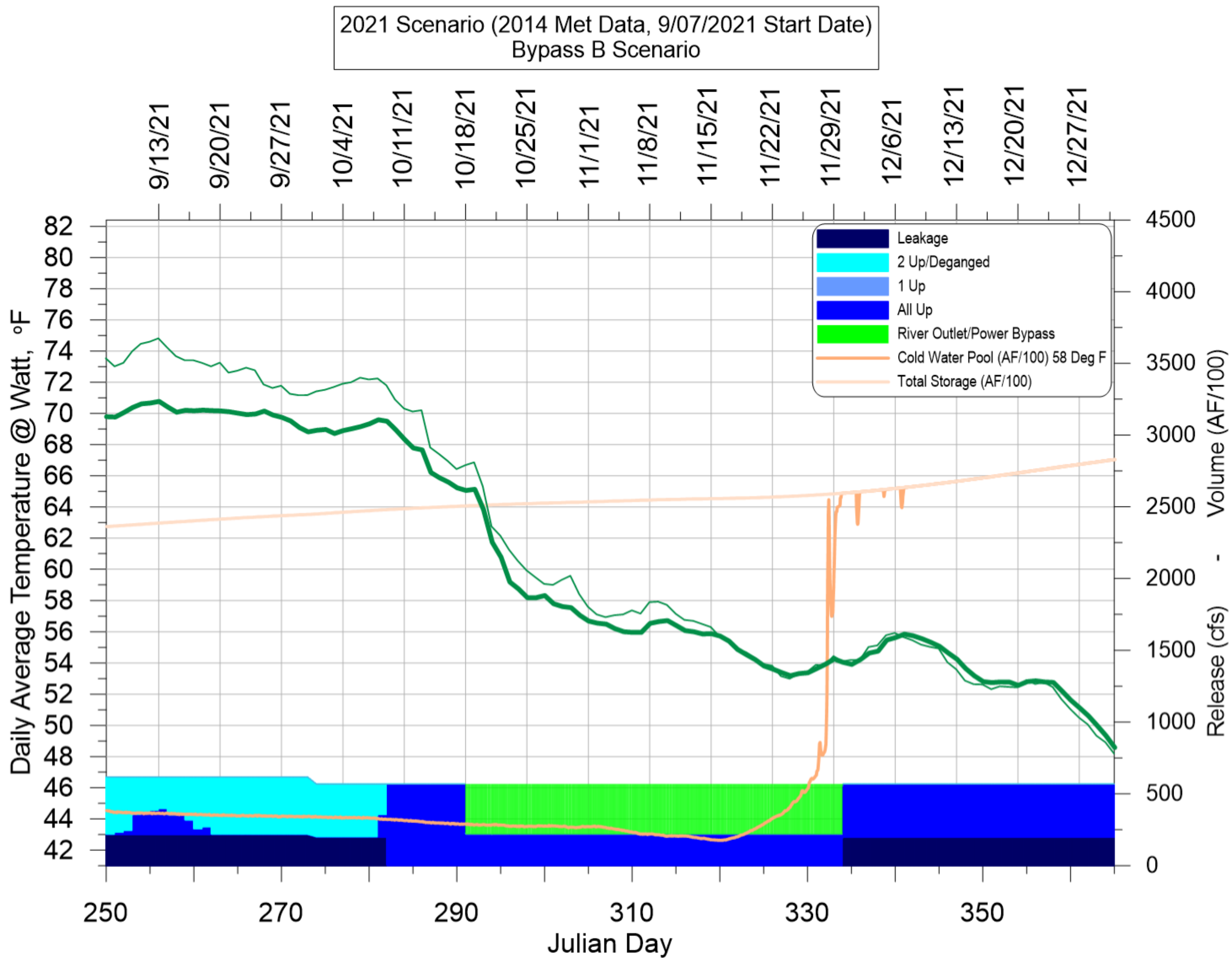


Bypass B Scenario – Modeled Temperature at Various Locations on LAR

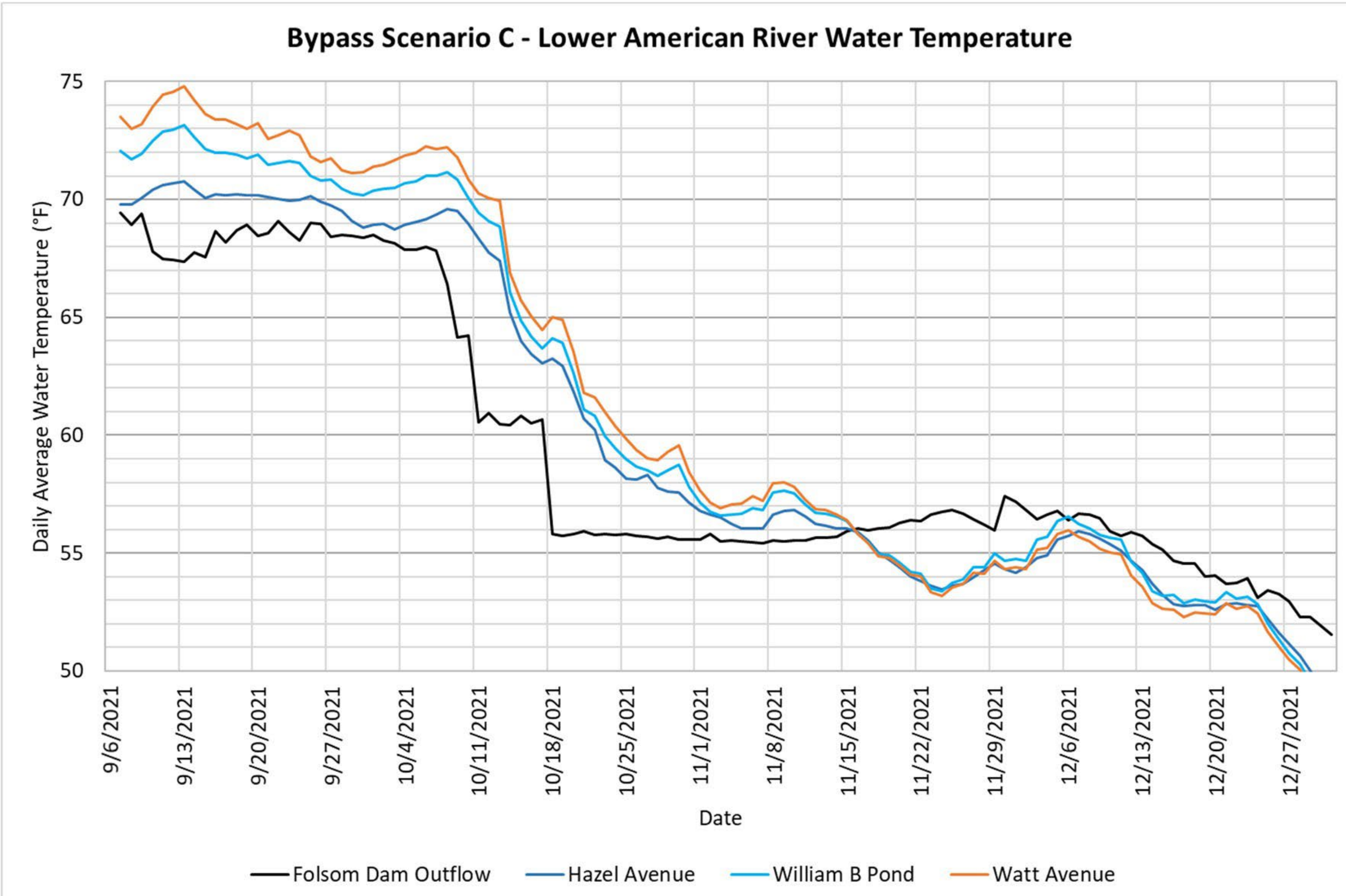


Bypass B Scenario

Thin green line is water temperature at Watt Ave Thicke green line is water temperature at Hazel Ave

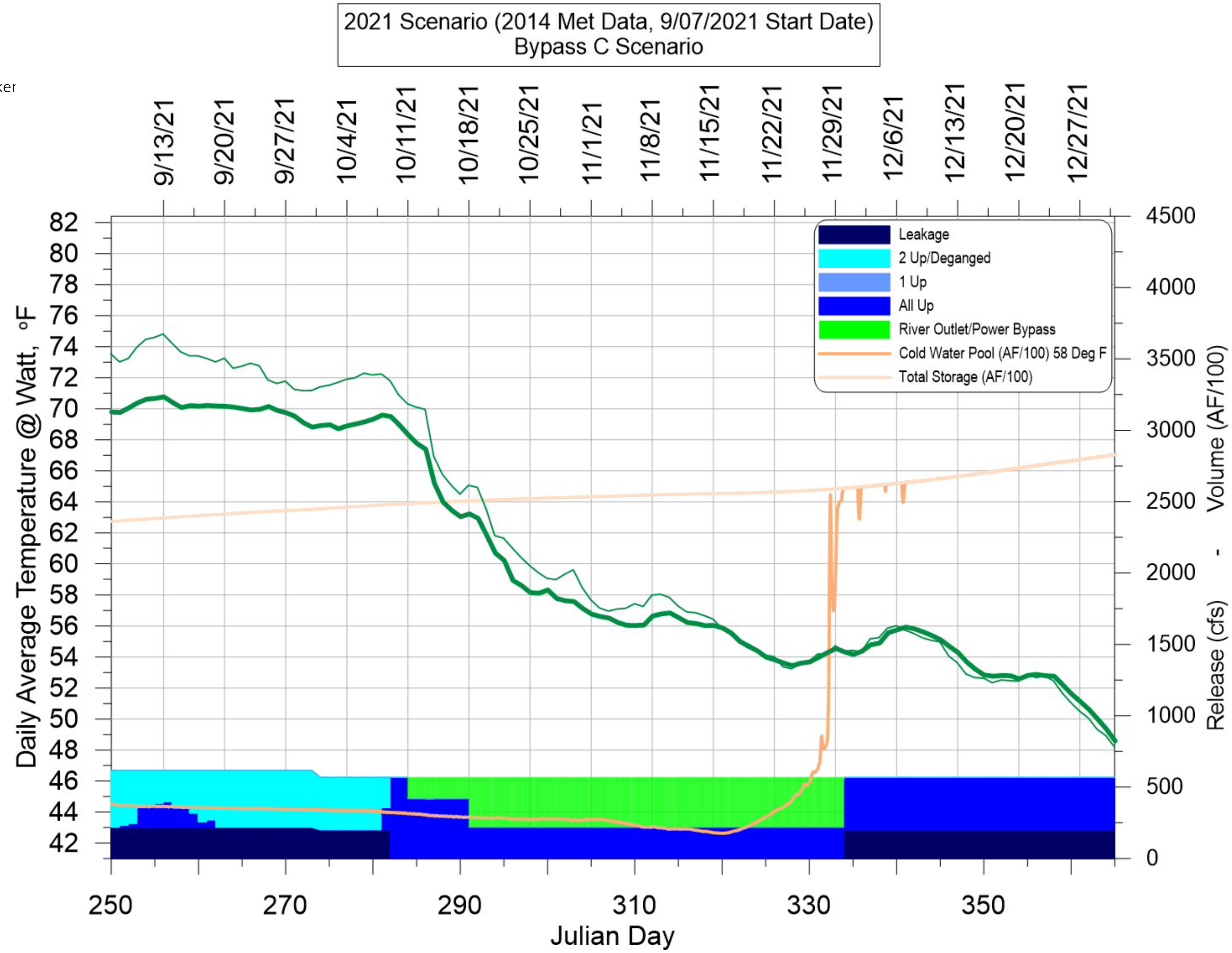


Bypass C Scenario – Modeled Temperature at Various Locations on LAR



Bypass C Scenario

Thin green line is water temperature at Watt Ave Thicker green line is water temperature at Hazel Ave



Appendix C

Water temperature input data and SacPAS outputs for the four scenarios.

EMERGENCE MODEL: SacPAS: Central Valley Prediction & Assessment of Salmon- Egg Growth Model: Spawning to Emergence v2.1.4

GENERATED: Fri Sep 24 11:02:57 2021

RUN SPECS

Category	Specs
Species	Fall Chinook
Development Model	Zeug
Target ATUs	958
Egg temperature effect	Exponential: Water Forum
Density effect	None
Eggs per redd	3000
Carcasses per redd	1
Offset used for redd timing	-12
Temperature Source	User Provided Hazel No Bypass.csv Column 2
Temperature Units	centigrade
Spawning Data Source	SacPAS database 201620152014 spnfem Carcass Counts

RUN RESULTS

Category	Results
Total Redds	649
Mean Emergence Day	394.6
Mean Emergence Date	30-Jan
Last Emergence Day	438
Last Emergence Date	14-Mar
Variance	672.1
STD	25.9
Expansion	14 Days
Eggs	1947000
Fry	1717160
Survival Egg to Fry	88.20%

DETAILS

Spawn Day	Redds	Duration	Emerge on	ATUs	Mean Temp.	Max Temp.	Eggs	Fry	Survival
275	1	59	334	968.1	16.64	20.88	3000	0	0
276	1	59	335	961.1	16.52	20.88	3000	0	0
277	1	60	337	967.2	16.34	20.88	3000	0	0
278	1	60	338	960	16.22	20.88	3000	0	0
279	1	61	340	966	16.06	20.88	3000	0	0
286	1	65	351	969.8	15.13	19.02	3000	253	0.08
287	2	65	352	964.1	15.04	18.82	6000	783	0.13
288	1	65	353	958.6	14.95	18.66	3000	547	0.18
289	1	66	355	966.6	14.85	18.47	3000	718	0.23
290	2	66	356	961.4	14.77	18.41	6000	1817	0.3
291	2	67	358	969.7	14.67	18.41	6000	2184	0.36
292	2	67	359	964.6	14.6	18.14	6000	2646	0.44
293	2	67	360	959.8	14.53	17.92	6000	3030	0.5
294	1	68	362	968.6	14.44	17.84	3000	1675	0.55
295	4	68	363	964.1	14.37	17.63	12000	7383	0.61
296	4	68	364	959.8	14.31	17.45	12000	7903	0.65
297	4	69	366	969	14.24	17.39	12000	8328	0.69
298	4	69	367	964.9	14.18	17.26	12000	8750	0.72
299	4	69	368	961	14.12	17.07	12000	9132	0.76
300	4	70	370	970.6	14.06	16.85	12000	9421	0.78
301	3	70	371	967.1	14.01	16.72	9000	7243	0.8
302	1	70	372	963.7	13.96	16.72	3000	2464	0.82
303	18	70	373	960.3	13.91	16.6	54000	45360	0.84
304	18	71	375	970.4	13.86	16.35	54000	46122	0.85
305	18	71	376	967.3	13.81	16.03	54000	46741	0.86
306	18	71	377	964.6	13.77	15.75	54000	47159	0.87
307	18	71	378	962.2	13.74	15.67	54000	47512	0.87
308	17	71	379	960	13.71	15.67	51000	45078	0.88
309	10	71	380	958	13.68	15.67	30000	26616	0.88
310	16	72	382	969.3	13.65	15.67	48000	42682	0.88
311	16	72	383	967.3	13.62	15.67	48000	42842	0.89
312	16	72	384	965	13.59	15.67	48000	43060	0.89
313	16	72	385	962.7	13.56	15.67	48000	43356	0.9

Spawn Day	Redds	Duration	Emerge on	ATUs	Mean Temp.	Max Temp.	Eggs	Fry	Survival
314	16	72	386	960.3	13.52	15.54	48000	43600	0.9
315	25	72	387	958.1	13.49	15.4	75000	68450	0.91
316	12	73	389	969.4	13.46	15.24	36000	32935	0.91
317	22	73	390	967.5	13.44	15.07	66000	60575	0.91
318	23	73	391	965.7	13.41	14.9	69000	63489	0.92
319	23	73	392	964.2	13.39	14.73	69000	63616	0.92
320	23	73	393	962.8	13.37	14.48	69000	63792	0.92
321	23	73	394	961.6	13.36	14.16	69000	63860	0.92
322	18	73	395	960.8	13.34	13.94	54000	50008	0.92
323	8	73	396	960.2	13.34	13.71	24000	22234	0.92
324	13	73	397	959.8	13.33	13.41	39000	36138	0.92
325	13	73	398	959.7	13.33	13.33	39000	36139	0.92
326	13	73	399	959.7	13.33	13.33	39000	36139	0.92
327	14	73	400	959.7	13.33	13.33	42000	38919	0.92
328	14	73	401	959.7	13.33	13.33	42000	38919	0.92
329	32	73	402	959.7	13.33	13.33	96000	88958	0.92
330	7	73	403	959.7	13.33	13.33	21000	19459	0.92
331	2	73	404	959.7	13.33	13.33	6000	5559	0.92
332	3	73	405	959.7	13.33	13.33	9000	8339	0.92
333	3	73	406	959.7	13.33	13.33	9000	8339	0.92
334	3	73	407	959.7	13.33	13.33	9000	8339	0.92
335	4	73	408	959.7	13.33	13.33	12000	11119	0.92
336	7	73	409	959.7	13.33	13.33	21000	19459	0.92
337	2	73	410	959.7	13.33	13.33	6000	5559	0.92
338	2	73	411	959.7	13.33	13.33	6000	5559	0.92
339	2	73	412	959.7	13.33	13.33	6000	5559	0.92
340	2	73	413	959.7	13.33	13.33	6000	5559	0.92
341	2	73	414	959.7	13.33	13.33	6000	5559	0.92
342	2	73	415	959.7	13.33	13.33	6000	5559	0.92
343	2	73	416	959.7	13.33	13.33	6000	5559	0.92
344	2	73	417	959.7	13.33	13.33	6000	5559	0.92
345	2	73	418	959.7	13.33	13.33	6000	5559	0.92
346	3	73	419	959.7	13.33	13.33	9000	8339	0.92
347	3	73	420	959.7	13.33	13.33	9000	8339	0.92
348	3	73	421	959.7	13.33	13.33	9000	8339	0.92

Spawn Day	Redds	Duration	Emerge on	ATUs	Mean Temp.	Max Temp.	Eggs	Fry	Survival
349	3	73	422	959.7	13.33	13.33	9000	8339	0.92
350	3	73	423	959.7	13.33	13.33	9000	8339	0.92
351	3	73	424	959.7	13.33	13.33	9000	8339	0.92
352	3	73	425	959.7	13.33	13.33	9000	8339	0.92
353	3	73	426	959.7	13.33	13.33	9000	8339	0.92
354	3	73	427	959.7	13.33	13.33	9000	8339	0.92
355	3	73	428	959.7	13.33	13.33	9000	8339	0.92
356	3	73	429	959.7	13.33	13.33	9000	8339	0.92
357	3	73	430	959.7	13.33	13.33	9000	8339	0.92
358	5	73	431	959.7	13.33	13.33	15000	13899	0.92
359	6	73	432	959.7	13.33	13.33	18000	16679	0.92
360	6	73	433	959.7	13.33	13.33	18000	16679	0.92
361	6	73	434	959.7	13.33	13.33	18000	16679	0.92
362	6	73	435	959.7	13.33	13.33	18000	16679	0.92
363	7	73	436	959.7	13.33	13.33	21000	19459	0.92
364	7	73	437	959.7	13.33	13.33	21000	19459	0.92
365	3	73	438	959.7	13.33	13.33	9000	8339	0.92

Uploaded data assumed beginning in non-leap year
TEMPERATURE INPUT

Day	Degree C
1	21
1	21
2	21
3	21
4	21
5	21
6	21
7	21
8	21
9	21
10	21
11	21
12	21
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42	21

Day	Degree C
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Day	Degree C
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Day	Degree C
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Day	Degree C
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Day	Degree C
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248	21
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251	20.98
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253	21.33
254	21.46
255	21.48
256	21.55
257	21.35
258	21.16
259	21.24
260	21.2
261	21.22
262	21.21
263	21.2
264	21.18
265	21.12
266	21.07
267	21.09
268	21.19
269	21.05
270	20.97
271	20.85
272	20.62

Day	Degree C
273	20.46
274	20.52
275	20.54
276	20.4
277	20.51
278	20.57
279	20.65
280	20.74
281	20.88
282	20.84
283	20.53
284	20.19
285	19.88
286	19.81
287	19.02
288	18.82
289	18.66
290	18.47
291	18.37
292	18.41
293	18.14
294	17.92
295	17.84
296	17.63
297	17.45
298	17.39
299	17.26
300	17.07
301	16.85
302	16.69
303	16.72
304	16.6
305	16.35
306	16.03
307	15.75
308	15.51
309	15.36
310	15.37
311	15.36
312	15.59
313	15.67
314	15.67
315	15.54
316	15.4
317	15.24
318	15.07

Day	Degree C
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320	14.73
321	14.48
322	14.16
323	13.94
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325	13.41
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327	13.33
328	13.33
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330	13.33
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Day	Degree C
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Day	Degree C
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Day	Degree C
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Day	Degree C
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Day	Degree C
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680	13.33
681	13.33
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685	13.33
686	13.33

Day	Degree C
687	13.33
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689	13.33
690	13.33
691	13.33
692	13.33
693	13.33
694	13.33
695	13.33
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700	13.33
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706	13.33
707	13.33
708	13.33
709	13.33
710	13.33
711	13.33
712	13.33
713	13.33
714	13.33
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729	13.33
730	13.33

EMERGENCE MODEL: [SacPAS: Central Valley Prediction & Assessment of Salmon- Egg Growth Model: Spawning to Emergence v2.1.4]

GENERATED: Fri Sep 24 11:00:27 2021

RUN SPECS

Category	Specs
Species	Fall Chinook
Development model	Zeug
Target ATUs	958
Egg temperature effect	Exponential: SALMOD / USBR / HCI
Density effect	None
Eggs per redd	3000
Carcasses per redd	1
Offset used for redd timing	-12
Temperature Source	User Provided Hazel No Bypass.csv Column 2 Temperature Units- centigrade
Spawning Data Source	SacPAS database 201620152014 spnfem Carcass Counts

RUN RESULTS

Category	Results
Total Redds	649
Mean Emergence Day	397.5
Mean Emergence Date	2-Feb
Last Emergence Day	438
Last Emergence Date	14-Mar
Variance	779.4
STD	27.9
Expansion	14 Days
Eggs	1947000
Fry	1487023
Survival Egg to Fry	76.38%

DETAILS

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
275	1	59	334	968.1	16.64	20.88	3000	0	0
276	1	59	335	961.1	16.52	20.88	3000	0	0
277	1	60	337	967.2	16.34	20.88	3000	0	0
278	1	60	338	960	16.22	20.88	3000	0	0

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
279	1	61	340	966	16.06	20.88	3000	0	0
286	1	65	351	969.8	15.13	19.02	3000	0	0
287	2	65	352	964.1	15.04	18.82	6000	0	0
288	1	65	353	958.6	14.95	18.66	3000	0	0
289	1	66	355	966.6	14.85	18.47	3000	0	0
290	2	66	356	961.4	14.77	18.41	6000	0	0
291	2	67	358	969.7	14.67	18.41	6000	0	0
292	2	67	359	964.6	14.6	18.14	6000	0	0
293	2	67	360	959.8	14.53	17.92	6000	0	0
294	1	68	362	968.6	14.44	17.84	3000	2	0
295	4	68	363	964.1	14.37	17.63	12000	88	0
296	4	68	364	959.8	14.31	17.45	12000	269	0.02
297	4	69	366	969	14.24	17.39	12000	561	0.04
298	4	69	367	964.9	14.18	17.26	12000	1078	0.08
299	4	69	368	961	14.12	17.07	12000	1795	0.14
300	4	70	370	970.6	14.06	16.85	12000	2587	0.21
301	3	70	371	967.1	14.01	16.72	9000	2504	0.27
302	1	70	372	963.7	13.96	16.72	3000	1018	0.33
303	18	70	373	960.3	13.91	16.6	54000	22542	0.41
304	18	71	375	970.4	13.86	16.35	54000	26771	0.49
305	18	71	376	967.3	13.81	16.03	54000	30130	0.55
306	18	71	377	964.6	13.77	15.75	54000	32426	0.6
307	18	71	378	962.2	13.74	15.67	54000	34006	0.62
308	17	71	379	960	13.71	15.67	51000	33229	0.65
309	10	71	380	958	13.68	15.67	30000	20085	0.66
310	16	72	382	969.3	13.65	15.67	48000	33012	0.68
311	16	72	383	967.3	13.62	15.67	48000	33923	0.7
312	16	72	384	965	13.59	15.67	48000	35248	0.73
313	16	72	385	962.7	13.56	15.67	48000	36766	0.76
314	16	72	386	960.3	13.52	15.54	48000	38387	0.79
315	25	72	387	958.1	13.49	15.4	75000	62153	0.82
316	12	73	389	969.4	13.46	15.24	36000	30685	0.85
317	22	73	390	967.5	13.44	15.07	66000	57549	0.87
318	23	73	391	965.7	13.41	14.9	69000	61227	0.88
319	23	73	392	964.2	13.39	14.73	69000	62056	0.89
320	23	73	393	962.8	13.37	14.48	69000	62633	0.9
321	23	73	394	961.6	13.36	14.16	69000	63055	0.91
322	18	73	395	960.8	13.34	13.94	54000	49529	0.91
323	8	73	396	960.2	13.34	13.71	24000	22063	0.91
324	13	73	397	959.8	13.33	13.41	39000	35894	0.92
325	13	73	398	959.7	13.33	13.33	39000	35902	0.92
326	13	73	399	959.7	13.33	13.33	39000	35902	0.92

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
327	14	73	400	959.7	13.33	13.33	42000	38663	0.92
328	14	73	401	959.7	13.33	13.33	42000	38663	0.92
329	32	73	402	959.7	13.33	13.33	96000	88374	0.92
330	7	73	403	959.7	13.33	13.33	21000	19331	0.92
331	2	73	404	959.7	13.33	13.33	6000	5523	0.92
332	3	73	405	959.7	13.33	13.33	9000	8285	0.92
333	3	73	406	959.7	13.33	13.33	9000	8285	0.92
334	3	73	407	959.7	13.33	13.33	9000	8285	0.92
335	4	73	408	959.7	13.33	13.33	12000	11046	0.92
336	7	73	409	959.7	13.33	13.33	21000	19331	0.92
337	2	73	410	959.7	13.33	13.33	6000	5523	0.92
338	2	73	411	959.7	13.33	13.33	6000	5523	0.92
339	2	73	412	959.7	13.33	13.33	6000	5523	0.92
340	2	73	413	959.7	13.33	13.33	6000	5523	0.92
341	2	73	414	959.7	13.33	13.33	6000	5523	0.92
342	2	73	415	959.7	13.33	13.33	6000	5523	0.92
343	2	73	416	959.7	13.33	13.33	6000	5523	0.92
344	2	73	417	959.7	13.33	13.33	6000	5523	0.92
345	2	73	418	959.7	13.33	13.33	6000	5523	0.92
346	3	73	419	959.7	13.33	13.33	9000	8285	0.92
347	3	73	420	959.7	13.33	13.33	9000	8285	0.92
348	3	73	421	959.7	13.33	13.33	9000	8285	0.92
349	3	73	422	959.7	13.33	13.33	9000	8285	0.92
350	3	73	423	959.7	13.33	13.33	9000	8285	0.92
351	3	73	424	959.7	13.33	13.33	9000	8285	0.92
352	3	73	425	959.7	13.33	13.33	9000	8285	0.92
353	3	73	426	959.7	13.33	13.33	9000	8285	0.92
354	3	73	427	959.7	13.33	13.33	9000	8285	0.92
355	3	73	428	959.7	13.33	13.33	9000	8285	0.92
356	3	73	429	959.7	13.33	13.33	9000	8285	0.92
357	3	73	430	959.7	13.33	13.33	9000	8285	0.92
358	5	73	431	959.7	13.33	13.33	15000	13808	0.92
359	6	73	432	959.7	13.33	13.33	18000	16570	0.92
360	6	73	433	959.7	13.33	13.33	18000	16570	0.92
361	6	73	434	959.7	13.33	13.33	18000	16570	0.92
362	6	73	435	959.7	13.33	13.33	18000	16570	0.92
363	7	73	436	959.7	13.33	13.33	21000	19331	0.92
364	7	73	437	959.7	13.33	13.33	21000	19331	0.92
365	3	73	438	959.7	13.33	13.33	9000	8285	0.92

Uploaded data assumed beginning in non-leap year
TEMPERATURE INPUT

Day	degree C
1	21
1	21
2	21
3	21
4	21
5	21
6	21
7	21
8	21
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Day	degree C
39	21
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Day	degree C
81	21
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Day	degree C
123	21
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Day	degree C
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Day	degree C
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Day	degree C
249	21
250	21
251	20.98
252	21.15
253	21.33
254	21.46
255	21.48
256	21.55
257	21.35
258	21.16
259	21.24
260	21.2
261	21.22
262	21.21
263	21.2
264	21.18
265	21.12
266	21.07
267	21.09
268	21.19
269	21.05
270	20.97
271	20.85
272	20.62
273	20.46
274	20.52
275	20.54
276	20.4
277	20.51
278	20.57
279	20.65
280	20.74
281	20.88
282	20.84
283	20.53
284	20.19
285	19.88
286	19.81
287	19.02
288	18.82
289	18.66
290	18.47

Day	degree C
291	18.37
292	18.41
293	18.14
294	17.92
295	17.84
296	17.63
297	17.45
298	17.39
299	17.26
300	17.07
301	16.85
302	16.69
303	16.72
304	16.6
305	16.35
306	16.03
307	15.75
308	15.51
309	15.36
310	15.37
311	15.36
312	15.59
313	15.67
314	15.67
315	15.54
316	15.4
317	15.24
318	15.07
319	14.9
320	14.73
321	14.48
322	14.16
323	13.94
324	13.71
325	13.41
326	13.33
327	13.33
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
585	13.33
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621	13.33
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623	13.33
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625	13.33
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Day	degree C
627	13.33
628	13.33
629	13.33
630	13.33
631	13.33
632	13.33
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Day	degree C
669	13.33
670	13.33
671	13.33
672	13.33
673	13.33
674	13.33
675	13.33
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677	13.33
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680	13.33
681	13.33
682	13.33
683	13.33
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693	13.33
694	13.33
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697	13.33
698	13.33
699	13.33
700	13.33
701	13.33
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703	13.33
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709	13.33
710	13.33

Day	degree C
711	13.33
712	13.33
713	13.33
714	13.33
715	13.33
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718	13.33
719	13.33
720	13.33
721	13.33
722	13.33
723	13.33
724	13.33
725	13.33
726	13.33
727	13.33
728	13.33
729	13.33
730	13.33

EMERGENCE MODEL: SacPAS: Central Valley Prediction & Assessment of Salmon- Egg Growth Model: Spawning to Emergence v2.1.4

GENERATED: Fri Sep 24 11:03:55 2021

RUN SPECS

Category	Specs
Species	Fall Chinook
Development model	Zeug
Target ATUs	958
Egg temperature effect	Linear
Density effect	None
Eggs per redd	3000
Carcasses per redd	1
Offset used for redd timing	-12
Temperature Source	User Provided Hazel No Bypass.csv Column 2
Temperature Units	centigrade
Spawning Data Source	SacPAS database 201620152014 spnfem Carcass Counts

RUN RESULTS

Category	Results
Total Redds	649
Mean Emergence Day	398.2
Mean Emergence Date	2-Feb
Last Emergence Day	438
Last Emergence Date	14-Mar
Variance	812.7
STD	28.5
Expansion	14 Days
Eggs	1947000
Fry	168140
Survival Egg to Fry	8.64%

DETAILS

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
275	1	59	334	968.1	16.64	20.88	3000	4	0
276	1	59	335	961.1	16.52	20.88	3000	5	0
277	1	60	337	967.2	16.34	20.88	3000	6	0
278	1	60	338	960	16.22	20.88	3000	7	0

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
279	1	61	340	966	16.06	20.88	3000	8	0
286	1	65	351	969.8	15.13	19.02	3000	26	0
287	2	65	352	964.1	15.04	18.82	6000	59	0
288	1	65	353	958.6	14.95	18.66	3000	34	0.01
289	1	66	355	966.6	14.85	18.47	3000	37	0.01
290	2	66	356	961.4	14.77	18.41	6000	84	0.01
291	2	67	358	969.7	14.67	18.41	6000	92	0.01
292	2	67	359	964.6	14.6	18.14	6000	104	0.01
293	2	67	360	959.8	14.53	17.92	6000	117	0.01
294	1	68	362	968.6	14.44	17.84	3000	63	0.02
295	4	68	363	964.1	14.37	17.63	12000	283	0.02
296	4	68	364	959.8	14.31	17.45	12000	314	0.02
297	4	69	366	969	14.24	17.39	12000	336	0.02
298	4	69	367	964.9	14.18	17.26	12000	370	0.03
299	4	69	368	961	14.12	17.07	12000	407	0.03
300	4	70	370	970.6	14.06	16.85	12000	432	0.03
301	3	70	371	967.1	14.01	16.72	9000	352	0.03
302	1	70	372	963.7	13.96	16.72	3000	127	0.04
303	18	70	373	960.3	13.91	16.6	54000	2487	0.04
304	18	71	375	970.4	13.86	16.35	54000	2609	0.04
305	18	71	376	967.3	13.81	16.03	54000	2804	0.05
306	18	71	377	964.6	13.77	15.75	54000	2991	0.05
307	18	71	378	962.2	13.74	15.67	54000	3169	0.05
308	17	71	379	960	13.71	15.67	51000	3153	0.06
309	10	71	380	958	13.68	15.67	30000	1947	0.06
310	16	72	382	969.3	13.65	15.67	48000	3174	0.06
311	16	72	383	967.3	13.62	15.67	48000	3332	0.06
312	16	72	384	965	13.59	15.67	48000	3517	0.07
313	16	72	385	962.7	13.56	15.67	48000	3719	0.07
314	16	72	386	960.3	13.52	15.54	48000	3933	0.08
315	25	72	387	958.1	13.49	15.4	75000	6479	0.08
316	12	73	389	969.4	13.46	15.24	36000	3171	0.08
317	22	73	390	967.5	13.44	15.07	66000	6085	0.09
318	23	73	391	965.7	13.41	14.9	69000	6632	0.09
319	23	73	392	964.2	13.39	14.73	69000	6885	0.09
320	23	73	393	962.8	13.37	14.48	69000	7119	0.1
321	23	73	394	961.6	13.36	14.16	69000	7318	0.1
322	18	73	395	960.8	13.34	13.94	54000	5842	0.1
323	8	73	396	960.2	13.34	13.71	24000	2634	0.1
324	13	73	397	959.8	13.33	13.41	39000	4320	0.11
325	13	73	398	959.7	13.33	13.33	39000	4328	0.11
326	13	73	399	959.7	13.33	13.33	39000	4328	0.11

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
327	14	73	400	959.7	13.33	13.33	42000	4661	0.11
328	14	73	401	959.7	13.33	13.33	42000	4661	0.11
329	32	73	402	959.7	13.33	13.33	96000	10654	0.11
330	7	73	403	959.7	13.33	13.33	21000	2330	0.11
331	2	73	404	959.7	13.33	13.33	6000	665	0.11
332	3	73	405	959.7	13.33	13.33	9000	998	0.11
333	3	73	406	959.7	13.33	13.33	9000	998	0.11
334	3	73	407	959.7	13.33	13.33	9000	998	0.11
335	4	73	408	959.7	13.33	13.33	12000	1331	0.11
336	7	73	409	959.7	13.33	13.33	21000	2330	0.11
337	2	73	410	959.7	13.33	13.33	6000	665	0.11
338	2	73	411	959.7	13.33	13.33	6000	665	0.11
339	2	73	412	959.7	13.33	13.33	6000	665	0.11
340	2	73	413	959.7	13.33	13.33	6000	665	0.11
341	2	73	414	959.7	13.33	13.33	6000	665	0.11
342	2	73	415	959.7	13.33	13.33	6000	665	0.11
343	2	73	416	959.7	13.33	13.33	6000	665	0.11
344	2	73	417	959.7	13.33	13.33	6000	665	0.11
345	2	73	418	959.7	13.33	13.33	6000	665	0.11
346	3	73	419	959.7	13.33	13.33	9000	998	0.11
347	3	73	420	959.7	13.33	13.33	9000	998	0.11
348	3	73	421	959.7	13.33	13.33	9000	998	0.11
349	3	73	422	959.7	13.33	13.33	9000	998	0.11
350	3	73	423	959.7	13.33	13.33	9000	998	0.11
351	3	73	424	959.7	13.33	13.33	9000	998	0.11
352	3	73	425	959.7	13.33	13.33	9000	998	0.11
353	3	73	426	959.7	13.33	13.33	9000	998	0.11
354	3	73	427	959.7	13.33	13.33	9000	998	0.11
355	3	73	428	959.7	13.33	13.33	9000	998	0.11
356	3	73	429	959.7	13.33	13.33	9000	998	0.11
357	3	73	430	959.7	13.33	13.33	9000	998	0.11
358	5	73	431	959.7	13.33	13.33	15000	1664	0.11
359	6	73	432	959.7	13.33	13.33	18000	1997	0.11
360	6	73	433	959.7	13.33	13.33	18000	1997	0.11
361	6	73	434	959.7	13.33	13.33	18000	1997	0.11
362	6	73	435	959.7	13.33	13.33	18000	1997	0.11
363	7	73	436	959.7	13.33	13.33	21000	2330	0.11
364	7	73	437	959.7	13.33	13.33	21000	2330	0.11
365	3	73	438	959.7	13.33	13.33	9000	998	0.11

Uploaded data assumed beginning in non-leap year
TEMPERATURE INPUT

Day	degree C
1	21
1	21
2	21
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
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256	21.55
257	21.35
258	21.16
259	21.24
260	21.2
261	21.22
262	21.21
263	21.2
264	21.18
265	21.12
266	21.07
267	21.09
268	21.19
269	21.05
270	20.97
271	20.85
272	20.62
273	20.46
274	20.52
275	20.54
276	20.4
277	20.51
278	20.57
279	20.65
280	20.74
281	20.88
282	20.84
283	20.53
284	20.19
285	19.88
286	19.81
287	19.02
288	18.82
289	18.66
290	18.47
291	18.37

Day	degree C
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293	18.14
294	17.92
295	17.84
296	17.63
297	17.45
298	17.39
299	17.26
300	17.07
301	16.85
302	16.69
303	16.72
304	16.6
305	16.35
306	16.03
307	15.75
308	15.51
309	15.36
310	15.37
311	15.36
312	15.59
313	15.67
314	15.67
315	15.54
316	15.4
317	15.24
318	15.07
319	14.9
320	14.73
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
712	13.33
713	13.33
714	13.33
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718	13.33
719	13.33
720	13.33
721	13.33
722	13.33
723	13.33
724	13.33
725	13.33
726	13.33
727	13.33
728	13.33
729	13.33
730	13.33

EMERGENCE MODEL: SacPAS: Central Valley Prediction & Assessment of Salmon- Egg Growth Model: Spawning to Emergence v2.1.4

GENERATED: Fri Sep 24 11:05:08 2021

RUN SPECS

Category	Specs
Species	Fall Chinook
Development model	Zeug
Target ATUs	958
Egg temperature effect	Exponential: Water Forum
Density Effect	None
Eggs per redd	3000
Carcasses per redd	1
Offset used for redd timing	-12
Temperature Source	User Provided Hazel Scenario A.csv Column 2
Temperature Units	centigrade
Spawning Data Source	SacPAS database 201620152014 spnfem Carcass Counts

RUN RESULTS

Category	Results
Total Redds	649
Mean Emergence Day	394.7
Mean Emergence Date	30-Jan
Last Emergence Day	438
Last Emergence Date	14-Mar
Variance	530.2
STD	23
Expansion	11 Days
Eggs	1947000
Fry	1769647
Survival Egg to Fry	90.89%

DETAILS

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
275	1	62	337	959.4	15.69	20.89	3000	0	0
276	1	63	339	965.7	15.54	20.89	3000	0	0
277	1	63	340	958.5	15.43	20.89	3000	0	0
278	1	64	342	964.6	15.28	20.89	3000	0	0
279	1	65	344	970.6	15.14	20.89	3000	0	0
286	1	68	354	961	14.33	19.01	3000	447	0.14

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
287	2	69	356	968.7	14.23	18.82	6000	1355	0.22
288	1	69	357	963.2	14.15	18.66	3000	930	0.31
289	1	70	359	971.2	14.07	18.46	3000	1195	0.39
290	2	70	360	966.1	13.99	18.41	6000	2896	0.48
291	2	70	361	961	13.92	18.41	6000	3438	0.57
292	2	71	363	969.3	13.84	18.09	6000	4109	0.68
293	2	71	364	964.5	13.77	17.52	6000	4624	0.77
294	1	71	365	960.3	13.71	17.32	3000	2451	0.81
295	4	72	367	969.7	13.65	16.76	12000	10238	0.85
296	4	72	368	966.2	13.61	16.51	12000	10468	0.87
297	4	72	369	963.1	13.56	16.35	12000	10653	0.88
298	4	72	370	960	13.52	16.2	12000	10796	0.89
299	4	73	372	970.5	13.48	16.11	12000	10899	0.9
300	4	73	373	967.7	13.44	15.46	12000	11007	0.91
301	3	73	374	965.6	13.41	14.82	9000	8290	0.92
302	1	73	375	964.1	13.39	14.5	3000	2768	0.92
303	18	73	376	962.9	13.37	14.05	54000	49948	0.92
304	18	73	377	962.2	13.36	13.78	54000	49973	0.92
305	18	73	378	961.8	13.36	13.73	54000	49985	0.92
306	18	73	379	961.4	13.35	13.73	54000	49996	0.92
307	18	73	380	961	13.35	13.67	54000	50007	0.92
308	17	73	381	960.8	13.34	13.67	51000	47233	0.92
309	10	73	382	960.7	13.34	13.67	30000	27784	0.92
310	16	73	383	960.8	13.34	13.67	48000	44455	0.92
311	16	73	384	960.8	13.34	13.67	48000	44454	0.92
312	16	73	385	960.5	13.34	13.67	48000	44461	0.92
313	16	73	386	960.2	13.34	13.67	48000	44468	0.92
314	16	73	387	959.9	13.33	13.47	48000	44476	0.92
315	25	73	388	959.7	13.33	13.33	75000	69498	0.92
316	12	73	389	959.7	13.33	13.33	36000	33359	0.92
317	22	73	390	959.7	13.33	13.33	66000	61159	0.92
318	23	73	391	959.7	13.33	13.33	69000	63938	0.92
319	23	73	392	959.7	13.33	13.33	69000	63938	0.92
320	23	73	393	959.7	13.33	13.33	69000	63938	0.92
321	23	73	394	959.7	13.33	13.33	69000	63938	0.92
322	18	73	395	959.7	13.33	13.33	54000	50039	0.92
323	8	73	396	959.7	13.33	13.33	24000	22239	0.92
324	13	73	397	959.7	13.33	13.33	39000	36139	0.92
325	13	73	398	959.7	13.33	13.33	39000	36139	0.92
326	13	73	399	959.7	13.33	13.33	39000	36139	0.92
327	14	73	400	959.7	13.33	13.33	42000	38919	0.92
328	14	73	401	959.7	13.33	13.33	42000	38919	0.92
329	32	73	402	959.7	13.33	13.33	96000	88958	0.92
330	7	73	403	959.7	13.33	13.33	21000	19459	0.92
331	2	73	404	959.7	13.33	13.33	6000	5559	0.92

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
332	3	73	405	959.7	13.33	13.33	9000	8339	0.92
333	3	73	406	959.7	13.33	13.33	9000	8339	0.92
334	3	73	407	959.7	13.33	13.33	9000	8339	0.92
335	4	73	408	959.7	13.33	13.33	12000	11119	0.92
336	7	73	409	959.7	13.33	13.33	21000	19459	0.92
337	2	73	410	959.7	13.33	13.33	6000	5559	0.92
338	2	73	411	959.7	13.33	13.33	6000	5559	0.92
339	2	73	412	959.7	13.33	13.33	6000	5559	0.92
340	2	73	413	959.7	13.33	13.33	6000	5559	0.92
341	2	73	414	959.7	13.33	13.33	6000	5559	0.92
342	2	73	415	959.7	13.33	13.33	6000	5559	0.92
343	2	73	416	959.7	13.33	13.33	6000	5559	0.92
344	2	73	417	959.7	13.33	13.33	6000	5559	0.92
345	2	73	418	959.7	13.33	13.33	6000	5559	0.92
346	3	73	419	959.7	13.33	13.33	9000	8339	0.92
347	3	73	420	959.7	13.33	13.33	9000	8339	0.92
348	3	73	421	959.7	13.33	13.33	9000	8339	0.92
349	3	73	422	959.7	13.33	13.33	9000	8339	0.92
350	3	73	423	959.7	13.33	13.33	9000	8339	0.92
351	3	73	424	959.7	13.33	13.33	9000	8339	0.92
352	3	73	425	959.7	13.33	13.33	9000	8339	0.92
353	3	73	426	959.7	13.33	13.33	9000	8339	0.92
354	3	73	427	959.7	13.33	13.33	9000	8339	0.92
355	3	73	428	959.7	13.33	13.33	9000	8339	0.92
356	3	73	429	959.7	13.33	13.33	9000	8339	0.92
357	3	73	430	959.7	13.33	13.33	9000	8339	0.92
358	5	73	431	959.7	13.33	13.33	15000	13899	0.92
359	6	73	432	959.7	13.33	13.33	18000	16679	0.92
360	6	73	433	959.7	13.33	13.33	18000	16679	0.92
361	6	73	434	959.7	13.33	13.33	18000	16679	0.92
362	6	73	435	959.7	13.33	13.33	18000	16679	0.92
363	7	73	436	959.7	13.33	13.33	21000	19459	0.92
364	7	73	437	959.7	13.33	13.33	21000	19459	0.92
365	3	73	438	959.7	13.33	13.33	9000	8339	0.92

Uploaded data assumed beginning in non-leap year
TEMPERATURE INPUT

Day	degree C
1	21
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Day	degree C
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265	21.12
266	21.07
267	21.1
268	21.2
269	21.05
270	20.97
271	20.84
272	20.61
273	20.46

Day	degree C
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277	20.5
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280	20.74
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291	18.37
292	18.41
293	18.09
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Day	degree C
724	13.33
725	13.33
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728	13.33
729	13.33
730	13.33

EMERGENCE MODEL: [SacPAS: Central Valley Prediction & Assessment of Salmon- Egg Growth Model: Spawning to Emergence v2.1.4]

GENERATED: Fri Sep 24 11:06:14 2021

RUN SPECS

Category	Specs
Species	Fall Chinook
Development model	Zeug Target ATUs
Target ATUs	958
Egg temperature effect	Exponential: SALMOD / USBR / HCI
Density Effect	None
Eggs per redd	3000
Carcasses per redd	1
Offset used for redd timing	-12
Temperature Source	User Provided Hazel Scenario A.csv Column 2
Temperature Units	centigrade
Spawning Data Source	SacPAS database 201620152014 spnfem Carcass Counts

RUN RESULTS

Category	Results
Total Redds	649
Mean Emergence Day	395.3
Mean Emergence Date	30-Jan
Last Emergence Day	438
Last Emergence Date	14-Mar
Variance	545.2
STD	23.3
Expansion	11 Days
Eggs	1947000
Fry	1720867
Survival Egg to Fry	88.39%

DETAILS

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
275	1	62	337	959.4	15.69	20.89	3000	0	0
276	1	63	339	965.7	15.54	20.89	3000	0	0
277	1	63	340	958.5	15.43	20.89	3000	0	0
278	1	64	342	964.6	15.28	20.89	3000	0	0
279	1	65	344	970.6	15.14	20.89	3000	0	0
286	1	68	354	961	14.33	19.01	3000	0	0
287	2	69	356	968.7	14.23	18.82	6000	0	0

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
288	1	69	357	963.2	14.15	18.66	3000	0	0
289	1	70	359	971.2	14.07	18.46	3000	0	0
290	2	70	360	966.1	13.99	18.41	6000	0	0
291	2	70	361	961	13.92	18.41	6000	0	0
292	2	71	363	969.3	13.84	18.09	6000	0	0
293	2	71	364	964.5	13.77	17.52	6000	643	0.1
294	1	71	365	960.3	13.71	17.32	3000	756	0.25
295	4	72	367	969.7	13.65	16.76	12000	5348	0.44
296	4	72	368	966.2	13.61	16.51	12000	6673	0.55
297	4	72	369	963.1	13.56	16.35	12000	7749	0.64
298	4	72	370	960	13.52	16.2	12000	8721	0.72
299	4	73	372	970.5	13.48	16.11	12000	9579	0.79
300	4	73	373	967.7	13.44	15.46	12000	10404	0.86
301	3	73	374	965.6	13.41	14.82	9000	8053	0.89
302	1	73	375	964.1	13.39	14.5	3000	2716	0.9
303	18	73	376	962.9	13.37	14.05	54000	49192	0.91
304	18	73	377	962.2	13.36	13.78	54000	49335	0.91
305	18	73	378	961.8	13.36	13.73	54000	49408	0.91
306	18	73	379	961.4	13.35	13.73	54000	49470	0.91
307	18	73	380	961	13.35	13.67	54000	49533	0.91
308	17	73	381	960.8	13.34	13.67	51000	46801	0.91
309	10	73	382	960.7	13.34	13.67	30000	27534	0.91
310	16	73	383	960.8	13.34	13.67	48000	44052	0.91
311	16	73	384	960.8	13.34	13.67	48000	44048	0.91
312	16	73	385	960.5	13.34	13.67	48000	44084	0.91
313	16	73	386	960.2	13.34	13.67	48000	44125	0.91
314	16	73	387	959.9	13.33	13.47	48000	44171	0.92
315	25	73	388	959.7	13.33	13.33	75000	69042	0.92
316	12	73	389	959.7	13.33	13.33	36000	33140	0.92
317	22	73	390	959.7	13.33	13.33	66000	60757	0.92
318	23	73	391	959.7	13.33	13.33	69000	63519	0.92
319	23	73	392	959.7	13.33	13.33	69000	63519	0.92
320	23	73	393	959.7	13.33	13.33	69000	63519	0.92
321	23	73	394	959.7	13.33	13.33	69000	63519	0.92
322	18	73	395	959.7	13.33	13.33	54000	49710	0.92
323	8	73	396	959.7	13.33	13.33	24000	22093	0.92
324	13	73	397	959.7	13.33	13.33	39000	35902	0.92
325	13	73	398	959.7	13.33	13.33	39000	35902	0.92
326	13	73	399	959.7	13.33	13.33	39000	35902	0.92
327	14	73	400	959.7	13.33	13.33	42000	38663	0.92
328	14	73	401	959.7	13.33	13.33	42000	38663	0.92
329	32	73	402	959.7	13.33	13.33	96000	88374	0.92
330	7	73	403	959.7	13.33	13.33	21000	19331	0.92
331	2	73	404	959.7	13.33	13.33	6000	5523	0.92
332	3	73	405	959.7	13.33	13.33	9000	8285	0.92

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
333	3	73	406	959.7	13.33	13.33	9000	8285	0.92
334	3	73	407	959.7	13.33	13.33	9000	8285	0.92
335	4	73	408	959.7	13.33	13.33	12000	11046	0.92
336	7	73	409	959.7	13.33	13.33	21000	19331	0.92
337	2	73	410	959.7	13.33	13.33	6000	5523	0.92
338	2	73	411	959.7	13.33	13.33	6000	5523	0.92
339	2	73	412	959.7	13.33	13.33	6000	5523	0.92
340	2	73	413	959.7	13.33	13.33	6000	5523	0.92
341	2	73	414	959.7	13.33	13.33	6000	5523	0.92
342	2	73	415	959.7	13.33	13.33	6000	5523	0.92
343	2	73	416	959.7	13.33	13.33	6000	5523	0.92
344	2	73	417	959.7	13.33	13.33	6000	5523	0.92
345	2	73	418	959.7	13.33	13.33	6000	5523	0.92
346	3	73	419	959.7	13.33	13.33	9000	8285	0.92
347	3	73	420	959.7	13.33	13.33	9000	8285	0.92
348	3	73	421	959.7	13.33	13.33	9000	8285	0.92
349	3	73	422	959.7	13.33	13.33	9000	8285	0.92
350	3	73	423	959.7	13.33	13.33	9000	8285	0.92
351	3	73	424	959.7	13.33	13.33	9000	8285	0.92
352	3	73	425	959.7	13.33	13.33	9000	8285	0.92
353	3	73	426	959.7	13.33	13.33	9000	8285	0.92
354	3	73	427	959.7	13.33	13.33	9000	8285	0.92
355	3	73	428	959.7	13.33	13.33	9000	8285	0.92
356	3	73	429	959.7	13.33	13.33	9000	8285	0.92
357	3	73	430	959.7	13.33	13.33	9000	8285	0.92
358	5	73	431	959.7	13.33	13.33	15000	13808	0.92
359	6	73	432	959.7	13.33	13.33	18000	16570	0.92
360	6	73	433	959.7	13.33	13.33	18000	16570	0.92
361	6	73	434	959.7	13.33	13.33	18000	16570	0.92
362	6	73	435	959.7	13.33	13.33	18000	16570	0.92
363	7	73	436	959.7	13.33	13.33	21000	19331	0.92
364	7	73	437	959.7	13.33	13.33	21000	19331	0.92
365	3	73	438	959.7	13.33	13.33	9000	8285	0.92

Uploaded data assumed beginning in non-leap year
TEMPERATURE INPUT

Day	degree C
1	21
1	21
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Day	degree C
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266	21.07
267	21.1
268	21.2
269	21.05
270	20.97
271	20.84
272	20.61
273	20.46
274	20.51
275	20.54
276	20.4

Day	degree C
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Day	degree C
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Day	degree C
727	13.33
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729	13.33
730	13.33

EMERGENCE MODEL: [SacPAS: Central Valley Prediction & Assessment of Salmon- Egg Growth Model: Spawning to Emergence v2.1.4]

GENERATED: Fri Sep 24 11:06:49 2021

RUN SPECS

Category	Specs
Species	Fall Chinook
Development model	Zeug
Target ATUs	958
Egg temperature effect	Linear
Density effect	None
Eggs per redd	3000
Carcasses per redd	1
Offset used for redd timing	-12
Temperature Source	User Provided Hazel Scenario A.csv Column 2
Temperature Units	centigrade
Spawning Data Source	SacPAS database 201620152014 spnfem Carcass Counts

RUN RESULTS

Category	Results
Total Redds	649
Mean Emergence Day	395.2
Mean Emergence Date	30-Jan
Last Emergence Day	438
Last Emergence Date	14-Mar
Variance	545.8
STD	23.3
Expansion	11 Days
Eggs	1947000
Fry	206967
Survival Egg to Fry	10.63%

DETAILS

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
275	1	62	337	959.4	15.69	20.89	3000	14	0
276	1	63	339	965.7	15.54	20.89	3000	16	0
277	1	63	340	958.5	15.43	20.89	3000	19	0
278	1	64	342	964.6	15.28	20.89	3000	22	0
279	1	65	344	970.6	15.14	20.89	3000	25	0
286	1	68	354	961	14.33	19.01	3000	76	0.02
287	2	69	356	968.7	14.23	18.82	6000	169	0.02

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
288	1	69	357	963.2	14.15	18.66	3000	96	0.03
289	1	70	359	971.2	14.07	18.46	3000	106	0.03
290	2	70	360	966.1	13.99	18.41	6000	240	0.04
291	2	70	361	961	13.92	18.41	6000	271	0.04
292	2	71	363	969.3	13.84	18.09	6000	297	0.04
293	2	71	364	964.5	13.77	17.52	6000	333	0.05
294	1	71	365	960.3	13.71	17.32	3000	184	0.06
295	4	72	367	969.7	13.65	16.76	12000	786	0.06
296	4	72	368	966.2	13.61	16.51	12000	854	0.07
297	4	72	369	963.1	13.56	16.35	12000	921	0.07
298	4	72	370	960	13.52	16.2	12000	990	0.08
299	4	73	372	970.5	13.48	16.11	12000	1029	0.08
300	4	73	373	967.7	13.44	15.46	12000	1100	0.09
301	3	73	374	965.6	13.41	14.82	9000	868	0.09
302	1	73	375	964.1	13.39	14.5	3000	299	0.09
303	18	73	376	962.9	13.37	14.05	54000	5550	0.1
304	18	73	377	962.2	13.36	13.78	54000	5647	0.1
305	18	73	378	961.8	13.36	13.73	54000	5708	0.1
306	18	73	379	961.4	13.35	13.73	54000	5763	0.1
307	18	73	380	961	13.35	13.67	54000	5818	0.1
308	17	73	381	960.8	13.34	13.67	51000	5516	0.1
309	10	73	382	960.7	13.34	13.67	30000	3249	0.1
310	16	73	383	960.8	13.34	13.67	48000	5196	0.1
311	16	73	384	960.8	13.34	13.67	48000	5191	0.1
312	16	73	385	960.5	13.34	13.67	48000	5226	0.1
313	16	73	386	960.2	13.34	13.67	48000	5266	0.1
314	16	73	387	959.9	13.33	13.47	48000	5309	0.11
315	25	73	388	959.7	13.33	13.33	75000	8324	0.11
316	12	73	389	959.7	13.33	13.33	36000	3995	0.11
317	22	73	390	959.7	13.33	13.33	66000	7325	0.11
318	23	73	391	959.7	13.33	13.33	69000	7658	0.11
319	23	73	392	959.7	13.33	13.33	69000	7658	0.11
320	23	73	393	959.7	13.33	13.33	69000	7658	0.11
321	23	73	394	959.7	13.33	13.33	69000	7658	0.11
322	18	73	395	959.7	13.33	13.33	54000	5993	0.11
323	8	73	396	959.7	13.33	13.33	24000	2663	0.11
324	13	73	397	959.7	13.33	13.33	39000	4328	0.11
325	13	73	398	959.7	13.33	13.33	39000	4328	0.11
326	13	73	399	959.7	13.33	13.33	39000	4328	0.11
327	14	73	400	959.7	13.33	13.33	42000	4661	0.11
328	14	73	401	959.7	13.33	13.33	42000	4661	0.11
329	32	73	402	959.7	13.33	13.33	96000	10654	0.11
330	7	73	403	959.7	13.33	13.33	21000	2330	0.11
331	2	73	404	959.7	13.33	13.33	6000	665	0.11
332	3	73	405	959.7	13.33	13.33	9000	998	0.11

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
333	3	73	406	959.7	13.33	13.33	9000	998	0.11
334	3	73	407	959.7	13.33	13.33	9000	998	0.11
335	4	73	408	959.7	13.33	13.33	12000	1331	0.11
336	7	73	409	959.7	13.33	13.33	21000	2330	0.11
337	2	73	410	959.7	13.33	13.33	6000	665	0.11
338	2	73	411	959.7	13.33	13.33	6000	665	0.11
339	2	73	412	959.7	13.33	13.33	6000	665	0.11
340	2	73	413	959.7	13.33	13.33	6000	665	0.11
341	2	73	414	959.7	13.33	13.33	6000	665	0.11
342	2	73	415	959.7	13.33	13.33	6000	665	0.11
343	2	73	416	959.7	13.33	13.33	6000	665	0.11
344	2	73	417	959.7	13.33	13.33	6000	665	0.11
345	2	73	418	959.7	13.33	13.33	6000	665	0.11
346	3	73	419	959.7	13.33	13.33	9000	998	0.11
347	3	73	420	959.7	13.33	13.33	9000	998	0.11
348	3	73	421	959.7	13.33	13.33	9000	998	0.11
349	3	73	422	959.7	13.33	13.33	9000	998	0.11
350	3	73	423	959.7	13.33	13.33	9000	998	0.11
351	3	73	424	959.7	13.33	13.33	9000	998	0.11
352	3	73	425	959.7	13.33	13.33	9000	998	0.11
353	3	73	426	959.7	13.33	13.33	9000	998	0.11
354	3	73	427	959.7	13.33	13.33	9000	998	0.11
355	3	73	428	959.7	13.33	13.33	9000	998	0.11
356	3	73	429	959.7	13.33	13.33	9000	998	0.11
357	3	73	430	959.7	13.33	13.33	9000	998	0.11
358	5	73	431	959.7	13.33	13.33	15000	1664	0.11
359	6	73	432	959.7	13.33	13.33	18000	1997	0.11
360	6	73	433	959.7	13.33	13.33	18000	1997	0.11
361	6	73	434	959.7	13.33	13.33	18000	1997	0.11
362	6	73	435	959.7	13.33	13.33	18000	1997	0.11
363	7	73	436	959.7	13.33	13.33	21000	2330	0.11
364	7	73	437	959.7	13.33	13.33	21000	2330	0.11
365	3	73	438	959.7	13.33	13.33	9000	998	0.11

Uploaded data assumed beginning in non-leap year
TEMPERATURE INPUT

Day	degree C
1	21
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Day	degree C
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263	21.2
264	21.18
265	21.12
266	21.07
267	21.1
268	21.2
269	21.05
270	20.97
271	20.84
272	20.61
273	20.46
274	20.51
275	20.54

Day	degree C
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282	20.84
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Day	degree C
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Day	degree C
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Day	degree C
726	13.33
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730	13.33

EMERGENCE MODEL: SacPAS: Central Valley Prediction & Assessment of Salmon- Egg Growth Model: Spawning to Emergence v2.1.4

GENERATED: Fri Sep 24 11:08:12 2021

RUN SPECS

Category	Specs
Species	Fall Chinook
Development model	Zeug
Target ATUs	958
Egg temperature effect	Exponential: Water Forum
Density effect	None
Eggs per redd	3000
Carcasses per redd	1
Offset used for redd timing	-12
Temperature Source	User Provided Hazel Scenario B.csv Column 2
Temperature Units	centigrade
Spawning Data Source	SacPAS database 201620152014 spnfem Carcass Counts

RUN RESULTS

Category	Results
Total Redds	649
Mean Emergence Day	394.6
Mean Emergence Date	30-Jan
Last Emergence Day	438
Last Emergence Date	14-Mar
Variance	509.1
STD	22.5
Expansion	10 Days
Eggs	1947000
Fry	1775799
Survival Egg to Fry	91.21%

DETAILS

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
275	1	63	338	959.6	15.44	20.89	3000	0	0
276	1	64	340	965.9	15.3	20.89	3000	0	0
277	1	64	341	958.7	15.19	20.89	3000	0	0
278	1	65	343	964.8	15.05	20.89	3000	0	0
279	1	66	345	970.8	14.91	20.89	3000	0	0
286	1	69	355	961.2	14.12	19.01	3000	542	0.18
287	2	70	357	968.9	14.03	18.82	6000	1645	0.27

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
288	1	70	358	963.4	13.95	18.66	3000	1129	0.37
289	1	70	359	958	13.88	18.46	3000	1452	0.48
290	2	71	361	966.2	13.8	18.41	6000	3515	0.58
291	2	71	362	961.2	13.73	18.41	6000	4172	0.69
292	2	72	364	969.5	13.65	17.69	6000	4986	0.83
293	2	72	365	965.1	13.59	16.52	6000	5353	0.89
294	1	72	366	961.9	13.55	15.99	3000	2724	0.9
295	4	72	367	959.2	13.51	15.11	12000	10989	0.91
296	4	73	369	970.8	13.48	14.86	12000	11002	0.91
297	4	73	370	969.3	13.46	14.63	12000	11023	0.91
298	4	73	371	968	13.44	14.63	12000	11036	0.91
299	4	73	372	966.8	13.43	14.63	12000	11049	0.92
300	4	73	373	965.5	13.41	14.33	12000	11064	0.92
301	3	73	374	964.5	13.4	14.24	9000	8304	0.92
302	1	73	375	963.6	13.38	14.19	3000	2770	0.92
303	18	73	376	962.8	13.37	13.92	54000	49957	0.92
304	18	73	377	962.2	13.36	13.73	54000	49975	0.92
305	18	73	378	961.8	13.36	13.73	54000	49986	0.92
306	18	73	379	961.5	13.35	13.73	54000	49994	0.92
307	18	73	380	961.2	13.35	13.73	54000	50001	0.92
308	17	73	381	961.1	13.35	13.73	51000	47225	0.92
309	10	73	382	961.1	13.35	13.73	30000	27780	0.92
310	16	73	383	961.1	13.35	13.73	48000	44447	0.92
311	16	73	384	961.1	13.35	13.73	48000	44447	0.92
312	16	73	385	960.8	13.34	13.73	48000	44454	0.92
313	16	73	386	960.4	13.34	13.73	48000	44463	0.92
314	16	73	387	960	13.33	13.56	48000	44473	0.92
315	25	73	388	959.8	13.33	13.38	75000	69497	0.92
316	12	73	389	959.7	13.33	13.34	36000	33359	0.92
317	22	73	390	959.7	13.33	13.33	66000	61159	0.92
318	23	73	391	959.7	13.33	13.33	69000	63938	0.92
319	23	73	392	959.7	13.33	13.33	69000	63938	0.92
320	23	73	393	959.7	13.33	13.33	69000	63938	0.92
321	23	73	394	959.7	13.33	13.33	69000	63938	0.92
322	18	73	395	959.7	13.33	13.33	54000	50039	0.92
323	8	73	396	959.7	13.33	13.33	24000	22239	0.92
324	13	73	397	959.7	13.33	13.33	39000	36139	0.92
325	13	73	398	959.7	13.33	13.33	39000	36139	0.92
326	13	73	399	959.7	13.33	13.33	39000	36139	0.92
327	14	73	400	959.7	13.33	13.33	42000	38919	0.92
328	14	73	401	959.7	13.33	13.33	42000	38919	0.92
329	32	73	402	959.7	13.33	13.33	96000	88958	0.92
330	7	73	403	959.7	13.33	13.33	21000	19459	0.92
331	2	73	404	959.7	13.33	13.33	6000	5559	0.92
332	3	73	405	959.7	13.33	13.33	9000	8339	0.92

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
333	3	73	406	959.7	13.33	13.33	9000	8339	0.92
334	3	73	407	959.7	13.33	13.33	9000	8339	0.92
335	4	73	408	959.7	13.33	13.33	12000	11119	0.92
336	7	73	409	959.7	13.33	13.33	21000	19459	0.92
337	2	73	410	959.7	13.33	13.33	6000	5559	0.92
338	2	73	411	959.7	13.33	13.33	6000	5559	0.92
339	2	73	412	959.7	13.33	13.33	6000	5559	0.92
340	2	73	413	959.7	13.33	13.33	6000	5559	0.92
341	2	73	414	959.7	13.33	13.33	6000	5559	0.92
342	2	73	415	959.7	13.33	13.33	6000	5559	0.92
343	2	73	416	959.7	13.33	13.33	6000	5559	0.92
344	2	73	417	959.7	13.33	13.33	6000	5559	0.92
345	2	73	418	959.7	13.33	13.33	6000	5559	0.92
346	3	73	419	959.7	13.33	13.33	9000	8339	0.92
347	3	73	420	959.7	13.33	13.33	9000	8339	0.92
348	3	73	421	959.7	13.33	13.33	9000	8339	0.92
349	3	73	422	959.7	13.33	13.33	9000	8339	0.92
350	3	73	423	959.7	13.33	13.33	9000	8339	0.92
351	3	73	424	959.7	13.33	13.33	9000	8339	0.92
352	3	73	425	959.7	13.33	13.33	9000	8339	0.92
353	3	73	426	959.7	13.33	13.33	9000	8339	0.92
354	3	73	427	959.7	13.33	13.33	9000	8339	0.92
355	3	73	428	959.7	13.33	13.33	9000	8339	0.92
356	3	73	429	959.7	13.33	13.33	9000	8339	0.92
357	3	73	430	959.7	13.33	13.33	9000	8339	0.92
358	5	73	431	959.7	13.33	13.33	15000	13899	0.92
359	6	73	432	959.7	13.33	13.33	18000	16679	0.92
360	6	73	433	959.7	13.33	13.33	18000	16679	0.92
361	6	73	434	959.7	13.33	13.33	18000	16679	0.92
362	6	73	435	959.7	13.33	13.33	18000	16679	0.92
363	7	73	436	959.7	13.33	13.33	21000	19459	0.92
364	7	73	437	959.7	13.33	13.33	21000	19459	0.92
365	3	73	438	959.7	13.33	13.33	9000	8339	0.92

Uploaded data assumed beginning in non-leap year
TEMPERATURE INPUT

Day	degree C
1	21
1	21
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Day	degree C
6	21
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Day	degree C
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Day	degree C
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254	21.46
255	21.48
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258	21.16
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260	21.21
261	21.23
262	21.21
263	21.2
264	21.18
265	21.12
266	21.07
267	21.1
268	21.2
269	21.05
270	20.97
271	20.84
272	20.61
273	20.46
274	20.51
275	20.54

Day	degree C
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277	20.5
278	20.57
279	20.65
280	20.74
281	20.89
282	20.84
283	20.53
284	20.18
285	19.88
286	19.81
287	19.01
288	18.82
289	18.66
290	18.46
291	18.37
292	18.41
293	17.69
294	16.52
295	15.99
296	15.11
297	14.86
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301	14.33
302	14.24
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Day	degree C
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Day	degree C
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Day	degree C
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719	13.33
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725	13.33

Day	degree C
726	13.33
727	13.33
728	13.33
729	13.33
730	13.33

EMERGENCE MODEL: [SacPAS: Central Valley Prediction & Assessment of Salmon- Egg Growth Model: Spawning to Emergence v2.1.4]

GENERATED: Fri Sep 24 11:09:28 2021

RUN SPECS

Category	Specs
Species	Fall Chinook
Development model	Zeug
Target ATUs	958
Egg temperature effect	Exponential: SALMOD / USBR / HCI
Density effect	None
Eggs per redd	3000
Carcasses per redd	1
Offset used for redd timing	-12
Temperature Source	User Provided Hazel Scenario B.csv Column 2
Temperature Units	centigrade
Spawning Data Source	SacPAS database 201620152014 spnfem Carcass Counts

RUN RESULTS

Category	Results
Total Redds	649
Mean Emergence Day	395
Mean Emergence Date	30-Jan
Last Emergence Day	438
Last Emergence Date	14-Mar
Variance	519
STD	22.7
Expansion	10 Days
Eggs	1947000
Fry	1741825
Survival Egg to Fry	89.46%

DETAILS

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
275	1	63	338	959.6	15.44	20.89	3000	0	0
276	1	64	340	965.9	15.3	20.89	3000	0	0
277	1	64	341	958.7	15.19	20.89	3000	0	0
278	1	65	343	964.8	15.05	20.89	3000	0	0
279	1	66	345	970.8	14.91	20.89	3000	0	0
286	1	69	355	961.2	14.12	19.01	3000	0	0
287	2	70	357	968.9	14.03	18.82	6000	0	0

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
288	1	70	358	963.4	13.95	18.66	3000	0	0
289	1	70	359	958	13.88	18.46	3000	0	0
290	2	71	361	966.2	13.8	18.41	6000	0	0
291	2	71	362	961.2	13.73	18.41	6000	0	0
292	2	72	364	969.5	13.65	17.69	6000	1111	0.18
293	2	72	365	965.1	13.59	16.52	6000	4103	0.68
294	1	72	366	961.9	13.55	15.99	3000	2388	0.79
295	4	72	367	959.2	13.51	15.11	12000	10236	0.85
296	4	73	369	970.8	13.48	14.86	12000	10421	0.86
297	4	73	370	969.3	13.46	14.63	12000	10553	0.87
298	4	73	371	968	13.44	14.63	12000	10633	0.88
299	4	73	372	966.8	13.43	14.63	12000	10714	0.89
300	4	73	373	965.5	13.41	14.33	12000	10808	0.9
301	3	73	374	964.5	13.4	14.24	9000	8147	0.9
302	1	73	375	963.6	13.38	14.19	3000	2727	0.9
303	18	73	376	962.8	13.37	13.92	54000	49243	0.91
304	18	73	377	962.2	13.36	13.73	54000	49349	0.91
305	18	73	378	961.8	13.36	13.73	54000	49409	0.91
306	18	73	379	961.5	13.35	13.73	54000	49454	0.91
307	18	73	380	961.2	13.35	13.73	54000	49494	0.91
308	17	73	381	961.1	13.35	13.73	51000	46759	0.91
309	10	73	382	961.1	13.35	13.73	30000	27506	0.91
310	16	73	383	961.1	13.35	13.73	48000	44008	0.91
311	16	73	384	961.1	13.35	13.73	48000	44006	0.91
312	16	73	385	960.8	13.34	13.73	48000	44046	0.91
313	16	73	386	960.4	13.34	13.73	48000	44097	0.91
314	16	73	387	960	13.33	13.56	48000	44152	0.91
315	25	73	388	959.8	13.33	13.38	75000	69032	0.92
316	12	73	389	959.7	13.33	13.34	36000	33139	0.92
317	22	73	390	959.7	13.33	13.33	66000	60757	0.92
318	23	73	391	959.7	13.33	13.33	69000	63519	0.92
319	23	73	392	959.7	13.33	13.33	69000	63519	0.92
320	23	73	393	959.7	13.33	13.33	69000	63519	0.92
321	23	73	394	959.7	13.33	13.33	69000	63519	0.92
322	18	73	395	959.7	13.33	13.33	54000	49710	0.92
323	8	73	396	959.7	13.33	13.33	24000	22093	0.92
324	13	73	397	959.7	13.33	13.33	39000	35902	0.92
325	13	73	398	959.7	13.33	13.33	39000	35902	0.92
326	13	73	399	959.7	13.33	13.33	39000	35902	0.92
327	14	73	400	959.7	13.33	13.33	42000	38663	0.92
328	14	73	401	959.7	13.33	13.33	42000	38663	0.92
329	32	73	402	959.7	13.33	13.33	96000	88374	0.92
330	7	73	403	959.7	13.33	13.33	21000	19331	0.92
331	2	73	404	959.7	13.33	13.33	6000	5523	0.92
332	3	73	405	959.7	13.33	13.33	9000	8285	0.92

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
333	3	73	406	959.7	13.33	13.33	9000	8285	0.92
334	3	73	407	959.7	13.33	13.33	9000	8285	0.92
335	4	73	408	959.7	13.33	13.33	12000	11046	0.92
336	7	73	409	959.7	13.33	13.33	21000	19331	0.92
337	2	73	410	959.7	13.33	13.33	6000	5523	0.92
338	2	73	411	959.7	13.33	13.33	6000	5523	0.92
339	2	73	412	959.7	13.33	13.33	6000	5523	0.92
340	2	73	413	959.7	13.33	13.33	6000	5523	0.92
341	2	73	414	959.7	13.33	13.33	6000	5523	0.92
342	2	73	415	959.7	13.33	13.33	6000	5523	0.92
343	2	73	416	959.7	13.33	13.33	6000	5523	0.92
344	2	73	417	959.7	13.33	13.33	6000	5523	0.92
345	2	73	418	959.7	13.33	13.33	6000	5523	0.92
346	3	73	419	959.7	13.33	13.33	9000	8285	0.92
347	3	73	420	959.7	13.33	13.33	9000	8285	0.92
348	3	73	421	959.7	13.33	13.33	9000	8285	0.92
349	3	73	422	959.7	13.33	13.33	9000	8285	0.92
350	3	73	423	959.7	13.33	13.33	9000	8285	0.92
351	3	73	424	959.7	13.33	13.33	9000	8285	0.92
352	3	73	425	959.7	13.33	13.33	9000	8285	0.92
353	3	73	426	959.7	13.33	13.33	9000	8285	0.92
354	3	73	427	959.7	13.33	13.33	9000	8285	0.92
355	3	73	428	959.7	13.33	13.33	9000	8285	0.92
356	3	73	429	959.7	13.33	13.33	9000	8285	0.92
357	3	73	430	959.7	13.33	13.33	9000	8285	0.92
358	5	73	431	959.7	13.33	13.33	15000	13808	0.92
359	6	73	432	959.7	13.33	13.33	18000	16570	0.92
360	6	73	433	959.7	13.33	13.33	18000	16570	0.92
361	6	73	434	959.7	13.33	13.33	18000	16570	0.92
362	6	73	435	959.7	13.33	13.33	18000	16570	0.92
363	7	73	436	959.7	13.33	13.33	21000	19331	0.92
364	7	73	437	959.7	13.33	13.33	21000	19331	0.92
365	3	73	438	959.7	13.33	13.33	9000	8285	0.92

Uploaded data assumed beginning in non-leap year
TEMPERATURE INPUT

Day	degree C
1	21
1	21
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Day	degree C
7	21
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261	21.23
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263	21.2
264	21.18
265	21.12
266	21.07
267	21.1
268	21.2
269	21.05
270	20.97
271	20.84
272	20.61
273	20.46
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275	20.54
276	20.4

Day	degree C
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288	18.82
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Day	degree C
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Day	degree C
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Day	degree C
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Day	degree C
727	13.33
728	13.33
729	13.33
730	13.33

EMERGENCE MODEL: [SacPAS: Central Valley Prediction & Assessment of Salmon- Egg Growth Model: Spawning to Emergence v2.1.4]
GENERATED: Fri Sep 24 11:10:28 2021

RUN SPECS

Category	Specs
Species	Fall Chinook
Development model	Zeug
Target ATUs	958
Egg temperature effect	Linear
Density effect	None
Eggs per redd	3000
Carcasses per redd	1
Offset used for redd timing	-12
Temperature Source	User Provided Hazel Scenario B.csv Column 2
Temperature Units	centigrade
Spawning Data Source	SacPAS database 201620152014 spnfem Carcass Counts

RUN RESULTS

Category	Results
Total Redds	649
Mean Emergence Day	395
Mean Emergence Date	30-Jan
Last Emergence Day	438
Last Emergence Date	14-Mar
Variance	522.1
STD	22.8
Expansion	10 Days
Eggs	1947000
Fry	208134
Survival Egg to Fry	10.68%

DETAILS

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
275	1	63	338	959.6	15.44	20.89	3000	18	0
276	1	64	340	965.9	15.3	20.89	3000	21	0
277	1	64	341	958.7	15.19	20.89	3000	25	0
278	1	65	343	964.8	15.05	20.89	3000	29	0
279	1	66	345	970.8	14.91	20.89	3000	33	0.01
286	1	69	355	961.2	14.12	19.01	3000	101	0.03
287	2	70	357	968.9	14.03	18.82	6000	225	0.03

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
288	1	70	358	963.4	13.95	18.66	3000	128	0.04
289	1	70	359	958	13.88	18.46	3000	145	0.04
290	2	71	361	966.2	13.8	18.41	6000	319	0.05
291	2	71	362	961.2	13.73	18.41	6000	360	0.06
292	2	72	364	969.5	13.65	17.69	6000	395	0.06
293	2	72	365	965.1	13.59	16.52	6000	438	0.07
294	1	72	366	961.9	13.55	15.99	3000	236	0.07
295	4	72	367	959.2	13.51	15.11	12000	1009	0.08
296	4	73	369	970.8	13.48	14.86	12000	1022	0.08
297	4	73	370	969.3	13.46	14.63	12000	1060	0.08
298	4	73	371	968	13.44	14.63	12000	1091	0.09
299	4	73	372	966.8	13.43	14.63	12000	1123	0.09
300	4	73	373	965.5	13.41	14.33	12000	1159	0.09
301	3	73	374	964.5	13.4	14.24	9000	890	0.09
302	1	73	375	963.6	13.38	14.19	3000	303	0.1
303	18	73	376	962.8	13.37	13.92	54000	5573	0.1
304	18	73	377	962.2	13.36	13.73	54000	5652	0.1
305	18	73	378	961.8	13.36	13.73	54000	5705	0.1
306	18	73	379	961.5	13.35	13.73	54000	5747	0.1
307	18	73	380	961.2	13.35	13.73	54000	5786	0.1
308	17	73	381	961.1	13.35	13.73	51000	5480	0.1
309	10	73	382	961.1	13.35	13.73	30000	3224	0.1
310	16	73	383	961.1	13.35	13.73	48000	5158	0.1
311	16	73	384	961.1	13.35	13.73	48000	5155	0.1
312	16	73	385	960.8	13.34	13.73	48000	5194	0.1
313	16	73	386	960.4	13.34	13.73	48000	5240	0.1
314	16	73	387	960	13.33	13.56	48000	5290	0.11
315	25	73	388	959.8	13.33	13.38	75000	8312	0.11
316	12	73	389	959.7	13.33	13.34	36000	3994	0.11
317	22	73	390	959.7	13.33	13.33	66000	7325	0.11
318	23	73	391	959.7	13.33	13.33	69000	7658	0.11
319	23	73	392	959.7	13.33	13.33	69000	7658	0.11
320	23	73	393	959.7	13.33	13.33	69000	7658	0.11
321	23	73	394	959.7	13.33	13.33	69000	7658	0.11
322	18	73	395	959.7	13.33	13.33	54000	5993	0.11
323	8	73	396	959.7	13.33	13.33	24000	2663	0.11
324	13	73	397	959.7	13.33	13.33	39000	4328	0.11
325	13	73	398	959.7	13.33	13.33	39000	4328	0.11
326	13	73	399	959.7	13.33	13.33	39000	4328	0.11
327	14	73	400	959.7	13.33	13.33	42000	4661	0.11
328	14	73	401	959.7	13.33	13.33	42000	4661	0.11
329	32	73	402	959.7	13.33	13.33	96000	10654	0.11
330	7	73	403	959.7	13.33	13.33	21000	2330	0.11
331	2	73	404	959.7	13.33	13.33	6000	665	0.11
332	3	73	405	959.7	13.33	13.33	9000	998	0.11

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
333	3	73	406	959.7	13.33	13.33	9000	998	0.11
334	3	73	407	959.7	13.33	13.33	9000	998	0.11
335	4	73	408	959.7	13.33	13.33	12000	1331	0.11
336	7	73	409	959.7	13.33	13.33	21000	2330	0.11
337	2	73	410	959.7	13.33	13.33	6000	665	0.11
338	2	73	411	959.7	13.33	13.33	6000	665	0.11
339	2	73	412	959.7	13.33	13.33	6000	665	0.11
340	2	73	413	959.7	13.33	13.33	6000	665	0.11
341	2	73	414	959.7	13.33	13.33	6000	665	0.11
342	2	73	415	959.7	13.33	13.33	6000	665	0.11
343	2	73	416	959.7	13.33	13.33	6000	665	0.11
344	2	73	417	959.7	13.33	13.33	6000	665	0.11
345	2	73	418	959.7	13.33	13.33	6000	665	0.11
346	3	73	419	959.7	13.33	13.33	9000	998	0.11
347	3	73	420	959.7	13.33	13.33	9000	998	0.11
348	3	73	421	959.7	13.33	13.33	9000	998	0.11
349	3	73	422	959.7	13.33	13.33	9000	998	0.11
350	3	73	423	959.7	13.33	13.33	9000	998	0.11
351	3	73	424	959.7	13.33	13.33	9000	998	0.11
352	3	73	425	959.7	13.33	13.33	9000	998	0.11
353	3	73	426	959.7	13.33	13.33	9000	998	0.11
354	3	73	427	959.7	13.33	13.33	9000	998	0.11
355	3	73	428	959.7	13.33	13.33	9000	998	0.11
356	3	73	429	959.7	13.33	13.33	9000	998	0.11
357	3	73	430	959.7	13.33	13.33	9000	998	0.11
358	5	73	431	959.7	13.33	13.33	15000	1664	0.11
359	6	73	432	959.7	13.33	13.33	18000	1997	0.11
360	6	73	433	959.7	13.33	13.33	18000	1997	0.11
361	6	73	434	959.7	13.33	13.33	18000	1997	0.11
362	6	73	435	959.7	13.33	13.33	18000	1997	0.11
363	7	73	436	959.7	13.33	13.33	21000	2330	0.11
364	7	73	437	959.7	13.33	13.33	21000	2330	0.11
365	3	73	438	959.7	13.33	13.33	9000	998	0.11

Uploaded data assumed beginning in non-leap year
TEMPERATURE INPUT

Day	degree C
1	21
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Day	degree C
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263	21.2
264	21.18
265	21.12
266	21.07
267	21.1
268	21.2
269	21.05
270	20.97
271	20.84
272	20.61
273	20.46

Day	degree C
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277	20.5
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Day	degree C
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Day	degree C
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721	13.33
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723	13.33

Day	degree C
724	13.33
725	13.33
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729	13.33
730	13.33

EMERGENCE MODEL: SacPAS: Central Valley Prediction & Assessment of Salmon- Egg Growth Model: Spawning to Emergence v2.1.4

RUN SPECS

Category	Specs
Species	Fall Chinook
Development model	Zeug
Target ATUs	958
Egg temperature effect	Exponential: Water Forum
Density effect	None
Eggs per redd	3000
Carcasses per redd	1
Offset used for redd timing	-12
Temperature Source	User Provided Hazel Scenario C.csv Column 2
Temperature Units	centigrade
Spawning Data Source	SacPAS database 201620152014 spnfem Carcass Counts

RUN RESULTS

Category	Results
Total Redds	649
Mean Emergence Day	394.5
Mean Emergence Date	30-Jan
Last Emergence Day	438
Last Emergence Date	14-Mar
Variance	514.1
STD	22.6
Expansion	9 Days
Eggs	1947000
Fry	1783995
Survival Egg to Fry	91.63%

DETAILS

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
275	1	64	339	964.9	15.29	20.89	3000	0	0
276	1	65	341	971.2	15.15	20.89	3000	0	0
277	1	65	342	964	15.04	20.89	3000	0	0
278	1	66	344	970.1	14.9	20.89	3000	0	0
279	1	66	345	962.8	14.79	20.89	3000	0	0
286	1	70	356	966.7	14	18.44	3000	1703	0.56
287	2	70	357	961.6	13.93	17.77	6000	4118	0.68
288	1	71	359	970.5	13.86	17.47	3000	2224	0.74

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
289	1	71	360	966.4	13.8	17.35	3000	2347	0.78
290	2	71	361	962.4	13.74	17.35	6000	4898	0.81
291	2	71	362	958.4	13.69	17.19	6000	5130	0.85
292	2	72	364	967.9	13.63	16.58	6000	5320	0.88
293	2	72	365	964.6	13.58	15.94	6000	5416	0.9
294	1	72	366	962	13.55	15.68	3000	2732	0.91
295	4	72	367	959.7	13.51	14.96	12000	10994	0.91
296	4	72	368	958	13.49	14.78	12000	11018	0.91
297	4	73	370	969.9	13.47	14.63	12000	11019	0.91
298	4	73	371	968.7	13.45	14.63	12000	11032	0.91
299	4	73	372	967.5	13.44	14.63	12000	11044	0.92
300	4	73	373	966.2	13.42	14.32	12000	11059	0.92
301	3	73	374	965.3	13.41	14.24	9000	8301	0.92
302	1	73	375	964.3	13.39	14.21	3000	2769	0.92
303	18	73	376	963.5	13.38	13.96	54000	49936	0.92
304	18	73	377	962.8	13.37	13.8	54000	49956	0.92
305	18	73	378	962.4	13.37	13.8	54000	49968	0.92
306	18	73	379	962.1	13.36	13.8	54000	49977	0.92
307	18	73	380	961.8	13.36	13.8	54000	49985	0.92
308	17	73	381	961.6	13.36	13.8	51000	47211	0.92
309	10	73	382	961.6	13.36	13.8	30000	27771	0.92
310	16	73	383	961.6	13.36	13.8	48000	44435	0.92
311	16	73	384	961.6	13.36	13.8	48000	44435	0.92
312	16	73	385	961.2	13.35	13.8	48000	44444	0.92
313	16	73	386	960.8	13.34	13.8	48000	44455	0.92
314	16	73	387	960.3	13.34	13.63	48000	44467	0.92
315	25	73	388	960	13.33	13.46	75000	69490	0.92
316	12	73	389	959.9	13.33	13.43	36000	33357	0.92
317	22	73	390	959.8	13.33	13.35	66000	61157	0.92
318	23	73	391	959.7	13.33	13.35	69000	63938	0.92
319	23	73	392	959.7	13.33	13.33	69000	63938	0.92
320	23	73	393	959.7	13.33	13.33	69000	63938	0.92
321	23	73	394	959.7	13.33	13.33	69000	63938	0.92
322	18	73	395	959.7	13.33	13.33	54000	50039	0.92
323	8	73	396	959.7	13.33	13.33	24000	22239	0.92
324	13	73	397	959.7	13.33	13.33	39000	36139	0.92
325	13	73	398	959.7	13.33	13.33	39000	36139	0.92
326	13	73	399	959.7	13.33	13.33	39000	36139	0.92
327	14	73	400	959.7	13.33	13.33	42000	38919	0.92
328	14	73	401	959.7	13.33	13.33	42000	38919	0.92
329	32	73	402	959.7	13.33	13.33	96000	88958	0.92
330	7	73	403	959.7	13.33	13.33	21000	19459	0.92
331	2	73	404	959.7	13.33	13.33	6000	5559	0.92
332	3	73	405	959.7	13.33	13.33	9000	8339	0.92
333	3	73	406	959.7	13.33	13.33	9000	8339	0.92

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
334	3	73	407	959.7	13.33	13.33	9000	8339	0.92
335	4	73	408	959.7	13.33	13.33	12000	11119	0.92
336	7	73	409	959.7	13.33	13.33	21000	19459	0.92
337	2	73	410	959.7	13.33	13.33	6000	5559	0.92
338	2	73	411	959.7	13.33	13.33	6000	5559	0.92
339	2	73	412	959.7	13.33	13.33	6000	5559	0.92
340	2	73	413	959.7	13.33	13.33	6000	5559	0.92
341	2	73	414	959.7	13.33	13.33	6000	5559	0.92
342	2	73	415	959.7	13.33	13.33	6000	5559	0.92
343	2	73	416	959.7	13.33	13.33	6000	5559	0.92
344	2	73	417	959.7	13.33	13.33	6000	5559	0.92
345	2	73	418	959.7	13.33	13.33	6000	5559	0.92
346	3	73	419	959.7	13.33	13.33	9000	8339	0.92
347	3	73	420	959.7	13.33	13.33	9000	8339	0.92
348	3	73	421	959.7	13.33	13.33	9000	8339	0.92
349	3	73	422	959.7	13.33	13.33	9000	8339	0.92
350	3	73	423	959.7	13.33	13.33	9000	8339	0.92
351	3	73	424	959.7	13.33	13.33	9000	8339	0.92
352	3	73	425	959.7	13.33	13.33	9000	8339	0.92
353	3	73	426	959.7	13.33	13.33	9000	8339	0.92
354	3	73	427	959.7	13.33	13.33	9000	8339	0.92
355	3	73	428	959.7	13.33	13.33	9000	8339	0.92
356	3	73	429	959.7	13.33	13.33	9000	8339	0.92
357	3	73	430	959.7	13.33	13.33	9000	8339	0.92
358	5	73	431	959.7	13.33	13.33	15000	13899	0.92
359	6	73	432	959.7	13.33	13.33	18000	16679	0.92
360	6	73	433	959.7	13.33	13.33	18000	16679	0.92
361	6	73	434	959.7	13.33	13.33	18000	16679	0.92
362	6	73	435	959.7	13.33	13.33	18000	16679	0.92
363	7	73	436	959.7	13.33	13.33	21000	19459	0.92
364	7	73	437	959.7	13.33	13.33	21000	19459	0.92
365	3	73	438	959.7	13.33	13.33	9000	8339	0.92

Uploaded data assumed beginning in non-leap year
TEMPERATURE INPUT

Day	degree C
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Day	degree C
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EMERGENCE MODEL: [SacPAS: Central Valley Prediction & Assessment of Salmon- Egg Growth Model: Spawning to Emergence v2.1.4]

GENERATED: Fri Sep 24 11:12:29 2021

RUN SPECS

Category	Specs
Species	Fall Chinook
Development model	Zeug
Target ATUs	958
Egg temperature effect	Exponential: SALMOD / USBR / HCI
Density effect	None
Eggs per redd	3000
Carcasses per redd	1
Offset used for redd timing	-12
Temperature Source	User Provided Hazel Scenario C.csv Column 2
Temperature Units	centigrade
Spawning Data Source	SacPAS database 201620152014 spnfem Carcass Counts

RUN RESULTS

Category	Results
Total Redds	649
Mean Emergence Day	394.9
Mean Emergence Date	30-Jan
Last Emergence Day	438
Last Emergence Date	14-Mar
Variance	523.4
STD	22.8
Expansion	9 Days
Eggs	1947000
Fry	1748666
Survival Egg to Fry	89.81%

DETAILS

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
275	1	64	339	964.9	15.29	20.89	3000	0	0
276	1	65	341	971.2	15.15	20.89	3000	0	0
277	1	65	342	964	15.04	20.89	3000	0	0
278	1	66	344	970.1	14.9	20.89	3000	0	0
279	1	66	345	962.8	14.79	20.89	3000	0	0
286	1	70	356	966.7	14	18.44	3000	0	0
287	2	70	357	961.6	13.93	17.77	6000	70	0.01

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
288	1	71	359	970.5	13.86	17.47	3000	191	0.06
289	1	71	360	966.4	13.8	17.35	3000	412	0.13
290	2	71	361	962.4	13.74	17.35	6000	1360	0.22
291	2	71	362	958.4	13.69	17.19	6000	2489	0.41
292	2	72	364	967.9	13.63	16.58	6000	3903	0.65
293	2	72	365	964.6	13.58	15.94	6000	4615	0.76
294	1	72	366	962	13.55	15.68	3000	2458	0.81
295	4	72	367	959.7	13.51	14.96	12000	10274	0.85
296	4	72	368	958	13.49	14.78	12000	10427	0.86
297	4	73	370	969.9	13.47	14.63	12000	10535	0.87
298	4	73	371	968.7	13.45	14.63	12000	10613	0.88
299	4	73	372	967.5	13.44	14.63	12000	10688	0.89
300	4	73	373	966.2	13.42	14.32	12000	10781	0.89
301	3	73	374	965.3	13.41	14.24	9000	8127	0.9
302	1	73	375	964.3	13.39	14.21	3000	2720	0.9
303	18	73	376	963.5	13.38	13.96	54000	49125	0.9
304	18	73	377	962.8	13.37	13.8	54000	49242	0.91
305	18	73	378	962.4	13.37	13.8	54000	49310	0.91
306	18	73	379	962.1	13.36	13.8	54000	49361	0.91
307	18	73	380	961.8	13.36	13.8	54000	49402	0.91
308	17	73	381	961.6	13.36	13.8	51000	46675	0.91
309	10	73	382	961.6	13.36	13.8	30000	27458	0.91
310	16	73	383	961.6	13.36	13.8	48000	43935	0.91
311	16	73	384	961.6	13.36	13.8	48000	43938	0.91
312	16	73	385	961.2	13.35	13.8	48000	43986	0.91
313	16	73	386	960.8	13.34	13.8	48000	44049	0.91
314	16	73	387	960.3	13.34	13.63	48000	44118	0.91
315	25	73	388	960	13.33	13.46	75000	68995	0.91
316	12	73	389	959.9	13.33	13.43	36000	33128	0.92
317	22	73	390	959.8	13.33	13.35	66000	60751	0.92
318	23	73	391	959.7	13.33	13.35	69000	63516	0.92
319	23	73	392	959.7	13.33	13.33	69000	63519	0.92
320	23	73	393	959.7	13.33	13.33	69000	63519	0.92
321	23	73	394	959.7	13.33	13.33	69000	63519	0.92
322	18	73	395	959.7	13.33	13.33	54000	49710	0.92
323	8	73	396	959.7	13.33	13.33	24000	22093	0.92
324	13	73	397	959.7	13.33	13.33	39000	35902	0.92
325	13	73	398	959.7	13.33	13.33	39000	35902	0.92
326	13	73	399	959.7	13.33	13.33	39000	35902	0.92
327	14	73	400	959.7	13.33	13.33	42000	38663	0.92
328	14	73	401	959.7	13.33	13.33	42000	38663	0.92
329	32	73	402	959.7	13.33	13.33	96000	88374	0.92
330	7	73	403	959.7	13.33	13.33	21000	19331	0.92
331	2	73	404	959.7	13.33	13.33	6000	5523	0.92
332	3	73	405	959.7	13.33	13.33	9000	8285	0.92

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
333	3	73	406	959.7	13.33	13.33	9000	8285	0.92
334	3	73	407	959.7	13.33	13.33	9000	8285	0.92
335	4	73	408	959.7	13.33	13.33	12000	11046	0.92
336	7	73	409	959.7	13.33	13.33	21000	19331	0.92
337	2	73	410	959.7	13.33	13.33	6000	5523	0.92
338	2	73	411	959.7	13.33	13.33	6000	5523	0.92
339	2	73	412	959.7	13.33	13.33	6000	5523	0.92
340	2	73	413	959.7	13.33	13.33	6000	5523	0.92
341	2	73	414	959.7	13.33	13.33	6000	5523	0.92
342	2	73	415	959.7	13.33	13.33	6000	5523	0.92
343	2	73	416	959.7	13.33	13.33	6000	5523	0.92
344	2	73	417	959.7	13.33	13.33	6000	5523	0.92
345	2	73	418	959.7	13.33	13.33	6000	5523	0.92
346	3	73	419	959.7	13.33	13.33	9000	8285	0.92
347	3	73	420	959.7	13.33	13.33	9000	8285	0.92
348	3	73	421	959.7	13.33	13.33	9000	8285	0.92
349	3	73	422	959.7	13.33	13.33	9000	8285	0.92
350	3	73	423	959.7	13.33	13.33	9000	8285	0.92
351	3	73	424	959.7	13.33	13.33	9000	8285	0.92
352	3	73	425	959.7	13.33	13.33	9000	8285	0.92
353	3	73	426	959.7	13.33	13.33	9000	8285	0.92
354	3	73	427	959.7	13.33	13.33	9000	8285	0.92
355	3	73	428	959.7	13.33	13.33	9000	8285	0.92
356	3	73	429	959.7	13.33	13.33	9000	8285	0.92
357	3	73	430	959.7	13.33	13.33	9000	8285	0.92
358	5	73	431	959.7	13.33	13.33	15000	13808	0.92
359	6	73	432	959.7	13.33	13.33	18000	16570	0.92
360	6	73	433	959.7	13.33	13.33	18000	16570	0.92
361	6	73	434	959.7	13.33	13.33	18000	16570	0.92
362	6	73	435	959.7	13.33	13.33	18000	16570	0.92
363	7	73	436	959.7	13.33	13.33	21000	19331	0.92
364	7	73	437	959.7	13.33	13.33	21000	19331	0.92
365	3	73	438	959.7	13.33	13.33	9000	8285	0.92

Uploaded data assumed beginning in non-leap year
TEMPERATURE INPUT

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Day	degree C
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266	21.07
267	21.1
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271	20.84
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274	20.51

Day	degree C
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277	20.5
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Day	degree C
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EMERGENCE MODEL: SacPAS: Central Valley Prediction & Assessment of Salmon- Egg Growth Model: Spawning to Emergence v2.1.4

GENERATED: Fri Sep 24 11:13:38 2021

RUN SPECS

Species	Fall Chinook
Development model	Zeug Target ATUs
Target ATUs	958
Egg temperature effect	Linear
Density effect	None
Eggs per redd	3000
Carcasses per redd	1
Offset used for redd timing	-12
Temperature Source	User Provided Hazel Scenario C.csv Column 2
Temperature Units	centigrade
Spawning Data Source	SacPAS database 201620152014 spnfem spnfem Carcass Counts

RUN RESULTS

Category	Results
Total Redds	649
Mean Emergence Day	395.1
Mean Emergence Date	30-Jan
Last Emergence Day	
Last Emergence Date	14-Mar
Variance	532.4
STD	23
Expansion	9 Days
Eggs	1947000
Fry	207371
Survival Egg to Fry	10.65%

DETAILS

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
275	1	64	339	964.9	15.29	20.89	3000	21	0
276	1	65	341	971.2	15.15	20.89	3000	25	0

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
277	1	65	342	964	15.04	20.89	3000	29	0
278	1	66	344	970.1	14.9	20.89	3000	34	0.01
279	1	66	345	962.8	14.79	20.89	3000	41	0.01
286	1	70	356	966.7	14	18.44	3000	118	0.03
287	2	70	357	961.6	13.93	17.77	6000	267	0.04
288	1	71	359	970.5	13.86	17.47	3000	144	0.04
289	1	71	360	966.4	13.8	17.35	3000	159	0.05
290	2	71	361	962.4	13.74	17.35	6000	350	0.05
291	2	71	362	958.4	13.69	17.19	6000	385	0.06
292	2	72	364	967.9	13.63	16.58	6000	410	0.06
293	2	72	365	964.6	13.58	15.94	6000	443	0.07
294	1	72	366	962	13.55	15.68	3000	236	0.07
295	4	72	367	959.7	13.51	14.96	12000	999	0.08
296	4	72	368	958	13.49	14.78	12000	1038	0.08
297	4	73	370	969.9	13.47	14.63	12000	1043	0.08
298	4	73	371	968.7	13.45	14.63	12000	1073	0.08
299	4	73	372	967.5	13.44	14.63	12000	1104	0.09
300	4	73	373	966.2	13.42	14.32	12000	1139	0.09
301	3	73	374	965.3	13.41	14.24	9000	875	0.09
302	1	73	375	964.3	13.39	14.21	3000	298	0.09
303	18	73	376	963.5	13.38	13.96	54000	5479	0.1
304	18	73	377	962.8	13.37	13.8	54000	5562	0.1
305	18	73	378	962.4	13.37	13.8	54000	5620	0.1
306	18	73	379	962.1	13.36	13.8	54000	5666	0.1
307	18	73	380	961.8	13.36	13.8	54000	5705	0.1
308	17	73	381	961.6	13.36	13.8	51000	5406	0.1
309	10	73	382	961.6	13.36	13.8	30000	3182	0.1
310	16	73	383	961.6	13.36	13.8	48000	5094	0.1
311	16	73	384	961.6	13.36	13.8	48000	5098	0.1
312	16	73	385	961.2	13.35	13.8	48000	5142	0.1
313	16	73	386	960.8	13.34	13.8	48000	5196	0.1
314	16	73	387	960.3	13.34	13.63	48000	5255	0.1
315	25	73	388	960	13.33	13.46	75000	8270	0.11
316	12	73	389	959.9	13.33	13.43	36000	3982	0.11
317	22	73	390	959.8	13.33	13.35	66000	7318	0.11
318	23	73	391	959.7	13.33	13.35	69000	7654	0.11
319	23	73	392	959.7	13.33	13.33	69000	7658	0.11
320	23	73	393	959.7	13.33	13.33	69000	7658	0.11
321	23	73	394	959.7	13.33	13.33	69000	7658	0.11
322	18	73	395	959.7	13.33	13.33	54000	5993	0.11

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
323	8	73	396	959.7	13.33	13.33	24000	2663	0.11
324	13	73	397	959.7	13.33	13.33	39000	4328	0.11
325	13	73	398	959.7	13.33	13.33	39000	4328	0.11
326	13	73	399	959.7	13.33	13.33	39000	4328	0.11
327	14	73	400	959.7	13.33	13.33	42000	4661	0.11
328	14	73	401	959.7	13.33	13.33	42000	4661	0.11
329	32	73	402	959.7	13.33	13.33	96000	10654	0.11
330	7	73	403	959.7	13.33	13.33	21000	2330	0.11
331	2	73	404	959.7	13.33	13.33	6000	665	0.11
332	3	73	405	959.7	13.33	13.33	9000	998	0.11
333	3	73	406	959.7	13.33	13.33	9000	998	0.11
334	3	73	407	959.7	13.33	13.33	9000	998	0.11
335	4	73	408	959.7	13.33	13.33	12000	1331	0.11
336	7	73	409	959.7	13.33	13.33	21000	2330	0.11
337	2	73	410	959.7	13.33	13.33	6000	665	0.11
338	2	73	411	959.7	13.33	13.33	6000	665	0.11
339	2	73	412	959.7	13.33	13.33	6000	665	0.11
340	2	73	413	959.7	13.33	13.33	6000	665	0.11
341	2	73	414	959.7	13.33	13.33	6000	665	0.11
342	2	73	415	959.7	13.33	13.33	6000	665	0.11
343	2	73	416	959.7	13.33	13.33	6000	665	0.11
344	2	73	417	959.7	13.33	13.33	6000	665	0.11
345	2	73	418	959.7	13.33	13.33	6000	665	0.11
346	3	73	419	959.7	13.33	13.33	9000	998	0.11
347	3	73	420	959.7	13.33	13.33	9000	998	0.11
348	3	73	421	959.7	13.33	13.33	9000	998	0.11
349	3	73	422	959.7	13.33	13.33	9000	998	0.11
350	3	73	423	959.7	13.33	13.33	9000	998	0.11
351	3	73	424	959.7	13.33	13.33	9000	998	0.11
352	3	73	425	959.7	13.33	13.33	9000	998	0.11
353	3	73	426	959.7	13.33	13.33	9000	998	0.11
354	3	73	427	959.7	13.33	13.33	9000	998	0.11
355	3	73	428	959.7	13.33	13.33	9000	998	0.11
356	3	73	429	959.7	13.33	13.33	9000	998	0.11
357	3	73	430	959.7	13.33	13.33	9000	998	0.11
358	5	73	431	959.7	13.33	13.33	15000	1664	0.11
359	6	73	432	959.7	13.33	13.33	18000	1997	0.11
360	6	73	433	959.7	13.33	13.33	18000	1997	0.11
361	6	73	434	959.7	13.33	13.33	18000	1997	0.11
362	6	73	435	959.7	13.33	13.33	18000	1997	0.11

SpawnDay	Redds	Duration	Emerge On	ATUs	Mean. Temp	Max. Temp	Eggs	Fry	Survival
363	7	73	436	959.7	13.33	13.33	21000	2330	0.11
364	7	73	437	959.7	13.33	13.33	21000	2330	0.11
365	3	73	438	959.7	13.33	13.33	9000	998	0.11

Uploaded data assumed beginning in non-leap year TEMPERATURE INPUT

Day	degree C
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Day	degree C
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Appendix D

Julian days used in synthetic temperature datasets and in SacPAS output. Calendar downloaded 09/27/21 from: http://www.cbr.washington.edu/sacramento/fishmodel/dayofyear.Xref.png

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	1	32	60	91	121	152	182	213	244	274	305	335	1
2	2	33	61	92	122	153	183	214	245	275	306	336	2
3	3	34	62	93	123	154	184	215	246	276	307	337	3
4	4	35	63	94	124	155	185	216	247	277	308	338	4
5	5	36	64	95	125	156	186	217	248	278	309	339	5
6	6	37	65	96	126	157	187	218	249	279	310	340	6
7	7	38	66	97	127	158	188	219	250	280	311	341	7
8	8	39	67	98	128	159	189	220	251	281	312	342	8
9	9	40	68	99	129	160	190	221	252	282	313	343	9
10	10	41	69	100	130	161	191	222	253	283	314	344	10
11	11	42	70	101	131	162	192	223	254	284	315	345	11
12	12	43	71	102	132	163	193	224	255	285	316	346	12
13	13	44	72	103	133	164	194	225	256	286	317	347	13
14	14	45	73	104	134	165	195	226	257	287	318	348	14
15	15	46	74	105	135	166	196	227	258	288	319	349	15
16	16	47	75	106	136	167	197	228	259	289	320	350	16
17	17	48	76	107	137	168	198	229	260	290	321	351	17
18	18	49	77	108	138	169	199	230	261	291	322	352	18
19	19	50	78	109	139	170	200	231	262	292	323	353	19
20	20	51	79	110	140	171	201	232	263	293	324	354	20
21	21	52	80	111	141	172	202	233	264	294	325	355	21
22	22	53	81	112	142	173	203	234	265	295	326	356	22
23	23	54	82	113	143	174	204	235	266	296	327	357	23
24	24	55	83	114	144	175	205	236	267	297	328	358	24
25	25	56	84	115	145	176	206	237	268	298	329	359	25
26	26	57	85	116	146	177	207	238	269	299	330	360	26
27	27	58	86	117	147	178	208	239	270	300	331	361	27
28	28	59	87	118	148	179	209	240	271	301	332	362	28
29	29		88	119	149	180	210	241	272	302	333	363	29
30	30		89	120	150	181	211	242	273	303	334	364	30
31	31		90		151		212	243		304	335	365	31