UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

February 16, 2018

Refer to NMFS No: WCR-2018-8920

Mr. Jeff Rieker
Operations Manager, Central Valley Project
U.S. Bureau of Reclamation
3310 El Camino Avenue, Suite 300
Sacramento, California 95821

Re: Transmittal of February Reservoir Operations Forecast Per RPA 1.2.3

Dear Mr. Rieker:

Thank you for the opportunity to review the U.S. Bureau of Reclamation's (Reclamation) February forecast and water supply allocations for water year 2018. Your February 14, 2018, letter included the results of the 90 and 50 percent exceedance Central Valley Project (CVP) reservoir operations forecasts, water temperature modeling, and this year's initial water supply allocations. For purposes of compliance with NMFS' June 4, 2009, conference and biological opinion on the long-term operation of the CVP and State Water Project (SWP, CVP/SWP operations Opinion) reasonable and prudent alternative (RPA) Action I.2.3, described in NOAA's National Marine Fisheries Service's (NMFS) April 7, 2011, amendment of the 2009 RPA[1], NMFS' concurrence is required prior to the initial water supply allocation of the year. The objective is to use a conservative forecast as early as possible to protect the cold water pool in Shasta Reservoir so that suitable spawning and egg/alevin incubation habitat can be maintained in the Sacramento River during the summer and fall season for federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), and threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*).

Returning adult winter-run in 2017 were born in 2014, when high water temperatures in the Sacramento River at the end of the summer and into the fall contributed to very low survival (~5%) of juveniles past Red Bluff Diversion Dam. As a result, total winter-run escapement in 2017 was just 1,155, which was the second lowest escapement over the past 20 years. Of those, more than 70% of the adults that returned in 2017 were of hatchery origin, due to triple the usual Livingston Stone National Fish Hatchery winter-run juvenile production contributing to that year class. As you know, water year 2017 was one of the wettest water years on record for the CVP, and Reclamation successfully implemented an operational study pursuant to the draft proposed

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[1] http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/Operations,%20Criteria%20and%20Plan/040711_ocap_opinion_2011_amendments.pdf

Shasta RPA amendment[2] that provided 53°F daily average temperature (DAT) at the Clear Creek California Data Exchange Center gaging station. As a result of the favorable water year 2017 hydrology, a relatively large cold water pool in Shasta Reservoir, and Reclamation's operations of Shasta Reservoir, the estimated egg-to-fry survival for winter-run juveniles was an above-average 44% (average is 23%). In addition, the end-of-September Shasta storage was an above normal 3.37 million acre-feet, indicating a good start to providing the necessary cold water habitat for winter-run in water year 2018. However, conditions in water year 2018 have become significantly drier, beginning in December 2017. In addition, winter-run Chinook salmon in brood year 2018 will be returning adults from winter-run born in 2015, when high water temperatures in the Sacramento River contributed to very low survival (~5%) of juveniles past Red Bluff Diversion Dam. In anticipation of poor in-river conditions, Livingston Stone National Fish Hatchery doubled its production of hatchery winter-run in 2015, and in February 2016, released ~400,000 juvenile winter-run into the Sacramento River in Redding. As a result of these circumstances affecting the brood year 2015 cohort, NMFS expects another low escapement of winter-run in 2018, with a high proportion of hatchery-origin fish. Because most winter-run return as three-year-olds, there are just three main year classes that support the population, and two have been severely depressed in abundance due to drought impacts in 2014 and 2015. The augmented hatchery releases for brood years 2014 and 2015 have provided the intended buffer to abundance, but those cohorts now have a hatchery influence far above the <15% hatchery fraction deemed best for conservation of the wild stock. Because the adults returning in brood year 2018 are from one of the two severely drought-impacted cohorts, it is very important to operate Shasta Reservoir conservatively this year to ensure that we are able to manage releases from the reservoir's cold water pool to provide and maintain adequate water temperatures in-river throughout key early life stages for winter-run Chinook salmon.

The February 2018 CVP reservoir operations forecast is based on estimated runoff within the Sacramento River basin as of February 1, 2018. The estimated annual inflow into Shasta Reservoir is 3.69 million acre-feet (MAF) in the 90 percent exceedance forecast. The projected storage in Shasta Reservoir is forecast to be at 3.80 MAF at the end of April 2018 and 2.19 MAF at the end of September in the 90 percent exceedance forecast, and the projected storage in Shasta Reservoir is forecast to be at 4.22 MAF at the end of April 2018 and 2.69 MAF at the end of September in the 50 percent exceedance forecast. The following table provides Reclamation's initial water supply allocations based on the 90 percent exceedance forecast:

February 90% Exceedance Municipal & Industrial (M&I) Water Service Contracts and Agricultural Water Service Contracts				
	North of Delta M&I	North of Delta Agricultural	South of Delta M&I	South of Delta Agricultural
Allocation	75%	50%	70%	20%

NMFS has reviewed Reclamation's February 2018 CVP reservoir operations 90 percent and 50 percent exceedance forecasts (Enclosure 1), and the corresponding water temperature model runs

[2] http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/nmfs_s_draft_proposed_2017_rpa_amendment_-_january_19__2017.pdf

(Enclosure 3). In addition, the NMFS-Southwest Fisheries Science Center (SWFSC) utilized the Keswick release and temperature data from the February CVP reservoir operations 90 percent and 50 percent exceedance forecasts as input into its River Assessment for Forecasting Temperature (RAFT) and temperature-dependent mortality model (Enclosure 3).

Based on the HEC5Q model runs, Reclamation projects the capability to meet a 56°F DAT at the Balls Ferry compliance point throughout the season. However, based on past analysis, there is an elevated degree of uncertainty in the September and October timeframe. Therefore, Reclamation utilized a relationship developed between the Shasta Reservoir volume less than 56°F at the end of September, and the projected water temperature at Balls Ferry (Figure 5 of Enclosure 2). Based on this relationship, results indicate that in September and October, Reclamation will not be able to meet a water temperature of 56°F DAT at Balls Ferry for 3 of the 4 forecasted scenarios (page 1 of Enclosure 2). In addition, despite including conservative forecasts of a 90% exceedance hydrologic forecast and 10% exceedance meteorological conditions, the meteorological data set did not include the most recent decade, of which northern California experienced some of the hottest days, weeks, months, and seasons on record. The NMFS-SWFSC utilized the Keswick release and temperature data from the February CVP reservoir operations 90 percent and 50 percent exceedance forecasts as input into its RAFT model while using meteorological conditions from 1990-2017. While the data set is not as broad as what Reclamation used in the historical record, it does capture the extreme air temperatures that northern California experienced over the last several years. Based on the RAFT model and data set used, the model outputs indicate that 56°F DAT at the Balls Ferry temperature compliance point will not be met, with exceedances throughout mid-June through mid-September in all 4 scenarios, and at times reaching 58°F. The following table provides the results from the temperature-dependent mortality model (details in enclosure 3).

February 2018 Hydrological Exceedance Forecast	**Meteorological Exceedance Forecast**	**Percent Temperature-Dependent Egg Mortality**		
		Mean	**Median**	**95% Confidence Interval**
50%	10%	43.07%	45.61%	1.08 – 74.77%
50%	50%	23.37%	18.82%	1.06 – 66.79%
90%	10%	40.06%	42.01%	0.23-73.77%
90%	50%	26.61%	22.54%	0.93-67.20%

Reclamation indicated that its approach to CVP water supply allocation determinations for south-of-Delta agricultural, and municipal and industrial, contracts this year relies heavily on the current relatively full Federal share of San Luis Reservoir. This is evidenced by the low export rates from the CVP throughout the summer months in both the 50% and 90% exceedance forecasts. NMFS agrees with that part of the assessment, and therefore, concurs with Reclamation's initial south-of-Delta allocations.

Past forecasts and temperature model runs have indicated that any inaccuracies in those model results typically result in less cold water volume in Shasta Reservoir, and/or warmer water temperatures either throughout or near the end of the temperature management season. Because of the dry hydrology, the 90% exceedance forecast, and the considerable uncertainties associated

with Reclamation's HEC5Q model (which are acknowledged in Reclamation's transmittal materials, and the RAFT model results), do not demonstrate an ability to meet 56°F DAT at Balls Ferry, NMFS cannot concur at this time on the proposed North of Delta allocations or forecasted operations. Therefore, at this time, RPA Action I.2.3.B (February Forecast, Based on 90 Percent Hydrology, Shows that Only Balls Ferry Compliance or 2.2 MAF EOS, but Not Both, Is Achievable) should be implemented. Specifically, RPA Action I.2.3.B requires Reclamation to implement the following actions:

"1) On or before February 15, Reclamation shall reduce Keswick releases to 3,250 cfs, unless NMFS concurs on an alternative release schedule. This reduction shall be maintained until a flow schedule is developed per procedures below.

2) In coordination with NMFS, by March 1, Reclamation shall develop an initial monthly Keswick release schedule, based on varying hydrology of 50 percent, 70 percent, and 90 percent (similar in format to the fall and winter action implementation procedures – see table above). These schedules shall be used as guidance for monthly updates and consultations.

3) Based on this guidance, Reclamation shall consult with NMFS monthly on Keswick releases. Reclamation shall submit a projected forecast, including monthly average release schedules and temperature compliance point to NMFS every month, within 7 business days of receiving the DWR runoff projections for that month. Within 3 business days of receiving this information from Reclamation, NMFS will review the draft schedule for consistency with the criteria below and provide written recommendations to Reclamation.

4) The initial monthly Keswick release schedule, and subsequent monthly updates, shall be developed based on the following criteria and including the following actions:

   a) Maintain minimum monthly average flows necessary to meet nondiscretionary delivery obligations and legal requirements.
   b) Provide for flow-related biological needs of spring life stages of all species covered by this Opinion in the Sacramento River and Delta, to the greatest extent possible.
   c) If operational changes are necessary to meet Delta outflow, X2, or other legal requirements during this time, then:

      - CVP/SWP Delta combined exports shall be curtailed to 2,000 cfs if necessary to meet legal requirements while maintaining a 3,250 cfs Keswick Dam release (or other planned release based on biological needs of species); and
      - if it is necessary to curtail combined exports to values more restrictive than 2000 cfs in order to meet Delta outflow, X2, or other legal requirements, then Reclamation and DWR shall, as an overall strategy, first, increase releases from Oroville or Folsom Dam; and
      - in general, Reclamation shall increase releases from Keswick Dam as a last resort.
      - Based on improvements in updated monthly hydrology, this restriction may be relaxed, with NMFS' concurrence."

NMFS looks forward to receiving and reviewing the updated hydrology in March, updated forecast and associated Keswick release schedule at that time. If Reclamation needs to make future water decisions in the interim, those decisions should be guided by the following Keswick release schedule for dry water year types, based on the draft proposed Shasta RPA amendment[3]:

Water Year Type	**Monthly Keswick release schedule (cfs)**						
	Apr	May	Jun	Jul	Aug	Sep	Oct
Dry	6,000	8,000	10,000	10,000	10,000	7,500	6,000

We appreciate Reclamation's indication in your letter that you will consult with NMFS on any changes to the current Keswick release of 3,250 cfs as a conservative approach, given the hydrology. We would like to continue to work with you over the coming weeks to iterate on what Keswick releases/operations might improve Shasta storage, providing for integrated operations at Folsom, Trinity, and Oroville Reservoirs, and the Delta, and therefore allow for allocation decisions to be made North of the Delta, when the March forecast is available.

Your letter notes that the north of Delta allocations are in conformance with Section 4005(e) of P.L. 114-322, the Water Infrastructure Improvements for the Nation (WIIN) Act. Section 4005(e)(2) directs the Secretary of the Interior to make every reasonable effort to allocate water to CVP agricultural water service contractors within the Sacramento River Watershed according for irrigation purposes according to the schedule provided, but Section 4005(e)(3) states that "[N]othing in paragraph (2) shall adversely affect any protections for the environment, including…any obligation of the Secretary of the Interior and the Secretary of Commerce under the smelt biological opinion, the salmonid biological opinion, or any other applicable biological opinion; including the Shasta Dam cold water pool requirements as set forth in the salmonid biological opinion…". Because the 90% exceedance forecast does not show that minimum temperature requirements will be met (i.e., 56°F DAT at Balls Ferry), NMFS concludes that providing allocations to all North of Delta contracts, other than required to meet health and safety or other recent drought-related or shortage policy appropriate levels of M&I water service contracts in the American and Sacramento River basin, is not supported by the analysis provided, and doing so according to the forecast provided would adversely affect the cold water pool and ability to meet requirements under the CVP/SWP operations Opinion. We are willing to work with you to confer on appropriate M&I water service contract levels next week, as necessary. In addition, while we cannot concur on the North of Delta agricultural water service contract allocations at this time, we understand and agree to work with you in your efforts to provide minimal needs to those contractors during the month of March, while we are discussing the system as a whole and updating the forecast.

In addition to our concerns about temperature, we reviewed the forecasted Keswick release schedules for the potential for winter-run Chinook salmon redd dewatering prior to complete fry emergence in the fall, and also fall-run Chinook salmon redd dewatering in the late fall and into the winter. Whatever Keswick release schedules are agreed to pursuant to the RPA, NMFS will work with Reclamation to minimize the potential for winter-run Chinook salmon redd

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3 http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/nmfs_s_draft_proposed_2017_rpa_amendment_-_january_19__2017.pdf

dewatering until complete emergence, and also to stabilize flows for fall-run Chinook salmon spawning and egg incubation.

NMFS and Reclamation are currently facing a very different set of conditions than those experience throughout the 2012-2016 drought, and also the wet water year in 2017, with consideration of a decent volume of water in Shasta Reservoir, coupled with the forecasted water year having a reasonable likelihood of a dry classification. As a result, there is significant uncertainty regarding the ability to meet temperatures sufficiently cold enough to ensure the protection of winter-run throughout the 2018 temperature management season. With this uncertainty in mind, and in consideration of the current reinitiation of consultation on CVP/SWP operations[4] NMFS reminds Reclamation of the requirements of section 7(d) of the Endangered Species Act to "not make any irreversible or irretrievable commitment of resources with respect to the agency action which has the effect of foreclosing the formulation or implementation of any reasonable and prudent alternative measures which would not violate subsection (a)(2)."

As a reminder, RPA Action I.2.3.B(4)(a) requires Reclamation to "Maintain minimum monthly average flows necessary to meet nondiscretionary delivery obligations and legal requirements." However, NMFS' CVP/SWP operations Opinion and incidental take statement[5] explicitly states that "In the event that Reclamation determines that delivery of quantities of water to any contractor is nondiscretionary for purposes of the ESA, any incidental take due to delivery of water to that contractor would not be exempted from the ESA section 9 take prohibition in this Opinion."

In summary, based on Reclamation's February forecast and temperature modeling, supplemented by the NMFS-SWFSC's RAFT model results:

- The Balls Ferry temperature compliance point will not be met, and therefore, RPA Action I.2.3.B should be implemented this year;
- NMFS concurs with Reclamation's south-of-Delta initial allocations, and we cannot concur with any North of Delta allocations at this time;
- If Reclamation needs to make future water decisions in the interim, those decisions should be guided by Keswick release schedule for dry water year types provided above and in the draft proposed Shasta RPA amendment;
- NMFS will continue to work with Reclamation to provide operational and temperature scenarios that have a higher likelihood of meeting the requirements of RPA Action I.2.3; and
- NMFS will work with Reclamation to adjust the Keswick release schedules in order to minimize the potential for winter-run and fall-run Chinook salmon redd dewatering.

Reclamation is currently reducing Keswick releases to reach a minimum of 3,250 cfs, which is the expected monthly average Keswick release schedule in both the 50% and 90% exceedance

[4] Reclamation's August 2, 2016, request for reinitiation of section 7 consultation can be found at http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/bureau_of_reclamation_s_request_to_reinitiate_the_2009_cvpswp_operations_consultation_-_august_2__2016.pdf

[5] Section 11.1.1, page 729 in the CVP/SWP operations Opinion (http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/Operations,%20Criteria%20and%20Plan/nmfs_biological_and_conference_opinion_on_the_long-term_operations_of_the_cvp_and_swp.pdf)

forecasts. Should Reclamation need to change the release schedule between now and the end of March, NMFS expects close coordination between our agencies to ensure that the habitat needs (*i.e.*, cold water, stable flows) of winter-run Chinook salmon continue to be met. In addition, NMFS requests to work with Reclamation on real-time management during the temperature management season.

Thank you for the recent discussions with your staff in meeting the requirements in RPA Action I.2.3. As you know, on January 19, 2017[6], NMFS issued to Reclamation a draft proposed 2017 RPA amendment, focused on Shasta RPA Action Suite I.2. As part of the amendment process, Reclamation agreed[7] to implement an operational study for Shasta Reservoir temperature management in water year 2017. I look forward to further communication between our agencies as we work on the annual Temperature Management Plan pursuant to RPA Action I.2.4 and consideration of another operational study in 2018 pursuant to the draft proposed 2017 Shasta RPA amendment.

NMFS also looks forward to continued coordination with Reclamation and stakeholders to discuss the Reinitiation of Consultation and further development and implementation of the science plan. We expect this dialogue with stakeholders will provide helpful context to supplement our ongoing conversations about how to manage Shasta resources for water supply and species over the long-term. If you have any questions regarding this letter, please feel free to contact me, or have your staff contact Mr. Garwin Yip at (916) 930-3611, or via e-mail at Garwin.yip@noaa.gov.

Sincerely,

Maria C. Rea
Assistant Regional Administrator

Enclosures:

1. 90 and 50 percent exceedance forecasts (2 pages)
2. Preliminary temperature analysis based on four scenarios cross-factoring 90 and 50 percent exceedance hydrology with 10 and 50 percent exceedance meteorology (8 pages)
3. RAFT and temperature-dependent mortality model results for the 4 forecast and meteorology scenarios (6 pages)

[6] http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/nmfs_s_draft_proposed_2017_rpa_amendment_-_january_19__2017.pdf

[7] http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/reclamation_s_response_to_nmfs_s_draft_proposed_2017_rpa_amendment_-_january_25__2017.pdf

cc: California Central Valley Office
Division Chron File: 151422SWR2006SA00268

Electronic copy only:

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ENCLOSURE 1

Estimated CVP Operations Feb 90% Exceedance

Storages

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

		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Trinity	**1776**	**1800**	**1842**	**1841**	**1676**	**1508**	**1353**	**1228**	**1114**	**1084**	**1066**	**1076**	**1108**
	Elev.	2327	2330	2330	2317	2304	2291	2279	2267	2264	2262	2263	2267
Whiskeytown	**205**	**206**	**206**	**238**	**238**	**238**	**238**	**238**	**230**	**206**	**206**	**206**	**206**
	Elev.	1199	1199	1209	1209	1209	1209	1209	1207	1199	1199	1199	1199
Shasta	**3349**	**3441**	**3812**	**3803**	**3712**	**3383**	**2891**	**2470**	**2192**	**2067**	**2062**	**2188**	**2385**
	Elev.	1026	1041	1040	1037	1024	1003	983	968	961	961	968	978
Folsom	**582**	**571**	**624**	**617**	**590**	**425**	**337**	**305**	**280**	**253**	**231**	**221**	**271**
	Elev.	425	431	430	427	407	393	388	383	378	374	372	382
New Melones	**1981**	**1940**	**1972**	**1901**	**1847**	**1793**	**1716**	**1658**	**1619**	**1589**	**1605**	**1622**	**1637**
	Elev.	1047	1050	1043	1038	1033	1025	1020	1016	1012	1014	1016	1017
San Luis	**973**	**920**	**942**	**899**	**824**	**560**	**273**	**99**	**164**	**284**	**322**	**370**	**542**
	Elev.	519	529	519	503	463	415	370	367	372	381	402	428
Total		8877	9397	9298	8887	7907	6808	5999	5598	5483	5492	5683	6149

State End of the Month Reservoir Storage (TAF)

Oroville	**1408**	**1510**	**1747**	**1748**	**1647**	**1456**	**1236**	**1078**	**1048**	**969**	**864**	**819**	**894**
	Elev.	732	758	758	747	725	698	676	671	659	642	634	647
San Luis	**763**	**805**	**910**	**827**	**717**	**548**	**375**	**210**	**121**	**36**	**60**	**168**	**218**
Total San Luis (TAF)	**1736**	**1725**	**1852**	**1726**	**1541**	**1108**	**649**	**308**	**286**	**320**	**383**	**538**	**760**

Monthly River Releases (TAF/cfs)

Trinity	TAF	17	18	36	92	47	28	53	52	23	18	18	18
	cfs	**300**	**300**	**600**	**1,498**	**783**	**450**	**857**	**870**	**373**	**300**	**300**	**300**
Clear Creek	TAF	11	12	13	13	17	9	9	9	12	12	12	12
	cfs	**200**	**200**	**218**	**216**	**288**	**150**	**150**	**150**	**200**	**200**	**200**	**200**
Sacramento	TAF	194	200	446	523	654	768	615	476	369	268	204	200
	cfs	**3500**	**3250**	**7500**	**8500**	**11000**	**12500**	**10000**	**8000**	**6000**	**4500**	**3320**	**3250**
American	TAF	139	126	159	155	224	137	84	76	62	62	62	61
	cfs	**2500**	**2053**	**2672**	**2514**	**3769**	**2227**	**1368**	**1269**	**1013**	**1045**	**1010**	**1000**
Stanislaus	TAF	59	12	91	76	22	15	15	15	49	12	12	14
	cfs	**1070**	**200**	**1537**	**1242**	**363**	**250**	**250**	**250**	**797**	**200**	**200**	**226**
Feather	TAF	97	80	101	49	54	92	92	71	61	57	58	58
	cfs	**1750**	**1300**	**1700**	**800**	**900**	**1500**	**1500**	**1200**	**1000**	**950**	**950**	**950**

Trinity Diversions (TAF)

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Carr PP	20	23	53	112	135	130	71	62	16	21	12	3
Spring Crk. PP	**20**	**30**	**23**	**105**	**120**	**120**	**60**	**60**	**30**	**15**	**12**	**10**

Delta Summary (TAF)

		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Tracy		135	136	24	25	25	40	100	250	249	95	84	210
USBR Banks		0	0	0	0	0	9	9	9	0	0	0	0
Contra Costa		14.0	12.7	12.7	12.7	9.8	11.1	12.7	14.0	16.8	18.4	18.3	14.0
Total USBR		149	149	37	37	35	60	122	273	266	113	102	224
State Export		161	205	18	18	20	25	20	60	66	160	217	210
Total Export		310	354	54	56	55	85	142	333	332	273	319	434
COA Balance		6	0	5	-10	9	23	19	65	22	22	22	22
Old/Middle River Std.													
Old/Middle R. calc.		-3,840	-4,301	-152	-279	-901	-1,302	-2,047	-4,530	-3,956	-3,570	-4,038	-5,463
Computed DOI		11436	11403	10405	7597	7598	4994	3497	3009	4002	4505	4506	5677
Excess Outflow		36	0	0	0	0	0	0	0	0	0	0	1171
% Export/Inflow		33%	33%	6%	7%	6%	11%	21%	47%	47%	44%	51%	58%
% Export/Inflow std.		45%	35%	35%	35%	35%	65%	65%	65%	65%	65%	65%	65%

Hydrology

	Trinity		Shasta		Folsom	New Melones	
Water Year Inflow (TAF)	474		3,447		1,562	776	
Year to Date + Forecasted % of mean	39%		62%		57%	73%	

CVP actual operations do not follow any forecasted operation or outlook; actual operations are based on real-time conditions.
CVP operational forecasts or outlooks represent general system-wide dynamics and do not necessarily address specific watershed/tributary details.
CVP releases or export values represent monthly averages.
CVP Operations are updated monthly as new hydrology information is made available December through May.

2/13/2018

ENCLOSURE 1

Estimated CVP Operations Feb 50% Exceedance

Storages

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

		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Trinity	**1776**	**1805**	**1901**	**1994**	**1912**	**1849**	**1742**	**1605**	**1477**	**1439**	**1426**	**1456**	**1521**
	Elev.	2327	2334	2341	2335	2330	2322	2312	2301	2298	2297	2300	2305
Whiskeytown	**205**	**206**	**206**	**238**	**238**	**238**	**238**	**238**	**230**	**206**	**206**	**206**	**206**
	Elev.	1199	1199	1209	1209	1209	1209	1209	1207	1199	1199	1199	1199
Shasta	**3349**	**3445**	**3985**	**4222**	**4160**	**3849**	**3325**	**2953**	**2694**	**2630**	**2619**	**2764**	**3170**
	Elev.	1026	1047	1056	1053	1042	1022	1006	994	991	990	997	1015
Folsom	**582**	**579**	**669**	**754**	**855**	**727**	**522**	**408**	**353**	**306**	**277**	**266**	**310**
	Elev.	426	436	445	455	442	419	404	396	388	383	381	389
New Melones	**1981**	**1952**	**1922**	**1864**	**1819**	**1768**	**1703**	**1643**	**1602**	**1562**	**1583**	**1610**	**1644**
	Elev.	1048	1045	1040	1035	1031	1024	1018	1014	1010	1012	1015	1018
San Luis	**966**	**966**	**966**	**881**	**740**	**427**	**181**	**39**	**68**	**178**	**363**	**568**	**704**
	Elev.	525	540	524	499	455	407	359	371	393	430	461	477
Total		8954	9648	9953	9725	8858	7711	6886	6424	6320	6474	6870	7554

State End of the Month Reservoir Storage (TAF)

Oroville	**1408**	**1677**	**2053**	**2125**	**2008**	**1784**	**1535**	**1386**	**1300**	**1206**	**1139**	**1201**	**1378**
	Elev.	750	788	794	783	761	734	717	706	694	685	693	716
San Luis	**763**	**838**	**1019**	**910**	**761**	**598**	**395**	**197**	**246**	**290**	**421**	**513**	**552**
Total San Luis (TAF)	**1729**	**1804**	**1985**	**1791**	**1501**	**1025**	**576**	**235**	**315**	**468**	**783**	**1082**	**1255**

Monthly River Releases (TAF/cfs)

Trinity	TAF	17	18	32	180	47	28	53	52	23	18	18	18
	cfs	**300**	**300**	**540**	**2,924**	**783**	**450**	**857**	**870**	**373**	**300**	**300**	**300**
Clear Creek	TAF	11	12	13	13	17	9	9	9	12	12	12	15
	cfs	**200**	**200**	**218**	**216**	**288**	**150**	**150**	**150**	**200**	**200**	**200**	**240**
Sacramento	TAF	205	200	297	492	625	799	615	506	338	327	246	200
	cfs	**3700**	**3250**	**5000**	**8000**	**10500**	**13000**	**10000**	**8500**	**5500**	**5500**	**4000**	**3250**
American	TAF	194	154	149	108	228	272	178	119	123	119	123	108
	cfs	**3500**	**2500**	**2500**	**1750**	**3839**	**4432**	**2891**	**2000**	**2000**	**2000**	**2000**	**1750**
Stanislaus	TAF	59	93	83	96	56	18	18	18	49	12	12	14
	cfs	**1070**	**1521**	**1400**	**1555**	**940**	**300**	**300**	**300**	**797**	**200**	**200**	**232**
Feather	TAF	97	80	119	92	119	187	156	143	123	104	61	108
	cfs	**1750**	**1300**	**2000**	**1500**	**2000**	**3050**	**2540**	**2400**	**2000**	**1750**	**1000**	**1750**

Trinity Diversions (TAF)

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Carr PP	22	35	36	24	71	84	85	76	26	25	9	0
Spring Crk. PP	**35**	**60**	**15**	**25**	**60**	**75**	**75**	**75**	**40**	**20**	**12**	**20**

Delta Summary (TAF)

		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Tracy		143	112	48	49	128	250	270	261	270	260	260	200
USBR Banks		0	0	0	0	0	26	26	26	0	0	0	0
Contra Costa		14.0	12.7	12.7	12.7	9.8	11.1	12.7	14.0	16.8	18.4	18.3	14.0
Total USBR		157	125	60	62	138	287	309	301	287	278	278	214
State Export		200	300	42	43	102	76	65	269	262	325	260	200
Total Export		357	425	102	105	240	363	374	570	549	603	538	414
COA Balance		0	0	0	0	0	0	0	138	138	138	138	138
Old/Middle River Std.													
Old/Middle R. calc.		-3,244	-3,490	71	281	-2,711	-4,527	-4,726	-7,386	-6,535	-7,652	-6,577	-4,903
Computed DOI		18677	22563	12372	10867	7598	6507	4002	3009	4246	4572	8329	14966
Excess Outflow		7276	11159	1109	3091	0	0	0	0	244	67	3823	10460
% Export/Inflow		25%	23%	10%	11%	27%	35%	43%	62%	59%	64%	50%	31%
% Export/Inflow std.		45%	35%	35%	35%	35%	65%	65%	65%	65%	65%	65%	65%

Hydrology

	Trinity		Shasta		Folsom		New Melones	
Water Year Inflow (TAF)	754		3,937		1,944		887	
Year to Date + Forecasted % of mean	62%		71%		71%		84%	

CVP actual operations do not follow any forecasted operation or outlook; actual operations are based on real-time conditions.
CVP operational forecasts or outlooks represent general system-wide dynamics and do not necessarily address specific watershed/tributary details.
CVP releases or export values represent monthly averages.
CVP Operations are updated monthly as new hydrology information is made available December through May.

2/13/2018

February 13, 2018

Upper Sacramento River – February 2018 Preliminary Temperature Analysis

Summary of Temperature Results by Month (Monthly Average Temperature °F)

Initial Compliance Location (°F DAT)	APR	MAY	JUN	JUL	AUG	SEP*	OCT*
February 90%-Exceedance Outlook – 10% Historical Meteorology							
Keswick Dam KWK	52.5	52.8	53.4	53.9	53.9	NA	NA
Sac. R. abv Clear Creek CCR	52.4	52.9	53.5	54.1	54.0	NA	NA
Balls Ferry BSF	54.1	55.2	55.3	55.4	55.3	57.3	57.3
February 90%-Exceedance Outlook – 50% Historical Meteorology							
Keswick Dam KWK	52.2	52.3	52.7	53.5	53.5	NA	NA
Sac. R. abv Clear Creek CCR	52.2	52.7	53.2	54.0	53.9	NA	NA
Balls Ferry BSF	53.9	55.6	55.5	55.9	55.7	56.6	56.6
February 50%-Exceedance Outlook – 10% Historical Meteorology							
Keswick Dam KWK	52.9	53.0	53.1	53.9	54.3	NA	NA
Sac. R. abv Clear Creek CCR	52.7	53.1	53.3	54.0	54.4	NA	NA
Balls Ferry BSF	54.8	55.5	55.1	55.3	55.7	56.3	56.3
February 50%-Exceedance Outlook – 50% Historical Meteorology							
Keswick Dam KWK	52.5	51.6	52.3	53.2	53.7	NA	NA
Sac. R. abv Clear Creek CCR	52.5	52.1	52.8	53.7	54.1	NA	NA
Balls Ferry BSF	54.5	55.3	55.3	55.5	55.9	55.8	55.8

* The HEC5Q model output is displayed above for the months April through August. Based on past analysis, the temperature model does not perform well in late September and October. One factor is that the modeled release temperatures are cooler than has historically been achieved when all release is through the side gates (lowest gates), especially when there's a large temperature gradient between the pressure relief gates (PRG) and the side gates. For the months of September and October estimated temperatures

are provided based on the Fall Temperature Index (graphic below). This relationship is an end of September Lake Shasta Volume less than 56°F and likely downstream temperature performance at Balls Ferry for the early fall months.

Temperature Model Inputs, Assumptions, Limitations and Uncertainty:

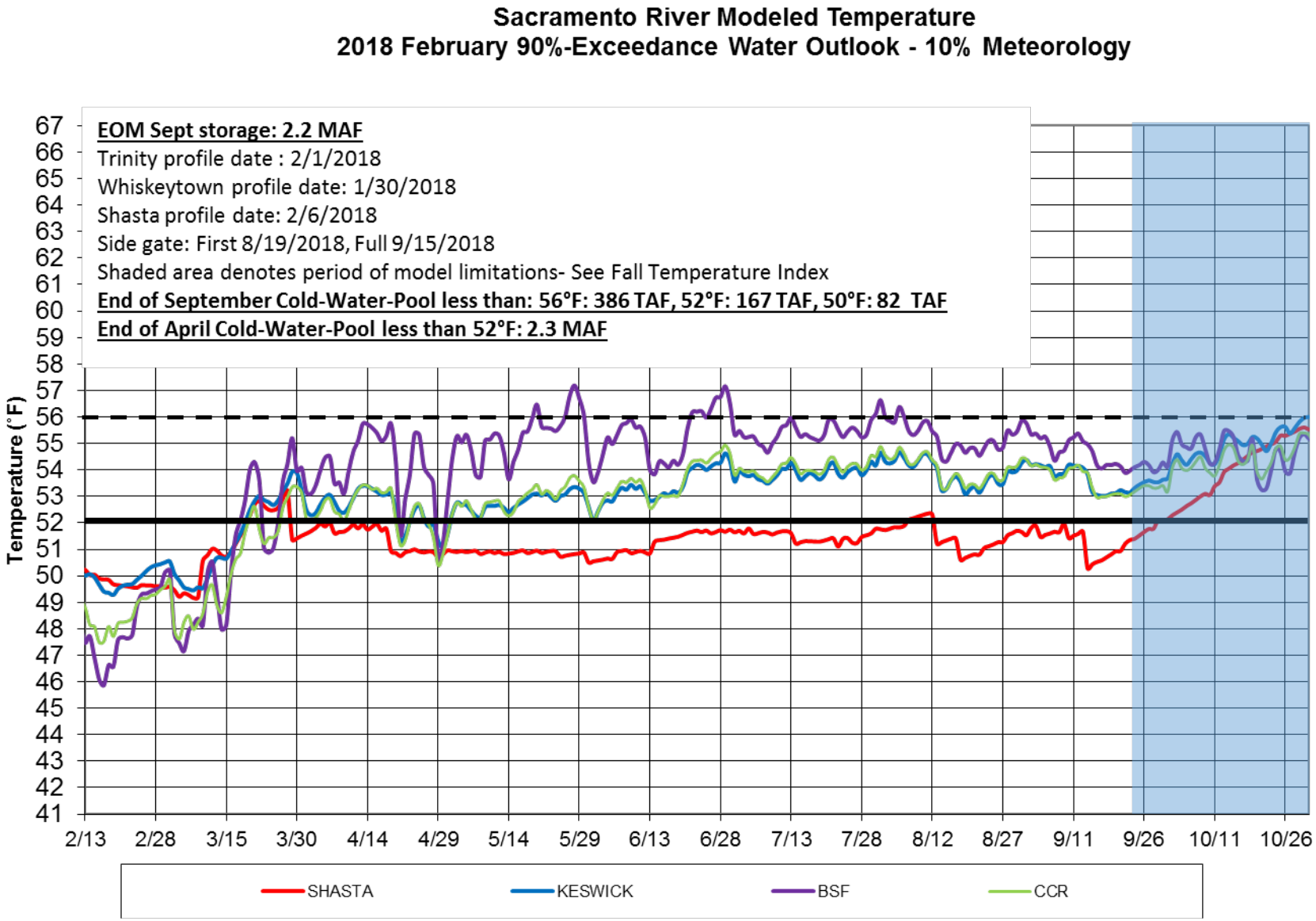
1. The latest available profiles for Shasta, Trinity, and Whiskeytown were taken on February 6, February 1, and January 30, respectively. Model results are sensitive to initial reservoir temperature conditions and the model performs best under highly stratified conditions. The February 2018 temperature profile does not yet exhibit conditions for ideal model computations (still nearly isothermal conditions). The model performs well after the reservoir stratifies, typically in late spring. The concern this year is assuming lower than actual inflow temperatures due to low snow/higher than normal air temperature conditions and not capturing the stratification with sufficient detail to project.
2. Guidance on forecasted flows from the creeks (e.g., Cow, Cottonwood, Battle, etc.) between Keswick Dam and Bend Bridge are not available beyond 5 days. Creek flows developed from the historical record that most closely reflects current conditions were used for all model runs. The resulting greater than normal creek flows cause additional warming in the upper Sacramento River during spring.
3. Operation is based on the February 2017 Operation Outlooks (monthly flows, reservoir release, and end-of-month reservoir storage) for the 90%- and 50%-exceedances. Trinity Lake inflows are updated with the CNRFC 90% runoff exceedance for both the 90% and 50% runoff exceedance studies.
4. Although mean daily flows and releases are temperature model inputs, they are based on the mean monthly values from the operation outlooks. Mean daily flow patterns are user defined and are generalized representations. It is important to note that these outlooks do not suggest a certain actual future outcome, but rather the statistical likelihood of an event occurring, including, but not limited to, projected storage and releases. Thus, the outlooks do not provide exact end of month storages or flow rates but general projections that will likely fall within the range of uncertainty based on the different hydrologic runoff conditions between the 90% and 50% runoff exceedance hydrology.
5. Cottonwood Creek flows, Keswick to Bend Bridge local flows, and ACID diversions are mean daily synthesized flows based on the available historical record for a 1922-2002 study period. Inflows were adjusted to a 75% historical exceedance for both the 90% and 50% runoff exceedance studies.
6. Meteorological inputs represent historical (1920 – 2005) monthly mean equilibrium temperature exceedance at 10% and 50% patterned after like months on a 6-hour timestep.
7. Meteorology, as well as the flow volume and pattern, significantly influences reservoir inflow temperatures and downstream tributary temperatures; and consequently, the development of the cold-water pool during winter and early spring.
8. Modified model coefficients more closely represent actual Keswick Dam temperatures. As a result, temperature predictions downstream of Keswick Dam are likely to be warmer than actual. Model re-calibrations efforts are underway.

Model Run Date February 13, 2018

Temperature Analysis Results:

Modeling runs explore Sacramento River compliance performance above Clear Creek confluence and Balls Ferry locations by varying hydrology and meteorology. The temperature results for the Sacramento River between Keswick Dam and Balls Ferry are shown in Figures 1 through 3. The relationship between end-of-September lake volume below 56°F and a Balls Ferry compliance through fall is based on the Figure 5.

Model Run	End of September Cold Water Pool <56°F (TAF)	First Side Gate	Full Side Gates
90% Hydro, 10% Met	386	8/19	9/15
90% Hydro, 50% Met	529	8/29	10/4
50% Hydro, 10% Met	602	9/5	9/24
50% Hydro, 50% Met	707	9/17	10/14


Sacramento River Modeled Temperature
2018 February 90%-Exceedance Water Outlook - 10% Meteorology
EOM Sept storage: 2.2 MAF
Trinity profile date : 2/1/2018
Whiskeytown profile date: 1/30/2018
Shasta profile date: 2/6/2018
Side gate: First 8/19/2018, Full 9/15/2018
Shaded area denotes period of model limitations- See Fall Temperature Index
End of September Cold-Water-Pool less than: 56°F: 386 TAF, 52°F: 167 TAF, 50°F: 82 TAF
End of April Cold-Water-Pool less than 52°F: 2.3 MAF
Temperature (°F)
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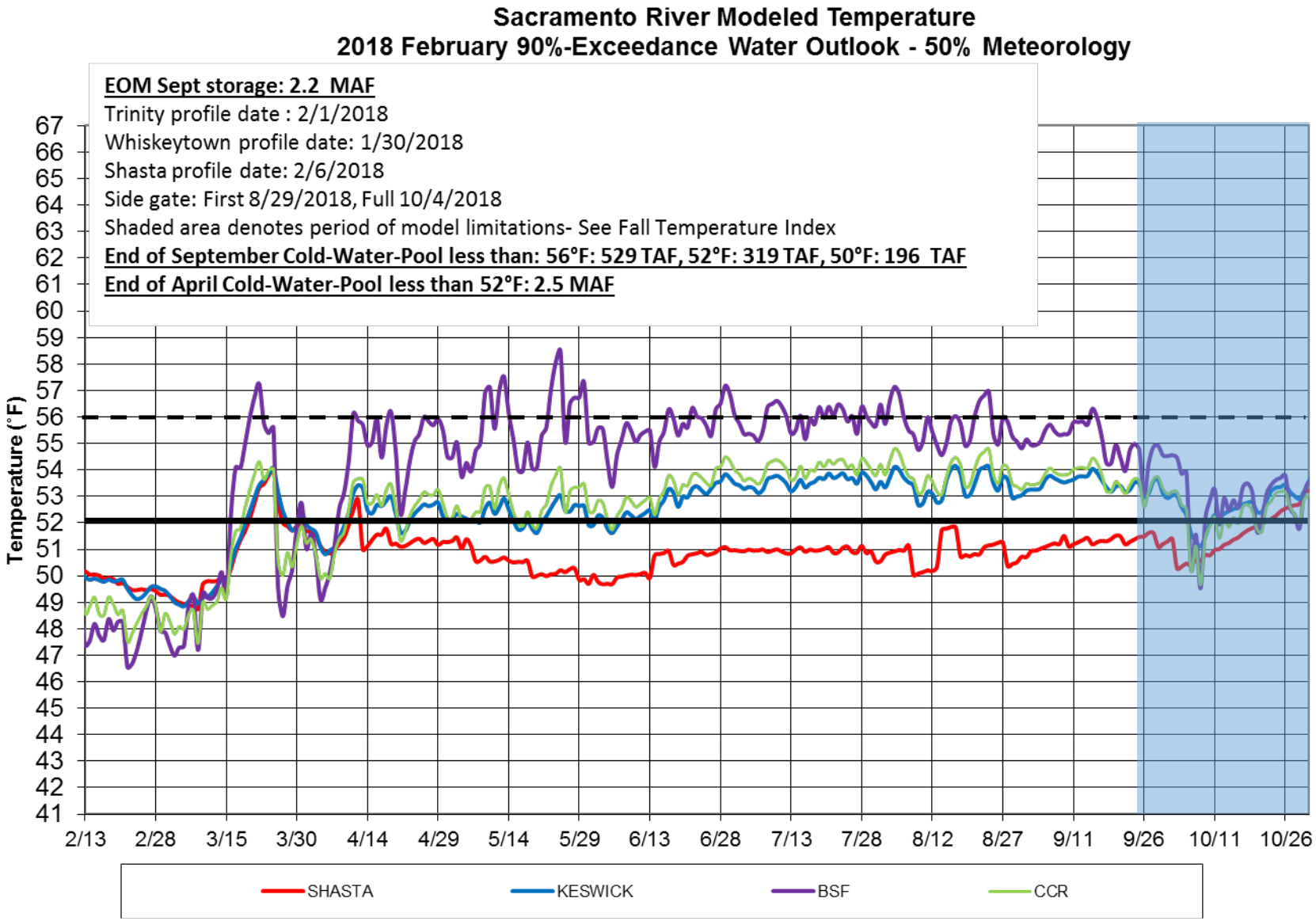
SHASTA
KESWICK
BSF
CCR

Figure 1


Sacramento River Modeled Temperature
2018 February 90%-Exceedance Water Outlook - 50% Meteorology
EOM Sept storage: 2.2 MAF
Trinity profile date : 2/1/2018
Whiskeytown profile date: 1/30/2018
Shasta profile date: 2/6/2018
Side gate: First 8/29/2018, Full 10/4/2018
Shaded area denotes period of model limitations- See Fall Temperature Index
End of September Cold-Water-Pool less than: 56°F: 529 TAF, 52°F: 319 TAF, 50°F: 196 TAF
End of April Cold-Water-Pool less than 52°F: 2.5 MAF
Temperature (°F)
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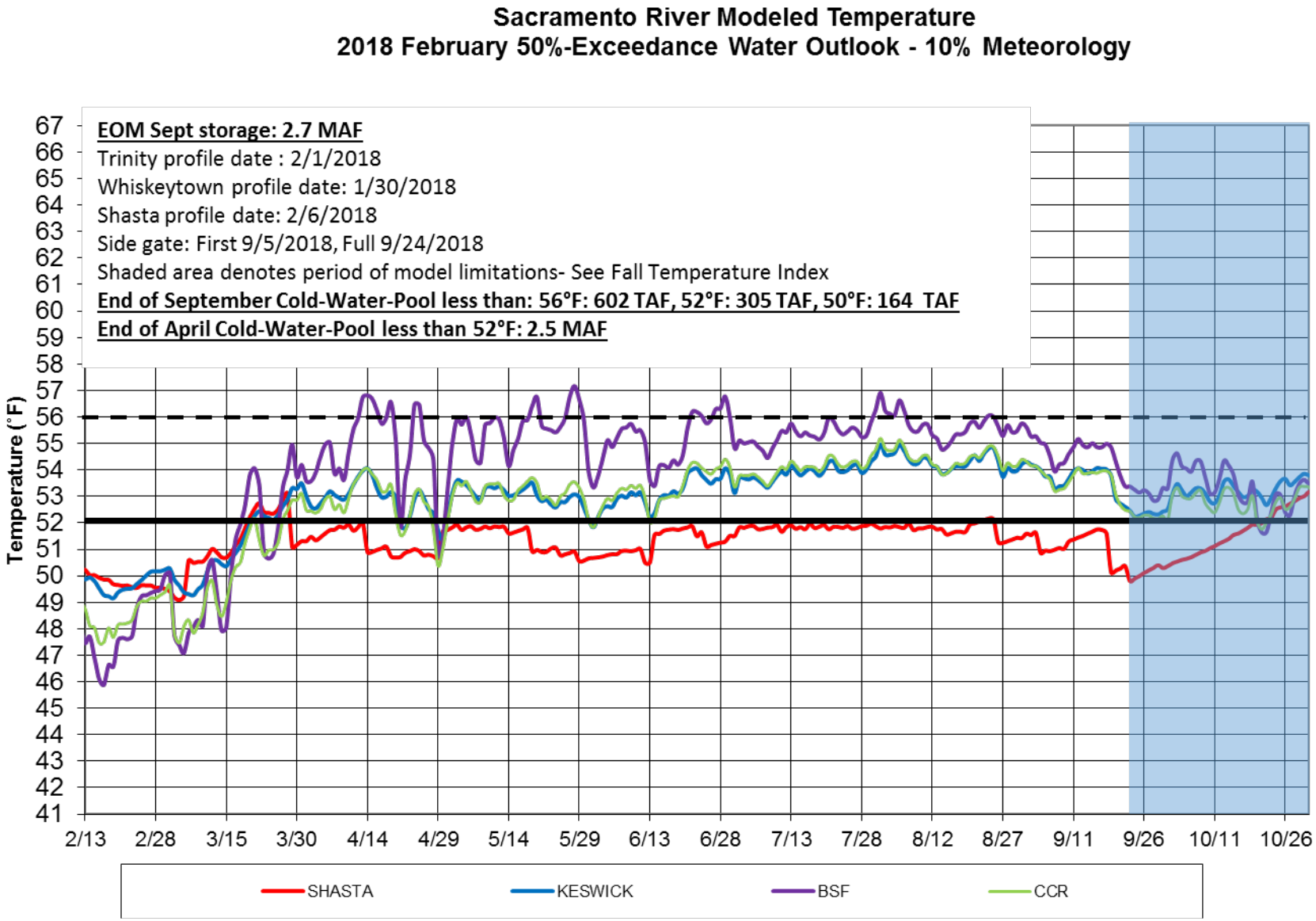
SHASTA
KESWICK
BSF
CCR

Figure 2


Sacramento River Modeled Temperature
2018 February 50%-Exceedance Water Outlook - 10% Meteorology
EOM Sept storage: 2.7 MAF
Trinity profile date : 2/1/2018
Whiskeytown profile date: 1/30/2018
Shasta profile date: 2/6/2018
Side gate: First 9/5/2018, Full 9/24/2018
Shaded area denotes period of model limitations- See Fall Temperature Index
End of September Cold-Water-Pool less than: 56°F: 602 TAF, 52°F: 305 TAF, 50°F: 164 TAF
End of April Cold-Water-Pool less than 52°F: 2.5 MAF
Temperature (°F)
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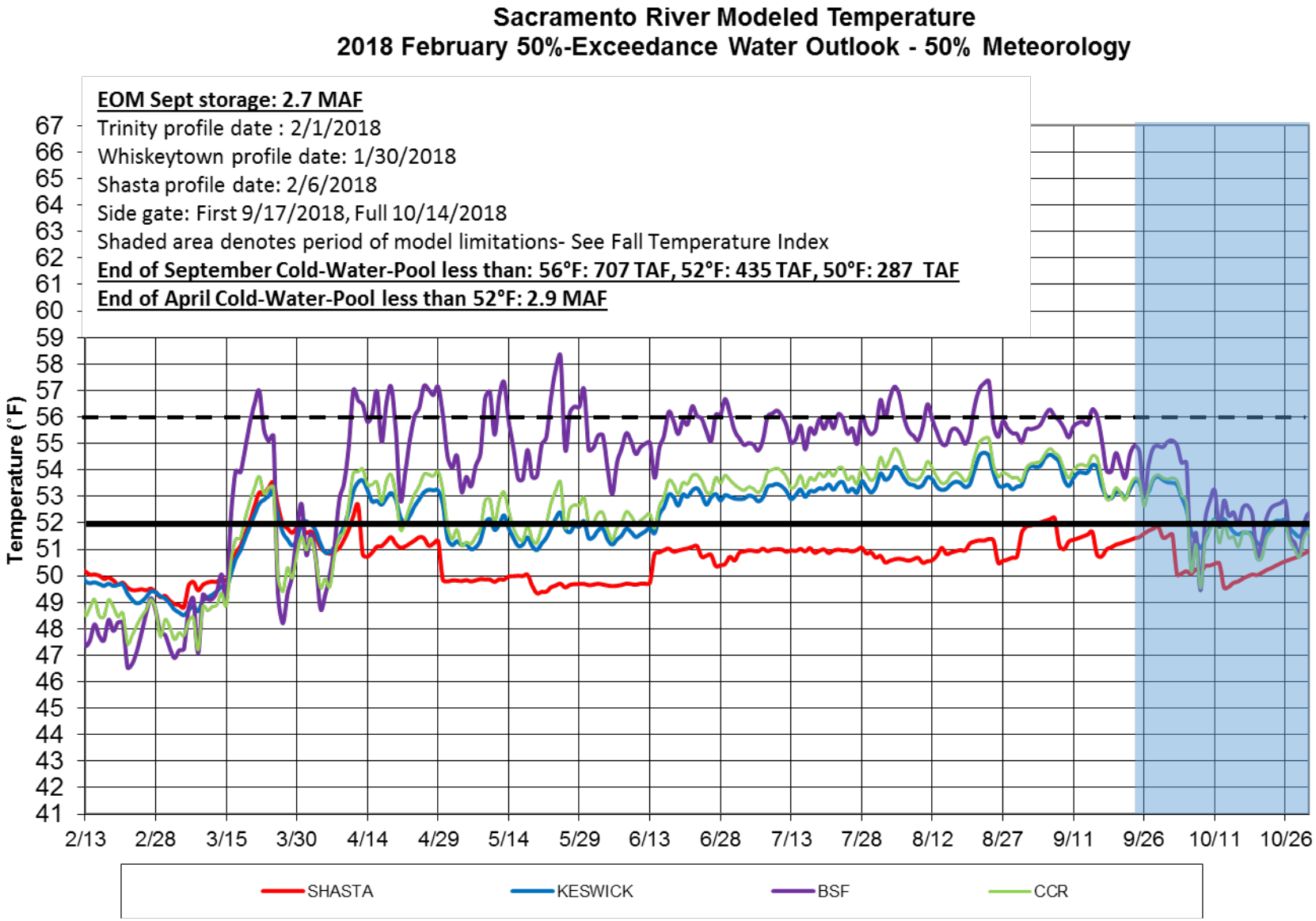
SHASTA
KESWICK
BSF
CCR

Figure 3


Sacramento River Modeled Temperature
2018 February 50%-Exceedance Water Outlook - 50% Meteorology
EOM Sept storage: 2.7 MAF
Trinity profile date : 2/1/2018
Whiskeytown profile date: 1/30/2018
Shasta profile date: 2/6/2018
Side gate: First 9/17/2018, Full 10/14/2018
Shaded area denotes period of model limitations- See Fall Temperature Index
End of September Cold-Water-Pool less than: 56°F: 707 TAF, 52°F: 435 TAF, 50°F: 287 TAF
End of April Cold-Water-Pool less than 52°F: 2.9 MAF
Temperature (°F)
67
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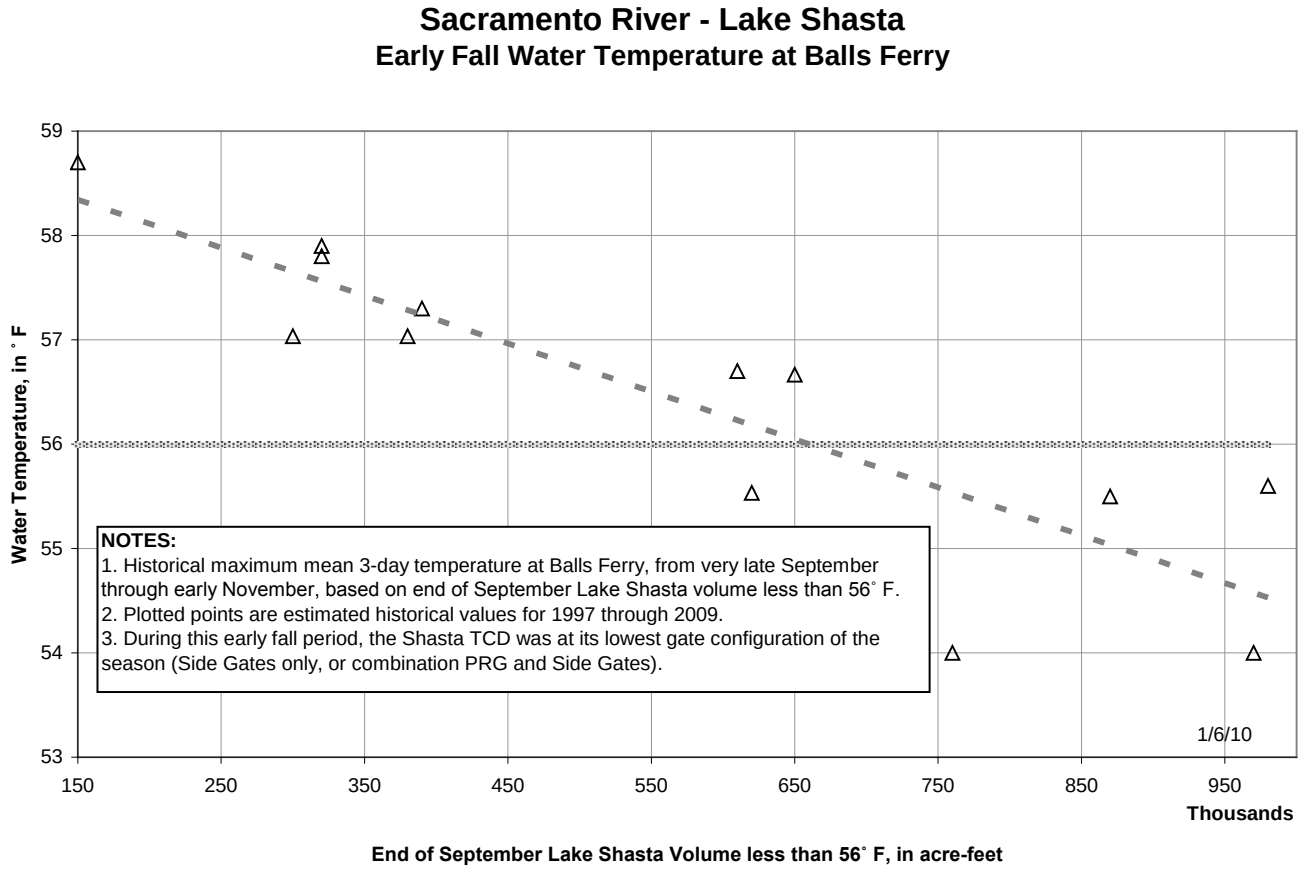
SHASTA
KESWICK
BSF
CCR

Figure 4

Figure 5 Model Performance and Fall Temperature Index:

1. Based on past analyses, the temperature model does not perform well in late September and October. One factor is that the modeled release temperatures are cooler than has historically been achieved when all release is through the side gates (lowest gates), especially when there's a large temperature gradient between the pressure relief gates (PRG) and the side gates.
2. Based on historical records, the end-of-September Lake Shasta volume below 56˚F is a good indicator of fall water temperature in the river reach to Balls Ferry.
3. For river temperatures not to exceed 56 ˚F downstream to Balls Ferry, the end-of-September lake volume less than 56˚F should be greater than about 600 TAF, see chart below:



Summary Document for Shasta/Keswick Operational Scenarios
Prepared by the Southwest Fisheries Science Center on Feb 14th, 2018

Below are results comparing four USBR scenarios ran February 12th 2017. Scenarios differ by hydrology (Input 50 or 90 percent exceedance) and air temperature (10 or 50 exceedance of L3MTO). Inputs from scenarios are used to generate daily average Sacramento River water temperatures using the RAFT model and associated temperature-dependent egg mortality and survival estimates using the NMFS temperature mortality model (Martin et al. 2017) for the 2018 temperature management season.

Further details of modeling methods are at: http://oceanview.pfeg.noaa.gov/CVTEMP/

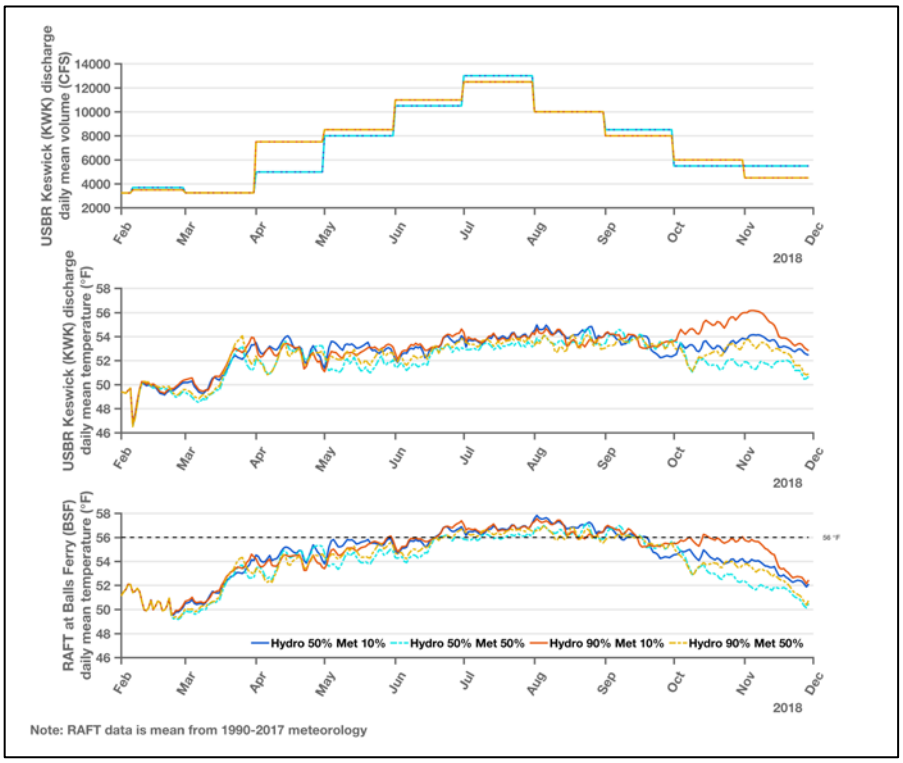


Figure 1: Summary plots showing differences in Keswick discharge volume and temperature, and Balls Ferry RAFT predicted temperature for four scenarios assessed.

Table 1: Estimated temperature-dependent egg mortality under different scenarios assuming a 2012-2017 spatial and temporal redd distribution.

Scenario	Mean (%)	Median (%)	Lower (%)	Upper (%)
Feb_14_2018_INPUT_50_OUTPUT_50_10L3MTO	43.07	45.61	1.08	74.77
Feb_14_2018_INPUT_50_OUTPUT_50_50L3MTO	23.37	18.82	1.06	66.79
Feb_14_2018_INPUT_90_OUTPUT_90_10L3MTO	40.06	42.01	0.23	73.77
Feb_14_2018_INPUT_90_OUTPUT_90_50L3MTO	26.61	22.54	0.93	67.20

Summary Document for Shasta/Keswick Operational Scenarios
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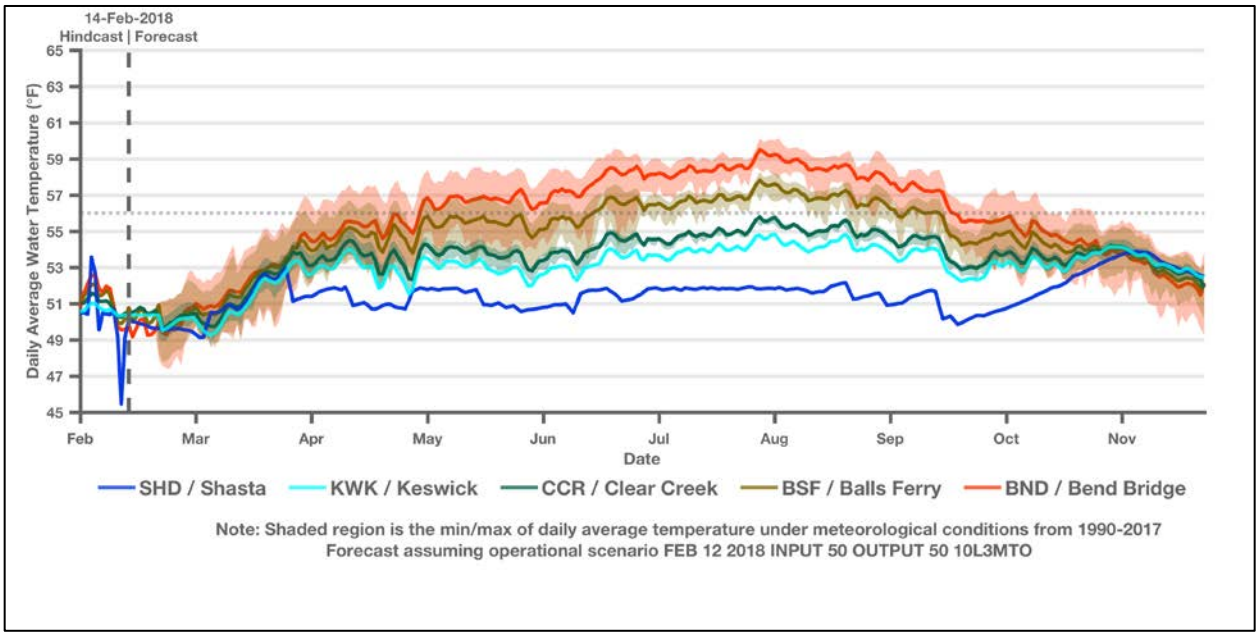

Figure 2: Estimated daily average water temperature produced by scenario input (Shasta and Keswick) and the RAFT model (Clear Creek, Balls Ferry, and Bend Bridge) under the Feb 12th 2018 Input_50_10_L3MTO scenario.

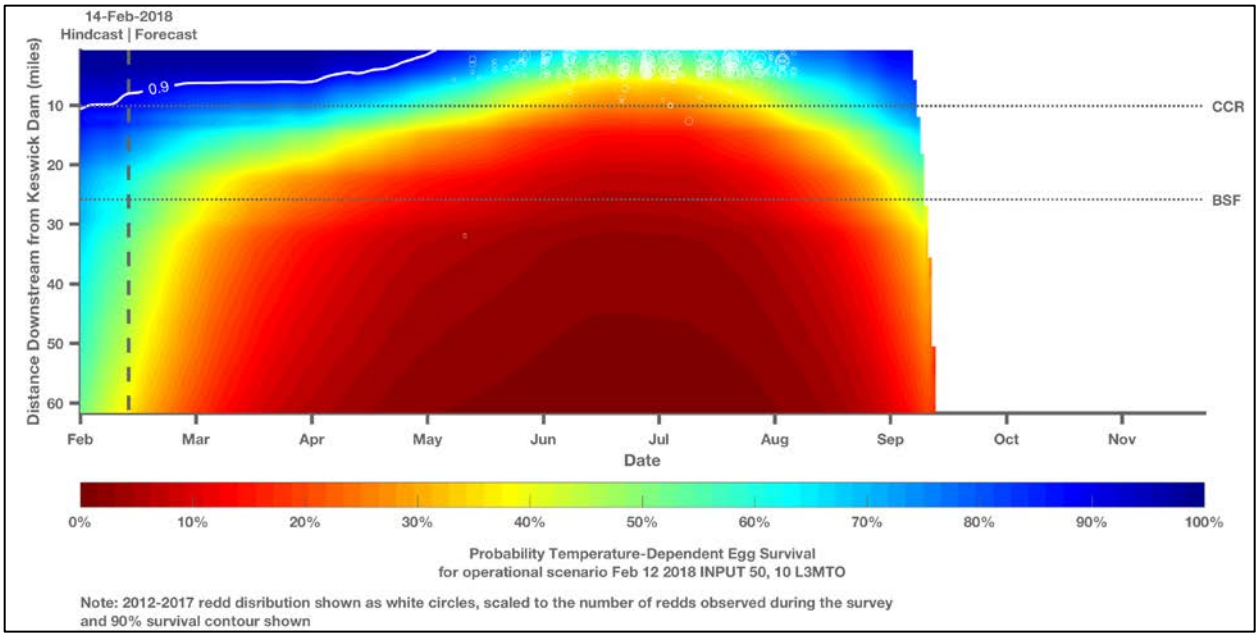

Figure 3: Estimated temperature-dependent egg survival produced by the NMFS temperature mortality model under the Feb 12th 2018 Input_50_10_L3MTO scenario.

Summary Document for Shasta/Keswick Operational Scenarios
Prepared by the Southwest Fisheries Science Center on Feb 14th, 2018

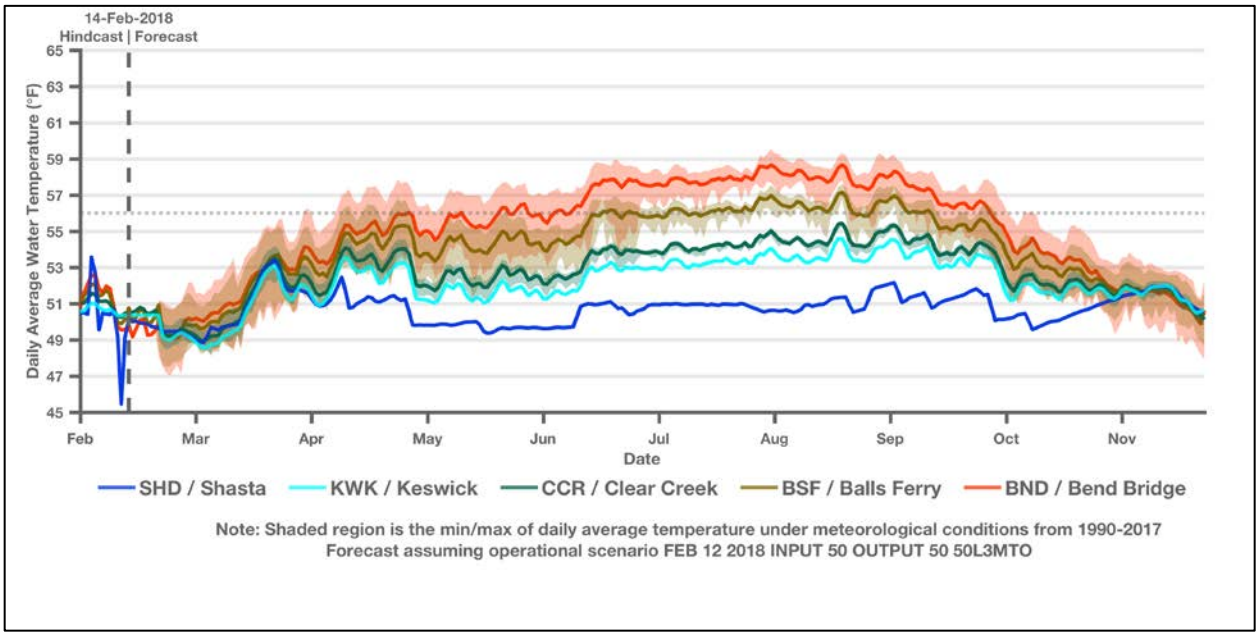

Figure 4: Estimated daily average water temperature produced by scenario input (Shasta and Keswick) and the RAFT model (Clear Creek, Balls Ferry, and Bend Bridge) under the Feb 12th 2018 Input_50_50_L3MTO scenario.

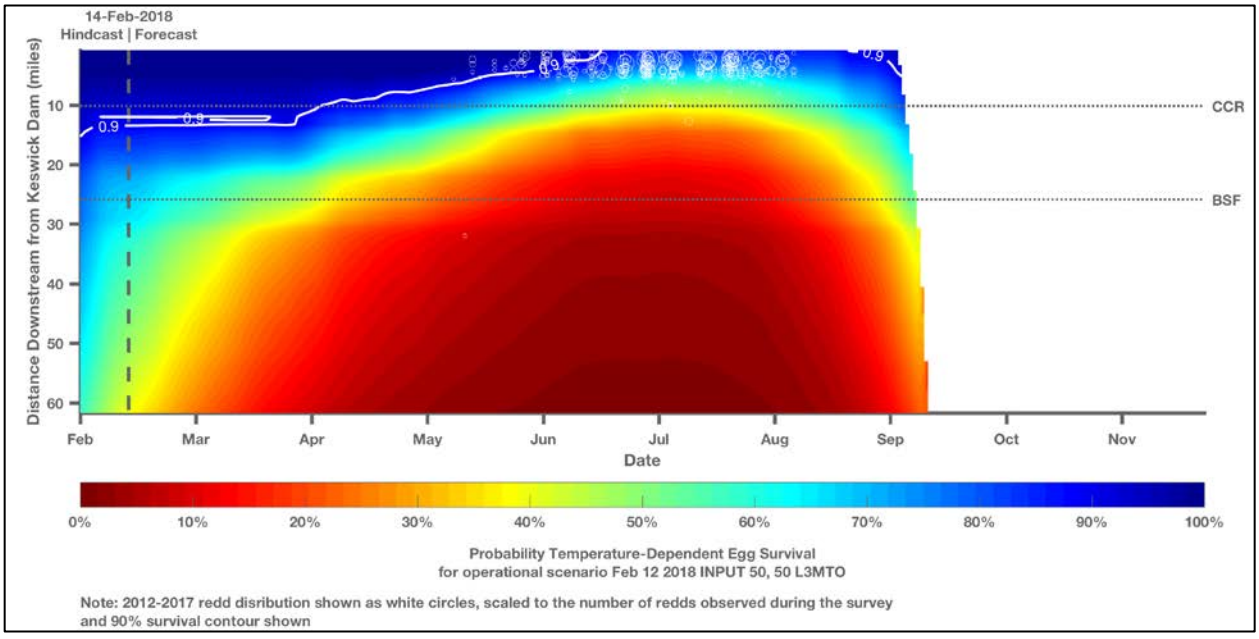

Figure 5: Estimated temperature-dependent egg survival produced by the NMFS temperature mortality model under the Feb 12th 2018 Input_50_50_L3MTO scenario.

Summary Document for Shasta/Keswick Operational Scenarios
Prepared by the Southwest Fisheries Science Center on Feb 14th, 2018

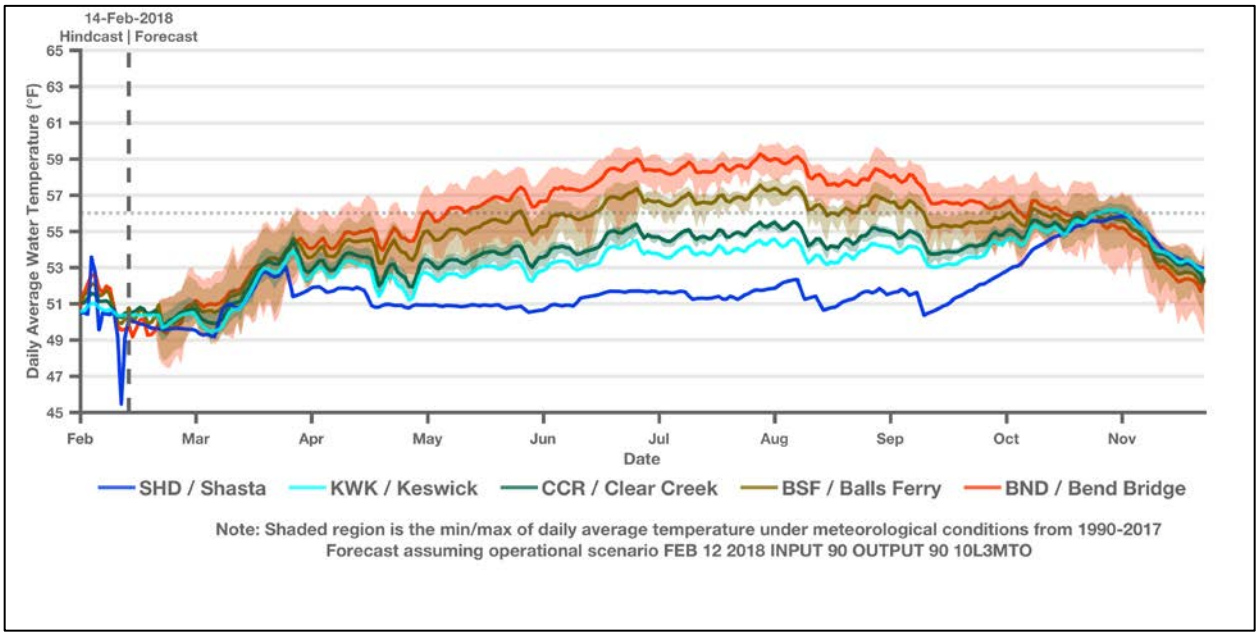

Figure 6: Estimated daily average water temperature produced by scenario input (Shasta and Keswick) and the RAFT model (Clear Creek, Balls Ferry, and Bend Bridge) under the Feb 12th 2018 Input_90_10_L3MTO scenario.

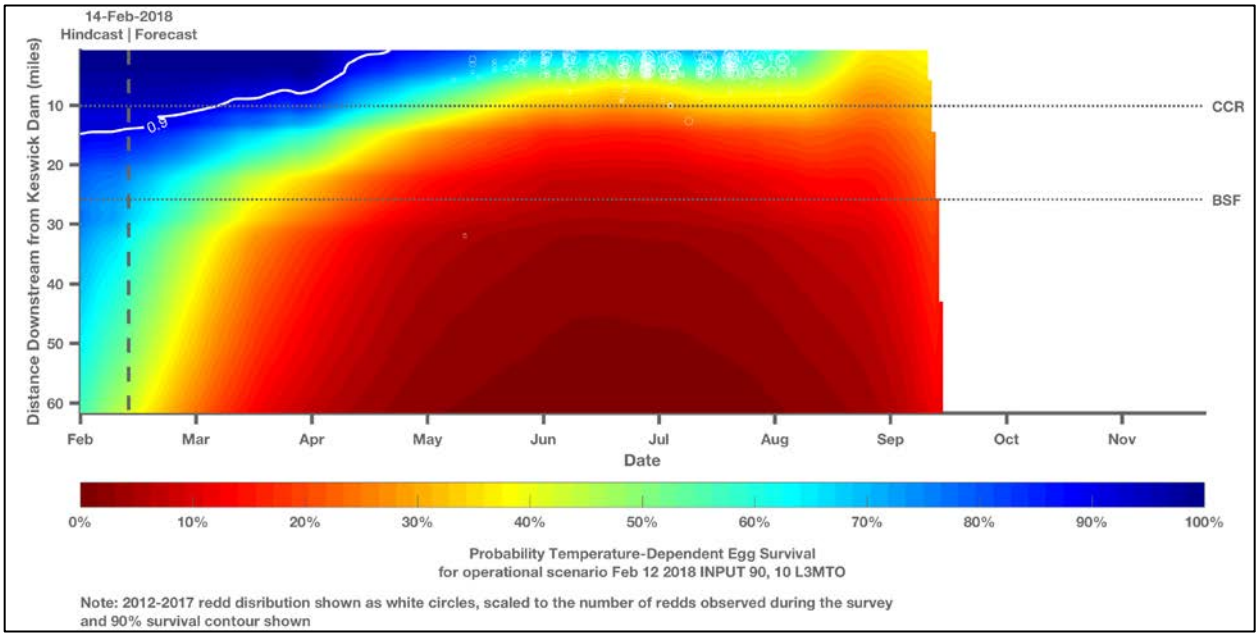

Figure 7: Estimated temperature-dependent egg survival produced by the NMFS temperature mortality model under the Feb 12th 2018 Input_90_10_L3MTO scenario.

Summary Document for Shasta/Keswick Operational Scenarios
Prepared by the Southwest Fisheries Science Center on Feb 14th, 2018

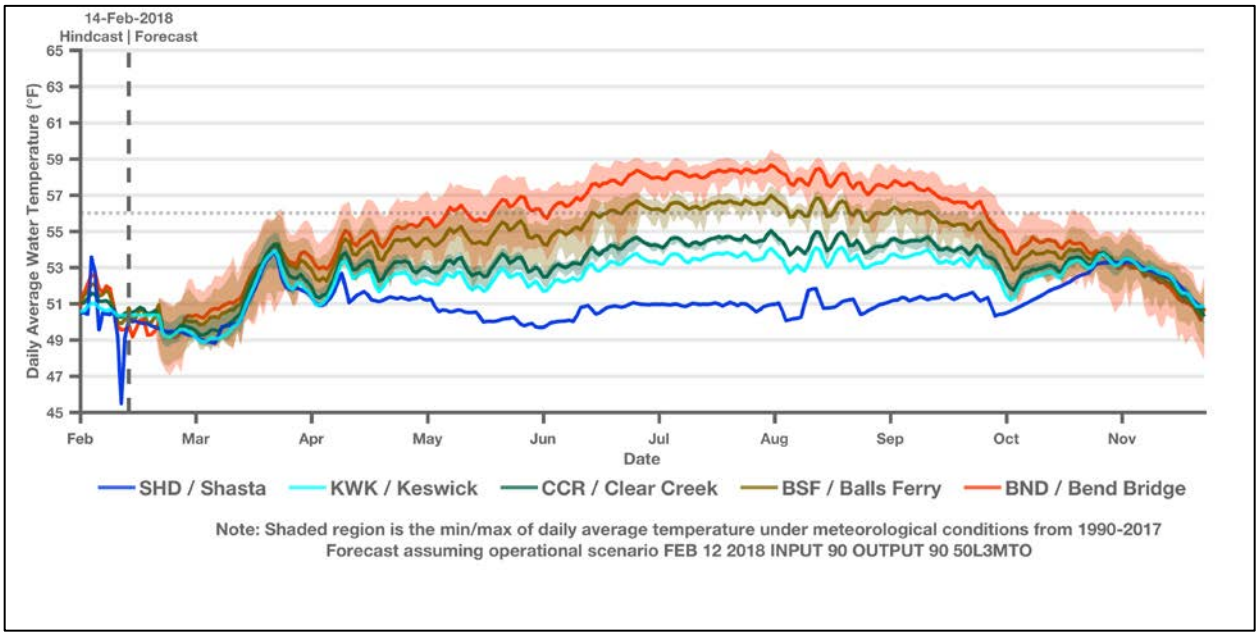

Figure 8: Estimated daily average water temperature produced by scenario input (Shasta and Keswick) and the RAFT model (Clear Creek, Balls Ferry, and Bend Bridge) under the Feb 12th 2018 Input_90_50_L3MTO scenario.

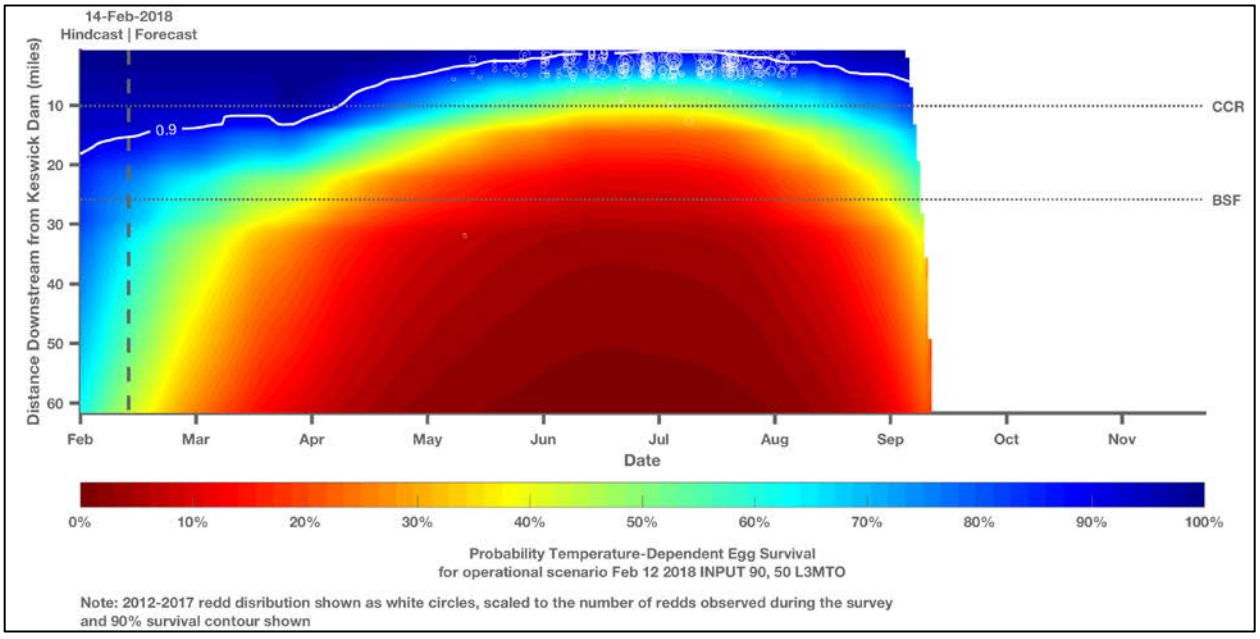

Figure 9: Estimated temperature-dependent egg survival produced by the NMFS temperature mortality model under the Feb 12th 2018 Input_90_50_L3MTO scenario.

Reference:

Martin, B. T., Pike, A., John, S. N., Hamda, N., Roberts, J., Lindley, S. T. and Danner, E. M. (2017), Phenomenological vs. biophysical models of thermal stress in aquatic eggs. Ecology Letters 20: 50–59. doi:10.1111/ele.12705