Methods and Modeling

Conceptual models of impacts from drought management actions were presented in the Biological Review for the February-March Project Description (Figure 1, Reclamation 2015). The potential effects of the proposed April through September 2015 operational actions are considered in the context of these conceptual models. Additionally, the biological opinions (NMFS 2009, USFWS 2008) were reviewed regarding biological linkage to the considered actions.

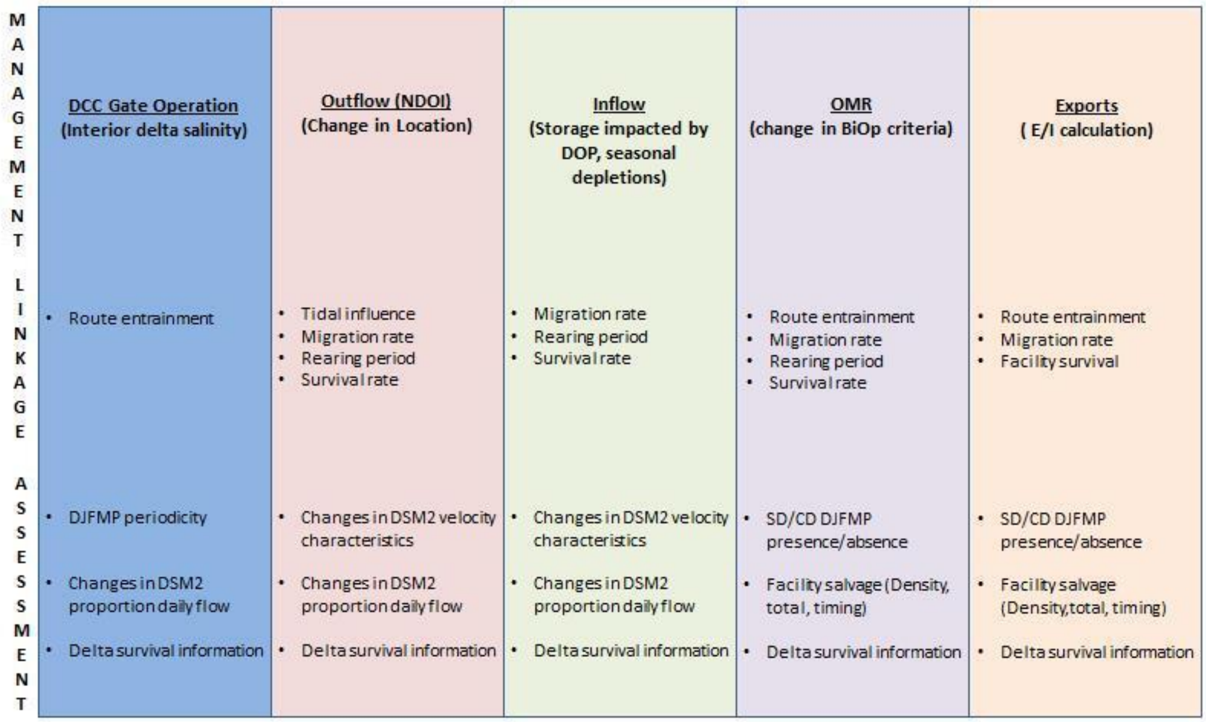

Figure 1 Conceptual model of drought contingency plan elements and their biological linkage to salmonids and assessment information available for evaluation.

Operational Forecast Model

The February 90% Operational Forecast provides potential tributary and Delta operational conditions. In particular, this information is useful for evaluating potential Central Valley Project and State Water Project (CVP and SWP) tributary operations during April through September. The reservoir releases in this forecast include implementation of RPA actions from the NMFS Biological Opinion on the Long Term Coordinated Operations of the CVP and SWP for Clear Creek, American River, and Stanislaus River. These are described in the Project Description, which includes some modifications of these actions. When these monthly average flows assume implementation different from the RPA, a qualitative description of habitat-related impacts are described. Temperature related impacts of the forecast related to divisions of the CVP are not included at this time, since the Sacramento River Temperature Task Group (SRRTG) is actively meeting to provide advice and review of the temperature forecast modeling to support development of the seasonal Sacramento Temperature Management Plan. Temperature management for the American River Group will be considered by the American River Group (ARG).

DSM2 Model

Delta Simulation Model II (DSM2) simulations were performed and evaluated for three operational management scenarios (Table 1). These simulations were designed to evaluate potential effects of the Project Description's reduced Sacramento and San Joaquin River outflow and other operational modifications on potential Delta hydrodynamics for the months of April through May when listed salmonids are most likely to be present in the Delta and hydrology forecasts are more foreseeable. These scenarios were concatenated to look at a 31-day pulse flow period ("April") and post-pulse period ("May") to evaluate DSM2 results. The Baseline scenario (Hydrology 1) represents an unmodified set of D-1641 standards for NDOI, Vernalis flows, and Delta Cross Channel Gate operations, while a Project Description scenario (Hydrology 2) included a modified NDOI and Vernalis flows.

The April modeled Vernalis average monthly flow, which were inclusive of an Appendix 2e pulse flow volume is likely positively biased compared to the predicted Vernalis average monthly flow during the pulse flow period, which in the TUCP is proposed to be no less than 710cfs. According to the modeled flows at Channel 6 (Mossdale, downstream of Vernalis but likely to have similar flow) summarized in Table 4 and 5, the modeled monthly average flow during April and May was 951 cfs, 241 cfs more than the 710 cfs proposed in the current TUCP order. Whether realized flows at Vernalis will more closely match the modeled flows or the proposed flows will depend on accretions and depletions during April and May. This uncertainty suggests modeled flows under the Project Description are likely greater than what will actually be observed, which influences the interpretation of any possible impacts on fishes resulting from the Project Description. Additionally, results from a hydrodynamic scenario with similar NDOI and Vernalis flows and an open DCC gate for two months are presented (Hydrology 2'). Other input values remained constant and reflected the best information available to DWR modelers when models were run on March 13, 2015. These flows do not necessarily reflect current forecast information and actual conditions have and will differ from the modeled scenarios. The modeled scenarios represent minimum values, yet provide the best evaluation approach to describing the worst conditions likely to be observed for the flow measures. These issues increase the uncertainty of assessments of impacts to all species reviewed.

Table 1. DSM2 Model Input for Scenarios Evaluated in the Biological Review. DSM2 Run Name is Listed Parenthetically for Each Scenario

	NDOI		Freeport flow (cfs)		Vernalis flow (cfs)		Combined Exports (cfs)		
Scenario	**April**	**May**	**April**	**May**	**April**	**May**	**April**	**May**	**DCC Status**
Baseline (Hydrology 1)	7,100		7,100- (VNS +export)		710 +3100 cfs (4/1 -5/1)		1,500		Closed
Project Description – DCC Gate Closed (Hydrology 2)	4,000		4,000-(Lower VNS +export)		300+App. 2e flow (4/1 – 5/1)[1]		1,500		Closed
Project Description -- DCC Gate Open (Hydrology 2')	4,000		4,000-(Lower VNS +export)		300+App. 2e flow (4/1 – 5/1)[1]		1,500		Open for 2 months

DSM2 modeling outputs for each scenario were used to evaluate the distribution of 15-minute flow and velocity values for multiple channels, including:

- Upstream of Head of Old River on San Joaquin (Channel 6)
- Downstream of Head of Old River on San Joaquin (Channel 9)
- Upstream of Stockton Deepwater Shipping Channel (Channel 12)
- Jersey Point on San Joaquin River (Channel 49)
- Sherman Island on San Joaquin River (Channel 50)
- Downstream of Head of Old River on Old River (Channel 54)
- Old River south of Railroad Cut (Channel 94)
- Old River at San Joaquin River (Channel 124)
- Middle River north of Railroad Cut (Channel 148)
- Three Mile Slough near San Joaquin River (Channel 310)
- Sacramento River near Sherwood Harbor (Channel 412)
- Sacramento River at Sutter Slough (Channel 388)
- Sacramento River upstream of Delta Cross Channel (Channel 421)
- Sacramento River downstream of Delta Cross Channel (Channel 422)

[1] The TUCP identifies proposed modification of the average monthly flow during the Vernalis 31-day pulse flow period to be no less than 710 cfs.

- Sacramento River upstream of Georgiana Slough (Channel 422)
- Sacramento river downstream of Georgiana Slough (Channel 423)
- Sacramento River near Cache Slough (Channel 429)
- Sherman Island on Sacramento River (Channel 434)

Hydrodynamic Metrics

Hydrodynamic metrics, such as daily mean velocity and flow were calculated (Tables 2-5). Additionally, mean daily proportion positive velocity, daily mean velocity, and daily mean flow were used to assess changes in the Delta at these locations. These were calculated over the separate April and May periods (Tables 6-7).

These data are also visualized spatially at both temporal steps to assess regional impacts and more complex hydrodynamics around the Delta Cross Channel and Head of Old River under each scenario. Daily proportion positive velocity is the percentage of the day that river flows have a positive velocity value (flows in downstream direction). Daily mean velocity and mean flow are the average of all values summed over the 24 hour period, which takes into account the effects of tidal stage on velocity magnitudes. These daily values are then averaged for the period of interest. The difference in the values of these hydrodynamic metrics between the Baseline and Project Description model run was calculated to assess how the metric was affected by the Project Description. We also calculated the difference in the values of these hydrodynamic metrics between the Project Description and Project Description with DCC gates open scenarios.

Density plots of DSM2 modeled 15-minute velocity data were developed for the eighteen channel nodes modeled for the two scenarios. Figures 2-23 show nodes showing variation between modeled scenarios in April and May periods for the different hydrology scenarios. These plots show low levels of change in the 15-minute velocity plots and in the lower river reaches tidal hydrodynamics and channel morphology drive channel velocities to a greater extent than the operational differences evaluated in the modeled scenarios. Figures 24-27 show spatially key channel nodes through the Delta during April and May for a few of the hydrodynamic metrics.

Differences in the river inflow between the Project Description and Baselines modeled scenarios are seen in the velocity plots at the upper extent of the tidal influence on the Sacramento near Sherwood Harbor (Figure 2-3) and San Joaquin river near Head of Old River (Figures 16-17). In the May portion of the model runs, there is a larger difference between the Baseline and Project Description modeled velocities due to reduced San Joaquin River contribution to the NDOI and thus greater flows at Freeport in May than April (Figures 2 and 3). At all other channel nodes during May and all nodes for the April portion of the model runs, the influence of these river inflows quickly dissipates as tides begin to dominate on the Sacramento (Figures 4-15). An open DCC gates during these months also impacts velocities upstream of the DCC gates (Channel node 421, Figures 6-7), and modeled results show a greater range of velocities, both negative and positive in this reach, due to increased flows rates downstream on an ebbing tide and upstream on a flooding tide. Modeled channel velocities in the Sacramento River near the DCC and Georgiana Slough differ between the Baseline and Project Description scenarios. Modeled results from the Project Description with an open DCC show a reduction in daily mean velocities in April and May downstream of the DCC (Channel node 422; Figures 8-9). At locations in the

North Delta further south, tidal conditions dominate and the range and magnitude of velocities observed in the modeling are similar into the western Delta (Figures 10-15).

Difference between the Project Description and Baseline model run influence the velocity along the San Joaquin River more during the modeled April period than May period (Figures 16-21) from upstream of Head of Old River to downstream of the Stockton Deepwater Ship Channel. These differences influence the proportion of daily positive flow (Tables 6-7), daily velocities (Tables 2-3), and daily flows (Tables 4-5). In the South Delta along Old and Middle River corridor, these changes are less significant due to the low export levels in the Baseline and Project Description model run. The modeled daily average hydrodynamic changes resulting from the proposed operations for both the April and May periods are small (Tables 4-5, approximately 62cfs for channel 148 in April and 152cfs in May) and do not show substantive differences in daily average velocities (Tables 2-3, Figure 22-23) between Baseline period at channel node 148 (Middle River north of Railroad Cut).

Table 2. Daily Mean Velocities (ft/sec) between Base and Project Description Model Scenarios and Their Difference (Hydrology 2 minus Hydrology 1) at All Channel Nodes during April

Date	Node 6			Node 9			Node 12			Node 49			Node 50		
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-Apr	1.20	0.26	-0.94	1.29	0.20	-1.09	1.05	0.19	-0.86	0.09	0.07	-0.03	0.10	0.08	-0.02
2-Apr	1.21	0.34	0.87	1.38	0.30	1.08	1.14	0.26	0.88	0.08	0.06	0.02	0.10	0.07	0.02
3-Apr	1.21	0.38	0.82	1.38	0.35	1.03	1.14	0.31	0.84	0.07	0.05	0.02	0.09	0.07	0.02
4-Apr	1.20	0.38	0.82	1.38	0.36	1.02	1.14	0.31	0.83	0.07	0.04	0.02	0.08	0.06	0.02
5-Apr	1.20	0.38	0.82	1.38	0.36	1.02	1.15	0.32	0.83	0.06	0.04	0.02	0.08	0.06	0.02
6-Apr	1.20	0.38	0.82	1.38	0.36	1.02	1.15	0.32	0.83	0.05	0.02	0.02	0.06	0.04	0.02
7-Apr	1.20	0.38	0.82	1.38	0.36	1.02	1.15	0.32	0.83	0.04	0.01	0.02	0.05	0.03	0.02
8-Apr	1.20	0.38	0.82	1.38	0.36	1.02	1.15	0.32	0.83	0.02	0.00	0.02	0.03	0.01	0.02
9-Apr	1.21	0.39	0.82	1.39	0.38	1.01	1.16	0.33	0.83	0.02	-0.01	0.02	0.03	0.00	0.02
10-Apr	1.21	0.40	0.81	1.41	0.42	0.99	1.17	0.36	0.81	0.02	0.00	0.02	0.03	0.01	0.02
11-Apr	1.21	0.40	0.81	1.42	0.42	0.99	1.19	0.38	0.81	0.05	0.03	0.02	0.06	0.04	0.02
12-Apr	1.22	0.40	0.82	1.41	0.41	1.00	1.19	0.38	0.82	0.09	0.06	0.02	0.09	0.07	0.02
13-Apr	1.21	0.39	0.82	1.41	0.40	1.01	1.18	0.36	0.82	0.10	0.08	0.02	0.11	0.09	0.02
14-Apr	1.21	0.39	0.82	1.40	0.39	1.01	1.17	0.35	0.82	0.11	0.09	0.02	0.12	0.10	0.02
15-Apr	1.20	0.38	0.83	1.38	0.36	1.02	1.17	0.34	0.82	0.11	0.09	0.02	0.13	0.10	0.02
16-Apr	1.20	0.38	0.82	1.37	0.35	1.02	1.15	0.33	0.83	0.11	0.09	0.02	0.13	0.11	0.02
17-Apr	1.19	0.37	0.81	1.36	0.34	1.02	1.14	0.31	0.83	0.11	0.09	0.02	0.13	0.11	0.02
18-Apr	1.18	0.37	0.81	1.35	0.34	1.01	1.13	0.31	0.82	0.10	0.08	0.02	0.12	0.10	0.02
19-Apr	1.18	0.37	0.81	1.35	0.35	1.00	1.13	0.31	0.82	0.08	0.05	0.02	0.10	0.08	0.02
20-Apr	1.18	0.37	0.80	1.35	0.35	1.00	1.14	0.31	0.82	0.05	0.03	0.02	0.08	0.05	0.02
21-Apr	1.18	0.38	0.81	1.36	0.35	1.01	1.14	0.32	0.83	0.03	0.01	0.02	0.05	0.03	0.02
22-Apr	1.19	0.38	0.81	1.38	0.36	1.02	1.15	0.32	0.83	0.02	0.00	0.02	0.03	0.01	0.02
23-Apr	1.20	0.40	0.81	1.40	0.40	1.00	1.16	0.34	0.82	0.02	-0.01	0.02	0.03	0.00	0.02
24-Apr	1.22	0.40	0.81	1.42	0.42	1.00	1.19	0.38	0.81	0.03	0.01	0.02	0.04	0.02	0.02
25-Apr	1.22	0.41	0.82	1.43	0.43	1.01	1.20	0.38	0.82	0.07	0.05	0.02	0.07	0.05	0.02
26-Apr	1.23	0.40	0.83	1.43	0.42	1.01	1.20	0.38	0.83	0.09	0.07	0.02	0.09	0.07	0.02
27-Apr	1.23	0.40	0.83	1.42	0.41	1.02	1.19	0.36	0.83	0.10	0.08	0.02	0.11	0.08	0.02
28-Apr	1.23	0.36	0.87	1.42	0.36	1.06	1.18	0.32	0.86	0.10	0.08	0.02	0.11	0.09	0.02
29-Apr	0.79	0.38	0.41	0.92	0.34	0.58	0.75	0.28	0.47	0.09	0.07	0.02	0.10	0.08	0.02
30-Apr	0.37	0.34	0.03	0.30	0.27	0.03	0.25	0.23	0.02	0.08	0.07	0.01	0.09	0.08	0.01

Date	Node 54			Node 94			Node 124			Node 148		
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-Apr	0.36	-0.06	-0.20	-0.01	-0.03	-0.04	-0.06	-0.06	0.01	-0.02	-0.03	-0.01
2-Apr	0.37	-0.06	0.18	-0.04	-0.03	0.02	-0.07	-0.06	-0.01	-0.03	-0.03	0.01
3-Apr	0.37	-0.06	0.16	-0.03	-0.03	0.02	-0.07	-0.06	-0.01	-0.03	-0.03	0.01
4-Apr	0.37	-0.06	0.16	-0.02	-0.03	0.02	-0.07	-0.06	-0.01	-0.02	-0.03	0.01
5-Apr	0.37	-0.06	0.16	-0.02	-0.03	0.02	-0.07	-0.06	-0.01	-0.02	-0.03	0.01
6-Apr	0.37	-0.07	0.16	-0.02	-0.03	0.02	-0.07	-0.07	-0.01	-0.03	-0.03	0.01
7-Apr	0.37	-0.07	0.16	-0.02	-0.03	0.02	-0.07	-0.07	-0.01	-0.03	-0.03	0.01
8-Apr	0.37	-0.07	0.16	-0.03	-0.04	0.02	-0.08	-0.07	-0.01	-0.03	-0.04	0.01
9-Apr	0.37	-0.06	0.17	-0.02	-0.04	0.02	-0.07	-0.06	-0.01	-0.03	-0.04	0.01
10-Apr	0.36	-0.05	0.17	0.01	-0.02	0.02	-0.06	-0.05	-0.01	-0.02	-0.02	0.01
11-Apr	0.36	-0.04	0.17	0.04	0.00	0.02	-0.05	-0.04	-0.01	0.00	0.00	0.01
12-Apr	0.36	-0.04	0.17	0.05	0.00	0.02	-0.05	-0.04	-0.01	0.01	0.00	0.01
13-Apr	0.36	-0.04	0.17	0.05	0.00	0.02	-0.05	-0.04	-0.01	0.01	0.00	0.01
14-Apr	0.36	-0.04	0.17	0.04	0.00	0.02	-0.05	-0.04	-0.01	0.01	0.00	0.01
15-Apr	0.36	-0.05	0.16	0.03	0.00	0.02	-0.06	-0.05	-0.01	0.00	0.00	0.01
16-Apr	0.36	-0.05	0.16	0.02	-0.01	0.02	-0.06	-0.05	-0.01	0.00	-0.01	0.01
17-Apr	0.36	-0.06	0.16	0.00	-0.02	0.02	-0.07	-0.06	-0.01	-0.01	-0.02	0.01
18-Apr	0.36	-0.06	0.16	-0.02	-0.03	0.02	-0.07	-0.06	-0.01	-0.02	-0.03	0.01
19-Apr	0.36	-0.07	0.16	-0.03	-0.03	0.02	-0.08	-0.07	-0.01	-0.03	-0.03	0.01
20-Apr	0.36	-0.07	0.16	-0.03	-0.04	0.02	-0.08	-0.07	-0.01	-0.03	-0.04	0.01
21-Apr	0.36	-0.07	0.16	-0.03	-0.04	0.02	-0.08	-0.07	-0.01	-0.03	-0.04	0.01
22-Apr	0.36	-0.07	0.16	-0.03	-0.04	0.02	-0.08	-0.07	-0.01	-0.03	-0.04	0.01
23-Apr	0.36	-0.06	0.16	-0.01	-0.03	0.02	-0.07	-0.06	-0.01	-0.03	-0.03	0.01
24-Apr	0.36	-0.05	0.17	0.03	-0.01	0.02	-0.05	-0.05	-0.01	0.00	-0.01	0.01
25-Apr	0.36	-0.04	0.17	0.05	0.00	0.02	-0.05	-0.04	-0.01	0.01	0.00	0.01
26-Apr	0.37	-0.04	0.17	0.05	0.00	0.02	-0.05	-0.04	-0.01	0.01	0.00	0.01
27-Apr	0.37	-0.04	0.18	0.04	0.00	0.02	-0.05	-0.04	-0.01	0.01	0.00	0.01
28-Apr	0.37	-0.04	0.19	0.03	-0.01	0.02	-0.05	-0.04	-0.01	0.00	-0.01	0.01
29-Apr	0.26	-0.04	0.09	0.01	-0.01	0.02	-0.05	-0.04	-0.01	-0.01	-0.01	0.01
30-Apr	0.16	-0.05	0.01	0.00	-0.01	0.00	-0.05	-0.05	0.00	-0.01	-0.01	0.00

Date	Node 310			Node 388			Node 412			Node 421			Node 422		
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-Apr	0.05	0.02	-0.03	0.52	0.46	-0.06	0.63	0.56	-0.07	0.51	0.45	-0.05	0.45	0.40	-0.05
2-Apr	0.04	0.01	0.03	0.51	0.44	0.07	0.63	0.53	0.10	0.50	0.43	0.07	0.44	0.38	0.06
3-Apr	0.03	0.00	0.03	0.51	0.44	0.07	0.63	0.53	0.10	0.50	0.43	0.07	0.44	0.38	0.06
4-Apr	0.02	0.00	0.03	0.52	0.44	0.07	0.64	0.54	0.10	0.50	0.43	0.07	0.44	0.38	0.06
5-Apr	0.01	-0.01	0.03	0.52	0.44	0.07	0.64	0.54	0.10	0.50	0.43	0.07	0.44	0.38	0.06
6-Apr	0.00	-0.02	0.03	0.51	0.44	0.07	0.64	0.54	0.10	0.50	0.43	0.07	0.44	0.38	0.06
7-Apr	-0.01	-0.03	0.03	0.51	0.44	0.08	0.64	0.54	0.10	0.50	0.43	0.07	0.44	0.38	0.06
8-Apr	-0.02	-0.05	0.03	0.51	0.44	0.08	0.64	0.54	0.10	0.50	0.43	0.07	0.44	0.38	0.06
9-Apr	-0.02	-0.05	0.03	0.51	0.44	0.08	0.65	0.55	0.10	0.51	0.44	0.07	0.45	0.38	0.06
10-Apr	-0.01	-0.04	0.02	0.54	0.46	0.07	0.66	0.56	0.10	0.52	0.46	0.07	0.46	0.40	0.06
11-Apr	0.03	0.00	0.02	0.58	0.50	0.07	0.67	0.57	0.10	0.54	0.47	0.07	0.48	0.42	0.06
12-Apr	0.06	0.03	0.02	0.58	0.51	0.07	0.67	0.57	0.10	0.55	0.48	0.07	0.48	0.42	0.06
13-Apr	0.07	0.05	0.03	0.58	0.50	0.07	0.67	0.57	0.10	0.54	0.47	0.07	0.48	0.42	0.06
14-Apr	0.07	0.05	0.03	0.57	0.50	0.07	0.66	0.56	0.10	0.54	0.47	0.07	0.48	0.41	0.06
15-Apr	0.07	0.05	0.03	0.56	0.49	0.07	0.65	0.55	0.10	0.53	0.46	0.07	0.47	0.41	0.06
16-Apr	0.07	0.04	0.03	0.55	0.48	0.07	0.64	0.54	0.10	0.52	0.45	0.07	0.46	0.40	0.06
17-Apr	0.06	0.04	0.03	0.54	0.47	0.07	0.64	0.54	0.10	0.51	0.44	0.07	0.45	0.39	0.06
18-Apr	0.05	0.03	0.03	0.53	0.46	0.07	0.64	0.54	0.10	0.50	0.43	0.07	0.45	0.38	0.06
19-Apr	0.03	0.00	0.03	0.53	0.46	0.07	0.64	0.54	0.10	0.50	0.43	0.07	0.44	0.38	0.06
20-Apr	0.00	-0.03	0.03	0.53	0.45	0.07	0.64	0.54	0.10	0.50	0.43	0.07	0.44	0.38	0.06
21-Apr	-0.02	-0.04	0.03	0.52	0.45	0.08	0.64	0.54	0.10	0.50	0.43	0.07	0.44	0.38	0.06
22-Apr	-0.03	-0.05	0.03	0.52	0.44	0.07	0.64	0.54	0.10	0.51	0.43	0.07	0.44	0.38	0.06
23-Apr	-0.02	-0.05	0.03	0.52	0.45	0.07	0.65	0.56	0.10	0.51	0.44	0.07	0.45	0.39	0.06
24-Apr	0.00	-0.02	0.02	0.56	0.49	0.07	0.67	0.58	0.10	0.54	0.47	0.07	0.48	0.42	0.06
25-Apr	0.04	0.02	0.02	0.59	0.51	0.07	0.68	0.58	0.10	0.56	0.49	0.07	0.49	0.43	0.06
26-Apr	0.06	0.04	0.02	0.58	0.51	0.07	0.69	0.59	0.10	0.56	0.49	0.07	0.49	0.43	0.06
27-Apr	0.07	0.04	0.03	0.57	0.50	0.08	0.68	0.58	0.10	0.55	0.48	0.07	0.49	0.43	0.06
28-Apr	0.06	0.04	0.03	0.57	0.50	0.07	0.68	0.59	0.08	0.55	0.48	0.06	0.48	0.43	0.06
29-Apr	0.04	0.03	0.01	0.71	0.50	0.21	0.86	0.58	0.27	0.67	0.48	0.18	0.59	0.43	0.16
30-Apr	0.02	0.02	0.00	0.73	0.50	0.23	0.88	0.59	0.29	0.70	0.49	0.22	0.62	0.43	0.19

Date	Node 423			Node 429			Node 434		
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-Apr	0.36	0.32	-0.05	0.33	0.29	-0.04	0.12	0.10	-0.01
2-Apr	0.36	0.29	-0.06	0.32	0.27	-0.05	0.11	0.09	-0.01
3-Apr	0.35	0.29	-0.06	0.32	0.27	-0.05	0.10	0.09	-0.01
4-Apr	0.35	0.28	-0.06	0.31	0.26	-0.05	0.09	0.08	-0.01
5-Apr	0.35	0.28	-0.06	0.31	0.26	-0.05	0.09	0.07	-0.01
6-Apr	0.35	0.28	-0.06	0.30	0.25	-0.05	0.08	0.06	-0.01
7-Apr	0.35	0.28	-0.07	0.30	0.25	-0.05	0.06	0.05	-0.01
8-Apr	0.35	0.28	-0.07	0.30	0.25	-0.05	0.05	0.04	-0.01
9-Apr	0.35	0.29	-0.07	0.30	0.25	-0.05	0.04	0.02	-0.01
10-Apr	0.37	0.31	-0.06	0.31	0.26	-0.05	0.03	0.02	-0.01
11-Apr	0.40	0.34	-0.06	0.34	0.29	-0.05	0.06	0.04	-0.01
12-Apr	0.41	0.35	-0.06	0.35	0.30	-0.05	0.09	0.07	-0.01
13-Apr	0.41	0.35	-0.06	0.36	0.31	-0.05	0.11	0.09	-0.01
14-Apr	0.40	0.34	-0.06	0.36	0.31	-0.05	0.12	0.11	-0.01
15-Apr	0.39	0.33	-0.06	0.35	0.30	-0.05	0.13	0.11	-0.01
16-Apr	0.38	0.32	-0.06	0.35	0.30	-0.05	0.13	0.12	-0.01
17-Apr	0.37	0.30	-0.06	0.35	0.30	-0.05	0.14	0.12	-0.01
18-Apr	0.35	0.29	-0.06	0.34	0.29	-0.05	0.13	0.12	-0.01
19-Apr	0.34	0.28	-0.06	0.32	0.28	-0.05	0.11	0.10	-0.01
20-Apr	0.34	0.27	-0.06	0.31	0.26	-0.05	0.09	0.07	-0.01
21-Apr	0.34	0.28	-0.06	0.30	0.25	-0.05	0.06	0.05	-0.01
22-Apr	0.34	0.28	-0.06	0.30	0.25	-0.05	0.04	0.03	-0.01
23-Apr	0.35	0.29	-0.06	0.30	0.25	-0.05	0.03	0.02	-0.01
24-Apr	0.39	0.33	-0.06	0.32	0.27	-0.05	0.04	0.03	-0.01
25-Apr	0.42	0.36	-0.06	0.35	0.30	-0.05	0.07	0.05	-0.01
26-Apr	0.43	0.37	-0.07	0.37	0.31	-0.05	0.09	0.08	-0.01
27-Apr	0.43	0.36	-0.07	0.37	0.32	-0.05	0.11	0.09	-0.01
28-Apr	0.42	0.36	-0.06	0.37	0.32	-0.05	0.11	0.10	-0.01
29-Apr	0.52	0.36	-0.16	0.44	0.32	-0.13	0.13	0.10	-0.03
30-Apr	0.54	0.35	-0.18	0.46	0.32	-0.15	0.13	0.10	-0.03

Table 3. Daily Mean Velocities (ft/sec) between Base and Project Description Model Scenarios and Their Difference (Hydrology 2 minus Hydrology 1) at All Channel Nodes during May

Date	Node 6			Node 9			Node 12			Node 49			Node 50			Node 54			Node 94			Node 124			Node 148		
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-May	0.35	0.21	0.14	0.26	0.15	0.11	0.21	0.13	0.08	0.06	0.05	0.01	0.08	0.07	0.01	0.16	-0.06	0.04	-0.05	-0.03	0.01	-0.06	-0.06	0.00	-0.03	-0.03	0.00
2-May	0.33	0.12	0.21	0.24	0.05	0.18	0.19	0.05	0.14	0.06	0.04	0.01	0.07	0.06	0.01	0.16	-0.06	0.07	-0.08	-0.04	0.01	-0.07	-0.06	0.00	-0.04	-0.04	0.00
3-May	0.33	0.12	0.21	0.24	0.05	0.19	0.18	0.04	0.14	0.05	0.04	0.01	0.07	0.06	0.01	0.16	-0.07	0.07	-0.09	-0.05	0.01	-0.07	-0.07	0.00	-0.04	-0.05	0.00
4-May	0.33	0.12	0.21	0.24	0.05	0.19	0.18	0.04	0.14	0.05	0.04	0.01	0.07	0.06	0.01	0.16	-0.07	0.07	-0.09	-0.05	0.01	-0.07	-0.07	0.00	-0.05	-0.05	0.00
5-May	0.33	0.12	0.21	0.24	0.05	0.19	0.19	0.05	0.14	0.04	0.03	0.01	0.06	0.05	0.01	0.16	-0.07	0.07	-0.09	-0.06	0.01	-0.08	-0.07	0.00	-0.05	-0.06	0.00
6-May	0.33	0.12	0.21	0.24	0.05	0.19	0.19	0.05	0.14	0.02	0.01	0.01	0.04	0.03	0.01	0.16	-0.07	0.07	-0.10	-0.06	0.01	-0.08	-0.07	0.00	-0.05	-0.06	0.00
7-May	0.34	0.13	0.21	0.24	0.06	0.18	0.19	0.05	0.14	0.01	0.00	0.01	0.03	0.02	0.01	0.17	-0.07	0.07	-0.10	-0.06	0.01	-0.08	-0.07	0.00	-0.06	-0.06	0.00
8-May	0.35	0.15	0.20	0.27	0.09	0.18	0.20	0.07	0.13	0.00	-0.01	0.01	0.01	0.00	0.01	0.16	-0.07	0.07	-0.09	-0.06	0.01	-0.07	-0.07	0.00	-0.06	-0.06	0.00
9-May	0.36	0.15	0.21	0.30	0.12	0.19	0.23	0.09	0.14	0.00	-0.01	0.01	0.01	0.00	0.01	0.16	-0.06	0.07	-0.06	-0.05	0.01	-0.06	-0.06	0.00	-0.04	-0.05	0.00
10-May	0.37	0.15	0.22	0.31	0.12	0.19	0.24	0.11	0.14	0.01	0.00	0.01	0.02	0.01	0.01	0.16	-0.05	0.07	-0.04	-0.03	0.01	-0.06	-0.05	0.00	-0.03	-0.03	0.00
11-May	0.37	0.15	0.22	0.31	0.12	0.19	0.25	0.11	0.14	0.04	0.03	0.01	0.04	0.04	0.01	0.16	-0.05	0.07	-0.03	-0.03	0.01	-0.06	-0.05	0.00	-0.02	-0.03	0.00
12-May	0.36	0.14	0.22	0.30	0.11	0.19	0.24	0.10	0.14	0.06	0.05	0.01	0.07	0.06	0.01	0.16	-0.05	0.08	-0.03	-0.03	0.01	-0.06	-0.05	0.00	-0.02	-0.03	0.00
13-May	0.36	0.14	0.22	0.29	0.10	0.19	0.23	0.09	0.14	0.07	0.06	0.01	0.08	0.07	0.01	0.16	-0.05	0.08	-0.04	-0.03	0.01	-0.05	-0.05	0.00	-0.02	-0.03	0.00
14-May	0.35	0.14	0.22	0.28	0.09	0.19	0.22	0.08	0.14	0.08	0.07	0.01	0.09	0.08	0.01	0.16	-0.05	0.08	-0.04	-0.03	0.01	-0.06	-0.05	0.00	-0.03	-0.03	0.00
15-May	0.33	0.12	0.21	0.26	0.07	0.18	0.22	0.08	0.14	0.09	0.07	0.01	0.10	0.09	0.01	0.16	-0.05	0.07	-0.04	-0.03	0.01	-0.06	-0.05	0.00	-0.03	-0.03	0.00
16-May	0.32	0.11	0.21	0.23	0.05	0.18	0.21	0.07	0.14	0.09	0.08	0.01	0.11	0.10	0.01	0.16	-0.06	0.07	-0.05	-0.03	0.01	-0.06	-0.06	0.00	-0.03	-0.03	0.00
17-May	0.32	0.11	0.21	0.22	0.04	0.19	0.19	0.05	0.14	0.09	0.07	0.01	0.11	0.10	0.01	0.16	-0.07	0.07	-0.06	-0.04	0.01	-0.07	-0.07	0.00	-0.03	-0.04	0.00
18-May	0.32	0.11	0.21	0.23	0.04	0.18	0.18	0.04	0.14	0.07	0.06	0.01	0.10	0.09	0.01	0.16	-0.07	0.07	-0.09	-0.05	0.01	-0.08	-0.07	0.00	-0.05	-0.05	0.00
19-May	0.32	0.12	0.20	0.23	0.05	0.18	0.18	0.04	0.14	0.05	0.04	0.01	0.08	0.07	0.01	0.16	-0.08	0.07	-0.10	-0.06	0.01	-0.08	-0.08	0.00	-0.05	-0.06	0.00
20-May	0.32	0.12	0.21	0.23	0.05	0.19	0.19	0.05	0.14	0.02	0.01	0.01	0.04	0.03	0.01	0.17	-0.08	0.06	-0.10	-0.06	0.01	-0.08	-0.08	0.00	-0.06	-0.06	0.00
21-May	0.33	0.13	0.20	0.24	0.06	0.18	0.19	0.06	0.13	0.00	-0.01	0.01	0.02	0.01	0.01	0.17	-0.08	0.07	-0.09	-0.06	0.01	-0.08	-0.08	0.00	-0.06	-0.06	0.00
22-May	0.35	0.15	0.20	0.28	0.10	0.18	0.21	0.07	0.13	0.00	-0.01	0.01	0.01	0.00	0.01	0.16	-0.07	0.06	-0.08	-0.06	0.01	-0.07	-0.07	0.00	-0.06	-0.06	0.00
23-May	0.37	0.15	0.21	0.30	0.12	0.19	0.23	0.10	0.14	0.00	-0.01	0.01	0.01	0.00	0.01	0.16	-0.06	0.07	-0.06	-0.05	0.01	-0.06	-0.06	0.00	-0.04	-0.05	0.00
24-May	0.37	0.15	0.22	0.31	0.12	0.19	0.24	0.10	0.14	0.02	0.01	0.01	0.02	0.01	0.01	0.16	-0.05	0.07	-0.05	-0.03	0.01	-0.05	-0.05	0.00	-0.03	-0.03	0.00
25-May	0.37	0.15	0.22	0.31	0.12	0.19	0.24	0.10	0.14	0.04	0.03	0.01	0.04	0.03	0.01	0.16	-0.05	0.08	-0.04	-0.03	0.01	-0.05	-0.05	0.00	-0.03	-0.03	0.00
26-May	0.37	0.15	0.23	0.30	0.11	0.19	0.23	0.09	0.14	0.05	0.04	0.01	0.06	0.05	0.01	0.16	-0.05	0.08	-0.05	-0.03	0.01	-0.05	-0.05	0.00	-0.03	-0.03	0.00
27-May	0.36	0.14	0.23	0.29	0.09	0.19	0.22	0.08	0.14	0.06	0.05	0.01	0.06	0.05	0.01	0.16	-0.05	0.08	-0.06	-0.03	0.01	-0.05	-0.05	0.00	-0.03	-0.03	0.00
28-May	0.36	0.13	0.22	0.28	0.08	0.19	0.21	0.07	0.14	0.06	0.05	0.01	0.07	0.06	0.01	0.16	-0.05	0.07	-0.05	-0.03	0.01	-0.05	-0.05	0.00	-0.03	-0.03	0.00
29-May	0.35	0.13	0.22	0.27	0.07	0.19	0.21	0.06	0.14	0.06	0.05	0.01	0.07	0.06	0.01	0.16	-0.05	0.07	-0.06	-0.04	0.01	-0.06	-0.05	0.00	-0.03	-0.04	0.00
30-May	0.33	0.12	0.21	0.26	0.07	0.19	0.21	0.06	0.14	0.06	0.05	0.01	0.07	0.06	0.01	0.16	-0.06	0.07	-0.06	-0.04	0.01	-0.06	-0.06	0.00	-0.03	-0.04	0.00
31-May	0.27	0.15	0.12	0.20	0.09	0.11	0.18	0.09	0.09	0.06	0.05	0.01	0.07	0.07	0.01	0.14	-0.06	0.04	-0.06	-0.03	0.01	-0.06	-0.06	0.00	-0.03	-0.03	0.00

Date	Node 310			Node 388			Node 412			Node 421			Node 422			Node 423			Node 429			Node 434		
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-May	0.00	0.00	0.00	0.71	0.51	0.21	0.88	0.61	0.26	0.69	0.50	0.20	0.61	0.44	0.17	0.52	0.35	-0.17	0.45	0.32	-0.13	0.12	0.09	-0.03
2-May	-0.01	-0.01	0.00	0.70	0.50	0.20	0.87	0.61	0.26	0.69	0.49	0.19	0.61	0.44	0.17	0.51	0.34	-0.17	0.44	0.31	-0.13	0.12	0.09	-0.03
3-May	-0.01	-0.01	0.00	0.70	0.50	0.20	0.87	0.62	0.26	0.68	0.49	0.19	0.60	0.44	0.17	0.50	0.34	-0.17	0.44	0.31	-0.13	0.12	0.09	-0.03
4-May	-0.01	-0.01	0.00	0.70	0.50	0.20	0.88	0.62	0.26	0.68	0.49	0.19	0.60	0.44	0.17	0.50	0.33	-0.17	0.44	0.31	-0.13	0.12	0.09	-0.03
5-May	-0.02	-0.02	0.00	0.70	0.50	0.20	0.88	0.62	0.26	0.68	0.49	0.19	0.60	0.43	0.17	0.50	0.33	-0.17	0.43	0.30	-0.13	0.11	0.09	-0.03
6-May	-0.04	-0.04	0.00	0.70	0.50	0.20	0.88	0.62	0.26	0.68	0.49	0.19	0.60	0.43	0.17	0.50	0.33	-0.17	0.43	0.29	-0.13	0.09	0.07	-0.03
7-May	-0.05	-0.05	0.00	0.70	0.50	0.20	0.88	0.62	0.26	0.69	0.50	0.19	0.61	0.44	0.17	0.50	0.33	-0.17	0.42	0.29	-0.13	0.08	0.05	-0.03
8-May	-0.06	-0.06	0.00	0.70	0.50	0.20	0.89	0.63	0.26	0.69	0.50	0.19	0.61	0.44	0.17	0.50	0.33	-0.17	0.42	0.29	-0.13	0.06	0.04	-0.03
9-May	-0.06	-0.06	0.00	0.71	0.52	0.20	0.90	0.64	0.25	0.70	0.52	0.18	0.62	0.46	0.16	0.51	0.35	-0.16	0.42	0.30	-0.13	0.05	0.03	-0.02
10-May	-0.03	-0.04	0.00	0.75	0.55	0.19	0.91	0.66	0.26	0.72	0.54	0.18	0.63	0.47	0.16	0.53	0.37	-0.16	0.44	0.31	-0.12	0.06	0.04	-0.02
11-May	-0.01	-0.01	0.00	0.77	0.57	0.20	0.92	0.67	0.26	0.73	0.55	0.18	0.65	0.48	0.16	0.56	0.39	-0.16	0.46	0.33	-0.13	0.08	0.06	-0.02
12-May	0.01	0.01	0.00	0.78	0.57	0.21	0.93	0.67	0.25	0.74	0.55	0.19	0.65	0.49	0.16	0.57	0.40	-0.17	0.48	0.34	-0.13	0.10	0.08	-0.03
13-May	0.02	0.01	0.00	0.78	0.57	0.21	0.92	0.67	0.25	0.73	0.55	0.19	0.65	0.48	0.16	0.57	0.40	-0.17	0.48	0.35	-0.13	0.12	0.10	-0.03
14-May	0.02	0.02	0.00	0.77	0.57	0.21	0.91	0.66	0.25	0.73	0.54	0.19	0.65	0.48	0.17	0.56	0.40	-0.16	0.48	0.35	-0.13	0.13	0.11	-0.03
15-May	0.02	0.02	0.00	0.77	0.56	0.20	0.90	0.65	0.25	0.73	0.54	0.19	0.64	0.48	0.17	0.55	0.39	-0.16	0.48	0.35	-0.13	0.14	0.12	-0.03
16-May	0.03	0.02	0.00	0.76	0.56	0.20	0.90	0.64	0.25	0.72	0.53	0.19	0.64	0.47	0.17	0.54	0.38	-0.16	0.48	0.35	-0.13	0.15	0.13	-0.03
17-May	0.02	0.02	0.00	0.74	0.54	0.20	0.90	0.64	0.25	0.71	0.52	0.19	0.63	0.46	0.17	0.53	0.37	-0.16	0.48	0.35	-0.13	0.15	0.13	-0.03
18-May	0.01	0.01	0.00	0.73	0.53	0.20	0.90	0.64	0.25	0.70	0.51	0.19	0.62	0.45	0.17	0.51	0.35	-0.16	0.46	0.34	-0.13	0.15	0.12	-0.03
19-May	-0.02	-0.02	0.00	0.73	0.53	0.20	0.90	0.65	0.25	0.70	0.51	0.19	0.62	0.45	0.17	0.51	0.34	-0.16	0.45	0.32	-0.13	0.13	0.10	-0.03
20-May	-0.05	-0.05	0.00	0.73	0.53	0.20	0.91	0.65	0.26	0.71	0.52	0.19	0.62	0.46	0.17	0.51	0.34	-0.17	0.44	0.31	-0.13	0.10	0.07	-0.03
21-May	-0.06	-0.06	0.00	0.73	0.53	0.20	0.91	0.66	0.26	0.71	0.52	0.19	0.63	0.46	0.17	0.52	0.35	-0.17	0.44	0.30	-0.13	0.08	0.05	-0.03
22-May	-0.06	-0.06	0.00	0.73	0.53	0.20	0.93	0.67	0.26	0.72	0.53	0.19	0.63	0.47	0.16	0.53	0.36	-0.17	0.44	0.31	-0.13	0.06	0.04	-0.03
23-May	-0.05	-0.05	0.00	0.75	0.55	0.20	0.94	0.69	0.25	0.73	0.55	0.18	0.65	0.49	0.16	0.55	0.38	-0.17	0.45	0.32	-0.13	0.06	0.03	-0.03
24-May	-0.03	-0.03	0.00	0.79	0.58	0.21	0.96	0.70	0.26	0.75	0.57	0.18	0.66	0.51	0.16	0.58	0.41	-0.16	0.47	0.34	-0.13	0.07	0.04	-0.02
25-May	-0.01	-0.01	0.00	0.81	0.59	0.22	0.97	0.71	0.26	0.76	0.58	0.18	0.67	0.51	0.16	0.60	0.44	-0.16	0.49	0.36	-0.13	0.09	0.06	-0.03
26-May	0.00	0.00	0.00	0.80	0.59	0.21	0.97	0.71	0.26	0.76	0.58	0.18	0.67	0.51	0.16	0.61	0.44	-0.17	0.50	0.37	-0.13	0.10	0.08	-0.03
27-May	0.00	0.00	0.00	0.80	0.59	0.21	0.97	0.71	0.26	0.76	0.58	0.18	0.67	0.51	0.16	0.60	0.44	-0.17	0.50	0.37	-0.13	0.11	0.09	-0.03
28-May	0.00	0.00	0.00	0.80	0.58	0.22	0.97	0.71	0.25	0.76	0.57	0.18	0.67	0.51	0.16	0.60	0.43	-0.17	0.50	0.37	-0.13	0.12	0.09	-0.03
29-May	0.00	-0.01	0.00	0.80	0.58	0.22	0.96	0.71	0.25	0.75	0.57	0.18	0.67	0.50	0.16	0.59	0.42	-0.17	0.50	0.37	-0.13	0.12	0.09	-0.03
30-May	0.00	0.00	0.00	0.80	0.58	0.22	0.96	0.70	0.25	0.75	0.57	0.18	0.66	0.50	0.16	0.58	0.42	-0.17	0.49	0.36	-0.13	0.12	0.10	-0.03
31-May	0.01	0.01	0.00	0.53	0.50	0.03	0.62	0.59	0.03	0.53	0.48	0.04	0.47	0.43	0.04	0.37	0.34	-0.03	0.34	0.31	-0.03	0.10	0.09	-0.01

Table 4. Daily Mean Flows (cfs) Between Base and Project Description Model Scenarios and Their Difference (Hydrology 2 minus Hydrology 1) at All Channel Nodes During April

Date	Node 6			Node 9			Node 12			Node 49			Node 50			Node 54			Node 94			Node 124			Node 148		
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-Apr	2984	662	2323	2235	333	1902	2165	299	1866	5024	3052	-1972	5393	3321	-2072	629	269	-360	-404	-678	-274	-2329	-2137	192	-334	-447	-113
2-Apr	3064	865	2199	2407	497	1910	2378	460	1918	4282	2379	-1903	4567	2564	-2004	637	326	-311	-563	-727	-164	-2496	-2221	276	-428	-489	-61
3-Apr	3067	973	2094	2411	594	1817	2382	561	1820	3729	1928	-1800	4023	2126	-1897	637	354	-283	-512	-651	-139	-2534	-2259	275	-413	-464	-51
4-Apr	3067	974	2093	2414	600	1814	2382	565	1818	3132	1345	-1787	3489	1605	-1884	634	347	-287	-441	-590	-149	-2578	-2306	271	-385	-442	-57
5-Apr	3069	976	2093	2419	610	1809	2387	573	1814	2498	706	-1793	2901	1014	-1886	632	342	-290	-394	-549	-156	-2583	-2319	264	-369	-429	-60
6-Apr	3071	977	2093	2420	610	1810	2388	573	1815	1556	-251	-1807	1766	-130	-1896	634	342	-291	-448	-605	-157	-2640	-2378	262	-405	-466	-62
7-Apr	3073	981	2092	2422	608	1814	2391	573	1818	736	-1081	-1817	579	-1323	-1902	636	349	-287	-454	-609	-156	-2672	-2407	265	-415	-475	-60
8-Apr	3077	982	2095	2430	615	1814	2393	574	1819	-73	-1900	-1827	-568	-2483	-1915	633	343	-290	-479	-637	-158	-2692	-2430	262	-447	-509	-61
9-Apr	3083	1000	2083	2444	644	1799	2402	596	1806	-525	-2334	-1809	-1182	-3077	-1894	631	336	-295	-396	-554	-158	-2486	-2229	257	-435	-495	-61
10-Apr	3086	1023	2063	2460	706	1754	2430	675	1755	-39	-1789	-1750	-721	-2567	-1846	627	329	-298	-169	-328	-159	-2098	-1854	245	-297	-356	-60
11-Apr	3083	1023	2060	2466	719	1747	2457	716	1742	2533	803	-1729	1734	-85	-1819	623	325	-298	76	-87	-163	-1875	-1650	225	-101	-165	-64
12-Apr	3075	1010	2066	2455	700	1755	2460	706	1754	5115	3338	-1777	4676	2811	-1864	622	326	-296	109	-53	-162	-1896	-1657	238	-64	-127	-64
13-Apr	3069	998	2071	2440	674	1766	2435	671	1764	6353	4545	-1808	6307	4403	-1904	622	328	-294	97	-62	-160	-1840	-1598	241	-71	-134	-63
14-Apr	3062	977	2085	2427	648	1779	2419	638	1781	6723	4898	-1826	6940	5019	-1921	623	334	-289	9	-145	-154	-1894	-1640	253	-116	-177	-61
15-Apr	3059	963	2096	2414	608	1806	2419	625	1794	6665	4830	-1835	7056	5127	-1929	627	342	-285	-69	-222	-154	-2087	-1820	267	-159	-220	-60
16-Apr	3059	961	2097	2404	582	1822	2395	585	1809	6353	4516	-1837	6797	4868	-1929	630	348	-282	-196	-347	-151	-2354	-2080	274	-229	-288	-58
17-Apr	3060	964	2097	2405	583	1822	2377	555	1822	6025	4191	-1834	6481	4553	-1928	631	348	-283	-304	-454	-150	-2511	-2240	271	-287	-344	-57
18-Apr	3062	965	2097	2406	584	1822	2370	544	1827	5006	3189	-1818	5592	3675	-1917	632	347	-284	-457	-609	-152	-2705	-2431	274	-393	-450	-57
19-Apr	3065	968	2097	2411	588	1822	2372	545	1828	3233	1432	-1801	4016	2111	-1905	633	348	-285	-517	-672	-155	-2864	-2594	270	-448	-508	-59
20-Apr	3069	972	2097	2417	596	1821	2381	553	1828	1173	-629	-1802	1627	-261	-1887	632	346	-286	-522	-678	-156	-2918	-2651	268	-461	-521	-60
21-Apr	3074	977	2097	2426	602	1824	2391	561	1830	-111	-1941	-1830	-376	-2291	-1915	631	346	-285	-517	-672	-155	-2939	-2670	269	-468	-528	-59
22-Apr	3081	985	2097	2438	613	1825	2396	566	1829	-816	-2643	-1827	-1493	-3408	-1915	630	346	-284	-502	-657	-155	-2843	-2577	266	-485	-545	-60
23-Apr	3089	1017	2072	2459	673	1786	2416	622	1794	-829	-2625	-1796	-1537	-3421	-1884	626	336	-290	-353	-506	-153	-2459	-2200	259	-426	-485	-59
24-Apr	3091	1030	2061	2475	722	1753	2453	705	1748	670	-1069	-1738	-66	-1904	-1838	623	330	-293	-19	-177	-158	-1967	-1730	237	-187	-248	-61
25-Apr	3086	1025	2060	2473	721	1752	2472	725	1747	3694	1951	-1743	2944	1114	-1830	624	328	-296	150	-12	-162	-1786	-1559	227	-41	-105	-64
26-Apr	3078	1012	2066	2455	702	1753	2463	710	1753	5824	4035	-1789	5550	3672	-1877	627	327	-300	162	-1	-164	-1710	-1477	233	-21	-85	-65
27-Apr	3072	1003	2069	2437	679	1759	2435	678	1757	6482	4669	-1813	6593	4686	-1907	630	329	-301	74	-89	-163	-1681	-1447	234	-72	-136	-64
28-Apr	3067	898	2169	2427	597	1830	2416	589	1827	6339	4493	-1846	6656	4713	-1943	631	314	-318	-47	-216	-169	-1767	-1525	242	-141	-207	-67
29-Apr	1712	748	964	1456	470	986	1501	466	1035	5488	3877	-1611	5849	4156	-1692	434	283	-151	-203	-329	-126	-1890	-1679	211	-214	-268	-54
30-Apr	670	616	53	398	361	37	404	366	37	4128	3417	-711	4406	3661	-745	259	246	-13	-228	-253	25	-1934	-1801	133	-220	-231	-11

Date	Node 310			Node 388			Node 412			Node 421			Node 422			Node 423			Node 429			Node 434		
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-Apr	152	-271	-423	879	773	-105	6492	5720	-772	3956	3531	-425	3968	3543	-424	2178	1862	-315	2247	1932	-315	6978	5912	-1066
2-Apr	2	-393	-396	873	738	-134	6498	5505	-993	3923	3364	-559	3925	3367	-558	2124	1733	-390	2170	1780	-390	6140	4945	-1195
3-Apr	-90	-459	-369	872	731	-141	6501	5481	-1020	3907	3312	-595	3902	3307	-595	2094	1686	-407	2123	1716	-407	5499	4289	-1210
4-Apr	-198	-565	-367	877	736	-141	6548	5528	-1020	3920	3325	-595	3910	3315	-595	2085	1676	-408	2101	1693	-408	4954	3753	-1201
5-Apr	-327	-695	-368	877	736	-142	6556	5535	-1021	3921	3324	-597	3907	3310	-597	2078	1667	-411	2072	1662	-410	4389	3187	-1202
6-Apr	-495	-866	-371	874	731	-142	6559	5535	-1023	3918	3319	-600	3902	3302	-600	2070	1657	-413	2031	1618	-413	3469	2263	-1206
7-Apr	-621	-992	-371	869	727	-142	6556	5529	-1028	3918	3316	-601	3899	3298	-602	2072	1656	-416	2000	1583	-417	2400	1189	-1211
8-Apr	-759	-1131	-371	870	727	-143	6600	5569	-1031	3953	3350	-603	3934	3331	-603	2088	1667	-421	1998	1578	-420	1415	194	-1221
9-Apr	-824	-1192	-368	869	727	-142	6649	5631	-1018	3978	3383	-595	3959	3365	-594	2106	1690	-416	2004	1591	-413	597	-612	-1209
10-Apr	-621	-975	-354	912	779	-133	6775	5768	-1007	4106	3545	-562	4084	3522	-562	2223	1833	-391	2091	1697	-393	394	-773	-1167
11-Apr	-37	-384	-346	989	855	-134	6872	5860	-1011	4262	3696	-566	4251	3688	-563	2424	2031	-394	2316	1928	-389	2265	1111	-1154
12-Apr	416	56	-360	996	861	-135	6893	5885	-1008	4288	3714	-574	4288	3714	-573	2496	2094	-403	2448	2047	-401	4975	3796	-1179
13-Apr	586	218	-368	989	853	-136	6872	5883	-989	4262	3681	-581	4267	3685	-581	2486	2081	-405	2487	2082	-405	6662	5463	-1199
14-Apr	579	205	-373	971	834	-137	6749	5752	-997	4207	3621	-586	4213	3626	-587	2424	2019	-405	2448	2043	-405	7466	6260	-1205
15-Apr	508	131	-377	953	815	-138	6655	5644	-1011	4147	3559	-587	4153	3564	-588	2346	1945	-402	2385	1981	-404	7765	6559	-1207
16-Apr	387	9	-378	934	796	-138	6616	5598	-1018	4074	3485	-588	4086	3496	-590	2260	1860	-400	2335	1933	-402	7838	6630	-1208
17-Apr	262	-116	-379	909	769	-141	6607	5586	-1020	3998	3407	-591	4014	3423	-591	2176	1779	-397	2266	1867	-399	7741	6529	-1212
18-Apr	62	-313	-375	898	755	-143	6610	5588	-1022	3946	3350	-596	3949	3354	-595	2085	1686	-399	2172	1773	-400	6988	5782	-1206
19-Apr	-268	-636	-368	897	753	-144	6619	5596	-1023	3926	3327	-599	3913	3314	-599	2024	1620	-404	2077	1674	-403	5540	4336	-1203
20-Apr	-650	-1021	-371	893	749	-144	6628	5603	-1025	3926	3324	-601	3905	3304	-602	2010	1603	-407	1976	1569	-406	3442	2249	-1192
21-Apr	-837	-1211	-374	887	744	-144	6628	5598	-1031	3939	3337	-602	3917	3314	-603	2020	1609	-411	1928	1516	-412	1584	374	-1211
22-Apr	-930	-1304	-374	881	739	-143	6636	5608	-1029	3964	3363	-601	3942	3342	-601	2032	1618	-414	1928	1517	-411	479	-735	-1214
23-Apr	-864	-1230	-367	887	748	-139	6739	5731	-1008	4036	3456	-580	4015	3435	-580	2103	1699	-404	1982	1578	-404	-33	-1232	-1199
24-Apr	-445	-794	-349	967	834	-133	6927	5920	-1008	4259	3697	-563	4239	3677	-562	2337	1944	-393	2199	1803	-395	759	-414	-1174
25-Apr	161	-187	-348	1008	871	-137	6995	5979	-1015	4379	3805	-574	4375	3802	-573	2546	2136	-410	2460	2055	-405	3443	2264	-1179
26-Apr	517	159	-358	1000	862	-138	6994	5979	-1015	4376	3796	-580	4381	3801	-580	2617	2201	-416	2595	2179	-415	5964	4761	-1203
27-Apr	586	222	-363	982	842	-140	6938	5938	-1000	4316	3732	-584	4324	3740	-584	2592	2176	-416	2615	2198	-417	7203	5988	-1215
28-Apr	504	122	-382	967	845	-122	6880	6039	-841	4269	3763	-506	4275	3767	-507	2536	2173	-363	2572	2206	-365	7528	6394	-1134
29-Apr	166	-39	-205	1235	842	-393	8897	6052	-2844	5254	3779	-1475	5248	3781	-1466	3168	2133	-1034	3173	2160	-1013	8467	6191	-2276
30-Apr	-194	-150	44	1280	847	-433	9168	6153	-3015	5564	3807	-1757	5569	3808	-1761	3292	2112	-1180	3325	2136	-1189	8297	5847	-2450

Table 5. Daily Mean Flows (cfs) Between Base and Project Description Model Scenarios and Their Difference (Hydrology 2 minus Hydrology 1) at All Channel Nodes During May

Date	Node 6			Node 9			Node 12			Node 49		
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-May	629	374	-255	335	170	-165	317	157	-159	2967	2234	-733
2-May	610	201	-409	306	24	-282	269	-11	-280	2354	1494	-860
3-May	608	195	-414	303	14	-289	255	-34	-289	2148	1295	-853
4-May	610	197	-414	306	15	-291	253	-38	-291	1801	955	-845
5-May	613	201	-412	309	17	-292	256	-35	-292	812	-4	-817
6-May	617	203	-415	309	16	-293	259	-31	-290	-599	-1432	-833
7-May	622	215	-406	313	25	-287	262	-23	-285	-1619	-2457	-838
8-May	645	251	-394	350	76	-274	287	8	-280	-2187	-3036	-848
9-May	665	261	-404	403	118	-285	352	67	-284	-2122	-2946	-824
10-May	668	259	-409	413	129	-284	386	103	-284	-926	-1728	-802
11-May	661	250	-410	407	124	-283	394	110	-283	1273	462	-811
12-May	649	237	-412	390	107	-283	379	96	-283	2889	2056	-833
13-May	644	231	-413	371	89	-283	351	68	-283	3736	2884	-852
14-May	634	224	-409	358	73	-285	331	48	-284	4228	3356	-872
15-May	606	195	-411	329	47	-283	318	32	-286	4357	3476	-881
16-May	599	184	-415	293	6	-287	291	4	-287	4327	3439	-888
17-May	599	184	-415	284	-8	-292	245	-45	-290	4027	3145	-882
18-May	603	188	-415	287	-6	-293	230	-63	-293	3043	2184	-859
19-May	608	195	-413	295	1	-294	237	-56	-293	977	156	-821
20-May	616	200	-415	301	7	-294	248	-41	-290	-1088	-1912	-824
21-May	625	224	-401	314	30	-284	261	-22	-283	-1969	-2802	-833
22-May	656	260	-396	369	93	-276	303	23	-281	-2176	-3006	-830
23-May	671	266	-405	411	125	-286	366	80	-285	-1732	-2539	-807
24-May	669	261	-408	415	132	-283	391	108	-283	-372	-1151	-779
25-May	662	251	-410	408	125	-283	393	110	-283	1482	697	-784
26-May	650	239	-411	392	107	-285	378	93	-285	2602	1801	-802
27-May	639	226	-413	373	87	-286	354	68	-287	2904	2085	-819
28-May	635	220	-415	361	74	-287	333	45	-288	3058	2224	-833
29-May	628	216	-413	348	58	-290	314	24	-290	2781	1945	-836
30-May	611	201	-410	337	46	-290	309	17	-291	2823	1984	-839
31-May	497	262	-235	249	71	-177	242	57	-186	2529	2053	-475

Date	Node 50			Node 54			Node 94			Node 124			Node 148		
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-May	3114	2348	-766	263	189	-74	-591	-626	-35	-2220	-2084	136	-396	-411	-15
2-May	2419	1519	-899	264	138	-126	-819	-888	-69	-2442	-2309	133	-509	-539	-29
3-May	2290	1395	-896	263	138	-125	-913	-969	-56	-2562	-2422	140	-572	-595	-23
4-May	2161	1268	-893	263	140	-123	-962	-1022	-61	-2662	-2522	140	-618	-643	-25
5-May	1326	469	-858	264	143	-120	-987	-1049	-62	-2736	-2599	137	-648	-674	-26
6-May	-398	-1263	-865	268	151	-117	-1010	-1074	-64	-2788	-2656	132	-673	-701	-28
7-May	-1938	-2809	-872	275	157	-118	-1013	-1076	-64	-2786	-2656	131	-694	-722	-28
8-May	-2798	-3677	-880	267	152	-115	-948	-1012	-64	-2618	-2490	128	-685	-713	-28
9-May	-2821	-3681	-860	261	142	-119	-759	-824	-64	-2314	-2192	122	-576	-604	-28
10-May	-1852	-2702	-850	262	136	-126	-583	-651	-68	-2062	-1949	113	-417	-447	-30
11-May	313	-538	-851	260	132	-128	-496	-565	-69	-2025	-1913	112	-348	-378	-30
12-May	2267	1395	-872	260	131	-129	-492	-561	-69	-2005	-1888	117	-344	-373	-30
13-May	3466	2572	-894	261	130	-131	-535	-603	-69	-2004	-1882	122	-369	-398	-29
14-May	4270	3356	-914	264	134	-131	-577	-646	-69	-2048	-1920	128	-395	-425	-30
15-May	4650	3727	-924	264	135	-129	-612	-679	-67	-2193	-2056	137	-419	-449	-29
16-May	4747	3817	-930	266	140	-126	-664	-729	-65	-2418	-2275	142	-449	-477	-28
17-May	4475	3550	-925	267	143	-124	-822	-882	-60	-2639	-2494	144	-528	-553	-26
18-May	3680	2773	-907	268	145	-123	-986	-1048	-62	-2819	-2674	146	-641	-666	-26
19-May	1739	871	-868	268	149	-119	-1053	-1116	-63	-2950	-2812	139	-701	-727	-27
20-May	-919	-1775	-856	273	158	-115	-1071	-1134	-63	-2973	-2841	131	-721	-749	-28
21-May	-2416	-3281	-866	277	160	-117	-1021	-1085	-64	-2868	-2741	126	-712	-741	-29
22-May	-2819	-3681	-862	266	152	-114	-926	-991	-64	-2589	-2468	122	-677	-705	-28
23-May	-2398	-3243	-845	262	143	-119	-735	-799	-64	-2218	-2104	113	-546	-574	-28
24-May	-1193	-2017	-825	262	135	-127	-579	-648	-69	-1922	-1819	102	-394	-423	-30
25-May	693	-129	-822	259	130	-128	-516	-586	-71	-1842	-1741	100	-343	-373	-30
26-May	2121	1282	-838	257	129	-128	-541	-610	-69	-1835	-1731	104	-357	-386	-29
27-May	2667	1810	-858	256	128	-128	-618	-687	-69	-1896	-1788	108	-403	-432	-29
28-May	2976	2103	-874	255	127	-128	-554	-625	-71	-1932	-1822	110	-372	-402	-30
29-May	2771	1895	-876	256	131	-126	-692	-759	-67	-2105	-1988	117	-447	-475	-29
30-May	2892	2011	-880	258	133	-125	-711	-776	-65	-2245	-2121	123	-455	-483	-28
31-May	2691	2179	-512	231	158	-74	-709	-765	-56	-2230	-2198	32	-458	-483	-25

Date	Node 310			Node 388			Node 412			Node 421		
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-May	-434	-415	19	1252	859	-393	9151	6413	-2737	5491	3887	-1604
2-May	-579	-593	-14	1234	848	-386	9140	6435	-2705	5449	3880	-1569
3-May	-634	-647	-13	1232	844	-388	9185	6478	-2706	5447	3871	-1575
4-May	-694	-705	-11	1239	850	-389	9240	6532	-2708	5462	3883	-1580
5-May	-889	-894	-5	1240	851	-389	9252	6541	-2711	5466	3881	-1585
6-May	-1150	-1158	-9	1237	849	-389	9259	6540	-2719	5472	3884	-1588
7-May	-1327	-1335	-8	1240	851	-389	9311	6585	-2726	5506	3920	-1586
8-May	-1415	-1426	-11	1236	849	-388	9338	6626	-2711	5522	3944	-1577
9-May	-1314	-1329	-16	1253	877	-376	9450	6772	-2678	5587	4068	-1519
10-May	-994	-1013	-19	1313	947	-366	9536	6867	-2669	5699	4223	-1476
11-May	-608	-615	-7	1353	972	-381	9625	6954	-2671	5812	4315	-1497
12-May	-368	-374	-5	1369	979	-390	9665	7007	-2657	5850	4339	-1511
13-May	-274	-283	-9	1367	973	-395	9616	6974	-2642	5831	4303	-1529
14-May	-233	-248	-15	1366	971	-394	9581	6923	-2657	5822	4277	-1545
15-May	-233	-252	-19	1352	961	-391	9513	6827	-2686	5789	4233	-1556
16-May	-261	-283	-23	1337	950	-387	9517	6815	-2703	5749	4189	-1560
17-May	-373	-395	-22	1312	921	-391	9557	6848	-2709	5697	4128	-1569
18-May	-556	-574	-18	1298	903	-395	9569	6857	-2712	5648	4068	-1580
19-May	-937	-943	-6	1301	906	-395	9626	6912	-2715	5658	4075	-1583
20-May	-1302	-1306	-4	1304	909	-395	9691	6969	-2722	5703	4122	-1581
21-May	-1431	-1433	-2	1301	906	-394	9710	6983	-2727	5732	4155	-1577
22-May	-1433	-1433	0	1305	911	-394	9796	7091	-2705	5783	4225	-1558
23-May	-1256	-1260	-4	1330	942	-389	9922	7245	-2678	5863	4367	-1497
24-May	-926	-932	-6	1402	1006	-396	10042	7368	-2675	5973	4524	-1449
25-May	-599	-599	0	1436	1026	-411	10117	7439	-2678	6039	4590	-1449
26-May	-433	-435	-2	1424	1023	-401	10106	7432	-2674	6034	4572	-1462
27-May	-415	-421	-6	1420	1019	-401	10112	7453	-2660	6019	4545	-1474
28-May	-407	-415	-8	1427	1015	-412	10114	7460	-2654	6007	4521	-1486
29-May	-477	-484	-7	1433	1013	-421	10108	7441	-2667	6009	4511	-1498
30-May	-473	-480	-7	1431	1015	-416	10111	7425	-2686	6025	4514	-1511
31-May	-336	-403	-67	914	844	-71	6364	6043	-321	4144	3789	-355

Date	Node 422			Node 423			Node 429			Node 434		
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-May	5495	3887	-1608	3187	2106	-1081	3216	2128	-1087	7582	5325	-2257
2-May	5451	3882	-1569	3118	2056	-1061	3149	2084	-1065	7286	5049	-2237
3-May	5444	3870	-1574	3085	2021	-1064	3119	2053	-1066	7258	5017	-2241
4-May	5453	3873	-1579	3067	1997	-1070	3100	2030	-1069	7089	4851	-2238
5-May	5450	3865	-1585	3045	1970	-1075	3054	1981	-1073	6300	4084	-2215
6-May	5452	3863	-1589	3036	1956	-1080	2992	1911	-1081	4832	2611	-2221
7-May	5483	3898	-1586	3051	1964	-1088	2973	1886	-1086	3424	1196	-2228
8-May	5498	3922	-1576	3061	1971	-1089	2957	1875	-1082	2352	134	-2218
9-May	5561	4042	-1519	3122	2066	-1056	2987	1936	-1050	1701	-456	-2157
10-May	5673	4203	-1470	3257	2241	-1017	3112	2099	-1014	2243	118	-2125
11-May	5797	4304	-1493	3421	2372	-1049	3306	2265	-1041	4221	2067	-2155
12-May	5845	4335	-1511	3483	2423	-1059	3420	2362	-1058	6190	3985	-2205
13-May	5831	4302	-1530	3461	2403	-1058	3446	2386	-1060	7507	5278	-2229
14-May	5823	4277	-1547	3428	2376	-1052	3442	2387	-1055	8431	6195	-2236
15-May	5793	4234	-1559	3371	2324	-1047	3407	2353	-1054	8964	6727	-2237
16-May	5760	4195	-1565	3313	2270	-1043	3389	2339	-1050	9373	7135	-2238
17-May	5711	4142	-1570	3238	2199	-1040	3337	2292	-1046	9465	7225	-2240
18-May	5646	4068	-1579	3143	2093	-1050	3231	2180	-1051	8707	6474	-2233
19-May	5641	4057	-1584	3108	2041	-1067	3138	2072	-1065	6890	4671	-2219
20-May	5680	4098	-1581	3138	2054	-1084	3082	1997	-1085	4635	2406	-2229
21-May	5708	4131	-1577	3174	2074	-1100	3084	1986	-1098	3181	935	-2245
22-May	5759	4202	-1557	3246	2142	-1104	3135	2038	-1097	2517	281	-2237
23-May	5838	4341	-1497	3364	2292	-1072	3235	2165	-1069	2423	223	-2199
24-May	5950	4506	-1444	3536	2507	-1029	3409	2382	-1027	3410	1233	-2177
25-May	6028	4582	-1445	3685	2647	-1039	3592	2562	-1030	5256	3058	-2198
26-May	6029	4568	-1461	3724	2677	-1047	3673	2629	-1044	6763	4524	-2239
27-May	6016	4542	-1475	3709	2659	-1050	3686	2636	-1050	7524	5259	-2265
28-May	6004	4517	-1487	3674	2622	-1052	3666	2612	-1055	7865	5585	-2281
29-May	6005	4505	-1500	3632	2575	-1057	3625	2565	-1061	7910	5620	-2290
30-May	6021	4508	-1513	3608	2543	-1065	3606	2535	-1071	8107	5814	-2293
31-May	4157	3791	-365	2250	2025	-225	2306	2055	-251	6044	5382	-662

Table 6. DSM2 Results for Mean Daily Proportion Positive Flows, Mean Daily Flow, and Mean Daily Velocity at Each Channel Node for April. Differences are calculated as Hydrology 2 or 2[1] minus Hydrology 1

Channel Nodes		Proportion Positive Daily Flow					Average Daily Flow (cfs)					Mean Daily Velocity (ft/s)				
		Baseline	Proposed	Difference between Baseline and Proposed	Proposed (DCC Open)	Difference between Baseline and Proposed (Open)	Baseline	Proposed	Difference between Baseline and Proposed	Proposed (DCC Open)	Difference between Baseline and Proposed (Open)	Baseline	Proposed	Difference between Baseline and Proposed	Proposed (DCC Open)	Difference Between Proposed and Proposed DCC Open
6	San Joaquin	0.99	0.89	-0.10	0.89	-0.01	2943	951	-1993	951	0.0	1.16	0.38	-0.78	0.38	0.00
9	San Joaquin	0.98	0.63	-0.35	0.63	0.00	2325	608	-1717	607	-0.4	1.33	0.36	-0.97	0.36	0.00
12	South Delta	0.98	0.58	-0.39	0.58	0.00	2303	585	-1718	585	-0.4	1.11	0.32	-0.79	0.32	0.00
49	Central Delta	0.53	0.53	0.00	0.53	0.00	3344	1576	-1768	2124	547.4	0.07	0.05	-0.02	0.05	0.01
50	Central Delta	0.53	0.52	0.00	0.53	0.00	3331	1473	-1858	2050	576.3	0.08	0.06	-0.02	0.07	0.01
54	San Joaquin	1.00	0.97	-0.03	0.96	0.00	610	330	-280	331	0.4	0.35	0.19	-0.16	0.19	0.00
94	South Delta	0.52	0.52	0.00	0.52	0.00	-251	-406	-155	-404	2.0	0.00	-0.02	-0.02	-0.02	0.00
124	South Delta	0.46	0.46	0.00	0.47	0.00	-2302	-2053	249	-2209	-155.2	-0.06	-0.06	0.01	-0.06	0.00
148	South Delta	0.52	0.52	0.00	0.52	0.00	-285	-345	-60	-348	-2.3	-0.01	-0.02	-0.01	-0.02	0.00
310	Central Delta	0.52	0.52	-0.01	0.52	0.00	-110	-461	-351	-261	199.3	0.03	0.00	-0.02	0.02	0.01
388	North Delta	0.65	0.62	-0.03	0.61	-0.02	943	787	-156	683	-103.9	0.55	0.47	-0.08	0.41	-0.06
412	North Delta	0.94	0.85	-0.09	0.84	-0.01	6856	5726	-1130	5727	0.5	0.66	0.56	-0.11	0.56	0.00
421	North Delta	0.71	0.66	-0.05	0.69	0.02	4163	3515	-648	3825	310.7	0.53	0.45	-0.08	0.49	0.04
422	North Delta	0.70	0.66	-0.04	0.61	-0.05	4157	3509	-648	2636	-872.8	0.47	0.40	-0.07	0.30	-0.10
423	North Delta	0.62	0.59	-0.02	0.57	-0.02	2303	1854	-449	1376	-478.1	0.38	0.31	-0.07	0.24	-0.08
429	North Delta	0.59	0.57	-0.02	0.56	-0.01	2284	1836	-448	1359	-476.8	0.34	0.28	-0.06	0.22	-0.06
434	North Delta	0.53	0.53	0.00	0.53	0.00	4689	3418	-1271	2839	-579.0	0.09	0.07	-0.01	0.07	-0.01

Table 7. DSM2 Results for Mean Daily Proportion Positive Flows, Mean Daily Flow, and Mean Daily Velocity at Each Channel Node for May. Differences are calculated as Hydrology 2 or 2[1] minus Hydrology 1

Channel Nodes		Proportion Positive Daily Flow					Average Daily Flow (cfs)					Mean Daily Velocity (ft/s)				
		Baseline	Proposed	Difference between Baseline and Proposed	Proposed (DCC Open)	Difference between Baseline and Proposed (Open)	Baseline	Proposed	Difference between Baseline and Proposed	Proposed (DCC Open)	Difference between Baseline and Proposed (Open)	Baseline	Proposed	Difference between Baseline and Proposed	Proposed (DCC Open)	Difference Between Proposed and Proposed DCC Open
6	San Joaquin	0.72	0.57	-0.15	0.57	0	627	228	-399	228	0	0.34	0.14	-0.21	0.14	0.00
9	San Joaquin	0.59	0.55	-0.04	0.55	0	343	64	-279	64	0	0.26	0.08	-0.18	0.08	0.00
12	South Delta	0.56	0.53	-0.03	0.53	0	308	30	-279	30	0	0.21	0.07	-0.14	0.07	0.00
49	Central Delta	0.52	0.52	0	0.53	0.01	1365	545	-820	1292	747	0.04	0.03	-0.01	0.04	0.01
50	Central Delta	0.52	0.52	0	0.52	0	1231	372	-859	1157	785	0.06	0.05	-0.01	0.06	0.01
54	San Joaquin	0.9	0.78	-0.12	0.77	-0.01	263	142	-120	142	0	0.16	0.09	-0.07	0.09	0.00
94	South Delta	0.51	0.5	-0.01	0.5	0	-758	-822	-64	-819	3	-0.07	-0.07	-0.01	-0.07	0.00
124	South Delta	0.46	0.46	0	0.46	0	-2352	-2230	122	-2435	-204	-0.06	-0.06	0.00	-0.07	-0.01
148	South Delta	0.51	0.51	0	0.51	0	-512	-539	-28	-543	-3	-0.04	-0.04	0.00	-0.04	0.00
310	Central Delta	0.51	0.51	0	0.52	0.01	-734	-745	-11	-476	269	-0.02	-0.02	0.00	0.00	0.02
388	North Delta	0.73	0.65	-0.08	0.62	-0.03	1311	929	-383	791	-138	0.74	0.54	-0.20	0.47	-0.07
412	North Delta	1	0.95	-0.05	0.95	0	9525	6911	-2614	6911	0	0.91	0.66	-0.25	0.66	0.00
421	North Delta	0.86	0.72	-0.14	0.75	0.03	5686	4187	-1499	4596	409	0.71	0.53	-0.18	0.58	0.05
422	North Delta	0.84	0.71	-0.13	0.63	-0.08	5677	4178	-1499	3078	-1100	0.63	0.47	-0.16	0.35	-0.12
423	North Delta	0.68	0.62	-0.06	0.59	-0.03	3281	2247	-1034	1604	-643	0.54	0.37	-0.16	0.27	-0.10
429	North Delta	0.63	0.59	-0.04	0.57	-0.02	3253	2219	-1035	1575	-644	0.46	0.33	-0.13	0.25	-0.08
434	North Delta	0.53	0.53	0	0.53	0	5980	3805	-2175	3021	-784	0.10	0.08	-0.02	0.07	-0.01

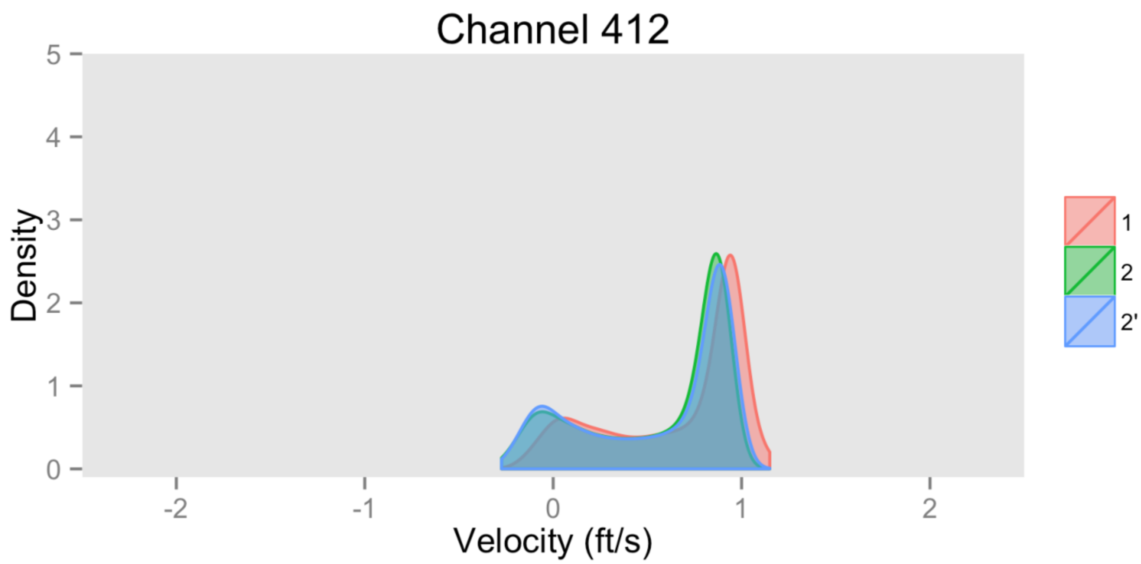

Figure 2. Density plot of velocity (ft/s) observed at DSM2 Channel Node 412 under three scenarios during the April modeled period (Sacramento River near Sherwood Harbor, North Delta)

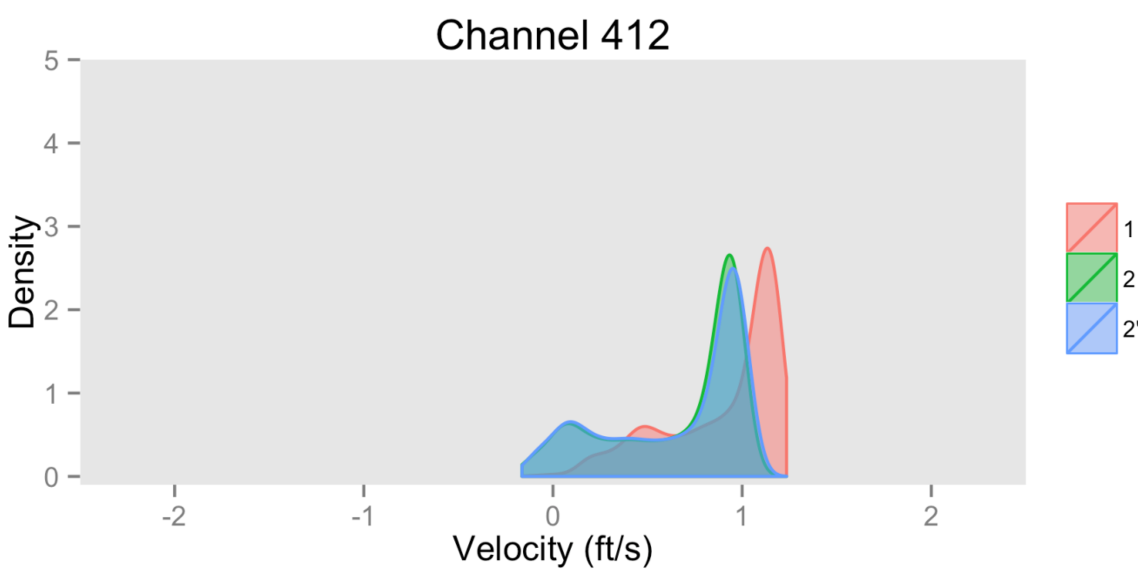

Figure 3. Density plot of velocity (ft/s) observed at DSM2 Channel Node 412 under three scenarios during the May modeled period (Sacramento River near Sherwood Harbor, North Delta)

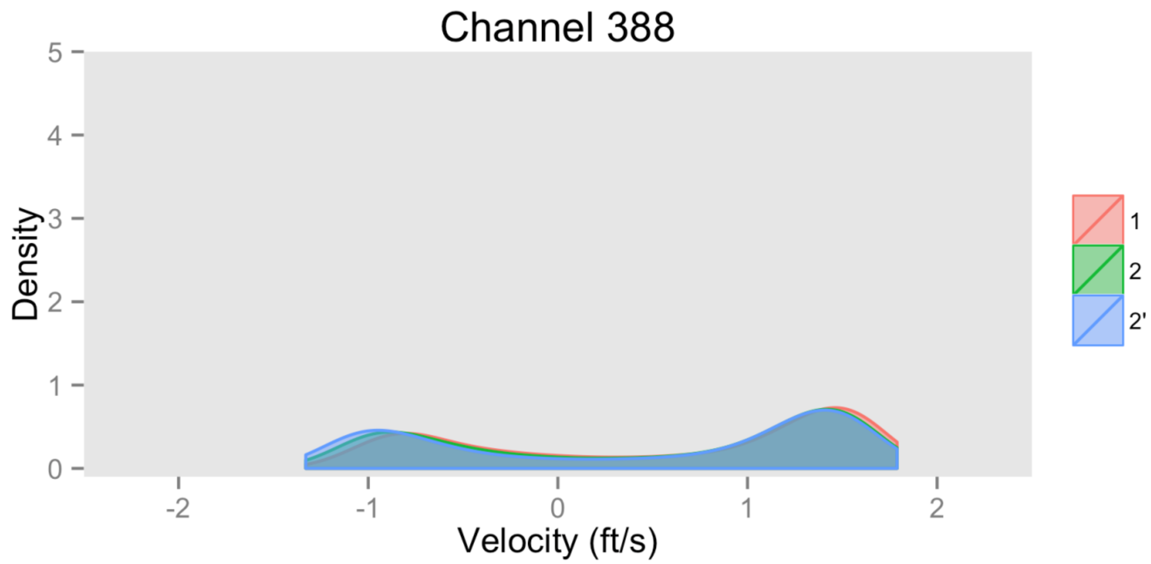

Figure 4. Density plot of velocity (ft/s) observed for DSM2 Channel 388, Sutter Slough and Sacramento River junction, in April

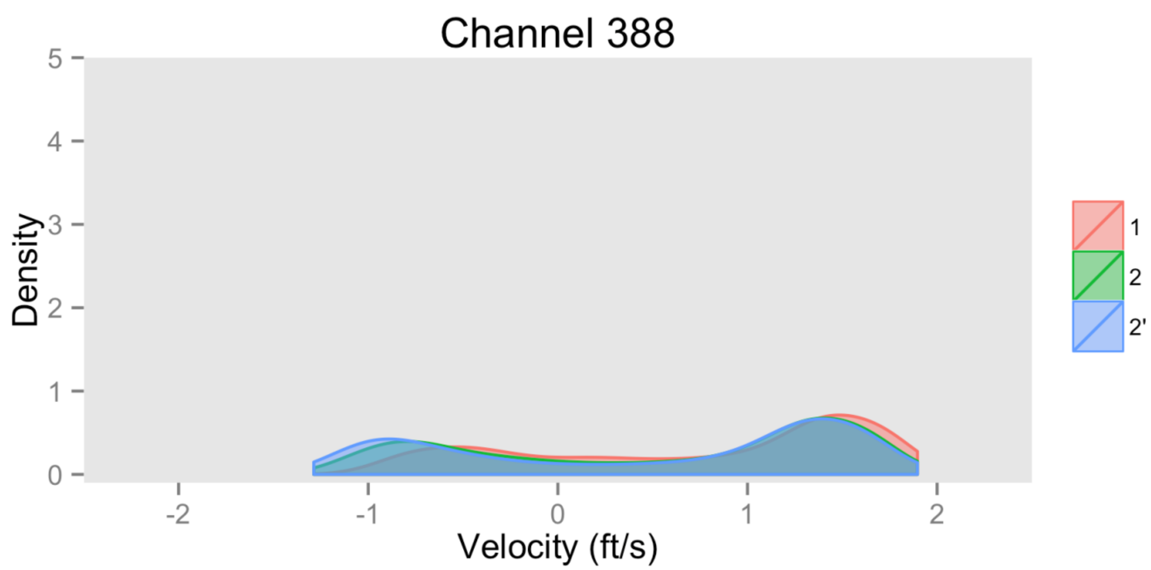

Figure 5. Density plot of velocity (ft/s) observed for DSM2 Channel 388, Sutter Slough and Sacramento River junction, in May

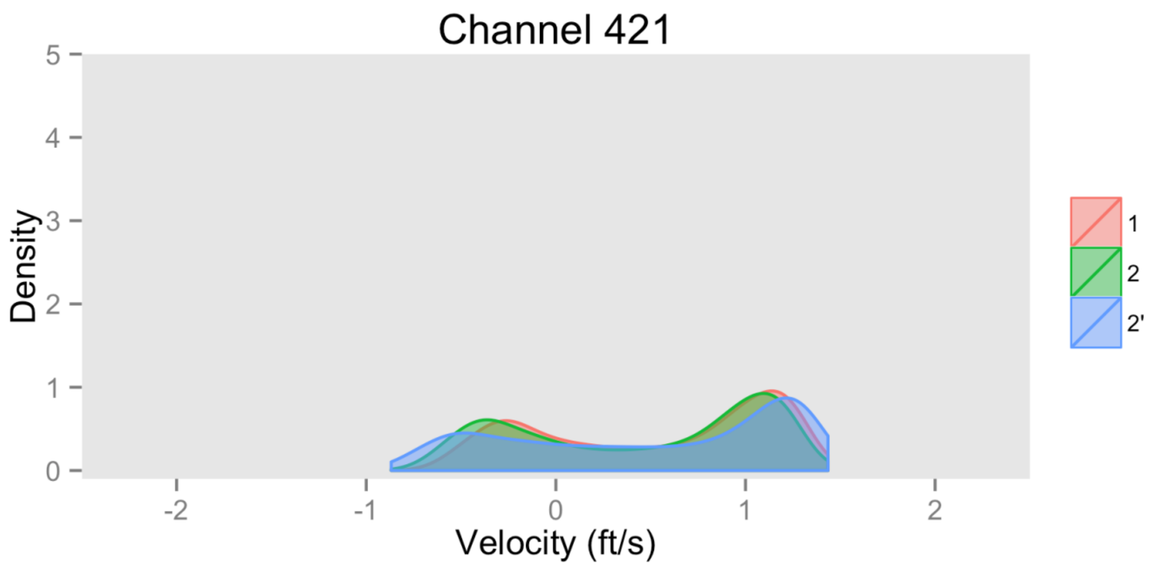

Figure 6. Density plot of velocity (ft/s) observed for DSM2 Channel 421, upstream of the DCC channel junction, in April

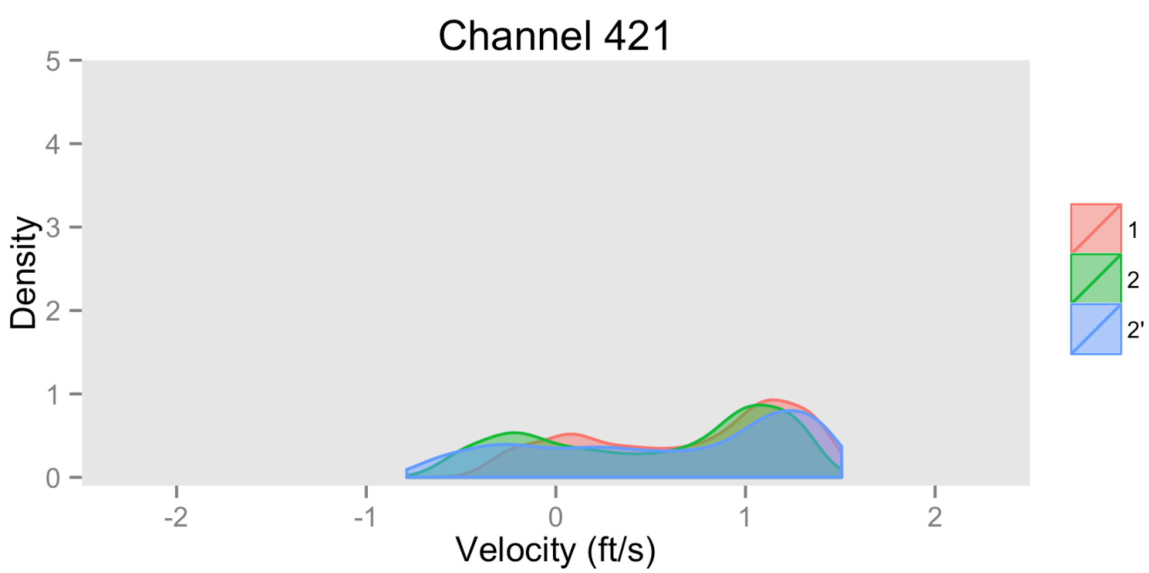

Figure 7. Density plot of velocity (ft/s) observed for DSM2 Channel 421, upstream of the DCC channel junction, in May

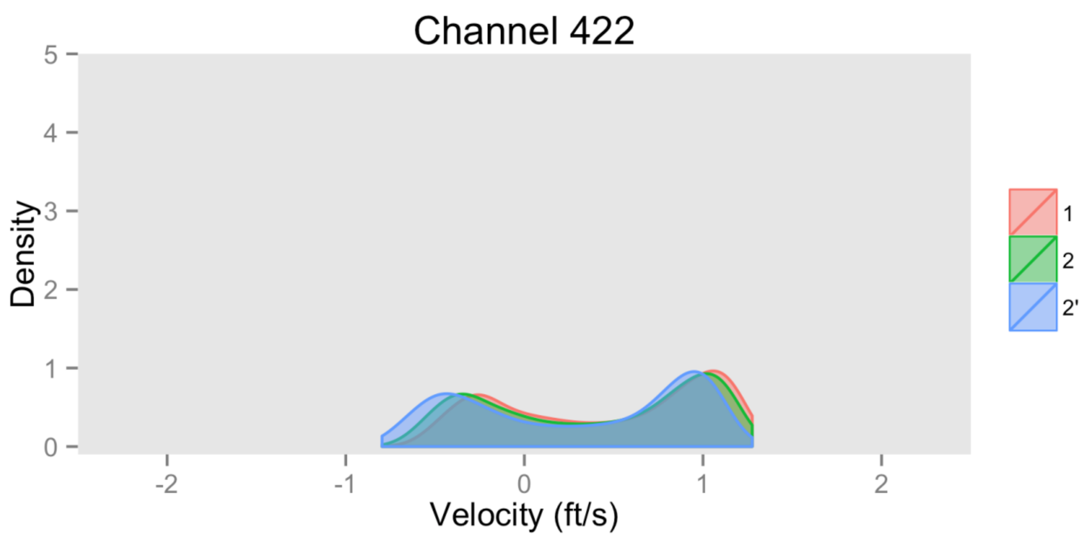

Figure 8. Density plot of velocity (ft/s) observed for DSM2 Channel 422, Sacramento River between Delta Cross Channel and Georgiana Slough in April

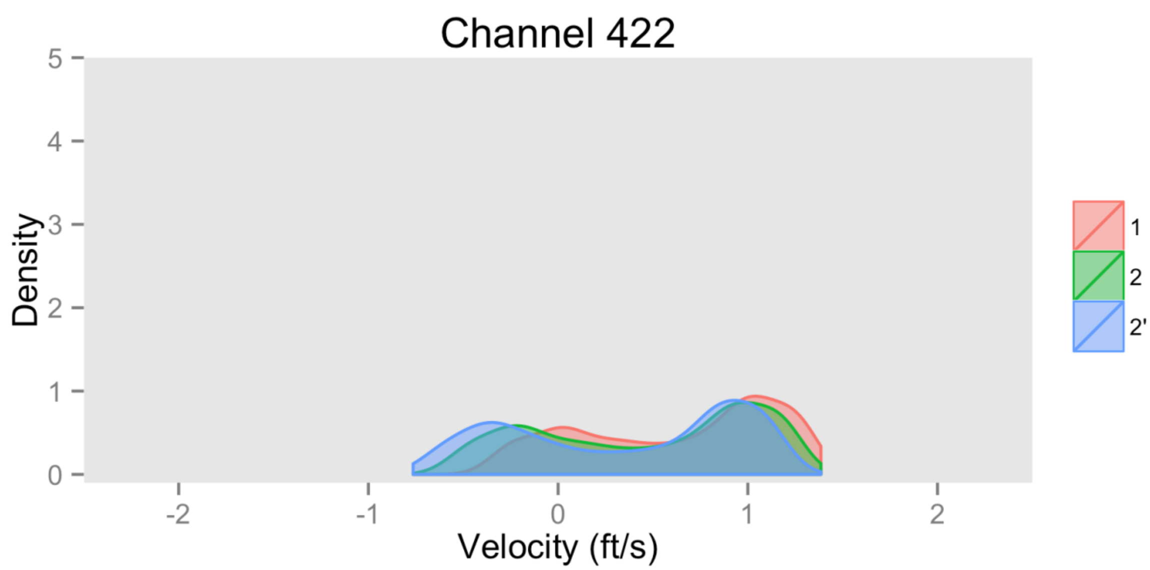

Figure 9. Density plot of velocity (ft/s) observed for DSM2 Channel 422, Sacramento River between Delta Cross Channel and Georgiana Slough in May

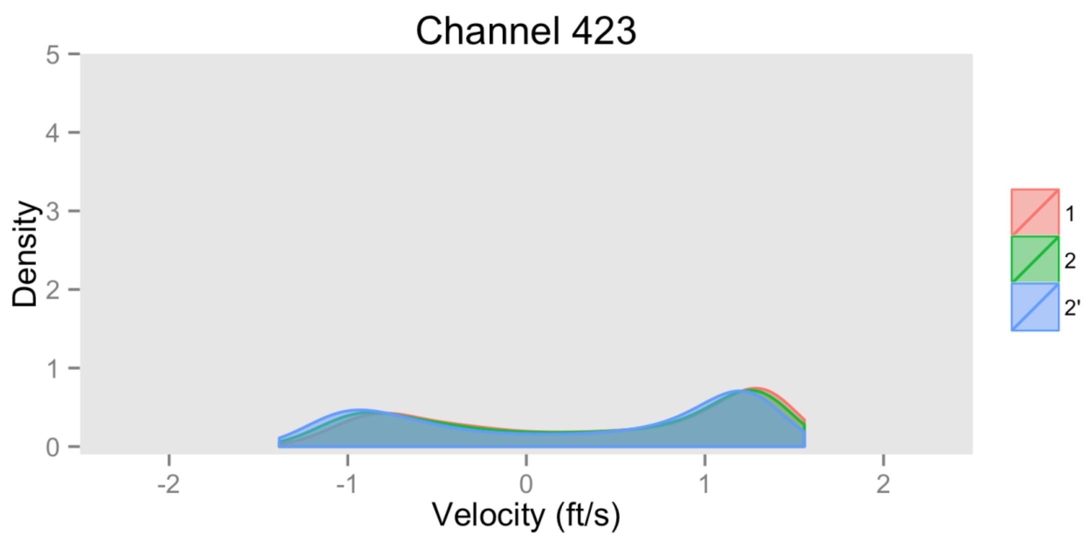

Figure 10. Density plot of velocity (ft/s) observed for DSM2 Channel 423, Sacramento River downstream of the Delta Cross Channel and Georgiana Slough in April

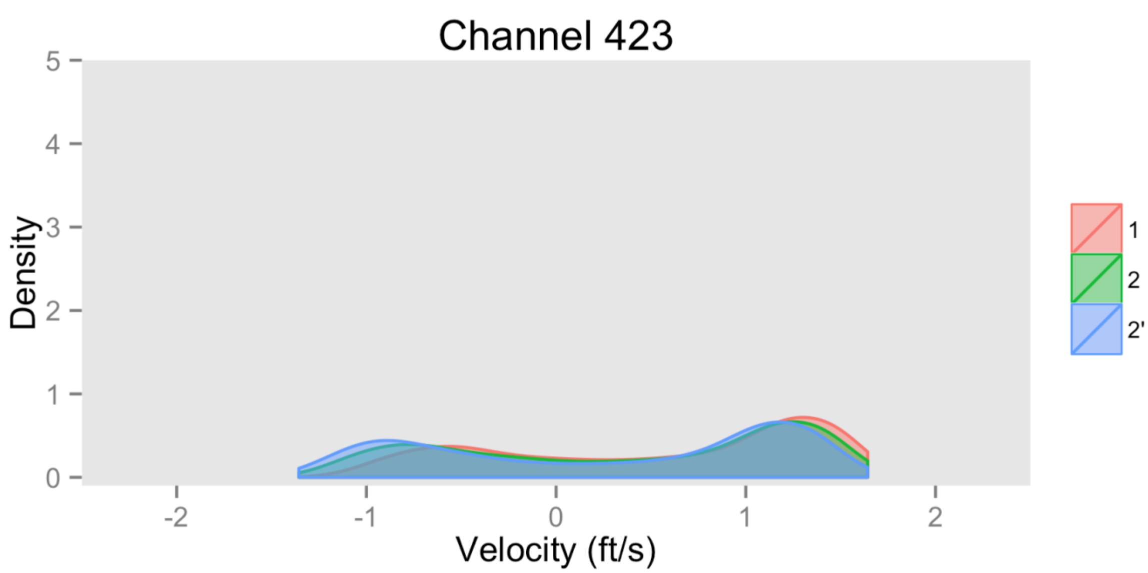

Figure 11. Density plot of velocity (ft/s) observed for DSM2 Channel 423, Sacramento River downstream of the Delta Cross Channel and Georgiana Slough in May

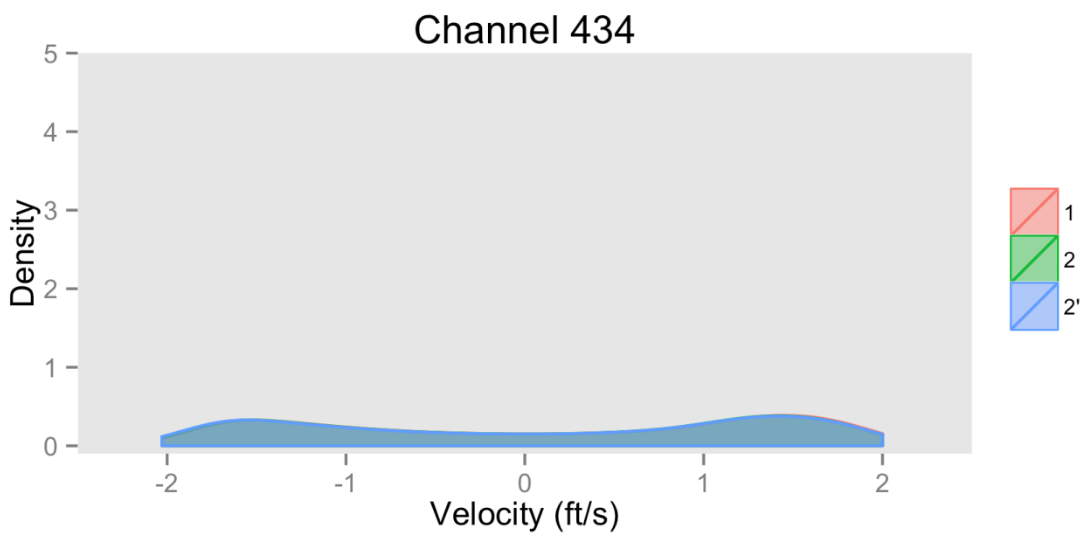

Figure 12. Density plot of velocity (ft/s) observed for DSM2 Channel 424, Sacramento River between Decker Island and Sherman Island in April

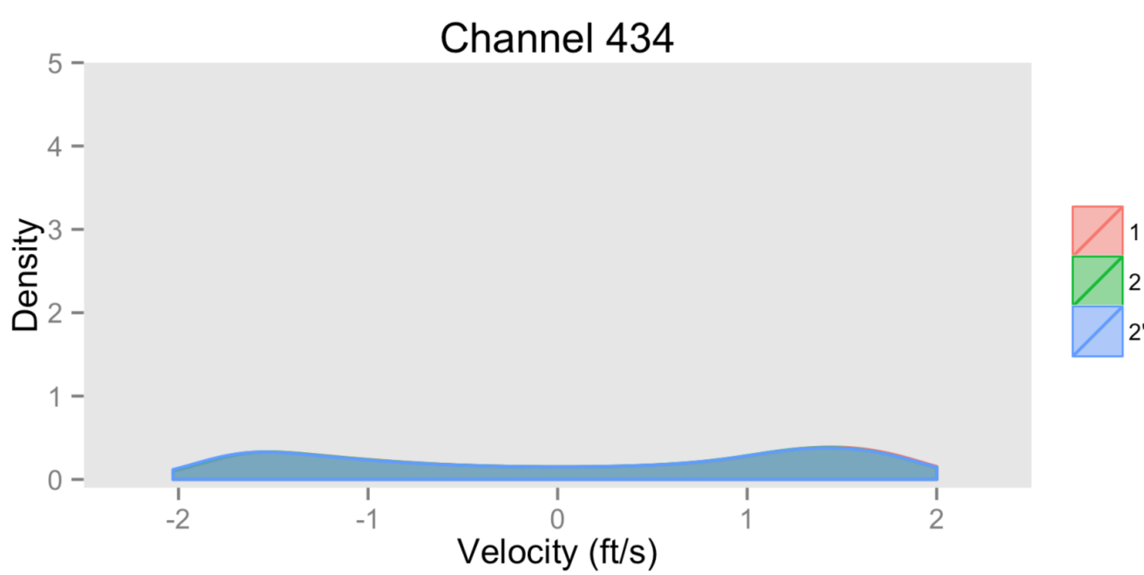

Figure 13. Density plot of velocity (ft/s) observed for DSM2 Channel 424, Sacramento River between Decker Island and Sherman Island in May

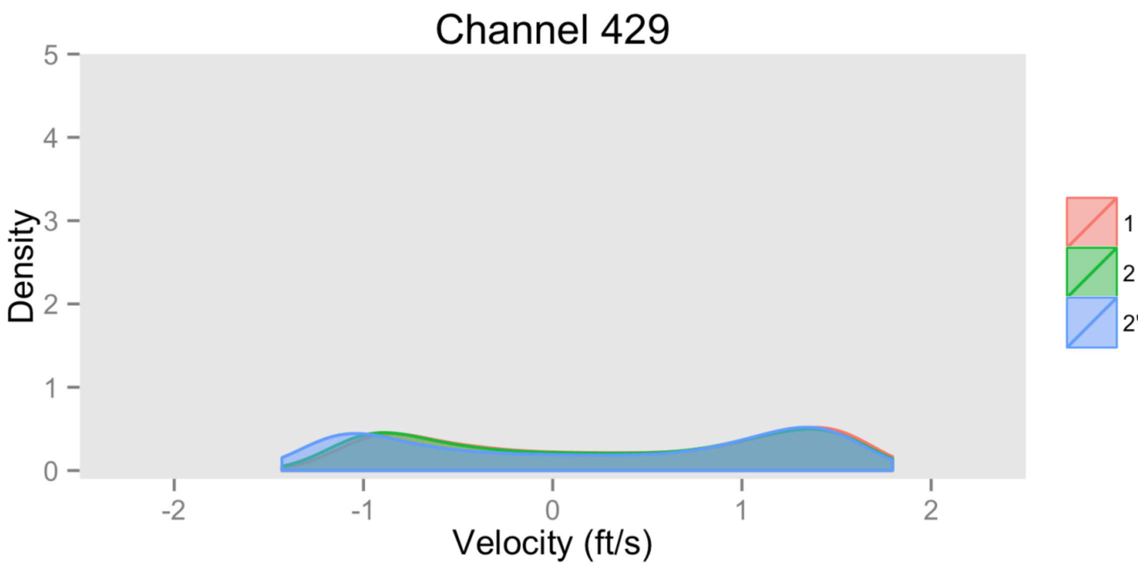

Figure 14. Density plot of velocity (ft/s) observed at DSM2 Channel Node 412 under three scenarios during the April modeled period (Sacramento River near Cache Slough, North Delta)

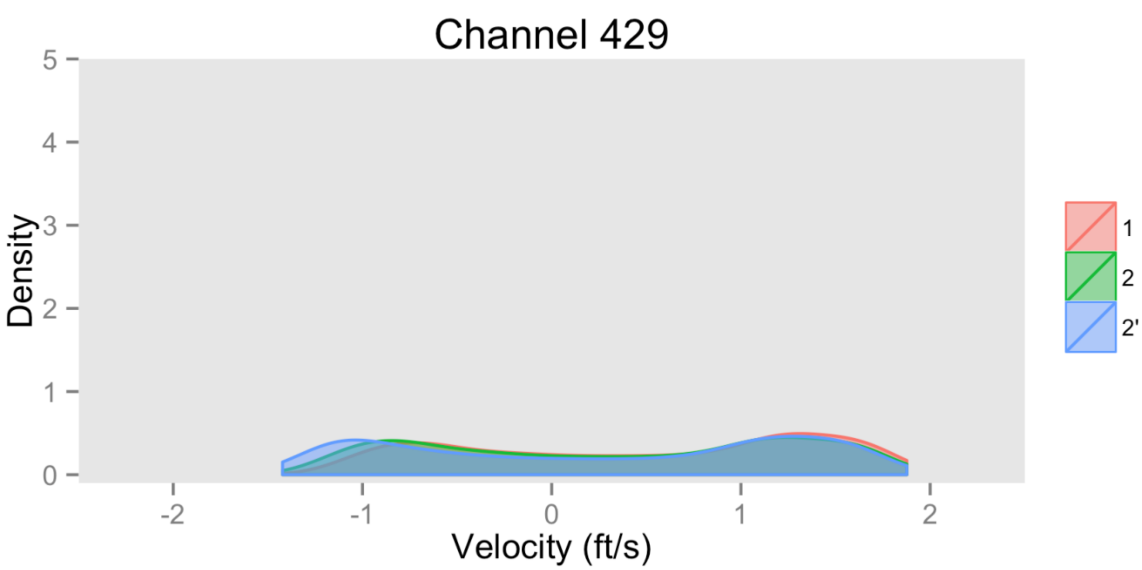

Figure 15. Density plot of velocity (ft/s) observed at DSM2 Channel Node 412 under three scenarios during the May modeled period (Sacramento River near Cache Slough, North Delta)

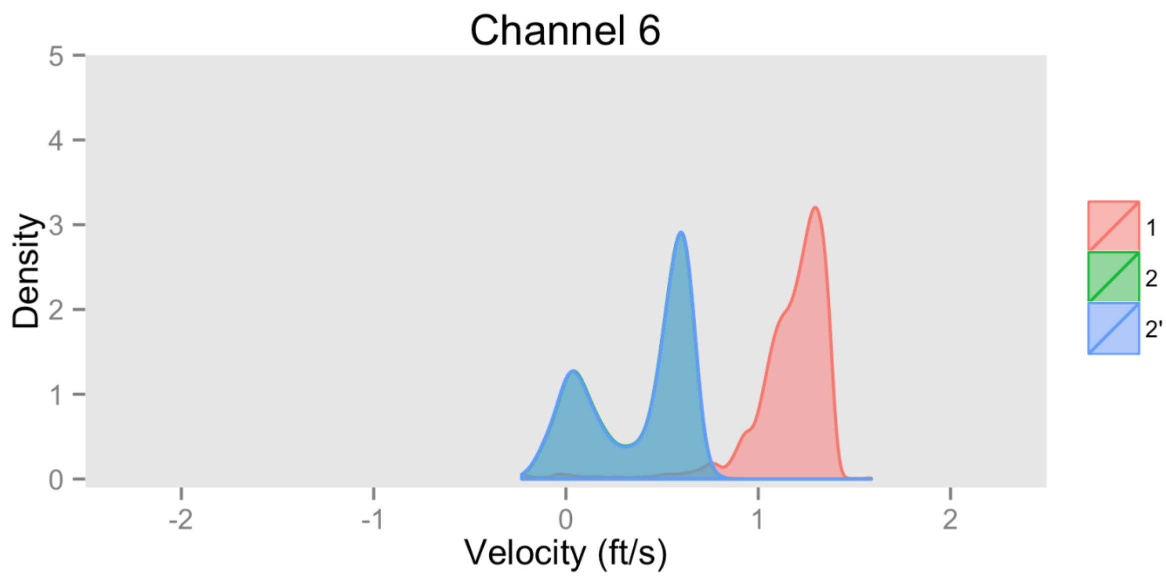

Figure 16. Density plot of velocity (ft/s) observed at DSM2 Channel Node 6 under three scenarios during the April modeled period (Upstream of Head of Old River on San Joaquin, San Joaquin)

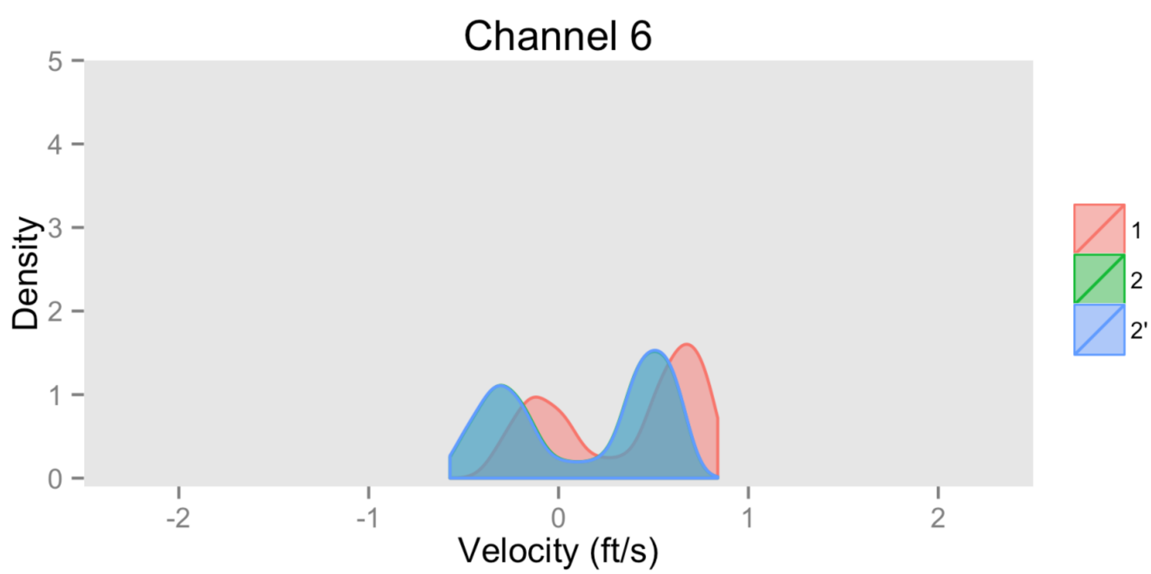

Figure 17. Density plot of velocity (ft/s) observed at DSM2 Channel Node 6 under three scenarios during the May modeled period (Upstream of Head of Old River on San Joaquin, San Joaquin)

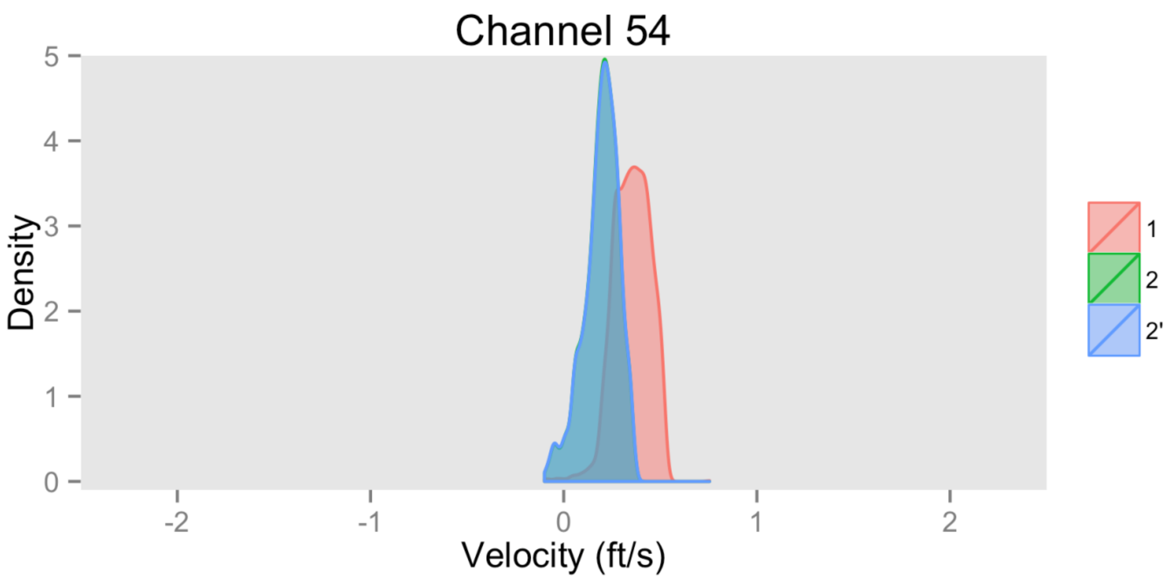

Figure 18. Density plot of velocity (ft/s) observed at DSM2 Channel Node 54 under three scenarios during the April modeled period Downstream of Head of Old River on Old River, San Joaquin)

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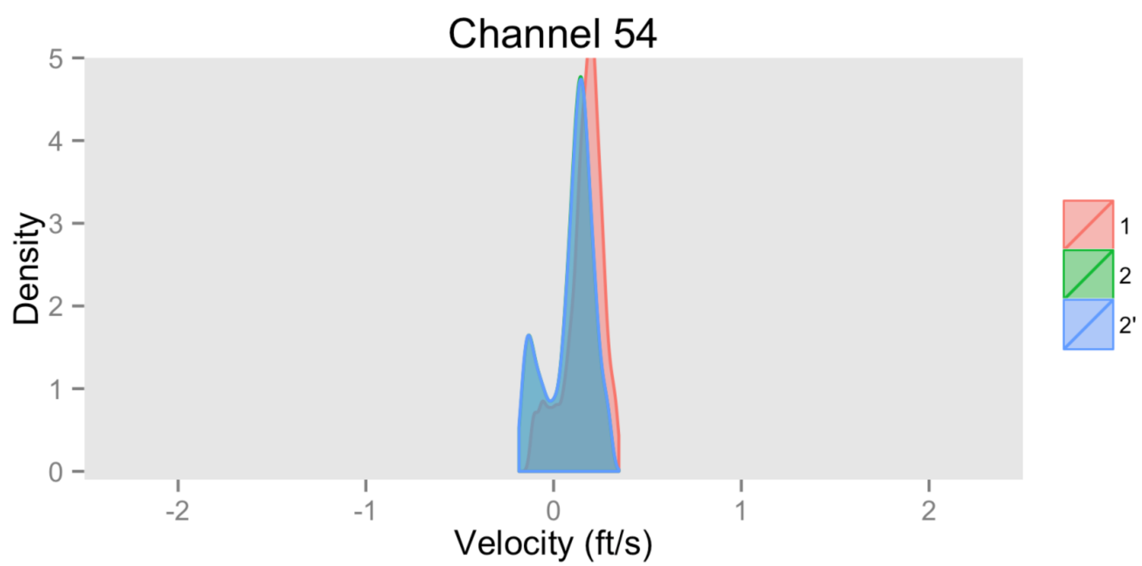

Figure 19. Density plot of velocity (ft/s) observed at DSM2 Channel Node 54 under three scenarios during the May modeled period (Downstream of Head of Old River on Old River, San Joaquin)

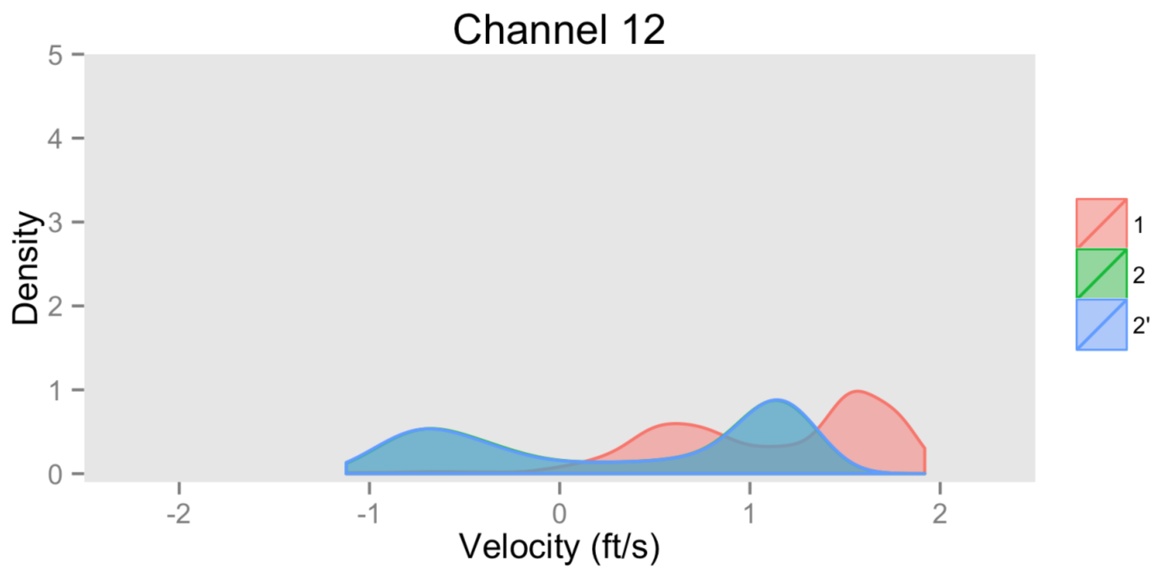

Figure 20. Density plot of velocity (ft/s) observed at DSM2 Channel Node 12 under three scenarios during the April modeled period (Upstream of Stockton Deepwater Shipping Channel , South Delta)

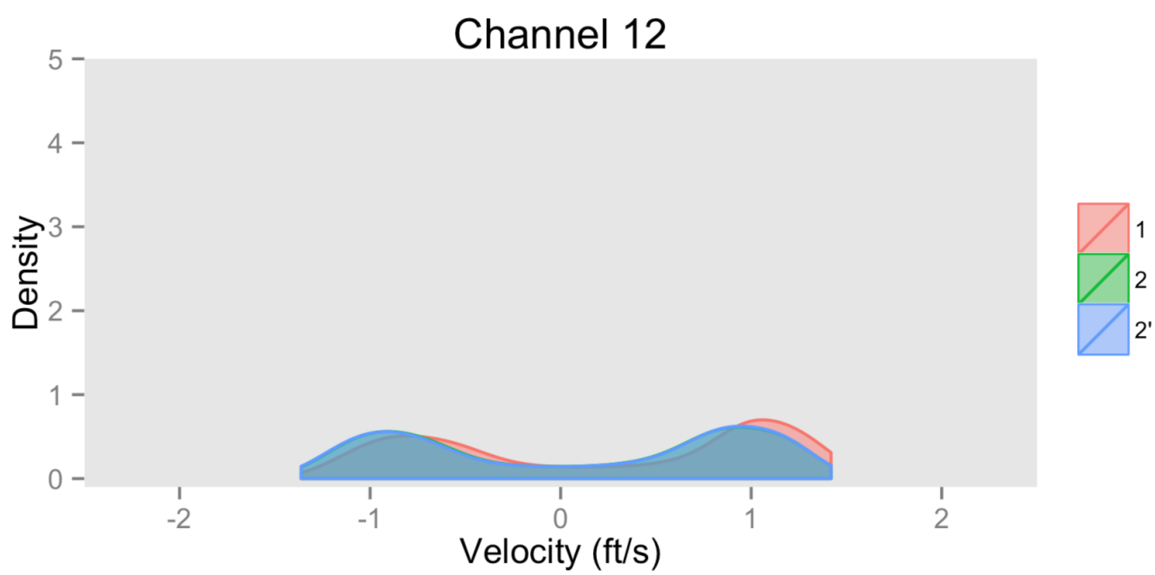

Figure 21. Density plot of velocity (ft/s) observed at DSM2 Channel Node 12 under three scenarios during the May modeled period (Upstream of Stockton Deepwater Shipping Channel , South Delta)

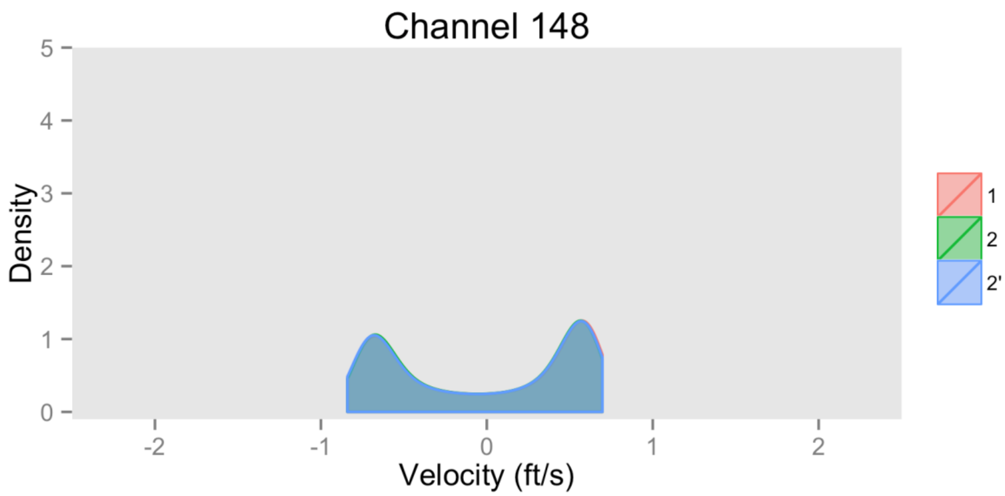

Figure 22. Density plot of velocity (ft/s) observed for DSM2 Channel 148, Middle River north of Railroad cut, in April

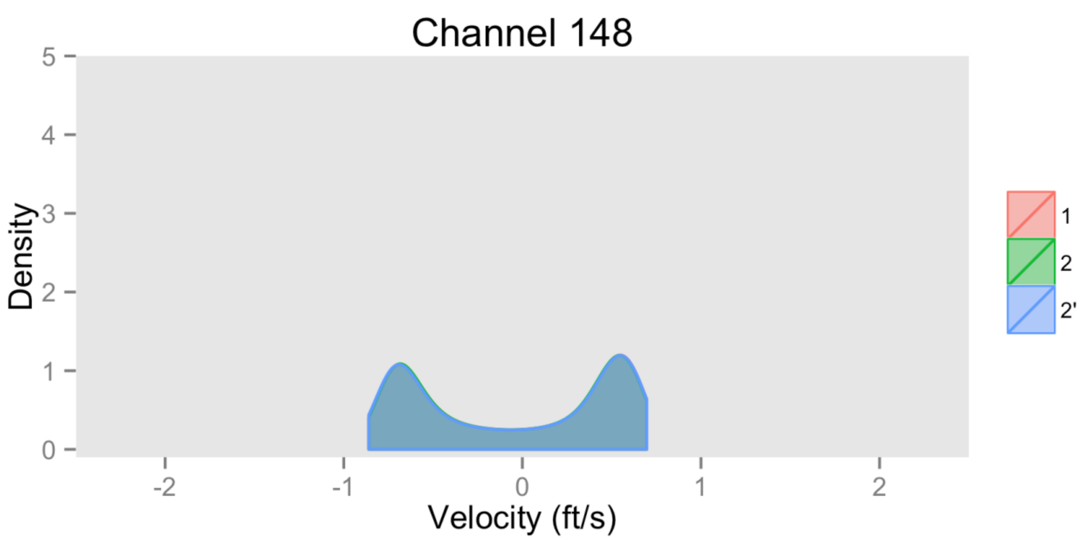

Figure 23. Density plot of velocity (ft/s) observed for DSM2 Channel 148, Middle River north of Railroad cut, in May

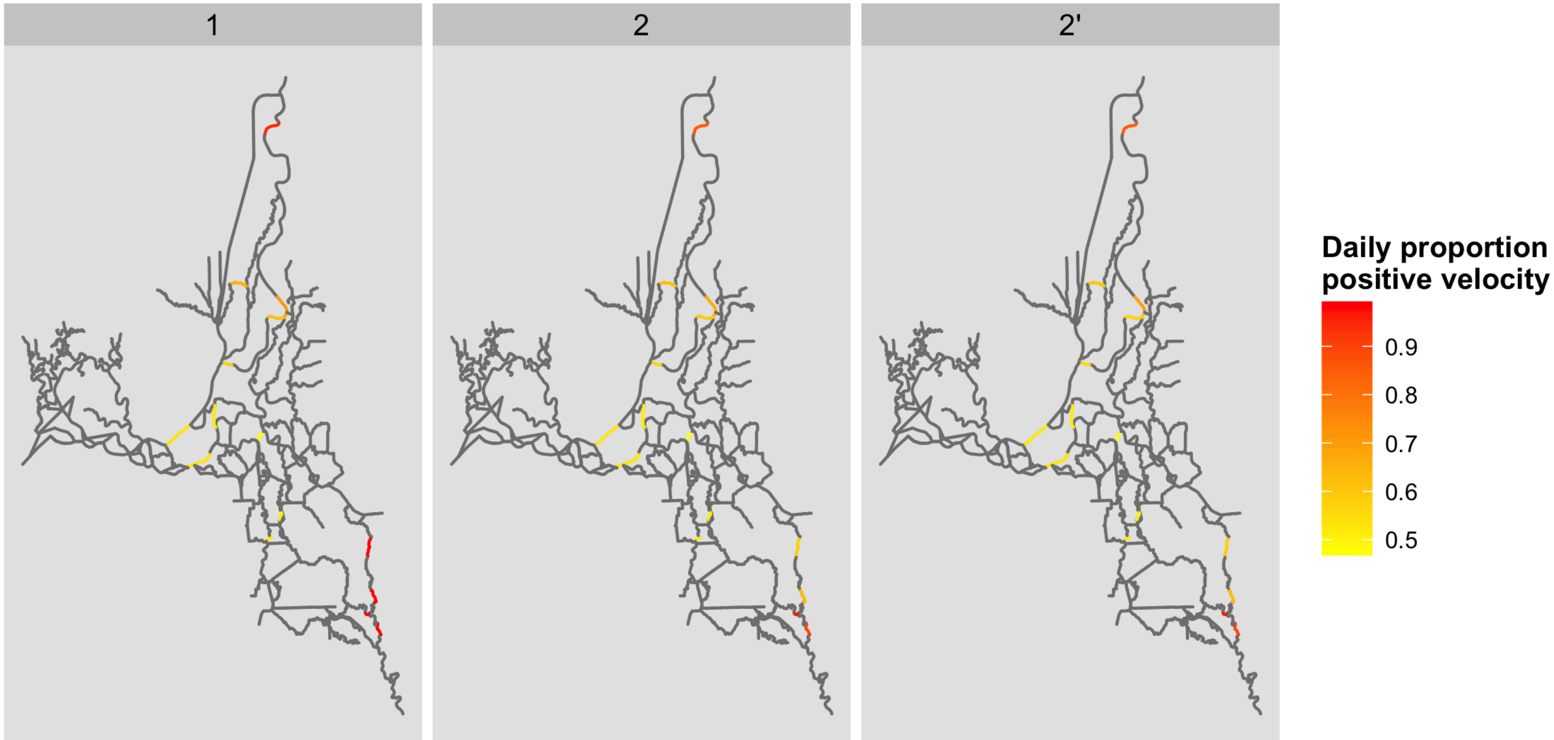

Figure 24. Maps of the Delta with Key Channels Color-Coded for Daily Proportion Positive Velocity, May 2015

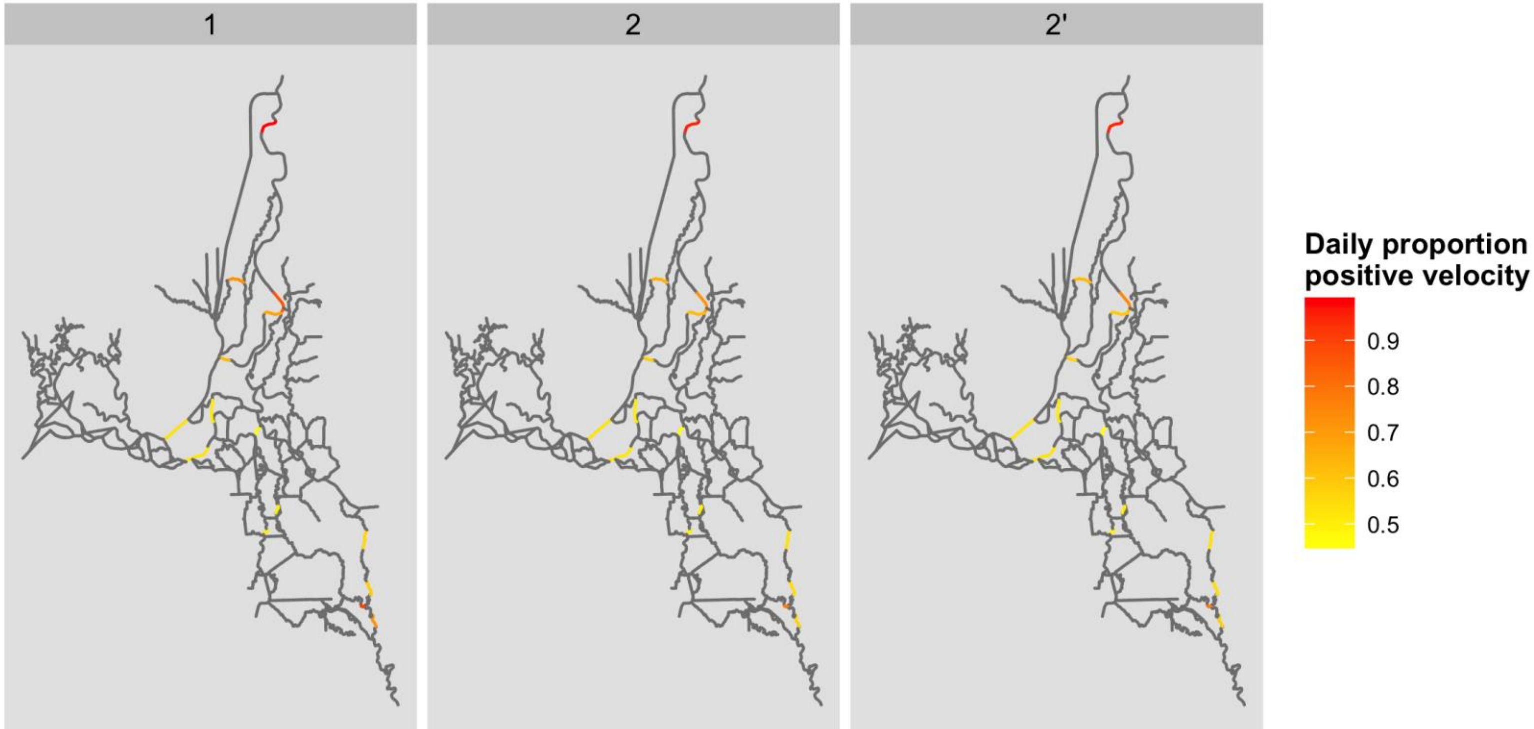

Figure 25. Maps of the Delta with Key Channels Color-Coded for Daily Proportion Positive Velocity, April 2015

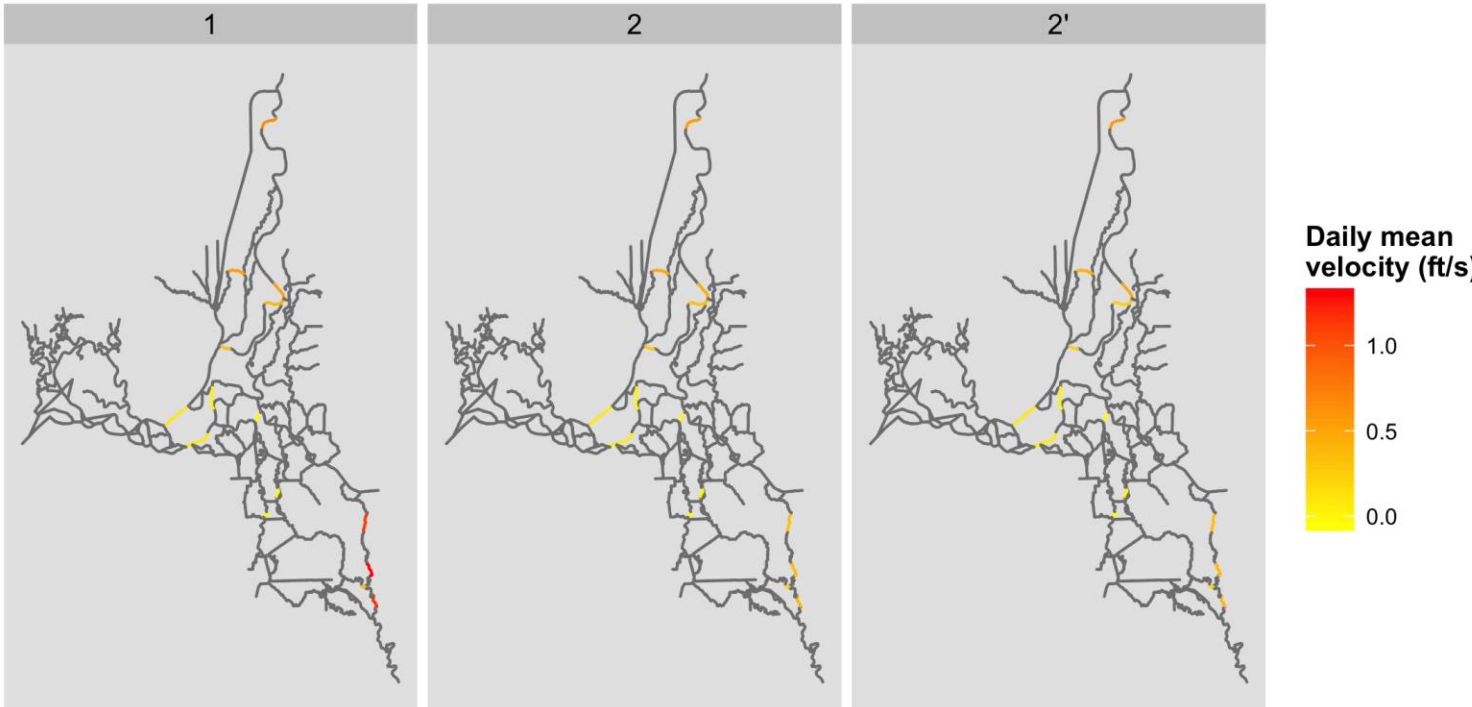

Figure 26. Maps of the Delta with Key Channels Color-Coded for Daily Mean Velocity Generated from DSM2, May 2015

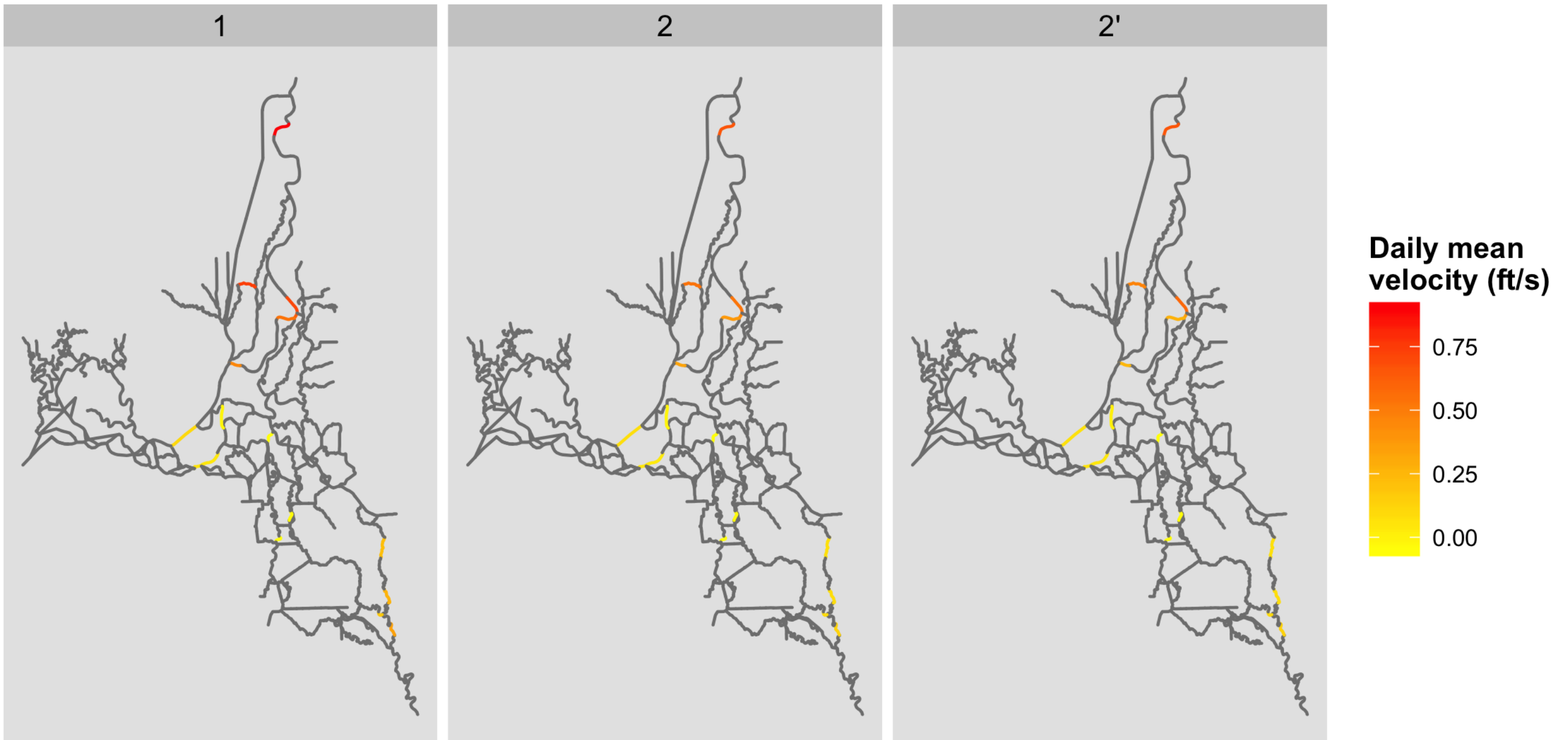

Figure 27. Maps of the Delta with Key Channels Color-Coded for Daily Mean Velocity Generated from DSM2, April 2015

Particle Tracking Model

For the purposes of the biological review, particle "entrainment" was assessed for the three scenarios: Baseline, Project Description with closed DCC gates, Project Description with open DCC gates (Table 1). Although the DSM2 particle tracking model does not currently incorporate a behavioral component, particles are considered dependable proxies for the relative effect of hydrological conditions on early-stage smelt larval movement because larvae are weak swimmers and are only minimally capable of selectively maintaining a position in the water column [*i.e.*, they tend to behave a lot like neutrally buoyant particles; see Kimmerer (2008). Six injection locations and seven flux locations were assessed (Figure 28). Daily entrainment flux fate at the CVP/SWP projects at the end of the model period (May 31) was considered and graphed for cumulative daily flux (Figure 29). Combined entrainment at the Projects was highest in both scenarios for particles inserted at Station 815 (near Prisoners Point on the San Joaquin River). The flux of particles past Chipps Island from all injection points are shown in Figures 30 and 31 for both the modeled Baseline and Project Description scenarios.

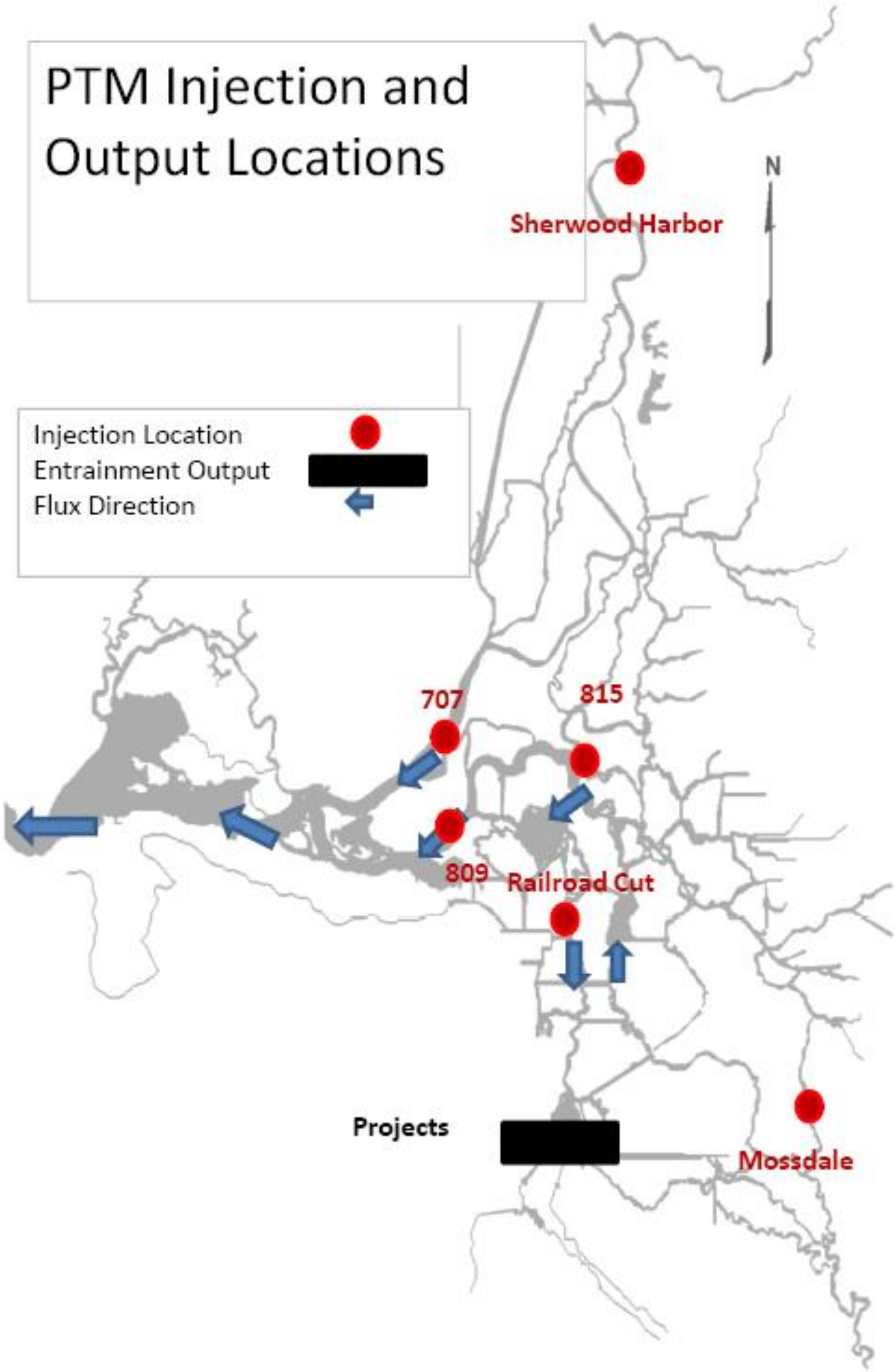

Figure 28. PTM Model injection and output locations. Six injection points are evaluated

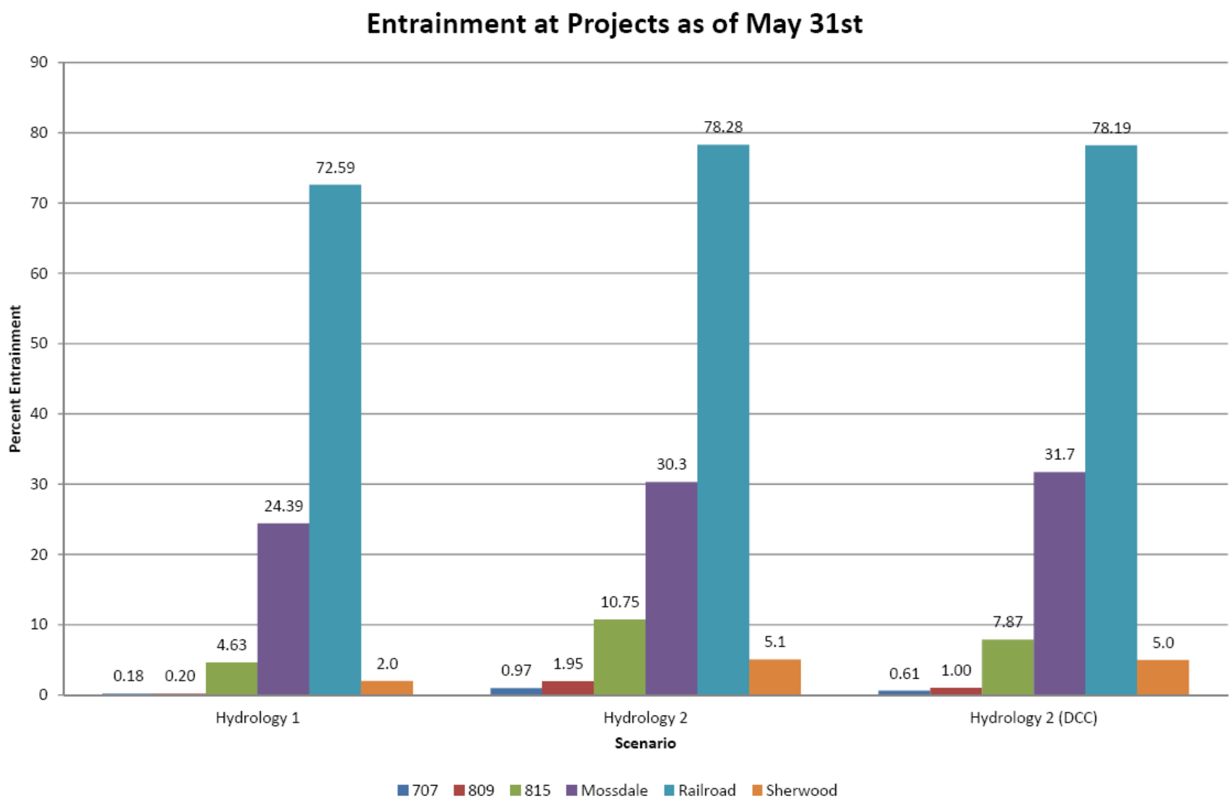

Figure 29. Entrainment at Projects from multiple injection locations under the Project Description (Hydrology 2) and Unmodified (Hydrology 1) model scenarios

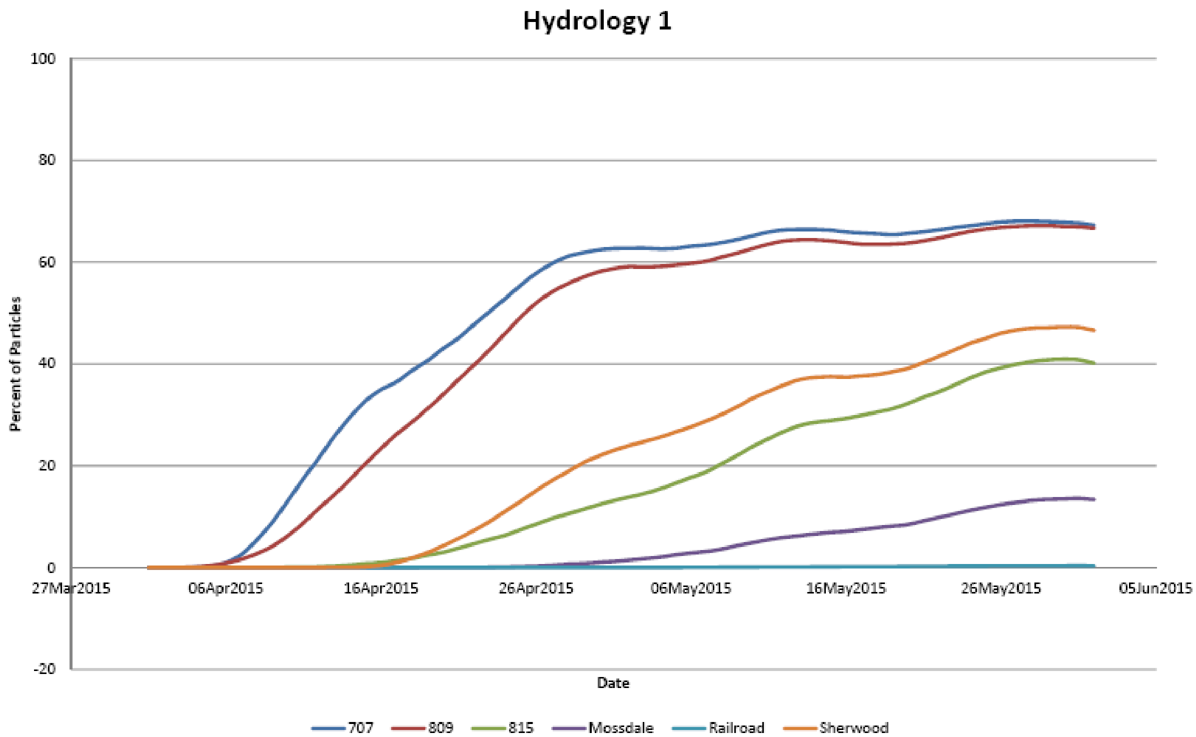

Figure 30. Flux Fate Past Chipps Island under the modeled Baseline scenario (Hydrology 1) for multiple injection locations

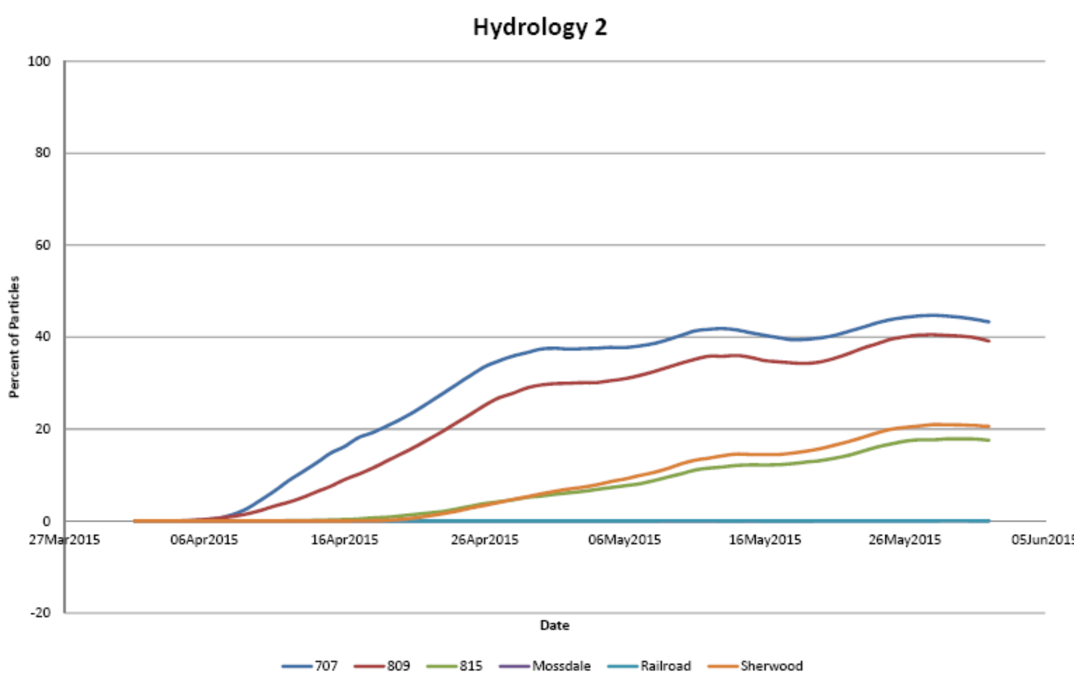

Figure 31. Flux Fate Past Chipps Island under the modeled Project Description scenario (Hydrology 2) for multiple injection locations

Status of the Species and Effects of Project Description

Status of Winter Run Chinook Salmon

A small number of winter-run Chinook Salmon (*Oncorhynchus tshawytscha*) (n=3,015; 90% CI= 2,741-3,290) returned to spawn in the upper Sacramento River in 2014. Of these 3,105 winter-run Chinook, 388 were collected at the Keswick trap for broodstock at Livingston Stone National Fish Hatchery. Assuming that 3-year old fish make up the majority of each spawning cohort, returning adults in 2014 were produced by a much smaller spawning escapement in 2011 (*i.e.*, 827 adult spawners). The effects of limited cold water storage and loss of temperature control out of Keswick Dam from mid-August through the fall of 2014 led to substantial egg and fry mortality. The mortality associated with this loss of temperature control was estimated to have affected up to 95% of the brood year 2014 eggs and fry (Doug Killam, CFDW, pers comm.). The average egg to fry mortality for brood year 2007-2012 was estimated to be 69% based on female escapement, fecundity, and the RBDD juvenile production index (Reclamation 2015).

As of March 11, 2015, approximately 408,704 juvenile winter-run Chinook Salmon were estimated to have migrated past the Red Bluff Diversion Dam (RBDD, Figures 32-33). The rotary screw traps at RBDD were operated for just 8 of 31 days during December 2014[2], a period when the Sacramento River flows and turbidity levels were at their highest. Very few natural-origin juvenile winter-run Chinook Salmon are hypothesized to remain upstream of the Delta and these are anticipated to migrate into the Delta and lower Sacramento River by the end of April based upon historical RBDD passage data (Tables 8-9). Monitoring data throughout the Sacramento River suggest that the majority of salmonids, including natural-origin juvenile winter-run Chinook Salmon are currently residing in the Lower Sacramento River and Delta (Figure 34, Tables 10-11). Detections of winter-run sized juveniles in the Chipps Island trawl monitoring have been low, but trending upwards, indicating that while few have migrated out of the Delta at this time, outmigration to the ocean is increasing (Figure 35). During April, the seaward migration of juvenile winter-run Chinook Salmon is likely to be completed due to changes in photoperiod and temperature, which stimulate smoltification and migratory behavior in these rearing fishes. Historical patterns indicate that the majority of out-migration typically occurs in March and is not complete until early spring (del Rosario *et al*. 2013). Discussions by the Delta Operations for Salmonids and Sturgeon (DOSS) team have estimated on March 17 that for the natural origin winter-run juveniles greater than 85% were rearing in the Delta, less than 15% had exited the Delta, and “few remaining stragglers” had yet to enter the Delta. A low level of salvage of winter-run sized juveniles has occurred during the winter, with a cumulative loss of 102 natural-origin winter-run sized juvenile Chinook as of March 20, 2015. This may be due to several factors, acting individually or in concert, including low population numbers, low exports, and low survival.

The entire production population of hatchery-origin winter-run Chinook Salmon were released into the upper Sacramento River in Redding from February 4-6, 2015. This segment of the

[2] Biweekly reports from RBDD are available at: http://www.fws.gov/redbluff/RBDD%20JSM%20Biweekly/2014/rbdd_jsmp_2014.html

winter-run population, which was released concurrently with a storm pulse, began entering the North Delta within a week after release based on monitoring data, coded wire tag recoveries, and acoustic tag detections. Detection of acoustic tags and recoveries of CWT tags have in occurred at the Sacramento I-80 receiver, in the Knights Landing rotary screw traps (RSTs), the Sacramento regional beach seines, and the Sacramento trawls occurring near Sherwood Harbor on the Sacramento River. Discussions by the DOSS team have estimated passage into the Delta to be approximately 70-85% for the hatchery winter-run Chinook salmon. A subset of this release group from LSNFH was tagged with JSAT acoustic telemetry tags (n=500) and provided another means to track the downstream migration of the hatchery-origin winter-run juveniles, in addition to the standard river, Delta, and salvage fish monitoring efforts already in place. As of March 16, 2015, approximately 27.8% of the acoustic tagged hatchery winter-run were observed to have entered the Delta at the I-80/50 bridge in Sacramento, based on at least 2 detections of each tag by the array on the bridge abutments. If only single detections are used (which could include some false positives), the percentage of the tagged hatchery fish reaching the North Delta is 39.2%. It is worth noting that the Tisdale Weir did overtop immediately following the release of these fish and adipose fin-clipped juvenile salmonids (indicative of hatchery fish which includes both winter-run Chinook Salmon released from LSNFH and late-fall Chinook salmon concurrently released from the Coleman National Fish Hatchery [CNFH]) were rescued from the downstream apron of the weir. This observation suggests that some proportion of the hatchery release groups from both the LSNFH and CNFH releases entered the Sutter Basin and took that route downstream. As of March 20, 2015, the total observed loss of hatchery winter-run, confirmed by CWT, at the salvage facilities is 8.40. The DOSS estimates for the hatchery winter-run Chinook and the detected passage of the telemetry tagged differ considerably, which could result from, in part, detections probabilities being reduced due to high turbidity and flows, differential migration rates or holding patterns.

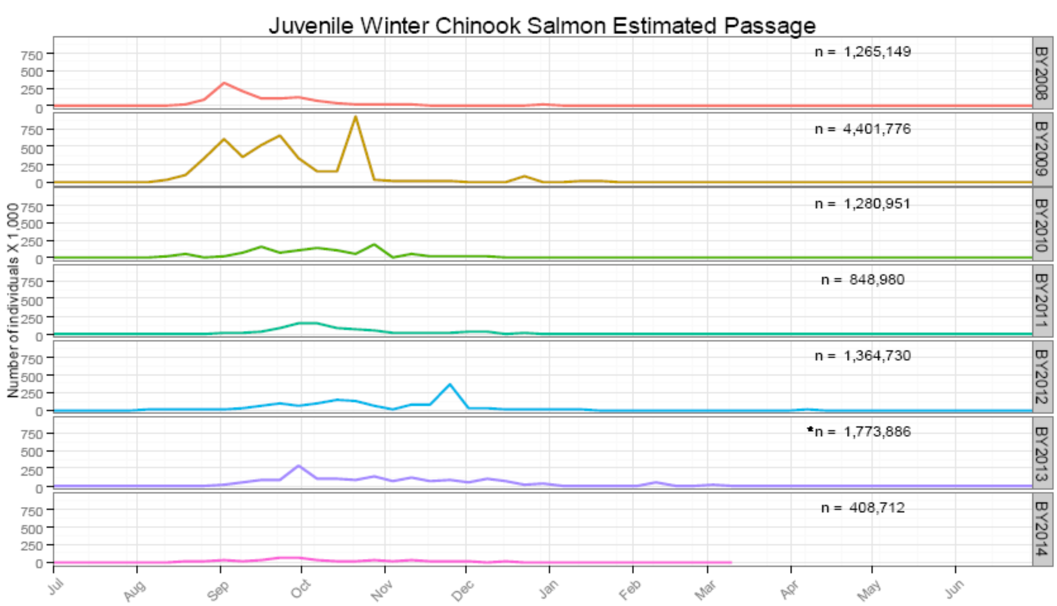

Figure 32. Weekly Estimated Passage of Juvenile Winter-run Chinook Salmon at Red Bluff Diversion Dam (RK 391) by Brood-Year (BY)[3]

[3] Fish sampled using rotary-screw traps for the period of July1, 2008 to present. Winter-run passage value interpolated using a monthly mean for the period October 1, 2013-October 17, 2013 due to government shutdown. Figure supplied by USFWS on March 11, 2015.

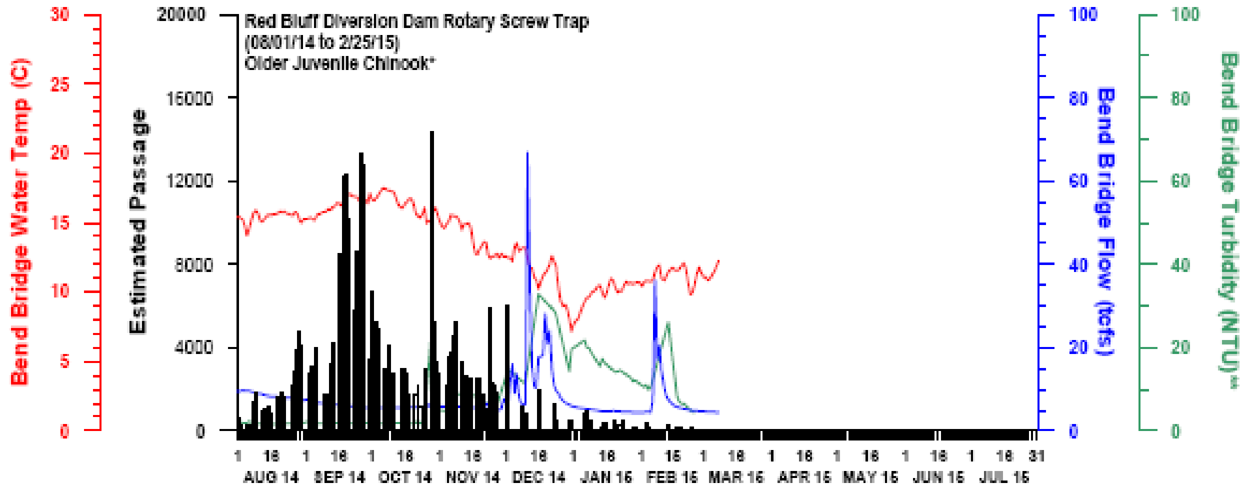

Figure 33. Red Bluff Diversion Dam Passage of Juvenile Older Chinook Salmon and Associated Environmental Data[4]

Table 8. Estimated Passage of Juvenile Winter Chinook Salmon at Red Bluff Diversion Dam (RK391) by Passage Quartile and Brood Year (BY)[5]

	Winter run Chinook Brood						
	2007	2008	2009	2010	2011	2012	2013
First	1/9/08	2/20/09	1/25/10	1/5/11	1/24/12	12/21/12	2/14/14
25%	1/25/08	3/1/09	3/3/10	3/16/11	3/22/12	3/18/13	3/5/14
50%	3/15/08	3/12/09	3/13/10	4/4/11	4/7/12	3/26/13	3/9/14
75%	3/25/08	3/26/09	3/31/10	4/15/11	4/11/12	4/4/13	3/14/14
Last	4/28/08	5/19/09	4/28/10	4/22/11	4/27/12	4/15/13	4/11/14

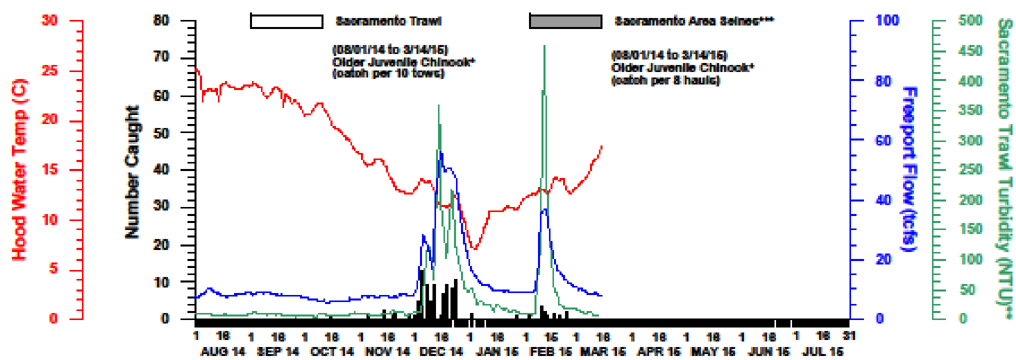

Figure 34. Sacramento Trawl and Sacramento Area Beach Seines Older Juvenile Chinook Salmon Catch Data and Associated Environmental Data[6]

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[4] Figure supplied by DWR on March 8, 2015

[6] Figure supplied by DWR on March 18, 2015.

Table 9. Weekly Catch of Juvenile Winter-run Chinook Salmon at Tisdale and Knights Landing Rotary Screw Traps for WY15 through March 13, 2015

	Tisdale								
	Wild Juveniles						Ad Clipped		
	Fall	Spring	Winter	Late fall	Steelhead		Salmon	Steelhead	Weekly Total
10/4/2014 - 10/10/2014	0	0	0	0	0		0	0	0
10/11/2014 - 10/17/2014	0	0	0	0	0		0	0	0
10/18/2014 - 10/24/2014	0	0	0	0	0		0	0	0
10/25/2014 - 10/31/2014	0	2	117	2	0		0	0	121
11/1/2014 - 11/7/2014	0	1	2	0	0		0	0	3
11/8/2014 - 11/14/2014	0	0	1	0	0		0	1	2
11/15/2014 - 11/21/2014	0	0	3	1	0		0	0	4
11/22/2014 - 11/28/2014	0	0	3	0	0		0	0	3
11/29/2014 - 12/5/2014	0	0	7	0	0		2	0	9
12/6/2014 - 12/12/2014	10	14	10	2	0		5	0	41
12/13/2014 - 12/19/2014	169	9	0	2	0		2	0	182
12/20/2014 - 12/26/2014	654	35	24	5	1		6	0	725
12/27/2014 - 1/2/2015	154	22	1	1	0		0	0	178
1/3/2015 - 1/9/2015	91	61	6	0	2		0	0	160
1/10/2015 - 1/16/2015	52	16	4	0	0		1	6	79
1/17/2015 - 1/23/2015	30	7	3	0	0		0	4	44
1/24/2015 - 1/30/2015	9	0	2	0	0		0	4	15
1/31/2015 - 2/6/2015	2	1	1	0	0		0	0	4
2/7/2015 - 2/13/2015	4795	43	3	0	0		193	18	5052
2/14/2015 - 2/20/2015	251	11	4	0	0		40	0	306
2/21/2015 - 2/27/2015	18	0	1	0	0		5	0	24
2/28/2015 - 3/6/2015	2	0	3	0	0		4	0	9
3/7/2015 - 3/13/2015	0	1	1	0	0		0	0	2
Species Total	6237	223	196	13	3	0	258	33	6963

	Knights Landing							
	Wild Juveniles					Ad Clipped		
	Fall	Spring	Winter	Late fall	Steelhead	Salmon	Steelhead	Weekly Total
10/4/2014 - 10/10/2014	0	0	1	0	0	0	0	1
10/11/2014 - 10/17/2014	0	0	0	0	0	0	0	0
10/18/2014 - 10/24/2014	0	1	0	0	0	0	0	1
10/25/2014 - 10/31/2014	0	1	95	4	0	0	0	100
11/1/2014 - 11/7/2014	0	0	2	0	0	0	0	2
11/8/2014 - 11/14/2014	0	0	2	0	0	0	0	2
11/15/2014 - 11/21/2014	0	0	3	0	0	0	0	3
11/22/2014 - 11/28/2014	0	0	2	0	0	0	0	2
11/29/2014 - 12/5/2014	0	0	2	0	0	0	0	2
12/6/2014 - 12/12/2014	17	50	32	8	0	24	0	131
12/13/2014 - 12/19/2014	148	88	5	1	0	4	0	246
12/20/2014 - 12/26/2014	411	112	14	4	0	8	0	549
12/27/2014 - 1/2/2015	13	6	0	1	0	0	0	20
1/3/2015 - 1/9/2015	15	13	0	2	0	2	0	32
1/10/2015 - 1/16/2015	25	13	0	1	0	0	7	46
1/17/2015 - 1/23/2015	12	6	0	0	0	0	5	23
1/24/2015 - 1/30/2015	3	1	0	0	0	1	0	5
1/31/2015 - 2/6/2015	1	0	0	0	0	0	0	1
2/7/2015 - 2/13/2015	6118	79	22	0	3	332	80	6634
2/14/2015 - 2/20/2015	674	21	7	0	2	102	25	831
2/21/2015 - 2/27/2015	7	0	3	0	0	5	0	15
2/28/2015 - 3/6/2015	0	0	0	0	0	0	0	0
3/7/2015 - 3/13/2015	2	0	0	0	0	1	0	3
Species Total	7446	391	190	21	5	479	117	8649

Table 10. **Lower Sacramento River and Delta beach seine and trawling recoveries of salmonids during WY 2015**[7]

	Wild juveniles					Ad clipped		
Beach Seine Region	**Fall**	**LateFall**	**Spring**	**Winter**	**Steelhead**	**Chinook**	**Steelhead**	**Regional Total**
Bay East	0	0	0	0	0	0	0	0
Bay West	0	0	0	0	0	0	0	0
Central Delta	36		10	1	0	0	1	48
Lower Sacramento	745	3	236	45	0	7	1	1037
North Delta	865	3	243	18	0	9	2	1140
Sacramento	216	2	55	8	2	10	0	293
South Delta					0	0	0	0
San Joaquin	2	0	0	0	0	0	0	2
Trawl								
Sacramento	116	5	17	11	0	17	0	166
Chipps				7	0	12	4	23
Jersey Point	371	1	5	2	0	0	4	383
Prisoners Pt	149	1	5	1	0	8	14	178
Species Total	2500	15	571	93	2	63	26	3270

[7] Trawl and beach seine data updated through March 16, 2015. Provided by USFWS Delta Juvenile Fish Monitoring Program.

Table 11. Salmonid presence in beach seines through different regions of the Delta during WY 2015

Week	Lower Sacramento	North Delta	Central Delta	San Joaquin	Sacramento	Grand Total
10/15/2014 - 10/21/2014	1					1
11/12/2014 - 11/18/2014		2				2
11/19/2014 - 11/25/2014		2				2
11/26/2014 - 12/2/2014	4				1	5
12/3/2014 - 12/9/2014	26	19			11	56
12/10/2014 - 12/16/2014	18	29			5	52
12/17/2014 - 12/23/2014	75	143			30	248
12/24/2014 - 12/30/2014	72	271	1		40	384
12/31/2014 - 1/6/2015	374	12			23	409
1/7/2015 - 1/13/2015	13	39	10		35	97
1/14/2015 - 1/20/2015	40	34	3		8	85
1/21/2015 - 1/27/2015	33	9				42
1/28/2015 - 2/3/2015	12	23			6	41
2/4/2015 - 2/10/2015	42	90	2		13	147
2/11/2015 - 2/17/2015	94	104			11	209
2/18/2015 - 2/24/2015	88	57	1	1	17	164
2/25/2015 - 3/3/2015	33	99	15		56	203
3/4/2015 - 3/10/2015	109	205	15		35	364
3/11/2015 - 3/13/2015	2			1		3
Grand Total	1036	1138	47	2	291	2415

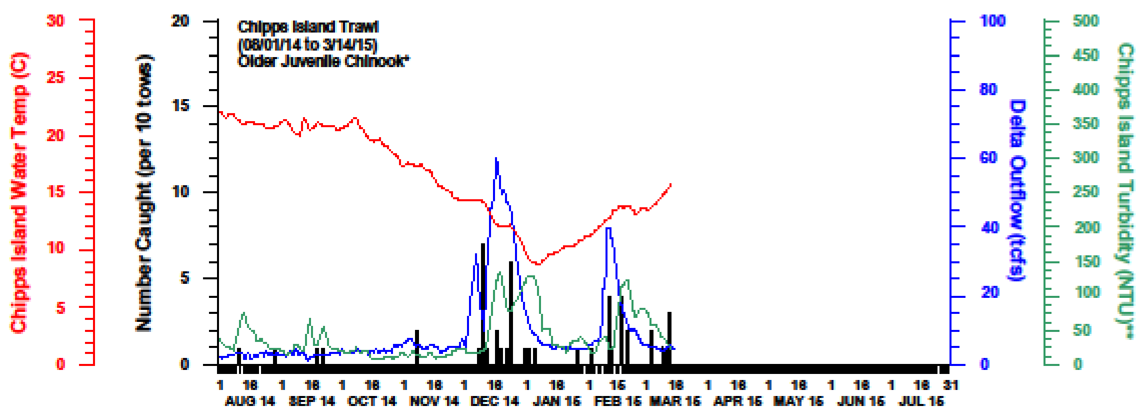

Figure 35. Chipps Island Trawl older juvenile Chinook Salmon catch data and associated environmental data[8]

Effects of Project Description on Winter-Run Chinook Salmon

The predicted distribution of winter-run Chinook Salmon during the Project Description period and a summary of potential effects is presented in Table 12, followed by more details per action type and location.

[8] Figure supplied by DWR March 17, 2015.

Table 12. Presence of Winter-run Chinook Salmon During the Project Description Period and Exposure to Potential Effects

Winter-run Chinook Salmon Life Stage	Life Stage Present	Tributary Habitat Effect	South/Central Delta Entrainment Effect	Facility Loss Effect
Egg/Alevin	This life stage will be present in the Sacramento River May through September for BY 15.			
Sacramento R	Yes	Yes[9]	N/A	N/A
Juvenile	This life stage will be present in the Delta during April and May for BY 14 and in the Sacramento during August to September for BY 15.			
Sacramento R	Yes	Reduced Survival	N/A	N/A
Delta	Yes	N/A	Yes	Uncertain
Adults	This life stage will be present in the Sacramento River and Delta during April through July			
Sacramento R	Yes	No Change	N/A	N/A
Delta	Yes	N/A	N/A	N/A

Sacramento River Actions

Temperature operations remain under discussion by the Sacramento River Temperature Task Group (SRTTG). The recent 90% temperature forecasts provided to the SRTTG in January and February both suggest that a temperature compliance point of 56ºF at the Clear Creek CDEC gaging station cannot be maintained through the winter-run Chinook Salmon egg incubation and fry rearing period. These forecasts suggest temperatures below 56ºF would no longer be attainable in mid-August to early September, which would suggest no potential impact on spawning adults. These forecasts suggest similar impacts as described during the late summer of WY 2014 (Figure 36). Impacts to egg and alevin stages are more difficult to predict due to uncertainties with actual spawn timing, redd locations, and observed hydrological and temperature profiles. A temperature management plan for the upper Sacramento River continues to be developed and an appropriate biological review will be provided upon its completion. Forecasted Sacramento River flows during the Project Description do not include large weekly fluctuations, and will incorporate ramping rates, which minimize stranding and isolation of winter-run Chinook Salmon juveniles.

[9] Temperature management and effects will be evaluated by the SRTTG.

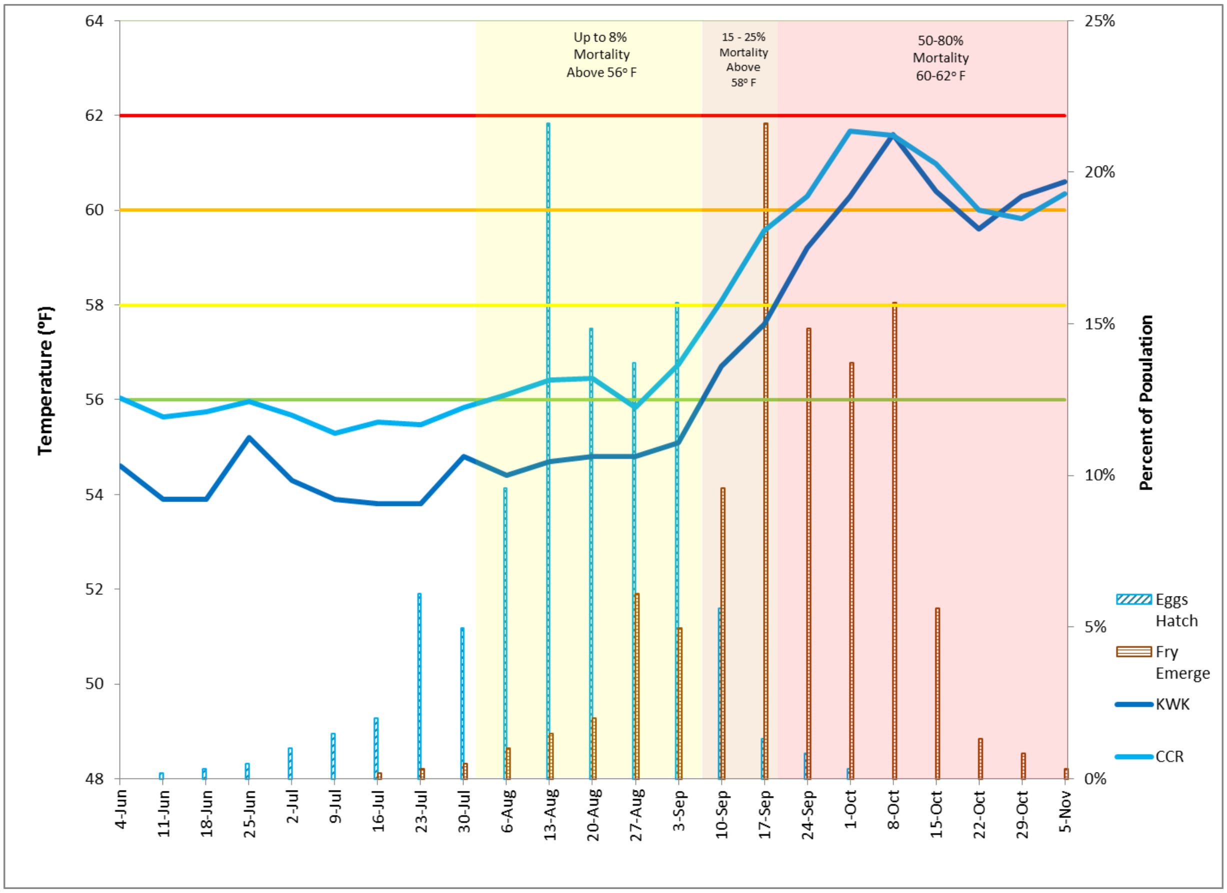

Figure 36. Water Temperatures at Keswick Dam (KWK) and Clear Creek Confluence (CCR, WY14 temperature compliance point) and Winter-run Chinook Salmon Early Life Stages between May 1 and November 6, 2014 [10]

Net Delta Outflow Index and Water Quality Modifications

The Project Description during the remainder of WY 2015 is intended to preserve storage in Shasta Reservoir and increase the cold water pool available for management of temperatures for winter-run Chinook Salmon as late into the summer as feasible. Under the Project Description, the Net Delta Outflow Index (NDOI) will be modified from a minimum monthly daily average of 7,100 cfs to no less than 4,000 cfs during the months of April through June, and no less than 3,000 cfs during the month of July. This reduction in NDOI will lead to reduced Keswick releases during these months, which may affect out migrating winter-run Chinook Salmon during the remainder of spring 2015. DOSS estimated on March 17, 2015 that <5% of natural winter-run and <15% of hatchery winter-run remain in the riverine habitat affected by these releases upstream of the Delta. Approximately 85% of each of these groups is projected to be within the Delta and subject to effects resulting from any modified operations. These effects have been described previously (NMFS 2014a, USBR 2014a, USBR 2014b), but are reviewed here again since the distribution and proportion of winter-run Chinook Salmon in the Delta and Sacramento River have changed since these prior assessments. The changes in hydrodynamics in the modeled scenarios are representative of a range of conditions possible during April and May, and do not reflect the influence of potential Delta drought barriers that may be installed in the Delta.

[10] Figure supplied by CDFW on January 20, 2015.

Although the NMFS BiOp (2009) does not contain outflow standards, the BiOp assumed that D-1641 standards would be met, which would afford protection to listed species and their designated critical habitats. The reduction in outflow as part of the Project Description may impact juvenile salmonids migrating through the North Delta between the Sherwood Harbor and the Sutter and Steamboat slough reach, where Sacramento River flows meet the tidally-dominated western Delta. The Project Description's reduction in Delta outflow to as low as 4000 cfs may reduce survival of out migrating winter-run Chinook Salmon, migrating through the North Delta through increased predation mediated by hydrodynamic and habitat mechanisms. Once out migrating fish reach the tidally-dominated western Delta (i.e., Sutter and Steamboat slough area downstream towards Chipps Island) or San Joaquin River under the minimum outflows identified in the Project Description, they are likely to encounter daily proportion of positive velocities and mean velocity that are similar to outflow conditions observed in the Baseline modeling (see, *e.g.*, Figures 10-15). There is a moderate level of uncertainty in these conclusions.

The Project Description's reduced outflow increases tidal excursion upstream (reduced daily proportion of positive velocities) into the waterways in the North Delta region primarily in April. In April, there is a reduction in the proportion of positive daily flows passing Georgiana Slough and/or an open Delta Cross Channel compared to May in both the Baseline and Project Description DSM2 modeling (Tables 6-7). Increased reverse flows and slower mean velocities result in longer travel times for migrating fish, which has been shown to reduce outmigration survival (Singer et al. 2013, Perry 2010, and Romine et al. 2013). Georgiana Slough flows become less positive as tidal excursion causes reversal in this channel when outflow is reduced. Reducing outflow also causes a decrease in the daily proportion of positive velocities through the Sacramento River downstream of Sutter and Steamboat sloughs confluence with the Sacramento River. These increased tidal excursions may increase juvenile entrainment into Georgiana Slough and, if open, the Delta Cross Channel. When the DCC gates are open, the daily mean channel velocity becomes even less positive in these reaches (Tables 6-7, Figures 8-9).When the DCC gates are open, the daily proportion of positive velocities further decreases in the Sacramento River upstream of the DCC gates and more noticeable between the DCC gate and Georgiana Slough. When the DCC is open, there is a reduction in the daily proportion of positive flows through Georgiana Slough. There is a low level of uncertainty in this conclusion.

At low outflow, channel margin habitat becomes exposed above the surface of the water and is unavailable to juvenile salmonids present. This lack of cover may reduce juvenile survival. It is hypothesized that lower outflows may intensify the density of littoral predators into a smaller, shallower area and/or decrease the quantity of cover available to outmigrating salmonids to avoid predators. There is a high level of uncertainty in this conclusion. Decreased daily mean velocities may result in increased residence time of juvenile winter-run Chinook Salmon, which is hypothesized to result in an increased size at ocean entry if they are rearing in areas with suitable environmental metrics and food resources. There is a high level of uncertainty in this conclusion.

Delta Cross Channel Gates

Under the Project Description, modified Delta Cross Channel Gates operations may occur based on water quality and fish presence. At this time, it is believed that an open DCC Gate has a low potential for entraining a substantial proportion of the juvenile winter-run Chinook Salmon population through this junction and into the Central Delta. This is because a majority of the natural (>95%) and hatchery (>70-85%) juvenile winter-run population is believed to already be in the Delta; many of those may have already passed this location and are currently residing downstream of the DCC gate location or have exited the system altogether and have emigrated to the marine environment. The remaining fraction of the natural and hatchery winter-run juvenile population that may still occur above the DCC location will be vulnerable to entrainment into an open DCC gate configuration as they emigrate downriver past the DCC gate location. Because outmigration of both natural and hatchery winter-run juveniles past Chipps Island is expected to be largely complete by mid-April, the Project Description's Modification of the DCC gate operations will affect winter-run in the North Delta compared to the Baseline scenario, but only for a short time. It is uncertain whether the increase in the likelihood of entrainment into the Central Delta will result in any change to facility loss of winter-run, both because the duration of the effect is expected to be short, and because the limited exports in the Project Description scenarios may not result in greater entrainment into the South Delta and facility loss (see discussion in "Exports" section).

If the DCC gates were open Sacramento River water will flow through the DCC and into the Mokelumne River system. This may result in some level of straying of upstream migrating adult Winter-run Chinook Salmon into the Mokelumne River system. It is expected that this may delay these adults on their upstream spawning migration. Adult winter-run Chinook Salmon which have entered the Mokelumne River system should be able to re-enter the Sacramento mainstem through the open DCC gates and continue their upstream movements. A delay in reaching the spawning grounds and an increase in energy expenditure may result. This could result in lower survival of juveniles produced from straying individuals, if temperatures in the upper river become unsuitable for egg and fry survival.

Exports

The Project Description scenario is expected to result in minimal additional entrainment of juvenile winter-run Chinook. Exports, barring a precipitation event substantial enough to produce natural and abandoned flows resulting in an NDOI greater than 5500cfs and closure of the DCC gates, if open, will be limited to combined 1500 cfs. The PTM for the Baseline and Project Description scenarios with Sherwood Harbor as the injection location (Figure 29) indicates that ~3% more particles are entrained at the export facilities in the modified scenarios (5% for Project Description (DCC Closed), 5.1% for Project Description (DCC open)) compared to the baseline (2%). The exposure to the increased risk of facility loss will occur in early April, after which the majority of juvenile winter-run Chinook are located further west and are exiting the Delta past Chipps Island. Considering that the majority of natural origin and hatchery winter-run are currently still rearing in the Delta and salvage of fish at the CVP/SWP fish collection facilities has occurred this season, concern for the entrainment risk at the projected export ranges would be a moderate risk of entrainment in early April, and low (for Winter-run) from mid-April onward.

Summary of Effects on Winter Run Chinook Salmon

The proposed operational modifications to the D-1641 flow and operational criteria may reduce through-Delta survival of migrating juvenile winter-run Chinook Salmon by the reducing the transit rate for these migrating salmonids, which may increase the predation potential. The timing of Delta exit appears to be fairly consistent over time and while less than 15% have been projected to have migrated out of the Delta, the remaining portion should exit during April and possibly into May (del Rosario 2013). While salvage of listed juvenile Chinook is projected to remain moderate due in part to the migratory behavior being displayed by winter-run Chinook Salmon juvenile and the low levels of exports, if exports increased during the Project Description in April and May, a measure to reduce the risks associated with entrainment loss would occur by shifting exports from the SWP to the CVP.

Status of Spring-Run Chinook Salmon

The 2014 spawning run of spring-run Chinook Salmon returning to the upper Sacramento River Basin was lower in four of seven locations compared to the 2013 escapement, with markedly lower escapement observed in Clear Creek, Butte Creek, and Feather River Hatchery (Table 13).

Table 13. Spring-run Chinook Escapement in 2013 and 2014

Tributary	2013	2014	Percent Change	Source
Battle Creek	608	429	-29	Laurie Earley, USFWS
Clear Creek	659	95	-86	
Antelope Creek	0	7	-	Matt Johnson, DFW
Mill Creek	644	679	+5.4	
Deer Creek	708	830	+17	
Butte Creek	16783	4815	-71	Clint Garman, DFW
Feather River Hatchery	4294	2825	-34	Penny Crenshaw, DWR

Spawning of spring-run Chinook salmon in the Sacramento River Basin occurs approximately from mid-August through mid-October, peaking in September. In 2014, this peak in spawning activity corresponded with the high Sacramento River temperatures downstream of Keswick Dam resulting in an elevated potential for high egg and alevin mortality. It is believed that spring-run Chinook salmon eggs in the Sacramento River underwent significant, and potentially complete mortality due to high water temperature downstream of Keswick Dam starting in mid-August when water temperatures downstream of Keswick Dam exceeded 56^{o}Fahrenheit (F) (see water temperatures in August through October in Figure 36) in WY 2014. Spring-run Chinook

Salmon eggs spawned in the tributaries to the Sacramento River may also have experienced warmer temperatures in 2014 due to low flows through late October, as well as scouring or sedimentation during rain events from late October through December.

Juvenile spring-run Chinook salmon begin emigration from Clear Creek soon after emergence, with passage near the mouth peaking in November through December and continuing to around May. Recent year passage indices are shown in Table 14. For BY 2014, extremely few juvenile Spring-run Chinook Salmon were observed migrating downstream past RBDD (Figure 37) during high winter flows, when spring-run Chinook Salmon originating from the upper Sacramento River, Clear Creek, and other northern tributaries are typically observed to outmigrate. As of March 11, 2015[11], only 35,435 BY 2014 spring-run Chinook Salmon were estimated to have passed Red Bluff Diversion Dam, and these low RBDD passage estimates are a concern. A second pulse of juvenile spring-run Chinook Salmon typically migrate past RBDD in the springtime (Poytress et al. 2014). However, this second pulse appears to positively bias estimates of spring-run Chinook passage due to the presence of millions of unmarked fall-run Chinook salmon hatchery fish released from the Coleman National Fish Hatchery on Battle Creek. These hatchery production fish typically overlap with the spring-run Chinook salmon category based on the length-at-date run assignments (Poytress et al. 2014).

Table 14. Passage Indices of Juvenile Spring-run Chinook Salmon with 90% and 95% Confidence Intervals for Brood Years (BY) 2003-2013 Captured by the Upper Rotary Screw Trap at River Mile (RM) 8.4 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service. The Adjusted Passage Index (Proportionate to Juveniles per Redd) Includes Redds Below the Trap, yet Above the Separation Weir. For BY 2013, Confidence Intervals and Adjusted Index Have Not Been Calculated Yet

Brood year	95% LCI	90% LCI	Passage index	90% UCI	95% UCI	Adjusted index	Juveniles per redd
2003	88,817	90,113	108,338	130,960	137,672	110,422	2,083
2004	87,439	90,417	107,054	131,700	136,701	110,028	2,974
2005	87,516	89,516	104,197	122,580	128,418	106,201	2,004
2006	111,749	113,659	127,197	144,692	148,539	149,318	1,843
2007	92,728	94,472	110,224	130,585	135,069	114,914	2,345
2008	88,834	89,653	96,166	102,920	104,402	121,622	1,414
2009	62,213	63,214	68,296	74,319	75,384	74,084	1,158
2010	15,228	15,618	17,359	19,416	19,910	19,288	1,929
2011	49,247	49,893	53,896	58,238	59,007	57,265	3,369
2012	16,124	16,363	17,891	19,695	20,020	19,447	778
2013			227,912				1,767

[11] Fish were sampled using rotary-screw traps for the period July 1, 2008 to present. Figure supplied by USFWS on March 11, 2015.

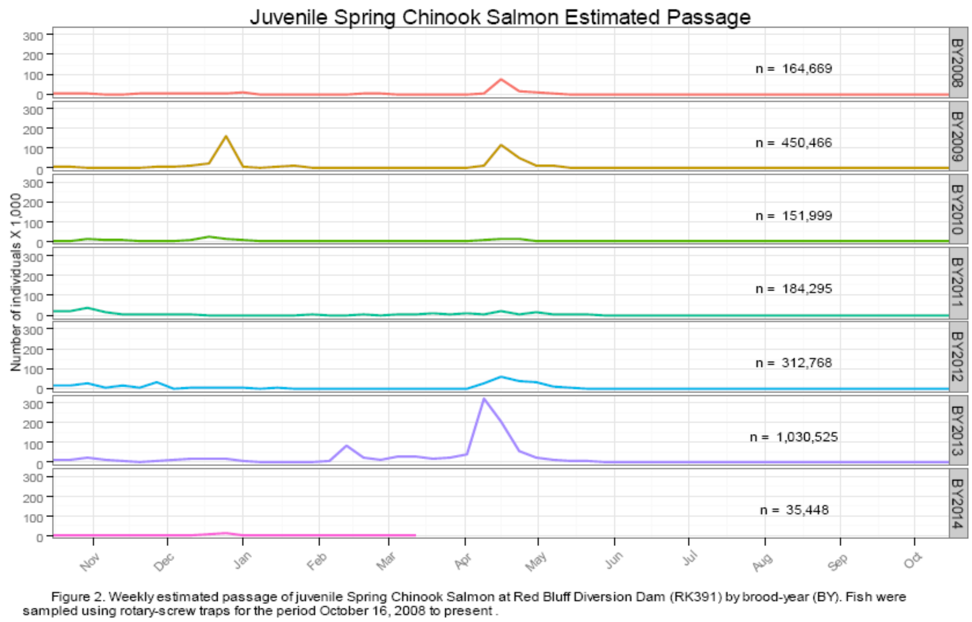

Figure 37. Weekly Estimated Passage of Juvenile Spring Run Chinook Salmon at Red Bluff Diversion Dam (RK 391) by brood year (BY)[12]

In fall 2014, yearling spring-run Chinook Salmon from Mill and Deer creeks experienced flow and temperature conditions typically associated with the outmigration of this life history expression from these tributaries. Although not currently monitored with RSTs, these tributaries have experienced flows (Figures 38-39) exceeding “First Alert” thresholds identified in the NMFS BiOp Action IV.1.2. Recent analyses of multiple years of RST data have determined that 99% of outmigrating yearlings are captured at flows greater than 95 cfs (Kevin Reece, DWR, pers. comm.).

Spring-run young-of-the-year (YOY) sized Chinook Salmon juveniles have been observed at the Tisdale Weir and Knights Landing RSTs since early December 2014 (Table 9). Likewise, juvenile YOY spring-run Chinook have been observed in the catch from multiple Delta beach seine regions, and in the standard trawling and special drought monitoring trawling surveys, including those in the Central Delta (Tables 10-11). Monitoring data suggest that the majority of surviving BY 2014 natural origin YOY juveniles are currently residing in the Delta, downstream of Knights Landing. No yearling spring-run Chinook Salmon have been caught in 2014 Delta monitoring, however, yearling spring-run observations are expected to be rare because of their relatively large size and strong swimming ability (associated with gear avoidance), and relatively low densities relative to YOY. The majority of YOY, yearling, and surrogate (hatchery late fall) spring-run are currently rearing in the Delta. This estimate is based on the best professional judgment of the biologists participating on the DOSS work team. No natural or hatchery origin spring-run Chinook Salmon have been salvaged at the fish collection facilities as of March 15, 2015.

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[12] Fish were sampled using rotary-screw traps for the period July 1, 2008 to present. Figure supplied by USFWS on March 11, 2015.

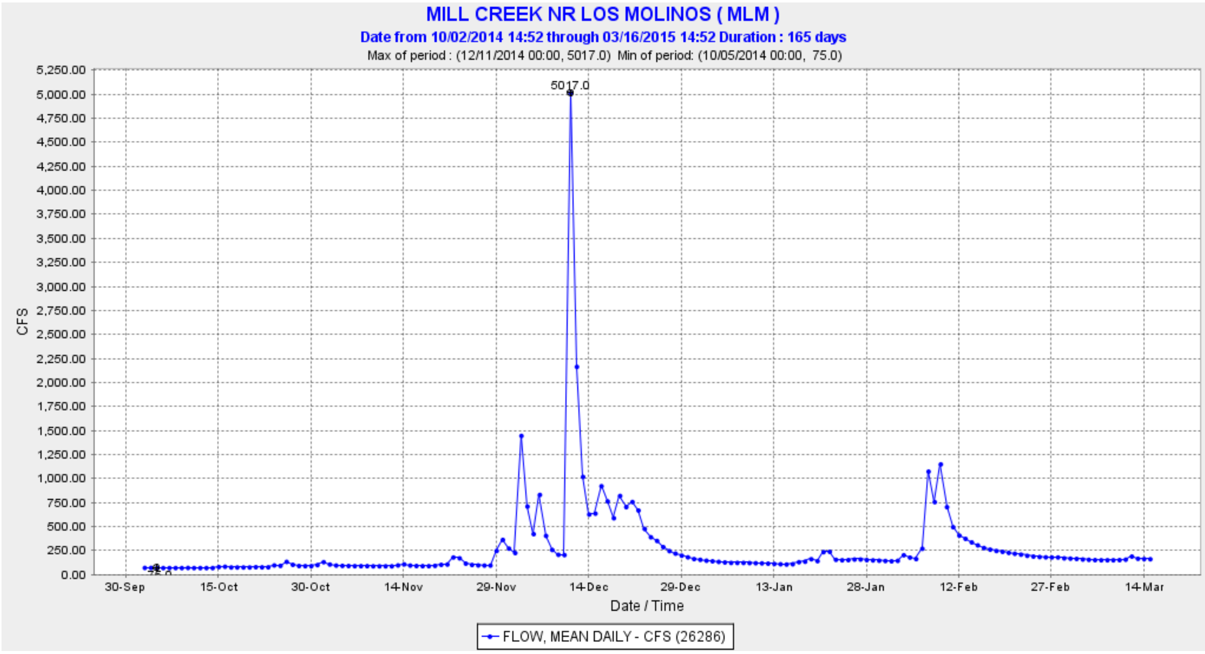

Figure 38. Mill Creek Mean Daily Flow (cubic feet per second) Measured near Los Molinos (MLM) During WY2015[13]

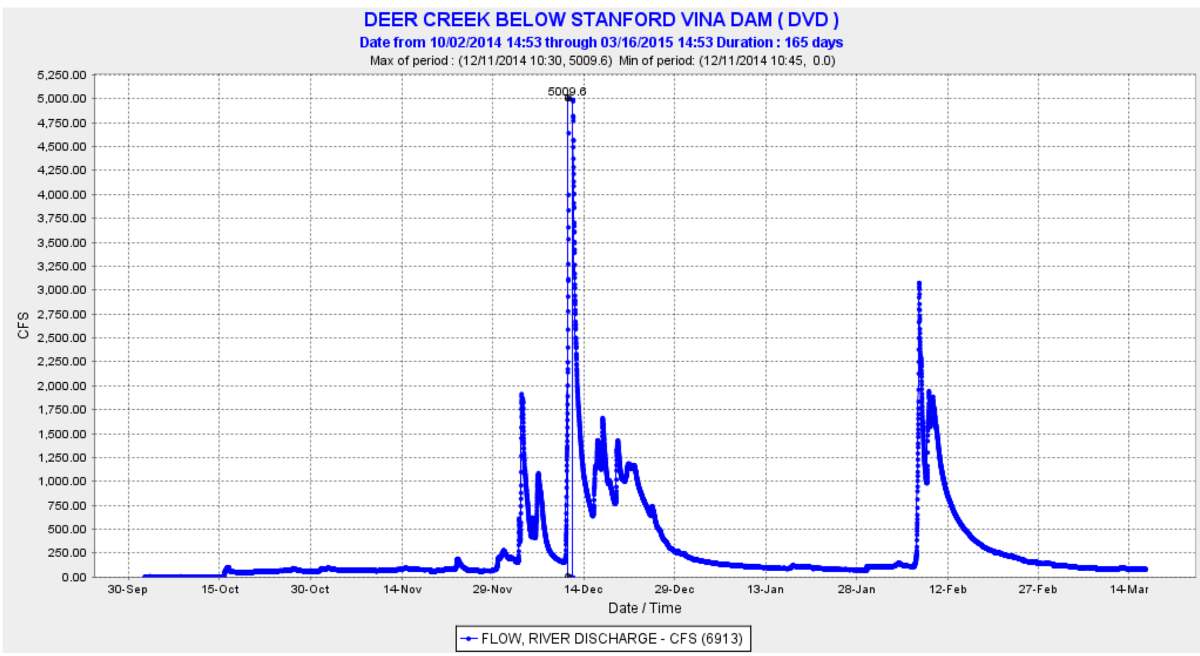

Figure 39. Deer Creek Discharge (cubic feet per second) Measured Downstream of Stanford Vina Dam (DVD) During WY2015[14]

[13] Downloaded from CDEC on March 16, 2015.

[14] Downloaded from CDEC on March 11, 2015.

Adult spring-run Chinook salmon will be entering the upper Sacramento River and Clear Creek during spring and continue into the summer of 2015, then holding until they start spawning in mid-August, with peak spawning occurring in September and completing by mid-October. Spring-run Chinook salmon spawning in Clear Creek occurs primarily upstream of a barrier weir installed at river mile 7 that separates spring-run and fall-run Chinook salmon spawning based on timing of entry into the tributary and protects spring-run Chinook salmon eggs from super-imposition by fall-run Chinook salmon spawners later in the year. Table 15 shows spring-run Chinook Salmon spawning distribution in Clear Creek. Distribution has shifted upstream somewhat through the years after removal of McCormick-Seltzer diversion dam (approximately RM 6.2) in 2000 and with repeated gravel additions.

Spring-run Chinook Salmon may spawn in the Sacramento River between RBDD and Keswick Dam in very low densities with only a total of 449 redds documented from 2001 to 2014 (average 37/year; range= 0-105; no data available for 2009 or 2011; CDFW unpublished data). Most spring-run Chinook Salmon redds (93 percent) have been documented upstream of Jelly's Ferry Bridge (river mile [RM] 265.9).

Table 15. Distribution of Spring run Chinook Salmon Redds in Clear Creek, 2003–2013. River miles (RM) Begin at the Confluence at RM 0, and End at Whiskeytown Dam at RM 18.3. Both RM 7 (0.6 miles) and RM 18 (0.3 miles) are Incomplete Miles. RM 7 was Not Available for Spring run Spawning in 2003-2005, and 2011 When the Weir Was Located at the Lower Site

Year	RM 7	RM 8	RM 9	RM 10	RM 11	RM 12	RM 13	RM 14	RM 15	RM 16	RM 17	RM 18	**Total**
2003	NA	4	5	9	2	3	0	15	3	4	5	3	**53**
2004	NA	9	1	9	2	0	2	4	3	3	4	0	**37**
2005	NA	4	2	11	4	0	1	4	10	3	11	2	**52**
2006	4	11	8	12	13	7	0	4	8	10	5	0	**82**
2007	0	6	1	5	0	2	1	1	7	15	11	0	**49**
2008	8	18	3	11	4	6	0	11	5	13	6	1	**86**
2009	3	8	2	15	4	1	4	6	4	4	13	0	**64**
2010	1	1	0	3	0	0	0	1	1	2	1	0	**10**
2011	NA	1	0	5	0	2	1	5	0	2	0	0	**16**
2012	1	2	1	7	2	1	2	5	2	2	0	0	**25**
2013	5	11	2	30	5	11	6	11	10	25	23	3	**142**
2014	1	6	3	12	1	6	2	6	4	4	10	0	**55**

Effects of Project Description on Spring-run Chinook Salmon

The predicted distribution of spring-run Chinook Salmon during the Project Description period and a summary of potential effects is presented in Table 16, followed by more details per action type and location.

Table 16. Presence of Spring run Chinook Salmon During the Project Description Period and Exposure to Potential Effects

Spring-run Chinook Salmon Life Stage	Life Stage Present	Tributary Habitat Effect	South/Central Delta Entrainment Effect	Facility Loss Effect
Egg	This life stage will be present in the Sacramento River in September			
Sacramento R	Yes	Yes	N/A	N/A
Clear Creek	Yes	Yes	N/A	N/A
Juvenile	This life stage will be present in the Sacramento River and Delta during April and May			
Sacramento R	Yes	Reduced Survival	N/A	N/A
Clear Creek	Yes	No Modification in Project	N/A	N/A
Delta	Yes	N/A	Increased	Uncertain
Adults	This life stage will be present in the Sacramento River and Delta during April through September			
Sacramento R	Yes	No Change	N/A	N/A
Delta	Yes	N/A	No Change	No Change

Sacramento River Actions

Temperature operations as part of the Project Description remain under discussion by the SRTTG. The 90% temperature forecasts provided to the SRTTG in January and February both forecast a temperature compliance point of 56ºF at the Clear Creek CDEC gaging station cannot be maintained during September when peak spring-run Chinook salmon spawning and egg incubation occurs. Impacts to egg and alevin stages are more difficult to predict due to uncertainties with actual spawn timing, redd locations, and observed hydrological and temperature profiles. A temperature management plan for the upper Sacramento River, including Clear Creek, continues to be developed and an appropriate biological review will be provided upon its completion. Forecasted Sacramento River flows during the Project Description include reduced releases from Shasta during September, which may cause some spring-run Chinook redd dewatering. Chinook redd dewatering at multiple locations was documented during Fall 2014 when Keswick flows were reduced below 5,000 cfs.

Net Delta Outflow Index and Water Quality Modifications

Drought operational actions impacting Sacramento River outflow proposed during the remainder of WY2015 are intended to preserve storage in Shasta Reservoir and increase the potential coldwater pool available for management of temperatures for both winter-run and spring-run Chinook Salmon. Similar to winter-run Chinook Salmon, the reduction in Keswick releases to meet modified spring D-1641 NDOI standards may affect outmigrating spring-run Chinook Salmon during the remainder of spring 2015. As of March 17, 2015, DOSS estimates that the majority (80-95%) of natural-origin YOY Spring-run Chinook Salmon are rearing in the Delta, with approximately 5-20% remaining upstream of the Delta and <5% have exited the Delta. In contrast, the entire cohort of yearling spring-run Chinook Salmon are either in, or have existed the Delta (approximately 50% each), with the exception of a few possible stragglers upstream of the Delta.

Effects to individuals remaining upstream would be similar to those described above for Winter-run Chinook Salmon upstream of the Delta. To review, reductions in Delta outflow to as low as 4,000 cfs during April and May may reduce migratory survival of any YOY spring-run Chinook Salmon migrating through the Sacramento River until reaching the tidally dominated North Delta through increased predation mediated by hydrodynamic and habitat mechanisms. Increased tidal excursions are likely to increase entrainment of any downstream migrating YOY into Georgiana Slough and, if open, the Delta Cross Channel. The reduced velocities in the lower Sacramento River due to reduced inflow is evident in the DSM2 modeling and increased tidal excursion occurs in this modeling causing less positive velocities until tides reduce the force of incoming riverine flows and mute any difference observed in the modeling from the Baseline and Project Description scenarios (Figures 2-11). The possible reductions in outflow through multiple distributaries in the North Delta may increase straying and travel time of adult spring-run Chinook Salmon in this region during April and May.

Rearing juvenile spring-run Chinook Salmon within the Delta are not expected to be affected by the Project Description's modifications to NDOI and Delta water quality standard during April and May. Flows are tidally dominated in the North Delta and Central Delta areas where rearing occurs (Figures 4-15). There is low certainty in our understanding of the juvenile salmonid biological processes affected by flow in the Delta. South Delta conditions in the Project Description scenario are similar to the Baseline scenario during April and May (Figures 22 and 23). There is moderate certainty in our understanding of how hydrodynamics and suitable habitats for rearing juvenile salmonids are affected in the Delta by the Project Description .

Clear Creek Actions

Temperature management on Clear Creek attempts to achieve a temperature compliance schedule to reduce thermal stress to over-summering steelhead and to spring-run Chinook Salmon during their holding, spawning, and incubation periods. Under the 90% Operation Forecast, monthly average flows in August and September are estimated to be 85 cfs and 150 cfs, respectively, and with those lower flows, there is a potential for temperature criteria to be exceeded during these months. Adult spring-run Chinook Salmon holding when temperatures exceed 60°F may experience higher pre-spawn mortality, and those surviving may have reduced egg viability. If temperatures exceed 56°F after September 15, there will be greater mortality of incubating eggs and pre-emergent fry. There is low uncertainty in this conclusion. The temperature management for Clear Creek will be coordinated through the Sacramento River Temperature Task Group under the SWRCB 90-5 requirements and as outlined in RPA Action I.1.5.

Delta Cross Channel Gates

Under the Project Description, modified Delta Cross Channel Gates operations may occur based on water quality and fish presence as described in the Project Description. Effects to spring-run Chinook Salmon are generally similar to those discussed above for winter-run Chinook whereby an open DCC Gate has a low potential for entraining juvenile spring-run Chinook Salmon through this junction and into the Central Delta due to most juvenile (about 85-95% YOY and 95% yearling) spring-Run Chinook Salmon having already passed this location earlier this year. There is a low potential for adult straying associated with some Sacramento River water flowing through the DCC and into the Mokelumne. Additionally, there is a low potential for temporary adult migration delays and associated lower egg viability due to physiological stress from increasing energy expenditures or increasing exposure to high water temperatures.

Exports

The Project Description scenario is expected to result in minimal additional entrainment of juvenile spring-run Chinook Salmon. Exports, barring a precipitation event substantial enough to produce natural and abandoned flows resulting in an NDOI greater than 5500cfs, and closure of the DCC gates, if open, will be limited to combined 1500 cfs. These low export levels are not expected to appreciably affect survival of juvenile spring-run Chinook Salmon emigrating through the Delta. The PTM run with Sherwood Harbor as the injection location (Figure 29) indicates that ~3% more particles are entrained at the export facilities in the modified scenarios (5% for Project Description (DCC Closed), 5.1% for Project Description (DCC open)) compared to the baseline (2%). Since export levels are the same between the Project Description and Baseline scenarios, the change in the risk of loss at the export facilities is likely unchanged between scenarios for fish in the interior delta, but, due to the expected increase in entrainment of fish into the central/south Delta, more fish might reach the interior Delta under the actions in the Project Description (even if, though to a lesser extent, if the DCC is closed). Therefore, the cumulative effect of exports due to the Project Description is uncertain, since that effect will depend on distribution of outmigrating spring-run Chinook salmon. The majority of natural origin Spring run Chinook Salmon are currently rearing in the Delta, yet as of March 15, 2015, no Spring run Chinook Salmon juveniles have been salvaged at the pumping plants. This is likely due to the very low juvenile productivity. The entrainment risk at the minimum export levels described in the Project Description is similar to the Baseline scenario, and remains low-to-moderate through April and May based on their current distribution and rarity.

Summary of Effects on Spring-run Chinook Salmon

The extreme drought conditions are causing increased stress to spring-run Chinook Salmon populations, with or without water project operations, in the form of low flows reducing rearing and migratory habitats, higher water temperatures affecting survival, and likely higher than normal predation rates. Water management over the first portion of WY 2015 has focused on maintaining a level of reservoir storage which is generally higher than what would have been in place at this time without the planning that has gone into attempting to reduce adverse effects on resources. The current drought operations plan strives to continue to save some water resources for the future in the hopes of minimizing long-term adverse effects of the drought.

Cumulatively, the Project Description modification to the D-1641 flow and operational criteria may reduce through-Delta survival of juvenile migrating spring-run Chinook Salmon and may modify their designated critical habitat during April and May. Changes in Sacramento River outflow during April and May can possibly delay adult spring-run Chinook salmon migration. Drought conditions and current reservoir storage levels have forecasted to impact the ability to maintain suitable water temperatures in the Upper Sacramento River and Clear Creek. Temperature effects on Clear Creek and in the Upper Sacramento may lead to possible higher pre-spawn mortality of adult Spring-run Chinook Salmon and reduced egg viability if temperatures exceed 60°F during August and early September, as well as greater mortality of incubating eggs and pre-emergent fry if temperatures exceed 56°F after September 15.

Status of Green Sturgeon

Information on green sturgeon is extremely limited. Adult green sturgeon will migrate into the upper Sacramento River through the Delta in March and April. Last year, a review of telemetric data found 26 tagged green sturgeon entered the San Francisco Bay with only half migrating upstream of RBDD (M. Thomas, UC Davis, pers. comm.). Already in 2015, one acoustically-tagged adult was recorded migrating past Sacramento this winter and based on typical migration rates, has likely reached Red Bluff (M. Thomas, UC Davis, pers. comm.).

Adult green sturgeon have been observed to overwinter in the Sacramento River, and a number of tagged 2014 adults appeared to still be present in the upper Sacramento River as of January, 2015 (R. Chase, Reclamation, pers. comm.), but it is unknown if they remained in this area during the past two months (M. Thomas, UC Davis, pers. comm.). Also, adult green sturgeon exit through the Lower Sacramento River during the summer and fall following their spawning, then return to SF Bay throughout this period also. Green sturgeon exit the San Francisco Bay late in the summer through the winter.

Spawning typically occurs from April through July. Spawning in the upper Sacramento River was documented during 2014 and associated larval green sturgeons were observed at RBDD during the summer of 2014 (n=316). This was greater than the long-term average of 186 fishes, but less than the highest number observed (i.e., >3,500 in 2011; Figure 40). At RBDD, two juvenile green sturgeon were also observed in the fall of 2014, but no additional fish have been recorded as of March 12, 2015 (Bill Poytress, USFWS, pers. comm.). At GCID, ten juvenile green sturgeon (TL= 110-285) were observed from September through October 2014 and no additional fish have been recorded as of March 9, 2015. Based on Israel and Klimley (2009), BY 2014 juvenile green sturgeon have likely migrated downstream from their natal spawning areas and are overwintering in the Lower Sacramento River and Delta.

Green sturgeon observations are extremely rare in the Delta, primarily related to the use of monitoring gear types that are not designed to sample the benthic habitats where green sturgeon are most likely to be found if they are present. Although the lower Sacramento and Delta fish monitoring surveys do not target benthic environments, they have captured juvenile green sturgeon in the past, but none have been observed in these surveys in recent years including during 2011 when high numbers were observed migrating downstream past RBDD. One dead green sturgeon (FL= 670mm) was removed from the SWP Fish Facility on February 9, 2015. In 2011, over a thousand juvenile green sturgeons were enumerated at RBDD and none were observed in Delta or Bay fish monitoring. While this absence in the monitoring may suggest no impact from Delta Cross Channel operations or outflow operations, it may also suggest the recruitment of juveniles may be limited before the species reaches one year old due to habitat, predation, or multiple stressors; which is a phenomenon that has been observed in other North American sturgeon species. More monitoring needs to be conducted in order to reduce this uncertainty.

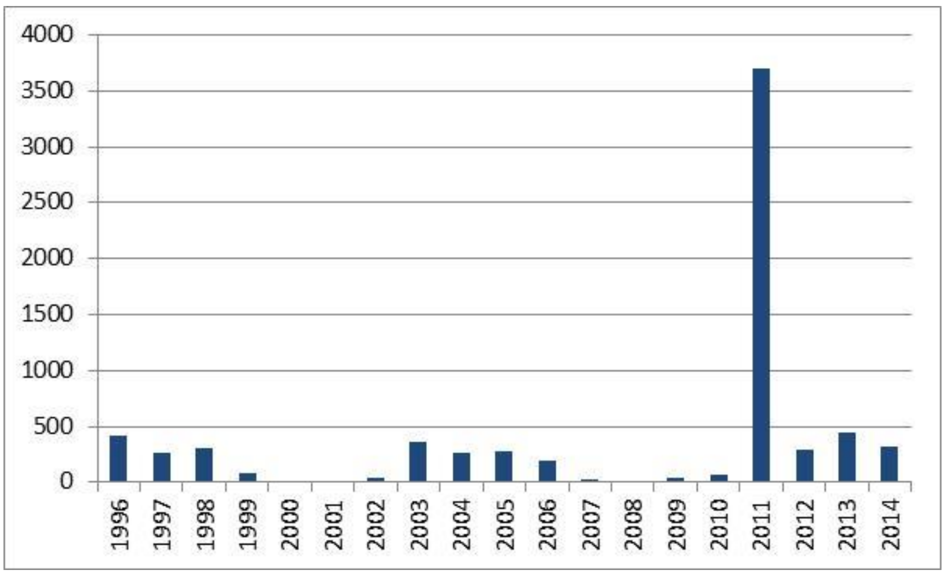

Figure 40. Larval Green sturgeon counted at Red Bluff Diversion Dam rotary screw traps[15]

Effects of Project Description on Green sturgeon

The predicted distribution of Green Sturgeon during the Project Description and a summary of potential effects are presented in Table 17, followed by more details per action type and location.

Sacramento River Outflow

The Project Description's reduction in upper Sacramento River CVP reservoir releases to meet modified spring and summer NDOI and Wilkin Slough standards may affect spawning green sturgeon. Although little is known about spawning habitat, these habitats do not seem limited. Adult green sturgeon spawn in specific locations presumably based on turbulent velocities, cold water temperatures, coarse substrate, presence of conspecifics, and large riverbank expansion bars likely to provide nursery habitats for larval and juveniles. The Project Description's

[15] The annual average catch is 426 fish. In 2011, an egg was observed directly upstream of the rotary traps; thus, the large number of fish in 2011 represents a unique sampling of a spawning event (Josh Gruber, USFWS, pers comm.). If 2011 data is removed, the annual average of juvenile green sturgeon counted is 183 fishes.

reservoir release operation, described in the 90% Forecast, is unlikely to influence habitat characteristics for larval or juvenile green sturgeon. There is low certainty in our understanding of how hydrodynamics is affected in these regions by the Project Description and suitable habitats for rearing and spawning.

Table 17. Presence of Green Sturgeon During the Project Description Period and Exposure to Potential Effects

Green sturgeon Life Stage	Life Stage Present	Tributary Habitat Effect	South/ Central Delta Entrainment Effect	Facility Loss Effect
Egg	This life stage will be present in the Sacramento River in April-June.			

Sacramento	Yes	No Change	N/A	N/A
Juvenile	This life stage will be present in the Sacramento River and Delta April-September.			
Sacramento R	Yes	No Change	N/A	N/A
Delta	Yes	N/A	No Change	No Change
Subadults	This life stage may be present in the Delta April- September.			
Delta	Limited	N/A	No Change	No Change
Adults	This life stage will be present in the Sacramento River and Delta April-September.			
River	Yes	No Change	N/A	N/A
Delta	Yes	N/A	No Change	No Change

Net Delta Outflow Index and Water Quality Modifications

Juveniles and sub-adult green sturgeon rearing and utilizing the Delta are not expected to be affected by the Project Description's modifications to NDOI and Delta water quality standard from April through September. Over the course of juvenile green sturgeon rearing in the Delta (1 to 3 years), the fish are exposed to a wide variety of flows, depending on where they happen to be at a particular moment. In most of the Delta where green sturgeon are expected to be rearing, flows are tidally dominated. The 90% Operational Forecast characterizes Delta flow conditions in the Central Delta (OMR flows); North Delta (NDOI flows); and South Delta (exports) where tidal conditions occur. There is low certainty in our understanding of the juvenile and sub-adult green sturgeon biological processes affected by flow in the Delta. Delta conditions in the Project Description scenario are similar to the Baseline scenario during April and May, and the 90% without a modeled 90% Forecast of the Baseline summer hydrology, it is difficult to determine the summertime impacts of the actions in the Project Description. The minimal exports during the summertime between June and September may be assumed to be less than any other hydrology, which would cause more negative summertime flows in the South and Central Delta regions due to pumping greater than the minimum health and safety diversion. This suggests the actions in the Project Description would cause a reduced risk to entrainment into these regions and the CVP/SWP fish collection facilities. There is moderate certainty in our understanding of how hydrodynamics is affected in the Delta by the Project Description and suitable habitats for foraging juvenile and sub-adult green sturgeon.

Adult green sturgeon will be potentially present in the Delta throughout the Project Description as they migrate into and out of the Sacramento River and possibly forage in the Delta during the summer. The reductions in outflow through multiple distributaries in the North Delta in the Project Description may increase straying and travel time of green sturgeon in this region during April through September. During these months, a substantial portion of adult green sturgeon will migrate through the North Delta. Foraging green sturgeon utilize Sacramento and interior migratory routes through the Delta, and also Steamboat slough during the summer. Since these areas are normatively used by green sturgeon, the impact of increased travel time is unlikely to negatively impact adult green sturgeon.

Delta Cross Channel

The Project Description's Modification of the DCC gate operations will have a similar, but lesser, potential effect on green sturgeon, as it potentially has on salmonids in the North Delta compared to the Baseline scenario. To review, opening the DCC gates provides an alternate outmigration route through the Central Delta for juvenile, subadult, and adult green sturgeon that may pass this location during April through September. The possible effect is less since green sturgeon utilize Sacramento and interior migratory routes through the Delta, and also Sutter and Steamboat sloughs often foraging and spend summer in the Western, Interior and Central Delta regardless of the DCC gates being open. Modeling of the Baseline and Project Description scenarios show South and Central Delta condition in May to be similar with no change in this regions' proportion positive daily flow, but some negative and positive impacts on average daily flows and velocities through these regions. Thus, while the likelihood of entrainment into the Central Delta during April and May may increase, these routes are not clearly less suitable or expose green sturgeon to greater risks at the minimum level of diversions described in the Project Description. The effect of entrainment into the Central Delta is unknown since it is hypothesized that hydrodynamic and habitat characteristics in this region are similar to those in the North Delta under the Project Description's hydrodynamic scenario.

Summary of Effects on Green sturgeon

Cumulatively, the Project Description's modifications in flow and water quality criteria should not reduce riverine or through-Delta survival of juvenile green sturgeon. The Project Description's changes in Sacramento River outflow during April and May can possibly delay juvenile, sub-adult, and adult green sturgeon migration. Modification to D-1641 Municipal and Industrial and Agricultural water quality standards in the Delta from April to September will not likely affect green sturgeon.

Status of Central Valley Steelhead

Sacramento River

Adult steelhead abundance is not estimated in the mainstem of the Sacramento River or any other waterways of the Central Valley. Much of the spawning is believed to occur in the tributaries of the Central Valley rather than in the mainstem rivers. Observed levels of catches of juvenile outmigrating *O. mykiss* at Red Bluff Diversion Dam have been low in 2014-2015 in comparison with recent past years. Peaks in juvenile downstream passage generally occur in the August/September time period; however, there was no peak emigration observed this past year. Fish emigrating during the peaks are primarily YOY *O. mykiss*. For a representation of smolt production from the upstream river and tributaries, the data need to be segregated by size. Larger fish pass mostly later in the fall and winter after the peaks in passage shown in Figure 41. A slight peak occurred in March of 2014. This peak was not present in the earlier years and may indicate a smolt emigration during one of the few significant rain events in 2014.

For WY2015 (as of March 9, 2015), 10 unmarked (two on 10/15/2014; five from 1/7/2015 and 1/27/2015; and three from 3/3/15-3/5/15) and 1,109 marked steelhead (from 1/7/2015 to 2/21/2015) were captured at the GCID RST. Marked fish likely originated from a Coleman Hatchery release of 688,000 brood year 2014 steelhead (100% marked with adipose clip only) in the Sacramento River at Bend Bridge (fish released in two groups: 144,700 on January 2, 2015, and 543,300 on January 5-9, 2015). For WY2015 (as of 3/8/15), three unmarked (two captured from 1/5/2015 and 1/8/2015, and one on 12/22/2014) and 33 marked steelhead (one on 11/8/14, 32 from 1/12/15-2/13/15) were observed at the Tisdale Weir RST; and five unmarked (2/10/15-2/14/15) and 117 clipped (2/8/15-2/19/15) steelhead were captured at Knights Landing RST. A low to moderate level of salvage of natural- and hatchery-origin, respectively, juvenile steelhead has occurred this winter, with a cumulative loss of 95 natural-origin and 1,754 hatchery-origin juvenile steelhead as of March 15, 2015.

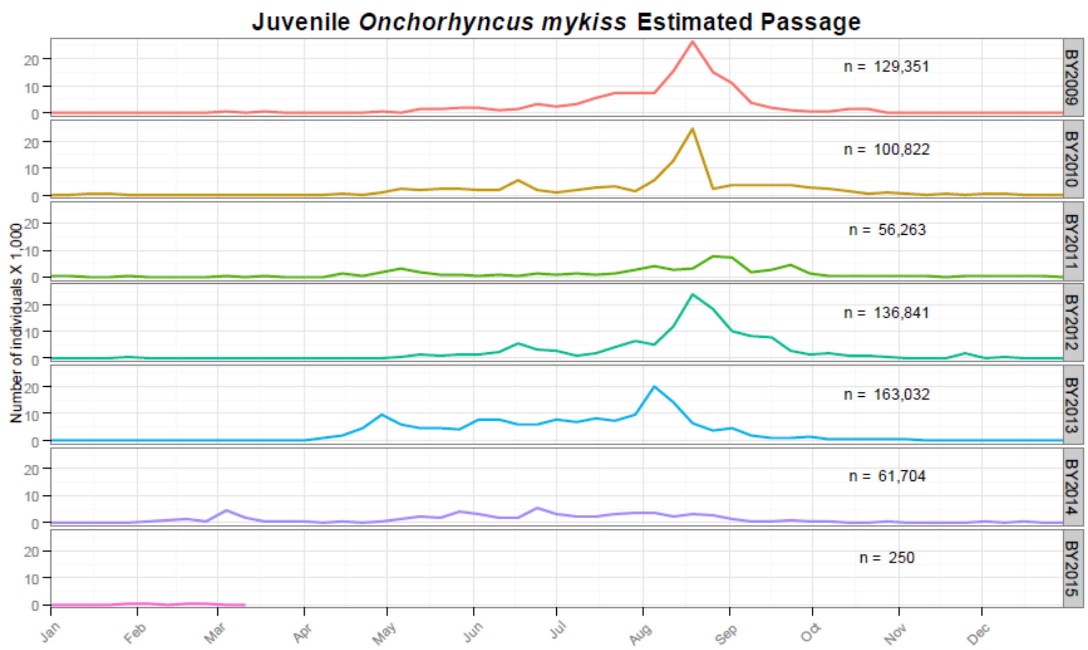

Figure 41. Weekly Estimated Passage of Juvenile Rainbow/steelhead trout at Red Bluff Diversion Dam (RK391) by Brood Year. Fish were Sampled Using Rotary-screw Traps for the Period January 1, 2009 to March 2015

Clear Creek

As of March 12, 2015, steelhead spawning surveys are underway on Clear Creek. Surveys are carried out from early December through the end of March. The preliminary steelhead redd index count for 2015 is 188 redds. Table 18 shows the redd index results through 2014. The redd index values include some mix of resident and anadromous *O. mykiss*.

The rotary screw traps on Clear Creek capture primarily YOY *O. mykiss* (not displayed here). Steelhead emigrating from Clear Creek are further monitored as they pass Red Bluff Diversion Dam in combination with other upper Sacramento River tributaries.

Table 18. Clear Creek Steelhead Redd Index 2003–2014

Year	Redd index
2003	78
2004	151
2005	144
2006	43
2007	165
2008	148
2009	409
2010	233
2011	218
2012	178
2013	239[a]
2014	313[a]

[a] In survey years 2013 and 2014, an additional survey reach was added at the downstream end of the study area. An additional 40 steelhead redds were counted in 2013, and 93 redds were counted in 2014 in this reach. USFWS is in the process of determining how to include these redds in the annual index for comparison to other years.

American River

Steelhead spawning in the American River occurs from late December to about late March or early April. Reclamation conducts bi-weekly steelhead spawning surveys throughout the spawning period. The American River in-river steelhead population consists primarily of hatchery-produced fish that spawn in the river, and the steelhead return is dominated by fish that return to the hatchery or are harvested prior to spawning in the river (Figure 42). Seining surveys conducted by CDFW throughout the summer and fall have shown that summer rearing distribution for steelhead essentially mirrors the spawning distribution. Mark and recapture of rearing steelhead has shown strong natal site fidelity. Although few recaptures of marked fish occur, the recaptures that do occur all happen within close proximity to the marking site (i.e., at the same riffle or the next riffle upstream or downstream). No thermal refugia have ever been found in the lower American River. The coolest water is essentially in the faster flowing sections of the river and the steelhead rear and feed primarily in the faster water areas (riffles predominantly) of the river through the summer.

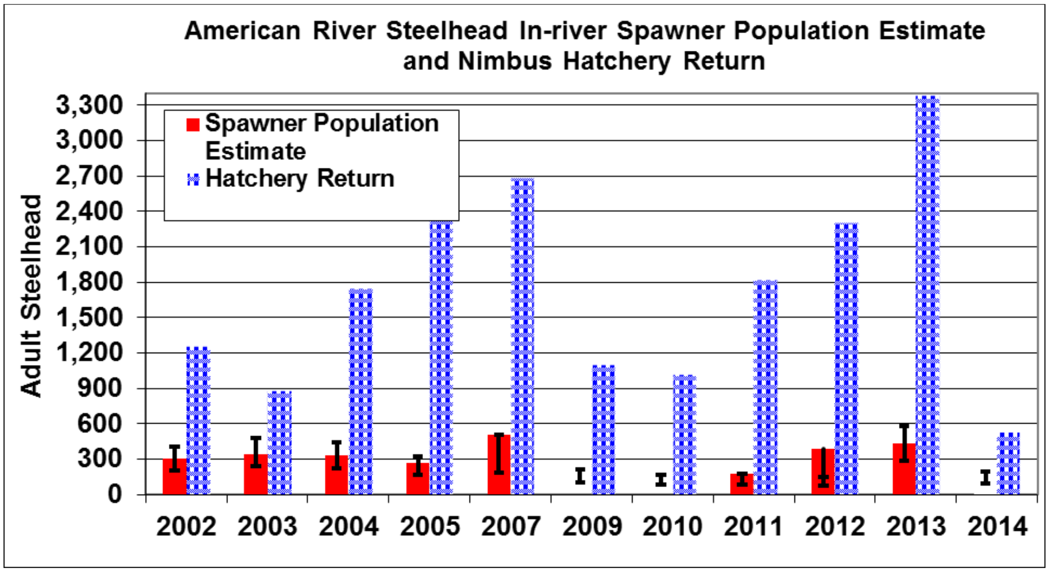

Figure 42. American River Steelhead Spawner Population Estimates Compared to Nimbus Hatchery Steelhead Return (updated from Hannon 2013). The Red Bars are Area Under the Curve Population Estimates (based on observations of adults holding on redds) and the Error Bars are the Redd Count Based Estimates. No 'Area Under the Curve' Based Estimates are Available for 2009, 2010, and 2014

Steelhead spawning surveys have identified few steelhead redds in the American River in 2015 from January through March 6 and hatchery returns have been near the lowest since the 1950s. The hatchery return for 2015 is 146 steelhead as of March 10 and only 46 of those were females. Nimbus flow releases have been 800–900 cfs throughout the spawning period, less than half the median flow of 2,000-3,000 cfs typically released during this time period. The majority of spawning is now complete based on the timing of spawning from past surveys (Hannon 2013). Figure 43 shows a comparison of spawning timing between the years surveys occurred. The 2015 spawning data are still draft but escapement appears to be very low. Coleman National Fish Hatchery steelhead eggs have been transferred to Nimbus Hatchery during January and February 2015 as part of a study evaluating replacing the Nimbus Hatchery steelhead broodstock with a broodstock that would be considered a part of the Central Valley steelhead distinct population segment. The low steelhead return has provided an opportunity to test an aspect of the broodstock replacement with Central Valley steelhead from Battle Creek/Coleman Hatchery. The goal of this egg transfer is to produce 150,000 steelhead smolts and evaluate their performance in the hatchery environment and in the American River following release from the hatchery.

The hatchery-produced steelhead in 2014 were all released into the river in May 2014 as YOY fish because water temperatures that supplied the hatchery raceways were anticipated to become lethal for fish reared in the hatchery over the summer.

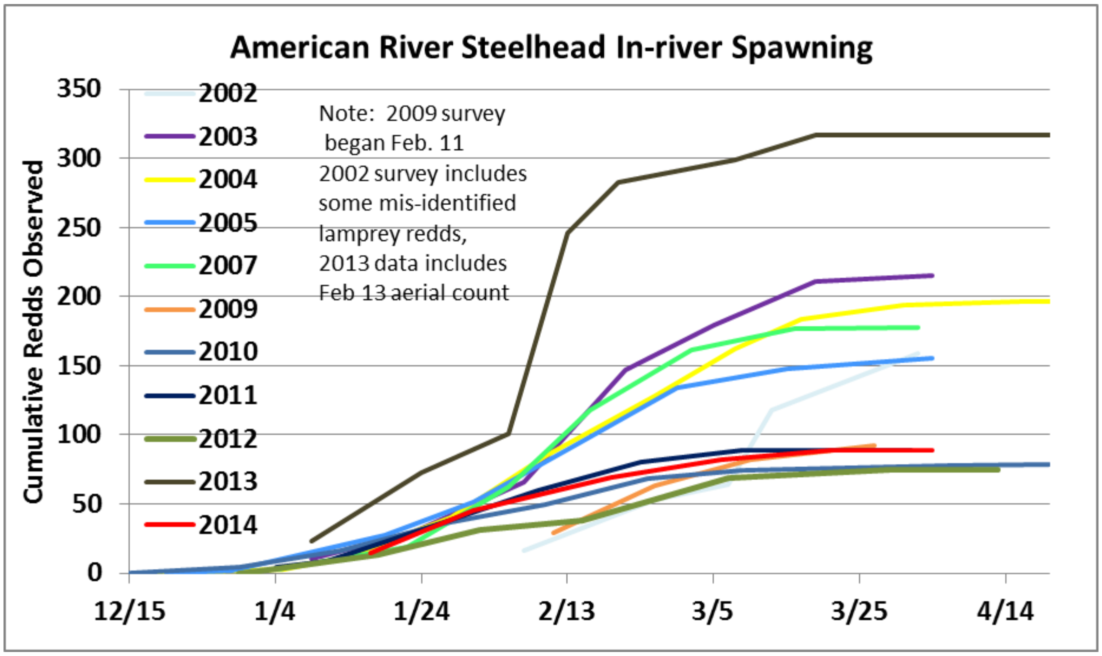

Figure 43. American River Steelhead Redd Observation Timing, 2002 - 2014

Stanislaus River

A weir on the Stanislaus River near Riverbank identifies *O. mykiss* passage using a VAKI camera. Two *O. mykiss* (> 16") and one *O. mykiss* (<16") were counted at the weir from October 2014 to December 15, 2014. Data after that have been unavailable.

Bergman et al. (2014) estimated a population of *O. mykiss* in an approximately 300 meter reach of the river immediately below Goodwin Dam to be 3,427 (SE =1,522) (95% CI = 1,492-7,873) using mark and recapture of trout identified using spot pattern recognition. This reach probably represents the highest density of trout in the river (based on snorkel survey observations) but indicates a much greater resident than anadromous component to the population. The stable cool water conditions in this tail-water area should allow at least the resident component of the population to persist through most drought conditions.

Steelhead spawn timing in the Stanislaus River is likely similar to other CVP rivers. Formal spawning surveys have not been conducted, but a trial survey was conducted by Reclamation and CDFW in February 2014 between Knights Ferry and Horseshoe Bar and near Goodwin Dam. Ten redds were found in the Knights Ferry reach and two were found in Goodwin Canyon at the cable crossing area. The redds are likely a mixture of resident and potentially anadromous *O. mykiss*. One of the redds was occupied by spawners with estimated lengths of 25 cm (10 inches) and 35 cm (14 inches). The California regulatory cutoff between steelhead and rainbow trout is 40 cm (16 inches) for anglers. The absence of abundant spawning near Goodwin Dam during this survey probably indicates mostly resident (later spawning) fish in that area.

Snorkel surveys conducted in 2003–2005 identified the first steelhead fry observations around mid-March to early April each year. Fry were observed between Goodwin Dam and Orange Blossom Bridge with observations in one year down to Valley Oak near the City of Oakdale.

None were observed below Valley Oak. This indicates that spawning was limited to the area mostly upstream of Orange Blossom Bridge. Higher rearing densities were always found from Goodwin Dam down to the Lover's Leap area. This likely coincides with the area of most spawning for both resident trout and steelhead. A majority of outmigrating steelhead smolts leave the Stanislaus River during the late winter and early spring. Based on recoveries of steelhead in the Caswell and Oakdale rotary screw traps, 50% of steelhead have emigrated by March 4 and 76% smolts have exited the Stanislaus River by the end of March (Figures 44-45).

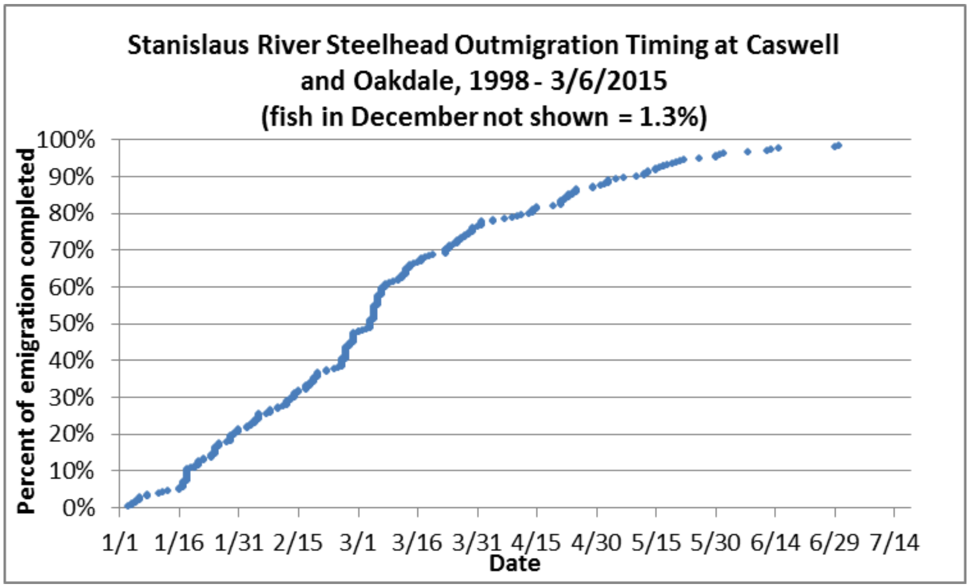

Figure 44. Stanislaus River Steelhead Outmigration Timing from Caswell Park and Oakdale Screw Traps, 1998-3/6/2015 (includes only fish rated as smolt index 5). Fish Leaving in December Constitute 1.3% of Migrants and Are Not Shown

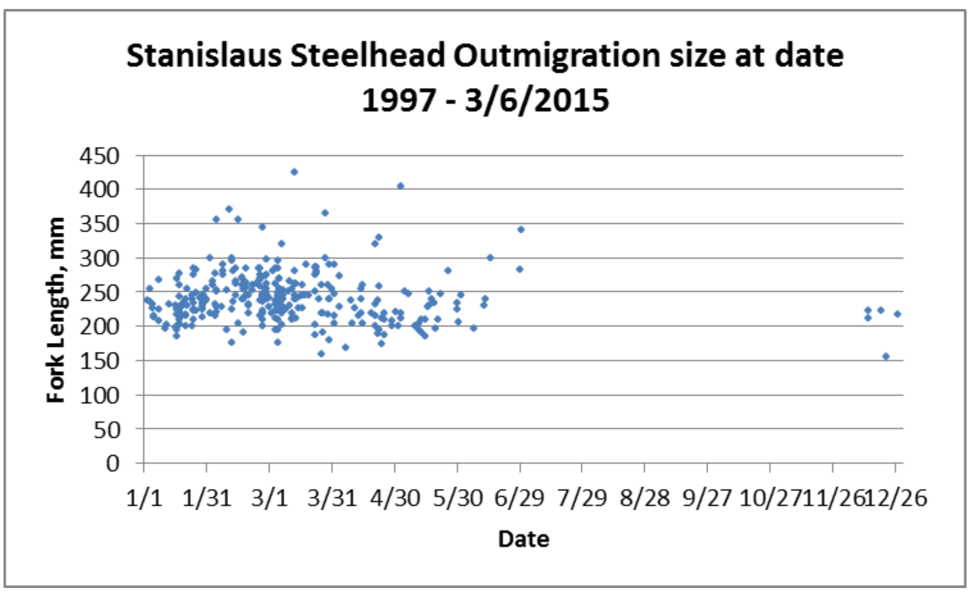

Figure 45. Stanislaus River Steelhead Outmigration Timing and Size from Oakdale and Caswell Rotary Screw Traps

Delta

Information on steelhead in the Delta is extremely limited. Steelhead smolts are seldom recovered in Sacramento River and Delta fish monitoring efforts due to sampling biases related to their large size and swimming ability. False negatives (*i.e.*, zero catches when the target species is present) are more likely with steelhead smolts than smaller older juvenile Chinook Salmon, but historic data can be assessed to consider their typical periodicity in Delta monitoring efforts. From 1998 to 2011, temporal observations of wild steelhead juveniles (n=2,137) collected in Delta monitoring efforts occurred less than 10% of the time in January, >30% of the time during February, and >20% of the time during March.

The temporal occurrence of Central Valley steelhead near and within the Delta is informed by recovery of natural steelhead in various monitoring surveys (Table 19). For WY2015 (as of March 9, 2015), 36 adipose-clipped steelhead and no unmarked steelhead have been recovered in various beach seine and trawling efforts in the Delta and Lower San Joaquin River. Of these, one marked steelhead was observed in the Chipps Island mid-water trawl (228 mm clipped fish on 3/2/15) and three marked steelhead were observed (one each) at Sacramento beach seine monitoring locations: Miller Park (300 mm acoustic tagged fish on 12/8/14); Sherwood Harbor (178 mm clipped fish on 2/17/15); and Verona (203 mm clipped fish on 2/17/15). Additionally, marked steelhead were observed at three Kodiak trawling locations including: Jersey Point (four clipped fish from 2/28/15-2/20/15), Prisoner's Point (fourteen clipped fish from 2/12/15-3/3/15), and Sherwood Harbor (fourteen clipped fish; one on 1/23/15 and thirteen from 2/9/15-2/20/15). No outmigrating steelhead have been observed in the Mossdale trawl yet; however, Figure 46 indicates that most steelhead are recorded at this location during April and May. Adipose clipped steelhead from Coleman National Fish Hatchery and Feather River Hatchery, are considered ESA listed Central Valley steelhead. No steelhead have been released from Nimbus Fish Hatchery to date in 2015. These fish were released in-river in May 2014 and marked with a secondary mark of a clipped pelvic fin. Fish monitoring at Mossdale on the lower San Joaquin River also encounter steelhead entering the Delta, and based on these information it is likely steelhead may still be migrating into the Delta from the San Joaquin in April and early May (Figure 46).

An expanded salvage of 22 natural origin and 450 adipose-clipped steelhead have been estimated at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps. Of these, all 22 natural origin and 382 adipose-clipped fish were salvaged at the SWP and no natural origin and 68 adipose-clipped fish were salvaged at the CVP fish collection facilities. Most steelhead have been salvaged during the past month. The high ratio of clipped to unclipped steelhead (17:1) likely indicates a low abundance of naturally-produced steelhead compared to the number of hatchery steelhead.

Table 19. Percentage of Juvenile Sacramento River Steelhead Entering the Delta, as Recovered at Various Monitoring Locations by Month. Data from the DJFMP and Chipp Island Trawl Data are from the 1976-2011 dataset

Month	DJFMP Beach Seines	Chipps Island
January	25	5
February	20	10
March	30	15
April	5	30
May	10	35
June	0	5
July	>5	0
August	0	0
September	0	0
October	0	0
November	0	0
December	<5	0

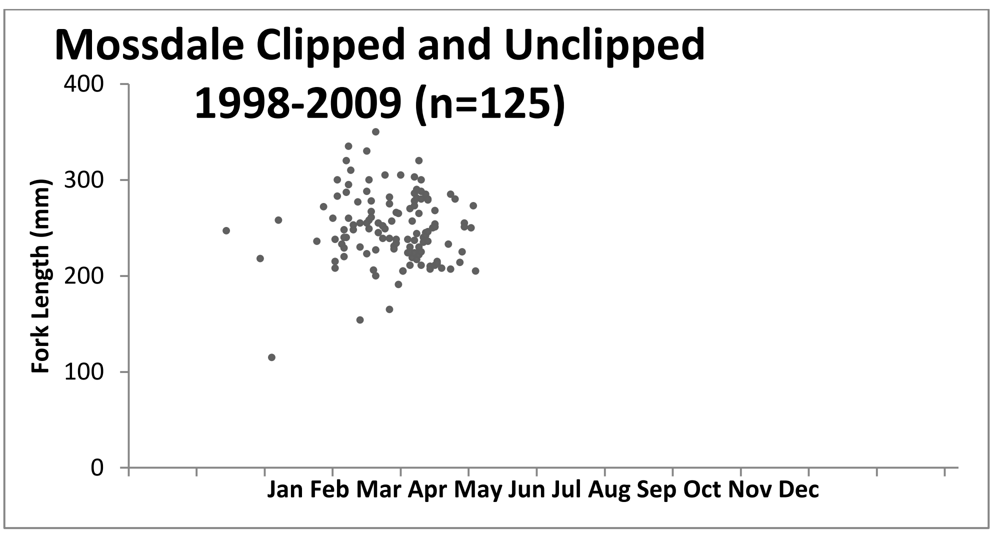

Figure 46. Fork Length by Date of Clipped and Unclipped Juvenile Steelhead Captured in the USFWS and CDFG Mossdale Trawl Fish Monitoring Study, 1998-2009

Effects of Project Description on Central Valley Steelhead

The predicted distribution of steelhead during the Project Description and a summary of potential effects is presented in Table 20, followed by more details per action type and location.

Table 20. Presence of Steelhead During the Project Description Period and Potential Effects

Steelhead Life Stage	Life Stage Present	Tributary Habitat Effect	South/Central Delta Entrainment Effect	Facility Loss Effect
Egg	This life stage will be present in the Sacramento River and tributaries April through May			
Sacramento R and tributaries	Yes	Yes	No	N/A
San Joaquin R and Stanislaus R	Yes	Yes	No	N/A
Juvenile	This life stage will be present in the Sacramento River, San Joaquin River and Delta during April through September			
Sacramento R and tributaries	Yes	Potentially reduced survival	N/A	N/A
San Joaquin R and Stanislaus R	Yes	Potentially reduced survival	N/A	N/A
Delta (Sac River side)	Yes	N/A	Increased	Uncertain
Delta (SJR side)	Yes	N/A	Increased	Increased
Adults	This life stage will be present in the Sacramento and San Joaquin Rivers and Delta during April-May and August-September			
Sacramento R and tributaries	Yes	No Change	No Change	No Change
San Joaquin R and Stanislaus R	Yes	No Change	No Change	No Change
Delta	Yes	No Change	No Change	No Change

Sacramento River Actions

Monthly average flows in the Sacramento River are forecast to be at the 3,250 cfs base flow in March and then increase to a high of a monthly average of 9,594 in July and then back down to

5,000 cfs in September. Rearing habitat limitations for steelhead have not been identified at the base flow. Water temperature management for Winter-run Chinook provides suitable conditions for the steelhead lifecycle throughout the year in habitat below Keswick Dam. During these drought conditions, the length of the suitable steelhead rearing habitat will be lower but rearing habitat availability is not expected to appreciably reduce the steelhead population in the mainstem Sacramento River. The end of the juvenile emigration period occurs during March through May. The base flows in the Sacramento River may potentially result in lower emigration survival than what would occur in wetter years. This effect of reduced emigration survival for steelhead originating from the Sacramento River basin is unquantified and is attributed to the persistent drought conditions continuing in WY 2015.

Water temperature conditions in the September time period for upstream migrating adult steelhead will be stressful and could result in delay of upstream migration through the lower Sacramento River until natural cooling with shorter day length occurs.

Net Delta Outflow Index and Water Quality Modifications

Similar to effects in the mainstem Sacramento River, the proposed lower outflow under drought conditions may result in lower survival of steelhead smolts emigrating to the ocean in the March through May period. This effect is unquantified and is attributed to the drought conditions necessitating modification of D-1641 Delta fish and environmental flow conditions. There is a high degree of uncertainty in this conclusion because this effect occurs largely in tidal areas so could be very slight.

Delta Cross Channel Gates

Under the Project Description, modified Delta Cross Channel Gates operations may occur based on water quality and fish presence. At this time, it is believed that an open DCC Gate has a low potential for entraining a substantial proportion of the juvenile Sacramento River steelhead. The remaining fraction of the natural and hatchery steelhead population that may still occur above the DCC location will be vulnerable to entrainment into an open DCC gate configuration as they emigrate downriver past the DCC gate location. Similar to Spring run Chinook Salmon, the Project Description's modification of the DCC gate operations will affect steelhead in the North Delta compared to the Baseline scenario, but only for a short time. It is uncertain whether the increase in the likelihood of entrainment into the Interior Delta will result in any change to facility loss of steelhead, both because the duration of the effect is expected to be short and because the limited exports in the Project Description scenarios may not result in greater entrainment into the South Delta and facility loss (see discussion in "Exports" section).

If the DCC gates were open Sacramento River water will flow through the DCC and into the Mokelumne River system. This may result in some level of straying of upstream migrating adult Winter-run Chinook Salmon into the Mokelumne River system. It is expected that this may delay these adults on their upstream spawning migration. Adult Winter-run Chinook Salmon which have entered the Mokelumne River system should be able to re-enter the Sacramento mainstem through the open DCC gates and continue their upstream movements. A delay in reaching the spawning grounds and an increase in energy expenditure may result. This could result in lower survival of juveniles produced from straying individuals, if temperatures in the upper river become unsuitable for egg and fry survival.

Clear Creek Actions

Flows on Clear Creek are forecast to range between 175 cfs and 85 cfs over the summer with the exception of springtime pulse as prescribed in the RPA to attract spring Chinook into the river. Steelhead rearing over the summer occurs in the upper reaches of Clear Creek with the downstream extent of suitable juvenile rearing habitat determined by water temperature. The extreme drought conditions will likely result in below average Trinity River diversions and thus a compressed length of the river suitable for oversummer rearing steelhead. Temperatures in the upper reaches of the stream are estimated to be suitable for rearing for the juvenile steelhead produced by the close to average number of adult spawners. A lower than average number of juvenile emigrants in 2016 per adult spawner could be expected to occur with the below normal habitat availability under the extreme drought conditions.

The temperature management for Clear Creek will be coordinated through the Sacramento River Temperature Task Group under the SWRCB 90-5 requirements and as outlined in RPA Action I.1.5. The temperature criteria are based on the Spring-run Chinook requirements and are expected to be protective of steelhead rearing through the summer. If these criteria are not met, juvenile steelhead habitat will be further restricted, predation by nonnatives may reduce survival, and disease may become more prevalent. The amount of uncertainty regarding Clear Creek effects is moderate.

American River Actions

Monthly flows in the American River are forecast to be held at 500 cfs through March and April. The lower than normal flows may enable cold water releases from Folsom to be maintained as long as possible through the summer. This will also result in a higher than normal rate of heating as water moves downstream. Flows will increase starting in May up to a peak of 3,035 cfs monthly average flows in July and then drop down to around 700 cfs in September. Reclamation will submit a draft temperature management plan to NMFS by May 1 per RPA Action II.2.

Considering the low steelhead escapement in the American River in 2015 it is hypothesized that water temperatures will be the limiting factor to the survival rate for rearing steelhead in 2015. Density dependence should not be a factor. Physical habitat and food should be less limiting than temperatures at the expected low rearing densities. However, if the Nimbus Hatchery steelhead are released in the spring or summer, as occurred in 2014, then density dependence would come into play under the low flow conditions.

American River at Hazel Avenue water temperatures were used to estimate steelhead emergence timing based on spawning timing (Figure 47). Temperatures after March 18 were estimated based on the near term weather forecast and additional warming expected to occur through April and May. The spawning timing for 2015 based on the bi-weekly spawning surveys is shown in Table 21. The emergence timing estimate used 600 accumulated temperature units to emergence (degrees C). Hazel Avenue temperatures reflect the coolest temperatures in the American River, thus emergence will be slightly earlier further downstream as water temperatures increase downstream up to a limit. The difference will be around a three to four day earlier emergence at Watt Avenue for the later season redds. High mortality is likely at over 59 F. Estimated emergence of fry from current year spawners should be completed by around May 4 (Table 18). Note that redds were included on March 28 based on timing in past surveys. This March 28 survey has not occurred as of this writing so this is a guess. In addition the redd survey data are still draft and subject to change.

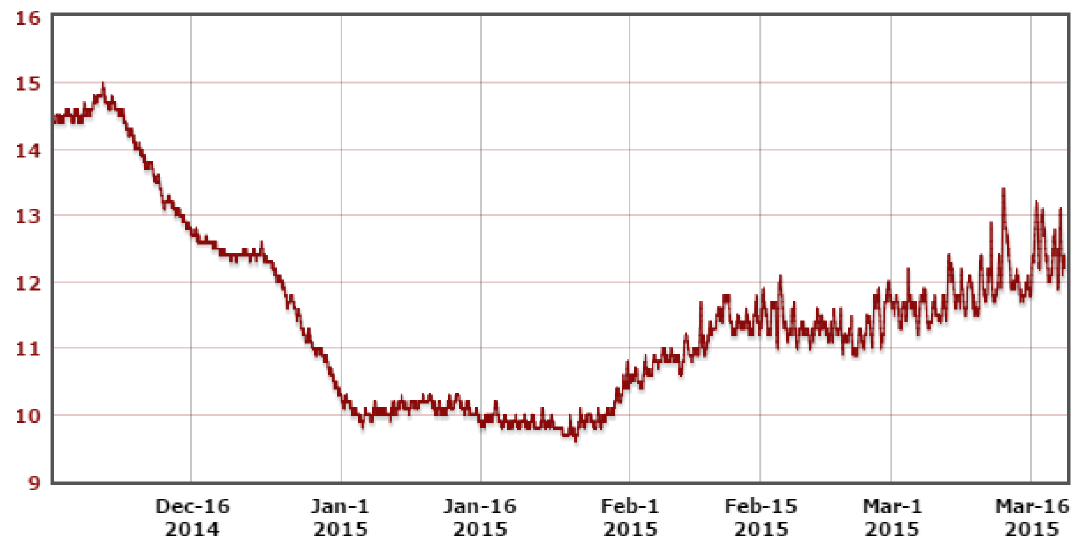

Figure 47. American River at Hazel Avenue water temperature (degrees C), December 2014 – March 19, 2015

Table 21. American River steelhead fry emergence from the gravel timing in 2015

Survey Date	Redds SH and unknown	**600 ATU emergence Date**	**Cumulative % emerged**
1/9/2015	0	**3/5/2015**	**0%**
1/23/2015	35	**3/17/2015**	**43%**
2/5/2015	35	**3/27/2015**	**85%**
2/20/2015	6	**4/7/2015**	**93%**
3/6/2015	4	**4/15/2015**	**98%**
3/28/2015[1]	2	**5/4/2015**	**100%**

[1] **The March 28 survey has not occurred so spawning on this date is a guess based on past experience.**

Based on the current preliminary spawning survey results at a fecundity of 5,732 eggs/ female (based on recent past hatchery data and size of fish observed on redds in 2015) and 1.5 redds per female about 313,000 eggs would be produced by the observed redds. A 25% egg to fry survival (lower survival than typically assumed due to currently warmer water that will reach levels that will likely reduce egg to fry survival for later spawners this year) would produce about 78,250 emergent fry. Eggs from the later spawning fish may not survive to emergence. CDFW is planning to conduct juvenile steelhead monitoring during the summer. Surveys would be conducted in close proximity to spawning areas and within restoration reaches and would enable an assessment of survival in the expected stressful water temperatures over the summer.

The steelhead smolts leaving the American River in spring of 2015are expected to complete emigration by around the end of April when temperatures under these drought conditions are expected to be affecting survival for fish leaving the river later. These fish are the progeny of steelhead that spawning in 2014 when water temperatures through the summer were stressful for rearing steelhead. These fish may have suffered mortality or left early. Estimates of fry to smolt survival for naturally spawned steelhead have ranged from 4% to 11% for brood years 2002 to 2010 (Table 22). The survival rate is likely to be lower under the drought conditions.

Table 22. Estimates of American River wild smolt production and hatchery smolt survival based on adult hatchery counts, spawner surveys and hatchery yearling releases (updated from Hannon 2013)

Adult Spawning Year	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Year smolts released or outmigrated	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Hatchery smolts released in Jan/Feb. of above year	426,920	439,490	250,440	422,380	394,292	454,570	410,330	455,140	419,160	281,705	467,023	402,300	400,060	385,887
In-river spawning adults	437	389	172	121	155		504		266	330	343	300		
Total Hatchery Produced Adult Return[1]	4,449	3,124	2,318	1,905	1,885	853	3,613	2,660	3,472	2,425	1,386	1,745	3,392	2,057
Unclipped Adults in hatchery	57	41	34	34	58	47	116		118	17	27	69	50	
Percent return of hatchery fish (clipped adult return divided by smolts released two years prior)	1.04%	0.71%	0.93%	0.45%	0.48%	0.19%	0.88%	0.58%	0.83%	0.86%	0.30%	0.43%	0.85%	0.53%
Wild smolts that outmigrated (two years prior)[2]	9,664	11,241	5,531	10,222	15,374	25,041	18,900		17,457	5,808	20,661	22,827	5,896	
Estimate of fry produced based on redd surveys[3]	825,864	182,125	181,323	175,564	246,592		272,340		230,640	402,931	447,057	325,897		
Fry to smolt survival estimated	In 2016	In 2015	In 2014	6%	5%	No Estir	4%	No Estir	11%	5%	No Estir	5%		

[1] assumes 20% recreational harvest based on angler surveys in 1999 and 2001 except 2009 and 2010 use actual creel survey estimates

[2] assumes same smolt to adult survival of wild smolts as for hatchery released smolts and that 10% of in-river spawners are naturally produced fish

[3] no adjustments made for potential missed redds

Conditions in the American River have met the criteria for a conference year under the flow management standard in compliance with the RPA. Therefore, operations will be adaptively managed in partnership with the fishery agencies and the Water Forum to best meet needs under the extreme drought conditions. There is a moderate level of uncertainty in the conclusions about American River steelhead.

Stanislaus River Actions

Stanislaus River flows under Appendix 2E of the 2009 BO are being coordinated with the Stanislaus Operations Group to provide the best conditions as feasible under the current drought situation. Mean monthly flows are projected to be around 460 cfs and 380 cfs in April and May respectively and then drop to a baseflow of 150 cfs through September. The Ripon dissolved oxygen standard of 7.0 ppm, described in SWRCB D-1422, is modified in the Project Description by moving the compliance location upstream to Orange Blossom Bridge over the project period. Given the *O. mykiss* population in the Stanislaus which has been sustained under flows of 150 cfs in past years it is hypothesized that the limiting factor to oversummer survival in 2015 will be water temperatures under the extreme drought conditions affecting conditions in the Stanislaus watershed. Summer operations on the Stanislaus may not be able to meet the temperature compliance schedule described in NMFS RPA Action III.1.2. The RPA will be followed regarding notification and Stanislaus Operations Group (SOG) advice. Under the expected flows and temperatures the oversummer steelhead rearing habitat will confined to the area upstream of Orange Blossom Bridge. The relaxation of the dissolved oxygen standard from Ripon to 7.0 at Orange Blossom Bridge could result in dissolved oxygen levels reaching lethal levels for fish at times in the Ripon area. A DO of 7.0 is considered protective of salmonids.

Steelhead rearing habitat will be reduced due to temperatures and may be marginal at Orange Blossom Bridge. A dissolved oxygen level of 7.0 and greater at Orange Blossom would be protective of steelhead over the summer in the area between Orange Blossom and Goodwin as DO will be higher on average further upstream.

We expect that spawning of steelhead will be complete by the end of March based on observations in other watersheds. At a temperature of 56°F (13.3°C) emergence of steelhead fry should be completed by May 15. If water temperature becomes greater than a mean daily temperature of 56°F in the redd locations, then emergence would be completed sooner, up to a limit. Mean daily water temperatures greater than 59°F (15°C) could result in very low egg to fry survival if they occur during the incubation period. Recent water temperatures near Goodwin Dam are shown in Figure 48. Resident trout often spawn later than steelhead, so it is likely that the fry from resident fish will continue to emerge past the May 15 date. It is hypothesized that some coldwater refugia should be present, particularly in the deep pools at and upstream of Knights Ferry so that *O. mykiss* populations will persist and the resident population will continue to maintain spawner abundance and juvenile productivity of *O. mykiss* on the Stanislaus River.

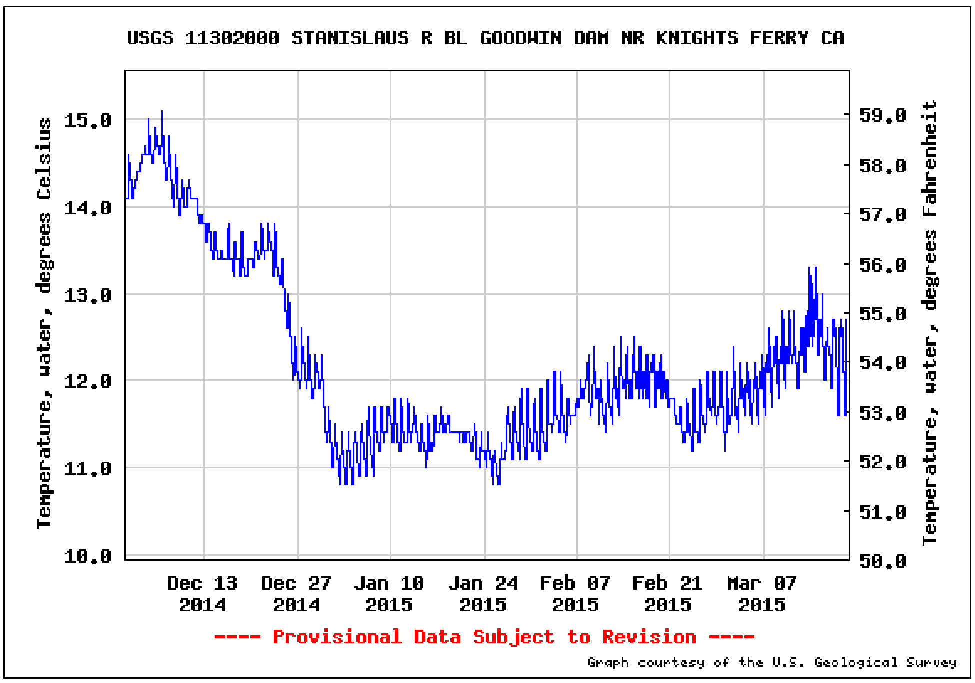

Figure 48. Stanislaus River below Goodwin Dam at the cable crossing water temperature, 12/1/2014 – 3/19/2015

Rotary screw traps in the Stanislaus at Caswell provide information on size and timing of steelhead emigrating from the Stanislaus. During late 2013 through March 6, 2015, no steelhead have been captured at Caswell. Trap calibrations are not conducted for *O.mykiss* but since capture rate is size-dependent for Chinook, larger steelhead are likely much less susceptible to capture than Chinook (Joe Merz, Cramer Fish Science, pers comm). Therefore zero steelhead captured does not represent an absence of emigration from the Stanislaus. The median date of steelhead exit from the Stanislaus based on screw trap data was March 4 for the period from 1997 to 2015.

A pulse flow as specified in the NMFS RPA (2011 amendment), based on SOG advice and NMFS determination, will be scheduled to occur sometime during the late March to April time period to provide migratory cues and flows for the last of the emigrating juvenile steelhead before downstream temperatures become inhospitable. The timing is being coordinated at the SOG. Dissolved oxygen concentration varies with temperature and the warming water temperatures in the spring may also result in stressful DO levels in the lower Stanislaus River in April and May.

The low quality habitat along routes to the ocean likely results in low emigration survival, especially in extreme drought conditions such as this and is likely a large contributor to why the steelhead component of the *O. mykiss* population in the San Joaquin basin is small. It is hypothesized that steelhead escapement in two years will be lower than during previous wetter years due to lower steelhead survival through the lower San Joaquin River between Durham Ferry (near the confluence of the Stanislaus River) and Lathrop than during previous wetter years as well as along the rest of the various routes to the ocean.

Adult steelhead upstream migration generally occurs in October and later in the Stanislaus River. A few may occasionally enter the river in September but this year conditions will likely be unsuitable in the lower San Joaquin and Stanislaus in September (low flows, high temperatures, stressful dissolved oxygen levels) so any steelhead that attempt to migrate early will likely be delayed.

There is a moderate level of uncertainty in conclusions regarding Stanislaus River steelhead.

Delta Exports

Delta exports are forecast to be at a low level due to the drought conditions. The low export levels are not expected to appreciably affect survival of steelhead emigrating through the delta from the Sacramento River. This emigration should be completed by early May when water temperature is likely to be warm for emigrating steelhead. Steelhead emigrating from the San Joaquin River prior to the HORB being in place are more likely to be salvaged at the CVP facility and be trucked downstream of the Delta. Under these extreme low flow conditions the steelhead that experience this route through the fish salvage facilities are hypothesized to have a better chance of survival to the ocean than those that continue down the mainstem San Joaquin River route. The degree of uncertainty with this conclusion is moderate.

No appreciable effect of the pumping levels on the early part of the adult upstream migration in September is expected to occur.

San Joaquin River I:E ratio and San Joaquin River downstream of Stanislaus River Confluence

The Project Description flows at Vernalis are hypothesized to result in less suitable conditions for steelhead emigration than would otherwise occur in the Baseline modeling. These conditions reduce survival of outmigrating San Joaquin basin steelhead downstream of the Stanislaus River confluence until tidal conditions dominate the South Delta. San Joaquin River flow limits are being reduced during the Vernalis pulse flow period and then will be no less than 300 cfs after the pulse until the end of May. Summer Vernalis flows would be no less than 200 cfs monthly average. Water temperatures are likely to be unsuitable for steelhead emigration by early May due to the drought conditions. These conditions in the San Joaquin following the pulse period are expected to be lethal to steelhead so that later emigrants are not likely to survive.

The Vernalis salinity standard is modified in the Project Description. Additional flows from the Stanislaus River and San Joaquin River tributaries would be required to meet the existing standard. The change in salinity in the San Joaquin River would not affect steelhead as they would not be present in the summer. The result of the low flows over the summer in the Stanislaus, which are enabled to occur with the salinity relaxation, are discussed above in the Stanislaus River section.

If there is a precipitation event outside of the pulse period, then the Project Description modifies RPA Action IV.2.1 to allow pumping to capture abandoned or natural flows in the Delta up to the OMR limits. If precipitation occurs then that would be the same period that steelhead would likely to emigrate. Pumping will occur preferentially at the Jones Pumping Plant if condition permit, which should increase salvage rates and reduce loss, due to lower pre-screen mortality at the Tracy Fish Collection Facility. In a future year, Reclamation and DWR would make available an amount of water equal to half the volume of any increased exports realized over the April – May period for the fishery agencies to shape. This could benefit steelhead in future years but would not benefit fish this year. The degree of uncertainty with this conclusion is moderate.

Summary of Effects on Steelhead

The drought conditions are causing increased stress to steelhead populations, with or without water project operations, in the form of low flows reducing rearing and migratory habitats, above normal water temperatures affecting survival, and likely higher than normal predation on juvenile steelhead. The water management over the last year has focused on maintaining a level of reservoir storage which is generally higher than what would be in place at this time without the planning that has gone into attempting to reduce adverse effects on resources. The Project Description strives to balance spring and summer operations between Shasta and Folsom divisions of the CVP to minimize affects across CVP tributaries in WY 2015. Steelhead survival will be low in 2015 in all tributaries and migratory pathways and is likely to result in a smaller returning year class of steelhead from those juvenile steelhead emigrating this year.

Battle Creek/Coleman Hatchery experienced one of the highest adult steelhead returns that has been measured and eggs from some of those fish are being provided to Nimbus Hatchery on the American River where the steelhead currently do not contribute to the Central Valley steelhead DPS. Although an experiment at this point, if these fish are successful in surviving to emigration next spring then they could contribute to increasing the proportion of Central Valley steelhead returning to the American River in the future and improving genetic diversity for Central Valley steelhead.

Status of Delta Smelt

As California enters a fourth year of drought, abundance of Delta Smelt has continued to decline. The 2014 Fall Midwater Trawl (FMWT) annual index for Delta Smelt was 9, which is the lowest reported fall index since the beginning of this survey in 1967, and approximately one half of the previous lowest index values of 17 (2009) and 18 (2013). These results and a detailed account of the spatial distribution of the adult population based on survey data at that time were described in the Biological Review of the Feb-Mar 2015 TUCP (Reclamation, 2015c). The third Spring Kodiak Trawl (SKT) survey for March 9 – 12, 2015 (Figure 49) yielded six adult Delta Smelt, a record low number for March (Figure 50) and a number that has only occurred over the period of record at this level once before in May surveys, when catches typically tail off because of post-spawn mortality. These winter survey results provide additional evidence that the Delta Smelt population is likely at an all-time low. The recent catch data also indicate most adult Delta Smelt may be in the Sacramento River and outside the influence of the export facilities.

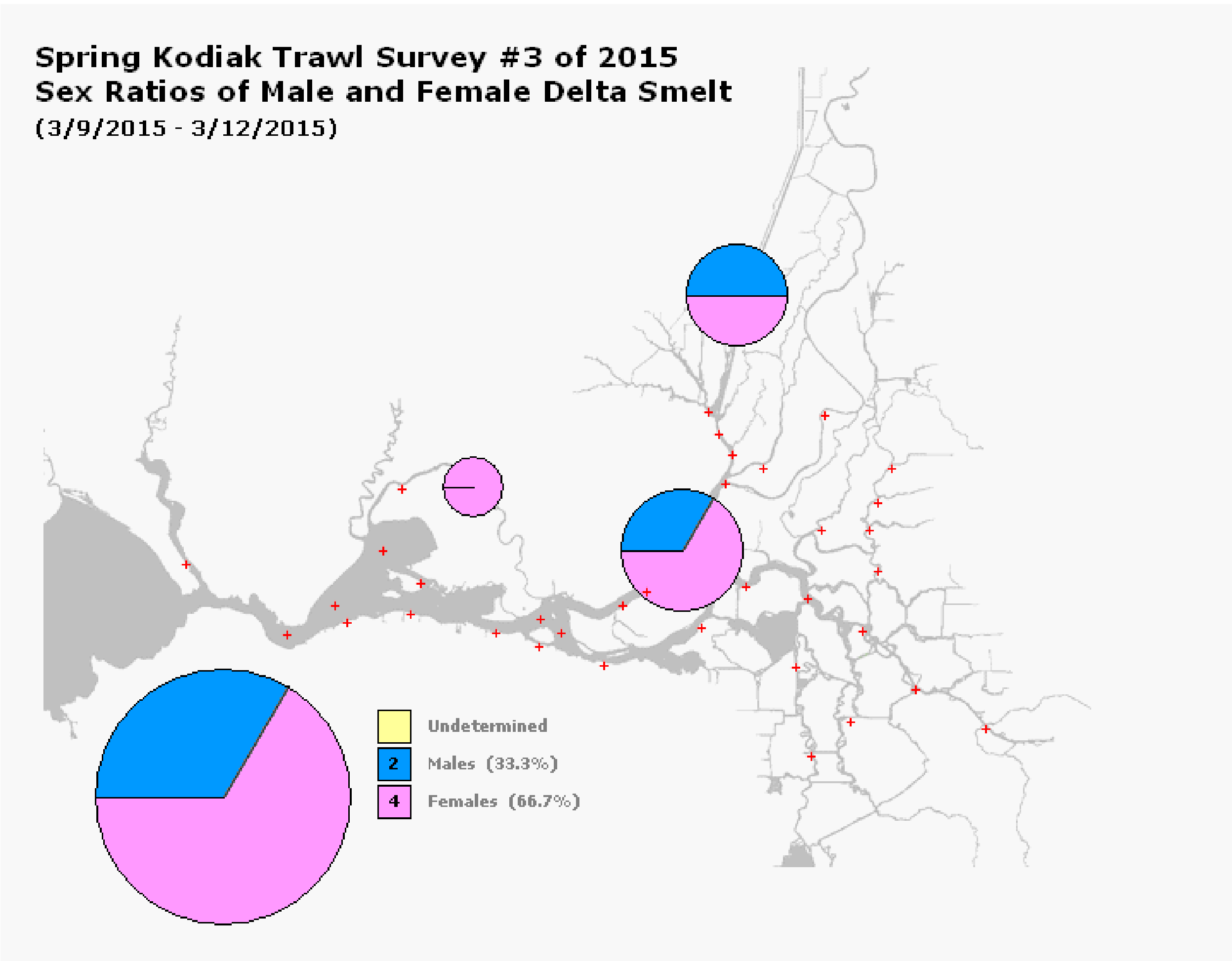

Figure 49. March distribution of adult Delta Smelt from Spring Kodiak Trawl #3

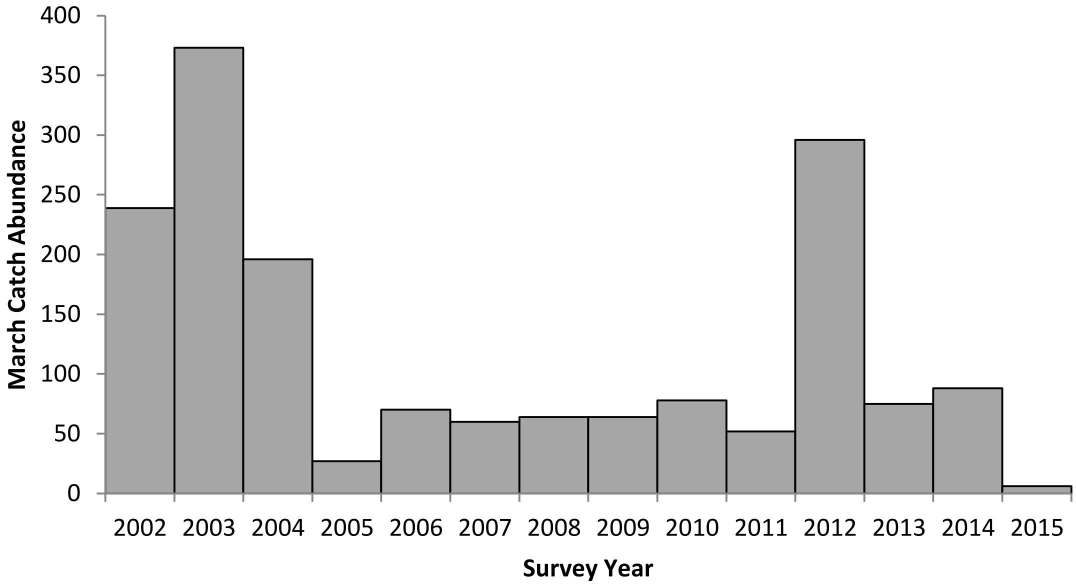

Figure 50. The number of Delta Smelt collected in March for Spring Kodiak Trawl surveys from 2002-2015

Drought Impacts

Research presented at the Interagency Ecological Program (IEP) workshop (March 18-20, 2015) showed that drought impacts Delta Smelt a number of ways. It can reduce the area of low salinity habitat to which they migrate for spawning and thereby reduce food availability for adults and for juveniles moving there to rear. Drought can indirectly impact reproductive potential by lowering the number of oocytes females produce (Hammack, 2015). This is brought about by a link between low outflow and elevated water temperature. Warming temperature shortens the spawning window, which causes fewer clutches to be produced per female (Jeffries, 2015). Both of these mechanisms combine with low adult abundance to impair population fecundity. Lower outflow also tends to reduce turbidity. Delta Smelt use turbid water to avoid predators and they also use it as foraging habitat (Hasenbein, 2015a). Otolith analysis has revealed that Delta Smelt, since 1999, experienced an 8% decline in growth between dry and wet years and spawning is more successful the north Delta during drought (Hobbs, 2015). The quality of their habitat is further compromised by concentrations of herbicides such as Diuron and Hexazinone, which increase with reduced outflow and have synergistic effects that reduce food availability for juveniles (Hasenbein, 2015b). Furthermore, warm, slow moving water characterized by drought promotes conditions in which parasites like Ich (*Ichthyophthirius multifiliis*;) and cyanobacteria like *Microcystis* thrive. Ich causes skin lesions to form on a variety of fish and has an increased prevalence among captive Delta Smelt above 17°C (Frank *et al.*, 2015). *Mycrocystis* is a toxic hepatotoxin that became established throughout the Delta in 2000 and also thrives in water above 17°C with low turbulence (Lehman, 2015). Because of the extended high water temperatures associated with drought, *Microcystis* blooms extended into December of 2014 (Lehman, 2015). This highly toxic cyanobacteria is known to kill phytoplankton, zooplankton and compromise fish health (Acuña *et al.*, 2012). Finally, the abundance of non-native Delta Smelt predators, such as black bass, increased in the Delta in response to the drought in 2014, mainly because it expanded their preferred habitat (Barnard, 2015). The same pattern was found for non-native competitors, such as clams like *Corbicula*, which seem to be expanding throughout the Delta despite the drought (Thompson, 2015).

Salvage

The estimated cumulative season total for adult Delta Smelt salvage is 68. No salvage has been reported since February 21st. The State Water Project (SWP) and Central Valley Project (CVP) initiated larval fish monitoring on March 2nd and February 24th, respectively. The frequency of larval fish samples at the CVP has been reduced at times due to heavy debris load in the salvage collections. Regardless, no larval Delta Smelt have been reported at either facility to date. However, pre-screen loss of all life stages (e.g., predation) may decouple entrainment at low densities so that fish entrained at low densities are not observed in salvage.

This is further supported by regular presence of adult Delta Smelt at Jersey Point and Prisoners point surveys for most of the winter indicate likely presence of larvae in the central Delta in spring. Daily "early-warning" sampling resumed during the week of February 2nd at Jersey and Prisoners Point in anticipation of storm conditions. Weekly sampling resumed the week of March 9th and no adult Delta Smelt have been caught at Jersey Point since March 16th (when one individual was caught) and no Delta Smelt have been caught at Prisoners Point since February 15th.

The 3-station average water temperature threshold of 12°C (Action 3 of the 2008 Biological Opinion (BO)) was first exceeded on February 2nd and was reported on March 15th to be 17.8°C. This suggests Delta Smelt spawning has occurred early this year. On March 16th, the Smelt Working Group (SWG) suggested the most likely reason for steep decline in catch of Delta Smelt in the SKT #3 survey (Figure 2) was fish may not have survived after a first spawn (SWG notes from 3/16/15) or they could have been avoiding the gear (Baxter). This hypothesis is partly supported by poor condition of the few mature fish caught in SKT #3. Hatching will likely continue over the next few weeks, although the peak of the spawning season has likely passed. As water temperatures rise, larvae are beginning to recruit to juvenile size, and a broader distribution in the central Delta may become evident by way of larval field surveys. Intermittent salvage of adult Delta Smelt indicates the likely presence of larvae in the central and southern Delta within the vicinity of the SWP and CVP pumps. Those larval and juvenile Delta Smelt hatching in the central and southern Delta are vulnerable to entrainment; however, exports are currently at minimum levels, resulting in favorable Old and Middle River (OMR) flows (SWG-notes from 3/16/15). A temperature off-ramp occurs when water temperature at Clifton Court Forebay reaches 25°C for three consecutive days (BO). This off-ramp typically occurs in late June or early July, although present unseasonably warm water temperatures may suggest an earlier temperature off-ramp (the calendar-based off-ramp is June 30th).

Effects of Proposed Action on Delta Smelt

The following discussion is based on DSM2 particle tracking model (PTM) simulations described earlier. When reviewing this section, it is important to remember that adult Delta Smelt do not behave as neutrally-buoyant particles so a literal translation of results into changes in entrainment or entrainment risk is not advisable. In particular, the model predictions of westward advection are not relevant. It is the changes in central/south Delta hydrodynamics that are of interest because these flow conditions may affect tide-surfing fishes seeking turbid fresh water.

To estimate the effects of the Proposed Action on Delta Smelt, a PTM from April to June was compared to baseline hydrological conditions, assuming an equally distributed population between injection points (Figure 28). Only particles located between Railroad Cut and the pumping facilities experienced flux towards the pumps. Throughout the rest of the Delta, particles either remained in the Delta or eventually moved west regardless of the outflow scenario.

The Baseline scenario represents a constant North Delta Outflow Index (NDOI) of 7100 cfs, while the Project Description scenarios (Hydrology 2 and 2') reduces NDOI to 4000 cfs, and in 2' an open DCC Gates. The Project Description uses the February 90% Operational Forecast for Central Valley hydrologic and operation conditions during the remainder of the Project Description's period. March exceedance forecast is under development and appears to be trending drier than the February 90% exceedance forecast. Reclamation and DWR are petitioning the State Water Board to adopt a Delta outflow standard of a minimum monthly NDOI for April, May and June to be no less than 4000 cfs and for July to be no less than 3000 cfs with a 7 day running average no less than 1000 cfs below the monthly average. Other input values remained constant and reflected the best information available to Department of Water Resources (DWR) modelers when models were run on March 17th, but it should be noted that particles were injected on April 1st and tracked through May 31st. The modeled conditions of the proposed reduction in NDOI resulted in slight overall increase in the final fate of particles at the facilities compared to baseline conditions (Figure 29).

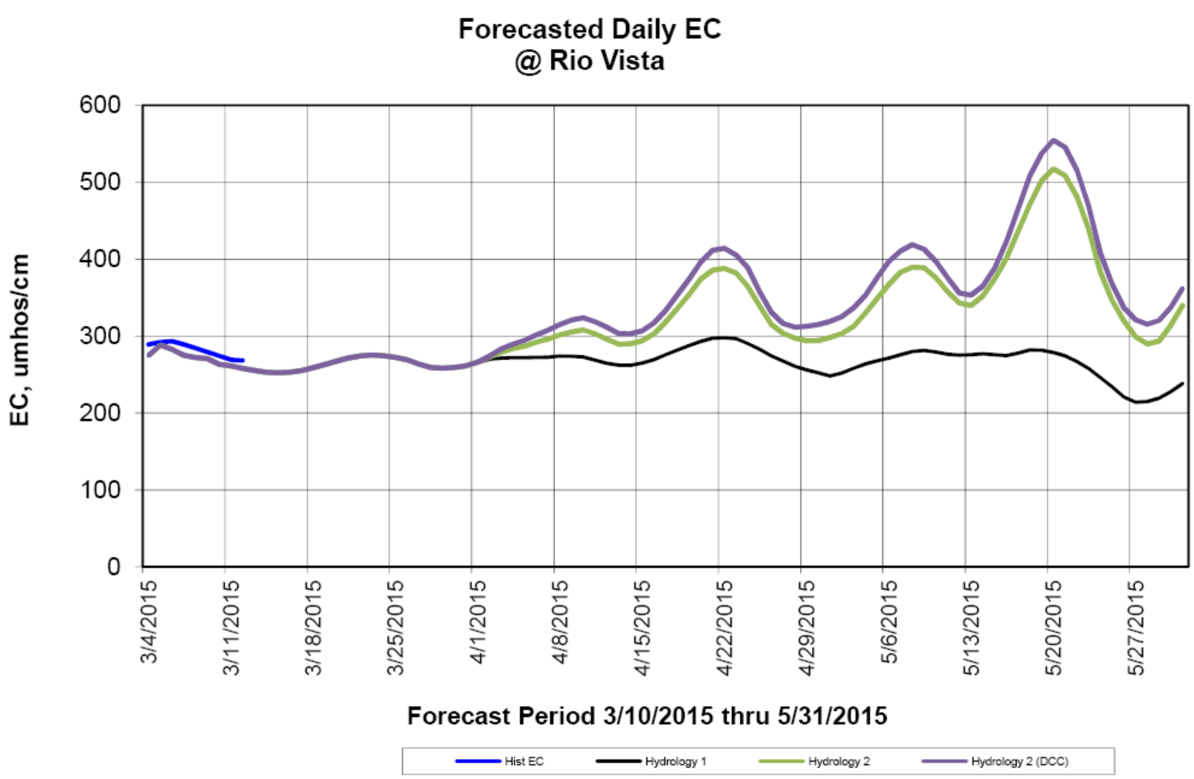

Figure 51. Forecasted electrical conductivity (EC) under different hydrologic scenarios from March – June, 2015 at Rio Vista

Similar to the effects review from 2014 (Reclamation, 2014), if such changes would remain through the summer , the 2 ppt isohaline (X2) will shift upstream and, given the general decrease in habitat suitability when the low-salinity zone moves upstream of Suisun Bay, is assumed to result in higher predation rates, and greater exposure to contaminant effects, losses in irrigation diversions, water temperatures stress, etc. (Feyrer et al., 2007) . Similar to the effects review from 2014 (Reclamation, 2014c), if such changes would remain through the summer, the 2 ppt isohaline (X2) will shift upstream and, given the general decrease in dynamic habitat with movement upstream of the low-salinity zone, would result in reduced spawning and rearing habitat (Feyrer *et al.*, 2007). Further constraints on habitat for juvenile Delta Smelt towards upstream spawning areas in the lower Sacramento/San Joaquin Rivers and the Cache Slough Complex/Sacramento Deep Water Ship Channel will reduce the quantity of available habitat, but will be within the range of salinity generally occupied by Delta Smelt during the summer and fall. As Sommer and Mejia (2013) noted, Delta Smelt are not confined to a narrow salinity range and occur from fresh water to relatively high salinity, even though the center of distribution is consistently associated with X2 (Sommer *et al.*, 2011). However, Nobriga *et al.* (2008) found the probability of occurrence of Delta Smelt was highest at low EC (1,000-5,000 µmhos/cm), and declines at higher EC. EC forecasts for Rio Vista and Emmaton (Figures- 51-52) and locations upstream are within this range during the period modeled. Therefore we conclude that while changes in salinity in the lower Sacramento River are within the physiological tolerances of Delta Smelt, the proposed modifications are expected to shift the Delta Smelt population further upstream. There is a relatively high level of uncertainty in these conclusions when compared to Reclamation (2014c) due to a lack of temporally projected data.

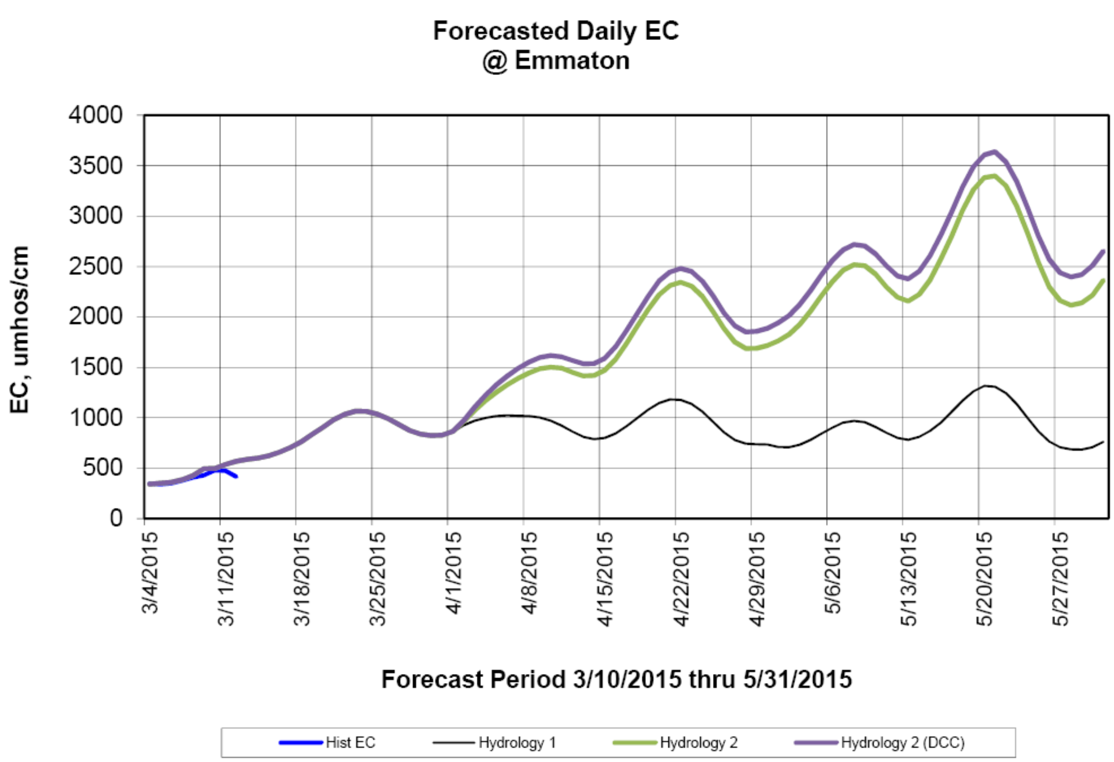

Figure 52. Forecasts of electrical conductivity (EC) under different hydrologic scenarios from March – June, 2015 at Emmaton

The upstream shift of Delta Smelt distribution on the Sacramento River will increase the potential for stochastic events to exacerbate mortality and density-dependent effects on the population (Feyrer *et al*., 2011). As an example, there may be water temperature increases during prolonged heat waves that would pose risks to Delta Smelt. In general, summer temperatures are higher in landward channels (Wagner, 2012), so reduced inflow is expected to shift the distribution of Delta Smelt into these warmer regions. In addition, with the shifting of X2 above the Sacramento-San Joaquin confluence, salinities may be too high downstream for juvenile Delta Smelt to move substantially seaward, where the maritime influence and larger water bodies maintain cooler water temperatures.

In the San Joaquin River, modeling suggests EC at Jersey Point will increase given the proposed action although it is similar to historical EC values (Figure 53). Regardless, it is inferred there would be little physiological effect on Delta Smelt from changes in salinity in the lower San Joaquin River, as ranges are well within the physiological tolerance level for the species (Nobriga *et al*., 2008). However, the increase in salinity may alter the distribution of Delta Smelt into less favorable areas within the lower San Joaquin (*e.g.*, Franks Tract).

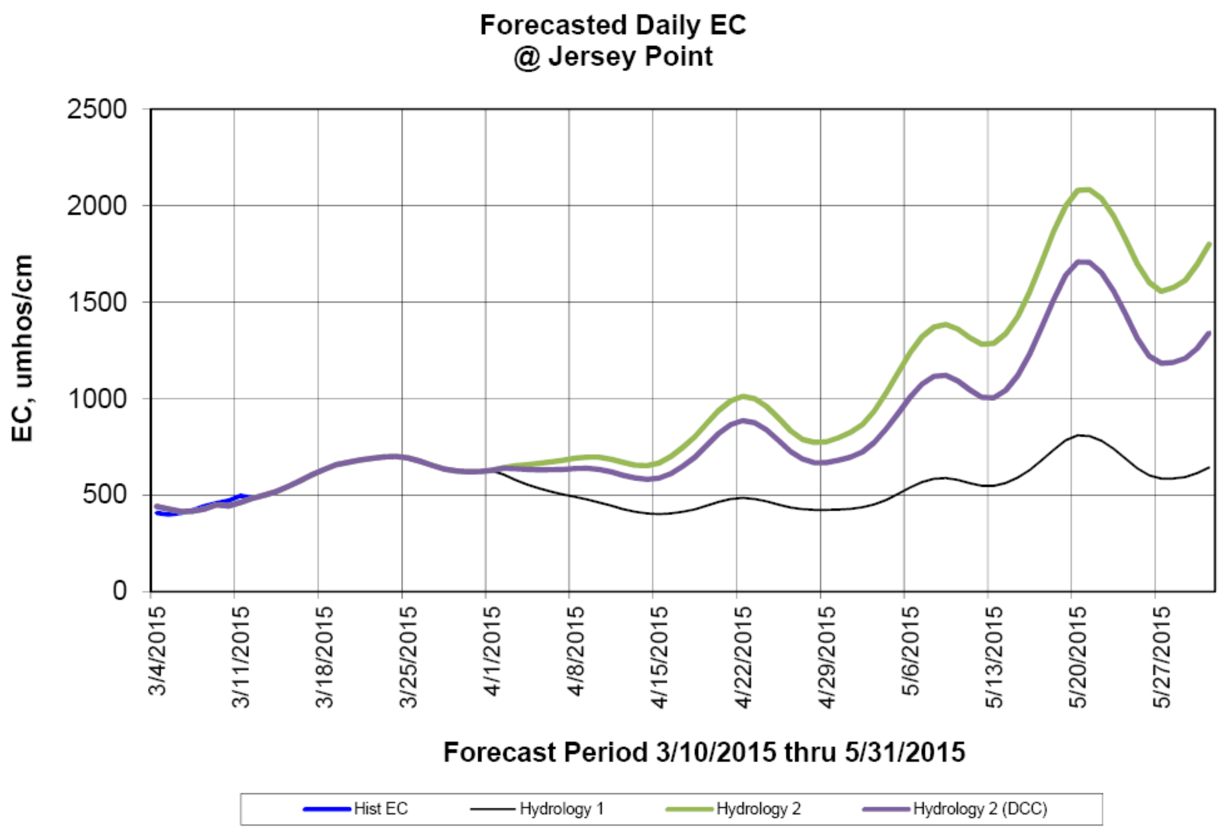

Figure 53. Forecasts of electrical conductivity (EC) under different hydrologic scenarios from March – June, 2015 at Jersey Point

Hydrodynamic Effects on Entrainment

The proposed modifications will result in lower outflows that may reduce survival of migrating young-of-year Delta smelt that are currently in the Interior Delta. For example, lower flows may expose them to loss at the CVP/SWP export facilities, and increase their travel time and exposure to degraded habitats and predators described above. For Delta Smelt residing in the north Delta, reduced outflow, while limiting available habitat, is not expected to result in additional entrainment. Modeling outputs suggest effects from the actions in the Project Description by reducing outflow are negligible through the end of May (Table 23). There is a low level of uncertainty in this conclusion.

Table 23. Presence of Delta Smelt During the Project Description Period and Potential Effects, based on the most recently available survey data[16]

Delta Smelt	Life stage Affected	Change in Risk of Lowered Recruitment	Change in Risk of Entrainment at Facilities	Certainty
Eggs	Attached to substrate with very low risk of entrainment			
Larvae	Presence has been established based on Smelt Larva Survey #5 and 20 mm Survey #1. This life stage has not yet recruited to most sampling gear			
Juvenile	Juvenile Delta Smelt (>20mm) have not yet been detected this year			
Adults	Distribution based on February 2015 Spring Kodiak Trawl survey and salvage at SWP/CVP export facilities			
No detections in South Delta	Yes	Not Applicable	Reduced	Moderate
Present in San Joaquin River	Yes	Not Applicable	Reduced	Moderate
Present in Sacramento River	No	Not Applicable	Not Affected	Moderate
Present in Confluence and down	No	Not Applicable	Not Affected	High

Food Availability

Prey availability is constrained by habitat use, which in turn affects what types of prey are encountered. Larval Delta Smelt are visual feeders. They find and select individual prey organisms and their ability to see prey in the water is enhanced by turbidity (Baskerville-Bridges & Lindberg, 2004). Thus, Delta Smelt diets are largely comprised of small invertebrates (i.e., zooplankton) that inhabit the estuary's turbid, low-salinity, open-water habitats. Larval Delta

[16] Distributions are based on monitoring data through March 16.

Smelt have particularly restricted diets (Nobriga, 2002). They do not feed on the full array of zooplankton with which they co-occur; they mainly consume three copepods: *Eurytemora affinis*, *Pseudodiaptomus forbesi*, and freshwater species of the family Cyclopidae. Further, the diets of first-feeding Delta Smelt larvae are largely restricted to the larval stages of these copepods. As Delta Smelt grow larger, mouth gape and swimming ability increase, enabling them to target larger copepods.

In the laboratory, a turbid environment (>25 Nephelometric Turbidity Units (NTU)) was necessary to elicit a first-feeding response (Baskerville-Bridges & Lindberg, 2004). Successful feeding seems to depend on a high density of food organisms and turbidity, and increases with stronger light conditions (Baskerville-Bridges & Lindberg, 2004; Mager *et al.*, 2003). The most common first prey of wild Delta Smelt larvae are larval stages of several copepod species which occur in the North Delta region. The variability of shallow and deep water habitat, and the resuspension of sediment due to wind and tidal action in the North Delta, may buffer effects of the proposed modifications because much, if not most, of the habitat in this region would remain suitable. Expectations for the North Delta contrast with the lower San Joaquin River where the upstream relocation of X2 may result in a greater proportion of the available habitat encompassing areas of high surface aquatic vegetation (SAV) and associated low turbidities. This could lower prey capture efficiency for Delta Smelt and increase predation rate on juveniles. There is moderate level of uncertainty in this conclusion.

In addition to turbidity effects, changes in flow may affect residence time, which in turn may influence planktonic production. Lower flows are expected to increase hydraulic residence times, potentially resulting in improved planktonic production (Lucas *et al.*, 2009). However, the specific effect is difficult to predict because benthic grazing can offset these benefits, hence the response of the food web to the changes in flow is unclear. There is a moderate level of uncertainty about this conclusion.

Summary of Effects on Delta Smelt

Adults

Small numbers of Delta Smelt adults and larvae observed in 2015 field surveys indicates the WY 2014 drought had a significant impact on the population. Like many other species in the Delta, the Delta Smelt population is showing low recruitment again this year due to effects of continued drought. Model results indicate the Proposed Action may increase entrainment risk for Delta Smelt moving around in the San Joaquin River above baseline conditions. As indicated by forecasted daily EC results, salinity is expected to shift the centroid of the distribution associated with X2 inland. If recent SKT and USFWS Jersey Point survey results reasonably reflect the current distribution of Delta Smelt, there is a diminishing presence of adult Delta Smelt in the vicinity of Jersey Point. Entrainment of these adults is unlikely to be a management issue this year. Published analyses of a 13-year dataset of salvage records at the CVP/SWP fish collection facilities indicate that increased salvage of adult Delta Smelt at the CVP/SWP occurs when turbidities increase in the South Delta and OMR flows are highly negative (Grimaldo *et al.*, 2009). Given the present low turbidity in the South Delta, migration of remaining adults into areas of elevated entrainment risk is not expected. The salvage of adult Delta Smelt typically ends by May (Reclamation 2014c). After the onset of spawning, salvage of adult Delta Smelt diminishes, with regulatory focus shifting from protection of adults to protection of larvae/juveniles by the end of March (as determined by water temperatures or biological triggers; BO).

Larvae and Juveniles

Delta Smelt have a strong positive association with the position of X2, with more downstream positions providing higher quality habitat (Feyrer *et al.*, 2011). Under the proposed action, it is likely summer Delta Smelt distributions will not be in areas optimal for growth and survival (Nobriga *et al.*, 2008). In previous low-flow years, when water quality conditions became less tolerable for Delta Smelt in the Cache Slough Complex, the North Delta population appeared to have the capability to move quickly downstream towards the low salinity zone. It is likely, given the strongly tidal nature of the Cache Slough Complex, Delta Smelt are able to ride these tidal flows to escape unfavorable habitat conditions in the North Delta. Under the current proposal, X2 would move further upstream, reducing the potential for downstream movement beyond the limitations already anticipated from the unmodified severe drought conditions. The proportion of the total population of Delta Smelt in the North Delta in summer appears to be highly variable (Feyrer, 2015), but can be relatively substantial (Sommer & Mejia, 2013). There is a moderate level of uncertainty about the expected effects in the North Delta.

Ongoing IEP monitoring, Early Warning Monitoring, and fish salvage operations, will continue to inform management and advisory groups who will be providing input to Reclamation on a near real-time basis.

Status of Longfin Smelt

In Bay Study trawls conducted during the beginning of February, 2015, the majority of adult Longfin Smelt were detected in Suisun Bay, the Confluence area, and the lower Sacramento River (Figures 54-55; note the different scales between the figures). As of March 16, 2015, no adult or age-1 Longfin Smelt have been detected at either the CVP or SWP fish facilities. Earlier in the season (January), adult Longfin Smelt was detected in the Early Warning sampling in the lower San Joaquin River at Jersey Point, though recent surveys have not detected any in this area. This presence indicates that larval Longfin may be present in the central and south Delta, which is corroborated by the detection of larval Longfin in larval fish sampling at the salvage facilities (see below).

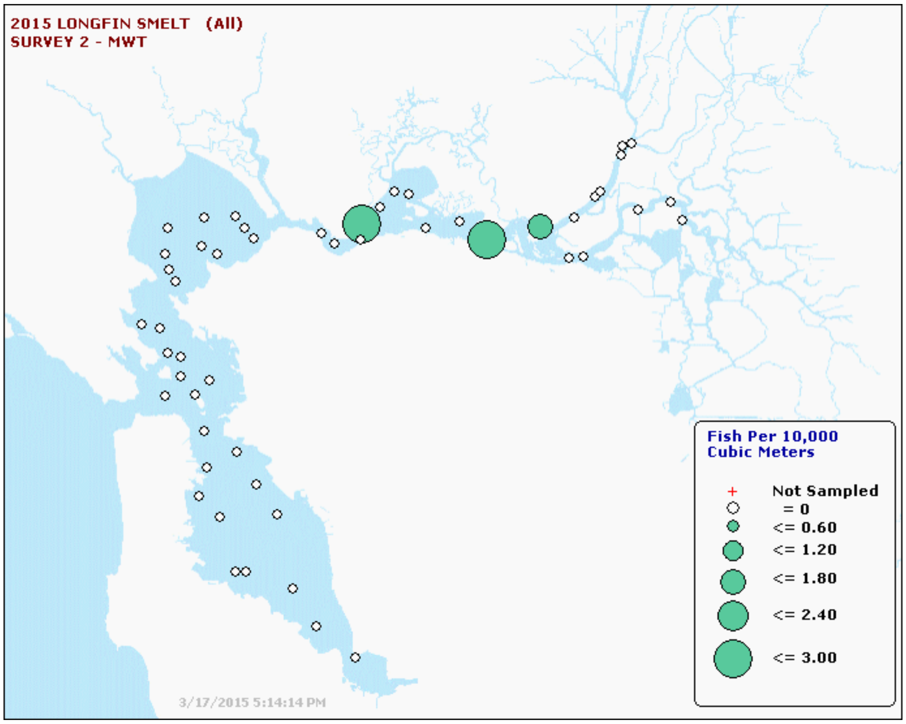

Figure 54. Distribution of adult Longfin Smelt in the Bay Study Midwater Trawl during February 2015

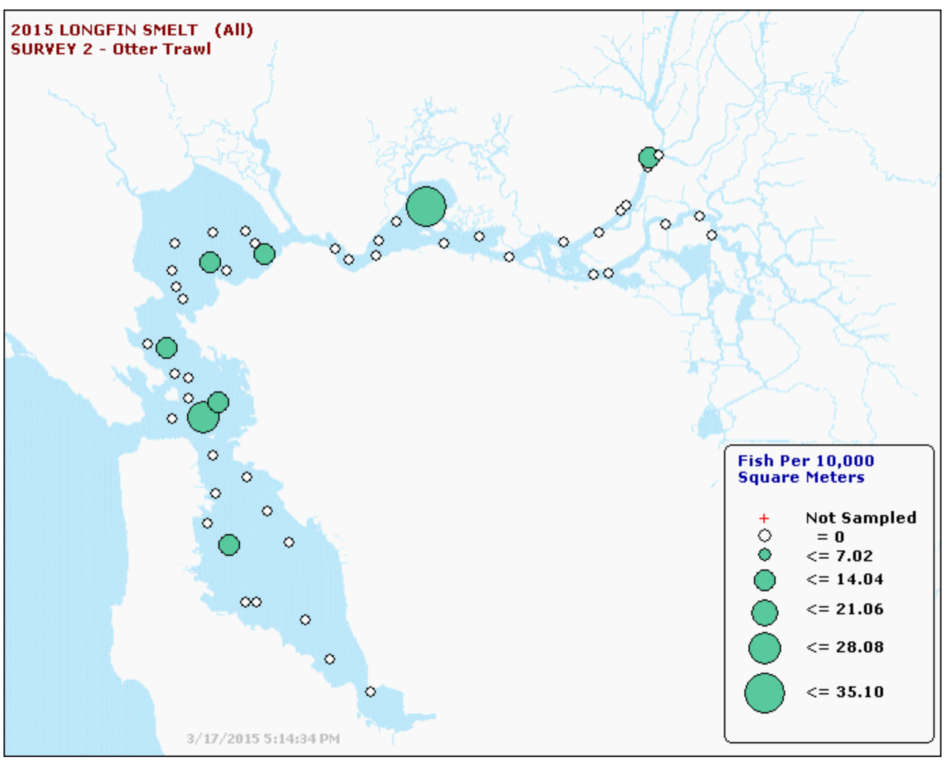

Figure 55. Distribution of adult Longfin Smelt in the Bay Study Otter Trawl during February 2015

The fifth Smelt Larva Survey (SLS), conducted during the week of March 2, 2015, found larval Longfin Smelt larvae were primarily distributed in the lower Sacramento River, at the confluence, and east of the confluence in Suisun Bay (Figure 56). Several larvae were also collected in the lower San Joaquin River at Jersey Point (n=1) and Oulton Point (n=3), and one larvae was collected in the south Delta at station 914 near Mildred Island. While larvae in these southern areas will be at a low to medium risk of entrainment during operations, larvae in the south Delta represent only 1% of the total larval catch in SLS #5 east of Carquinez Straights (n=101). As of March 16, 2015, one larvae each have been collected at the CVP and SWP salvage facilities, (February 27 and March 3, respectively). Compared to previous years, it appears Longfin Smelt spawning in 2015 is substantially reduced and larval abundances are low.

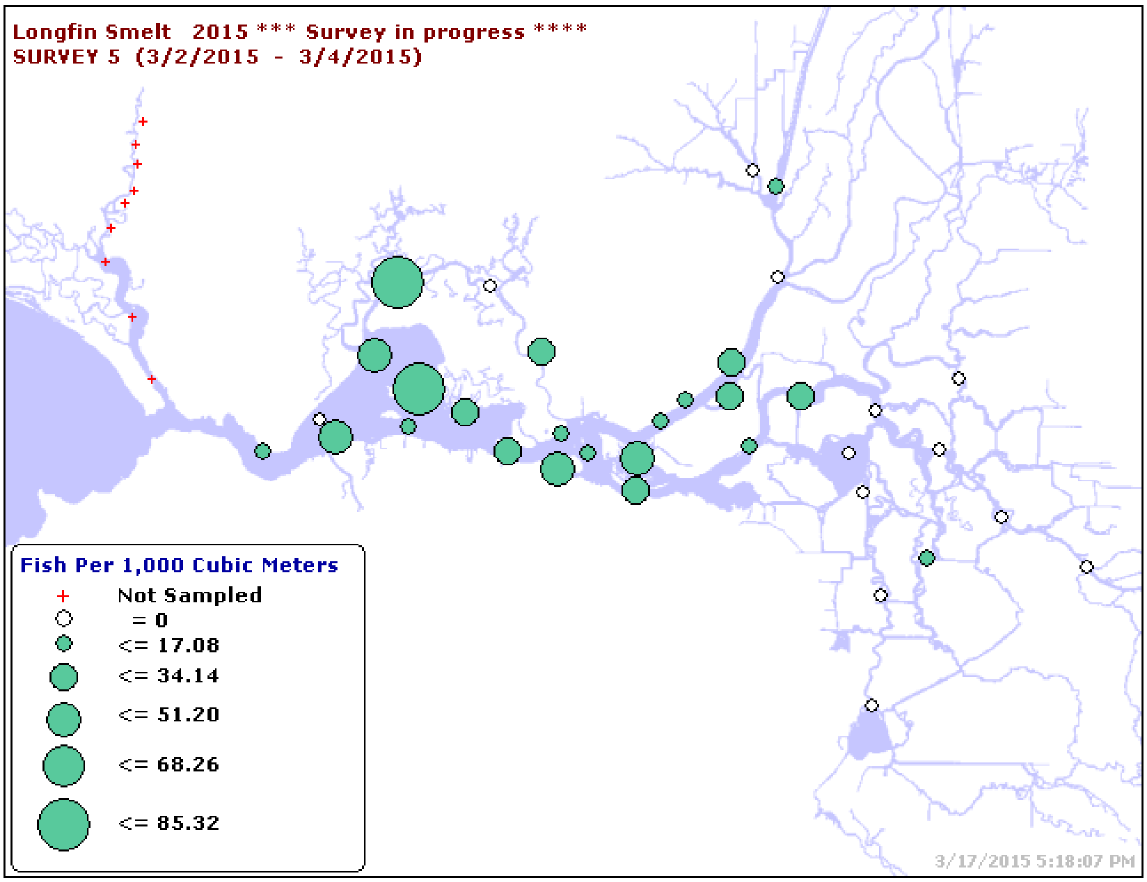

Figure 56. Distribution of larval Longfin Smelt from the Smelt Larva Survey #5 conducted in early March, 2015

It is likely that Longfin Smelt spawning is close to ending. However, the historical presence of recently-hatched larvae in sampling during March and April, indicates that spawning can continue into March (CDFG, 2009). It is possible Longfin Smelt distributed near the confluence may yet make spawning forays into the central and south Delta, which would put them at increased risk of entrainment, although these risks are inherently unquantifiable at this time due to the unprecedented circumstances of continued drought conditions (Table 24).

Table 24. Presence of Longfin Smelt During the Project Description Period and Potential Effects, based on the most recently available survey data [17]

Longfin Smelt	Life stage Affected	Change in Risk of Lowered Recruitment	Change in Risk of Entrainment at Facilities	Certainty
Eggs	Attached to substrate with very low risk of entrainment			
Larvae	Distribution based on Smelt Larva Survey #5			
~1% South Delta	Yes	Increased	Increased	High
~11% San Joaquin River	Yes	Increased	No Change	Moderate
~22% Sacramento River	Yes	Increased	No Change	Moderate
~66% Confluence and Suisun	Yes	Increased	No Change	Moderate
Juvenile	Juvenile Longfin (>20mm) have not yet been detected this year			
Adults	Distribution based on February 2015 Bay Study survey			
0% South Delta	Not Applicable	Not Applicable	Not Applicable	Moderate
0% San Joaquin River	Not Applicable	Not Applicable	Not Applicable	Moderate
<5% Sacramento River	No	Not Affected	Not Affected	Moderate
95% Confluence, Suisun & SF Bay	No	Not Affected	Not Affected	High

Effect of Proposed Action on Longfin Smelt

To estimate the effect of the proposed decrease in outflow on Longfin Smelt, particle tracking models were run using hydrology from the proposed action and baseline conditions, assuming an equally distributed population between injection points (Figure 29). The modeled conditions of the proposed reduced outflow to 4,000 cfs resulted in small changes in the fate of the majority of particles (at the end of the modeling period) compared to baseline conditions. Under all modeled conditions, particles originating from within the south Delta (injection node Railroad Cut) had the majority of particles arriving at the state and federal pumping facilities by May 31 (Figure 29). Of these particles, 78% were entrained at the pumping facilities as of May 31 under the proposed decrease in flows, compared to 73% under baseline. For particles originating at Prisoner's Point, 11% were entrained at the export facilities versus 5% under baseline conditions. Flux past Chipps for these particles was 17% compared to 40% for baseline conditions. Of the

[17] Distributions are based on monitoring data through March 16.

particles injected at Jersey Point under the proposed action, the percentage that moved past Chipps Island by May 31 was 40% (vs. 68% for baseline conditions) and entrainment at the facilities was 2% (vs. 0% for baseline conditions). For particles seeded in the Sacramento River (station 707) at Three-mile Slough above Decker Island, only 1% were entrained to the export facilities versus 0% under baseline conditions. Flux past Chipps Island for these particles was 45% versus 66% under baseline conditions. As larval Longfin Smelt are distributed in the lower San Joaquin and Sacramento Rivers, the general reduction in flux past Chipps Island negatively affect downstream larval transport. However, the majority of larval Longfin detected in SLS #5 were downstream of Chipps Island, so the population level impacts of this reduced flux may not be substantial. However, it is impossible to quantify whether the differences between baseline conditions and the proposed action are truly biologically significant to the Longfin Smelt populations without knowledge of the size of the population and more detailed knowledge of their distribution. However, a qualitative prediction is possible based on the PTM results and a historical relationship between outflow and Longfin Smelt recruitment.

The proposed action will reduce outflow, and increased outflow is one of the best predictors of Longfin Smelt year class strength (CDFG 2009). Therefore, it is likely the proposed action will exacerbate poor Longfin Smelt recruitment and survival already expected in 2015 due to the severity of the drought. Given the results of the PTM model, it is likely that Longfin Smelt larvae in the San Joaquin River (Prisoner's Point and upstream) and in the south Delta will have a somewhat increased risk of entrainment into the south Delta as part of the Proposed Action, where they are not expected to survive warming water temperatures (Table 24). Longfin Smelt already located in the south Delta, near Frank's Tract and within Old and Middle Rivers will be at high risk of entrainment at the export facilities under both baseline conditions and the proposed action. Larvae in other parts of the San Joaquin River and elsewhere in the Delta will also see an increase, though slight, in export entrainment risk.

Summary of Effects on Longfin Smelt

Like other species, Longfin Smelt are likely to experience poor recruitment this year due to effects of the continuing drought. Low spawning and larval detection rates this year seem to verify these low survival rates. The reduction in outflow due to the proposed action will likely have some negative impact on Longfin spawning and recruitment, though this effect is hard to quantify given the already poor environmental conditions due to the drought. The Proposed Action is unlikely to increase entrainment of Longfin Smelt to the export facilities in any substantive manner, as recent surveys indicate that the majorities of both adult and larval Longfin Smelt are distributed outside the zone of influence of the pumps. However, larval Longfin Smelt that are in the San Joaquin River (near Prisoner's Point), and especially those in the south Delta, will be at elevated risk of entrainment into the facilities.

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