



# United States Department of the Interior

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APR 18 2018

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IN REPLY REFER TO:

CVO-100

ENV-7.00

APR 18 2018

VIA ELECTRONIC MAIL AND U.S. MAIL

Ms. Maria Rea  
Assistant Regional Administrator  
California Central Valley Area Office  
650 Capital Mall, Suite 5-100  
Sacramento, CA 95814

Subject: Transmittal of April 2018 Reservoir Operations Forecasts

Dear Ms. Rea:

Pursuant to Reasonable and Prudent Alternative (RPA) Action I.2.3 of the 2009 National Marine Fisheries Service (NMFS) Biological Opinion (BiOp), this transmittal provides the Bureau of Reclamation's update to our projected Keswick Dam releases. Enclosed (Enclosure 1) are Reclamation's updated Central Valley Project (CVP) operational projections for the coming spring and summer, and a set of Sacramento River temperature modeling results for the projected operations. The outlooks and modeling runs are based on April 1, 2018, hydrologic conditions and a forecast of reservoir inflows assuming both a 90 percent exceedance hydrology, and a 50 percent exceedance hydrology. As stated in previous correspondence, these outlooks do not suggest a certain actual future outcome, but rather the statistical likelihood of projected outcomes, including, but not limited to, projected storage and releases as well as temperature performance. Thus, the outlooks do not provide exact end-of-month storages, flow rates, or anticipated water temperatures, but general projections that will likely fall within the range of uncertainty based on the different hydrologic runoff conditions between the 90 percent and 50 percent hydrology.

The enclosed temperature modeling results are based on the April 1 hydrologic forecasts and a Shasta Lake temperature stratification profile from April 3, 2018. The results of the HEC-5Q modeling software indicate the ability to meet a 56 degree daily average temperature (DAT) at a compliance location of Balls Ferry. Based on the positive changes to hydrologic and reservoir conditions, the certainty in meeting temperatures at this location and metric has significantly improved from previous months, as shown in the attached results. We plan to further discuss the improvements in operational conditions during tomorrow's (April 19, 2018) Sacramento River Temperature Task Group (SRTTG) technical workshop on operations and temperature management.

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2

The Keswick monthly average releases at the 90 percent exceedance hydrology for April 1, as shown in the enclosed operational outlooks, are projected to be 8,000 cubic feet per second (cfs) in May. It should be noted that we anticipate the actual release rate to vary throughout the month, as we are currently anticipating a need to operate to real-time conditions based on higher demands during certain times of the month due to projected diversion patterns. Ranges of projected average monthly releases for the remainder of the months of the year can be found in the enclosed tables. With these projected releases and other operating conditions throughout the CVP system, Reclamation anticipates the ability to support increases to our allocations, which we intend to do in the very near future as we have discussed with your office. We plan to engage in further dialog at the aforementioned SRTTG Technical Workshop regarding specifics of the projected operations.

We look forward to our continued coordination as we develop our final Sacramento River temperature management plan for 2018. As identified at last month's SRTTG meeting, our initial temperature management plan development is intended to be informed by interactions with the various agencies and stakeholders through the following forums:

- April 19th: SRTTG Technical Workshop to discuss CVP Operations and Shasta Temperature Management
- April 25th: Stakeholder workshop to discuss Shasta Temperature Management
- April 26th: SRTTG Meeting

We look forward to NMFS' involvement at these meetings and workshops. Please contact Elizabeth Kiteck at 916-979-2684 or Randi Field at 916-979-2066 if you have any questions regarding this transmittal.

Sincerely,



Jeff Rieker  
Operations Manager

Enclosure

**Estimated CVP Operations Mar 90% Exceedance**

**Storages**

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

		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Trinity		1844	1964	1893	1782	1679	1555	1439	1409	1390	1400	1432	1518	1615
	Elev.	2338	2333	2325	2318	2308	2298	2295	2294	2295	2297	2305	2313	
Whiskeytown		207	238	238	238	238	238	230	206	206	206	206	206	
	Elev.	1209	1209	1209	1209	1209	1207	1199	1199	1199	1199	1199	1199	
Shasta		3880	4132	4011	3656	3077	2630	2351	2226	2221	2351	2548	2895	3351
	Elev.	1052	1048	1035	1011	991	977	970	970	977	987	1003	1023	
Folsom		817	793	904	825	591	449	402	345	296	256	306	412	576
	Elev.	449	459	452	427	410	403	395	386	379	388	405	426	
New Melones		2019	1977	1946	1922	1848	1784	1740	1709	1721	1735	1747	1770	1789
	Elev.	1050	1047	1045	1038	1032	1028	1025	1026	1027	1028	1031	1033	
San Luis		876	773	574	266	88	8	72	198	382	526	666	699	762
	Elev.	510	485	445	421	399	414	431	451	476	491	493	505	
<b>Total</b>		9877	9567	8689	7521	6665	6234	6093	6215	6474	6905	7500	8298	

**State End of the Month Reservoir Storage (TAF)**

Oroville														
San Luis		898	849	761	652	609	510	566	593	605	719	746	723	803
<b>Total San Luis (TAF)</b>		1774	1622	1335	919	697	518	638	791	986	1245	1411	1422	1565

**Monthly River Releases (TAF/cfs)**

Trinity	TAF	36	92	47	28	53	52	23	18	18	18	17	18
	cfs	600	1,498	783	450	857	870	373	300	300	300	300	300
Clear Creek	TAF	13	13	17	9	9	9	12	12	12	12	11	12
	cfs	218	216	288	150	150	150	200	200	200	200	200	200
Sacramento	TAF	297	492	625	799	645	476	369	268	200	200	180	200
	cfs	5000	8000	10500	13000	10500	8000	6000	4500	3250	3250	3250	3250
American	TAF	506	77	167	293	204	107	92	89	92	61	56	77
	cfs	8500	1250	2811	4768	3311	1798	1500	1500	1500	1000	1005	1250
Stanislaus	TAF	83	96	56	18	18	18	49	12	12	14	13	12
	cfs	1400	1555	940	300	300	300	797	200	200	232	236	200
Feather	TAF	208	92	119	215	123	108	77	74	77	77	69	108
	cfs	3500	1500	2000	3500	2000	1815	1250	1250	1250	1250	1250	1759

**Trinity Diversions (TAF)**

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Carr PP	39	67	85	80	71	62	16	21	12	3	2	15
Spring Crk. PP	10	60	70	70	60	60	30	15	12	10	20	30

**Delta Summary (TAF)**

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Tracy	93	61	53	225	260	262	265	250	190	190	120	200
USBR Banks	0	0	0	18	18	18	0	0	0	0	0	0
Contra Costa	12.7	12.7	9.8	11.1	12.7	14.0	16.8	18.4	18.3	14.0	14.0	12.7
<b>Total USBR</b>	106	74	63	254	291	294	282	268	208	204	134	213
State Export	77	31	47	121	64	150	151	106	186	190	127	200
<b>Total Export</b>	182	105	110	375	355	444	433	374	394	394	261	413
COA Balance	25	25	0	0	0	87	87	87	87	87	46	46

Old/Middle River Std.												
Old/Middle R. calc.	-164	146	-1,354	-4,912	-4,693	-5,945	-5,221	-4,877	-4,978	-4,960	-3,536	-5,040

Computed DOI	30476	9516	7900	6507	4002	3009	4067	4572	6767	9728	11400	12379
Excess Outflow	19079	1610	0	0	0	0	65	67	2261	3725	0	976
% Export/Inflow	8%	11%	13%	35%	40%	54%	54%	52%	47%	41%	29%	34%
% Export/Inflow std.	35%	35%	35%	65%	65%	65%	65%	65%	65%	65%	45%	35%

**Hydrology**

Water Year Inflow (TAF)	Trinity	Shasta	Folsom	New Melones
Year to Date + Forecasted	627	3,621	2,352	972
% of mean	52%	65%	86%	92%

Estimated CVP Operations Mar 50% Exceedance

Storages

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

		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Trinity	1844	1878	1860	1773	1659	1514	1381	1343	1330	1360	1425	1535	1629
	Elev.	2332	2331	2325	2316	2304	2293	2290	2288	2291	2297	2306	2314
Whiskeytown	207	238	238	238	238	238	230	206	206	206	206	206	206
	Elev.	1209	1209	1209	1209	1209	1207	1199	1199	1199	1199	1199	1199
Shasta	3880	4167	4117	3801	3266	2874	2647	2552	2601	2792	3198	3682	4240
	Elev.	1054	1052	1040	1019	1002	991	987	989	998	1016	1036	1056
Folsom	817	823	946	831	660	598	538	489	460	449	477	530	595
	Elev.	452	463	452	435	428	421	415	411	410	414	420	428
New Melones	2019	1999	2017	2021	1961	1898	1857	1815	1832	1855	1887	1941	1918
	Elev.	1052	1054	1054	1049	1043	1039	1035	1037	1039	1042	1047	1045
San Luis	876	804	582	389	200	97	150	268	449	656	801	918	966
	Elev.	512	481	454	428	414	436	462	493	524	524	536	543
<b>Total</b>		9909	9760	9052	7984	7219	6802	6673	6878	7318	7994	8812	9554

State End of the Month Reservoir Storage (TAF)

Oroville													
San Luis	898	844	716	627	563	544	685	829	974	1131	985	1021	1062
<b>Total San Luis (TAF)</b>	1774	1648	1297	1015	763	642	835	1097	1423	1787	1786	1939	2028

Monthly River Releases (TAF/cfs)

Trinity	TAF	36	92	47	28	53	52	23	18	18	18	17	18
	cfs	600	1,498	783	450	857	870	373	300	300	300	300	300
Clear Creek	TAF	13	13	17	9	9	9	12	12	12	15	11	12
	cfs	218	216	288	150	150	150	200	200	200	240	200	200
Sacramento	TAF	268	461	625	799	645	476	369	268	200	200	278	307
	cfs	4500	7500	10500	13000	10500	8000	6000	4500	3250	3250	5000	5000
American	TAF	476	154	252	250	136	132	123	119	123	123	208	246
	cfs	8000	2500	4229	4067	2217	2226	2007	2000	2000	2000	3750	4000
Stanislaus	TAF	83	96	56	18	18	18	49	12	12	14	13	93
	cfs	1400	1555	940	300	300	300	797	200	200	232	236	1521
Feather	TAF	208	92	149	246	246	119	108	104	108	108	97	108
	cfs	3500	1500	2500	4000	4000	2000	1750	1750	1750	1750	1750	1750

Trinity Diversions (TAF)

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Carr PP	35	24	71	84	85	76	26	25	9	0	2	35
Spring Crk. PP	15	25	60	75	75	75	40	20	12	20	35	60

Delta Summary (TAF)

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Tracy	129	74	219	273	273	261	265	254	260	205	215	221
USBR Banks	0	0	0	24	24	24	0	0	0	0	0	0
Contra Costa	12.7	12.7	9.8	11.1	12.7	14.0	16.8	18.4	18.3	14.0	14.0	12.7
<b>Total USBR</b>	142	86	229	308	310	299	282	272	278	219	229	234
<b>State Export</b>	105	18	106	141	183	261	298	275	260	50	215	187
<b>Total Export</b>	247	105	335	449	493	560	580	547	538	269	444	421
<b>COA Balance</b>	25	25	0	0	16	153	230	224	224	224	224	224

Old/Middle River Std.												
Old/Middle R. calc.	-483	281	-3,941	-5,605	-6,217	-7,257	-6,923	-6,927	-6,577	-3,086	-4,826	-3,440

Computed DOI	33838	13388	7900	6507	4002	3009	4002	4505	8329	17569	23954	25849
Excess Outflow	22441	4441	0	0	0	0	0	0	3823	11566	12553	14445
% Export/Inflow	10%	9%	33%	40%	50%	62%	62%	62%	50%	20%	25%	20%
% Export/Inflow std.	35%	35%	35%	65%	65%	65%	65%	65%	65%	65%	45%	35%

Hydrology

Water Year Inflow (TAF)	Trinity	539	Shasta	3,864	Folsom	2,536	New Melones	1080
Year to Date + Forecasted % of mean	45%	70%	93%	102%				

April 18, 2018

## Upper Sacramento River – April 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	Late Sep-Oct Uncertainty Estimation
<b>March 90%-Exceedance Outlook – 10% Historical Meteorology</b>								
<b>Keswick Dam KWK</b>	52.8	52.0	52.5	53.4	53.9	54.2	52.7	54 - 57
<b>Sac. R. abv Clear Creek CCR</b>	53.0	52.6	53.1	54.0	54.3	54.5	52.6	54 - 58
<b>Balls Ferry BSF</b>	55.3	56.0	56.0	56.0	56.0	56.0	53.7	55 - 59
<b>March 90%-Exceedance Outlook – 50% Historical Meteorology</b>								
<b>Keswick Dam KWK</b>	52.3	52.4	52.9	53.8	54.0	53.9	52.7	53 - 56
<b>Sac. R. abv Clear Creek CCR</b>	52.3	52.9	53.4	54.2	54.4	54.1	52.4	54 - 57
<b>Balls Ferry BSF</b>	54.1	56.0	56.0	56.0	56.0	55.5	53.0	55 - 58
<b>March 50%-Exceedance Outlook – 10% Historical Meteorology</b>								
<b>Keswick Dam KWK</b>	52.9	51.7	52.4	53.4	53.9	54.1	52.7	54 - 57
<b>Sac. R. abv Clear Creek CCR</b>	53.1	52.4	53.1	54.0	54.3	54.4	52.6	54 - 58
<b>Balls Ferry BSF</b>	55.4	56.0	55.9	56.0	56.0	56.0	53.6	55 - 59
<b>March 50%-Exceedance Outlook – 50% Historical Meteorology</b>								
<b>Keswick Dam KWK</b>	52.3	52.0	52.7	53.8	54.0	54.6	51.7	53 - 55
<b>Sac. R. abv Clear Creek CCR</b>	52.3	52.7	53.3	54.2	54.3	54.7	51.5	53 - 57
<b>Balls Ferry BSF</b>	54.3	56.0	55.9	56.0	56.0	56.0	52.2	54 - 58

\* The HEC5Q model output is displayed above for the months April through October. 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, an uncertainty

estimate is provided based on the Fall Temperature Index (graphics below). This is based on a historical relationship between end-of-September Lake Shasta Volume less than 56°F and likely downstream temperature performances for the early fall months. The range represents the 90% confidence interval based on that data. Refinement of the concepts for those estimates is underway.

#### **Temperature Model Inputs, Assumptions, Limitations and Uncertainty:**

1. The latest available profiles for Shasta, Trinity, and Whiskeytown were taken on April 3, April 4, and April 3 respectively. Model results are sensitive to initial reservoir temperature conditions and the model performs best under highly stratified conditions. The April 2018 temperature profile does not yet exhibit conditions for ideal model computations (still nearly isothermal conditions although warming will initiate stratification). The model performs well after the reservoir stratifies, typically in late spring. The concern this year is assuming over or under estimations with variable hydrologic and meteorological 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 low creek flows cause significant additional warming in the upper Sacramento River during spring.
3. Operation is based on the April 2018 Operation Outlooks and DWR Bulletin 120 inflow projections (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 the 90% 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 95% historical exceedance for both the 90% and 50% runoff exceedance studies.
6. Meteorological inputs represent NOAA NWS Climate Prediction Center L3MTO (based on historical 1961 – 2005 monthly mean equilibrium temperature exceedance at 10% and 50% patterned after like months on a 6-hour time-step). Assumed inflow temperature remain static inputs and do not vary with the assumed meteorology. Efforts to extend to more recent years are under way.
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 April 16, 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 4. The fall uncertainty estimation relationship between end-of-September lake volume below 56°F and a Balls Ferry compliance through fall is based on the Figure 5.

<b>Model Run</b>	<b>End of September Cold Water Pool &lt;56°F (TAF)</b>	<b>First Side Gate</b>	<b>Full Side Gates</b>
90% Hydro, 10%L3MTOMet	558	9/7	10/5
90% Hydro, 50% L3MTOMet	699	9/25	NA
50% Hydro, 10% L3MTOMet	587	9/5	10/4
50% Hydro, 50% L3MTOMet	778	10/4	10/26

## Sacramento River Modeled Temperature 2018 April 90%-Exceedance Water Outlook - 10% L3MTO Meteorology

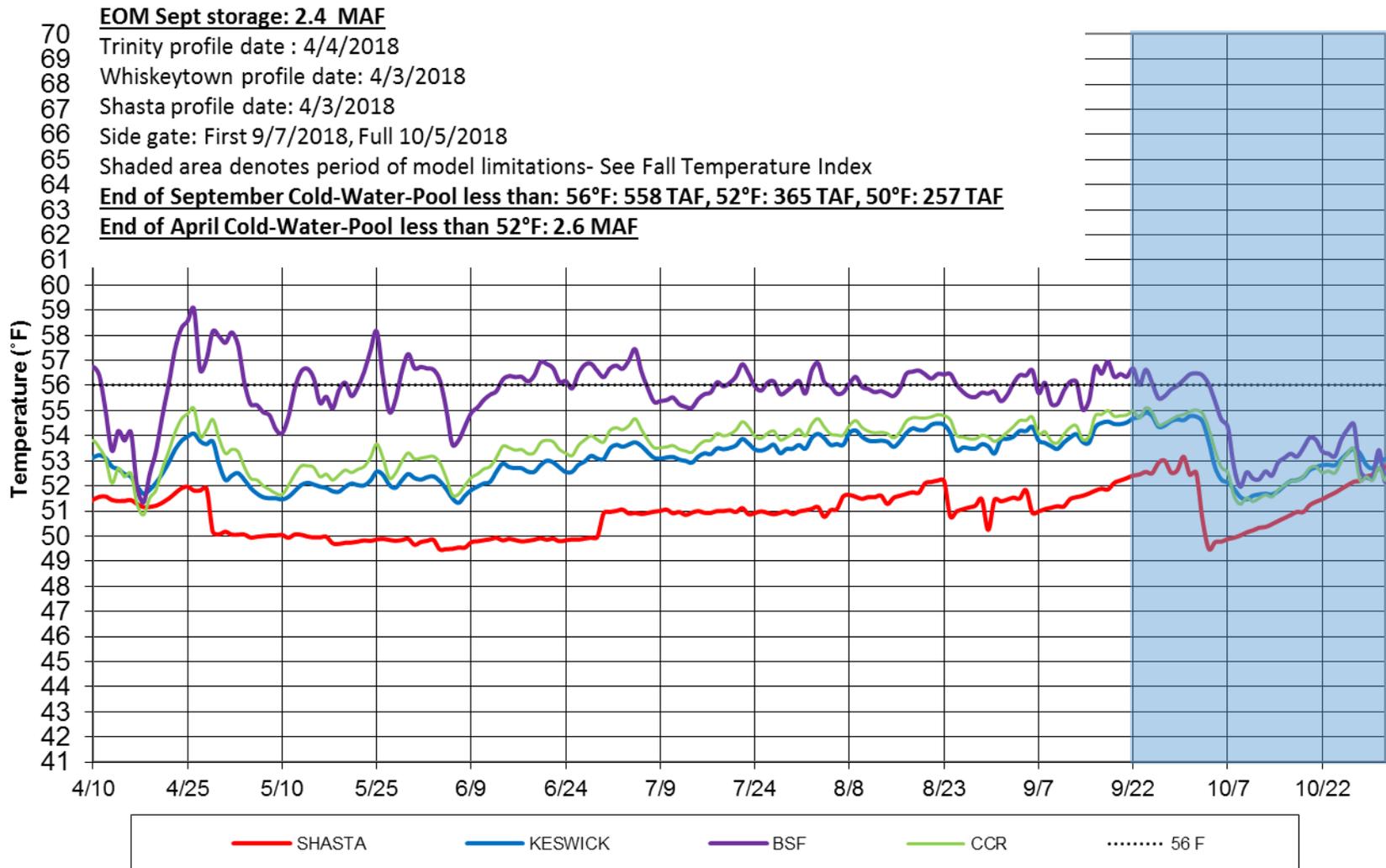


Figure 1

## Sacramento River Modeled Temperature 2018 April 90%-Exceedance Water Outlook - 50% L3TMO Meteorology

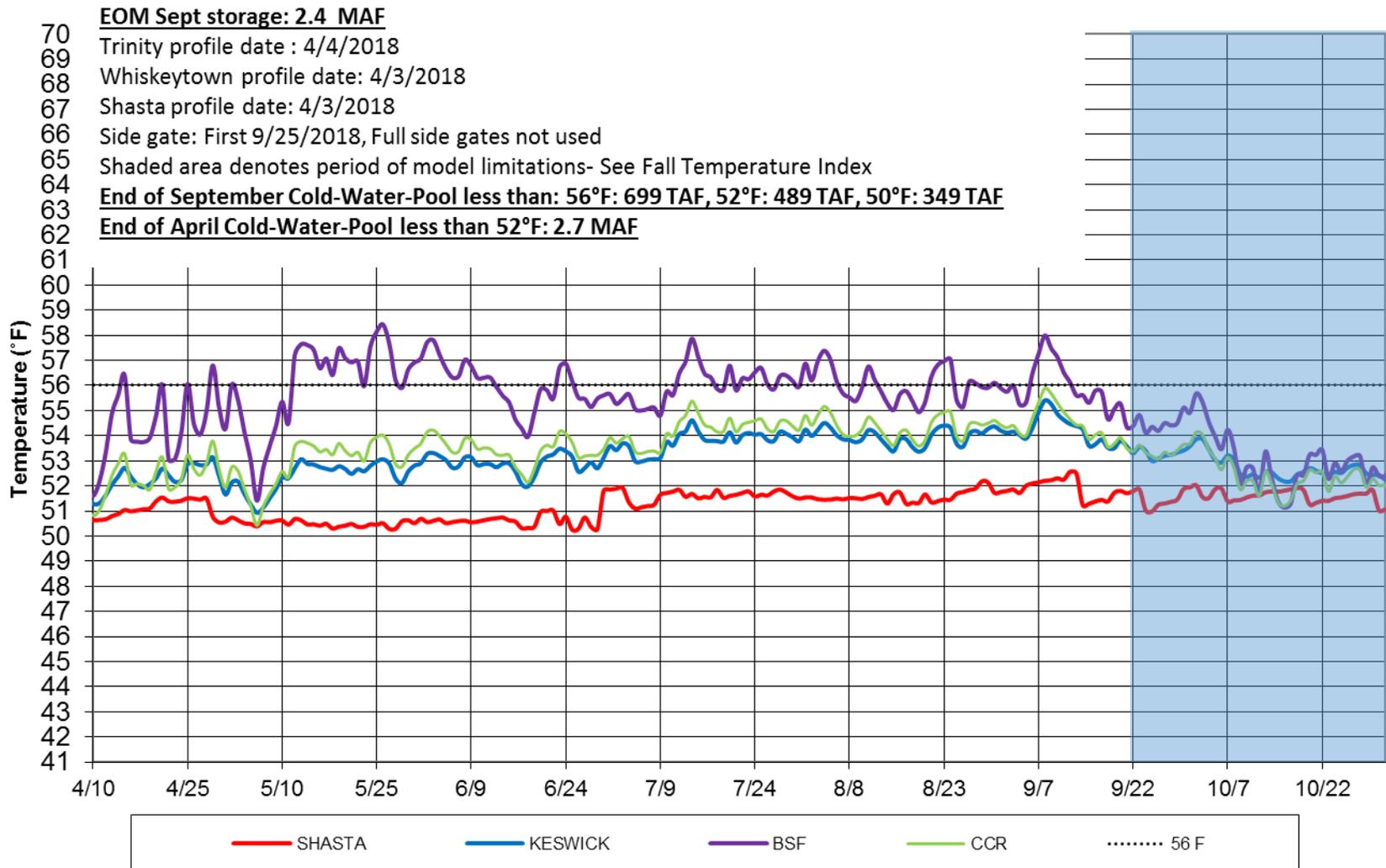


Figure 2

## Sacramento River Modeled Temperature 2018 April 50%-Exceedance Water Outlook - 10% L3MTO Meteorology

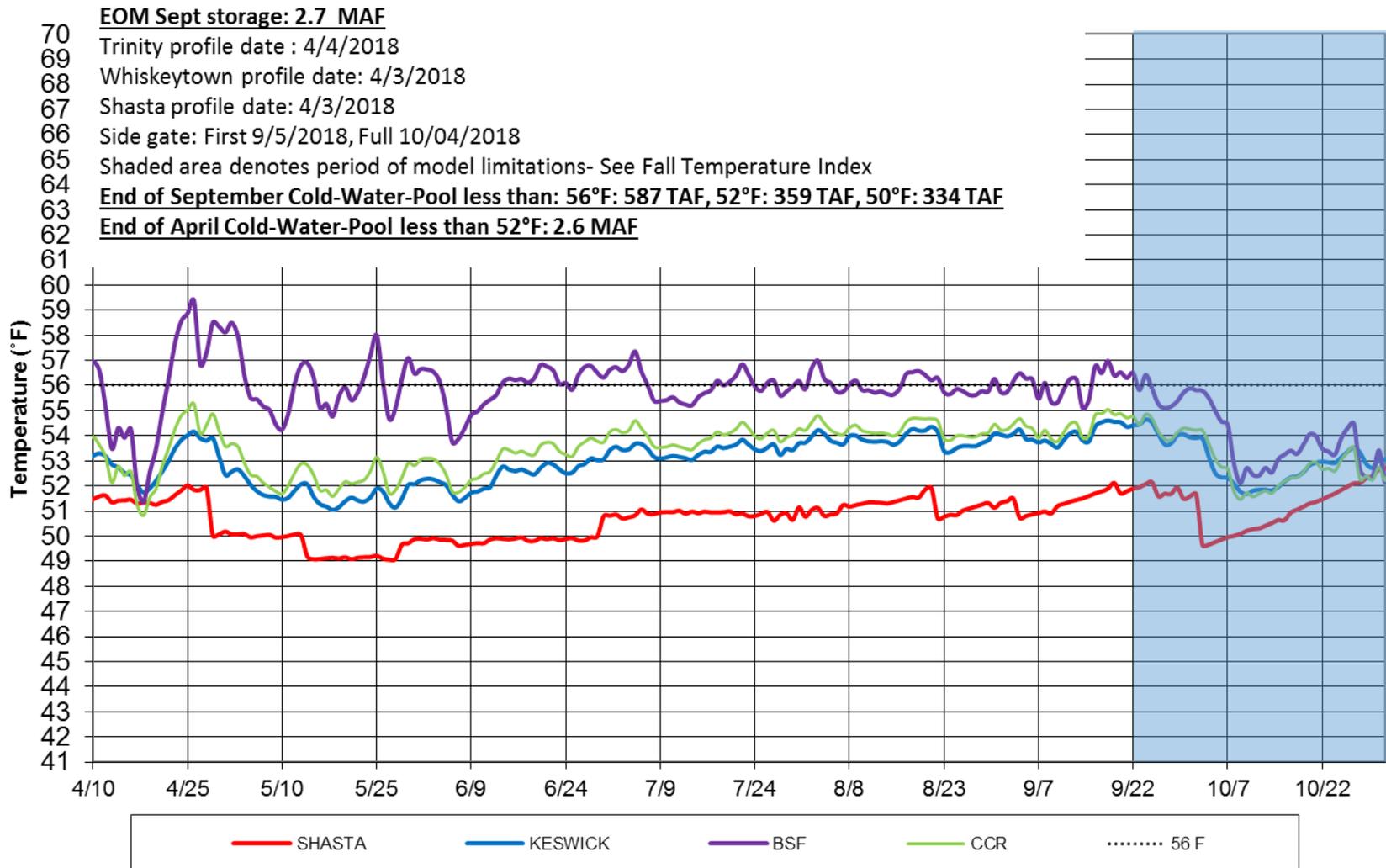


Figure 3

## Sacramento River Modeled Temperature 2018 April 50%-Exceedance Water Outlook - 50% L3MTO Meteorology

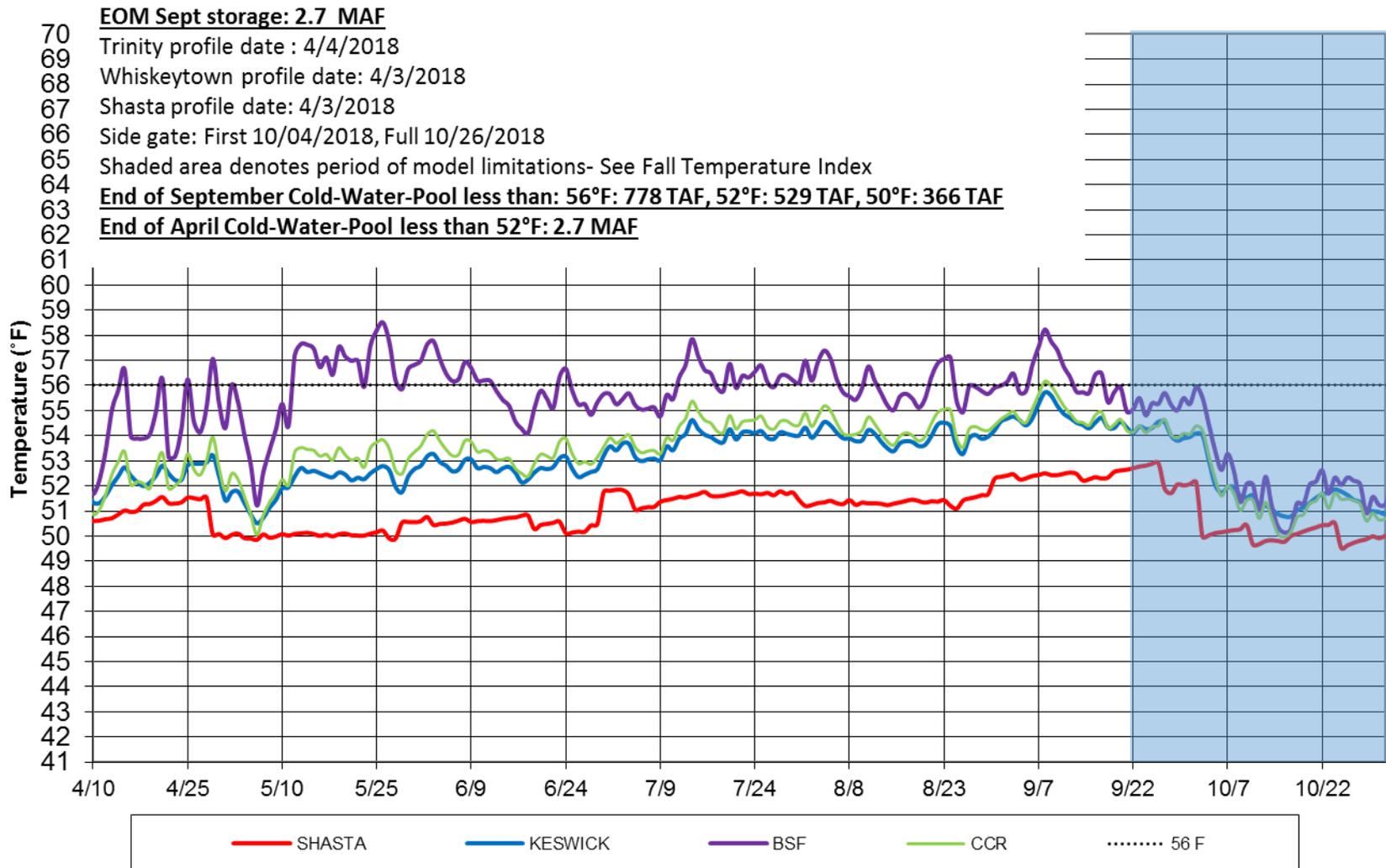
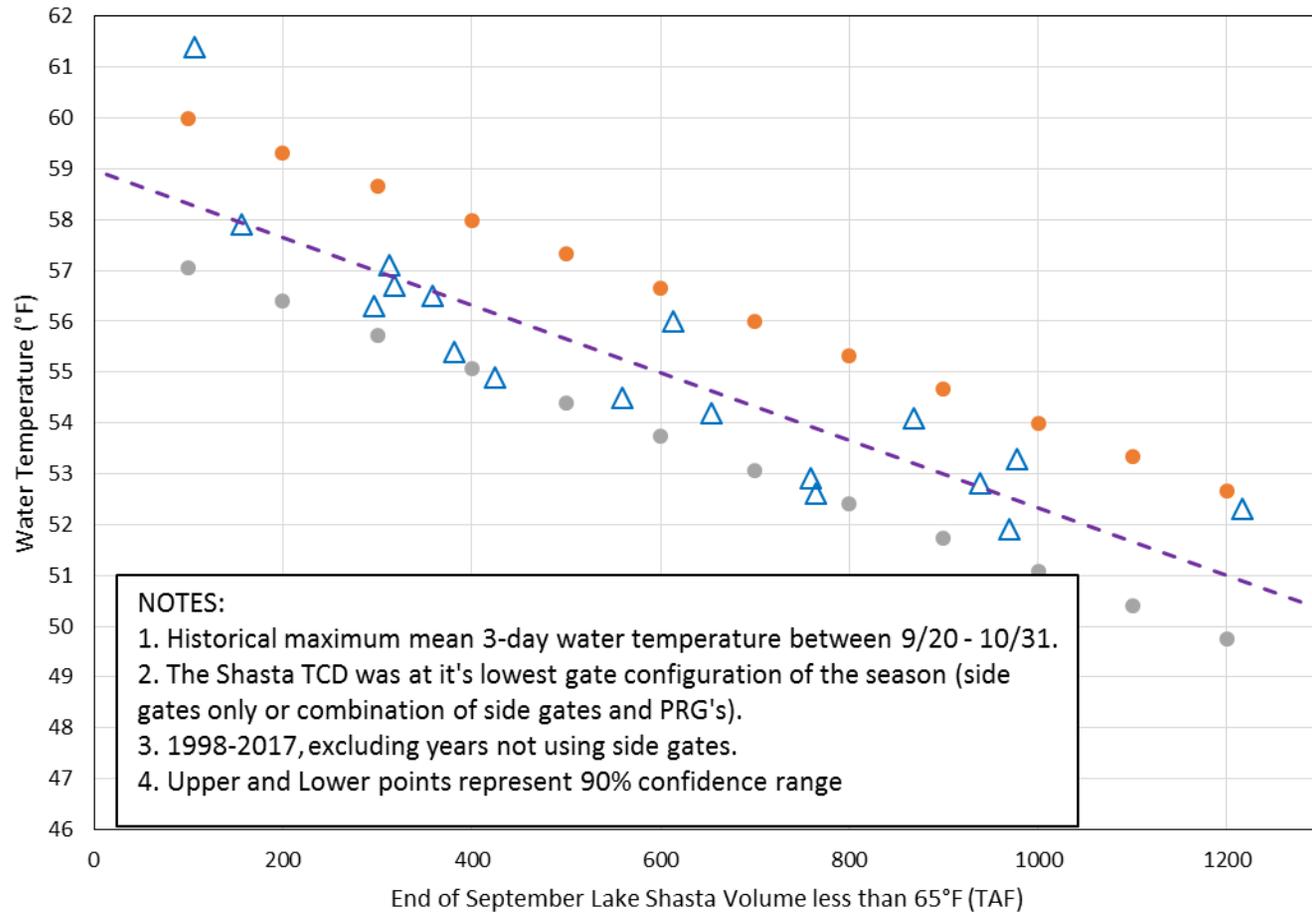


Figure 4

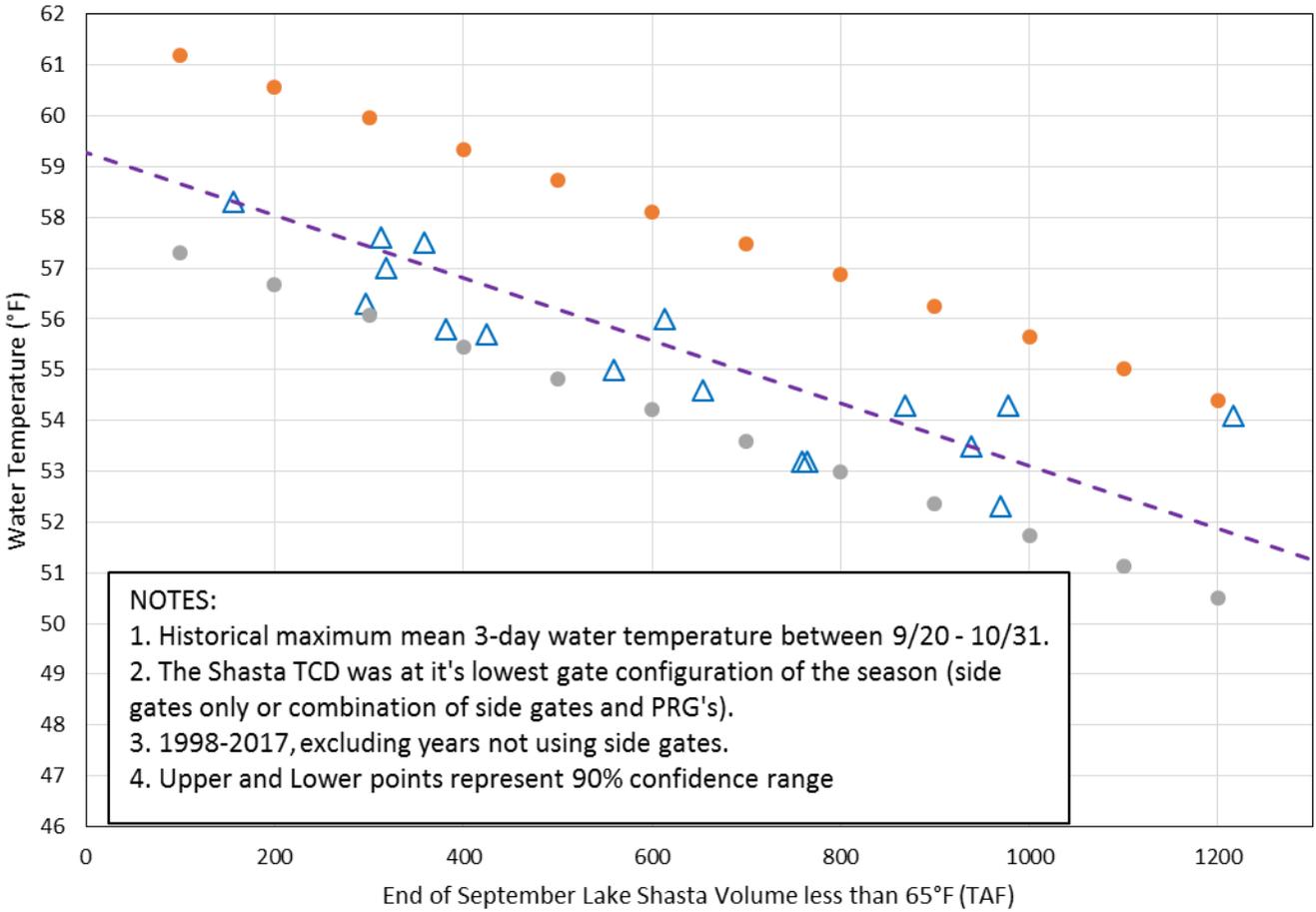
Figure 5 Model Performance and Fall Temperature Index:

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 can be used as an indicator of fall water temperature in the river reach to Balls Ferry.
3. Based on these records and estimates, the index below illustrates a range of uncertainty in the ability to meet for river temperatures not to exceed 56 °F downstream based on the end-of-September lake volume less than 56°F; see charts below.
4. Refinement of these estimates and concepts is currently underway.

### Sacramento River - Lake Shasta Early Fall Water Temperature - Keswick (KWK)



### Sacramento River - Lake Shasta Early Fall Water Temperature - Sac River above Clear Creek (CCR)



### Sacramento River - Lake Shasta Early Fall Water Temperature - Balls Ferry (BSF)

