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Attachment C.A

CALSIM and DSM2 Results for the Preliminary Proposal Modeling Scenarios

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Attachment C.A

CALSIM and DSM2 Results for the Preliminary Proposal Modeling Scenarios

C.A.1 Introduction

The CALSIM operations model and the DSM2 Delta model were used as the primary tools for determining the physical flow changes resulting from the preliminary proposal. This attachment provides detailed descriptions and summaries of the basic results from these models. The CALSIM II model was used to evaluate the Central Valley Project (CVP) and State Water Project (SWP) system operations for existing and future levels of water supply demands with expected climate change effects on runoff, potential future Sacramento–San Joaquin River Delta (Delta) facilities, and current or alternative operational requirements in the Delta. Key model outputs include reservoir storage levels, downstream river flows, water diversions, Delta exports, water deliveries, and Delta outflow. The DSM2 Delta model was used to simulate hydrodynamics, water quality (salinity), and particle tracking (water movement) within the Delta.

CALSIM II simulates CVP and SWP operations assuming a repeat of the historical (measured) monthly inflow hydrology for the Central Valley region for water years (WY) 1922–2003, with appropriate adjustments for current land use and water demands. The model uses an optimization algorithm to calculate SWP and CVP reservoir and Delta operations (exports, outflow) to meet assumed water demands on a monthly time step. Reservoir storage, releases, and Delta conditions are controlled by many different objectives. The model results are governed by specified "weights" for meeting (satisfying) the various regulatory and operational priorities. The Delta outflow–salinity response is approximated with Artificial Neural Network (ANN) "internal multiple regression equations." Delta exports and outflow, along with X2 position and electrical conductivity (EC) at a few key regulatory locations, are the major model outputs. The CALSIM II model is described in detail by Draper et al. (2004) and the California Department of Water Resources (DWR) (2002), and has been subjected to two peer reviews in the past 8 years (Close et al. 2003; Lund et al. 2006). Much more information on the CALSIM model can be found at this DWR website:

<http://baydeltaoffice.water.ca.gov/modeling/hydrology/CalSim/index.cfm>

The CALSIM model has been peer-reviewed by two technical panels; these peer reviews and DWR/U.S. Department of the Interior, Bureau of Reclamation (Reclamation) responses to questions and suggestions about the model methods, assumptions, and accuracy (calibration) are available at this DWR website:

<http://baydeltaoffice.water.ca.gov/modeling/hydrology/CalSimII/index.cfm>

DWR and Reclamation recently have developed a simplified (alternative screening) version of the CALSIM model, called CalLite. The description of the CalLite model introduces many of the basic operational rules and assumptions and provides a valuable introduction to CVP and SWP operations.

<http://baydeltaoffice.water.ca.gov/modeling/hydrology/CalLite/index.cfm>

DSM2 is a one-dimensional (with branched-channels) model used to simulate hydrodynamics, water quality, and particle tracking in the Delta (Anderson and Mierzwa 2002). DSM2 was used to describe the existing conditions in the Delta and to simulate expected changes with the preliminary proposal

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and climate change (sea level rise). The DSM2 model has three separate components: HYDRO, QUAL, and particle tracking models (PTM). HYDRO simulates tidal flows, tidal velocities, and tidal elevations for the specified Delta channel geometry and tidal boundary elevations at Martinez. QUAL simulates the concentrations of conservative (i.e., no decay or growth) and non-conservative (sources and sinks) water quality constituents given the tidal flows simulated by HYDRO. PTM simulates mixing and transport of neutrally buoyant particles based on the channel geometry and tidal flows simulated by HYDRO. A good introduction to the DSM2 model and results from the most recent calibration effort to match the tidal effects of the flooding of Liberty Island are presented by CH2MHill (2009).

Both the CALSIM model and the DSM2 model were used extensively for the 2008 Biological Assessment for the Operations Criteria and Plan (OCAP) for the CVP and SWP, prepared for the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) (for their endangered species evaluations) by Reclamation and DWR. The CALSIM model is described in Appendix D and the DSM2 model is described in Appendix F of the 2008 BA. These documents are available at the Reclamation website:

<http://www.usbr.gov/mp/cvo/ocap_page.html>

C.A.2 Modeling Scenarios

Six scenarios have been simulated to support the effects analysis. Four of these CALSIM cases are different baselines and two are the simulated BDCP preliminary proposal (PP) conditions for the early long-term (ELT) and late long-term (LLT). The first baseline (EBC1) uses the assumption that the Fall X2 portion of the 2008 USFWS Biological Opinion (BiOp) is not applicable for Delta operations (U.S. Fish and Wildlife Service 2008). The second baseline (EBC2) uses the assumption that the Fall X2 portion of the 2008 USFWS BiOp is applicable for Delta operations. The other two baselines, EBC2_ELT and EBC2_LLT, use the assumption that the Fall X2 is applicable for the ELT (2025) and the LLT (2060) conditions. The ELT and LLT included changes in assumed water supply demands, sea level rise, restoration, and climate change. Table C.A-1 lists the six modeling cases.

Table C.A-1. Definition of Analytical Conditions

Condition	Description
Existing Biological Conditions 1 (EBC1)	This condition assumes current operations based on the 2008 USFWS and 2009 NMFS BiOps, excluding the Fall X2 actions. Ultimately, this would be similar to how the CVP/SWP has been operated since 2009.
Existing Biological Conditions 2 (EBC2)	This condition assumes current operations based on the 2008 USFWS and 2009 NMFS BiOps, including the Fall X2 actions called for in the USFWS BiOp.
EBC2_ELT	This condition assumes that EBC2 continues into the future and includes conditions expected in Year 15 of the PP (2025).
EBC2_LLT	This condition assumes that EBC2 continues into the future and includes conditions expected in Year50 of the PP (2060).
PP_ELT	This condition reflects the preliminary proposal in Year 15 (with the new intake facility but prior to full implementation of the restoration activities).
PP_LLT	This condition assumes full implementation of the BDCP preliminary proposal, and reflects Year 50.
USFWS = U.S. Fish and Wildlife Service; NMFS = National Marine Fisheries Service; BiOp = biological opinion; CVP/SWP = Central Valley Project/State Water Project.	

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C.A.3 CALSIM Reservoir Operations and Downstream Flows

The following sections describe the CALSIM-simulated changes for each upstream reservoir and associated downstream river flows. The reservoir inflows assumed for CALSIM were adjusted for the ELT and LLT timeframes. These adjustments are described in Appendix 2.A, *Climate Change*.

C.A.3.1 Simulated Changes in Trinity Reservoir Operations

The inflows to Trinity Reservoir averaged about 1,275 thousand acre-feet per year (taf/yr), and the Lewiston Reservoir inflows were about 125 taf/yr. The Trinity River monthly flows are specified in the Trinity River Restoration Plan as a function of the Trinity Reservoir inflows (runoff) and these were simulated to average about 700 taf/yr. The Trinity River flows are therefore about half of the Trinity Reservoir inflows.

Table C.A-2 shows the Trinity Reservoir end-of-month storage patterns for 1922–2003 for the six CALSIM cases. The maximum storage of about 2,500 thousand acre-feet (taf) was achieved only once in June over the period of simulation for each of the cases. In all other months the maximum storage is controlled by flood control rules (i.e., safety of dam overtopping) as indicated by the maximum monthly values that were simulated in 20–30% of the years. For example, the maximum storage in October–December was 1,850 taf and the maximum storage in January was 1,900 taf. Operation of Trinity Reservoir is controlled by the maximum storage, the required river releases, and exports through the Carr tunnel and powerhouse to the Sacramento River. Spills are generally rare for the Trinity Reservoir. The EBC2_ELT and EBC2_LLT cases showed lower median storage values than the EBC2 baseline, perhaps reflecting the increased runoff in the winter months, and the slightly less inflow during the summer and fall. Lower storage at the end of April, when the high Trinity River flows are required, resulted in lower storage throughout the summer and fall. There was a greater drawdown of summer storage (lower carryover storages) for the PP cases in ELT and LLT.

Figure C.A-1 shows the simulated Trinity Reservoir monthly storage for EBC1 and EBC2 as well as the two PP cases for the 1922–2003 sequence. The major difference between EBC1 and EBC2 is that EBC2 requires more releases in September following above normal or wet years for the Fall X2. EBC1 and the two PP cases do not include this Fall X2 requirement. Although the monthly minimum storage was reduced by about 100 taf in many years, the carryover storage (i.e., end of September storage, often the lowest each year) was reduced by 100 taf to 300 taf in several years when the baseline carryover storage was between 500 taf and 1,500 taf. For years with storage below the Trinity target carryover storage of 600 taf (specified in the 2009 NMFS BiOp and Trinity River Restoration), the carryover storage was similar.

Figure C.A-2 shows the simulated monthly Trinity Reservoir storage for EBC1, EBC2, and the two PP cases for the 1994–2003 sequence (most recent years in CALSIM). Although these 10 years were relatively wet, the additional simulated drawdown in WY 2001 reduced the Trinity storage and there was not enough inflow for the storage to recover to the EBC1 levels in 2002 or 2003. The simulated effects of climate change on the ELT and LLT inflow appeared to have the greatest effect on the Trinity storage.

Table C.A-3 shows the Trinity River flows for the six cases. The monthly flows were nearly identical, with only a few months of simulated spills being slightly different in these six CALSIM cases.

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Monthly flow requirements increase in the spring months depending on the runoff but remain at 300 cubic feet per second (cfs) from November through March in all years, except for uncontrolled spills. The Trinity River prescribed baseline flows are increased slightly in April to 500 cfs and are increased dramatically in May and June, according to runoff conditions. Flows in July are about 1,000 cfs in most years and flows in August through October are about 500 cfs. Because the Trinity River flows are specified as a function of runoff, they do not change with the different baselines or PP cases.

Figure C.A-3 shows the simulated Trinity River storage for EBC1, EBC2, and the two PP cases for the 1922–2003 sequence. The monthly flows are all between 300 cfs and 6,000 cfs (flood control maximum). The specified flows are highest in May. The highest specified monthly flow in May is 4,700 cfs in years with the highest inflow. Figure C.A-4 shows the simulated monthly Trinity River flows at Lewiston for the EBC1, EBC2, and the two PP cases for the 1994–2003 sequence. The only changes in Trinity River flows were caused by slightly different reservoir spills caused by the different inflow sequences assumed for the EBC1 and the ELT and LLT conditions.

Table C.A-4 shows the Trinity exports for the six cases. The Trinity River exports are generally controlled by Trinity Reservoir storage, Shasta Reservoir storage (balancing rules), Trinity Reservoir inflows, and the Central Valley Project (CVP) Western Area Power Association (WAPA) power demands. The annual average exports were not changed substantially from the EBC1 to the PP cases. The annual average exports were 535 taf for the EBC1 case, 516 taf for the PP_ELT case, and 552 taf for the PP_LLT case. The three EBC2 (with Fall X2) baselines were 539 taf, 527 taf and 554 taf. The assumed Trinity Reservoir inflows were shifted into the winter months and were slightly higher for the ELT and LLT timeframes, allowing slightly different exports for each case. The monthly Trinity export flows were highest in July–October with a lower export flow in January–March and much lower exports in the other months. This monthly export pattern was similar for the six cases.

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Table C.A-2. CALSIM-Simulated Monthly Distribution of Trinity Reservoir Storage (taf)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
A. EBC1												
Min	240	240	264	327	361	482	603	619	638	555	412	240
10%	641	689	675	674	814	890	1,041	1,028	1,009	820	697	651
20%	917	884	969	1,054	1,121	1,233	1,364	1,339	1,271	1,133	1,031	950
30%	1,196	1,188	1,234	1,297	1,387	1,500	1,650	1,637	1,611	1,495	1,360	1,247
40%	1,271	1,274	1,314	1,359	1,537	1,699	1,869	1,832	1,773	1,601	1,409	1,295
50%	1,353	1,364	1,440	1,584	1,718	1,834	1,981	1,912	1,840	1,694	1,532	1,408
60%	1,469	1,510	1,668	1,750	1,868	2,006	2,159	2,090	2,017	1,853	1,695	1,551
70%	1,744	1,796	1,846	1,848	1,965	2,098	2,215	2,206	2,143	2,006	1,872	1,770
80%	1,850	1,847	1,850	1,900	2,000	2,100	2,264	2,290	2,270	2,184	2,083	1,970
90%	1,850	1,850	1,850	1,900	2,000	2,100	2,299	2,329	2,366	2,270	2,150	1,975
Max	1,850	1,850	1,850	1,900	2,208	2,100	2,300	2,420	2,447	2,270	2,150	1,975
Avg	1,326	1,336	1,385	1,447	1,557	1,679	1,827	1,822	1,787	1,650	1,513	1,393
B. PP_ELT												
Min	240	240	245	262	271	419	530	535	527	307	240	240
10%	534	583	584	595	733	908	1,000	959	916	738	591	548
20%	860	897	936	1,022	1,081	1,197	1,303	1,257	1,227	1,067	964	888
30%	1,039	1,053	1,134	1,178	1,320	1,445	1,602	1,551	1,510	1,350	1,184	1,068
40%	1,153	1,163	1,215	1,261	1,496	1,686	1,750	1,718	1,631	1,463	1,295	1,184
50%	1,243	1,244	1,377	1,522	1,644	1,792	1,938	1,876	1,724	1,526	1,390	1,275
60%	1,356	1,405	1,564	1,655	1,834	1,973	2,115	2,020	1,897	1,725	1,555	1,419
70%	1,546	1,560	1,717	1,802	1,946	2,070	2,210	2,159	2,061	1,906	1,760	1,617
80%	1,777	1,807	1,850	1,900	2,000	2,100	2,247	2,239	2,158	2,006	1,859	1,740
90%	1,850	1,850	1,850	1,900	2,000	2,100	2,270	2,344	2,277	2,180	2,083	1,966
Max	1,850	1,850	1,850	1,952	2,314	2,181	2,300	2,420	2,447	2,270	2,150	1,975
Avg	1,233	1,255	1,320	1,399	1,523	1,647	1,786	1,764	1,693	1,541	1,396	1,280
C. PP_LLT												
Min	191	202	234	240	240	320	380	401	365	240	216	184
10%	308	359	495	484	657	837	855	815	774	663	509	352
20%	629	685	691	808	938	1,068	1,230	1,103	1,072	892	767	663
30%	806	787	860	931	1,125	1,226	1,374	1,353	1,245	1,064	951	868
40%	904	923	1,089	1,146	1,353	1,509	1,569	1,534	1,436	1,253	1,081	972
50%	1,090	1,100	1,173	1,346	1,531	1,708	1,858	1,762	1,628	1,404	1,231	1,127
60%	1,202	1,241	1,358	1,563	1,688	1,894	2,043	1,957	1,802	1,603	1,433	1,309
70%	1,355	1,374	1,520	1,633	1,836	1,998	2,144	2,085	1,915	1,737	1,586	1,431
80%	1,580	1,595	1,661	1,820	1,994	2,100	2,228	2,183	2,018	1,866	1,736	1,616
90%	1,764	1,769	1,847	1,900	2,000	2,100	2,268	2,306	2,172	2,051	1,917	1,775
Max	1,850	1,850	1,850	2,030	2,447	2,245	2,300	2,420	2,447	2,270	2,150	1,975
Avg	1,072	1,089	1,171	1,278	1,425	1,565	1,704	1,656	1,548	1,380	1,235	1,125

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
D. EBC2												
Min	240	240	243	256	278	431	521	545	557	515	313	240
10%	629	689	679	694	786	857	1,038	1,051	1,006	847	724	637
20%	890	891	958	1,017	1,090	1,196	1,317	1,306	1,253	1,106	994	908
30%	1,091	1,112	1,169	1,224	1,364	1,437	1,575	1,540	1,552	1,405	1,241	1,128
40%	1,214	1,220	1,306	1,328	1,518	1,645	1,823	1,794	1,708	1,551	1,374	1,263
50%	1,356	1,345	1,396	1,561	1,694	1,826	1,975	1,924	1,827	1,682	1,502	1,391
60%	1,429	1,470	1,653	1,739	1,825	1,942	2,117	2,035	1,952	1,790	1,622	1,481
70%	1,646	1,720	1,759	1,820	1,935	2,100	2,218	2,185	2,124	1,989	1,868	1,731
80%	1,850	1,827	1,850	1,900	2,000	2,100	2,263	2,292	2,265	2,176	2,055	1,968
90%	1,850	1,850	1,850	1,900	2,000	2,100	2,300	2,330	2,367	2,270	2,150	1,975
Max	1,850	1,850	1,850	1,900	2,208	2,100	2,300	2,420	2,447	2,270	2,150	1,975
Avg	1,302	1,312	1,364	1,428	1,538	1,662	1,813	1,808	1,772	1,634	1,493	1,372
E. EBC2_ELT												
Min	212	240	240	252	270	418	530	534	527	318	240	200
10%	502	588	585	598	699	906	970	916	854	731	609	513
20%	806	854	872	945	1,051	1,136	1,315	1,224	1,167	1,050	921	833
30%	1,000	1,007	1,059	1,103	1,214	1,366	1,473	1,448	1,385	1,244	1,127	1,040
40%	1,141	1,162	1,218	1,265	1,477	1,681	1,784	1,743	1,653	1,467	1,279	1,171
50%	1,222	1,274	1,388	1,505	1,639	1,776	1,922	1,863	1,722	1,549	1,378	1,264
60%	1,394	1,415	1,584	1,662	1,802	1,936	2,139	2,036	1,912	1,748	1,541	1,429
70%	1,577	1,598	1,666	1,786	1,943	2,068	2,212	2,145	2,062	1,916	1,767	1,622
80%	1,808	1,787	1,799	1,900	2,000	2,100	2,251	2,237	2,187	2,056	1,894	1,780
90%	1,850	1,844	1,850	1,900	2,000	2,100	2,284	2,345	2,302	2,183	2,114	1,946
Max	1,850	1,850	1,850	1,952	2,314	2,181	2,300	2,420	2,447	2,270	2,150	1,975
Avg	1,223	1,237	1,301	1,378	1,506	1,633	1,775	1,752	1,681	1,535	1,391	1,274
F. EBC2_LLT												
Min	211	240	240	240	246	326	386	407	352	240	240	200
10%	296	319	473	613	651	815	834	763	750	641	500	444
20%	700	721	759	914	1,001	1,100	1,226	1,130	1,104	980	875	756
30%	808	857	939	1,031	1,161	1,373	1,510	1,409	1,325	1,140	996	883
40%	1,050	1,068	1,100	1,169	1,312	1,533	1,640	1,580	1,468	1,314	1,144	1,071
50%	1,107	1,154	1,245	1,433	1,582	1,744	1,867	1,806	1,644	1,430	1,245	1,111
60%	1,309	1,300	1,422	1,562	1,721	1,943	2,097	1,982	1,863	1,703	1,513	1,368
70%	1,406	1,425	1,520	1,677	1,897	2,070	2,191	2,063	1,929	1,775	1,632	1,456
80%	1,577	1,540	1,642	1,790	2,000	2,100	2,216	2,196	2,018	1,868	1,720	1,576
90%	1,762	1,707	1,814	1,900	2,000	2,100	2,279	2,311	2,243	2,102	1,977	1,849
Max	1,850	1,850	1,850	2,026	2,447	2,245	2,300	2,420	2,447	2,270	2,150	1,975
Avg	1,110	1,118	1,203	1,312	1,460	1,601	1,737	1,685	1,583	1,433	1,283	1,163

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Table C.A-3. CALSIM-Simulated Monthly Distribution of Trinity River Flows (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	0	300	300	300	300	300	427	1,498	783	450	450	450	369
10%	373	300	300	300	300	300	460	1,498	783	450	450	450	370
20%	373	300	300	300	300	300	460	2,924	783	450	450	450	453
30%	373	300	300	300	300	300	460	2,924	783	450	450	450	453
40%	373	300	300	300	300	300	493	4,189	2,120	1,102	450	450	648
50%	373	300	300	300	300	300	493	4,189	2,120	1,102	450	450	649
60%	373	300	300	300	300	300	540	4,570	2,526	1,102	450	450	702
70%	373	300	300	300	300	300	540	4,570	2,526	1,102	450	450	743
80%	373	300	300	300	300	300	540	4,709	2,526	1,102	450	450	817
90%	373	300	300	1,118	1,194	1,112	600	4,709	4,626	1,102	450	450	1,009
Max	373	5,201	6,000	6,000	6,000	6,000	2,920	4,709	6,000	3,274	450	450	1,885
Avg	368	360	545	671	634	611	584	3,779	2,108	923	450	450	696
B. PP_ELT													
Min	0	0	300	300	300	300	427	1,498	783	450	0	0	297
10%	373	300	300	300	300	300	427	1,498	783	450	450	450	370
20%	373	300	300	300	300	300	460	2,924	783	450	450	450	453
30%	373	300	300	300	300	300	460	2,924	783	450	450	450	453
40%	373	300	300	300	300	300	493	4,189	2,120	1,102	450	450	648
50%	373	300	300	300	300	300	493	4,189	2,120	1,102	450	450	649
60%	373	300	300	300	300	300	540	4,570	2,526	1,102	450	450	702
70%	373	300	300	300	300	300	540	4,570	2,526	1,102	450	450	817
80%	373	300	300	300	300	300	540	4,709	2,526	1,102	450	450	877
90%	373	300	300	1,768	2,421	1,357	600	4,709	4,626	1,102	450	450	1,115
Max	373	3,514	6,000	6,000	6,000	6,000	2,937	4,709	6,000	2,103	450	450	1,972
Avg	364	328	647	763	757	690	592	3,753	2,226	890	445	445	721
C. PP_LLT													
Min	0	0	0	40	300	300	427	1,498	783	0	0	0	247
10%	373	300	300	300	300	300	427	1,498	783	450	450	450	370
20%	373	300	300	300	300	300	460	2,924	783	450	450	450	453
30%	373	300	300	300	300	300	460	2,924	783	450	450	450	453
40%	373	300	300	300	300	300	493	4,189	2,120	1,102	450	450	648
50%	373	300	300	300	300	300	493	4,189	2,120	1,102	450	450	649
60%	373	300	300	300	300	300	540	4,570	2,526	1,102	450	450	702
70%	373	300	300	300	300	300	540	4,570	2,526	1,102	450	450	801
80%	373	300	300	300	300	300	540	4,709	4,626	1,102	450	450	848
90%	373	300	300	598	3,484	300	600	4,709	4,626	1,102	450	450	1,184
Max	373	2,499	6,000	6,000	6,000	6,000	4,066	4,709	4,626	1,133	450	450	1,923
Avg	344	309	514	718	816	664	622	3,766	2,286	866	434	422	712

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	0	0	300	300	300	300	427	1,498	783	450	450	450	369
10%	373	300	300	300	300	300	460	1,498	783	450	450	450	370
20%	373	300	300	300	300	300	460	2,924	783	450	450	450	453
30%	373	300	300	300	300	300	460	2,924	783	450	450	450	453
40%	373	300	300	300	300	300	493	4,189	2,120	1,102	450	450	648
50%	373	300	300	300	300	300	493	4,189	2,120	1,102	450	450	649
60%	373	300	300	300	300	300	540	4,570	2,526	1,102	450	450	702
70%	373	300	300	300	300	300	540	4,570	2,526	1,102	450	450	745
80%	373	300	300	300	300	300	540	4,709	2,526	1,102	450	450	817
90%	373	300	300	486	1,194	560	600	4,709	4,626	1,102	450	450	987
Max	373	5,261	5,139	6,000	6,000	6,000	2,920	4,709	6,000	3,274	450	450	1,889
Avg	368	357	529	650	642	590	584	3,779	2,108	923	450	450	692
E. EBC2_ELT													
Min	0	0	300	300	300	300	427	1,498	783	450	0	0	274
10%	373	300	300	300	300	300	427	1,498	783	450	450	450	370
20%	373	300	300	300	300	300	460	2,924	783	450	450	450	453
30%	373	300	300	300	300	300	460	2,924	783	450	450	450	453
40%	373	300	300	300	300	300	493	4,189	2,120	1,102	450	450	648
50%	373	300	300	300	300	300	493	4,189	2,120	1,102	450	450	649
60%	373	300	300	300	300	300	540	4,570	2,526	1,102	450	450	702
70%	373	300	300	300	300	300	540	4,570	2,526	1,102	450	450	813
80%	373	300	300	300	300	300	600	4,709	2,526	1,102	450	450	847
90%	373	300	300	839	2,195	331	600	4,709	4,626	1,102	450	450	1,053
Max	373	5,755	6,000	6,000	6,000	6,000	2,937	4,709	6,000	2,103	450	450	2,019
Avg	354	354	611	703	702	654	605	3,753	2,226	890	445	436	710
F. EBC2_LLT													
Min	0	0	0	147	300	300	427	1,498	783	0	0	0	269
10%	373	300	300	300	300	300	427	1,498	783	450	450	450	370
20%	373	300	300	300	300	300	460	2,924	783	450	450	450	453
30%	373	300	300	300	300	300	460	2,924	783	450	450	450	453
40%	373	300	300	300	300	300	493	4,189	2,120	1,102	450	450	648
50%	373	300	300	300	300	300	493	4,189	2,120	1,102	450	450	649
60%	373	300	300	300	300	300	540	4,570	2,526	1,102	450	450	702
70%	373	300	300	300	300	300	540	4,570	2,526	1,102	450	450	776
80%	373	300	300	300	300	300	540	4,709	4,626	1,102	450	450	817
90%	373	300	300	559	2,181	300	600	4,709	4,626	1,102	450	450	1,064
Max	373	3,263	6,000	6,000	6,000	6,000	4,066	4,709	4,626	1,133	450	450	1,905
Avg	344	318	466	684	795	676	630	3,766	2,286	866	434	423	707

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Table C.A-4. CALSIM-Simulated Monthly Distribution of Trinity River Exports (taf)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	0	0	0	0	0	0	0	0	0	0	3	0	150
10%	15	0	0	0	0	0	0	0	0	78	76	15	288
20%	15	0	0	0	0	0	0	0	0	92	92	60	361
30%	46	0	0	0	0	0	6	0	3	92	92	77	409
40%	46	6	6	6	0	6	9	0	15	92	95	89	468
50%	46	8	6	6	5	6	15	0	15	92	108	89	530
60%	46	26	15	7	6	6	18	0	45	108	123	119	578
70%	77	30	15	15	6	12	24	6	45	123	123	119	636
80%	109	30	22	37	6	15	30	15	45	137	154	149	704
90%	120	54	57	112	14	51	75	15	76	203	181	154	829
Max	203	124	108	159	56	203	156	147	191	203	203	196	1,169
Average	61	20	17	28	5	16	24	10	30	110	115	97	535
B.PP_ELT													
Minimum	0	0	0	0	0	0	0	0	0	1	15	2	150
10%	4	0	0	0	0	0	0	0	0	61	80	54	295
20%	15	0	0	0	0	0	6	0	0	92	92	60	369
30%	15	0	0	0	0	0	6	0	9	92	92	86	408
40%	29	6	0	1	0	6	13	0	15	92	108	89	444
50%	46	6	6	6	0	6	16	0	17	96	117	89	488
60%	46	8	6	6	6	7	22	0	45	123	123	89	535
70%	46	29	9	7	6	12	24	6	45	123	138	119	622
80%	77	30	15	15	6	15	30	11	45	163	154	119	684
90%	109	30	24	100	13	43	53	15	82	202	173	152	780
Maximum	203	120	131	203	38	203	121	125	164	203	203	181	1,057
Average	47	16	11	24	5	17	23	9	36	114	121	94	516
C. PP_LLT													
Minimum	0	0	0	0	0	0	0	0	0	3	7	7	67
10%	6	0	0	0	0	0	0	0	0	92	77	27	280
20%	15	6	0	0	0	0	0	0	0	92	92	60	407
30%	15	6	5	0	0	0	6	0	15	92	92	60	447
40%	39	6	6	6	0	6	13	0	15	92	103	72	496
50%	46	9	6	6	2	6	15	0	15	108	123	89	553
60%	46	20	6	6	6	8	20	0	45	123	135	89	597
70%	46	30	11	15	6	12	24	6	51	154	138	119	663
80%	84	30	15	27	6	15	31	11	74	172	160	119	727
90%	149	34	21	106	14	52	47	15	97	203	200	153	766
Maximum	203	196	200	203	77	203	137	109	186	203	203	196	1,190
Average	55	21	13	30	6	20	21	7	44	124	121	89	552

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	0	0	0	0	0	0	0	0	0	0	15	12	150
10%	15	0	0	0	0	0	0	0	0	67	72	49	280
20%	15	0	0	0	0	0	1	0	0	92	92	60	356
30%	46	6	4	0	0	0	6	0	3	92	92	89	399
40%	46	6	6	6	0	3	9	0	12	92	95	89	474
50%	46	17	6	6	6	6	15	0	15	92	108	89	541
60%	71	30	14	6	6	6	18	0	38	108	123	119	581
70%	96	30	15	15	6	12	23	6	45	123	123	119	621
80%	110	30	15	35	6	15	26	15	45	152	166	144	705
90%	124	34	35	104	14	44	58	15	81	203	195	155	814
Max	203	124	162	203	47	203	137	147	191	203	203	186	1,041
Average	65	20	15	26	5	16	22	10	31	110	119	100	539
EBC2_ELT													
Min	0	0	0	0	0	0	0	0	0	0	0	15	138
10%	1	0	0	0	0	0	0	0	0	32	81	35	296
20%	15	0	0	0	0	0	5	0	0	92	92	60	370
30%	15	6	4	0	0	0	6	0	3	92	92	69	402
40%	41	6	6	6	0	6	10	0	15	92	99	89	450
50%	46	9	6	6	0	6	15	0	15	92	108	89	494
60%	46	30	12	8	6	6	17	0	45	108	123	89	569
70%	77	30	15	15	6	12	22	6	45	123	143	119	641
80%	77	30	15	40	6	15	26	15	45	154	169	119	734
90%	113	37	27	106	13	40	42	15	81	202	189	156	817
Max	190	163	142	203	51	203	138	125	186	203	203	196	1,075
Average	51	22	15	29	4	16	20	10	35	109	121	95	527
EBC2_LLT													
Min	0	0	0	0	0	0	0	0	0	0	0	0	61
10%	6	0	0	0	0	0	0	0	0	30	77	43	296
20%	15	6	0	0	0	0	5	0	0	92	92	60	379
30%	15	6	4	0	0	0	7	0	5	92	92	60	423
40%	42	6	6	6	0	0	14	0	15	92	108	89	482
50%	46	9	6	6	6	6	15	0	15	92	123	93	503
60%	46	25	13	11	6	6	20	0	45	108	123	119	571
70%	74	30	15	15	6	12	24	6	45	123	150	119	663
80%	84	30	15	29	6	15	32	15	50	138	170	148	731
90%	114	87	21	123	14	48	58	15	89	199	203	163	894
Max	203	196	159	203	76	203	137	148	196	203	203	196	1,102
Average	54	29	14	29	6	18	24	11	38	107	125	99	554

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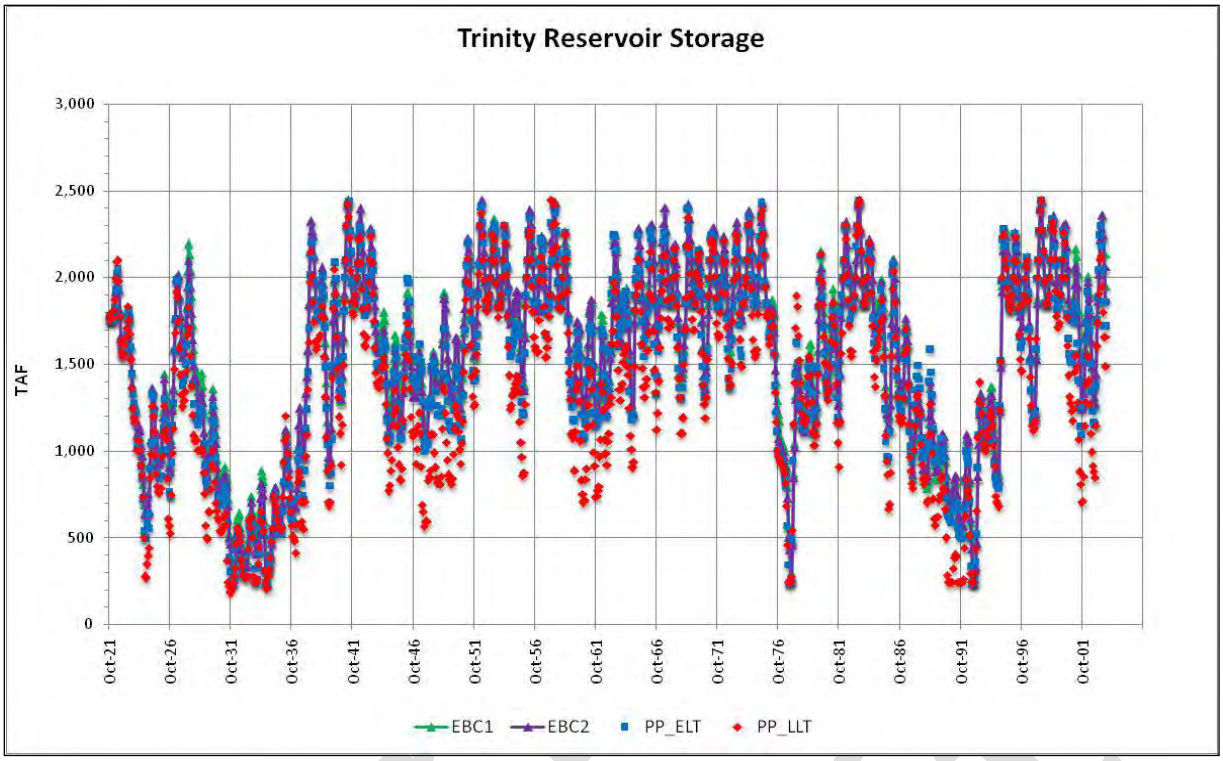

Figure C.A-1. CALSIM-Simulated Monthly Trinity Reservoir Storage for WY 1922–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

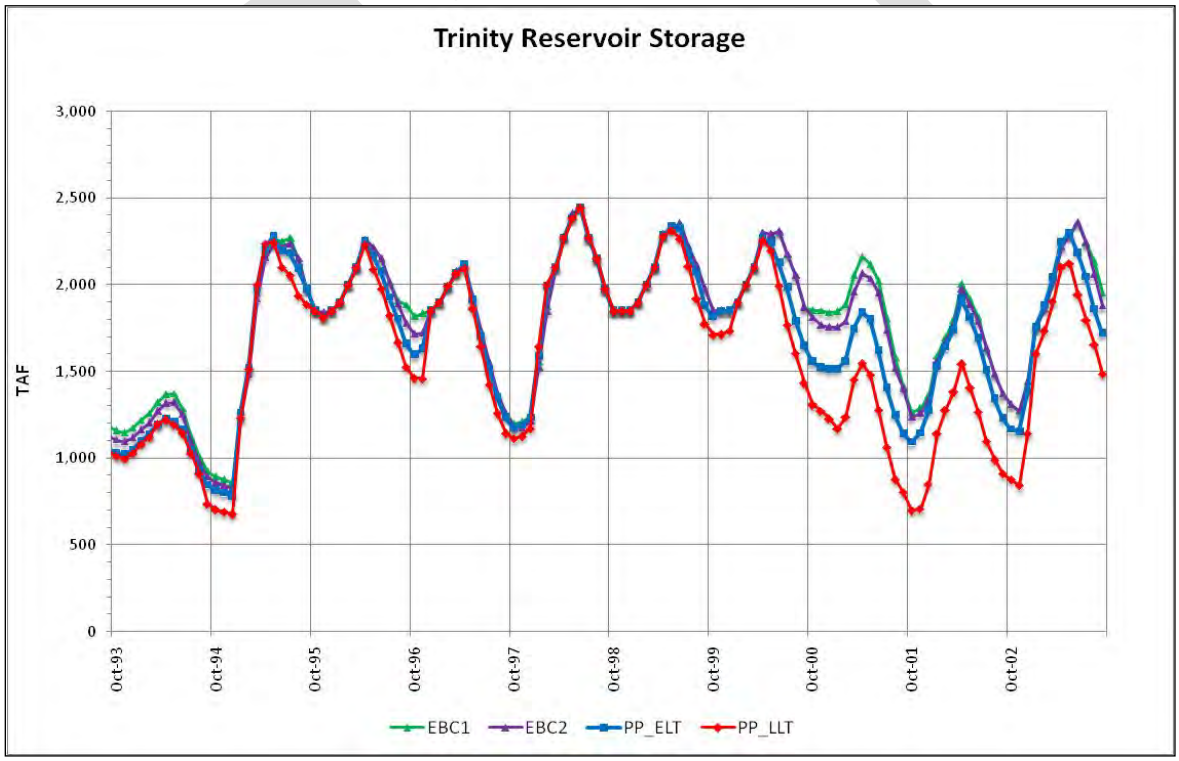

Figure C.A-2. CALSIM-Simulated Monthly Trinity Reservoir Storage for WY 1994–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

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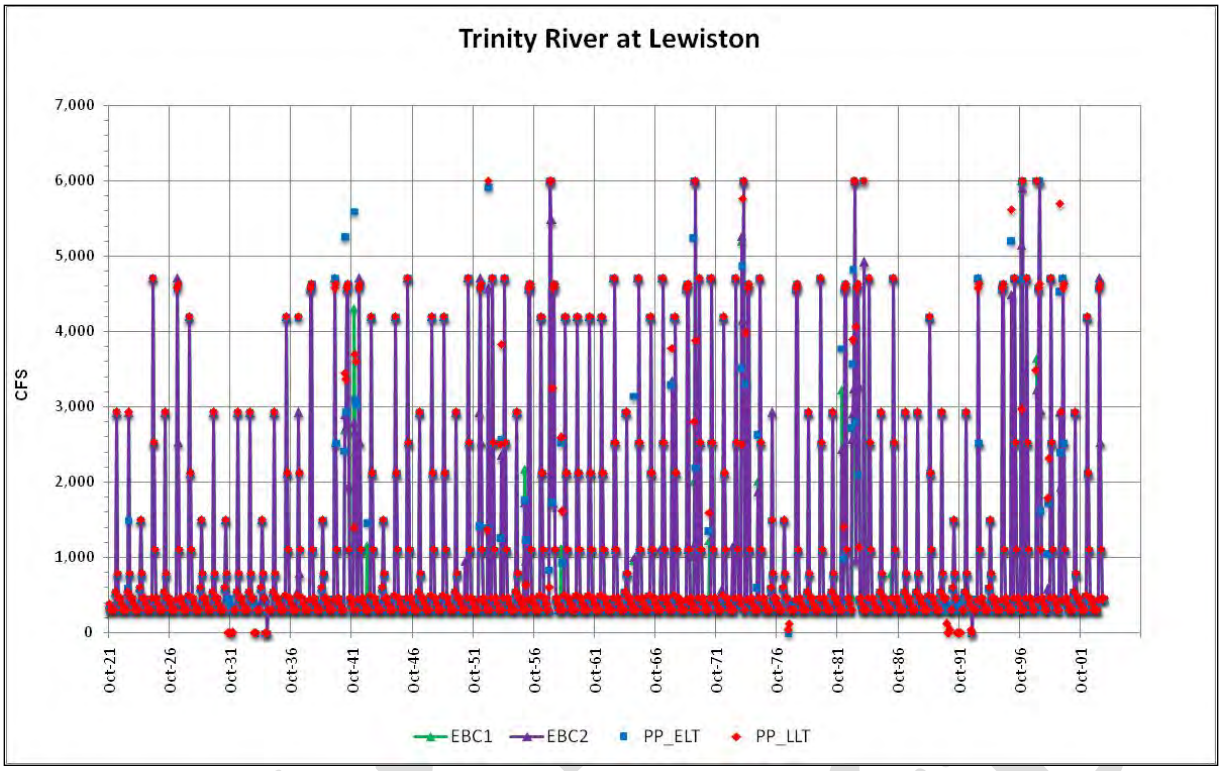

Figure C.A-3. CALSIM-Simulated Monthly Trinity River Flow at Lewiston for WY 1922–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

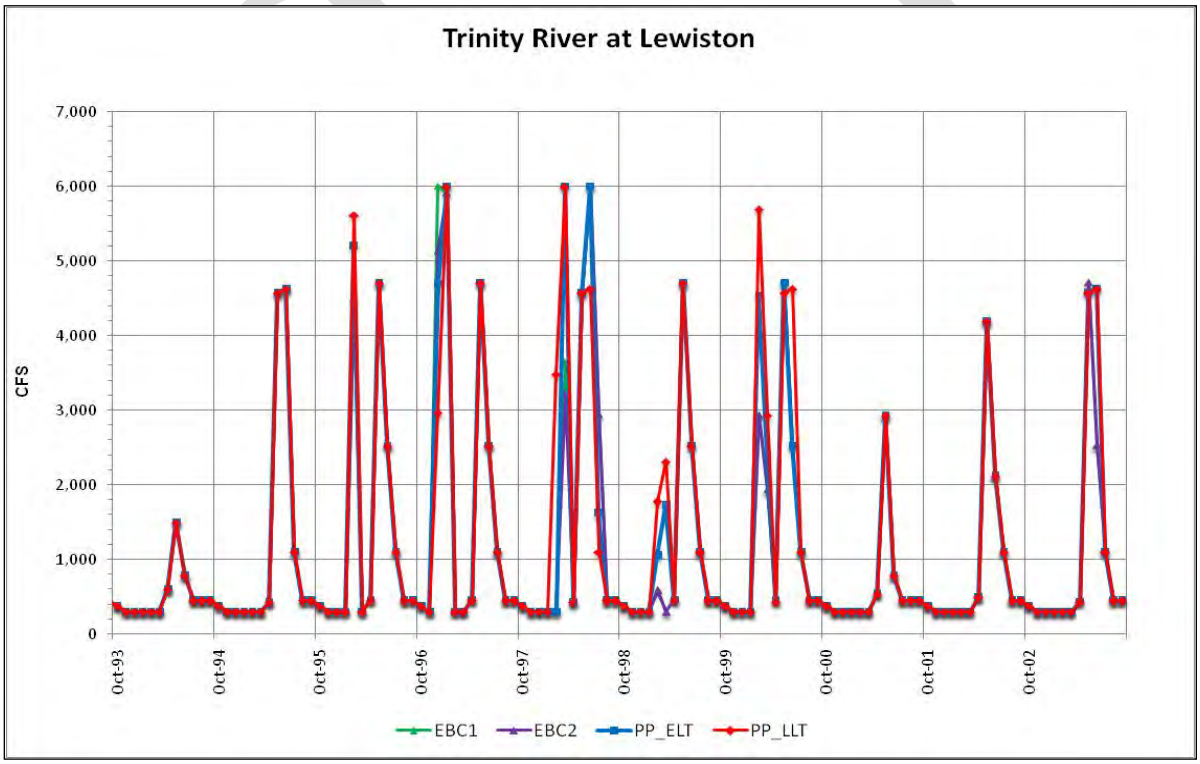

Figure C.A-4. CALSIM-Simulated Monthly Trinity River Flow at Lewiston for WY 1994–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

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C.A.3.2 Simulated Changes in Shasta Reservoir Operations

The simulated Shasta Reservoir operations generally depend on the Shasta inflows, the Shasta flood control rules, the minimum required Keswick flows, and the downstream water diversions (along the Sacramento River and in the Delta). Because Shasta operations are coordinated with other CVP reservoirs (Trinity and Folsom) as well as with the SWP Oroville Reservoir and Delta operations, major changes in the operations of these upstream reservoirs are not expected. Because the preliminary proposal would not change the basic Delta flow objectives, only relatively small changes in upstream reservoir operations are expected.

Table C.A-5 shows the monthly distributions of the CALSIM-simulated Shasta Reservoir storage patterns for the six CALSIM cases. The maximum flood control storage (indicated as the maximum monthly values) is about 3,250 taf in October and November, and increases from about 4,300 taf in December to about 4,250 taf in March. The maximum storage of about 4,550 taf was simulated only in April, May, and June of wet years. The EBC1 median storage volumes were less than 3,000 taf in October and November; about 3,250 taf in December and January; 3,500 taf in February; about 4,000 taf in March; about 4,250 in April and May; about 3,900 taf in June; 3,400 in July; and about 3,000 taf in August and September. These median storage levels were reduced by about 100 taf to 200 taf for the PP_ELT case and the median storage levels were reduced by more than 500 taf in most months (May through December) for the PP_LLT case. The PP cases in some years had storage levels and seasonal fluctuations that were similar to the EBC1 case, but the storage levels were considerably reduced in many of the simulated years.

The simulated median storage levels for the three EBC2 scenarios were somewhat less than the EBC1 baseline in September, October, and November because these are the months when the additional outflow is required to meet the Fall X2 requirements under the EBC2 scenario. Some of this additional outflow is supplied from increased releases from Shasta Reservoir. The median storage levels were reduced by about 100 taf to 150 taf from EBC1 to EBC2, and were further reduced by the effects of climate change for the EBC2_ELT and EBC2_LLT baselines.

Figure C.A-5 shows the simulated monthly Shasta Reservoir storage for EBC1 and the PP_ELT and PP_LLT for the 1922–2003 sequence. The simulated carryover storage (end-of September storage) for the PP_ELT and PP_LLT cases was reduced by 250 taf to 500 taf in several years when the EBC1 carryover storage was between 1,500 taf and 3,500 taf. For several years with baseline storage below the Shasta target carryover storage of 1,900 taf (specified in the 2009 NMFS BiOp), the preliminary proposal carryover storage was reduced further than the baseline. Figure C.A-6 shows the simulated monthly Shasta Reservoir storage for EBC1, EBC2 and the two PP cases for the 1994–2003 sequence. Although these 10 years were relatively wet, the additional drawdown simulated for the PP cases in WY 2001 reduced the carryover storage, and the storage was not able to fully recover in 2002 or 2003 to the EBC1 level. The simulated carryover storage for the PP_ELT and PP_LLT cases was less than the target of 1.9 million acre-feet (maf) in several additional years.

Table C.A-6 shows the CALSIM-simulated Sacramento River flows at Keswick for each of the modeled cases. The simulated changes in Shasta Reservoir and Trinity Reservoir operations are combined in the monthly Keswick flows. The Sacramento River at Keswick flow includes all of the Shasta runoff (there are no substantial diversions upstream) and an average of about 700 taf/yr of Trinity River runoff that is exported to the Sacramento River for hydropower production. The total flow simulated at Keswick was nearly the same for the six cases; the EBC1 flow averaged 6,253 taf/yr, the PP_ ELT averaged 6,288 taf/yr, and the PP_ LLT averaged 6,386 taf/yr. EBC2,

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EBC2_ELT, and EBC2_LLT had similar average flows of 6,259 taf/yr for EBC2, 6,300 taf/yr for EBC2_ELT, and 6,385 taf/yr for EBC2_LLT, reflecting the slight increase in assumed runoff with climate change.

CALSIM-simulated Keswick flows in almost all months were regulated to remain above the 3,250 cfs minimum flow for fish habitat in the fall and winter months (October–March). All flows during the summer months were regulated to remain less than the Keswick hydropower turbine capacity of 15,000 cfs. The peak summer flows of 15,000 cfs were simulated in July of most years. The baseline median (50%) flows were between 4,000 cfs and 6,000 cfs from September through April, and increased to about 7,500 cfs in May, about 10,000 cfs in June, about 13,000 cfs in July, and about 10,500 in August. These monthly median flows at Keswick were not changed substantially from the EBC1 baseline for the PP_ELT and PP_LLT cases. The monthly median flows for EBC2, EBC2_ELT, and EBC2_LLT cases also were similar. Although the monthly distribution of Keswick flows was very similar for all six CALSIM cases, some of the years had increased releases that caused a greater drawdown of the Trinity and Shasta storage levels.

Figure C.A-7 shows the simulated Sacramento River flows at Keswick Dam for EBC1 and PP_ELT and PP_LLT for the 1922–2003 sequence. The monthly flows are generally between 3,250 cfs (minimum flow requirement) and 15,000 cfs (Keswick powerhouse capacity). There are much higher flows in a few years caused by Shasta Reservoir flood control releases (spills). The major differences between the EBC1 flows and the PP_ELT and PP_LLT flows were caused by different inflow sequences assumed for the EBC1 and the PP_ELT and PP_LLT conditions. Figure C.A-8 shows the simulated monthly Sacramento River flows at Keswick Dam for the EBC1 and the PP_ELT and PP_LLT cases for the 1994–2003 sequence. The higher flows were different (flood control effects), and the flows in the fall months of some years were sometimes larger for the PP_ELT and PP_LLT cases compared to the EBC1 flows.

Table C.A-7 shows the CALSIM-simulated Sacramento River flows at Wilkins Slough (just above the Feather River) for the six cases. The simulated monthly flows are generally higher than the monthly Keswick flows because of the additional runoff from the Sacramento River tributaries, including Battle Creek (350 taf/yr average runoff), Mill Creek (215 taf/yr), Thomes Creek (205 taf/yr), Deer Creek (225 taf/yr), Big Chico Creek (110 taf/yr), Stony Creek (380 taf/yr), and Butte Creek (290 taf/yr).

The minimum flow target of 5,000 cfs at Wilkins Slough generally is maintained by CVP operations, but the minimum target flow is reduced in critical years. The Sacramento River at Wilkins Slough higher flows are regulated by the diversions at the three flood bypass weirs between Butte City and Wilkins Slough (Moulton Weir, Colusa Weir, and Tisdale Weir). The maximum monthly Wilkins Slough flow (channel capacity) is about 25,000 cfs. The average annual flow simulated at Wilkins Slough was nearly the same for the six cases; the EBC1 flow averaged 7,159 taf/yr, the PP_ ELT averaged 7,084 taf/yr, and the PP_ LLT averaged 7,264 taf/yr. The average annual flow for the EBC2, EBC2_ELT, and EBC2_LLT at Wilkins Slough were between 7,200 taf/yr and 7,300 taf/yr. There were no substantial changes in the monthly distribution of flows at Wilkins Slough. The CALSIM estimates of the flood bypass weir spills and Butte Creek flows in the Sutter Bypass are added to the Feather River separately near the mouth of the Feather, so the full water balance for the Sacramento River flow (without the Feather River flow) cannot be determined easily. The Sacramento River flow at Verona and the Fremont Weir spill to the Yolo Bypass provide a good record of the simulated Sacramento River and Feather River water balance (i.e., net flow from runoff and diversions).

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Table C.A-5. CALSIM-Simulated Monthly Distribution of Shasta Reservoir Storage (taf)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
A. EBC1												
Min	550	550	672	802	911	1,485	1,559	1,408	942	639	550	550
10%	1,285	1,406	1,452	1,814	2,167	2,804	2,704	2,886	2,503	1,889	1,587	1,490
20%	2,058	2,250	2,287	2,656	2,976	3,366	3,755	3,615	3,202	2,604	2,223	2,187
30%	2,569	2,585	2,696	2,948	3,282	3,550	3,946	3,819	3,410	2,959	2,682	2,654
40%	2,712	2,760	2,985	3,152	3,412	3,756	4,074	4,144	3,686	3,184	2,810	2,813
50%	2,885	2,983	3,234	3,256	3,530	3,896	4,208	4,276	3,898	3,383	3,005	2,969
60%	3,157	3,155	3,276	3,399	3,633	3,980	4,294	4,454	4,048	3,484	3,200	3,152
70%	3,214	3,216	3,309	3,522	3,681	4,033	4,361	4,552	4,233	3,719	3,373	3,334
80%	3,250	3,251	3,328	3,552	3,794	4,118	4,455	4,552	4,355	3,961	3,668	3,400
90%	3,250	3,252	3,347	3,640	3,920	4,221	4,511	4,552	4,480	4,082	3,700	3,400
Max	3,250	3,252	3,368	3,725	4,432	4,384	4,552	4,552	4,500	4,150	3,700	3,400
Avg	2,624	2,645	2,777	3,029	3,299	3,644	3,936	3,961	3,654	3,172	2,838	2,723
B. PP_ELT												
Min	550	550	606	641	703	1,322	1,455	1,291	726	550	550	550
10%	1,252	1,213	1,235	1,968	2,268	2,503	2,522	2,640	2,347	1,873	1,552	1,491
20%	2,058	2,026	2,102	2,418	2,970	3,367	3,585	3,363	3,005	2,422	2,091	2,089
30%	2,289	2,399	2,605	2,861	3,252	3,492	3,829	3,659	3,308	2,763	2,519	2,468
40%	2,494	2,581	2,821	3,169	3,307	3,756	3,975	3,932	3,452	2,938	2,634	2,585
50%	2,674	2,838	3,181	3,314	3,479	3,848	4,140	4,130	3,573	3,053	2,721	2,637
60%	2,870	3,103	3,270	3,368	3,570	3,965	4,256	4,236	3,810	3,176	2,890	2,836
70%	3,085	3,236	3,310	3,515	3,675	4,016	4,336	4,463	4,078	3,451	3,120	3,010
80%	3,250	3,252	3,338	3,552	3,745	4,116	4,428	4,552	4,248	3,766	3,403	3,278
90%	3,250	3,252	3,359	3,640	3,920	4,195	4,479	4,552	4,392	3,882	3,533	3,392
Max	3,250	3,252	3,372	3,725	4,552	4,386	4,552	4,552	4,500	4,111	3,700	3,400
Avg	2,483	2,550	2,718	2,980	3,259	3,601	3,863	3,837	3,454	2,936	2,640	2,548
C. PP_LLT												
Min	503	521	550	550	550	961	942	659	575	550	550	550
10%	630	631	865	1,106	1,660	1,862	2,260	1,955	1,598	1,148	857	748
20%	1,339	1,360	1,442	1,940	2,567	2,820	3,004	2,844	2,327	2,002	1,705	1,625
30%	1,770	1,788	2,057	2,405	2,955	3,363	3,431	3,289	2,840	2,396	2,088	2,138
40%	1,919	2,023	2,409	2,720	3,252	3,493	3,738	3,681	3,134	2,570	2,332	2,308
50%	2,153	2,269	2,693	3,248	3,393	3,790	4,058	3,843	3,351	2,841	2,557	2,469
60%	2,451	2,574	2,978	3,321	3,516	3,950	4,173	4,073	3,475	2,907	2,671	2,643
70%	2,659	2,858	3,154	3,429	3,629	4,000	4,289	4,315	3,832	3,210	2,856	2,788
80%	2,815	3,024	3,267	3,547	3,694	4,118	4,380	4,517	4,058	3,476	3,108	3,034
90%	3,152	3,249	3,328	3,620	3,848	4,162	4,479	4,552	4,262	3,687	3,278	3,157
Max	3,250	3,252	3,370	3,725	4,552	4,249	4,552	4,552	4,500	4,082	3,700	3,400
Avg	2,081	2,165	2,413	2,755	3,086	3,440	3,664	3,588	3,144	2,636	2,355	2,284

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
D. EBC2												
Min	550	550	667	794	831	1,414	1,515	1,385	870	604	550	550
10%	1,379	1,291	1,451	1,869	2,094	2,818	2,699	2,977	2,500	1,984	1,694	1,575
20%	2,107	2,075	2,320	2,662	2,890	3,351	3,725	3,568	3,162	2,618	2,191	2,235
30%	2,391	2,514	2,538	2,913	3,267	3,534	3,888	3,778	3,426	2,879	2,627	2,521
40%	2,598	2,630	2,785	3,013	3,377	3,687	4,058	4,080	3,701	3,200	2,850	2,658
50%	2,794	2,864	3,060	3,252	3,471	3,873	4,173	4,273	3,875	3,371	3,019	2,831
60%	2,943	2,937	3,188	3,358	3,567	3,940	4,292	4,482	4,036	3,462	3,144	2,983
70%	3,110	2,981	3,252	3,402	3,654	4,010	4,396	4,552	4,214	3,695	3,333	3,119
80%	3,214	3,109	3,293	3,541	3,739	4,106	4,456	4,552	4,339	3,936	3,619	3,235
90%	3,250	3,252	3,328	3,616	3,848	4,226	4,503	4,552	4,465	4,079	3,700	3,376
Max	3,250	3,252	3,367	3,678	4,433	4,397	4,552	4,552	4,500	4,150	3,700	3,400
Avg	2,555	2,545	2,710	2,981	3,259	3,613	3,911	3,942	3,631	3,145	2,809	2,628
E. EBC2_ELT												
Min	536	550	550	565	702	1,321	1,451	1,291	676	550	550	550
10%	1,057	1,036	1,064	1,822	2,051	2,604	2,492	2,614	2,321	1,751	1,350	1,217
20%	1,941	1,983	2,165	2,513	2,810	3,226	3,530	3,285	2,877	2,377	2,037	2,013
30%	2,223	2,284	2,425	2,717	3,252	3,439	3,790	3,666	3,363	2,776	2,471	2,374
40%	2,490	2,498	2,615	3,051	3,323	3,718	3,984	4,003	3,580	3,025	2,686	2,556
50%	2,616	2,617	2,948	3,242	3,449	3,766	4,139	4,227	3,779	3,195	2,867	2,704
60%	2,764	2,733	3,081	3,316	3,524	3,960	4,273	4,423	3,973	3,361	3,055	2,833
70%	2,855	2,898	3,249	3,388	3,649	4,018	4,370	4,530	4,172	3,547	3,219	2,990
80%	3,057	3,043	3,275	3,530	3,744	4,115	4,438	4,552	4,280	3,775	3,463	3,051
90%	3,250	3,251	3,317	3,621	3,844	4,212	4,479	4,552	4,432	3,909	3,575	3,306
Max	3,250	3,252	3,349	3,723	4,552	4,381	4,552	4,552	4,500	4,150	3,700	3,400
Avg	2,401	2,408	2,608	2,912	3,210	3,563	3,834	3,848	3,505	2,979	2,661	2,474
F. EBC2_LLT												
Min	537	550	550	550	550	979	650	653	550	550	550	550
10%	618	655	889	1,467	1,756	2,075	2,104	2,034	1,663	1,180	894	803
20%	1,599	1,558	1,693	2,082	2,771	2,985	3,214	2,984	2,586	2,054	1,776	1,754
30%	1,867	1,948	2,118	2,541	2,984	3,416	3,581	3,604	3,129	2,561	2,222	2,018
40%	2,143	2,176	2,423	2,785	3,261	3,490	3,880	3,830	3,406	2,813	2,454	2,331
50%	2,302	2,339	2,610	3,030	3,359	3,754	4,113	4,099	3,642	3,041	2,665	2,436
60%	2,495	2,461	2,783	3,252	3,494	3,959	4,227	4,293	3,817	3,151	2,806	2,601
70%	2,605	2,520	3,045	3,364	3,646	4,007	4,347	4,475	4,085	3,450	3,033	2,695
80%	2,728	2,749	3,252	3,530	3,730	4,107	4,403	4,552	4,173	3,568	3,273	2,848
90%	3,054	3,093	3,304	3,608	3,831	4,180	4,478	4,552	4,403	3,754	3,348	3,035
Max	3,250	3,252	3,349	3,678	4,552	4,365	4,552	4,552	4,500	4,150	3,700	3,400
Avg	2,128	2,141	2,415	2,774	3,129	3,488	3,738	3,720	3,330	2,771	2,438	2,242

Draft

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Table C.A-6. CALISM-Simulated Monthly Distribution of Sacramento River at Keswick Dam Flows (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	2,686	3,250	3,250	3,250	3,250	3,250	3,250	3,773	7,283	8,616	7,053	4,026	4,258
10%	4,569	3,634	3,250	3,250	3,250	3,250	3,390	5,453	8,843	10,948	8,638	4,586	4,541
20%	5,071	4,243	3,466	3,250	3,250	3,250	4,500	6,116	9,405	11,744	9,222	5,002	5,016
30%	5,542	4,398	3,946	3,439	3,250	3,250	4,674	6,536	9,690	12,114	9,688	5,215	5,285
40%	5,811	4,693	4,000	3,805	3,878	3,578	5,595	7,171	10,016	12,617	10,110	5,536	5,633
50%	6,101	4,915	4,260	4,355	4,500	4,500	5,881	7,655	10,382	13,031	10,501	5,982	6,424
60%	6,433	5,290	4,541	4,500	5,748	4,500	6,443	8,151	11,013	13,601	10,718	6,398	7,031
70%	7,428	5,589	6,361	7,627	9,363	8,789	7,178	9,000	11,423	14,362	11,129	7,140	7,630
80%	8,603	7,059	10,673	12,895	18,724	12,828	8,284	9,139	11,890	15,000	11,520	9,366	8,858
90%	9,030	8,982	16,051	20,739	27,408	18,579	11,598	10,914	12,553	15,000	12,504	11,338	12,555
Max	9,996	27,986	29,991	52,735	44,007	46,295	30,037	15,837	18,485	16,277	14,207	12,991	6,253
Avg	6,530	5,845	7,267	8,614	10,355	8,728	7,038	7,967	10,742	13,123	10,476	6,899	6,253
B. PP_ELT													
Min	2,702	2,911	3,250	3,250	3,250	3,250	3,250	3,875	7,422	8,874	3,538	2,356	3,540
10%	4,000	3,551	3,250	3,250	3,250	3,250	3,720	5,412	8,530	11,088	7,672	4,361	4,256
20%	4,138	4,000	3,316	3,250	3,250	3,250	4,500	6,087	9,462	11,813	8,533	5,389	4,532
30%	4,715	4,116	3,699	3,251	3,250	3,250	4,500	6,598	10,100	12,258	9,117	5,692	4,797
40%	5,181	4,357	4,000	3,822	4,070	3,928	5,179	7,275	10,845	12,909	9,440	5,877	5,191
50%	5,566	4,543	4,133	4,482	4,500	4,500	5,593	7,769	11,311	13,831	9,880	6,125	5,835
60%	5,796	4,865	4,511	5,528	5,382	4,500	6,244	8,326	11,939	14,818	10,236	6,395	6,671
70%	6,092	5,243	6,197	9,119	13,124	8,359	7,166	8,911	12,355	15,000	10,584	6,882	7,084
80%	7,501	5,670	12,016	14,800	21,412	12,718	8,966	9,468	13,424	15,000	10,989	7,269	7,964
90%	8,414	6,824	19,507	22,889	29,940	18,832	10,891	10,794	15,000	15,000	11,358	7,503	8,976
Max	11,200	30,292	33,201	58,978	51,790	47,351	30,893	14,536	15,066	16,138	15,000	12,180	12,696
Avg	5,841	5,277	7,758	9,416	11,363	8,764	6,958	7,965	11,457	13,400	9,755	6,285	6,288
C. PP_LLT													
Min	2,777	2,886	3,209	3,250	3,250	3,250	3,250	3,250	6,206	4,607	2,648	2,803	3,151
10%	3,904	3,488	3,250	3,250	3,250	3,250	3,772	5,350	8,515	10,077	7,475	3,921	4,126
20%	4,386	4,000	3,408	3,250	3,250	3,250	4,500	6,074	10,052	11,115	8,125	4,373	4,798
30%	5,698	4,000	3,695	3,644	3,264	3,404	4,541	6,471	11,034	12,167	8,654	5,067	5,013
40%	6,665	4,000	4,000	4,247	4,115	4,007	5,431	7,088	11,813	12,818	9,261	5,603	5,375
50%	7,749	4,172	4,000	4,500	4,500	4,500	6,064	7,729	12,444	13,980	9,642	5,804	5,899
60%	8,718	4,456	4,377	6,462	4,782	4,546	6,630	8,518	13,202	14,684	9,957	6,226	6,605
70%	10,127	4,646	6,097	9,195	9,838	8,417	7,674	9,183	13,824	15,000	10,325	6,550	7,138
80%	12,371	4,939	8,740	10,789	22,169	12,351	8,918	9,870	14,679	15,000	10,863	6,923	8,099
90%	14,788	5,796	16,623	20,427	30,081	20,172	10,582	11,905	15,000	15,000	11,449	7,237	9,250
Max	15,000	25,124	32,513	60,328	51,261	46,363	29,690	15,000	15,000	16,167	14,383	11,794	12,372
Avg	8,242	4,968	6,958	9,503	11,442	8,924	7,127	8,124	12,195	13,155	9,403	5,794	6,386

Draft

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	2,836	3,250	3,250	3,250	3,250	3,250	3,250	3,739	7,297	8,618	7,054	3,365	3,569
10%	4,236	3,483	3,250	3,250	3,250	3,250	3,702	5,340	8,958	10,712	8,740	4,448	4,226
20%	4,892	4,008	3,252	3,250	3,250	3,250	4,500	5,969	9,561	11,779	9,166	5,031	4,510
30%	5,566	4,358	3,524	3,250	3,255	3,301	4,535	6,514	9,761	12,341	9,557	5,586	4,892
40%	5,791	4,668	3,842	3,811	3,919	3,947	5,349	6,854	10,121	12,826	10,101	5,894	5,235
50%	5,971	5,196	4,000	4,333	4,500	4,500	5,678	7,526	10,464	13,319	10,613	6,552	5,717
60%	6,270	5,859	4,239	4,500	4,500	4,500	6,264	8,192	10,966	13,815	10,847	8,125	6,565
70%	6,628	6,927	5,348	7,438	9,287	8,305	7,131	8,962	11,527	14,871	11,098	9,953	7,096
80%	7,426	8,853	8,732	10,515	18,724	11,832	7,685	9,199	12,054	15,000	11,857	12,194	7,736
90%	8,711	9,871	15,046	18,980	27,436	18,400	11,571	10,801	12,853	15,000	12,773	13,110	9,025
Max	9,992	27,546	26,142	52,735	44,007	46,295	30,037	15,837	18,485	16,218	14,304	16,438	12,453
Avg	6,196	6,348	6,694	8,274	10,217	8,560	6,899	7,856	10,838	13,219	10,557	8,070	6,259
E. EBC2_ELT													
Min	2,615	2,911	3,250	3,250	3,250	3,250	3,250	3,577	7,416	9,064	3,724	3,027	3,403
10%	4,000	3,483	3,250	3,250	3,250	3,250	3,702	5,164	8,420	10,796	8,334	3,999	4,151
20%	4,572	4,000	3,270	3,250	3,250	3,250	4,500	5,919	8,914	11,930	8,886	4,480	4,442
30%	5,430	4,253	3,528	3,325	3,250	3,250	4,500	6,323	9,867	12,706	9,343	5,118	4,814
40%	5,786	4,628	3,871	3,982	3,669	3,753	5,034	6,485	10,127	13,356	9,709	5,692	5,197
50%	5,950	5,143	4,000	4,482	4,500	4,500	5,490	7,016	10,496	13,979	10,115	6,857	5,758
60%	6,504	6,005	4,298	4,500	4,798	4,500	5,893	7,638	11,040	14,624	10,377	8,516	6,804
70%	6,759	7,468	5,256	8,759	11,833	7,719	6,866	7,953	11,472	14,971	10,885	10,133	7,371
80%	7,234	8,669	10,503	11,726	21,412	12,188	7,646	8,608	12,694	15,000	11,466	11,615	7,965
90%	8,223	10,203	16,985	19,967	29,826	18,389	10,159	9,640	13,638	15,000	12,131	13,463	9,130
Max	10,094	28,457	33,201	58,978	51,790	47,351	30,893	13,219	15,066	15,177	14,087	15,000	12,732
Avg	6,038	6,399	7,278	8,829	11,015	8,577	6,748	7,321	10,797	13,424	10,108	7,926	6,300
F. EBC2_LLT													
Min	2,693	2,884	3,209	3,250	3,250	3,250	3,250	3,250	7,385	4,655	2,703	2,708	3,316
10%	4,000	3,488	3,250	3,250	3,250	3,250	3,719	5,152	8,411	10,946	7,947	3,931	4,129
20%	4,746	4,000	3,270	3,250	3,250	3,250	4,500	5,452	9,142	12,171	9,316	4,401	4,605
30%	5,645	4,070	3,516	3,251	3,250	3,250	4,500	6,003	9,933	12,809	9,708	4,651	4,939
40%	6,046	4,411	3,830	3,947	3,565	3,753	4,803	6,353	10,506	13,901	10,065	5,448	5,266
50%	6,558	4,920	4,000	4,482	4,500	4,500	5,443	6,832	10,924	14,614	10,472	6,372	5,776
60%	7,209	5,980	4,326	4,500	4,500	4,500	6,119	7,428	11,643	15,000	10,867	8,654	6,620
70%	7,800	7,335	4,796	9,386	9,054	7,710	6,649	7,885	12,368	15,000	11,454	10,764	7,312
80%	8,567	9,100	7,205	11,727	21,836	12,767	7,995	8,717	13,151	15,000	11,791	12,938	8,136
90%	9,552	10,388	16,297	20,731	30,081	20,167	10,223	10,849	14,209	15,000	12,290	14,750	9,392
Max	14,104	23,506	32,513	60,146	51,005	46,363	30,978	12,313	15,000	20,916	16,592	15,399	12,305
Avg	6,752	6,324	6,557	9,215	11,039	8,800	6,733	7,233	11,160	13,689	10,269	8,094	6,385

Draft

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Table C.A-7. CALSIM-Simulated Monthly Distribution of Sacramento River Flow (cfs) at Wilkins Slough

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	3,151	3,621	4,036	4,567	4,882	5,427	4,862	4,666	5,526	5,565	4,989	3,574	4,034
10%	4,525	4,821	5,197	5,978	6,401	6,016	5,624	5,046	6,194	7,114	5,920	4,636	4,927
20%	5,152	5,162	5,690	7,545	8,386	8,512	6,326	5,672	6,773	7,296	6,500	5,305	5,524
30%	5,240	5,503	6,332	8,291	11,062	9,568	6,670	6,217	7,059	7,473	6,575	5,362	5,873
40%	5,431	5,785	7,794	9,937	13,533	11,678	6,937	6,398	7,198	7,884	6,601	5,449	6,169
50%	5,747	6,356	8,822	12,029	16,606	14,854	7,087	6,563	7,252	8,553	6,658	5,744	6,838
60%	6,195	6,862	12,467	17,750	19,911	16,491	7,691	6,739	7,320	9,394	7,344	6,249	7,762
70%	7,405	7,843	15,450	19,481	20,924	19,051	10,350	7,364	7,550	9,647	7,898	7,244	8,233
80%	8,540	10,039	19,881	21,305	21,548	20,293	16,956	10,137	8,271	10,147	8,263	9,557	8,594
90%	9,491	14,519	21,354	22,354	22,759	21,663	19,193	13,809	9,067	10,416	8,910	11,616	9,940
Max	15,096	21,678	22,810	24,057	24,537	24,249	22,121	20,085	20,653	14,498	10,857	14,554	12,877
Avg	6,600	7,865	11,633	13,912	15,476	14,269	10,100	8,256	7,719	8,774	7,297	6,955	7,159
B. PP_ELT													
Min	3,069	3,366	3,946	4,498	4,436	5,377	4,734	4,580	5,299	5,402	3,672	2,709	3,933
10%	4,224	4,606	5,054	6,199	6,647	6,890	5,239	5,245	6,134	7,073	5,056	3,855	5,022
20%	4,677	4,988	5,885	7,369	7,731	8,768	6,130	5,788	7,150	7,585	5,388	5,345	5,339
30%	5,026	5,239	6,584	8,339	11,135	9,660	6,632	6,358	7,362	8,155	6,042	5,483	5,770
40%	5,210	5,616	7,865	9,976	13,443	11,637	6,998	6,582	7,656	8,539	6,458	5,677	6,082
50%	5,286	6,006	9,201	12,173	17,276	14,350	7,253	6,789	8,018	9,231	6,560	6,125	7,006
60%	5,396	6,524	12,401	18,143	19,726	16,398	7,904	7,603	8,392	9,630	6,610	6,317	7,637
70%	5,889	7,129	15,053	19,813	21,118	19,127	10,562	8,885	8,748	9,899	6,676	6,886	8,265
80%	7,499	9,330	19,964	21,457	21,616	20,251	17,204	10,473	9,681	10,168	7,047	7,278	8,678
90%	8,853	12,125	21,439	22,593	22,942	21,752	18,958	12,747	10,371	10,745	7,871	8,117	9,594
Max	11,400	21,839	23,240	24,185	24,662	24,249	22,185	19,723	19,737	12,329	11,484	14,102	12,309
Avg	5,935	7,388	11,723	14,075	15,609	14,303	10,107	8,332	8,388	8,934	6,528	6,314	7,084
C. PP_LLT													
Min	2,947	3,405	4,013	4,490	5,050	5,392	4,735	4,579	5,143	4,087	2,796	3,346	3,852
10%	3,779	4,185	5,026	6,369	6,552	7,217	5,633	5,235	6,197	6,214	4,838	3,832	5,093
20%	5,160	4,737	5,845	7,754	8,422	8,997	6,166	5,898	7,799	7,295	5,453	4,820	5,606
30%	5,725	5,190	6,421	9,515	11,050	9,813	6,450	6,817	8,210	7,880	5,645	5,065	6,099
40%	6,223	5,439	8,085	10,672	13,113	12,118	7,450	7,520	8,744	8,628	6,047	5,372	6,388
50%	7,822	5,627	9,124	13,013	17,368	14,519	7,800	8,089	9,357	9,414	6,311	5,565	7,062
60%	9,561	6,208	12,938	18,060	19,502	16,249	9,298	8,603	9,764	9,735	6,595	6,017	7,752
70%	10,275	7,061	15,055	19,994	21,130	18,825	11,026	8,963	10,139	10,012	6,756	6,490	8,460
80%	11,999	8,984	19,135	21,314	21,653	20,259	15,658	9,910	10,573	10,324	7,183	6,904	8,927
90%	14,053	11,673	21,274	22,523	22,951	21,958	19,012	12,743	11,050	10,987	7,982	7,585	9,565
Max	15,993	21,536	23,150	24,197	24,662	24,249	22,096	19,463	19,721	11,699	11,298	13,686	11,518
Avg	8,370	7,092	11,701	14,329	15,610	14,368	10,284	8,529	9,160	8,854	6,374	5,900	7,264

Draft

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	3,226	3,621	3,983	5,081	4,848	5,403	4,723	4,664	5,536	5,585	4,926	3,598	4,005
10%	4,533	4,615	4,827	6,152	6,603	6,426	5,488	5,025	6,184	7,061	5,714	4,375	4,842
20%	5,059	4,915	5,618	7,220	7,928	8,628	6,131	5,524	6,637	7,161	6,421	4,904	5,495
30%	5,255	5,820	6,120	8,312	11,136	9,668	6,410	5,831	7,043	7,623	6,524	5,508	5,811
40%	5,388	6,728	7,549	9,938	13,133	11,724	6,708	6,098	7,215	8,052	6,597	5,860	6,122
50%	5,628	7,467	8,966	11,350	16,728	14,716	7,071	6,499	7,263	8,702	6,706	6,475	6,845
60%	5,911	8,577	12,292	16,728	19,916	16,321	7,694	6,681	7,431	9,479	7,171	7,712	7,803
70%	6,453	10,137	15,073	19,379	20,930	18,671	10,416	7,304	7,695	9,829	7,818	10,318	8,484
80%	7,392	11,549	19,496	21,307	21,549	20,297	17,000	10,185	8,564	10,104	8,375	12,190	8,977
90%	9,053	12,982	21,077	22,031	22,716	21,666	19,222	13,782	9,244	10,548	9,658	13,252	9,850
Max	14,073	21,690	22,809	24,057	24,539	24,249	22,128	20,122	20,588	13,778	11,167	15,304	12,722
Avg	6,233	8,488	11,405	13,816	15,445	14,280	10,028	8,129	7,759	8,776	7,283	8,076	7,208
E. EBC2_ELT													
Min	2,815	3,369	3,950	4,499	4,860	5,379	4,687	4,581	5,378	5,346	3,863	3,372	3,837
10%	4,017	4,195	4,829	6,311	6,600	6,284	5,214	4,833	6,129	7,080	5,550	3,890	4,989
20%	4,832	4,925	5,717	7,499	7,522	8,770	6,077	5,353	6,718	7,348	6,075	4,429	5,404
30%	5,385	6,158	6,168	8,396	11,076	9,672	6,330	5,801	7,038	8,331	6,491	5,056	5,750
40%	5,542	7,038	7,591	9,990	13,272	11,582	6,513	5,980	7,220	8,948	6,579	5,783	6,036
50%	5,824	7,747	8,927	11,414	16,673	13,831	6,986	6,271	7,356	9,590	6,689	6,651	6,888
60%	6,198	8,651	12,252	16,689	19,721	16,255	7,503	6,751	7,701	9,886	6,844	8,718	7,854
70%	6,814	10,027	15,320	19,835	21,069	18,755	10,548	7,104	8,153	10,107	7,209	9,755	8,629
80%	7,271	11,531	20,361	21,451	21,614	20,318	17,205	9,708	8,860	10,534	7,672	12,149	9,068
90%	7,868	12,734	21,172	22,303	22,863	21,750	18,956	12,678	9,651	10,732	8,947	13,412	9,566
Max	14,370	21,750	23,240	24,186	24,662	24,249	22,185	19,722	19,734	12,554	10,988	15,409	12,342
Avg	6,123	8,566	11,544	13,887	15,469	14,192	9,922	7,757	7,826	9,096	6,984	7,990	7,186
F. EBC2_LLT													
Min	2,944	3,377	3,767	4,381	4,325	5,387	4,691	4,580	5,377	4,274	3,633	3,000	3,822
10%	4,146	4,117	5,075	6,217	6,545	6,205	5,231	4,875	6,217	7,050	5,438	3,869	5,026
20%	5,190	5,061	5,752	7,534	7,487	8,654	5,959	5,518	6,921	7,623	6,292	4,314	5,597
30%	5,661	5,752	6,317	8,495	11,096	9,755	6,151	5,871	7,304	8,952	6,609	4,781	5,920
40%	6,278	7,044	7,541	10,542	13,131	11,312	6,570	6,118	7,593	9,526	6,778	5,545	6,217
50%	6,871	7,877	8,924	12,196	17,374	13,490	7,000	6,431	8,153	9,937	7,108	6,246	6,991
60%	7,258	9,009	12,010	16,657	19,787	16,149	7,816	7,150	8,448	10,279	7,530	9,388	8,161
70%	7,900	10,226	14,094	19,976	20,986	18,829	10,554	8,149	8,873	10,513	7,799	10,887	8,660
80%	8,734	11,234	19,077	21,352	21,662	20,485	16,537	9,133	9,408	10,802	8,549	13,480	9,129
90%	9,419	13,517	21,266	22,419	22,884	21,963	19,002	10,638	10,245	11,113	9,346	13,950	9,654
Max	12,216	21,466	23,150	24,197	24,662	24,249	22,171	19,464	19,719	17,207	13,305	15,398	11,540
Avg	6,851	8,504	11,346	14,019	15,466	14,165	9,879	7,697	8,239	9,446	7,289	8,186	7,291

Draft

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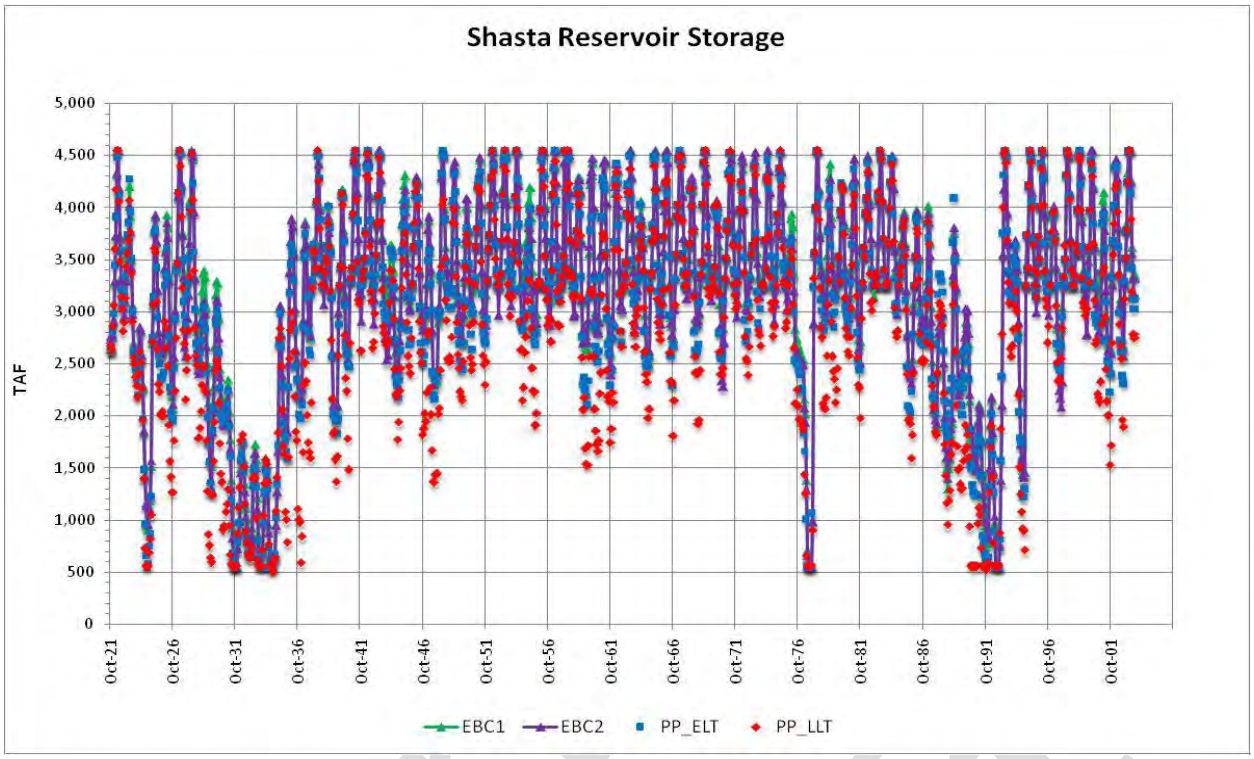

Figure C.A-5. CALSIM-Simulated Monthly Shasta Reservoir Storage for WY 1922–2003 for the EBC1 and EBC2 Baseline and PP_ELT and PP_LLT Cases

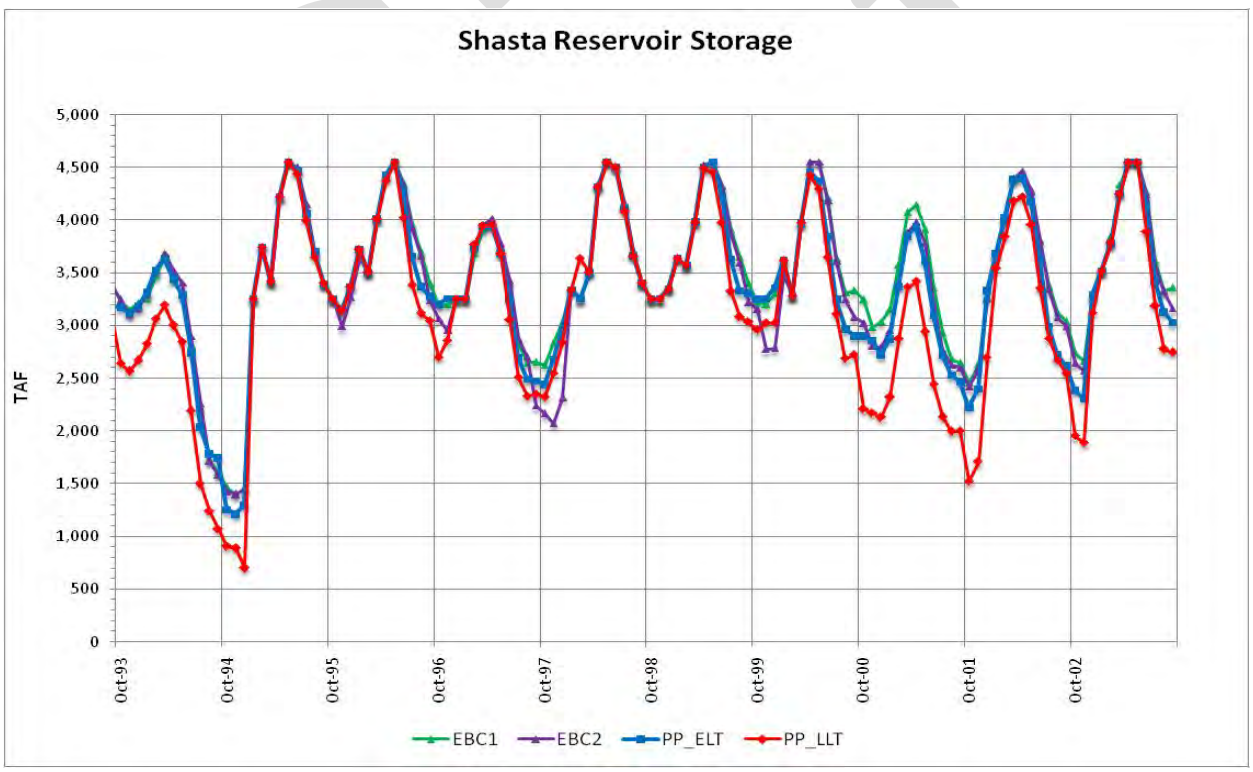

Figure C.A-6. CALSIM-Simulated Monthly Shasta Reservoir Storage for WY 1994–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

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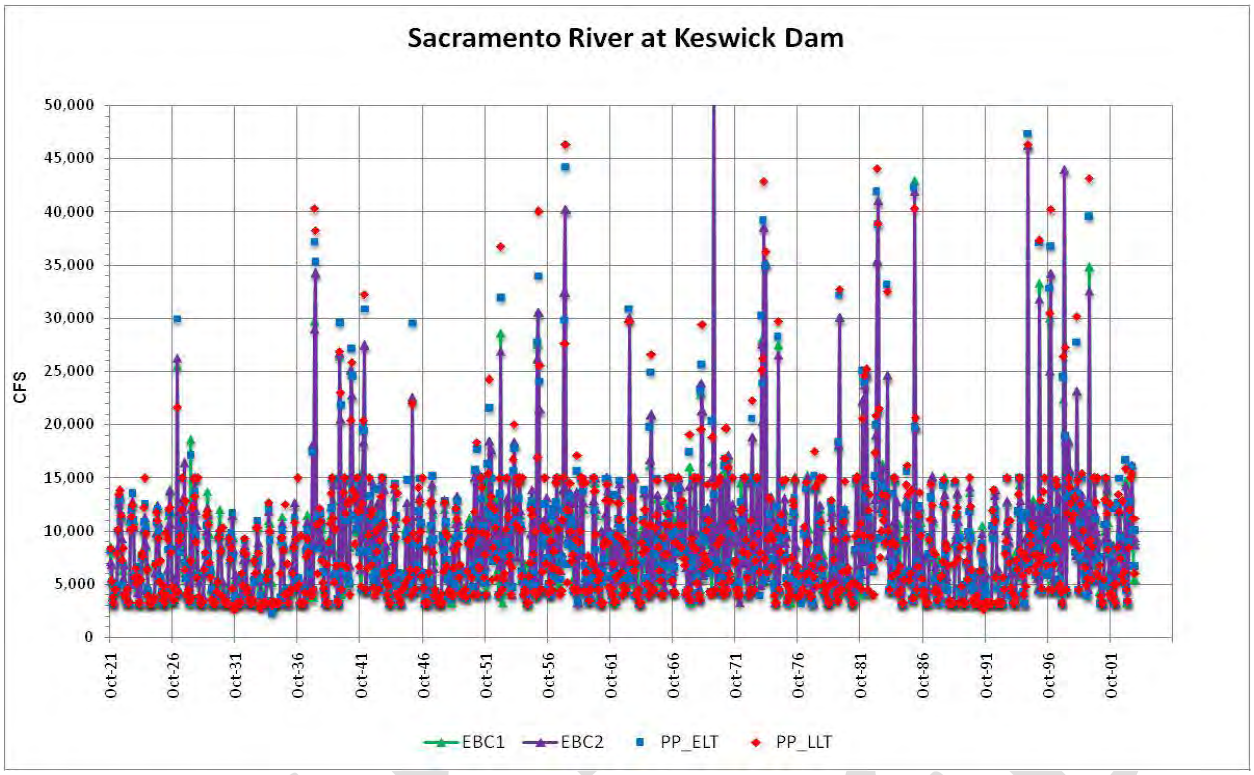

Figure C.A-7. CALSIM-Simulated Monthly Sacramento River Flow at Keswick for WY 1922–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

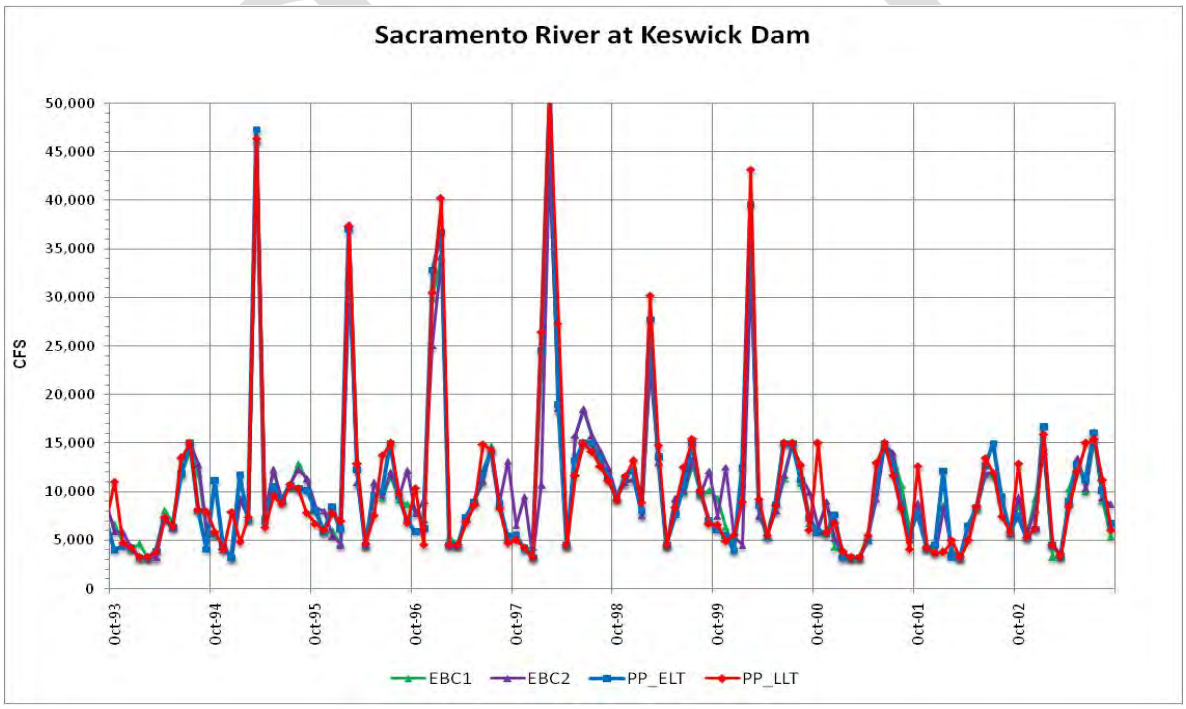

Figure C.A-8. CALSIM-Simulated Monthly Sacramento River Flow at Keswick for WY 1994–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

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C.A.3.3 Simulated Changes in Oroville Reservoir Operations

Table C.A-8 shows the monthly distributions of the CALSIM-simulated Oroville Reservoir storage patterns for the six CALSIM cases. The maximum storage of about 3,500 taf was simulated only in May and June. The maximum flood control storage is about 3,150 taf from October to March. There are some variations caused by runoff conditions (snow vs. rain) but this generally limits the amount of water that can be stored in the winter months of January–March. The Oroville Reservoir maximum flood control storage increases in April, and full storage is allowed in May. The EBC1 monthly median storage volumes for Oroville Reservoir were about 2,000 taf in October and November, increased to about 2,750 taf in January–March, and were about 3,250 taf in April–June, decreasing during the summer to 2,000 taf in September. These median storage levels were reduced by about 100 taf to 200 taf for the PP_ELT case and were reduced by 300 taf to 400 taf in most months (except February–April) for the PP_LLT case.

The simulated Oroville Reservoir storage for the three EBC2 cases was substantially reduced in September, October, and November because some of the increased Delta outflow needed to meet the Fall X2 requirements was released from Oroville. The median September storage for the EBC2 was about 150 taf lower, and the median November storage was about 250 taf lower than the corresponding EBC1 storage. The median storage in September–November for the EBC2_ELT case was about 200 taf below the EBC2 case, and the median storage in September–November for the EBC2_LLT case was about 400 taf lower than the EBC2 case.

Figure C.A-9 shows the simulated monthly Oroville Reservoir storage for EBC1 and the PP_ELT and PP_LLT cases for the 1922–2003 sequence. The simulated carryover storage was reduced by 500 taf to 1,000 taf in several years when the EBC1 carryover storage was between 1,500 taf and 3,000 taf. When the EBC1 Oroville carryover storage was about 1,000 taf (target minimum storage), the PP_ELT and PP_LLT simulations were similar, although minimum storage of about 750 taf was simulated in several years for the PP_LLT case. The minimum target storage of 1,000 taf was simulated in many more years for the PP_ELT and PP_LLT cases. Figure C.A-10 shows the simulated monthly Oroville Reservoir storage for EBC1, EBC2 and the two PP cases for the 1994–2003 sequence. Although these 10 years were relatively wet, the additional drawdown in WY 1993 (beginning of graph sequence) reduced the amount of water available from Oroville for the PP_ELT case by 500 taf and for the PP_LLT case by 1,000 taf in WY 1994. The additional Oroville storage drawdown at the end of the simulation (WY 2003) was 800 taf for the PP_ELT case and 1,000 taf for the PP_LLT case.

Table C.A-9 shows the CALSIM-simulated Feather River flow below the Thermalito release to the river (upstream of Gridley). There is a constant release of 900 cfs into the low-flow section of the Feather River between the Feather River Hatchery and the Thermalito discharge. The minimum flows in the October to March period range from 900 cfs to 1,700 cfs. The minimum flows in April and May are 1,000 cfs. For the EBC1, the median flows in April, May and June are relatively low, reflecting the 2008 USFWS BiOp and 2009 NMFS BiOp limitations on Delta exports during these months. Simulated releases from Oroville Reservoir increase dramatically in July and August, corresponding to the increased Delta export/inflow (E/I) ratio of 65% and the peak water supply demands in the summer months. In comparison, the PP_ELT and PP_LLT cases show increased Oroville Reservoir releases in April, May, and June and decreased Oroville Reservoir releases in July, August, and September.

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Figure C.A-11 shows the simulated Feather River flows at Thermalito (discharge to river) for EBC1 and the PP_ELT and PP_LLT cases for the 1922–2003 sequence. The monthly flows are generally between 1,000 cfs (minimum flow requirement) and 10,000 cfs, but several years had higher monthly flows of 25,000 cfs to 50,000 cfs caused by flood control releases from Oroville Reservoir. The major differences between the EBC1 flows and the PP_ELT and PP_LLT flows were the magnitude of the flood control releases caused by different inflow sequences assumed for the EBC1 and the PP_ELT and PP_LLT. Figure C.A-12 shows the simulated monthly Feather River flows at Thermalito for the EBC1 and the PP_ELT and PP_LLT cases for the 1994–2003 sequence. The higher flows (flood control spills) and the monthly flows in the summer and fall months (i.e., controlled releases) of some years were different for the PP_ELT and PP_LLT cases compared to the EBC1 flows.

Table C.A-10 shows the CALSIM-simulated Feather River flow near the confluence, but not including the Sutter Bypass (and Butte Creek flows) for the EBC1 and the PP_ELT and PP_LLT cases. The Feather River flow is increased by the Yuba River, Bear River, and a few smaller tributary streams. The average simulated annual volume of the Feather River at the mouth is about 5,600 taf/yr for the EBC1, about 2,425 taf/yr more than the Feather River below Thermalito. Most of this water is from the Yuba River (average unimpaired flow of about 2,300 taf/yr) and the Bear River (average unimpaired flow of about 320 taf/yr). The assumed effects of climate change reduced the average flow by about 25 taf/yr for the PP_ELT and by about 75 taf/yr for the PP_LLT.

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Table C.A-8. CALSIM-Simulated Monthly Distribution of Oroville Reservoir Storage (taf)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
A. EBC1												
Min	630	654	807	1,009	1,097	1,212	1,139	1,079	870	634	634	642
10%	1,031	1,065	1,145	1,293	1,480	1,720	1,759	2,024	1,858	1,283	1,065	1,012
20%	1,156	1,220	1,291	1,490	1,892	2,248	2,563	2,666	2,467	1,885	1,378	1,194
30%	1,443	1,426	1,512	1,891	2,203	2,584	2,807	2,847	2,697	2,105	1,614	1,464
40%	1,690	1,792	2,004	2,217	2,588	2,788	3,100	3,179	3,025	2,422	2,010	1,828
50%	2,031	2,081	2,337	2,688	2,788	2,841	3,205	3,371	3,199	2,651	2,232	2,099
60%	2,169	2,291	2,559	2,788	2,788	2,938	3,237	3,520	3,380	2,789	2,399	2,239
70%	2,408	2,583	2,787	2,792	2,853	2,981	3,293	3,538	3,538	2,959	2,563	2,461
80%	2,778	2,876	2,812	2,869	2,946	3,025	3,352	3,538	3,538	3,037	2,862	2,831
90%	3,161	3,046	2,987	2,976	3,052	3,116	3,395	3,538	3,538	3,378	3,278	3,221
Max	3,163	3,163	3,163	3,163	3,211	3,163	3,470	3,538	3,538	3,538	3,538	3,351
Avg	1,980	2,032	2,141	2,305	2,470	2,644	2,918	3,053	2,945	2,460	2,162	2,054
B. PP_ELT												
Min	580	602	842	1,025	1,033	1,346	1,145	1,109	881	637	625	621
10%	1,099	1,136	1,119	1,330	1,533	1,771	1,832	1,733	1,593	1,425	1,190	1,148
20%	1,219	1,290	1,357	1,593	1,911	2,197	2,408	2,461	2,268	1,780	1,495	1,358
30%	1,458	1,423	1,507	1,797	2,283	2,620	2,872	2,818	2,467	2,025	1,676	1,578
40%	1,697	1,738	1,875	2,121	2,549	2,788	3,083	3,034	2,755	2,242	1,843	1,765
50%	1,822	1,890	2,146	2,576	2,788	2,825	3,174	3,173	2,857	2,366	2,060	1,957
60%	2,044	2,142	2,511	2,788	2,788	2,941	3,236	3,310	2,972	2,487	2,175	2,097
70%	2,326	2,603	2,788	2,788	2,845	2,981	3,283	3,451	3,074	2,757	2,359	2,249
80%	2,670	2,773	2,867	2,854	2,921	3,034	3,320	3,538	3,381	2,959	2,693	2,668
90%	2,900	2,974	2,945	2,939	3,056	3,104	3,365	3,538	3,538	3,204	2,998	2,937
Max	3,163	3,163	3,163	3,116	3,229	3,163	3,470	3,538	3,538	3,522	3,497	3,351
Avg	1,913	1,984	2,118	2,285	2,483	2,656	2,898	2,960	2,734	2,344	2,074	1,995
C. PP_LLT												
Min	670	655	755	749	758	1,175	1,120	1,041	808	744	671	674
10%	1,015	1,018	1,005	1,267	1,456	1,700	1,697	1,644	1,497	1,224	1,137	1,081
20%	1,121	1,153	1,266	1,397	1,768	1,989	2,183	2,097	1,944	1,613	1,327	1,183
30%	1,261	1,332	1,349	1,619	2,043	2,479	2,528	2,511	2,156	1,745	1,454	1,325
40%	1,422	1,454	1,605	1,916	2,319	2,788	2,868	2,822	2,408	1,962	1,677	1,577
50%	1,568	1,604	1,874	2,387	2,788	2,796	3,141	3,006	2,626	2,168	1,813	1,684
60%	1,758	1,898	2,231	2,623	2,788	2,909	3,212	3,158	2,791	2,305	1,972	1,867
70%	2,123	2,235	2,420	2,788	2,811	2,960	3,238	3,312	2,914	2,438	2,136	2,117
80%	2,287	2,420	2,632	2,788	2,856	3,023	3,295	3,538	3,205	2,719	2,406	2,348
90%	2,491	2,575	2,788	2,854	2,986	3,093	3,352	3,538	3,372	2,933	2,669	2,627
Max	3163	3,008	3,107	3,091	3,385	3,163	3,470	3,538	3,538	3,468	3,385	3,351
Avg	1,676	1,733	1,906	2,153	2,390	2,579	2,791	2,797	2,521	2,120	1,846	1,762

Draft

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
D. EBC2												
Min	710	759	823	951	966	1,210	1,099	1,041	823	766	766	749
10%	945	987	1,151	1,345	1,518	1,767	1,917	1,973	1,735	1,197	1,044	972
20%	1,161	1,187	1,271	1,552	1,833	2,138	2,387	2,469	2,303	1,697	1,299	1,186
30%	1,353	1,311	1,493	1,747	2,016	2,368	2,676	2,844	2,645	2,076	1,643	1,453
40%	1,627	1,624	1,730	1,973	2,375	2,784	3,045	3,122	2,937	2,326	1,898	1,628
50%	1,732	1,818	1,995	2,268	2,651	2,806	3,161	3,281	3,119	2,545	2,150	1,834
60%	1,931	2,048	2,195	2,554	2,788	2,914	3,227	3,489	3,297	2,675	2,290	1,967
70%	2,100	2,185	2,387	2,729	2,788	2,953	3,283	3,538	3,538	2,952	2,547	2,163
80%	2,285	2,409	2,733	2,788	2,844	3,014	3,320	3,538	3,538	3,030	2,820	2,335
90%	2,651	2,744	2,799	2,853	2,961	3,063	3,362	3,538	3,538	3,315	3,213	2,778
Max	3,163	3,119	3,139	3,091	3,078	3,163	3,470	3,538	3,538	3,538	3,538	3,351
Avg	1,773	1,831	1,973	2,175	2,385	2,594	2,867	3,005	2,892	2,406	2,105	1,837
E. EBC2_ELT												
Min	643	665	840	995	1,167	1,182	1,062	987	764	701	689	685
10%	870	925	1,025	1,253	1,424	1,618	1,828	1,808	1,579	1,052	973	930
20%	1,011	1,079	1,221	1,483	1,732	2,011	2,204	2,285	2,060	1,491	1,117	1,063
30%	1,168	1,236	1,436	1,586	1,928	2,336	2,666	2,614	2,350	1,712	1,320	1,177
40%	1,372	1,457	1,624	1,835	2,312	2,642	2,844	2,962	2,753	2,164	1,752	1,454
50%	1,537	1,545	1,767	2,073	2,574	2,788	3,122	3,174	2,971	2,350	1,953	1,639
60%	1,708	1,827	1,961	2,413	2,788	2,831	3,218	3,387	3,195	2,539	2,117	1,749
70%	1,879	1,930	2,199	2,579	2,788	2,944	3,276	3,504	3,390	2,763	2,366	1,965
80%	1,966	2,054	2,435	2,788	2,804	2,994	3,303	3,538	3,535	2,939	2,540	2,047
90%	2,346	2,440	2,788	2,813	2,961	3,059	3,354	3,538	3,538	3,039	2,802	2,284
Max	3,163	3,008	3,025	3,091	3,153	3,163	3,470	3,538	3,538	3,522	3,497	3,351
Avg	1,564	1,636	1,838	2,088	2,349	2,555	2,816	2,913	2,764	2,230	1,894	1,624
F. EBC2_LLT												
Min	495	535	595	787	796	929	811	774	715	652	578	544
10%	786	804	904	1,161	1,407	1,627	1,667	1,497	1,305	942	834	805
20%	873	935	1,104	1,308	1,638	1,912	2,170	2,152	1,911	1,297	953	898
30%	1,050	1,098	1,231	1,512	1,875	2,290	2,411	2,369	2,121	1,496	1,164	1,076
40%	1,177	1,221	1,337	1,694	2,132	2,499	2,745	2,712	2,415	1,833	1,462	1,260
50%	1,321	1,354	1,533	1,912	2,384	2,786	3,013	3,042	2,816	2,190	1,691	1,406
60%	1,425	1,442	1,817	2,150	2,672	2,809	3,213	3,305	2,970	2,346	1,893	1,523
70%	1,543	1,680	1,962	2,516	2,788	2,937	3,245	3,396	3,148	2,498	2,070	1,655
80%	1,766	1,849	2,149	2,787	2,788	2,983	3,292	3,538	3,310	2,680	2,250	1,843
90%	1,902	2,079	2,701	2,788	2,961	3,056	3,354	3,538	3,535	2,894	2,432	1,931
Max	2,943	3,008	3,107	3,091	3,388	3,163	3,470	3,538	3,538	3,468	3,418	3,084
Avg	1,347	1,411	1,657	1,971	2,278	2,495	2,739	2,795	2,582	2,025	1,667	1,408

Administrative Draft

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Table C.A-9. CALSIM-Simulated Monthly Distribution of Feather River Flows (cfs) below Thermalito

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	900	900	900	800	900	800	750	750	856	1,441	750	773	1,176
10%	921	900	1,014	900	900	800	802	1,000	1,258	3,180	1,090	1,000	1,669
20%	1,700	1,200	1,356	1,175	1,200	1,283	1,000	1,000	1,982	6,536	2,061	1,000	1,846
30%	1,994	1,700	1,700	1,200	1,700	1,700	1,000	1,000	2,482	7,647	2,971	1,273	2,199
40%	2,491	1,700	1,700	1,700	1,700	2,771	1,000	1,139	2,985	8,181	4,870	1,595	2,368
50%	3,147	1,709	1,700	1,700	3,640	4,351	1,229	1,517	3,295	8,455	6,001	2,247	2,660
60%	3,621	2,247	3,064	3,091	4,711	5,308	1,774	2,022	3,570	8,700	6,341	2,680	3,330
70%	3,976	2,500	3,814	4,423	8,596	6,835	2,900	3,052	3,906	8,948	6,763	2,925	3,843
80%	4,000	2,500	4,250	7,711	12,078	10,140	3,835	5,812	4,449	9,393	7,097	3,187	4,517
90%	4,000	4,179	10,091	13,829	17,525	14,397	7,778	10,283	6,126	9,879	7,670	3,429	5,347
Max	6,826	14,550	24,329	40,940	23,673	34,035	18,979	20,380	11,675	10,000	8,566	5,110	8,066
Avg	2,940	2,349	3,973	5,277	6,340	6,487	3,073	3,661	3,632	7,674	4,935	2,201	3,174
B. PP_ELT													
Min	900	900	800	801	900	800	750	750	1,000	1,000	750	773	884
10%	1,517	904	900	900	900	1,000	1,000	1,000	2,111	1,911	1,384	1,000	1,550
20%	1,936	1,209	1,344	900	1,200	1,700	1,000	1,000	2,514	2,827	2,365	1,000	1,838
30%	2,370	1,700	1,700	1,242	1,700	1,700	1,000	1,227	2,699	3,757	3,385	1,000	2,024
40%	2,875	1,700	1,700	1,700	1,700	2,734	1,107	1,960	3,225	4,874	3,655	1,000	2,220
50%	3,882	1,700	1,723	1,700	3,433	4,693	1,977	2,389	4,032	5,822	3,904	1,056	2,895
60%	4,000	2,057	2,729	3,584	5,475	6,634	2,958	2,842	5,063	6,302	4,353	1,372	3,359
70%	4,000	2,500	3,867	5,520	10,365	8,043	3,507	4,905	5,896	7,004	4,724	1,788	4,029
80%	4,000	2,500	5,788	10,528	13,729	11,029	4,065	6,642	6,714	8,168	5,094	2,061	4,615
90%	4,000	2,500	11,609	18,085	20,348	15,241	8,389	8,747	8,490	9,885	7,395	2,575	5,812
Max	4,920	16,211	32,238	45,810	28,988	39,929	21,317	18,809	10,383	10,000	10,000	3,806	7,913
Avg	3,117	2,191	4,433	6,351	7,320	7,176	3,464	3,985	4,601	5,642	4,214	1,494	3,256
C. PP_LLT													
Min	900	900	900	801	800	800	750	750	1,462	1,000	750	773	950
10%	1,420	1,180	1,200	900	900	1,000	1,000	1,000	2,046	2,103	1,362	1,000	1,478
20%	1,969	1,345	1,470	1,200	1,231	1,651	1,000	1,002	2,475	2,698	2,587	1,000	1,696
30%	2,891	1,700	1,700	1,564	1,700	1,700	1,035	1,636	2,977	3,383	3,177	1,000	1,998
40%	3,760	1,700	1,700	1,700	1,795	2,505	1,697	2,369	3,404	5,398	3,578	1,035	2,253
50%	4,000	1,734	1,826	1,700	3,702	4,098	2,443	2,929	4,396	5,798	3,974	1,267	2,901
60%	4,000	2,500	2,378	2,141	5,980	5,369	3,140	3,384	4,887	6,164	4,297	1,434	3,390
70%	4,000	2,500	3,959	4,207	9,798	8,596	3,931	4,304	5,843	6,817	4,536	1,724	3,998
80%	4,000	2,500	5,333	8,546	14,753	12,468	4,675	6,257	6,631	8,139	4,921	2,117	4,715
90%	4,000	2,500	8,556	18,065	21,972	16,705	8,424	7,853	7,916	9,563	8,114	2,463	5,854
Max	4,746	15,517	33,811	48,316	33,202	42,044	20,642	15,251	10,952	10,000	10,000	4,584	7,449
Avg	3,256	2,160	4,012	6,118	7,699	7,396	3,627	3,798	4,667	5,597	4,159	1,518	3,255

Draft

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	900	900	900	800	900	800	750	750	1,000	1,441	1,000	773	930
10%	907	900	931	900	900	800	802	1,000	1,592	2,854	1,358	1,008	1,642
20%	1,700	1,200	1,303	1,200	1,200	1,074	1,000	1,000	2,102	6,311	1,821	1,657	1,839
30%	1,973	1,700	1,700	1,350	1,700	1,700	1,000	1,000	2,689	7,694	3,365	2,396	2,027
40%	2,472	1,700	1,700	1,700	1,700	1,918	1,000	1,143	2,979	8,324	5,171	2,958	2,260
50%	3,161	2,152	1,769	1,700	1,732	3,652	1,131	1,389	3,340	8,473	5,974	3,409	2,504
60%	3,532	2,500	2,793	1,700	3,309	5,185	1,653	2,054	3,727	8,814	6,440	5,078	3,319
70%	3,969	2,500	3,604	1,700	6,114	6,341	2,982	2,853	4,031	9,116	6,740	7,282	3,849
80%	4,000	2,500	4,469	5,220	10,810	9,321	4,150	5,840	4,449	9,679	6,994	8,768	4,646
90%	4,000	2,500	5,943	13,870	16,371	14,190	7,797	10,303	6,146	10,000	7,353	9,706	5,666
Max	5,232	14,550	24,329	40,947	21,724	34,037	18,991	20,399	11,681	10,000	8,599	10,000	7,836
Avg	2,817	2,243	3,462	4,669	5,502	5,953	3,078	3,635	3,725	7,724	4,998	4,835	3,179
E. EBC2_ELT													
Min	900	900	800	801	900	800	750	750	1,000	1,000	750	773	970
10%	1,017	900	900	900	900	815	852	1,000	1,516	4,425	1,189	1,000	1,553
20%	1,369	1,200	1,208	900	1,200	1,098	1,000	1,000	2,119	6,969	3,764	1,257	1,844
30%	1,700	1,700	1,700	1,277	1,700	1,700	1,000	1,000	2,638	7,877	4,852	1,993	2,041
40%	1,915	1,700	1,700	1,700	1,700	1,700	1,000	1,420	2,968	8,472	5,651	2,612	2,284
50%	3,206	1,700	1,700	1,700	1,700	3,192	1,191	1,765	3,364	8,741	6,175	3,381	2,588
60%	3,799	2,500	1,781	1,700	3,647	5,485	1,864	2,439	3,639	9,125	6,529	6,753	3,287
70%	4,000	2,500	3,194	1,700	6,129	7,853	2,827	2,748	3,866	9,566	6,820	7,737	3,891
80%	4,000	2,500	4,011	4,983	11,826	10,763	3,824	5,438	4,077	9,956	7,223	8,540	4,694
90%	4,000	2,500	5,123	14,407	20,124	14,801	8,391	8,245	4,514	10,000	7,596	9,563	5,912
Max	4,930	16,211	31,663	45,818	28,333	39,935	21,317	18,816	8,604	10,000	8,197	10,000	7,686
Avg	2,756	2,148	3,349	4,970	6,166	6,653	3,150	3,420	3,318	8,041	5,396	4,788	3,270
F. EBC2_LLT													
Min	900	900	800	801	800	800	750	750	975	1,000	750	773	1,014
10%	999	946	900	900	900	820	787	1,000	2,337	4,762	1,130	1,000	1,603
20%	1,264	1,200	1,200	900	1,200	1,387	1,000	1,000	3,001	7,426	3,441	1,007	1,782
30%	1,658	1,598	1,700	1,350	1,700	1,700	1,000	1,070	3,267	8,287	5,812	1,362	2,022
40%	1,756	1,700	1,700	1,700	1,700	1,916	1,000	1,669	3,433	8,642	6,314	2,304	2,253
50%	3,390	1,700	1,700	1,700	2,007	2,657	1,364	2,202	3,617	8,959	6,626	3,408	2,494
60%	3,980	2,500	1,700	1,700	3,106	5,068	2,019	2,653	3,852	9,257	6,754	6,219	3,233
70%	4,000	2,500	2,502	2,152	4,539	8,097	2,954	3,015	4,001	9,574	7,036	7,724	3,999
80%	4,000	2,500	3,736	4,226	12,670	11,259	3,587	4,047	4,367	9,800	7,218	8,233	4,832
90%	4,000	2,505	4,618	14,816	20,547	15,985	8,424	6,279	4,845	10,000	7,691	9,042	5,963
Max	4,943	11,480	33,811	48,328	33,204	42,050	20,642	15,271	5,978	10,000	9,425	10,000	7,390
Avg	2,747	2,058	2,837	4,995	6,444	6,902	3,084	3,005	3,628	8,157	5,634	4,601	3,264

Draft

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Table C.A-10. CALSIM-Simulated Monthly Distribution of Feather River Flows (cfs) at Confluence [Includes Yuba and Bear River flows but not Sutter Bypass flows]

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	900	900	0	1,200	900	750	1,121	750	750	750	750	997	1,429
10%	1,292	1,280	1,213	2,726	1,932	2,325	2,800	2,800	2,806	5,681	2,572	2,502	2,519
20%	1,700	1,700	1,700	3,656	4,013	3,762	3,283	2,802	3,343	7,110	3,329	2,769	3,084
30%	2,573	2,009	2,502	4,457	4,355	5,009	3,815	3,400	3,621	7,878	4,361	3,238	3,395
40%	3,036	2,325	2,826	4,905	5,501	6,364	4,488	4,089	4,014	8,386	6,029	3,759	3,741
50%	3,397	2,576	3,596	6,123	9,041	9,693	5,745	4,552	4,366	8,756	6,950	4,192	4,506
60%	3,905	2,813	4,137	8,661	12,476	12,101	6,712	5,154	4,724	8,962	7,346	4,445	5,626
70%	4,296	3,008	4,847	10,996	16,450	16,724	8,242	8,065	5,626	9,576	7,744	4,648	7,204
80%	4,663	3,598	6,220	18,500	23,958	19,889	13,158	11,558	7,905	9,829	8,070	4,923	7,990
90%	5,120	4,898	16,011	24,942	33,358	30,702	21,318	17,869	12,387	10,362	8,392	5,286	10,250
Max	11,009	22,986	48,410	98,370	77,827	58,603	49,201	34,934	24,621	12,123	9,028	7,623	14,197
Avg	3,446	3,216	6,279	11,938	13,744	13,521	8,796	7,697	6,197	8,322	5,941	3,937	5,601
B. PP_ELT													
Min	1,071	900	900	1,200	900	750	2,354	750	750	750	750	819	1,652
10%	1,702	1,353	1,277	2,678	2,220	2,161	3,145	2,565	2,403	1,728	2,296	2,347	2,307
20%	2,376	1,702	1,703	3,734	3,743	3,647	3,729	2,846	2,800	2,795	3,006	2,559	2,714
30%	2,664	1,965	2,336	4,496	4,560	5,396	4,465	3,550	3,309	3,729	3,582	2,657	3,251
40%	3,296	2,276	2,958	5,359	6,045	7,009	5,125	4,372	4,169	5,138	4,023	2,823	3,725
50%	3,887	2,447	3,863	7,320	9,096	9,303	5,983	4,693	5,532	5,633	4,538	3,129	4,339
60%	4,321	2,717	4,826	8,972	13,430	13,942	6,632	6,727	6,369	6,270	4,680	3,333	5,788
70%	4,454	2,879	6,084	12,334	18,080	18,123	8,370	8,949	7,695	7,156	5,151	3,488	7,476
80%	4,635	3,222	8,173	22,250	27,748	21,179	12,531	11,183	9,353	8,030	5,692	3,767	8,269
90%	4,883	4,726	15,320	33,010	36,756	31,833	20,968	15,611	13,197	9,635	8,017	4,083	10,945
Max	11,372	25,298	62,002	105,952	87,881	69,122	52,705	34,150	21,259	10,988	11,789	6,319	15,148
Avg	3,643	3,140	7,241	13,429	15,367	14,393	9,129	7,773	6,500	5,607	4,726	3,154	5,658
C. PP_LLT													
Min	1,200	900	0	1,200	900	750	953	750	750	1,006	750	936	1,270
10%	1,754	1,398	1,244	2,573	1,943	2,180	3,336	2,362	2,112	1,495	1,829	2,472	2,115
20%	2,550	1,712	1,712	3,321	3,647	3,763	4,182	2,888	2,486	2,473	2,721	2,577	2,664
30%	2,940	1,920	2,607	4,331	4,821	5,325	5,019	3,665	3,211	2,925	3,468	2,718	3,250
40%	3,777	2,208	3,285	5,217	6,797	6,677	5,361	4,150	4,492	4,874	4,071	2,881	3,748
50%	4,074	2,435	4,005	6,461	9,146	8,303	6,297	4,727	5,315	5,536	4,587	3,058	4,178
60%	4,363	2,767	5,235	8,470	13,134	13,674	6,870	6,028	6,548	5,919	4,727	3,295	5,694
70%	4,500	2,901	6,285	12,860	17,219	18,762	8,349	7,793	7,534	6,489	5,064	3,568	7,488
80%	4,649	3,050	7,701	22,190	30,165	23,087	11,917	10,629	8,743	7,853	5,524	3,714	8,314
90%	4,945	4,374	12,028	33,391	38,741	33,535	19,404	12,659	10,776	9,491	7,899	4,066	10,810
Max	11,509	23,667	63,811	109,827	93,110	72,559	51,631	29,970	17,423	10,908	11,739	6,687	14,728
Avg	3,770	2,958	6,777	13,636	16,017	14,806	9,242	7,034	5,946	5,291	4,554	3,172	5,600

Admin Draft

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	900	900	0	1,200	900	750	1,082	750	750	750	750	995	1,301
10%	1,307	1,283	1,214	2,404	1,803	2,372	2,800	2,772	3,089	5,300	2,006	2,562	2,456
20%	1,700	1,777	1,701	2,948	2,992	3,215	3,281	2,800	3,368	7,002	3,360	2,901	2,947
30%	2,489	2,267	2,470	3,820	4,193	4,592	3,807	3,358	3,681	8,014	4,718	4,198	3,293
40%	2,855	2,434	3,147	4,491	4,819	6,493	4,621	4,073	4,119	8,563	6,259	4,763	3,642
50%	3,381	2,622	3,589	5,419	7,011	7,704	5,754	4,534	4,532	8,945	6,787	5,104	4,293
60%	3,934	2,798	4,293	8,120	10,554	11,872	6,846	5,120	4,991	9,279	7,279	7,842	5,697
70%	4,203	3,048	4,903	11,117	16,078	15,333	8,299	7,404	5,870	9,751	7,748	9,310	7,377
80%	4,456	3,233	5,966	17,555	23,678	19,915	13,201	11,602	7,928	10,014	7,977	10,850	8,411
90%	4,851	4,514	12,681	21,963	30,951	29,662	21,388	17,879	12,386	10,482	8,455	11,524	10,637
Max	11,104	23,067	48,404	98,431	74,875	58,624	49,219	34,947	24,601	12,198	9,266	12,642	13,971
Avg	3,314	3,161	5,796	11,346	12,922	13,001	8,811	7,665	6,271	8,374	5,977	6,581	5,611
E. EBC2_ELT													
Min	422	900	0	1,062	900	750	986	750	750	750	750	984	923
10%	1,507	1,298	1,212	2,281	1,902	2,173	2,800	2,800	2,723	5,075	2,197	2,518	2,464
20%	1,700	1,722	1,700	2,929	3,067	3,151	3,185	2,969	3,101	6,893	4,303	2,603	2,885
30%	1,922	2,110	2,002	3,948	4,234	4,328	3,784	3,418	3,285	7,951	6,184	3,459	3,179
40%	2,529	2,399	2,954	4,605	5,239	6,010	4,530	3,762	3,714	8,497	6,431	4,493	3,525
50%	3,593	2,573	3,626	5,627	7,323	8,276	5,719	4,408	4,093	8,764	6,834	5,525	4,212
60%	3,934	2,869	4,200	8,506	11,258	12,254	6,516	4,791	4,314	9,101	7,192	8,456	5,767
70%	4,234	3,012	4,958	11,247	17,673	18,076	8,356	6,562	5,036	9,444	7,785	9,553	7,401
80%	4,557	3,239	6,733	17,574	27,593	21,181	12,544	10,249	6,002	9,881	8,033	10,778	8,517
90%	4,729	4,659	13,016	24,469	33,675	31,767	20,974	15,610	8,263	10,297	8,321	11,422	11,337
Max	11,374	25,289	61,994	106,015	83,407	69,116	52,692	34,149	21,247	11,167	9,350	11,835	14,883
Avg	3,266	3,115	6,152	12,049	14,212	13,846	8,805	7,198	5,236	8,164	6,172	6,490	5,698
F. EBC2_LLT													
Min	1,138	900	0	1,132	900	750	929	750	750	1,000	750	956	1,062
10%	1,459	1,243	1,238	2,647	1,932	2,345	2,800	2,429	2,661	4,208	1,751	2,473	2,341
20%	1,678	1,636	1,700	2,988	2,772	3,493	3,284	2,835	3,059	6,930	3,571	2,566	2,688
30%	1,840	1,921	2,057	4,079	4,458	4,580	3,636	3,445	3,464	8,018	6,732	2,652	3,286
40%	2,265	2,256	3,138	4,812	5,880	5,736	4,439	3,751	3,746	8,315	7,016	4,358	3,527
50%	3,649	2,441	3,708	5,895	7,887	8,237	5,285	3,997	4,300	8,799	7,281	5,260	4,049
60%	3,956	2,684	4,334	8,436	10,974	12,680	6,332	4,453	4,650	9,086	7,590	7,965	5,773
70%	4,274	2,922	4,989	10,366	17,143	16,333	8,091	5,981	5,415	9,349	7,768	9,526	7,409
80%	4,461	3,118	5,777	18,356	27,994	22,827	11,930	8,686	6,169	9,727	8,043	10,217	8,467
90%	4,846	4,403	10,944	26,139	35,587	33,527	19,396	12,198	8,067	9,931	8,430	11,429	11,052
Max	11,477	19,626	63,824	109,911	89,751	72,551	51,609	29,973	17,418	10,646	11,057	12,092	14,636
Avg	3,243	2,873	5,599	12,509	14,761	14,300	8,689	6,237	4,951	8,009	6,313	6,289	5,639

Draft

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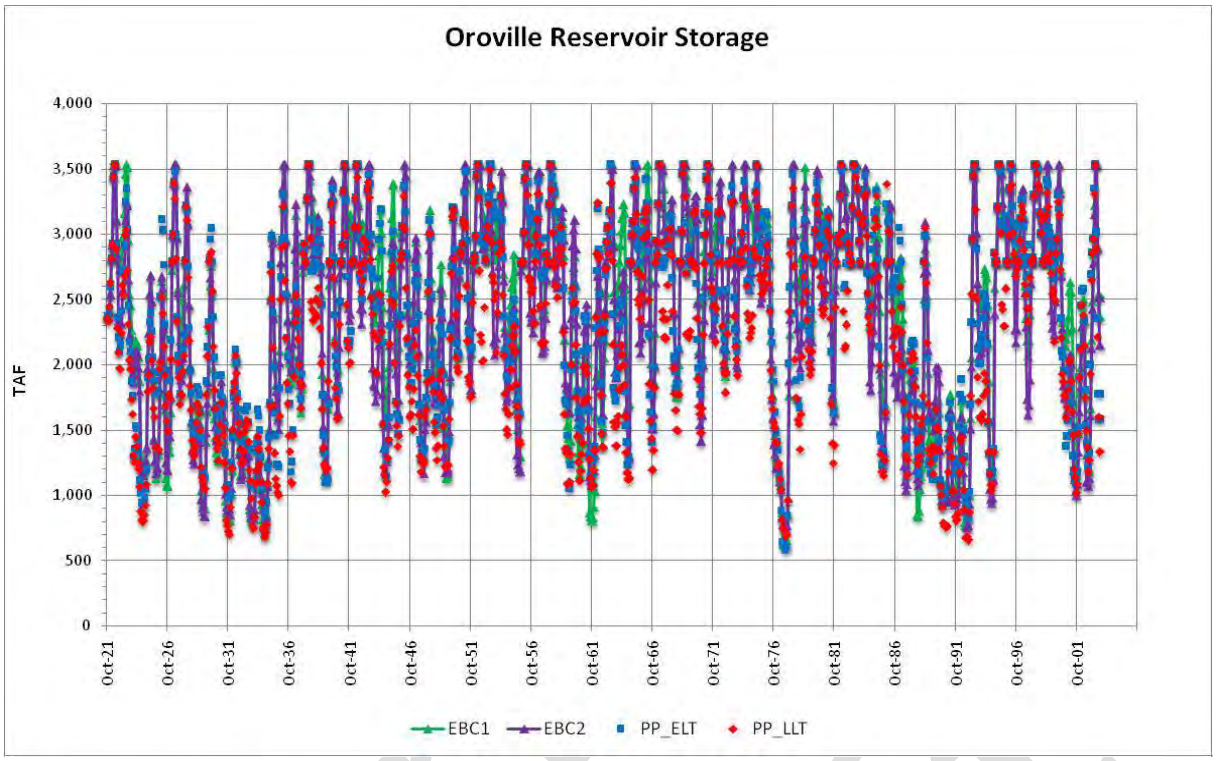

Figure C.A-9. CALSIM-Simulated Monthly Oroville Reservoir Storage for WY 1922–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

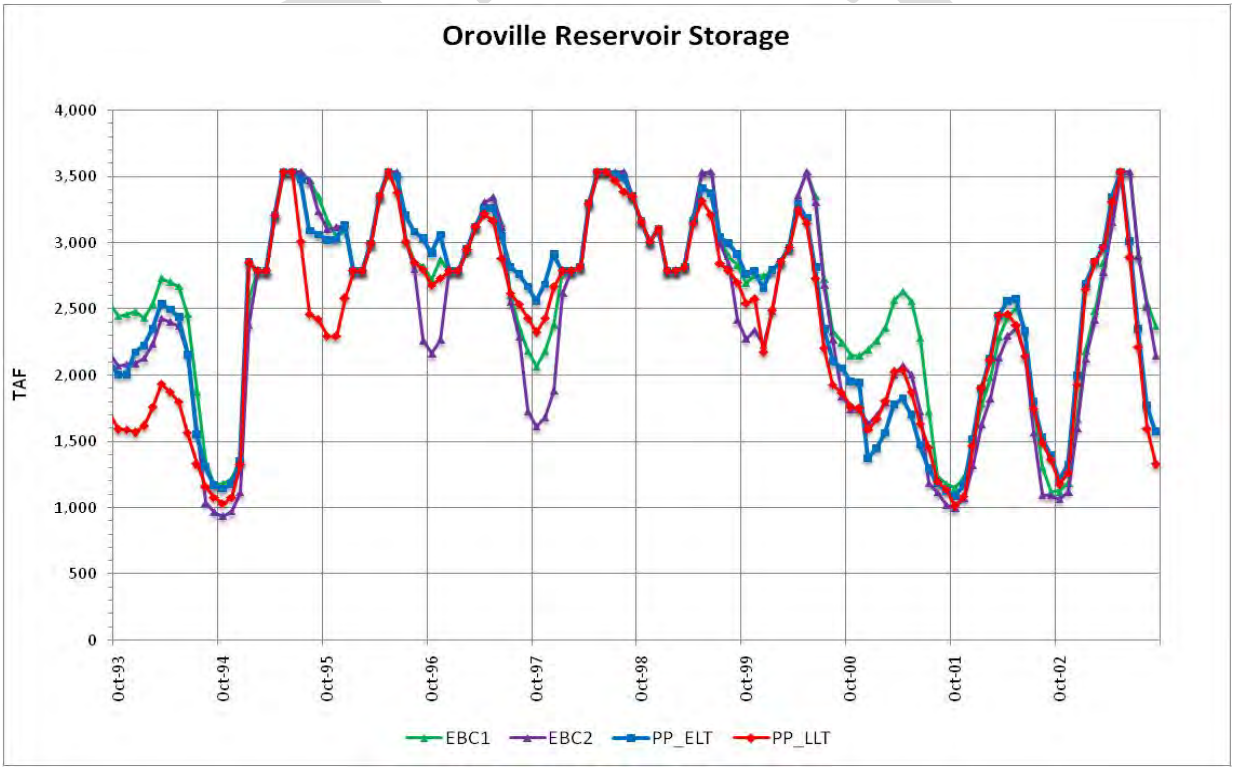

Figure C.A-10. CALSIM-Simulated Monthly Oroville Reservoir Storage for WY 1994–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

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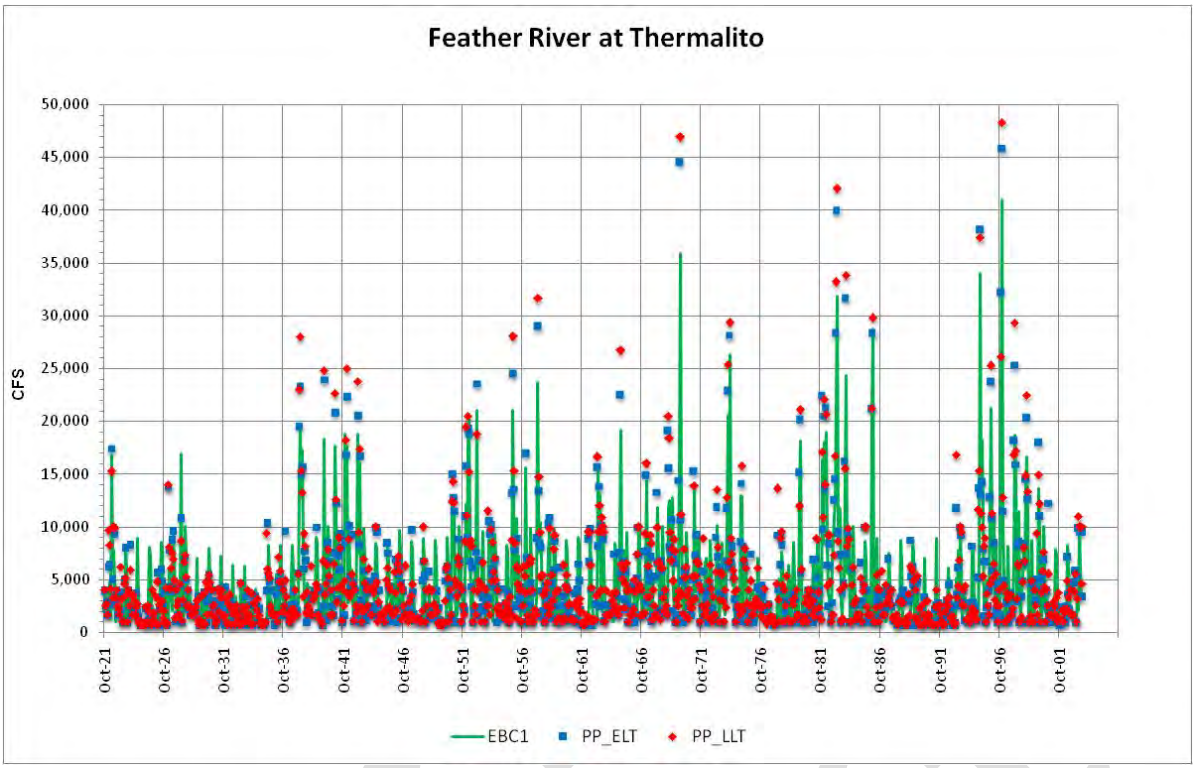

Figure C.A-11. CALSIM-Simulated Monthly Feather River Flow at Thermalito Afterbay for WY 1922–2003 for the EBC1 Baseline and PP_ELT and PP_LLT

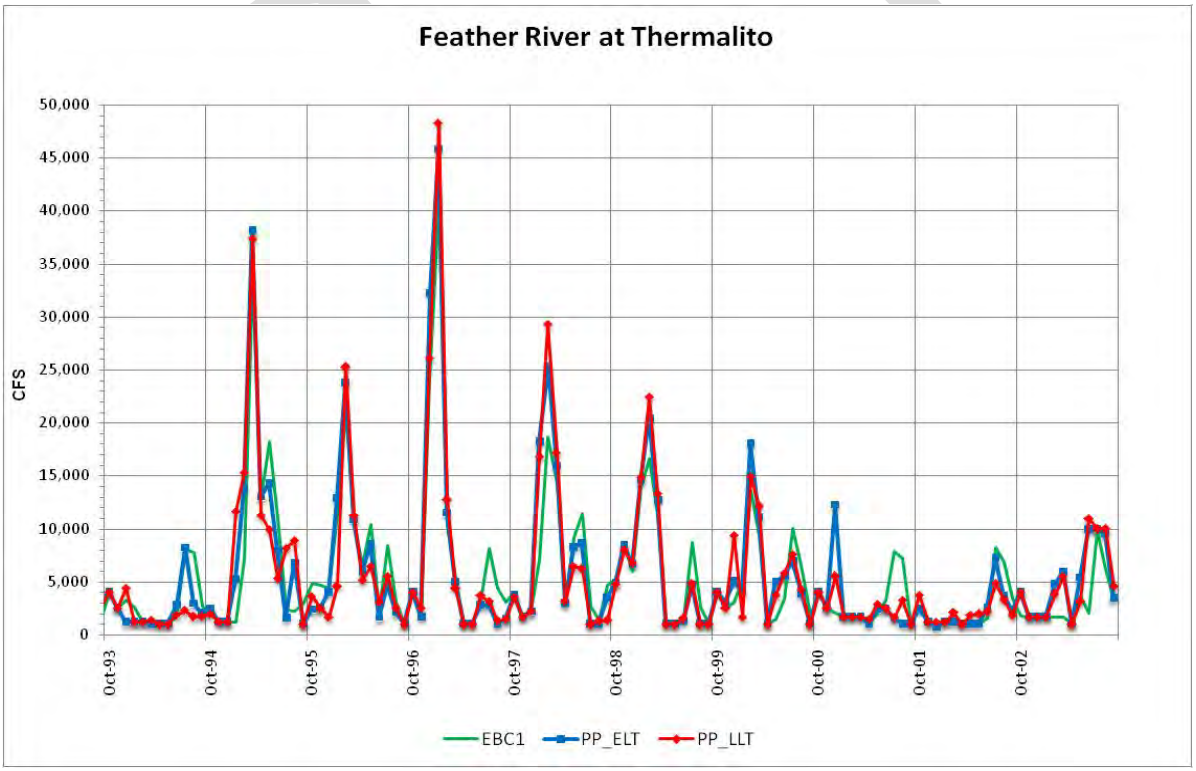

Figure C.A-12. CALSIM-Simulated Monthly Feather River Flow at Thermalito Afterbay for 1994–2003 for the EBC1 Baseline and PP_ELT and PP_LLT

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C.A.3.4 Simulated Fremont Weir Spills into the Yolo Bypass

Table C.A-11 shows the CALSIM-simulated Sacramento River flow at Verona for the six CALSIM cases. Verona is located just downstream of the Feather River confluence, the Butte Bypass outflow, and the Fremont Weir that spills to the Yolo Bypass. The total outflow from the Feather River and the Sacramento River watersheds can be calculated as the sum of the Verona flow and the Fremont Weir spill to the Yolo Bypass. The CALSIM-simulated average annual Sacramento River flow at Verona was about 13,000 taf/yr for the EBC1. The average annual flow at Verona was about 500 taf/yr less for the PP_ELT and PP_LLT cases because the proposed notch (gate) in the Fremont Weir would spill additional water from the Sacramento River into the Yolo Bypass.

Table C.A-12 shows the CALSIM-simulated Fremont Weir diversions for the six CALSIM cases. The EBC1 results indicate that the existing Fremont Weir generally only spills to the Yolo Bypass during major storms in the months of December–April. Spills in May are rare. The average annual Fremont Weir spill volume was about 1,500 taf/yr for the EBC1. By adding the Fremont Weir spill volume to the Verona flow volume, an average annual simulated flow of 14,500 taf/yr from the Sacramento River watershed upstream of Verona (from 20,000 square miles) is contributing to the Sacramento River and Yolo Bypass flows. Total average water diversions of about 4,500 taf/yr are used for agricultural purposes in the Sacramento Valley upstream of Verona.

Table C.A-12 shows that the PP_ELT and PP_LLT cases would increase the probability of Fremont Weir spills by 20% to 30% during December–April because of the combination of climate change (increased monthly runoff) and the notched weir that would allow flows of 2,000 cfs to 5,000 cfs into the Yolo Bypass at a lower Sacramento River flow (spill at 25,000 cfs Sacramento River flow rather than 55,000 cfs under existing conditions). The average Fremont Weir spill volume for the PP_ELT and PP_LLT cases was increased by about 750 taf/yr. The CALSIM model includes a 100 cfs attraction flow for the fish ladder or ramp structures in all months except July and August.

Figure C.A-13 shows the CALSIM-simulated Fremont Weir flow (spill) for the WY 1922–2003 sequence. The periods of high Sacramento River flow are variable from year to year, so the number of months with Fremont Weir spills and the magnitude of the flows are also variable. Because the periods and magnitudes of Fremont Weir spills are controlled by the Sacramento River flow, the simulated flows for each of the cases were quite similar. Figure C.A-14 shows the simulated Fremont Weir flows for the last 10-years of the CALSIM sequence. These years were exceptionally wet, with spills in almost all years. Although the CALSIM model included the effects of the Freemont Weir gate, which would spill at lower flows in the months of December-April, it is difficult to detect the difference in the monthly flows. Figure C.A-15 shows the simulated Fremont Weir flows for just the EBC2_LLT and the PP_LLT cases. The effects of the Fremont Weir gate on increased flows at the beginning and ending of the Yolo Bypass inundation period each year can be identified.

Figure C.A-16 shows the CALSIM results for the EBC1 (existing Fremont Weir) and the PP_ELT case (with notch). Because the historical daily flows on the Sacramento River were used in developing the monthly average Fremont Spill estimates, some baseline Fremont Weir spills occur in months with less than 55,000 cfs flow at Verona. The Fremont Weir spill increases rapidly once the monthly average Verona flow reaches about 55,000 cfs. The PP_ELT case indicates the increased magnitude of Fremont Weir spills caused by the proposed notch in the Fremont Weir to allow about 2,000 cfs diversion when the Verona flow reaches about 25,000 cfs, and 5,000 cfs when the Verona flow reaches 55,000 cfs.

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Table C.A-11. CALSIM-Simulated Monthly Distribution of Sacramento River Flows (cfs) at Verona.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1 (cfs)													
Min	4,656	4,421	5,532	6,489	7,299	6,640	7,587	5,700	7,444	8,012	5,451	4,633	5,809
10%	6,827	6,719	7,824	10,401	10,359	10,189	8,860	7,442	8,813	12,350	9,111	7,611	7,637
20%	7,401	7,456	9,469	11,194	12,754	13,582	9,404	8,813	9,575	14,773	10,749	9,093	8,846
30%	8,052	8,183	10,547	12,340	17,463	16,506	10,541	9,423	10,187	15,538	11,675	9,884	9,613
40%	8,764	8,889	12,145	16,008	21,770	19,719	11,170	9,978	10,558	16,166	12,911	10,156	10,165
50%	9,249	9,584	13,606	21,418	27,576	23,606	13,872	10,642	11,126	16,520	13,590	10,708	11,565
60%	9,906	10,145	15,889	26,657	37,154	30,306	16,185	11,951	11,708	17,144	13,807	11,168	15,001
70%	10,749	11,180	20,571	36,479	43,613	38,269	19,703	14,660	12,547	17,739	14,210	11,618	15,894
80%	11,934	13,423	31,537	48,032	51,810	45,783	32,150	23,258	14,790	18,624	15,075	12,714	17,353
90%	13,174	20,186	44,903	54,056	59,434	56,177	45,138	34,208	20,157	19,106	15,397	15,566	20,999
Max	25,416	43,063	62,316	71,150	72,880	69,022	59,675	49,743	49,782	20,104	18,331	21,765	27,856
Avg	9,861	11,565	19,752	27,583	31,979	28,888	19,759	15,840	13,295	16,271	12,813	11,220	13,169
B. PP_ELT (cfs)													
Min	4,402	4,501	5,424	6,239	7,084	7,478	8,025	5,820	7,009	6,495	4,812	4,366	5,655
10%	6,456	6,268	8,034	10,062	10,151	9,615	9,276	7,824	9,033	8,781	8,116	7,446	7,475
20%	7,317	7,232	9,419	11,000	12,805	13,875	9,907	9,128	9,865	10,259	8,623	8,155	8,158
30%	8,264	7,863	10,610	13,640	15,903	16,768	10,646	9,766	10,947	11,390	9,333	8,699	8,906
40%	8,733	8,119	12,771	16,110	20,888	18,566	11,886	10,349	11,748	12,851	10,036	9,004	9,724
50%	9,276	8,539	14,081	19,234	25,263	21,910	14,152	11,149	12,768	14,267	10,360	9,357	11,117
60%	9,610	9,147	15,891	25,375	37,339	26,340	16,257	13,801	14,909	14,744	10,703	9,953	14,362
70%	9,895	9,967	18,891	36,036	41,744	35,744	19,027	17,798	15,634	15,335	11,358	10,512	15,561
80%	10,254	12,906	30,008	47,524	52,379	42,154	26,306	22,100	17,074	17,108	13,000	11,139	16,468
90%	12,563	17,953	42,667	54,680	61,422	54,942	41,370	31,031	20,109	18,319	14,436	12,228	20,098
Max	24,743	44,769	65,750	73,837	75,937	70,485	60,218	47,311	44,647	21,262	19,905	19,454	25,797
Avg	9,348	10,838	19,689	27,241	31,373	27,711	18,905	15,878	14,169	13,680	10,831	9,710	12,595
C. PP_LLT (cfs)													
Min	4,500	4,718	5,587	6,176	7,621	7,162	8,252	5,512	6,943	5,568	5,316	5,387	5,686
10%	6,190	6,025	7,588	10,705	10,428	10,227	9,658	7,873	8,985	8,124	6,909	6,668	7,501
20%	7,790	6,694	10,391	11,583	13,048	14,127	10,351	9,597	10,286	9,836	8,618	7,886	8,499
30%	9,296	7,205	11,705	14,691	16,564	15,980	11,755	10,233	11,505	11,151	9,580	8,226	8,901
40%	10,355	7,765	12,687	17,132	20,374	18,654	13,225	11,348	12,228	12,584	9,896	8,674	9,842
50%	11,888	8,266	14,339	19,164	24,386	21,373	14,184	12,440	13,735	13,957	10,254	9,366	11,264
60%	12,935	8,756	16,544	24,231	35,438	26,088	16,012	14,564	14,896	14,988	10,644	9,724	14,464
70%	14,131	9,923	18,929	32,490	41,687	35,556	19,296	17,395	16,477	15,842	11,199	10,091	15,569
80%	15,418	12,299	27,450	47,881	53,840	43,944	25,681	20,593	17,699	16,440	11,887	10,833	16,630
90%	18,451	17,162	37,179	53,965	61,406	55,030	40,949	25,564	20,169	17,473	14,456	11,657	19,699
Max	24,704	41,650	65,657	74,515	76,666	70,953	60,068	43,071	40,902	21,569	20,916	16,792	24,155
Avg	11,917	10,334	19,240	27,327	31,600	27,786	19,218	15,359	14,383	13,304	10,568	9,328	12,656

Draft

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	4,417	4,425	5,506	8,273	7,159	6,852	7,382	5,782	7,858	7,483	5,803	4,943	5,832
10%	6,816	6,325	7,597	10,076	10,277	9,710	8,742	7,368	8,862	11,811	8,579	7,489	7,751
20%	7,139	7,044	9,842	10,956	12,595	12,556	9,304	8,706	9,846	14,434	10,845	8,919	8,609
30%	7,514	8,205	10,842	12,273	15,343	16,776	10,403	9,008	10,092	15,496	11,766	9,597	9,460
40%	8,137	9,505	11,830	15,989	20,943	19,629	10,940	9,842	10,491	16,263	12,701	10,885	10,171
50%	8,954	10,974	13,152	19,282	26,694	23,103	13,844	10,547	11,473	16,734	13,491	12,196	11,312
60%	9,435	11,972	15,604	24,562	37,191	29,579	16,666	11,745	11,919	17,462	13,948	17,608	15,390
70%	9,898	13,544	19,334	36,540	42,406	36,308	19,853	14,593	12,877	18,060	14,189	18,933	16,469
80%	10,993	14,945	30,164	47,136	51,851	46,359	32,327	23,350	14,778	18,660	14,954	22,724	17,938
90%	12,514	18,149	39,748	54,501	59,421	54,976	45,197	33,963	20,187	19,307	15,942	25,171	21,296
Max	26,602	42,261	62,305	71,167	72,500	69,020	59,683	49,705	49,612	20,272	18,631	27,193	27,454
Avg	9,344	12,145	19,089	27,013	31,446	28,456	19,710	15,679	13,401	16,321	12,820	14,941	13,258
E. EBC2_ELT													
Min	4,581	4,124	5,521	6,315	6,881	6,921	7,452	5,916	7,724	6,710	5,394	4,597	5,593
10%	6,208	6,227	7,158	10,227	10,012	9,664	8,793	7,173	9,080	11,761	7,972	7,007	7,625
20%	7,038	6,913	9,334	11,381	12,256	12,583	9,460	8,425	9,434	13,746	10,939	7,928	8,399
30%	7,451	8,750	10,656	13,343	15,091	17,056	9,802	8,915	10,020	15,552	11,684	8,756	9,367
40%	7,885	9,788	11,802	15,986	21,118	19,184	10,861	9,501	10,422	16,362	12,431	10,504	9,759
50%	8,866	11,087	13,096	19,396	27,496	22,657	13,587	10,204	11,038	17,098	13,605	12,335	11,323
60%	9,875	12,173	15,320	24,432	39,236	30,278	16,241	11,260	11,610	17,743	14,101	17,610	15,212
70%	10,557	13,292	19,829	37,731	42,599	36,643	19,763	13,414	12,326	18,748	14,323	19,911	16,520
80%	11,083	15,383	32,553	47,087	54,116	46,362	30,475	20,405	13,062	19,234	15,134	23,109	18,114
90%	12,098	17,692	42,784	55,093	60,055	55,693	44,960	31,126	16,407	19,715	16,004	24,874	21,202
Max	26,939	42,955	65,747	73,859	75,325	70,483	60,214	47,323	44,705	20,690	18,183	26,976	26,221
Avg	9,181	12,146	19,506	27,430	32,062	28,700	19,488	14,820	12,441	16,464	12,713	14,777	13,218
F. EBC2_LLT													
Min	4,628	4,124	5,777	6,129	6,185	7,034	7,502	5,353	7,331	6,562	5,622	4,459	5,514
10%	5,793	6,150	7,312	10,404	10,270	10,165	8,740	7,862	9,406	11,381	8,928	6,820	7,500
20%	7,439	6,828	8,858	11,194	12,823	12,941	9,435	8,255	10,061	13,821	10,602	7,440	8,567
30%	8,644	7,882	11,024	14,589	15,780	16,053	10,123	9,061	10,644	15,399	12,407	8,340	9,302
40%	9,227	9,371	11,787	16,988	21,191	19,263	10,724	9,879	11,516	17,368	13,417	9,454	9,952
50%	9,718	11,134	13,835	19,598	27,738	22,562	12,949	10,265	12,025	17,991	13,827	11,442	11,329
60%	10,876	12,490	15,466	25,221	37,639	29,434	15,642	11,789	12,505	18,565	14,332	19,209	15,443
70%	11,384	13,459	18,325	35,090	43,187	38,267	19,298	13,946	12,829	18,990	14,977	21,179	16,521
80%	11,645	14,756	27,672	47,897	55,335	48,100	29,941	18,349	13,515	19,457	15,355	24,019	18,029
90%	12,707	16,548	39,831	54,003	60,158	55,722	44,507	26,294	15,374	19,933	16,042	25,191	21,073
Max	24,700	41,148	65,656	74,165	76,211	70,949	60,061	43,096	40,979	23,711	21,286	27,488	24,747
Avg	9,900	11,846	18,852	27,795	32,192	28,877	19,298	13,828	12,576	16,651	13,204	14,755	13,221

Draft

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Table C.A-12. CALSIM-Simulated Monthly Distribution of Fremont Weir Flows (cfs) into Yolo Bypass

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year (taf)
A. EBC1													
Min	0	0	0	0	0	0	0	0	0	0	0	0	0
10%	0	0	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	0	0	0	0
40%	0	0	0	0	0	0	0	0	0	0	0	0	2
50%	0	0	0	0	0	0	0	0	0	0	0	0	190
60%	0	0	0	0	1,014	0	0	0	0	0	0	0	719
70%	0	0	0	945	4,562	274	0	0	0	0	0	0	1,552
80%	0	0	163	6,615	10,476	4,328	0	0	0	0	0	0	3,111
90%	0	0	8,900	2,5431	35,828	18,376	1,191	0	0	0	0	0	5,646
Max	1,370	10,695	5,0174	10,5276	116,073	92,002	33,696	7,838	2,137	0	0	0	9,877
Avg	17	263	2,388	7,170	9,269	5,946	1,014	110	26	0	0	0	1,557
B. PP_ELT													
Min	100	100	100	100	100	100	100	100	100	0	0	100	60
10%	100	100	100	100	100	100	100	100	100	0	0	100	95
20%	100	100	100	101	138	232	100	100	100	0	0	100	212
30%	100	100	100	174	532	604	100	100	100	0	0	100	297
40%	100	100	115	972	1,977	1,298	101	100	100	0	0	100	385
50%	100	100	268	1,928	3,404	2,223	132	100	100	0	0	100	754
60%	100	100	578	3,432	5,583	3,548	352	100	100	0	0	100	1,486
70%	100	100	1,365	5,682	8,192	5,187	1,027	100	100	0	0	100	2,382
80%	100	100	3,928	11,063	13,894	7,341	4,164	100	100	0	0	100	4,314
90%	100	100	13,567	31,660	45,336	18,152	5,903	100	100	0	0	100	7,259
Max	1,159	15,246	71,596	122,039	135,139	101,131	37,083	4,770	240	0	0	100	12,393
Avg	113	433	4,247	10,087	12,809	8,188	2,256	158	102	0	0	100	2,290
C. PP_LLT													
Min	100	100	100	100	100	100	100	100	100	0	0	100	60
10%	100	100	100	100	100	100	100	100	100	0	0	100	94
20%	100	100	100	108	143	150	100	100	100	0	0	100	215
30%	100	100	100	332	596	584	100	100	100	0	0	100	277
40%	100	100	113	1,079	1,961	1,359	119	100	100	0	0	100	378
50%	100	100	251	1,638	3,232	2,168	177	100	100	0	0	100	706
60%	100	100	649	2,896	5,237	3,657	375	100	100	0	0	100	1,357
70%	100	100	1,679	5,048	9,356	5,728	1,136	100	100	0	0	100	2,479
80%	100	100	2,878	11,974	15,547	8,001	4,022	100	100	0	0	100	4,054
90%	100	100	10,029	31,930	45,540	24,952	5,753	100	100	0	0	100	7,452
Max	1,140	8,851	71,011	126,271	139,688	104,051	36,149	1,201	100	0	0	100	13,027
Avg	113	302	3,409	10,373	13,383	8,736	2,195	113	100	0	0	100	2,308

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year (taf)
D. EBC2													
Min	0	0	0	0	0	0	0	0	0	0	0	0	0
10%	0	0	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	0	0	0	0
40%	0	0	0	0	0	0	0	0	0	0	0	0	0
50%	0	0	0	0	0	0	0	0	0	0	0	0	117
60%	0	0	0	0	246	0	0	0	0	0	0	0	593
70%	0	0	0	964	2,553	252	0	0	0	0	0	0	1,460
80%	0	0	0	5,537	9,668	4,084	0	0	0	0	0	0	2,851
90%	0	0	5,703	21,049	34,099	13,589	1,257	0	0	0	0	0	5,606
Max	2,010	8,759	50,102	105,383	113,700	91,992	33,746	7,784	1,999	0	0	0	9,877
Avg	25	225	2,043	6,879	8,856	5,744	1,025	109	24	0	0	0	1,481
E. EBC2_ELT													
Min	0	0	0	0	0	0	0	0	0	0	0	0	0
10%	0	0	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	0	0	0	0
40%	0	0	0	0	0	0	0	0	0	0	0	0	0
50%	0	0	0	0	0	0	0	0	0	0	0	0	187
60%	0	0	0	0	837	0	0	0	0	0	0	0	629
70%	0	0	0	1,250	4,544	405	0	0	0	0	0	0	1,811
80%	0	0	0	7,416	12,129	4,996	0	0	0	0	0	0	3,476
90%	0	0	9,454	23,544	41,843	16,433	1,617	0	0	0	0	0	6,737
Max	2,217	10,548	71,577	122,180	131,325	101,117	37,060	4,675	147	0	0	0	11,760
Avg	27	268	2,800	8,003	10,636	6,488	1,142	58	2	0	0	0	1,747
F. EBC2_LLT													
Min	0	0	0	0	0	0	0	0	0	0	0	0	0
10%	0	0	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	0	0	0	0
40%	0	0	0	0	0	0	0	0	0	0	0	0	1
50%	0	0	0	0	0	0	0	0	0	0	0	0	115
60%	0	0	0	0	821	0	0	0	0	0	0	0	602
70%	0	0	0	849	3,953	621	0	0	0	0	0	0	1,893
80%	0	0	0	9,090	14,222	5,684	0	0	0	0	0	0	3,272
90%	0	0	5,079	23,714	42,108	17,813	1,744	0	0	0	0	0	6,970
Max	1,012	6,381	71,007	124,085	136,849	104,026	36,105	1,108	0	0	0	0	12,320
Avg	12	159	2,151	8,533	11,171	7,037	1,142	14	0	0	0	0	1,793

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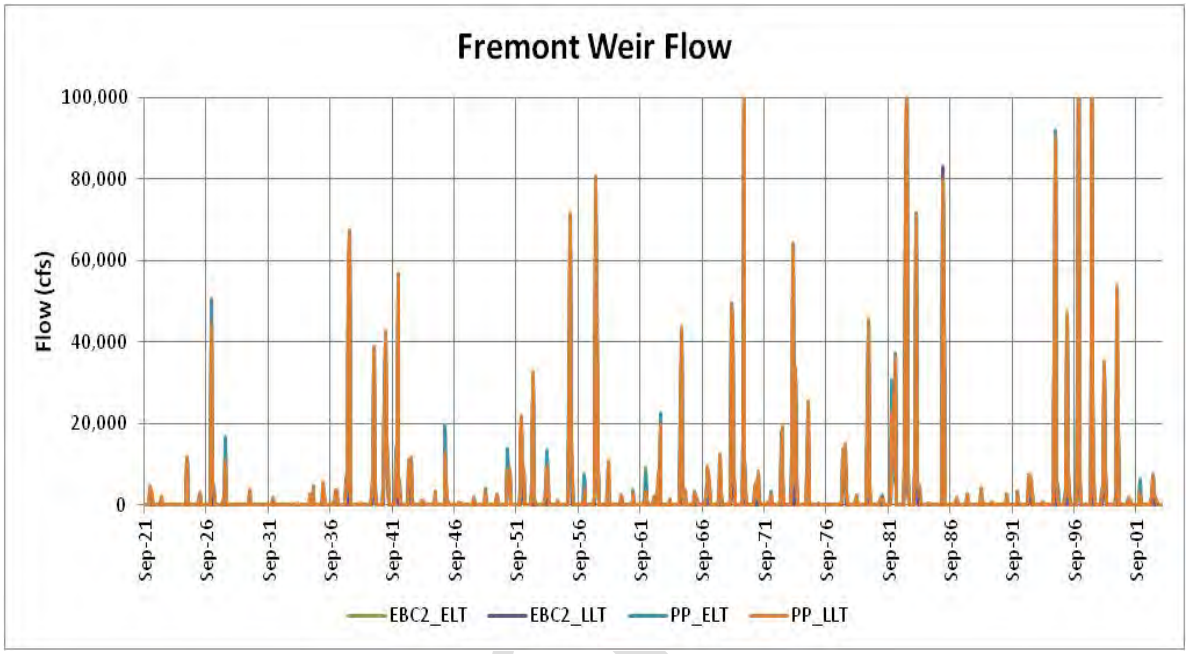

Figure C.A-13. CALSIM-Simulated Monthly Fremont Weir Spill (cfs) for WY 1922–2003 for the EBC2 Baselines and PP_ELT and PP_LLT Cases

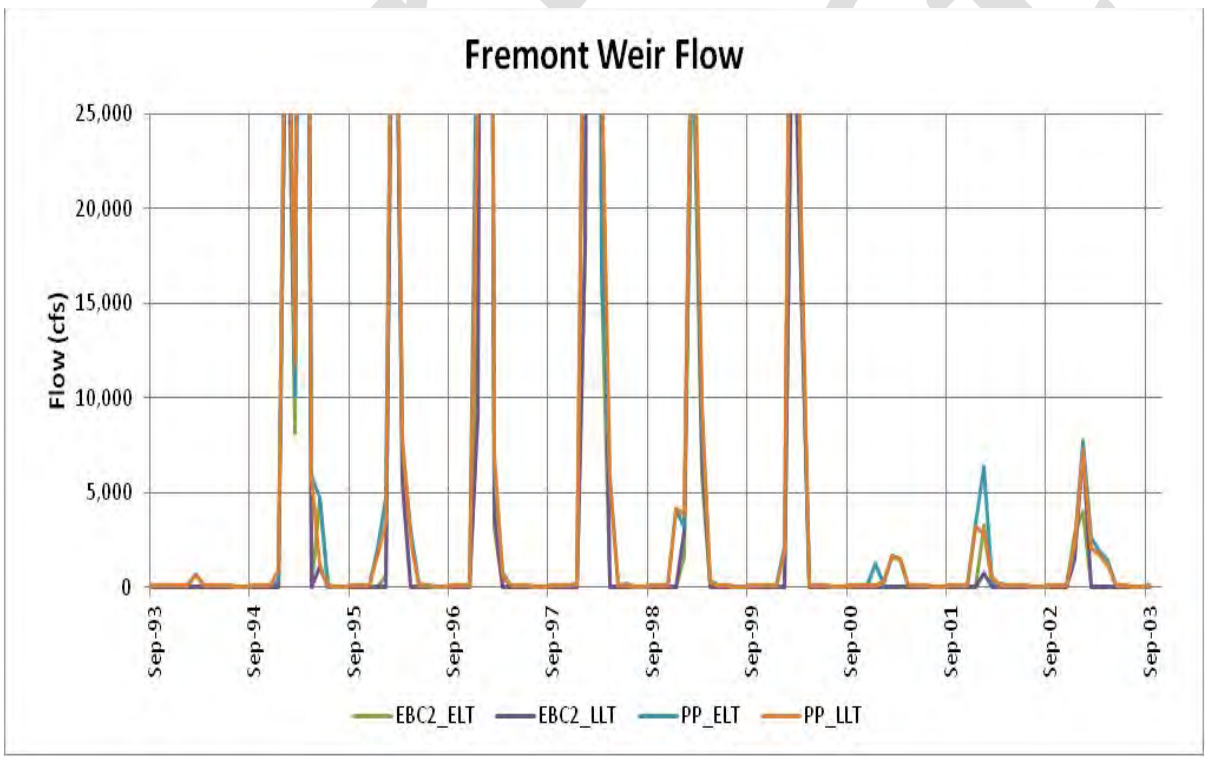

Figure C.A-14. CALSIM-Simulated Monthly Fremont Weir Spill (cfs) for WY 1994–2003 for the EBC2 Baselines and PP_ELT and PP_LLT Cases

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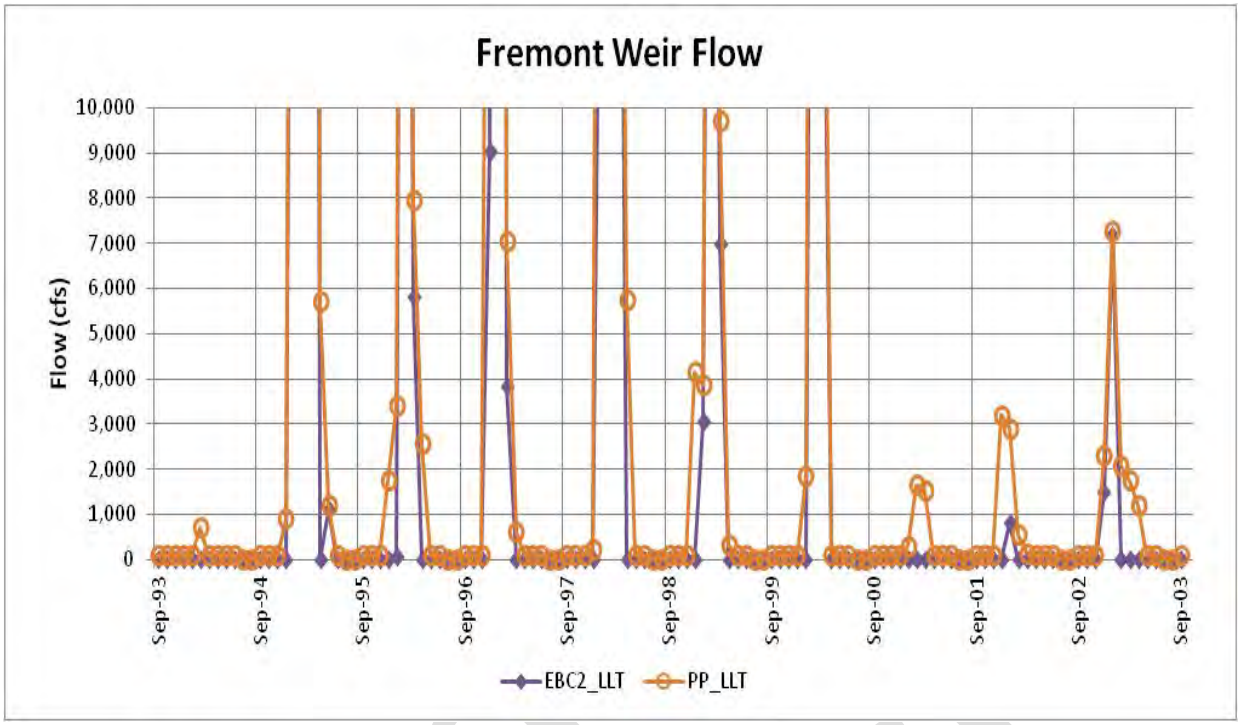

Figure C.A-15. CALSIM-Simulated Monthly Fremont Weir Spill (cfs) for WY 1994–2003 for the EBC2_LLT Baseline and PP_LLT Case

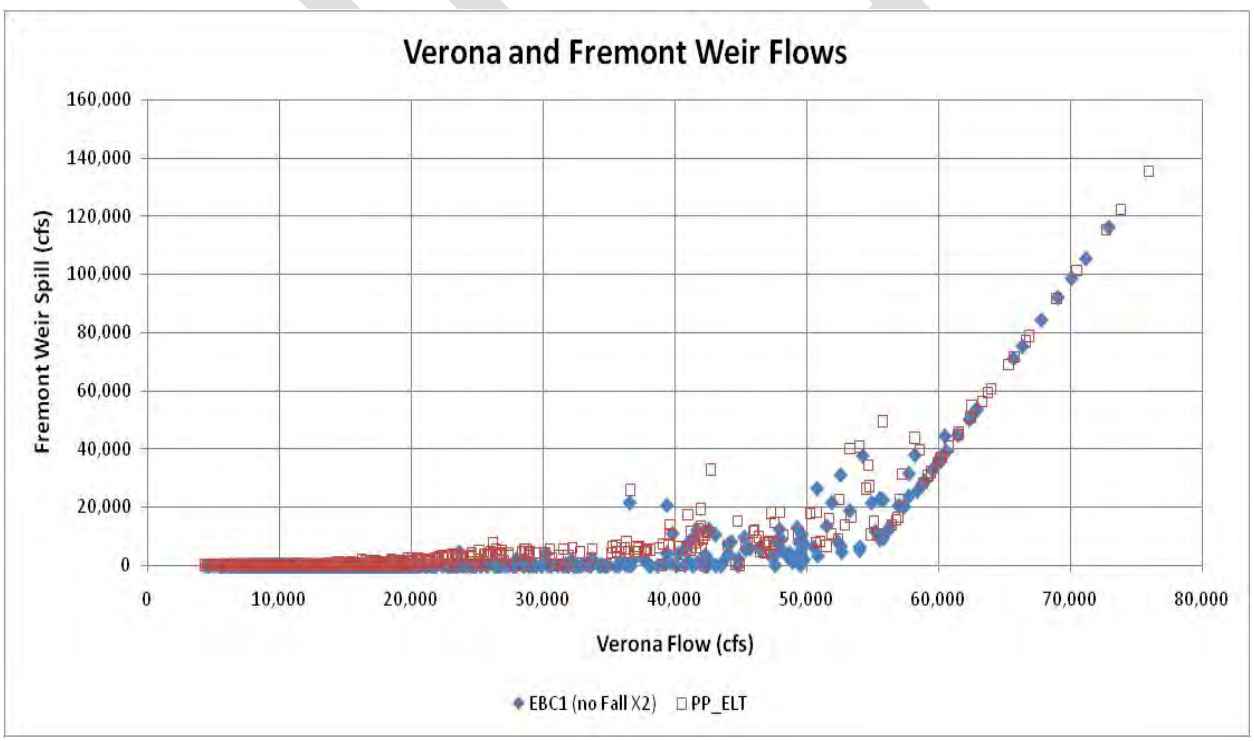

Figure C.A-16. CALSIM-Simulated Monthly Fremont Weir Spill (cfs) and Sacramento River Flow (cfs) at Verona for 1922–2003 for the EBC1 Baseline and PP_ELT Cases

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C.A.3.5 Simulated Changes in Folsom Reservoir Operations

Table C.A-13 shows the monthly distributions of the CALSIM-simulated Folsom Reservoir storage patterns for the six CALSIM cases. The maximum storage of about 975 taf was simulated only in May and June. The maximum flood control storage is about 575 taf from November to February. There are some variations caused by runoff conditions (snow vs. rain) and upstream storage, but this generally limits the amount of water that can be stored in Folsom Reservoir during the winter months of December–March. The Folsom Reservoir maximum flood control storage increases in March and April, and full storage is allowed in May. The EBC1 monthly median storage volumes for Folsom Reservoir were about 500 taf to 600 taf in October through March, increased to 800 taf in April, increased to 975 taf (full) in May and June, and decreased to 750 taf in July, 650 taf in August and 600 taf in September. These monthly median storage levels were reduced by about 100 taf to 200 taf for the PP_ELT case and were reduced by 200 taf to 300 taf in most months (except February–April) for the PP_LLT case. Some of the reduced carryover storage is caused by the increased CVP municipal water supply diversions from Folsom Reservoir that was assumed for the ELT and LLT cases. The simulated Folsom Reservoir monthly median storage levels for the EBC2 cases were very similar to the EBC1 and PP_ELT and PP_LLT cases. The carryover storage was reduced by about 100 taf for the EBC2_ELT case and was reduced by about 200 taf for the EBC2_LLT case compared to the EBC2 for existing hydrology. This suggests that the major factors in the reduced simulated carryover storage are the effects of increased upstream water supply diversions and climate change (shifting in the inflow). The simulated Folsom Reservoir storage does not appear to show much of a direct effect from the preliminary proposal.

Figure C.A-17 shows the simulated monthly Folsom Reservoir storage for the EBC1 and the PP_ELT and PP_LLT cases for the 1922–2003 sequence. The CALSIM-simulated carryover storage for the PP_ELT and PP_LLT cases was reduced by 200 taf to 300 taf in several years when the baseline carryover storage was between 400 taf and 600 taf. Because CALSIM does not have a reservoir carryover target, the increased demands are not balanced by reduced releases, and the reservoir storage is reduced by the increased demands. Actual CVP operations likely would factor in a carryover storage target for coldwater pool and recreation uses. Figure C.A-18 shows the simulated monthly Folsom Reservoir storage for EBC1 and the PP_ELT and PP_LLT cases for the 1994–2003 sequence. Although these 10 years were relatively wet, the reduced carryover storage levels in WY 1994 and in WY 2000–2003 for the PP_ELT and PP_LLT appear to be lower than recent years of actual Folsom Reservoir operations.

Table C.A-14 shows the CALSIM-simulated American River flow below Nimbus Dam (Fair Oaks) for the six CALSIM cases. The minimum flows below Nimbus depend on runoff and Folsom storage, but generally maintain flows above 1,500 cfs in all months. For the EBC1, the median monthly American River flows were 1,500 cfs in October and about 2,000 cfs from November–January, with higher flows of 2,500 cfs to 3,500 cfs caused by flood control releases from February to June. The simulated Folsom Reservoir release flows in July often were increased to 5,000 cfs because the Delta E/I ratio was increased to 65% and these flows could be exported for south-of-Delta water supply. Releases in August and September often were limited by the target reservoir drawdown for recreation uses and coldwater pool. The simulated PP_ELT and PP_LLT cases generally released more water in January–March and slightly less water in the spring and summer. The average annual release flow for the EBC1 was about 2,475 taf/yr, about 2,386 taf/yr for the PP_ELT case, and about 2,335 taf/yr for the PP_LLT case. The water supply diversions therefore were increased by about 100 taf/yr for the PP_ELT and by about 150 taf/yr for the PP_LLT. The annual average release flows for the three

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EBC2 cases showed this same reduction in Folsom Reservoir releases, caused by the increased water supply diversions (and slightly reduced inflows for the ELT and LLT cases). The simulated PP_ELT and PP_LLT cases did not change the Folsom Reservoir operations substantially.

Figure C.A-19 shows the simulated American River flows at Nimbus Dam for EBC1 and the two PP cases for the 1922–2003 sequence. The monthly flows are generally between 1,000 cfs (minimum flow requirement in most years) and 5,000 cfs, but several years had higher monthly flows of 10,000 cfs to 40,000 cfs caused by flood control releases from Folsom Reservoir. The major differences between the EBC1 flows and the PP flows were the magnitude of the flood control releases caused by different inflow sequences assumed for the EBC1 and the ELT and LLT conditions. Figure C.A-20 shows the simulated monthly American River flows at Nimbus Dam for the EBC1 and the two PP cases for the 1994–2003 sequence. The higher flows (flood control spills) and the monthly flows in the summer and fall months (i.e., controlled releases) of some years were different for the PP cases compared to the EBC1 flows.

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Table C.A-13. CALSIM-Simulated Monthly Distribution of Folsom Reservoir Storage (taf)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
A. EBC1												
Min	90	90	152	161	126	185	174	177	157	90	90	90
10%	301	297	285	318	359	465	498	519	499	376	326	310
20%	361	374	359	385	427	563	682	734	640	469	391	381
30%	411	420	404	431	467	601	755	824	743	554	476	452
40%	480	459	476	481	506	622	800	929	874	667	577	532
50%	583	544	516	521	536	634	800	975	975	751	659	613
60%	603	568	546	560	553	645	800	975	975	781	725	650
70%	632	575	571	570	563	659	800	975	975	807	767	650
80%	642	575	575	575	573	667	800	975	975	891	800	650
90%	652	575	575	575	575	672	800	975	975	950	800	650
Max	720	575	575	575	575	675	800	975	975	950	800	650
Avg	505	467	468	479	494	598	727	850	823	684	600	525
B. PP_ELT												
Min	90	90	129	149	114	194	173	168	138	90	90	90
10%	200	227	244	295	356	475	488	494	444	299	251	218
20%	305	323	323	346	413	541	627	657	549	391	345	335
30%	350	357	370	430	461	600	732	744	611	453	411	393
40%	392	402	429	468	505	623	798	830	714	490	455	442
50%	461	442	494	514	546	637	800	944	762	564	513	488
60%	515	510	519	556	561	655	800	974	856	606	562	535
70%	584	551	559	569	567	662	800	975	932	705	605	593
80%	622	575	575	575	575	668	800	975	968	791	708	650
90%	646	575	575	575	575	672	800	975	975	854	750	650
Max	720	575	575	575	575	675	800	975	975	916	800	650
Avg	448	428	445	470	494	598	717	820	734	570	508	468
C. PP_LLT												
Min	90	0	61	90	90	93	90	90	90	90	90	90
10%	115	133	193	184	301	398	425	397	353	197	126	130
20%	228	226	242	291	357	517	566	545	426	312	264	259
30%	271	280	286	366	405	570	685	656	551	340	312	310
40%	302	307	345	406	457	616	748	763	603	414	375	361
50%	337	346	382	458	515	632	798	865	661	500	452	434
60%	374	391	455	538	549	647	800	919	748	539	475	464
70%	434	414	502	563	561	658	800	961	807	576	519	502
80%	474	495	568	572	568	667	800	975	867	659	569	556
90%	617	570	575	575	575	670	800	975	938	748	658	613
Max	720	575	575	575	575	675	800	975	975	925	800	650
Avg	354	346	387	429	461	577	689	764	650	477	420	400

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
D. EBC2												
Min	90	90	146	160	127	142	130	136	114	90	90	90
10%	272	256	252	304	355	456	475	509	459	354	317	289
20%	339	337	345	366	412	521	607	684	612	439	377	366
30%	372	385	394	423	429	590	746	812	725	506	438	396
40%	440	430	433	458	492	623	800	916	834	615	548	493
50%	501	469	479	497	527	637	800	975	964	731	618	539
60%	573	499	506	544	556	652	800	975	975	766	701	587
70%	607	516	548	563	563	661	800	975	975	797	742	617
80%	626	540	574	574	572	667	800	975	975	912	800	642
90%	644	572	575	575	575	672	800	975	975	950	800	650
Max	720	575	575	575	575	675	800	975	975	950	800	650
Avg	474	433	446	465	487	593	717	839	808	665	578	492
E. EBC2_ELT												
Min	90	90	90	90	121	147	126	121	92	90	90	90
10%	176	207	234	283	350	449	461	488	443	274	199	187
20%	315	308	317	338	402	522	613	663	561	389	341	324
30%	343	361	362	386	429	590	731	773	681	435	389	365
40%	375	401	399	444	484	623	800	874	766	528	485	420
50%	434	420	451	489	543	636	800	975	882	618	525	481
60%	470	448	469	533	558	652	800	975	968	700	604	514
70%	509	479	530	560	563	662	800	975	975	751	672	556
80%	554	507	575	571	575	667	800	975	975	837	752	589
90%	621	555	575	575	575	671	800	975	975	909	800	633
Max	720	575	575	575	575	675	800	975	975	950	800	650
Avg	422	400	429	454	485	591	713	823	773	601	523	446
F. EBC2_LLT												
Min	90	90	90	90	90	90	90	90	90	90	90	90
10%	92	115	212	233	330	402	431	463	410	180	90	91
20%	243	259	255	313	360	502	605	585	443	322	285	259
30%	292	299	306	347	417	570	686	706	601	372	332	317
40%	319	330	346	412	474	611	797	835	692	443	396	353
50%	348	351	389	457	518	629	800	917	770	527	428	385
60%	380	376	429	529	555	649	800	970	822	581	491	419
70%	415	399	492	561	562	660	800	975	878	618	547	469
80%	473	424	546	572	570	667	800	975	961	716	620	526
90%	548	494	575	575	575	672	800	975	975	798	718	575
Max	720	575	575	575	575	675	800	975	975	950	800	650
Avg	354	341	388	431	469	580	697	791	712	509	439	379

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Table C.A-14. CALSIM-Simulated Monthly Distribution of American River Flows (cfs) at Nimbus Dam

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year
A. EBC1													
Min	500	527	520	800	800	299	357	307	359	442	250	355	417
10%	1,210	949	952	1,141	1,225	891	925	925	1,429	1,891	1,256	906	1,119
20%	1,500	1,534	1,499	1,542	1,445	1,143	1,445	1,339	1,750	2,930	1,752	1,207	1,339
30%	1,500	1,714	1,782	1,700	1,565	1,508	1,668	1,445	1,904	3,150	2,263	1,622	1,569
40%	1,500	1,925	2,000	1,700	2,413	1,843	2,057	1,750	2,344	3,623	2,502	2,041	1,830
50%	1,500	2,009	2,000	2,005	3,504	2,524	2,385	2,875	2,850	4,123	2,719	2,570	2,153
60%	1,500	2,398	2,000	3,087	4,750	3,426	3,287	3,591	3,197	4,577	2,920	3,193	2,541
70%	1,500	2,657	2,507	4,684	6,367	4,132	4,121	4,228	4,295	4,982	3,090	3,687	3,123
80%	1,723	3,062	4,444	6,735	9,108	5,544	5,098	5,048	5,136	5,000	3,823	4,177	3,754
90%	2,257	4,282	7,245	10,559	11,669	8,886	6,694	8,326	7,207	5,000	4,280	4,311	4,181
Max	4,421	16,015	19,792	31,370	32,258	16,210	14,475	11,423	14,418	6,499	4,700	5,110	6,186
Avg	1,605	2,706	3,519	4,502	5,218	3,762	3,305	3,587	3,699	3,838	2,707	2,663	2,475
B. PP_ELT													
Min	500	500	500	425	800	317	335	305	357	367	293	324	401
10%	802	813	800	936	1,149	800	826	826	1,285	1,041	800	800	976
20%	1,223	1,247	1,150	1,395	1,445	1,117	1,197	1,268	1,838	2,406	1,037	1,015	1,259
30%	1,500	1,605	1,739	1,700	1,474	1,493	1,750	1,623	2,638	2,754	1,683	1,528	1,423
40%	1,500	1,689	2,000	1,700	2,157	1,860	2,122	1,810	3,157	2,981	1,750	1,533	1,750
50%	1,500	1,925	2,000	1,872	3,419	2,778	2,313	2,453	3,393	3,430	1,750	1,533	2,028
60%	1,500	1,987	2,000	2,850	5,169	3,846	3,178	3,080	3,861	3,876	1,939	1,533	2,480
70%	1,500	2,423	2,077	4,743	7,020	4,518	4,129	3,597	4,144	4,463	2,235	1,714	3,140
80%	1,500	2,802	4,450	7,689	10,229	5,821	4,963	4,597	4,891	5,000	2,526	2,592	3,572
90%	1,689	4,064	9,778	11,923	14,288	9,608	6,912	8,027	5,382	5,000	2,884	3,121	4,319
Max	4,973	17,620	22,009	36,011	36,737	18,874	16,549	12,386	10,897	5,000	3,613	4,162	6,257
Avg	1,492	2,488	3,794	4,853	5,835	3,973	3,327	3,317	3,639	3,359	1,847	1,759	2,386
C. PP_LLT													
Min	500	500	5	267	437	317	259	293	250	250	252	305	366
10%	800	800	800	803	800	800	800	800	1,135	892	577	557	913
20%	874	923	803	1,193	1,294	835	1,400	1,452	1,737	2,019	800	800	1,209
30%	1,339	1,208	1,136	1,668	1,445	1,350	1,685	1,750	2,535	2,515	1,417	1,264	1,359
40%	1,500	1,593	1,750	1,700	2,357	1,750	1,873	1,944	3,112	2,745	1,750	1,518	1,721
50%	1,500	1,712	1,869	1,927	3,739	2,868	2,535	2,308	3,546	3,291	1,750	1,533	1,934
60%	1,778	1,919	2,000	2,571	5,321	4,010	3,114	2,645	3,936	3,527	1,750	1,533	2,416
70%	2,241	1,925	2,000	5,645	7,583	4,822	4,302	3,059	4,340	4,044	1,964	1,533	3,106
80%	2,716	1,925	3,463	8,519	11,230	6,066	4,998	3,832	4,874	4,946	2,226	1,533	3,638
90%	3,651	2,401	8,619	13,543	15,947	9,192	6,987	6,542	5,000	5,000	2,507	1,727	4,109
Max	5,000	15,826	23,686	38,305	39,251	20,206	16,572	10,928	7,739	5,000	3,326	3,815	6,250
Avg	1,920	1,957	3,413	5,207	6,210	4,123	3,407	2,973	3,400	3,191	1,657	1,393	2,335

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year
D. EBC2													
Min	500	506	500	800	800	317	357	305	357	362	346	327	391
10%	812	800	800	817	1,156	885	1,007	1,001	1,217	1,746	988	889	1,045
20%	1,416	1,416	1,385	1,506	1,445	1,104	1,380	1,199	1,709	2,584	1,456	1,317	1,257
30%	1,500	1,625	1,682	1,700	1,445	1,520	1,649	1,445	1,750	2,943	1,848	1,533	1,469
40%	1,500	1,925	2,000	1,700	1,849	1,757	1,867	1,750	2,313	3,182	2,291	1,974	1,767
50%	1,500	2,033	2,000	1,750	2,953	2,438	2,384	2,781	2,728	3,777	2,466	2,427	2,040
60%	1,500	2,249	2,000	2,696	4,693	3,357	2,956	3,367	3,009	4,597	2,813	2,997	2,426
70%	1,500	3,057	2,000	4,628	6,242	4,159	4,152	4,006	3,940	5,000	3,204	3,941	3,087
80%	1,521	3,514	3,219	6,629	9,060	5,404	4,977	4,819	4,974	5,000	3,621	4,274	3,648
90%	1,704	4,363	7,170	10,397	11,402	8,680	6,537	8,103	6,925	5,000	4,017	4,752	4,140
Max	3,355	17,253	19,679	31,335	32,184	16,578	14,403	11,266	14,137	6,073	4,457	5,000	6,090
Avg	1,483	2,734	3,259	4,363	5,065	3,698	3,249	3,456	3,534	3,642	2,535	2,680	2,389
E. EBC2_ELT													
Min	500	500	500	800	800	317	349	305	357	310	258	336	380
10%	802	808	800	910	917	800	800	802	1,074	1,449	800	800	916
20%	1,079	1,161	1,208	1,352	1,347	920	1,136	1,102	1,531	2,300	1,131	920	1,229
30%	1,392	1,443	1,613	1,675	1,445	1,378	1,522	1,329	1,750	2,764	1,750	1,533	1,479
40%	1,500	1,683	1,942	1,700	2,018	1,866	2,070	1,750	1,910	3,152	1,781	1,578	1,656
50%	1,500	1,925	2,000	1,750	3,095	2,593	2,275	2,239	2,316	3,707	2,083	2,072	2,057
60%	1,500	1,977	2,000	2,850	5,041	3,847	3,211	3,132	2,858	4,090	2,337	2,549	2,439
70%	1,582	2,592	2,000	5,089	6,850	4,309	4,155	3,519	3,618	4,983	2,714	3,386	3,203
80%	1,838	2,926	3,306	7,619	10,320	5,820	4,980	4,388	4,207	5,000	2,973	4,002	3,651
90%	2,488	3,691	8,361	11,923	14,287	9,608	6,912	8,027	5,382	5,000	3,307	4,280	4,321
Max	4,004	17,875	21,955	36,011	36,759	18,882	16,549	12,386	10,897	5,000	4,702	5,000	6,263
Avg	1,559	2,523	3,617	4,865	5,710	3,947	3,271	3,231	3,041	3,509	2,115	2,389	2,393
F. EBC2_LLT													
Min	551	500	500	358	437	317	250	285	250	265	252	325	365
10%	800	800	800	800	902	800	800	800	959	1,349	800	721	909
20%	902	809	800	1,152	1,264	824	1,164	988	1,513	2,331	939	802	1,175
30%	1,181	1,162	1,214	1,488	1,445	1,466	1,513	1,358	1,761	2,923	1,540	1,420	1,403
40%	1,479	1,413	1,620	1,700	2,020	2,092	1,760	1,611	2,347	3,559	1,750	1,533	1,644
50%	1,500	1,593	1,786	1,750	3,198	2,908	2,609	1,759	2,673	4,072	1,839	1,548	1,958
60%	1,509	1,683	2,000	2,559	5,186	3,902	3,070	2,357	3,015	4,657	1,927	1,917	2,379
70%	1,710	1,925	2,000	5,362	6,966	4,749	4,203	2,624	3,266	5,000	2,323	2,588	3,159
80%	1,948	2,541	2,621	8,534	11,151	6,067	4,987	3,495	3,811	5,000	2,586	3,527	3,632
90%	2,799	2,943	8,472	13,543	15,920	9,685	6,898	6,542	5,000	5,000	3,007	4,089	4,254
Max	3,729	15,826	24,195	38,305	39,261	20,206	16,572	10,928	7,739	5,330	4,608	5,000	6,191
Avg	1,592	2,043	3,297	5,194	6,112	4,187	3,334	2,676	2,825	3,670	1,874	2,068	2,337

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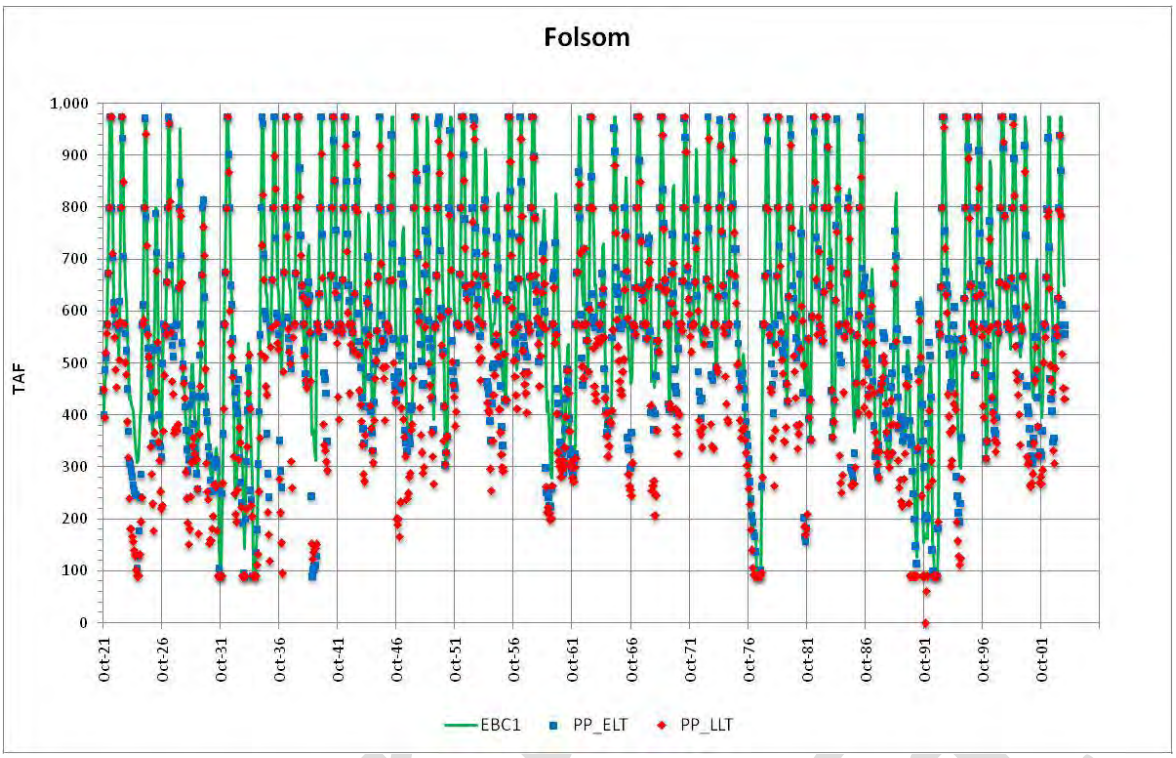

Figure C.A-17. CALSIM-Simulated Monthly Folsom Reservoir Storage for 1922–2003 for the EBC1 Baseline and PP_ELT and PP_LLT

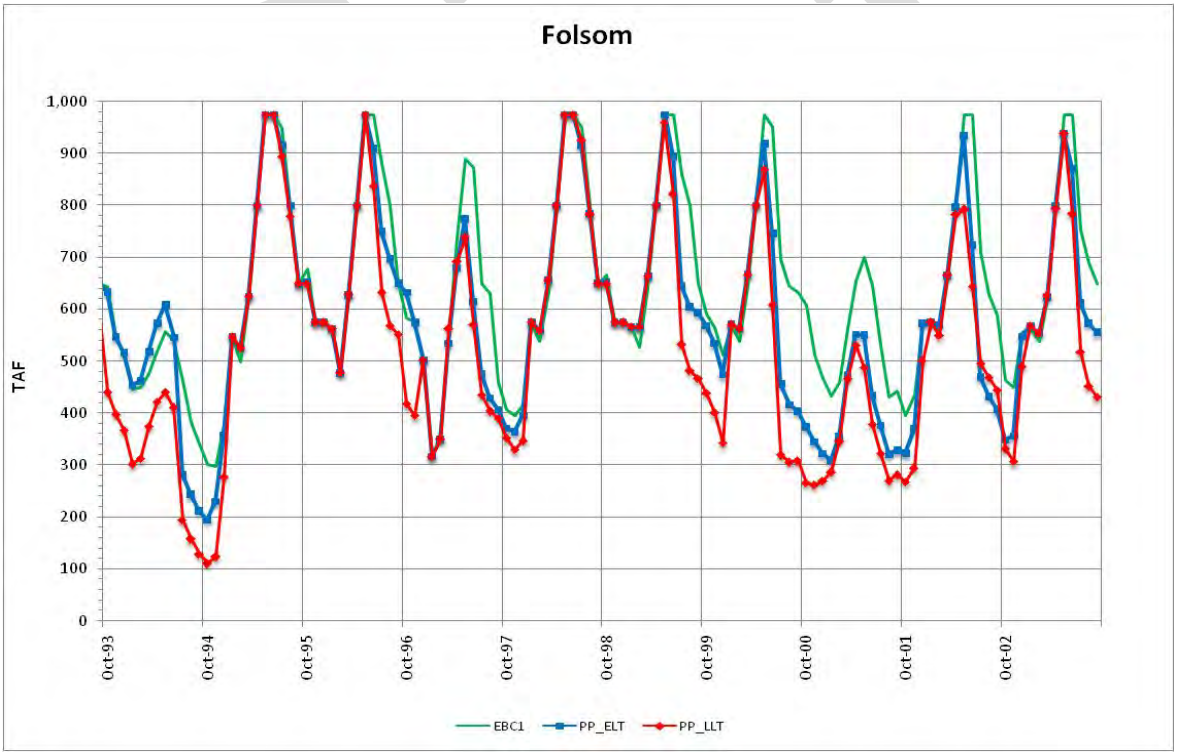

Figure C.A-18. CALSIM-Simulated Monthly Folsom Reservoir Storage for 1994–2003 for the EBC1 Baseline and PP_ELT and PP_LLT

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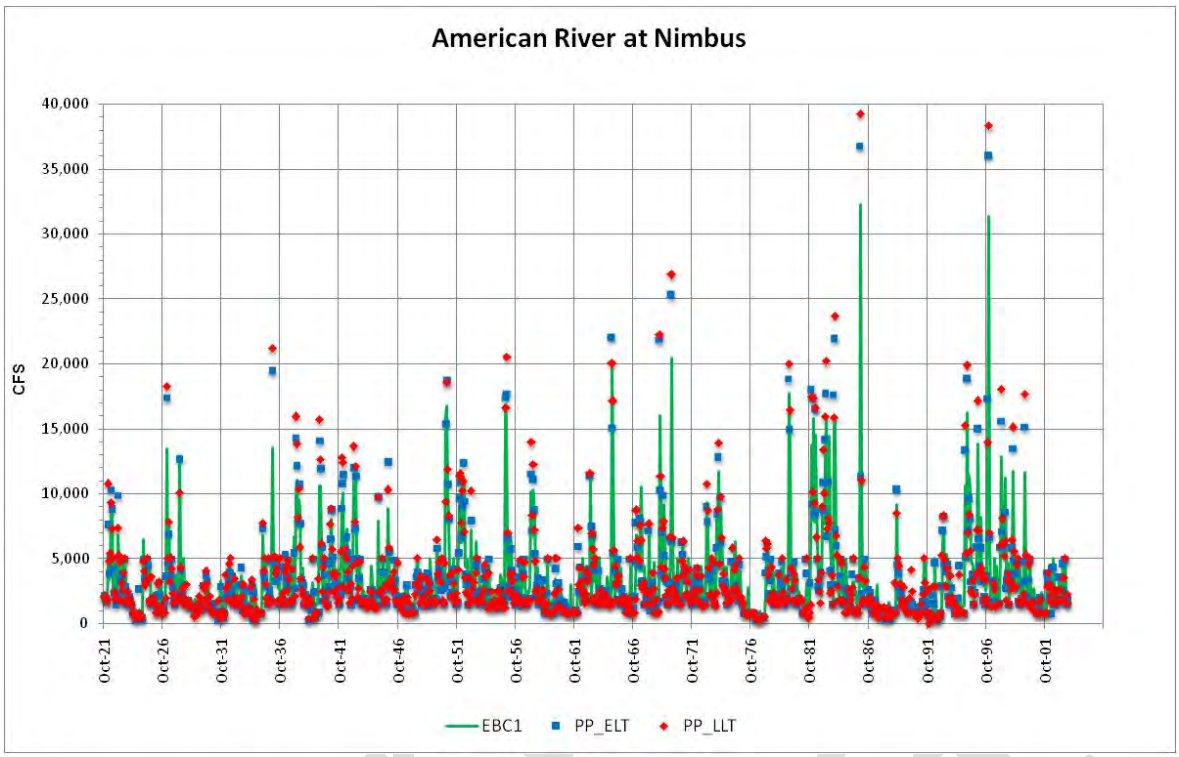

Figure C.A-19. CALSIM-Simulated Monthly American River Flow at Nimbus for 1922–2003 for the EBC1 Baseline and PP_ELT and PP_LLT

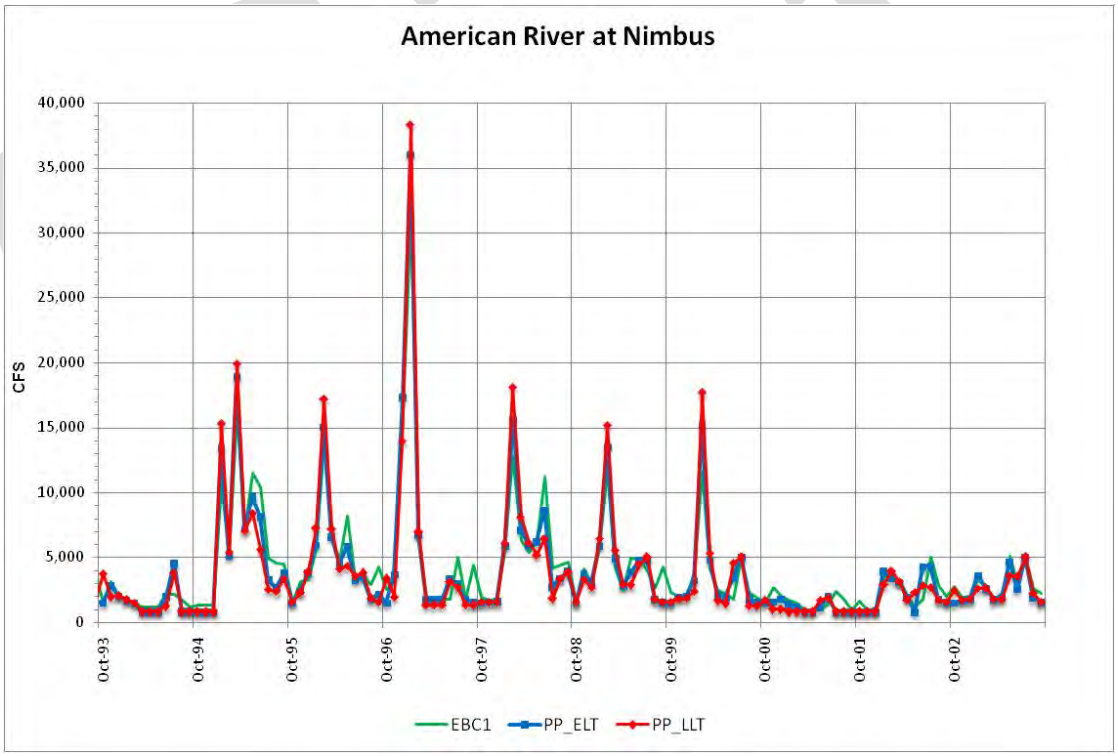

Figure C.A-20. CALSIM-Simulated Monthly American River Flow at Nimbus for 1994–2003 for the EBC1 Baseline and PP_ELT and PP_LLT

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C.A.3.6 Simulated Changes in New Melones Reservoir Operations

New Melones Reservoir is the only CVP reservoir in the San Joaquin River basin that might be operated differently with the preliminary proposal. Operation of Millerton Reservoir (Friant Dam) is being managed under the San Joaquin River Restoration Program. However, the New Melones operations are already fully constrained by the existing contracts and fish flows, in addition to the 2009 NMFS BiOp requirements for increased flow in April and May.

Table C.A-15 shows the CALSIM-simulated New Melones Reservoir storage for the six CALSIM cases. The maximum storage of about 2,400 taf was simulated only in May and June. The maximum flood control storage is about 2,000 taf from October to March. Because the New Melones Reservoir is quite large relative to the average Stanislaus River runoff of about 1,000 taf/yr, the maximum flood control levels limit storage only in a sequence of wet years when the storage level has increased. The New Melones Reservoir maximum flood control storage increases in April to 2,200 taf, and full storage is allowed in May. The EBC1 monthly median storage volumes for New Melones Reservoir were about 1,500 taf from October through January, increased to about 1,600 taf in February through July, and were about 1,500 taf in July–September. The seasonal variation each year is much greater than this monthly median pattern would suggest because New Melones reservoir storage increases with spring runoff and decreases with summer diversions for irrigation. The annual average irrigation diversions were about 600 taf/yr, and the average seasonal storage reduction from May to September was about 200 taf. The monthly median storage levels of New Melones Reservoir were not changed substantially for the PP_ELT and PP_LLT cases because, although there was a small reduction in the New Melones inflow for the assumed ELT and LLT conditions, the operations of New Melones for irrigation diversions and minimum monthly fish flows were not changed by the preliminary proposal Delta operations. Figure C.A-21 shows the simulated monthly New Melones Reservoir storage for the EBC1 and the PP_ELT and PP_LLT cases for the 1922–2003 sequence. The CALSIM-simulated storage variations for the PP_ELT and PP_LLT cases were nearly identical to the EBC1 baseline. Figure C.A-22 shows the simulated monthly New Melones Reservoir storage for EBC1 and the PP_ELT and PP_LLT cases for the 1994–2003 sequence. The reduced carryover storage levels in WY 1993 (beginning of graph sequence) were the result of lower runoff during the dry period of 1987–1993. The higher inflows simulated in December and January of WY 1997 for the PP_ELT and PP_LLT conditions apparently allowed higher diversions and higher release flows so that the carryover storage at the end of WY 1997 was lower than the EBC1 baseline. In most years the simulated New Melones Reservoir storage values for the PP_ELT and PP_LLT cases were identical to the EBC1.

Figure C.A-23 shows the simulated Stanislaus River flows for the EBC1 baseline and the two PP cases for the 1922–2003 sequence. River flows are normally between 250 cfs and 2,500 cfs. Higher flows indicate flood control releases (spills) from New Melones Reservoir. The PP_ELT and PP_LLT sometimes caused increased flood control releases when the assumed inflows were higher than the EBC1 inflows when the reservoir was filled to maximum flood control levels. Figure C.A-24 shows the simulated Stanislaus River flows for the EBC1 and the PP_ELT and PP_LLT cases for the 1994–2003 sequence. Most of the years had very similar flows, but some years had difference caused by the slightly different assumed inflows for the EBC1 and the PP_ELT and PP_LLT cases.

Table C.A-16 shows the CALSIM-simulated Stanislaus River flow at the confluence (Ripon) for the six CALSIM cases. The minimum flows below Goodwin Dam depend on runoff and New Melones

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storage, but generally the river maintains flows above 200 cfs to 300 cfs in all months (based on 10% cumulative flows). The minimum flows in April and May are about 700 cfs because the 2009 NMFS BiOp emphasizes the flows in these months for increased survival of fall-run Chinook salmon. For the EBC1, the median monthly Stanislaus River flows were about 900 cfs in October for adult Chinook attraction flows, and about 300 cfs from November–January for Chinook egg incubation, with higher flows of 500 cfs in February, 650 cfs in March, and about 1,500 cfs in April and May during outmigration of fall-run Chinook juveniles (smolts). The simulated median flows in June were about 600 cfs, and the July–September median flows were about 450 cfs. The simulated PP_ELT and PP_LLT flows were nearly identical to the EBC1, except that there were fewer months with reservoir spills (higher river flows) because the assumed inflows were reduced for the PP_ELT and PP_LLT conditions.

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Table C.A-15. CALSIM-Simulated Monthly Distribution of New Melones Reservoir Storage (taf)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
A. EBC1												
Min	80	80	98	229	242	292	297	203	149	94	80	80
10%	664	688	723	745	754	768	694	662	764	732	672	642
20%	987	973	990	1,006	1,044	1,138	1,103	1,180	1,140	1,102	1,064	1,036
30%	1,185	1,223	1,252	1,314	1,334	1,342	1,281	1,296	1,358	1,315	1,243	1,210
40%	1,324	1,364	1,383	1,457	1,519	1,526	1,486	1,505	1,504	1,441	1,373	1,344
50%	1,448	1,465	1,480	1,555	1,640	1,671	1,631	1,641	1,632	1,596	1,518	1,481
60%	1,514	1,555	1,640	1,692	1,779	1,779	1,746	1,736	1,710	1,638	1,571	1,536
70%	1,630	1,650	1,691	1,777	1,852	1,876	1,849	1,857	1,855	1,794	1,706	1,666
80%	1,758	1,761	1,790	1,849	1,934	1,956	1,876	1,930	1,991	1,955	1,860	1,805
90%	1,872	1,880	1,936	1,954	1,970	1,990	1,971	2,080	2,147	2,069	1,974	1,914
Max	1,970	1,970	1,970	2,116	1,970	2,030	2,220	2,414	2,420	2,300	2,130	2,000
Avg	1,342	1,353	1,387	1,438	1,492	1,516	1,492	1,526	1,547	1,485	1,406	1,364
B. PP_ELT												
Min	80	80	103	227	280	302	275	184	123	80	80	80
10%	730	737	757	763	815	801	756	794	838	771	717	719
20%	894	888	918	921	1,028	1,074	1,074	1,135	1,092	1,044	977	940
30%	1,129	1,172	1,205	1,234	1,294	1,332	1,292	1,313	1,279	1,214	1,165	1,146
40%	1,302	1,329	1,331	1,395	1,431	1,438	1,428	1,485	1,495	1,445	1,372	1,325
50%	1,370	1,375	1,405	1,538	1,582	1,623	1,583	1,612	1,573	1,496	1,420	1,401
60%	1,461	1,506	1,585	1,653	1,728	1,742	1,688	1,689	1,693	1,629	1,534	1,509
70%	1,598	1,606	1,665	1,738	1,809	1,840	1,768	1,850	1,856	1,773	1,669	1,624
80%	1,663	1,693	1,741	1,765	1,881	1,920	1,908	1,947	1,955	1,889	1,778	1,719
90%	1,784	1,790	1,857	1,953	1,970	2,004	1,982	2,104	2,127	2,027	1,914	1,841
Max	1,970	1,970	1,970	2,363	2,135	2,030	2,220	2,420	2,420	2,300	2,130	2,000
Avg	1,302	1,312	1,350	1,407	1,468	1,497	1,478	1,520	1,532	1,457	1,370	1,325
C. PP_LLT												
Min	80	80	106	122	179	203	178	88	80	80	80	80
10%	604	611	631	645	697	671	645	732	677	606	551	559
20%	815	824	840	888	928	1,024	1,029	1,049	1,026	944	878	838
30%	1,061	1,075	1,114	1,170	1,213	1,228	1,196	1,280	1,252	1,177	1,096	1,055
40%	1,196	1,195	1,237	1,328	1,367	1,428	1,393	1,410	1,370	1,294	1,231	1,210
50%	1,301	1,309	1,330	1,475	1,547	1,575	1,527	1,577	1,516	1,436	1,365	1,319
60%	1,451	1,434	1,512	1,575	1,658	1,717	1,670	1,620	1,658	1,599	1,512	1,463
70%	1,544	1,542	1,591	1,663	1,736	1,803	1,766	1,841	1,793	1,703	1,608	1,565
80%	1,609	1,610	1,669	1,711	1,858	1,882	1,878	1,920	1,928	1,816	1,693	1,647
90%	1,701	1,702	1,766	1,842	1,970	2,007	1,969	2,072	2,067	1,949	1,824	1,758
Max	1,970	1,970	1,970	2,388	2,163	2,030	2,220	2,420	2,420	2,300	2,130	2,000
Avg	1,225	1,232	1,271	1,336	1,409	1,449	1,437	1,471	1,466	1,379	1,291	1,246

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
D. EBC2												
Min	107	103	121	270	372	436	407	314	261	208	148	123
10%	746	752	776	836	867	864	799	773	889	841	773	736
20%	1,024	1,003	1,009	1,050	1,091	1,149	1,139	1,213	1,177	1,142	1,100	1,070
30%	1,215	1,225	1,303	1,319	1,336	1,410	1,338	1,337	1,403	1,346	1,279	1,238
40%	1,354	1,381	1,423	1,461	1,516	1,517	1,499	1,535	1,533	1,465	1,401	1,364
50%	1,461	1,468	1,488	1,578	1,633	1,675	1,634	1,645	1,641	1,597	1,528	1,492
60%	1,528	1,550	1,635	1,686	1,767	1,798	1,733	1,743	1,707	1,653	1,582	1,543
70%	1,627	1,646	1,686	1,767	1,840	1,863	1,843	1,854	1,853	1,782	1,699	1,669
80%	1,751	1,757	1,777	1,846	1,923	1,950	1,880	1,921	2,007	1,956	1,861	1,799
90%	1,892	1,921	1,928	1,943	1,970	1,989	1,979	2,073	2,149	2,073	1,980	1,919
Max	1,970	1,970	1,970	2,116	1,970	2,030	2,220	2,413	2,420	2,300	2,130	2,000
Avg	1,370	1,379	1,411	1,460	1,514	1,540	1,516	1,551	1,574	1,514	1,435	1,394
E. EBC2_ELT												
Min	80	80	103	229	282	304	277	186	125	80	80	80
10%	732	739	759	765	817	802	757	794	840	773	719	721
20%	893	887	920	920	1,028	1,074	1,074	1,137	1,094	1,043	976	939
30%	1,129	1,173	1,203	1,233	1,294	1,332	1,292	1,313	1,277	1,214	1,164	1,145
40%	1,302	1,328	1,331	1,395	1,429	1,437	1,428	1,485	1,495	1,445	1,371	1,324
50%	1,371	1,376	1,403	1,538	1,581	1,623	1,583	1,611	1,572	1,495	1,420	1,400
60%	1,461	1,506	1,585	1,653	1,728	1,742	1,688	1,687	1,692	1,629	1,534	1,509
70%	1,598	1,606	1,665	1,738	1,809	1,838	1,768	1,850	1,856	1,773	1,669	1,624
80%	1,662	1,693	1,740	1,765	1,880	1,920	1,908	1,947	1,955	1,889	1,778	1,719
90%	1,784	1,789	1,856	1,953	1,970	2,004	1,982	2,104	2,127	2,027	1,914	1,841
Max	1,970	1,970	1,970	2,363	2,135	2,030	2,220	2,420	2,420	2,300	2,130	2,000
Avg	1,301	1,312	1,350	1,407	1,467	1,497	1,478	1,520	1,532	1,456	1,370	1,325
F. EBC2_LLT												
Min	80	80	106	122	180	204	179	88	80	80	80	80
10%	605	612	632	646	697	671	645	733	678	607	552	560
20%	814	823	839	887	928	1,016	1,028	1,049	1,024	942	877	837
30%	1,059	1,074	1,111	1,170	1,211	1,230	1,196	1,280	1,251	1,177	1,095	1,055
40%	1,196	1,194	1,237	1,327	1,367	1,425	1,392	1,408	1,370	1,294	1,231	1,212
50%	1,301	1,308	1,330	1,475	1,547	1,574	1,527	1,577	1,515	1,436	1,365	1,319
60%	1,450	1,433	1,510	1,575	1,658	1,717	1,669	1,619	1,657	1,598	1,510	1,462
70%	1,544	1,543	1,578	1,662	1,734	1,800	1,766	1,841	1,793	1,703	1,608	1,566
80%	1,605	1,607	1,669	1,711	1,856	1,880	1,877	1,920	1,926	1,806	1,693	1,642
90%	1,701	1,702	1,765	1,842	1,970	2,007	1,969	2,072	2,067	1,949	1,824	1,758
Max	1,970	1,970	1,970	2,388	2,164	2,030	2,220	2,420	2,420	2,300	2,130	2,000
Avg	1,224	1,231	1,270	1,335	1,408	1,448	1,436	1,470	1,465	1,378	1,290	1,246

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Table C.A-16. CALSIM-Simulated Monthly Distribution of Stanislaus River Flow (cfs) at Goodwin Dam

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	76	136	175	219	138	168	453	454	244	246	0	9	192
10%	322	248	206	260	241	315	791	641	336	339	347	322	318
20%	719	263	243	289	335	468	985	767	377	388	377	373	346
30%	766	270	267	311	415	535	1228	869	411	404	401	403	403
40%	823	302	286	325	459	604	1331	961	475	407	428	423	432
50%	918	325	304	343	497	667	1669	1379	630	422	439	434	500
60%	964	347	318	387	550	1478	1841	1503	1103	468	451	462	587
70%	995	378	341	449	592	1616	1967	1638	1215	528	480	529	644
80%	1073	437	388	489	670	1787	2089	1782	1367	628	556	586	744
90%	1152	481	503	580	1858	2027	2347	1861	1584	785	682	770	1047
Max	1987	3463	5132	8185	6356	6175	2907	2448	4960	4501	2678	3093	2557
Avg	867	410	450	635	827	1167	1562	1271	932	607	560	595	596
B. PP_ELT													
Min	71	126	135	123	121	168	385	371	246	58	0	9	161
10%	293	248	200	250	229	275	550	529	297	306	349	322	289
20%	710	263	241	276	244	370	836	678	341	342	372	373	317
30%	752	270	263	304	316	438	1,081	788	371	376	401	404	364
40%	822	302	285	321	371	484	1,273	896	426	381	428	423	395
50%	874	325	301	336	399	520	1,536	1,282	625	413	439	434	459
60%	957	341	311	362	455	1,150	1,732	1,491	1,105	468	450	444	523
70%	995	360	336	420	496	1,603	1,940	1,638	1,219	511	466	505	629
80%	1,073	434	385	483	703	1,738	2,045	1,736	1,348	616	556	569	737
90%	1,137	471	507	724	2,468	2,032	2,281	1,830	1,584	807	646	756	1,028
Max	1,926	3,879	6,187	8,129	8,269	6,518	3,186	2,616	5,071	3,844	2,246	2,792	2,523
Avg	840	409	459	638	847	1,135	1,475	1,211	951	588	530	567	582
C. PP_LLT													
Min	57	101	111	107	103	163	361	371	3	19	9	94	139
10%	284	248	200	220	227	275	526	524	298	310	349	312	275
20%	702	263	228	276	241	337	832	631	338	354	372	365	317
30%	745	269	262	304	276	381	1,018	780	370	371	394	401	364
40%	812	294	281	321	353	468	1,271	834	414	385	428	423	389
50%	836	320	292	338	389	489	1,335	913	629	418	439	434	417
60%	889	337	307	354	426	552	1,636	1,352	1,105	468	450	444	484
70%	980	348	330	384	467	1,506	1,790	1,477	1,220	528	461	486	596
80%	1,058	384	378	450	609	1,620	1,967	1,704	1,375	736	515	559	714
90%	1,129	471	483	545	1,182	1,925	2,104	1,838	1,759	1,188	593	670	918
Max	1,995	2,982	5,410	8,129	8,269	7,461	3,362	2,570	4,873	3,214	1,823	2,315	2,526
Avg	808	386	414	615	724	1,071	1,387	1,125	912	590	491	535	547

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	110	156	165	145	127	168	427	444	226	249	277	209	207
10%	330	248	223	260	236	318	717	596	297	304	349	322	300
20%	735	263	243	289	257	384	1000	735	363	335	378	373	339
30%	768	270	270	308	322	475	1190	877	414	377	401	404	391
40%	827	302	286	325	389	506	1331	930	470	381	428	423	433
50%	934	325	304	343	432	665	1675	1403	633	418	439	435	497
60%	964	348	316	387	474	1478	1841	1503	1105	468	454	462	589
70%	995	378	341	449	569	1616	1967	1638	1222	528	480	529	645
80%	1073	435	388	489	703	1787	2091	1782	1397	628	556	586	744
90%	1152	481	503	580	1763	2027	2347	1861	1584	785	682	770	1036
Max	1975	3414	5077	8129	6297	6143	2873	2450	4999	4537	2706	3081	2547
Avg	869	409	453	624	780	1140	1551	1263	926	610	566	594	590
E. EBC2_ELT													
Min	71	126	136	123	121	168	385	371	246	85	11	9	163
10%	293	248	200	250	229	275	550	529	297	305	349	322	289
20%	710	263	241	276	244	370	836	678	340	339	372	373	317
30%	752	270	263	304	316	438	1081	788	371	371	401	404	364
40%	822	302	285	321	371	486	1273	896	439	381	428	423	395
50%	874	325	301	336	399	520	1536	1282	625	413	439	434	459
60%	957	341	311	362	455	1150	1732	1491	1105	468	450	444	525
70%	995	360	336	420	496	1603	1944	1638	1219	511	466	505	629
80%	1073	434	385	483	703	1738	2045	1734	1348	616	556	569	737
90%	1137	471	507	704	2468	2029	2281	1830	1597	807	646	756	1028
Max	1926	3879	6187	8129	8269	6518	3186	2613	5071	3844	2246	2792	2523
Avg	840	409	459	638	847	1134	1475	1211	952	588	530	567	582
F. EBC2_LLT													
Min	57	102	111	107	103	163	361	371	3	8	9	9	134
10%	282	248	200	220	227	275	522	524	298	303	349	312	275
20%	702	263	232	276	241	337	832	631	338	351	372	365	317
30%	745	269	263	304	276	381	1,018	780	370	371	394	401	365
40%	812	294	285	321	354	468	1,271	829	414	386	428	423	389
50%	836	320	297	338	389	492	1,338	913	644	418	439	434	417
60%	889	337	311	354	426	552	1,636	1,352	1,105	468	450	444	484
70%	980	348	336	384	467	1,506	1,790	1,477	1,219	528	461	486	596
80%	1,058	384	380	450	609	1,620	1,967	1,704	1,374	734	515	559	718
90%	1,129	471	485	545	1,182	1,925	2,104	1,830	1,759	1,189	593	670	921
Max	1,995	2,982	5,410	8,129	8,269	7,461	3,362	2,558	4,873	3,214	1,823	2,315	2,526
Avg	808	386	417	615	723	1,071	1,387	1,125	914	590	491	533	547

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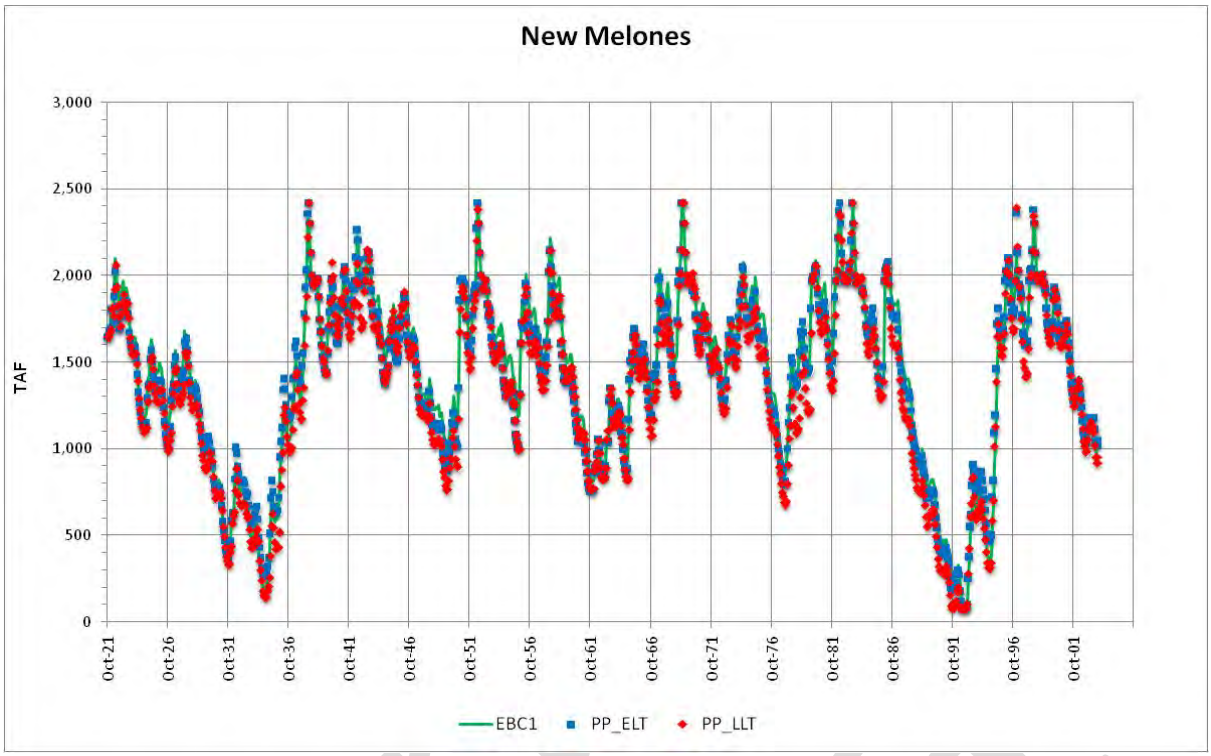

Figure C.A-21. CALSIM-Simulated Monthly New Melones Reservoir Storage for 1922–2003 for the EBC1 Baseline and PP_ELT and PP_LLT

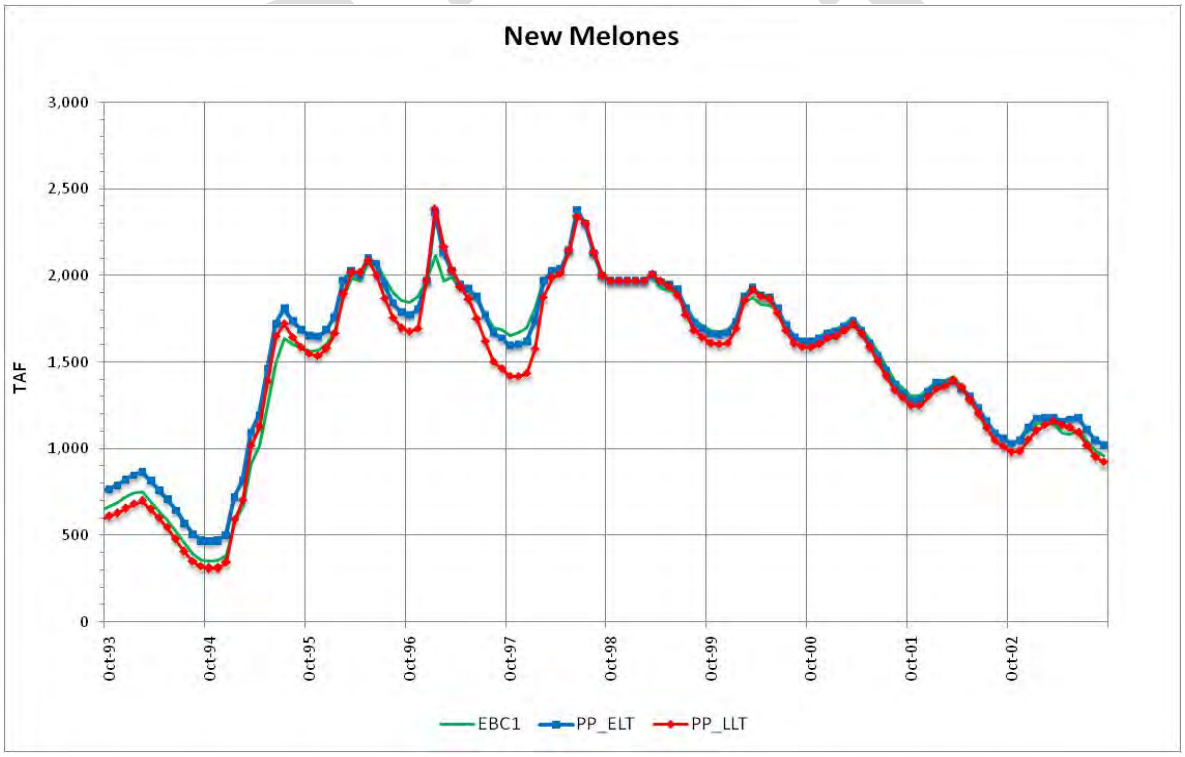

Figure C.A-22. CALSIM-Simulated Monthly New Melones Reservoir Storage for 1994–2003 for the EBC1 Baseline and PP_ELT and PP_LLT

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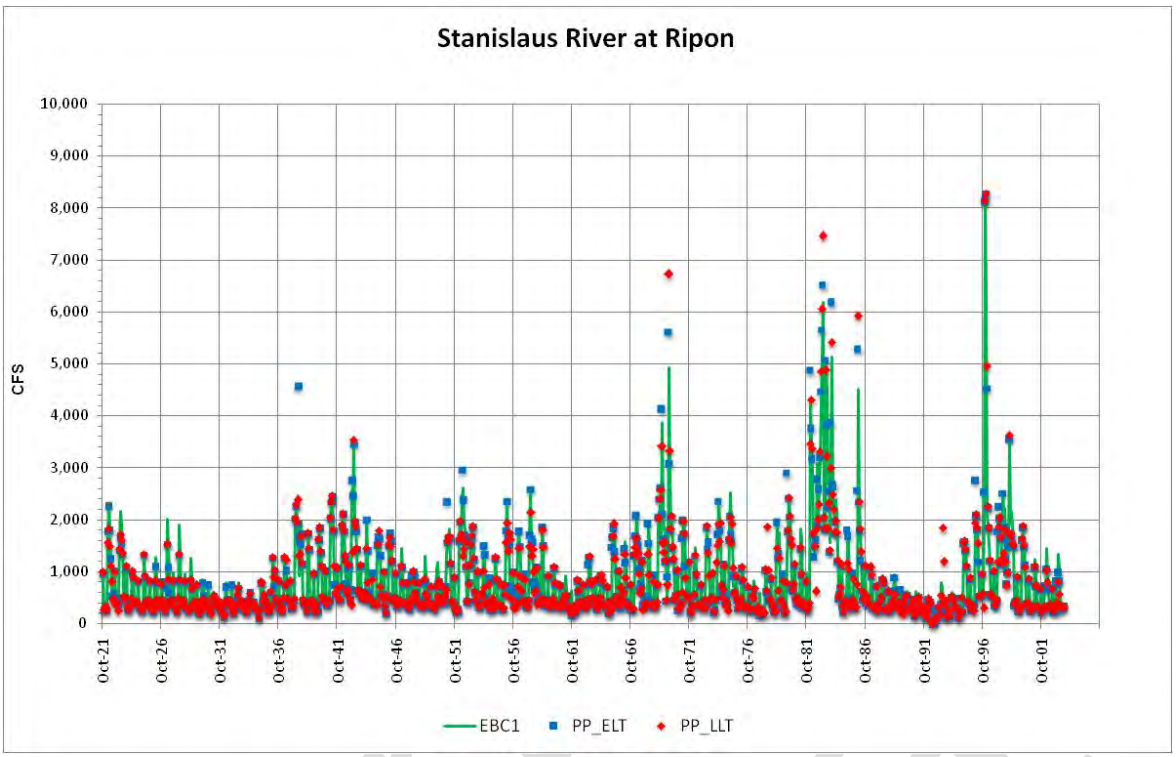

Figure C.A-23. CALSIM-Simulated Monthly Stanislaus River Flow at Ripon for 1922–2003 for the EBC1 Baseline and PP_ELT and PP_LLT

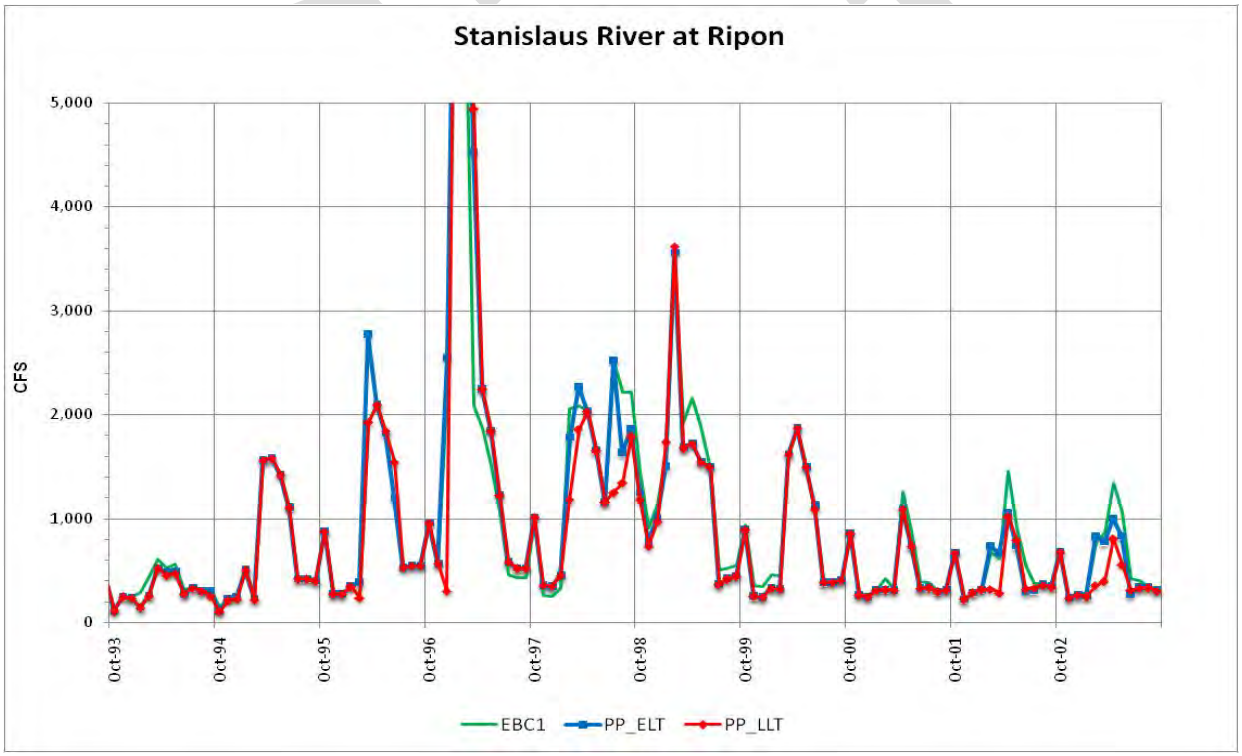

Figure C.A-24. CALSIM-Simulated Monthly Stanislaus River Flow at Ripon for 1994–2003 for the EBC1 Baseline and PP_ELT and PP_LLT

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C.A.4 CALSIM Delta Flows

This section discusses Delta channel flows and the likely effects of the preliminary proposal facilities and operations on Delta channel flows and salinity conditions. The Delta flow evaluations for the preliminary proposal rely on the DWR and Reclamation joint planning model (CALSIM II) simulation results for likely future reservoir and Delta operations with the preliminary proposal.

The major effects of the preliminary proposal Delta operations will be evaluated from changes in the monthly CALSIM-simulated flows in the Delta, including the inflows, outflows, and exports in the north Delta and south Delta. These monthly Delta inflows and outflows are also used to estimate the major channel flows within the Delta, including the Sacramento diversions into Steamboat Slough and Sutter Slough, the Delta Cross Channel (DCC) and Georgiana Slough, and Threemile Slough. The San Joaquin River diversions into Paradise Cut (flood bypass channel) and the diversions into the head of Old River are estimated from the San Joaquin River flow, the assumed head of Old River barrier (gate) and the south Delta exports. The Old River and Middle River flow (OMR) flowing north past Bacon Island can be estimated from the monthly San Joaquin River flow and the south Delta exports. A comparison of these important monthly Delta flows for the six CALSIM cases is shown and described in this section of CALSIM results for the preliminary proposal effects analysis.

The CALSIM model incorporates the State Water Resources Control Board (State Water Board) water right Decision 1641 (D-1641) objectives as well as the several Delta Actions that are included in the 2008 USFWS BiOp and the 2009 NMFS BiOp on the CVP/SWP OCAP. These are the operating rules for the baseline conditions that were used for evaluating the effects of the preliminary proposal. The Delta facilities and operating rules (objectives) will be described, and the CALSIM results for each important Delta location then will be summarized.

C.A.4.1 Delta Facilities and Operations

The following description of CVP and SWP facilities and existing operational constraints in the Delta is provided to establish current operational conditions needed to evaluate preliminary proposal changes in Delta flows for the effects analysis.

C.A.4.1.1 Delta Pumping Capacity

The CVP Tracy facility, about 5 miles north of Tracy, consists of six pumps, including one rated at 800 cfs, two rated at 850 cfs, and three rated at 950 cfs. Maximum pumping capacity is about 5,100 cfs. The CVP Tracy facility is located at the end of an earth-lined intake channel about 2.5 miles long. At the head of the intake channel, louver screens that are part of the CVP Tracy Fish Collection Facility intercept fish, which are collected and transported by tanker truck to release sites near Antioch. Other CVP facilities in the Delta include the DCC and the Contra Costa Canal (CCC). The DCC is a gated diversion channel, just over a mile long, connecting the Sacramento River near Walnut Grove with Snodgrass Slough. Flows into the DCC from the Sacramento River are controlled by two 60-foot-wide by 30-foot-high radial gates. When the gates are open, water flows from the Sacramento River through the DCC to natural channels of the lower Mokelumne and San Joaquin Rivers and toward the interior Delta to supply the CCC and the CVP Tracy facility in the south Delta and improve water quality by reducing saltwater intrusion from Antioch.

The CCC originates at Rock Slough, about 4 miles southeast of Oakley, and supplies the Contra Costa Water District (CCWD). The canal and associated facilities are part of the CVP but are operated and

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maintained by the CCWD. CCWD now also operates a diversion on Old River just south of the State Route (SR) 4 Bridge that provides the intake for Los Vaqueros Reservoir and connects with the CCC; however, this intake and Los Vaqueros Reservoir are not CVP facilities. CCWD is constructing an alternative intake on Victoria Canal about 1 mile northeast of Old River.

The CVP Jones Pumping Plant (CVP Jones) has an authorized capacity of 4,600 cfs. This is equivalent to 9,125 acre-feet per day (af/day). Table C.A-17 compares the CVP monthly demands to the maximum possible CVP Tracy monthly pumping. The full CVP monthly demands usually exceed the CVP monthly pumping capacity in the May–August period. Water must be stored in San Luis Reservoir during the winter period to supply the typical CVP demands. If the CVP Jones pumps were at maximum permitted capacity (4,600 cfs) for the entire year, they would deliver about 3,330 taf/yr (about 275 taf each month). This is unlikely to occur, however because there are required periods for maintenance of the pump units and the hydrology in the Delta may not allow full pumping every day of the year. The Delta-Mendota Canal (DMC) capacity generally declines to about 4,200 cfs at the O'Neill pumping plant near Los Banos. CVP Jones pumping is limited during the October–June period when diversions from the upper DMC (near CVP Tracy) are low. The DMC–California Aqueduct Intertie facility being constructed will allow full pumping of 4,600 cfs year-round by pumping about 500 cfs from the DMC to the aqueduct during these winter months. Because the demand for CVP water pumped at the CVP Jones pumping plant is more than 3,000 taf/yr, full CVP delivery depends on wheeling capacity at SWP Harvey O. Banks Pumping Plant (SWP Banks) to deliver some of this water each year.

The Central Valley Project Improvement Act (CVPIA) (Anadromous Fish Restoration Program [AFRP]) has introduced additional constraints on the CVP Tracy pumping capacity. A portion of the Section 3406(b)(2) water that is dedicated to anadromous fish restoration purposes (maximum of 800 taf) normally is allocated by USFWS to reduced pumping during the April–June period for fish entrainment protection. Therefore, under current regulations, it is difficult for the CVP Jones pumping plant to supply the full CVP demands. During some wet years, flows from the upper San Joaquin River (Friant Dam) and the Kings River can meet San Joaquin River Exchange Contractor demands at the Mendota Pool and allow CVP Jones pumping plant to supply other CVP contractor demands.

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Table C.A-17. CVP Tracy Pumping Plant Demands and Pumping Capacity

Month	Monthly CVP Tracy Demand (taf)	Maximum Volume at 4,600 cfs Tracy Capacity (taf)	Additional Needed from San Luis Reservoir (taf)
October	204	283	–
November	123	274	–
December	107	283	–
January	137	283	–
February	166	255	–
March	192	283	–
April	236	274	–
May	344	283	61
June	502	274	228
July	583	283	300
August	476	283	193
September	262	274	–
Total	3,332	3,330	784

cfs = cubic feet per second.
taf = thousand acre-feet.

SWP Banks has an installed capacity of about 10,668 cfs (two units of 375 cfs, five units of 1,130 cfs, and four units of 1,067 cfs). The SWP water rights for diversions specify a maximum of 10,350 cfs. With full diversion capacity (20,530 af/day) each day of the year, SWP Banks is theoretically capable of pumping 7,493 taf each year. The current permitted Clifton Court Forebay (CCF) diversion capacity of 6,680 cfs would provide a maximum of about 4,836 taf/yr if the full diversion could be maintained every day of the year. Additional permitted diversions of one-third of the San Joaquin River at Vernalis is allowed under the current permit rule for a 90-day period from December 15 to March 15, if the Vernalis flow is above 1,000 cfs. This additional increment of permitted diversions (3,670 cfs) could yield a maximum of 655 taf/yr (for a total of 5,490 taf) if the San Joaquin River flow at Vernalis was higher than about 11,000 cfs for the entire 90-day period (an unlikely hydrologic condition). Diversion and pumping at 10,350 cfs for each day of the year (20,540 af/day), if it were possible, would yield a potential water supply of about 7,480 taf/yr.

The monthly pumping capacity of SWP Banks with these pumping limits is given in Table C.A-18. The seasonal SWP demands are highest in the summer months, requiring a portion of the demands to be supplied from San Luis Reservoir storage. San Luis Reservoir releases often are needed during these months because SWP Banks pumping is limited during April–June by a combination of Vernalis Adaptive Management Program (VAMP) and the 35% export/inflow ratio that is specified in D-1641 from February through June.

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Table C.A-18. SWP Harvey O. Banks Pumping Plant Demands and Maximum Pumping Capacity

Month	Monthly SWP Banks Demand (taf)	Maximum Volume at 6,680 cfs Banks Capacity (taf)	Additional Needed from San Luis Reservoir (taf)	Maximum Volume at 10,350 cfs Banks Capacity (taf)
October	295	411	–	635
November	261	397	–	615
December	245	411	–	635
January	173	411	–	635
February	203	371	–	575
March	235	411	–	635
April	302	397	–	615
May	407	411	–	635
June	520	397	123	615
July	541	411	130	635
August	532	411	121	635
September	404	397	7	615
Total	4,118	4,836	381	7,480

taf = thousand acre-feet.

There are aqueduct and reservoir storage losses (i.e., evaporation and seepage) that are simulated by CALSIM to be about 170 taf/yr, so SWP Banks pumping for full SWP Banks (south-of-Delta) delivery must be about 4,300 taf. Only in a few years will there be sufficient Delta inflow each month to satisfy the in-Delta water diversions, meet the required Delta outflow for water quality and fisheries protection, supply the full CVP Jones pumping, and also allow SWP Banks pumping of 4,300 taf.

C.A.4.1.2 Delta Outflow Requirements

The minimum monthly Delta outflow objectives were developed by the State Water Board to protect the salinity range for agricultural uses and the estuarine aquatic habitat, and are included in D-1641. The monthly outflows from February to June are calculated (on a daily basis) to satisfy the X2 objective. Minimum monthly flows for July range from 4,000 cfs in critical years to 8,000 cfs in wet years. The August outflows range from 3,000 cfs in critical years to 4,000 cfs in below normal years or higher. The September minimum outflow is 3,000 cfs in all year types. The October minimum outflows are 3,000 in critical and 4,000 cfs in all other year types. The November and December minimum outflows are 3,500 cfs in critical and 4,500 cfs in all other year types.

C.A.4.1.3 Delta Salinity Objectives

There are several Delta locations with specified salinity objectives. Some of these protect aquatic habitat conditions, some protect agricultural diversions within the Delta, and some protect diversions for municipal water supply. SWP and CVP operations are required to protect these salinity objectives. The salinity objectives at Emmaton on the Sacramento River and at Jersey Point on the San Joaquin River often control Delta outflow during the irrigation season from April through August. The compliance values as well as the period of compliance change with WY type.

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C.A.4.1.4 X2 Objectives

The location of the estuarine salinity gradient is regulated during the months of February–June by the X2 (i.e., the position of the 2 parts per thousand [ppt] salinity gradient) objective in the 1995 WQCP (D-1641). The X2 position must remain downstream of Collinsville (kilometer 81 upstream from the Golden Gate Bridge) for the entire 5-month period. This requires a minimum outflow of about 7,100 cfs. The X2 objective specifies the number of days each month when the location of X2 must be downstream of Chipps Island (kilometer 75) or downstream of the Port Chicago electrical conductivity (EC) monitoring station (kilometer 64). The number of days depends on the previous month's runoff index value.

C.A.4.1.5 Maximum Export/Inflow Ratio

D-1641 includes a maximum E/I ratio objective to limit the fraction of Delta inflows that are exported. This objective was developed to protect fish species and to reduce entrainment losses. Delta exports are considered to be CVP Tracy and SWP Banks. Delta inflows are the measured river inflows (not including rainfall runoff in the Delta). The maximum E/I ratio is 0.35 for February through June and 0.65 for the remainder of the year. If the January eight-river runoff index is less than 1 maf (about 30% of the years), the February E/I ratio is increased to 0.45. CVP and SWP have agreed to share the allowable exports equally if the E/I ratio is limiting exports.

C.A.4.1.6 Delta Cross Channel Operations

Reclamation operates the DCC to improve the transfer of water from the Sacramento River to the export facilities at the CVP Jones pumping plant, and to improve water quality in the south Delta by reducing seawater intrusion. The DCC gates are closed when flows in the Sacramento River at Freeport reach about 25,000 cfs to reduce scour on the downstream side of the gates and to reduce potential flooding on the Mokelumne River channels. D-1641 provides for closure of the DCC gates from February 1 through May 20 for fish protection. From November through January, the DCC may be closed for up to an additional 45 days (half of the time). The gates also may be closed for 14 days during the period of May 21 through June 15. Reclamation determines the timing and duration of these DCC closures through consultation with USFWS, California Department of Fish and Game (DFG), and NMFS. Monitoring for fish presence and movement in the Sacramento River and Delta, the salvage of salmon at the Tracy and Skinner facilities, and hydrologic cues (e.g., storm events) are used to determine the timing of DCC closures. The 2009 NMFS BiOp extended the period of DCC closure for fish protection from December 1 to January 31. The DCC gates are closed anytime from October 1 to November 30 when fish are present, as determined by NMFS and DFG.

C.A.4.1.7 Old and Middle River Flow Objectives

The 2008 USFWS BiOp included new restrictions for reverse OMR flows. These reverse OMR flow restrictions are based on real-time monitoring and adaptive management triggers and off-ramps (relaxations). The period of potential reverse OMR restrictions begins in December and extends through June. Action 1 requires a 14-day reduction in exports to provide no more than 2,500 cfs reverse OMR flow to protect the "initial pulse" of migrating adult delta smelt. Action 2 protects adult delta smelt prior to spawning. The potential range of reverse OMR flow is 1,250 cfs (least pumping) to 5,000 cfs (most pumping). Highs flows (>10,000 cfs San Joaquin River at Vernalis) will relax this OMR restriction. Action 3 protects juvenile delta smelt in the south Delta. The range of reverse OMR flow is again 1,250 cfs to 5,000 cfs. This OMR restriction extends until June 30 unless the CCF

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temperature exceeds 25°C (77°F), the lethal temperature for delta smelt. The USFWS smelt committee (adaptive management for delta smelt and longfin smelt) is responsible for reductions in reverse OMR flow between 5,000 cfs and 2,000 cfs (the USFWS minimum allowed reverse OMR flow).

The 2009 NMFS BiOp included slightly different limits for reverse OMR flows. Action IV.2.3 requires a maximum reverse OMR flow of 5,000 cfs (toward the export pumps) from January 1 through June 15. There are adaptive criteria based on fish salvage that would reduce the reverse OMR limits to 2,500 cfs (allowing 1,000 cfs higher pumping than USFWS limits). The NMFS OMR limits end when Mossdale temperatures are greater than 22°C (72°F) for a week because this temperature is considered lethal for juvenile outmigration; few juveniles are caught in the Mossdale trawl once temperatures are above 70°F.

C.A.4.1.8 San Joaquin River Flow and Export Restrictions

D-1641 included objectives for the San Joaquin River flow at Vernalis during the X2 period of February–June and during the 30-day period of maximum fall-run Chinook juvenile migration through the Delta (nominally April 15 to May 15). Maximum exports during this juvenile migration period and installation of a temporary rock barrier at the head of Old River also were specified as part of this experimental flow program, referred to as the VAMP, that was implemented by Reclamation (water purchases) in coordination with the AFRP fish flows on the Stanislaus River. The flow targets for this migration period were determined from the expected flow at Vernalis without the VAMP supplementary water, and the export restrictions were linked to the target flows each year. The 12-year VAMP (2000–2010) has ended.

The 2009 NMFS BiOp extended the period of San Joaquin River flows at Vernalis for fall-run juvenile and steelhead outmigration benefits to be April1–May 31 and specified the target flow as a function of New Melones storage and Stanislaus runoff. Maximum exports during the 2-month migration period also are specified with an export/San Joaquin River flow ratio that depends on the San Joaquin River water year type. For critical years, the maximum export/San Joaquin River is 1.0. The minimum San Joaquin River flow in April and May is about 1,500 cfs, which is necessary to meet the Vernalis EC objective of 1,000 µS/cm. This is about one pump at Banks and one pump at Jones considered necessary for "health and safety" to supply the municipal water supplies dependent on the DMC and California Aqueduct flows. The export/San Joaquin River ratio is 0.5 in dry years, 0.33 in below normal years, and 0.25 in above normal and wet years. A San Joaquin River flow of 6,000 cfs would be required to allow pumping to be greater than 1,500 cfs. These export restrictions are much stronger than the D-1641 VAMP limits, and apply for 2 months.

A separate Action IV.3 requires reduction in the combined export pumping to 6,000 cfs under conditions that many fish are captured in the Sacramento Kodiak trawl or Knights Landing screw-traps or in the CVP/SWP salvage in November and December. If more than the specified fish number are caught or salvaged during January–April, the reverse OMR flow restriction is reduced from 5,000 cfs to 4,000 cfs.

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C.A.4.2 Simulated Changes in Delta Channel Flows

The CALSIM results for the Delta are shown for the six CALSIM cases. The four major Delta inflows (Sacramento River, San Joaquin River, Yolo Bypass, and Mokelumne River) are shown first. Then the San Joaquin River diversions into the head of Old River, the south Delta exports, and the resulting OMR flows are summarized. Next the six diversions from the Sacramento River at Sutter Slough, Steamboat Slough, the north Delta intakes, the DCC, Georgiana Slough, and Threemile Slough are summarized. Then the Sacramento River flow at Rio Vista, the San Joaquin River flow at Antioch, and the Delta outflow are summarized for the six CALSIM cases. Finally, the salinity estimates from CALSIM, including the X2 location and the monthly EC at four of the Delta EC compliance locations (Emmaton, Jersey Point, Rock Slough and Los Vaqueros intake), are summarized. More accurate estimates of changes in Delta salinity (EC) are shown for the DSM2 model results.

C.A.4.2.1 Sacramento River at Freeport Flows

Table C.A-19 shows the CALSIM-simulated Sacramento River flow at Freeport for the six CALSIM cases. The EBC1 and two future PP cases are shown on the first page, and the three EBC2 baseline cases are shown on the second page. The Sacramento River flow at Freeport is usually the major Delta inflow and would be the water available for diversion at the proposed north Delta intakes. The average annual inflow at Freeport was about 15,650 taf/yr for the EBC1 baseline and was reduced slightly to about 15,000 taf/yr for the PP cases. Because the assumed effects of climate change increased the Sacramento River runoff only slightly (150 taf), and the assumed increases in water supply diversions were moderate (250 taf/yr), this reduction in average Sacramento River at Freeport flow was caused largely by the increased Fremont Weir spills to the Yolo Bypass of about 750 taf/yr as described above.

The median monthly flows at Freeport for the EBC1 baseline were about 11,000 cfs in October and about 12,000 cfs in November. The median flows increased to 16,000 cfs in December, to 25,000 cfs in January, to 33,500 cfs in February, and to 27,000 cfs in March because of storm event runoff. The EBC1 median flow in April was 16,000 cfs and was about 13,000 cfs from May to September, but was increased to about 20,000 cfs in July because this was the first month with increased E/I ratio. Reservoir releases often were increased in July to take advantage of this increased E/I for south-of-Delta exports. The EBC1 median flow was about 16,000 cfs in August and 13,000 cfs in September because the high reservoir releases in July could not be sustained in most years.

The CALSIM-simulated monthly median flows for the two PP cases were similar to each other, but were shifted in comparison to the EBC1 baseline in some months. The Freeport median flows were similar in October, November, and December for the EBC1 and PP cases. The Freeport median flows in January, February, and March for the PP cases were about 3,000 cfs less than the EBC1 flows, reflecting the increased spills at the Fremont Weir into the Yolo Bypass. The April and May median flows at Freeport were similar for the PP cases and the EBC1 baseline conditions. The June median flows were increased for the PP cases. The Freeport median flows in July, August, and September were reduced by about 3,000 cfs, likely reflecting the new north Delta intakes that allow higher exports in April, May, and June and allow the exports to be distributed more evenly during the peak agricultural demand period of April through September.

Figure C.A-25 shows the CALSIM-simulated monthly Sacramento River flow at Freeport for WY 1922–2003 for the EBC1 baseline and the PP_ELT and PP_LLT cases. The great majority of the monthly flows are between 10,000 cfs and 25,000 cfs. The Sacramento River channel capacity

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downstream of Sacramento is about 80,000 cfs, so there are no simulated monthly flows of greater than 80,000 cfs. The Sacramento River inflows for the PP_ELT and PP_LLT cases appear to follow the same pattern, although almost every month is slightly different.

Figure C.A-26 shows the CALSIM-simulated monthly Sacramento River flow at Freeport for WY 1994–2003 for the EBC1 baseline and the PP_ELT and PP_LLT cases. For this recent 10-year sequence, several of the high monthly flows are different because of the different inflows and reservoir spill sequences. The monthly variations in the summer flows June–September are more extreme than observed in recent years.

Figure C.A-27 shows the monthly range of Sacramento River flows at Freeport for the EBC1 baseline and the PP_ELT case, shown as the monthly 10% cumulative flow distribution lines. These are the same monthly values shown in Table C.A-19 presented graphically. These graphs highlight the seasonal patterns of Sacramento River inflows, reflecting both the seasonal runoff from December through April and the hydrologic variability between different years. It should be remembered that the months with higher average flows actually are caused by one or more storm events (lasting 10–20 days) added to managed releases from the upstream reservoirs. Monthly average flows are more representative of actual daily flows in the summer and fall when storm events are less frequent.

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Table C.A-19. CALSIM-Simulated Monthly Distribution of Sacramento River Flows (cfs) at Freeport

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year
A. EBC1													
Min	5,918	6,947	6,608	7,483	8,473	7,851	7,788	5,447	8,310	8,539	7,150	7,193	6,556
10%	7,694	8,451	9,896	12,533	13,059	11,666	9,806	8,901	10,361	14,669	10,150	8,062	8,671
20%	9,000	9,642	11,585	13,339	14,885	15,383	11,232	10,131	11,721	17,257	13,450	11,043	10,656
30%	9,804	10,841	12,950	15,694	19,946	19,191	12,034	10,982	12,374	19,278	15,229	12,051	11,519
40%	10,626	11,177	15,011	19,442	24,695	22,066	13,316	12,101	12,691	19,645	15,692	12,776	12,284
50%	11,278	12,179	16,439	24,758	33,438	27,155	16,221	13,689	13,373	19,911	16,172	13,212	13,232
60%	11,766	13,576	18,406	30,911	43,446	33,804	20,554	15,293	13,924	20,443	16,605	13,660	17,349
70%	12,858	14,563	24,821	41,045	51,013	43,112	23,516	18,662	15,247	21,374	16,921	14,104	19,046
80%	13,765	15,847	36,152	56,012	60,934	51,777	38,496	27,859	20,410	22,708	17,588	17,116	20,672
90%	15,407	24,427	51,094	63,434	68,256	61,156	50,243	41,972	26,032	23,545	18,025	19,590	24,097
Max	32,562	54,287	76,342	77,922	76,675	81,283	71,967	59,039	60,868	25,689	20,448	26,631	33,866
Avg	11,696	14,834	23,734	31,874	37,057	32,865	23,236	19,303	16,633	19,748	15,358	13,847	15,659
B. PP_ELT													
Min	6,050	6,799	6,968	7,274	8,218	8,927	8,152	5,530	7,952	8,616	5,763	5,985	6,614
10%	7,455	7,659	10,041	12,491	12,628	11,619	10,481	8,883	10,785	9,456	8,237	8,088	8,267
20%	9,089	9,080	11,991	13,581	15,474	16,357	11,625	10,427	12,497	12,562	9,907	9,492	9,782
30%	9,860	10,298	13,168	16,283	18,601	19,726	12,845	11,095	13,165	14,410	10,860	10,058	10,831
40%	10,797	10,967	15,040	18,778	24,367	21,107	13,748	11,978	14,475	16,094	11,894	10,421	12,015
50%	11,009	11,414	16,888	22,567	30,585	24,452	16,301	14,082	15,937	17,506	12,450	10,863	12,875
60%	11,389	12,351	18,916	29,077	43,744	28,989	19,896	16,307	17,564	18,364	12,776	11,470	16,801
70%	11,596	13,720	22,439	41,254	49,775	40,993	23,099	20,849	19,636	19,155	13,509	12,308	18,240
80%	12,067	15,507	34,358	56,071	60,974	50,505	31,868	27,299	20,810	20,260	15,805	13,079	20,094
90%	14,446	23,450	54,622	65,605	69,748	62,055	46,276	39,241	23,489	22,550	16,945	14,152	23,865
Max	30,113	57,485	80,914	78,058	77,820	80,188	74,451	57,445	53,458	25,491	20,237	23,297	31,642
Avg	11,187	14,108	24,019	31,752	37,032	31,865	22,502	19,109	17,466	16,667	12,545	11,438	15,020
C. PP_LLT													
Min	5,110	5,729	6,332	6,446	8,462	8,304	8,668	5,320	8,505	8,525	7,641	6,795	6,126
10%	7,356	8,068	9,476	12,796	12,624	11,716	11,259	8,968	10,903	9,809	7,935	7,781	8,567
20%	9,150	8,407	12,764	14,430	15,928	15,413	11,905	11,320	12,191	10,982	8,771	8,753	9,771
30%	11,281	9,549	14,538	17,298	19,504	19,194	13,914	12,381	12,976	13,931	10,941	9,708	10,911
40%	13,062	10,051	15,613	20,188	23,083	21,021	15,005	13,294	15,500	15,171	11,485	10,008	11,787
50%	13,995	10,597	17,349	22,707	29,745	24,660	16,484	14,084	17,467	16,710	11,976	10,414	12,873
60%	15,299	11,470	19,095	26,788	42,849	29,594	20,131	16,924	18,147	18,334	12,532	11,117	16,816
70%	16,703	12,534	22,382	38,865	49,590	40,847	22,685	21,296	19,449	19,029	12,773	11,767	18,474
80%	18,413	14,880	32,703	56,741	62,850	51,830	32,224	24,385	21,263	20,254	13,492	12,545	19,992
90%	20,340	21,034	47,760	65,296	70,682	62,082	45,731	33,600	24,588	21,645	16,737	13,391	23,375
Max	30,218	55,396	81,077	80,439	80,032	79,177	74,338	50,028	47,508	25,879	21,549	20,892	29,686
Avg	14,207	13,097	23,302	32,064	37,516	32,007	22,893	18,249	17,450	16,175	12,129	10,771	15,031

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year
D. EBC2													
Min	5,944	5,966	7,044	9,901	8,671	8,017	7,485	5,559	8,380	8,374	7,006	7,380	6,190
10%	7,724	7,865	9,623	12,225	12,630	11,451	9,678	8,420	10,713	14,381	9,284	7,807	8,612
20%	9,066	8,992	12,159	13,579	15,095	14,381	11,168	9,881	11,538	16,709	13,547	10,497	10,334
30%	9,199	10,200	13,690	15,369	18,222	19,428	11,763	10,711	12,277	18,569	14,856	11,769	11,362
40%	9,694	12,721	14,548	19,294	24,023	21,972	13,096	11,835	12,772	19,609	15,497	12,541	12,168
50%	10,918	14,250	15,714	22,536	33,681	25,252	16,326	13,500	13,443	20,092	15,968	13,750	13,037
60%	11,269	15,609	18,052	26,683	43,545	33,598	20,663	14,860	14,155	20,433	16,685	20,575	17,242
70%	11,783	17,634	22,585	38,630	48,893	41,582	23,830	18,205	15,332	21,463	17,000	23,482	19,609
80%	12,758	18,970	33,606	55,337	60,800	52,762	38,919	27,562	20,400	22,816	17,308	27,456	21,523
90%	14,604	22,094	49,626	62,341	67,960	61,307	50,497	41,800	26,090	24,026	18,243	29,485	24,835
Max	33,102	54,738	76,389	78,032	76,794	81,371	72,174	58,744	60,463	24,971	20,024	31,418	33,470
Avg	11,156	15,663	23,087	31,371	36,583	32,474	23,234	19,041	16,583	19,626	15,213	17,577	15,740
E. EBC2_ELT													
Min	5,476	5,979	7,079	7,345	7,808	8,024	7,531	5,626	8,381	8,345	6,755	5,551	6,008
10%	7,486	7,784	9,549	12,362	12,593	11,274	9,848	8,917	10,368	13,400	8,993	7,566	8,439
20%	8,486	8,684	11,790	13,606	14,878	14,272	10,661	10,054	11,651	16,243	13,296	8,836	10,078
30%	9,191	10,626	13,534	15,773	17,828	19,068	11,457	10,529	12,148	17,788	13,893	10,590	10,931
40%	9,378	12,375	14,263	18,961	24,057	21,665	12,958	11,091	12,535	18,783	15,092	11,873	12,055
50%	11,157	14,174	15,595	22,916	34,533	25,294	15,490	12,122	13,096	20,041	15,735	12,930	13,037
60%	11,888	16,115	17,960	26,525	46,303	33,515	20,107	12,933	13,501	21,024	16,458	21,051	17,842
70%	12,533	16,914	23,000	38,682	49,350	42,469	23,188	15,743	13,946	23,334	16,834	22,114	19,648
80%	13,539	18,606	36,051	57,205	63,212	55,737	36,254	24,954	16,249	23,940	17,219	27,231	21,386
90%	14,381	22,028	51,773	65,029	70,368	62,162	50,496	36,500	20,318	24,526	17,574	29,272	24,646
Max	33,307	57,481	80,913	78,060	77,817	80,189	74,448	57,535	53,462	24,898	19,249	29,955	32,075
Avg	11,087	15,445	23,694	31,974	37,612	32,837	23,024	17,964	15,134	19,665	14,757	17,159	15,662
F. EBC2_LLT													
Min	5,957	5,447	6,919	6,399	7,112	7,835	7,894	5,055	8,906	8,345	7,858	5,594	6,507
10%	7,626	7,467	9,040	12,248	12,534	11,736	10,202	8,824	11,081	12,424	9,275	7,701	8,409
20%	9,090	8,515	11,822	13,694	15,979	15,217	11,284	9,818	12,057	16,013	13,147	8,103	10,061
30%	10,560	9,757	13,724	17,458	18,823	18,689	11,529	11,019	12,846	18,338	14,318	9,197	11,161
40%	11,467	12,089	14,374	20,243	24,156	21,425	12,262	11,369	13,436	20,200	15,397	10,717	11,854
50%	12,323	14,220	15,914	22,929	34,780	25,417	15,040	12,033	13,684	21,510	15,956	12,835	12,808
60%	12,929	15,236	18,327	26,612	44,753	32,769	19,970	12,679	14,609	22,623	16,386	22,141	17,763
70%	13,143	16,591	21,769	40,737	51,446	43,836	23,034	15,449	15,670	23,385	16,766	23,658	19,656
80%	13,552	17,941	31,611	56,848	65,667	56,138	37,671	21,900	16,565	24,014	17,279	27,036	21,433
90%	14,521	21,110	48,896	65,972	70,606	64,144	49,479	28,944	18,921	24,512	17,778	29,056	24,230
Max	29,556	53,905	81,058	80,420	80,029	79,179	74,332	50,112	47,550	25,438	19,962	31,347	30,231
Avg	11,857	14,692	22,789	32,496	38,028	33,164	22,892	16,422	15,098	20,020	15,039	16,857	15,601

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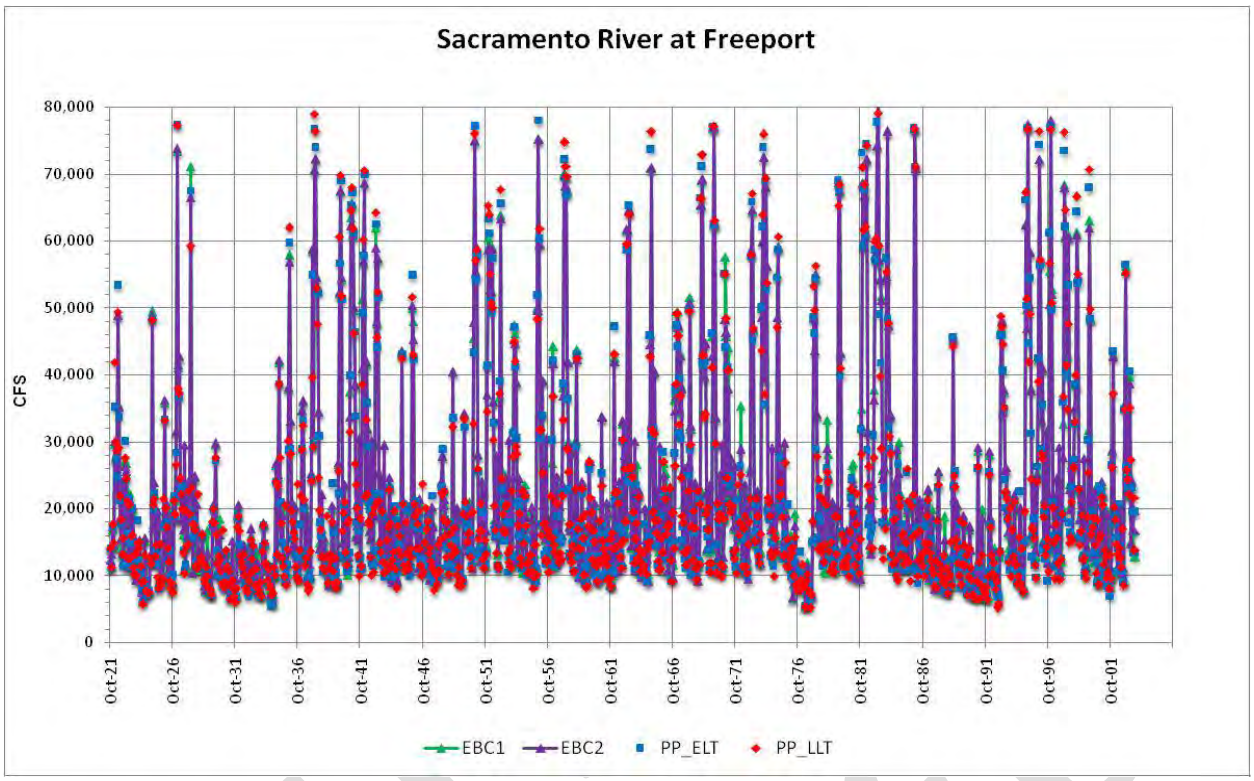

Figure C.A-25. CALSIM-Simulated Monthly Sacramento River Flow at Freeport for WY 1922–2003 for EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

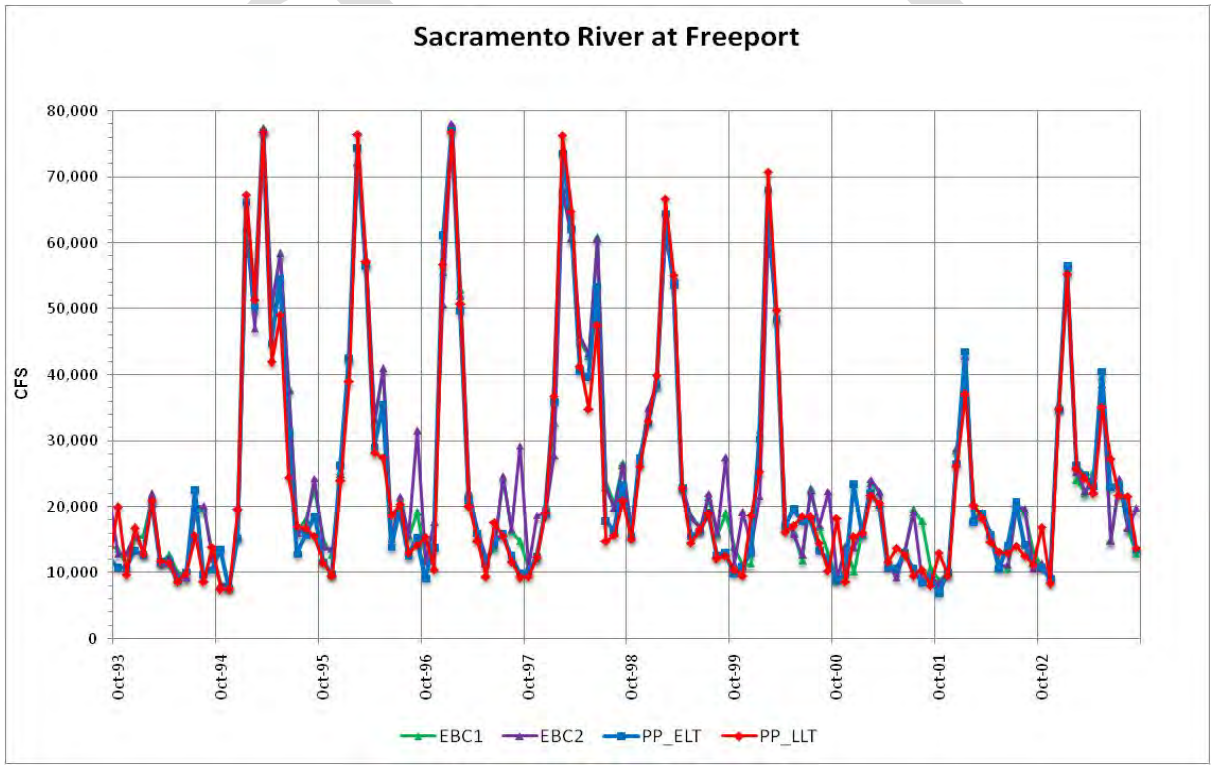

Figure C.A-26. CALSIM-Simulated Monthly Sacramento River Flow at Freeport for WY 1994–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

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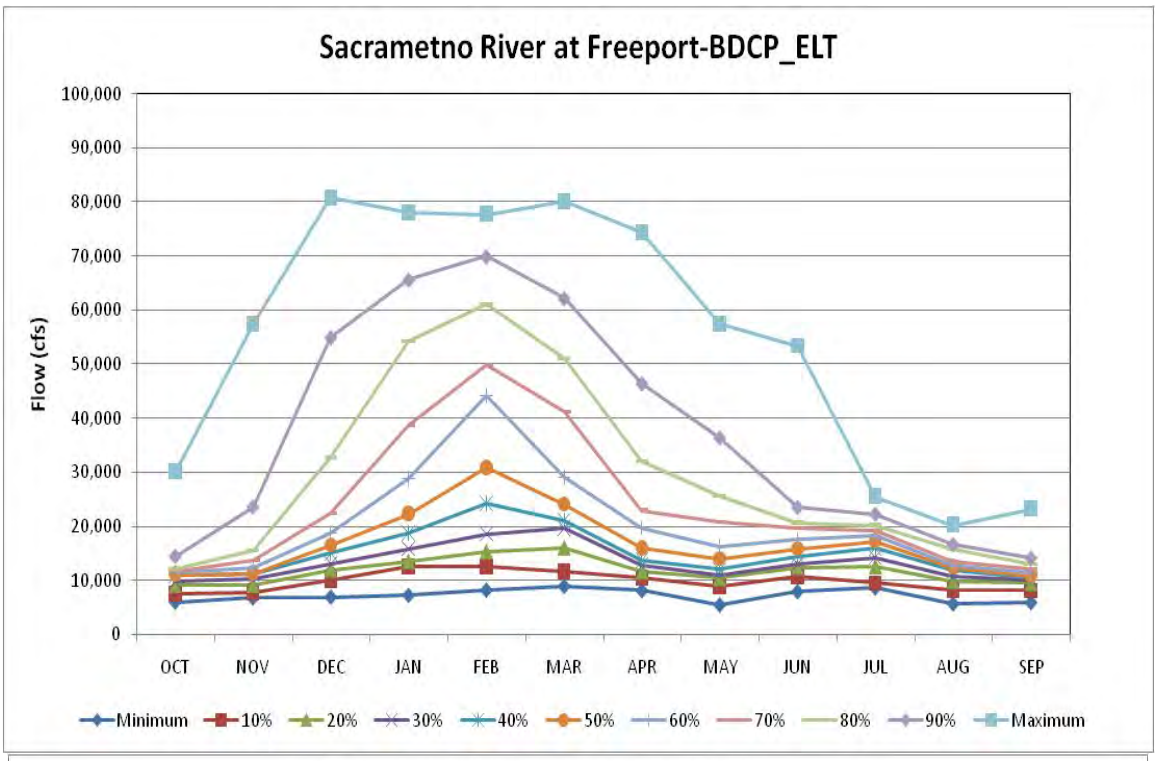

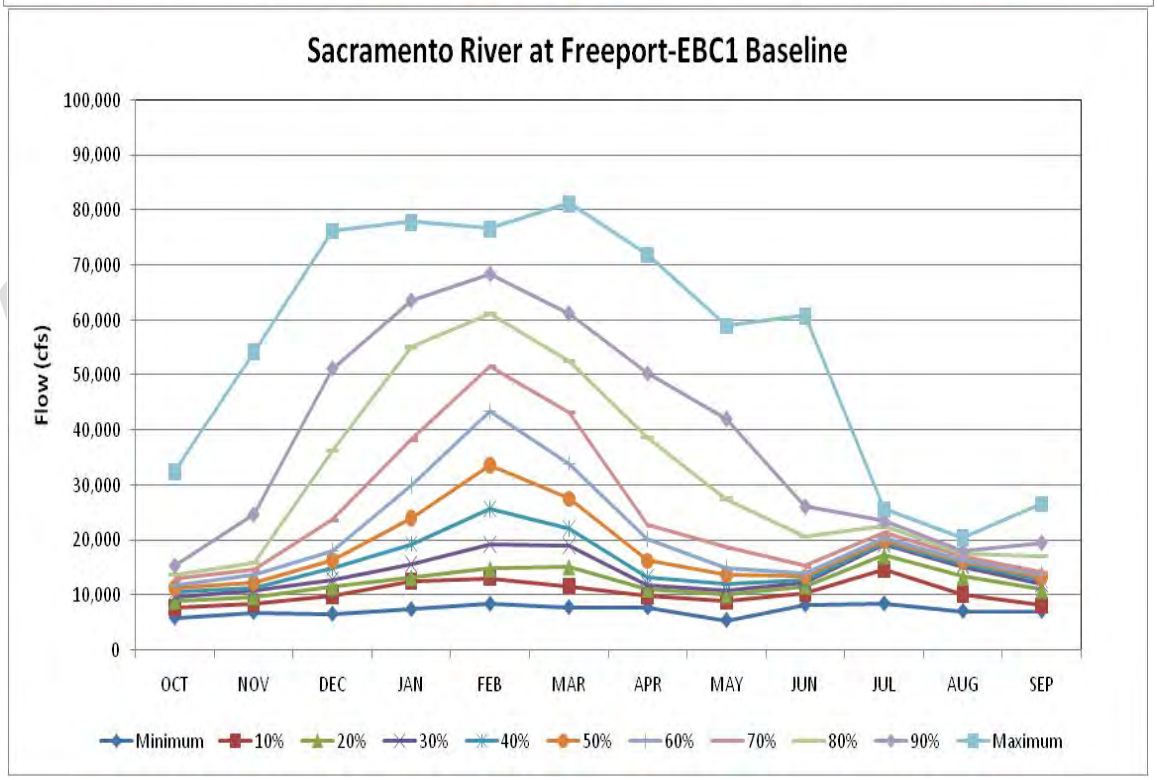

Figure C.A-27. CALSIM-Simulated Monthly Cumulative Distribution of Sacramento River at Freeport Flows for WY 1922–2003 for the EBC1 and PP_ELT Cases

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C.A.4.2.2 San Joaquin River at Vernalis Flows

Table C.A-20 shows the CALSIM-simulated San Joaquin River flows at Vernalis for the six CALSIM cases. The only changes in the San Joaquin River flows are caused by the assumed climate change effects on reduced San Joaquin River (above Friant Dam) and reduced tributary inflows. The monthly flows simulated for the 82-year sequence reflect the runoff, upstream reservoir storage and flood control operations (spills), water supply diversions for beneficial uses, and reservoir releases for fish habitat and migration benefits. The D-1641 EC objectives at Vernalis sometimes require additional releases from New Melones Reservoir.

The monthly minimum flows reflect the minimum required flow to satisfy the Vernalis EC objective. The EC objective is 700 microSiemens per centimeter (µS/cm) from April through August, which requires a minimum flow of about 1,500 cfs. The EC objective is 1,000 µS/cm from September to March, which requires a minimum flow of about 1,000 cfs. The CALSIM-simulated monthly flows include several years with less than these minimum expected flows. The high salinity conditions are part of the baseline conditions and do not change the preliminary proposal effects analysis. Using the 10% cumulative values as representative of low-flow conditions for the EBC1 baseline, the September–January 10% (cumulative) flows are about 1,500 cfs. The February–May 10% flows are about 2,000 cfs, and the June–August 10% flows are about 1,000 cfs. The San Joaquin River at Vernalis monthly median flows for the EBC1 baseline are 2,500 cfs in October because fall-run Chinook salmon attraction flows are simulated (part of D-1641 objectives and 2009 NMFS BiOp). The median flows are about 2,000 cfs in November–January, about 3,250 cfs in February and March, about 5,000 cfs in April and May (required by the 2009 NMFS BiOp), about 2,500 cfs in June, about 1,500 cfs in July–August, and 2,000 cfs in September.

Table C.A-20 indicates that the CALSIM-simulated monthly flows (distributions) for the PP_ELT and PP_LLT cases are nearly the same. The monthly flows for the three EBC2 baseline cases are also nearly identical, as judged by the monthly distribution of flows. The CALSIM-simulated annual average San Joaquin River flow at Vernalis was 3,060 taf/yr for the EBC1 baseline and was reduced slightly (1%) to 3,026 taf/yr for the PP_ELT case, and by 6% to 2,885 taf/yr for the PP_LLT case. The CALSIM-simulated annual average San Joaquin River flows were 3,024 taf/yr for the EBC2 baseline, 3,020 taf/yr for the EBC2_ELT baseline, and 2,879 taf/yr for the EBC2_LLT baseline cases. These differences are caused by the assumed climate change runoff and are not affected by the preliminary proposal. There are no effects of the preliminary proposal Delta operations on the San Joaquin River flows.

Figure C.A-28 shows the CALSIM-simulated monthly San Joaquin River flow at Vernalis for WY 1922–2003 for the EBC1 baseline and PP_ELT and PP_LLT cases. Many years have no flows higher than 3,000 cfs. Most flood control flows (spills) in higher runoff years are between 5,000 cfs and 20,000 cfs, with just a few years having flows of 40,000 cfs or more. The January 1997 monthly flow was simulated to be 60,000 cfs for the EBC1 baseline and was the highest in the 82-year sequence. The January 1997 flow was simulated to increase to 70,000 cfs for the PP_ELT and PP_LLT cases. The historical average January 1997 Vernalis flow was estimated from the upstream flow records (because San Joaquin River levees failed and flow bypassed the Vernalis gage location) to have been about 50,000cfs. Figure C.A-29 shows the CALSIM-simulated monthly San Joaquin River flow at Vernalis for WY 1922–2003 for the EBC1 baseline and PP_ELT and PP_LLT cases. The only differences in these cases are caused by slight differences in the flood control spill amounts in the wet years. The PP_ELT and PP_LLT cases often showed slightly lower spill amounts, although for January 1997 the ELT and LLT cases flows were increased substantially. These graphs suggest that

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there would be no upstream changes in the San Joaquin River reservoir operations caused by the preliminary proposal Delta operations.

Table C.A-20. CALSIM-Simulated Monthly Distribution of San Joaquin River Flows (cfs) at Vernalis

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	817	1,226	1,280	1,219	1,795	1,278	1,146	1,113	574	536	346	731	833
10%	1,644	1,637	1,636	1,625	2,154	1,838	2,043	1,941	1,077	956	1,086	1,489	1,156
20%	2,049	1,769	1,795	1,803	2,274	2,110	2,608	2,585	1,420	1,184	1,267	1,687	1,453
30%	2,196	1,876	1,863	2,071	2,354	2,293	3,429	3,293	1,529	1,287	1,367	1,770	1,624
40%	2,314	1,981	1,983	2,200	2,503	2,717	4,194	3,780	1,861	1,439	1,454	1,854	1,833
50%	2,546	2,071	2,064	2,396	3,477	3,225	5,220	4,372	2,367	1,641	1,541	1,961	1,993
60%	2,807	2,243	2,143	2,481	4,405	5,894	5,677	5,175	2,892	1,847	1,775	2,277	2,796
70%	2,975	2,399	2,319	3,273	6,158	7,611	6,570	5,613	3,351	2,124	2,400	2,557	3,372
80%	3,175	2,595	2,845	5,116	9,547	9,119	7,803	7,669	7,050	3,664	2,833	2,804	4,334
90%	3,596	2,902	4,363	9,686	15,593	14,474	12,960	13,526	11,935	7,289	3,181	3,312	5,731
Max	7,297	16,535	24,103	60,130	34,213	48,433	27,278	25,444	27,901	24,293	9,122	7,933	16,027
Avg	2,639	2,448	3,219	4,777	6,388	6,648	6,351	6,148	4,583	3,239	2,072	2,338	3,060
B. PP_ELT													
Min	845	1,295	1,239	1,078	1,606	1,183	1,089	1,101	626	366	354	863	821
10%	1,459	1,609	1,567	1,590	1,939	1,659	1,950	1,821	1,071	895	1,086	1,454	1,123
20%	1,928	1,741	1,727	1,754	2,027	1,877	2,452	2,352	1,224	1,067	1,189	1,595	1,391
30%	2,103	1,840	1,869	2,027	2,278	2,280	3,164	3,061	1,446	1,199	1,328	1,725	1,500
40%	2,294	1,957	1,938	2,177	2,497	2,557	4,011	3,741	1,793	1,406	1,429	1,826	1,784
50%	2,504	2,057	2,047	2,413	3,437	3,121	5,128	4,370	2,271	1,550	1,507	1,917	1,977
60%	2,729	2,195	2,119	2,584	4,618	5,418	5,643	5,088	2,788	1,787	1,669	2,100	2,768
70%	2,885	2,315	2,334	3,524	6,483	7,804	6,447	5,634	3,086	2,005	1,906	2,461	3,221
80%	3,110	2,655	2,801	5,099	9,252	9,255	8,309	8,047	5,727	2,599	2,529	2,660	4,380
90%	3,516	2,921	4,765	12,194	17,348	15,855	13,524	14,590	9,132	5,785	2,819	3,207	5,973
Max	8,345	17,579	28,904	68,487	37,163	50,536	28,309	30,217	27,769	18,591	7,512	6,750	16,089
Avg	2,568	2,457	3,407	5,065	6,690	6,742	6,286	6,351	3,971	2,665	1,863	2,228	3,026
C. PP_LLT													
Min	832	1,271	1,215	1,062	1,606	1,183	1,055	1,063	370	305	352	857	792
10%	1,386	1,608	1,567	1,588	1,833	1,658	1,634	1,792	1,036	880	1,065	1,428	1,120
20%	1,879	1,738	1,727	1,765	1,998	1,833	2,430	2,328	1,165	1,023	1,163	1,530	1,332
30%	2,010	1,829	1,869	2,040	2,192	2,140	3,180	2,715	1,302	1,118	1,232	1,646	1,485
40%	2,179	1,929	1,966	2,326	2,497	2,431	3,387	3,313	1,744	1,400	1,413	1,794	1,757
50%	2,442	1,994	2,092	2,417	3,155	2,861	4,882	4,513	2,182	1,512	1,504	1,898	1,902
60%	2,688	2,135	2,145	2,627	4,793	4,228	5,560	5,094	2,549	1,785	1,635	2,083	2,538
70%	2,832	2,248	2,420	3,458	6,059	7,434	6,514	5,340	3,078	1,969	1,814	2,256	3,109
80%	2,933	2,517	2,966	5,034	8,795	8,835	8,642	6,694	3,989	2,481	2,157	2,525	4,024
90%	3,313	2,812	3,655	10,917	15,351	15,911	14,364	13,474	5,717	4,148	2,716	3,125	5,806
Max	11,015	15,664	26,411	70,542	38,520	52,685	28,240	29,873	22,042	12,478	5,888	6,265	15,817
Avg	2,521	2,378	3,230	5,067	6,352	6,763	6,292	6,072	3,209	2,190	1,715	2,146	2,885

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	890	1,222	1,274	1,100	1,606	1,183	1,092	1,076	540	543	664	921	833
10%	1,627	1,609	1,612	1,575	1,973	1,674	1,977	1,850	1,071	924	1,108	1,477	1,120
20%	2,028	1,746	1,766	1,753	2,204	1,888	2,480	2,467	1,252	1,124	1,247	1,660	1,433
30%	2,173	1,853	1,835	2,018	2,280	2,280	3,410	3,153	1,474	1,199	1,332	1,748	1,595
40%	2,293	1,957	1,955	2,150	2,444	2,632	4,187	3,731	1,821	1,392	1,425	1,828	1,795
50%	2,524	2,044	2,035	2,338	3,285	3,076	5,201	4,448	2,330	1,582	1,506	1,936	1,951
60%	2,795	2,216	2,114	2,450	4,284	5,824	5,659	5,158	2,842	1,799	1,780	2,269	2,767
70%	2,976	2,368	2,290	3,219	6,020	7,508	6,545	5,595	3,321	2,149	2,421	2,549	3,325
80%	3,154	2,562	2,816	4,981	9,399	9,029	7,751	7,664	7,128	3,685	2,815	2,779	4,274
90%	3,580	2,873	4,284	9,596	15,380	14,340	12,921	13,455	11,946	7,294	3,160	3,254	5,705
Max	7,227	16,468	23,983	59,985	34,054	48,303	27,210	25,400	27,952	24,338	9,113	7,851	15,977
Avg	2,622	2,416	3,178	4,705	6,250	6,520	6,305	6,106	4,547	3,229	2,056	2,314	3,024
E. EBC2_ELT													
Min	845	1,295	1,240	1,078	1,606	1,183	1,089	1,101	626	393	354	863	822
10%	1,459	1,609	1,567	1,589	1,938	1,658	1,947	1,817	1,070	897	1,087	1,454	1,121
20%	1,926	1,741	1,727	1,753	2,027	1,874	2,451	2,351	1,214	1,064	1,186	1,589	1,382
30%	2,102	1,840	1,868	2,018	2,277	2,280	3,161	3,055	1,441	1,180	1,314	1,722	1,499
40%	2,292	1,957	1,940	2,172	2,496	2,556	4,010	3,731	1,784	1,394	1,424	1,822	1,781
50%	2,504	2,057	2,030	2,388	3,435	3,120	5,125	4,369	2,271	1,532	1,494	1,912	1,948
60%	2,727	2,186	2,114	2,571	4,654	5,418	5,642	5,080	2,786	1,781	1,662	2,096	2,751
70%	2,883	2,295	2,324	3,184	6,457	7,803	6,446	5,633	3,081	2,001	1,901	2,457	3,230
80%	3,107	2,517	2,771	5,067	9,252	9,198	8,263	8,047	5,720	2,585	2,521	2,659	4,376
90%	3,516	2,906	4,682	12,197	17,352	15,857	13,529	14,597	9,120	5,778	2,819	3,206	5,974
Max	8,197	17,579	28,904	68,490	37,163	50,536	28,296	30,214	27,769	18,591	7,512	6,750	16,080
Avg	2,565	2,441	3,366	5,040	6,699	6,739	6,286	6,347	3,969	2,658	1,858	2,226	3,020
F. EBC2_LLT													
Min	832	1,271	1,215	1,062	1,606	1,183	1,055	1,065	370	305	352	857	791
10%	1,386	1,608	1,567	1,588	1,833	1,658	1,634	1,789	1,038	884	1,066	1,423	1,120
20%	1,878	1,737	1,727	1,792	1,998	1,834	2,430	2,326	1,162	1,014	1,167	1,527	1,329
30%	2,010	1,829	1,868	2,017	2,192	2,139	3,177	2,715	1,303	1,108	1,221	1,644	1,488
40%	2,179	1,929	1,957	2,298	2,496	2,431	3,386	3,309	1,743	1,388	1,397	1,791	1,745
50%	2,439	1,994	2,070	2,371	3,296	2,861	4,882	4,511	2,180	1,506	1,492	1,893	1,892
60%	2,689	2,128	2,138	2,637	4,880	4,228	5,560	5,089	2,542	1,779	1,634	2,079	2,526
70%	2,830	2,231	2,392	3,187	6,061	7,433	6,513	5,338	3,077	1,968	1,807	2,252	3,108
80%	2,932	2,406	2,806	4,719	8,794	8,835	8,640	6,693	3,981	2,461	2,155	2,521	3,997
90%	3,313	2,812	4,087	10,918	15,352	15,914	14,360	13,477	5,717	4,146	2,716	3,124	5,804
Max	10,609	15,527	26,411	70,547	38,520	52,685	28,236	29,861	22,042	12,478	5,888	6,265	15,792
Avg	2,515	2,367	3,211	5,018	6,361	6,763	6,291	6,069	3,206	2,184	1,710	2,144	2,879

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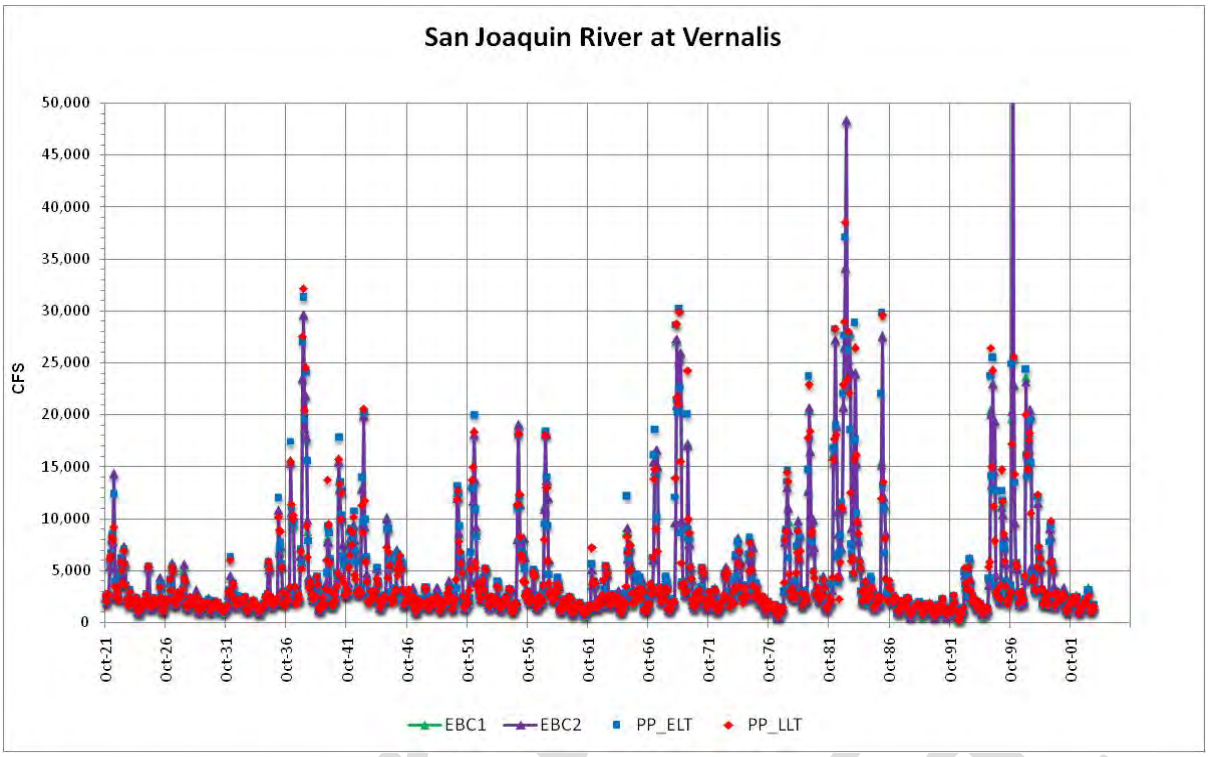

Figure C.A-28. CALSIM-Simulated Monthly San Joaquin River Flow at Vernalis for WY 1922–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

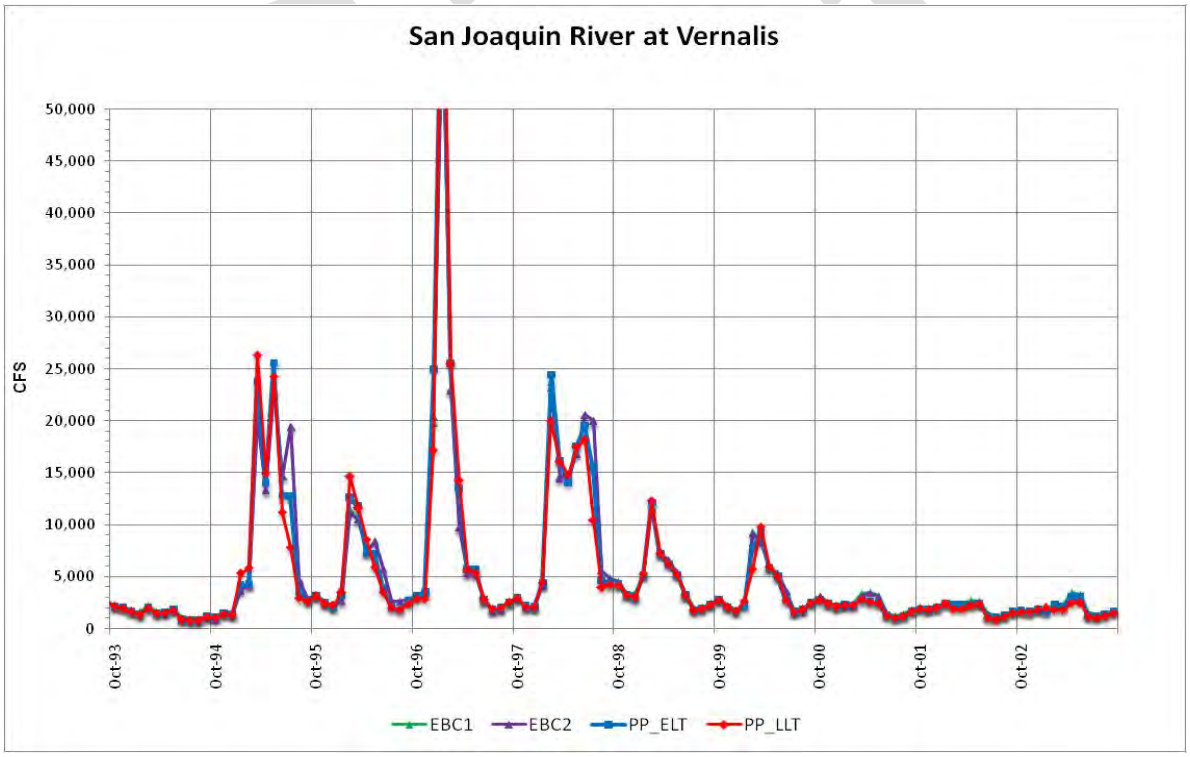

Figure C.A-29. CALSIM-Simulated Monthly San Joaquin River Flow at Vernalis for WY 1994–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

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C.A.4.2.3 Yolo Bypass Flows to the Delta

Table C.A-21 shows the CALSIM-simulated San Joaquin River flows at Vernalis for the six CALSIM cases. The Yolo Bypass flow is nearly identical to the Fremont Weir spills (Table C.A-12) with the addition of the Cache Creek and Putah Creek flows entering Yolo Bypass in months with relatively high runoff. The Yolo Bypass inflow carries all Sacramento inflow greater than the 80,000-cfs channel capacity.

Figure C.A-30 shows the CALSIM-simulated monthly Yolo Bypass flow to the Delta for WY 1922–2003 for the EBC1 baseline and PP_ELT and PP_LLT cases. The high flow months with spills at the Fremont Weir into the Yolo Bypass are nearly identical for the EBC1 baseline and the PP_ELT and PP_LLT cases. Figure C.A-31 shows the CALSIM-simulated monthly Yolo Bypass flow to the Delta for WY 1994–2003. Although the PP_ELT and PP_LLT cases allow some additional flows into the Yolo Bypass at the Fremont Weir, the monthly sequences of Yolo Bypass flows are very similar. A few more months have flows of 3,000 cfs to 5,000 cfs (notch capacity) and the high flow months have slightly more flow (5,000 cfs).

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Table C.A-21. CALSIM-Simulated Monthly Distribution of Yolo Bypass Flow (cfs) to Delta [Existing Monthly Distributions for EBC1 (no Fall X2 requirements)]

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year
A. EBC1 (cfs)													
Min	0	0	0	0	0	0	39	38	52	41	41	22	28
10%	8	0	0	4	1	6	53	50	61	47	53	50	54
20%	17	0	0	50	58	47	73	56	63	47	54	54	128
30%	34	1	5	115	234	115	86	60	64	47	54	56	179
40%	40	5	36	315	700	359	110	62	65	47	54	57	273
50%	47	8	155	552	2,361	940	133	65	66	47	54	57	597
60%	50	9	313	1,888	5,306	1,737	196	67	66	47	54	57	1,210
70%	57	40	955	4,016	7,657	3,425	532	70	66	47	54	57	2,518
80%	59	105	2,852	12,944	17,808	7,921	3,162	75	66	47	54	82	4,497
90%	74	425	13,029	34,322	44,019	23,884	6,581	314	66	47	181	168	7,854
Max	7,102	12,427	55,567	132,155	126,877	118,412	40,899	8,889	3269	47	654	414	13,751
Avg	144	432	3,669	9,989	12,908	8,508	2,428	267	120	47	102	81	2,301
B. PP_ELT (cfs)													
Min	100	100	100	100	100	102	150	140	153	41	42	120	101
10%	105	100	100	124	124	151	170	153	162	48	54	152	141
20%	115	100	123	174	278	260	187	159	164	48	55	155	313
30%	129	105	158	503	702	818	212	163	166	48	55	158	475
40%	140	108	378	1,129	3,662	1,663	239	165	167	48	55	159	658
50%	145	110	583	2,578	5,386	3,014	297	168	167	48	55	159	1,171
60%	153	133	998	5,344	10,088	5,117	497	170	168	48	55	159	2,090
70%	159	151	2,011	8,507	12,712	8,493	2,054	173	168	48	55	159	3,257
80%	162	258	5,991	17,540	22,335	11,050	7,374	178	168	48	55	160	5,750
90%	163	631	18,509	41,487	54,003	26,649	10,346	338	168	48	289	240	9,572
Max	2,468	16,412	82,064	149,100	146,836	132,072	44,772	5640	1111	48	628	374	16,571
Avg	184	629	5,758	13,259	16,712	10,887	3,695	310	183	48	105	172	3,092
C. PP_LLT (cfs)													
Min	100	100	100	100	100	102	149	126	153	41	42	120	101
10%	105	100	100	108	152	149	180	153	162	48	54	152	155
20%	116	100	110	250	338	269	200	158	164	48	55	155	317
30%	129	101	197	643	690	711	231	162	166	48	55	158	452
40%	140	105	324	1,280	2,789	1,601	259	164	167	48	55	159	571
50%	145	109	577	2,306	4,893	2,985	315	167	167	48	55	159	1,100
60%	154	120	985	5,054	9,663	4,864	545	169	168	48	55	159	1,903
70%	160	150	1,942	8,103	12,875	8,667	2,318	172	168	48	55	159	3,479
80%	163	245	5,775	18,243	25,916	12,349	6,877	177	168	48	55	161	5,380
90%	175	575	13,808	42,074	57,276	28,861	10,305	182	168	48	174	252	10,005
Max	2,452	12,892	82,969	159,540	151,821	138,907	43,817	2029	954	48	628	452	17,514
Avg	187	461	4,785	13,676	17,391	11,505	3,621	238	181	48	101	178	3,115

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year
D. EBC2													
Min	0	0	0	0	0	0	42	40	53	41	42	23	27
10%	6	0	0	0	0	7	56	53	62	48	54	52	65
20%	17	0	0	30	58	45	78	59	64	48	55	55	121
30%	29	1	15	110	228	115	88	63	66	48	55	58	173
40%	41	6	60	326	609	279	111	65	67	48	55	59	240
50%	46	9	148	503	1,941	917	135	68	67	48	55	59	605
60%	53	23	342	1,921	4,711	1,571	190	70	68	48	55	59	1,148
70%	59	50	973	4,182	7,177	3,283	635	73	68	48	55	59	2,368
80%	62	145	2,777	10,765	17,696	8,113	3,203	78	68	48	55	64	4,300
90%	63	475	9,981	32,898	44,314	21,993	6,614	276	68	48	165	164	7,645
Max	3,433	12,702	55,535	132,313	124,413	118,511	41,037	8,809	3,047	48	628	525	13,769
Avg	98	414	3,336	9,709	12,490	8,315	2,461	265	118	48	100	84	2,226
E. EBC2_ELT													
Min	0	0	0	0	0	0	42	40	53	41	42	23	27
10%	9	0	0	0	0	7	56	53	62	48	54	52	65
20%	17	0	0	23	58	45	78	59	64	48	55	56	124
30%	29	1	20	62	228	90	88	63	66	48	55	58	170
40%	42	5	74	243	609	249	111	65	67	48	55	59	248
50%	49	9	165	496	2,224	793	135	68	67	48	55	59	668
60%	54	17	365	1,912	5,068	2,055	229	70	68	48	55	59	1,243
70%	60	50	973	4,779	8,395	3,475	635	73	68	48	55	59	2,589
80%	63	145	2,924	12,835	20,635	8,407	3,203	78	68	48	55	85	4,956
90%	75	475	11,359	36,092	50,595	23,666	6,801	238	68	48	174	165	8,559
Max	3,635	15,313	82,043	149,398	142,950	132,056	44,748	5,544	1,017	48	628	554	15,936
Avg	104	457	4,279	11,128	14,511	9,174	2,587	210	83	48	101	89	2,542
F. EBC2_LLT													
Min	0	0	0	0	0	0	42	26	53	41	42	21	27
10%	6	0	0	0	4	7	56	53	62	48	54	52	66
20%	17	0	0	42	65	45	78	58	64	48	55	56	122
30%	32	2	20	79	228	90	95	62	66	48	55	58	165
40%	43	6	60	243	609	229	114	64	67	48	55	59	246
50%	49	9	137	482	2,195	802	139	67	67	48	55	59	570
60%	54	25	328	2,005	4,990	2,026	229	69	68	48	55	59	1,254
70%	60	50	797	4,805	8,687	4,466	635	72	68	48	55	59	2,859
80%	63	145	2,777	14,445	24,550	9,902	3,203	77	68	48	55	134	4,647
90%	74	475	8,414	36,552	52,985	26,415	7,160	82	68	48	174	266	8,930
Max	2,387	10,327	83,492	159,837	148,910	138,877	43,771	1,936	854	135	610	554	16,800
Avg	87	326	3,526	11,835	15,146	9,795	2,596	138	82	49	100	102	2,601

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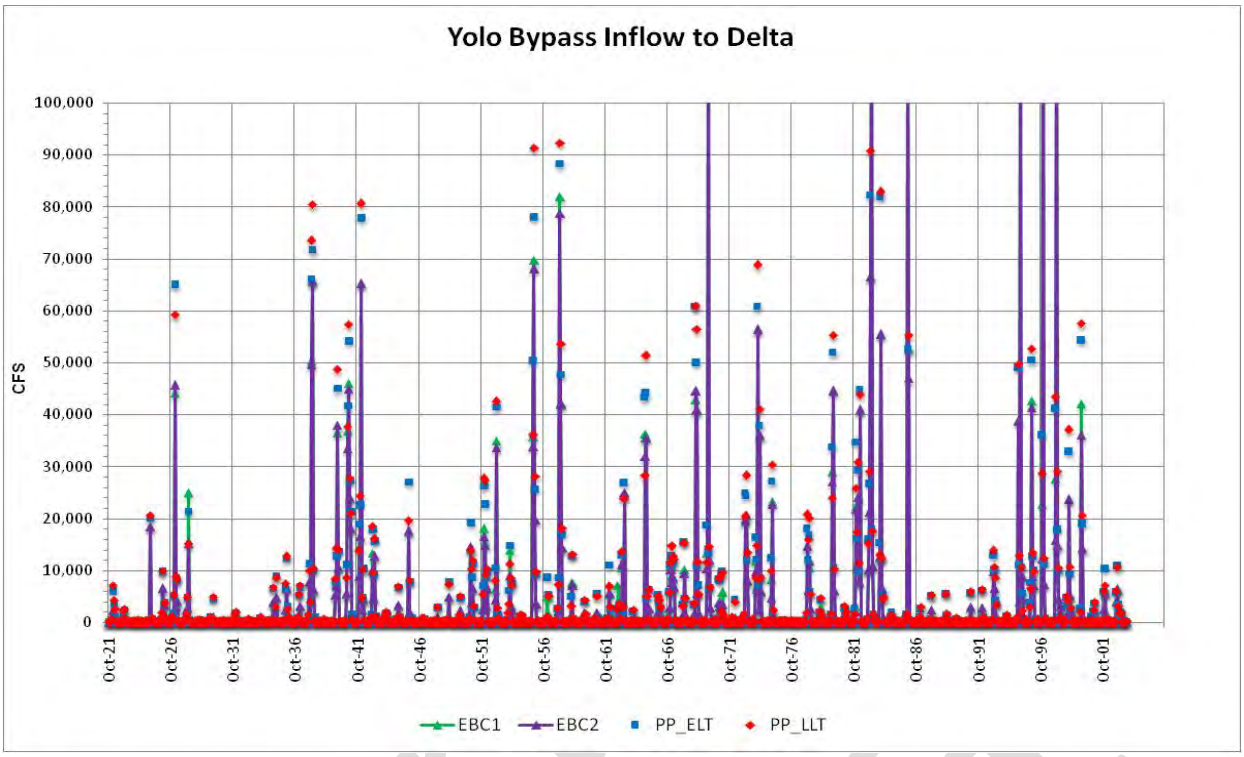

Figure C.A-30. CALSIM-Simulated Monthly Yolo Bypass Inflow to the Delta for WY 1922–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

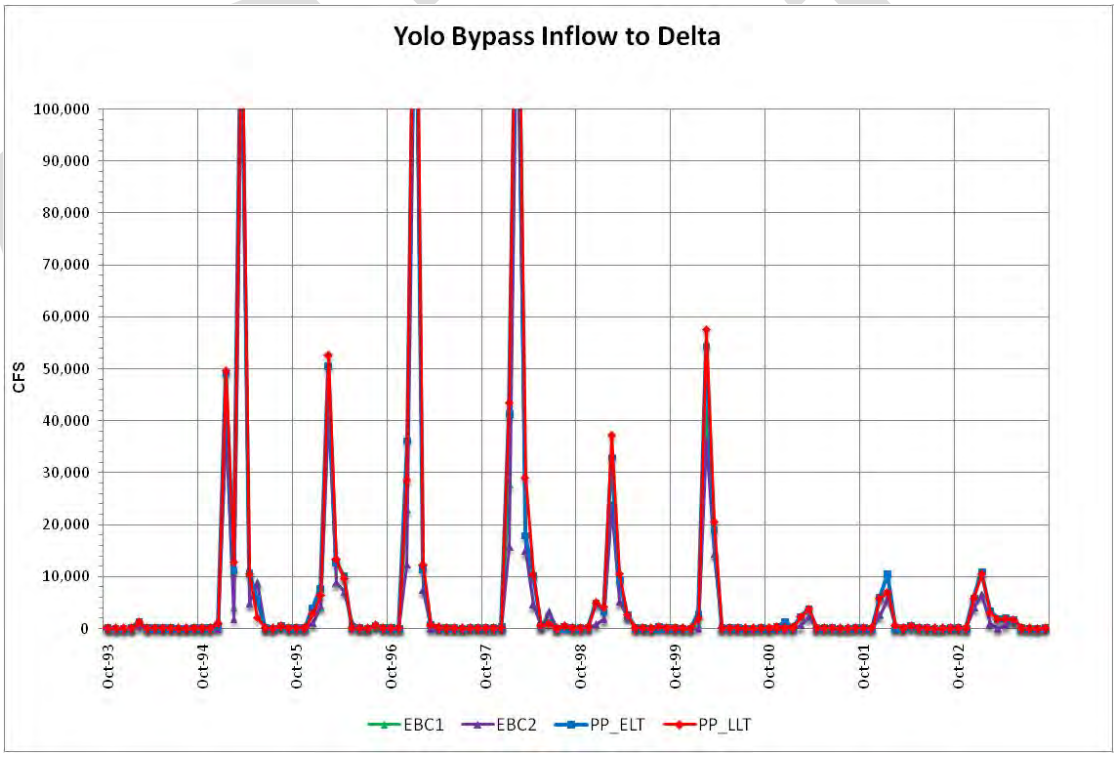

Figure C.A-31. CALSIM-Simulated Monthly Yolo Bypass Inflow to the Delta for WY 1994–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

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C.A.4.2.4 Mokelumne River and Cosumnes River Flows to the Delta

Table C.A-22 shows the CALSIM-simulated Mokelumne River and Cosumnes River inflow to the Delta for the six CALSIM cases. The Cosumnes River has only a few small reservoirs and the flows are very similar to unimpaired in the winter months. Agricultural diversions generally deplete the flows in the summer and fall. The Mokelumne River was developed by East Bay Municipal Utility District (EBMUD) for municipal water supply, and Woodbridge Irrigation District has major diversion from the river at Woodbridge Dam. The CALSIM monthly inflows from the Mokelumne River near Thornton, just below the Cosumnes River, are very low during the summer months. These flows were nearly identical for all CALSIM cases. The median monthly flows were greater than 500 cfs only in January–May. The annual average inflow for the EBC1 and EBC2 (existing hydrology) cases was 666 taf/yr. The annual average inflow for the ELT cases was 670 taf/yr, and the annual average inflow for the LLT cases was 648 taf/yr. Although some of the CALSIM monthly flows were slightly different from case to case, there were no effects from the preliminary proposal on these river flows.

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Table C.A-22. CALSIM-Simulated Monthly Distribution of Mokelumne and Cosumnes River Flow (cfs) to Delta

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	35	66	61	56	97	79	92	21	0	0	0	1	36
10%	46	129	167	254	337	483	269	158	8	0	0	6	131
20%	104	196	232	329	494	642	542	309	37	5	1	6	214
30%	130	219	290	388	677	794	647	405	121	5	3	6	265
40%	138	264	317	509	851	904	824	691	304	11	8	11	320
50%	176	288	358	641	1,149	1,048	1,160	1,095	552	157	149	143	492
60%	189	307	425	858	1,559	1,470	1,413	1,376	787	342	322	329	696
70%	193	330	462	1,368	2,225	1,942	1,747	1,669	997	483	454	445	813
80%	206	428	798	2,222	2,827	2,180	1,993	1,969	1,377	630	584	585	1,218
90%	209	839	2,092	3,723	3,968	3,235	3,300	3,878	2,094	789	758	761	1,501
Max	462	5,939	7,077	12,395	11,488	8,990	7,684	6,576	4,239	1,906	1,673	1,653	2,718
Avg	158	474	887	1,460	1,809	1,662	1,503	1,463	779	315	289	291	666
B. PP_ELT													
Min	32	74	77	100	164	145	79	21	0	0	0	0	61
10%	90	153	177	244	351	456	256	147	8	0	0	5	142
20%	115	197	232	312	474	614	518	275	36	5	1	5	200
30%	127	226	284	395	661	787	584	408	114	5	3	5	254
40%	141	254	327	486	832	874	774	627	266	11	8	10	305
50%	160	272	373	626	1,236	996	1,086	976	446	96	104	97	468
60%	172	298	443	802	1,746	1,414	1,332	1,241	674	217	205	247	720
70%	179	319	512	1,408	2,376	1,745	1,601	1,575	939	307	302	414	866
80%	184	465	879	2,368	3,084	2,217	1,845	2,031	1,165	427	409	485	1,177
90%	214	867	2,747	3,977	4,685	3,467	3,441	3,687	1,798	612	484	661	1,581
Max	537	6,399	9,148	14,197	13,116	9,189	7,729	6,428	3,856	1,495	1,369	996	2,707
Avg	154	497	1,054	1,565	2,014	1,675	1,442	1,392	697	239	200	231	670
C. PP_LLT													
Min	31	70	74	98	158	142	75	20	0	0	0	0	58
10%	86	137	166	263	341	442	243	139	8	0	0	4	139
20%	108	181	223	302	486	613	503	247	35	5	1	5	201
30%	118	204	261	384	655	759	587	392	111	5	3	5	250
40%	138	228	308	499	867	858	712	587	238	11	8	10	292
50%	151	243	358	629	1,193	995	1,005	864	371	71	77	93	457
60%	163	257	436	849	1,705	1,281	1,245	1,149	551	152	170	239	642
70%	170	295	518	1,387	2,341	1,852	1,493	1,375	739	236	265	339	841
80%	175	389	830	2,670	3,085	2,304	1,798	1,964	1,037	350	290	443	1,132
90%	204	742	2,316	4,363	4,886	3,518	3,300	3,415	1,704	449	406	515	1,513
Max	575	5,365	8,492	14,221	12,824	10,012	7,645	6,407	3,469	1,315	901	954	2,749
Avg	150	429	999	1,660	2,033	1,700	1,384	1,289	616	183	156	213	648

Draft

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	35	66	77	104	187	167	92	21	0	0	0	1	68
10%	91	166	185	270	371	491	269	163	8	0	0	6	146
20%	128	213	232	329	494	640	572	311	37	5	1	6	214
30%	133	232	290	388	697	803	647	436	121	5	3	6	265
40%	149	265	317	509	851	909	805	634	304	11	8	11	316
50%	174	288	370	639	1,163	1,038	1,160	1,055	511	143	133	121	488
60%	188	302	432	790	1,494	1,454	1,413	1,296	765	305	284	291	679
70%	193	332	465	1,321	2,210	1,926	1,747	1,725	1,048	451	426	429	879
80%	203	437	757	2,190	2,924	2,155	1,968	1,940	1,339	589	543	544	1,201
90%	212	840	2,075	3,706	4,278	3,511	3,277	3,847	2,060	751	720	723	1,484
Max	490	5,928	7,067	12,394	11,260	8,973	7,657	6,531	4,203	1,866	1,634	1,613	2,700
Avg	163	477	902	1,469	1,832	1,685	1,504	1,446	766	300	274	276	666
E. EBC2_ELT													
Min	32	74	77	100	164	145	79	21	0	0	0	0	61
10%	90	153	177	244	351	456	256	147	8	0	0	5	142
20%	115	197	232	312	474	614	518	275	36	5	1	5	200
30%	127	226	284	395	661	787	584	408	114	5	3	5	254
40%	141	254	327	486	832	874	774	627	266	11	8	10	305
50%	160	272	373	626	1,236	996	1,086	976	446	96	104	97	468
60%	172	298	443	802	1,746	1,414	1,332	1,241	674	217	205	247	720
70%	179	319	512	1,408	2,376	1,745	1,601	1,575	939	307	302	414	866
80%	184	465	879	2,368	3,084	2,217	1,845	2,031	1,165	427	409	485	1,177
90%	214	867	2,747	3,977	4,685	3,467	3,441	3,687	1,798	612	484	661	1,581
Max	537	6,399	9,148	14,197	13,116	9,189	7,729	6,428	3,856	1,495	1,369	996	2,707
Avg	154	497	1,054	1,565	2,014	1,675	1,442	1,392	697	239	200	231	670
F. EBC2_LLT													
Min	31	70	74	98	158	142	75	20	0	0	0	0	58
10%	86	137	166	263	341	442	243	139	8	0	0	4	139
20%	108	181	223	302	486	613	503	247	35	5	1	5	201
30%	118	204	261	384	655	759	587	392	111	5	3	5	250
40%	138	228	308	499	867	858	712	587	238	11	8	10	292
50%	151	243	358	629	1,193	995	1,005	864	371	71	77	93	457
60%	163	257	436	849	1,705	1,281	1,245	1,149	551	152	170	239	642
70%	170	295	518	1,387	2,341	1,852	1,493	1,375	739	236	265	339	841
80%	175	389	830	2,670	3,085	2,304	1,798	1,964	1,037	350	290	443	1,132
90%	204	742	2,316	4,363	4,886	3,518	3,300	3,415	1,704	449	406	515	1,513
Max	575	5,365	8,492	14,221	12,824	10,012	7,645	6,407	3,469	1,315	901	954	2,749
Avg	150	429	999	1,660	2,033	1,700	1,384	1,289	616	183	156	213	648

C.A.4.2.5 San Joaquin River Diversions to Old River

Table C.A-23 shows the CALSIM-simulated San Joaquin River diversion into the head (i.e., upstream end) of Old River, just downstream of Mossdale. This is the first of the Delta channel divergences (splits) that are calculated in CALSIM. The CALSIM model calculates the head of Old River flow in order to determine the net OMR flow between the south Delta exports and the central Delta (measured at Bacon Island).

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The flow splits in CALSIM were developed from the DSM2 tidal flow model results. A full description of these Delta channel flow splits is given in Appendix D, *DSM2 Delta Tidal Hydraulic and Water Quality Modeling Methods and Results*, in the October 2005 South Delta Improvements Program (SDIP) Draft Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (Jones & Stokes 2005). One can assume that the equations in the current version of CALSIM are similar to the equations presented in Appendix D of the SDIP Draft EIS/EIR.

The tidal hydraulic conditions at the head of Old River are complex because this location is near the upstream end of strong tidal fluctuations in the San Joaquin River. The average tidal variation in the San Joaquin River at the head of Old River is about 3 feet from high tide to low tide. Surprisingly, the natural flow split (without any south Delta pumping) is almost exactly equal, with half of the San Joaquin River flow entering Old River, and half flowing downstream in the San Joaquin River to Stockton. Interestingly, very little San Joaquin River flow enters Old River on ebb tide (decreasing tidal elevation). But during flood tide, the majority of the San Joaquin River flow from upstream and some tidal flow from downstream enter Old River; the flood tide and the San Joaquin River flow "squeeze" most of the water into Old River. South Delta pumping has an effect on the tidal variation in Old River and generally reduces the tidal elevations, which causes slightly more of the San Joaquin River to enter Old River. The DSM2-simulated tidal flow split, averaged over a tidal day or a tidal month (to account for the spring-tide and neap-tide variations within the lunar month), results in an Old River diversion increase of 5% of the combined CVP and SWP pumping. About 50 cfs more enters Old River for every 1,000 cfs of CVP or SWP pumping. This is a substantial factor only when the San Joaquin River flow is relatively low. For example, when the San Joaquin River flow at Vernalis is 1,500 cfs (typical summer flow), the natural flow split would be 750 cfs into Old River. But if the CVP and SWP combined pumping was 10,000 cfs, an additional 500 cfs would be diverted into Old River, leaving just 250 cfs flow at Stockton. This effect of pumping on the head of Old River flow is reduced somewhat when the temporary rock barriers are installed in Old River near the DMC and in the Grant Line Canal.

Table C.A-23 indicates that the CALSIM-calculated head of Old River flows are slightly more than 50% of the San Joaquin River flows at Vernalis (Table C.A-20). Using the monthly median flows for illustration, the calculated October median head of Old River flow was 555 cfs, while the median Vernalis flow was about 2,500 cfs. The November median flow was 334 cfs, while the San Joaquin River flow was 2,071 cfs. The head of Old River rock barrier is assumed to be installed each year during October and November to increase the San Joaquin River flow at Stockton for improved adult fall-run Chinook attraction flow. The calculated flow through the culverts or over the top of the weir was about 20% of the San Joaquin River flow. The median head of Old River flow for December through May was about half of the San Joaquin River at Vernalis flow. The median flows in June through September were about 40% of the San Joaquin River flow at Vernalis because of the effects of the south Delta rock barriers. The annual average head of Old River diversion flow was nearly the same for the six CALSIM cases. The annual average head of Old River flow was 1,272 taf/yr for EBC1; 1,254 taf/yr for EBC2;1,266 for EBC2_ELT; 1,209 taf/yr for EBC2_LLT; 1,269 taf/yr for PP_ELT; and 1212 taf/yr for PP_LLT. These changes were caused by climate change effects. The preliminary proposal would cause no changes in the head of Old River flow.

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Table C.A-23. CALSIM-Simulated Monthly Distribution of Head of Old River Flows (cfs) near Mossdale

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	143	-926	145	159	-245	685	623	607	215	199	119	275	356
10%	340	-202	734	777	1,011	931	1,045	997	425	374	429	544	491
20%	437	69	863	848	1,074	1,071	1,311	1,300	569	470	505	614	607
30%	472	188	910	891	1,141	1,157	1,698	1,634	615	513	547	643	663
40%	500	288	948	972	1,181	1,312	2,058	1,864	754	577	583	673	762
50%	555	334	972	1,059	1,417	1,573	2,542	2,142	966	662	620	711	834
60%	608	364	1,022	1,194	1,894	2,270	2,757	2,520	1,186	748	718	823	1,084
70%	651	386	1,090	1,293	2,394	3,357	3,177	2,727	1,378	864	980	923	1,293
80%	701	416	1,233	2,116	3,961	4,026	3,758	3,695	2,928	1,509	1,161	1,010	1,769
90%	747	452	1,656	2,998	5,758	5,840	6,166	6,454	4,975	3,028	1,307	1,190	2,449
Max	1,686	1,736	11,952	33,241	18,231	26,195	12,332	12,067	11,665	10,153	3,796	2,828	7,341
Avg	571	232	1,430	2,117	2,743	3,098	3,043	2,979	1,894	1,331	842	845	1,272
B. PP_ELT													
Min	150	-854	-11	377	-284	638	585	590	229	127	123	322	348
10%	296	-45	742	757	918	845	991	927	413	349	429	531	471
20%	408	210	823	833	962	943	1,226	1,177	477	421	472	581	548
30%	450	287	890	916	1,096	1,070	1,561	1,512	571	476	530	628	612
40%	495	330	938	1,019	1,143	1,253	1,960	1,832	716	563	573	663	732
50%	545	353	982	1,137	1,279	1,429	2,488	2,129	917	623	606	696	818
60%	598	369	1,032	1,213	1,994	2,152	2,729	2,467	1,133	723	673	760	1,055
70%	636	399	1,099	1,351	2,624	3,369	3,109	2,724	1,259	814	773	888	1,257
80%	679	422	1,216	2,177	3,896	4,002	3,985	3,860	2,366	1,063	1,034	959	1,747
90%	748	463	1,941	4,395	7,171	6,762	6,437	6,944	3,795	2,398	1,155	1,153	2,669
Max	1,935	2,072	14,821	37,924	19,915	27,537	12,886	14,302	11,604	7,764	3,122	2,409	7,444
Avg	557	288	1,526	2,276	2,911	3,177	3,004	3,062	1,630	1,091	755	806	1,269
C. PP_LLT													
Min	147	(735)	355	500	(295)	638	569	572	121	102	122	320	336
10%	279	(18)	769	720	901	845	840	914	400	343	420	522	470
20%	396	253	853	869	945	930	1,215	1,166	453	403	461	558	540
30%	427	317	900	943	1,020	1,056	1,568	1,349	510	443	490	600	601
40%	468	333	945	1,032	1,143	1,167	1,669	1,631	697	561	566	652	717
50%	530	361	984	1,158	1,258	1,364	2,372	2,197	881	608	604	689	787
60%	589	380	1,032	1,201	1,679	1,814	2,681	2,470	1,036	722	659	754	975
70%	623	411	1,091	1,312	2,464	3,085	3,141	2,585	1,255	799	734	816	1,219
80%	647	455	1,171	1,973	3,433	4,121	4,132	3,223	1,638	1,013	878	911	1,679
90%	737	507	1,677	3,595	5,772	7,262	6,818	6,418	2,362	1,712	1,112	1,124	2,519
Max	2,571	1,987	13,319	39,105	20,580	28,762	12,877	14,140	9,205	5,202	2,441	2,237	7,371
Avg	547	320	1,449	2,291	2,699	3,203	3,012	2,930	1,311	892	692	777	1,212

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	161	-933	165	118	-325	638	587	578	193	201	252	342	352
10%	336	-234	707	746	918	844	1,004	941	413	361	438	540	470
20%	432	79	846	824	971	959	1,239	1,231	491	445	497	604	585
30%	466	198	897	870	1,109	1,155	1,678	1,554	583	476	532	636	645
40%	495	293	928	955	1,150	1,280	2,044	1,828	729	557	571	664	741
50%	550	327	949	1,034	1,364	1,526	2,522	2,165	942	637	605	702	816
60%	612	360	1,011	1,169	1,839	2,236	2,738	2,501	1,157	728	720	820	1,069
70%	654	381	1,081	1,273	2,307	3,255	3,155	2,706	1,357	874	989	920	1,277
80%	696	405	1,235	2,064	3,880	3,926	3,722	3,679	2,953	1,518	1,154	1,001	1,742
90%	742	450	1,633	3,100	5,633	5,785	6,153	6,411	4,974	3,030	1,298	1,170	2,426
Max	1,669	1,718	11,871	33,148	18,130	26,113	12,293	12,036	11,681	10,172	3,792	2,799	7,313
Avg	567	230	1,411	2,083	2,674	3,036	3,010	2,947	1,871	1,327	835	836	1,254
E. EBC2_ELT													
Min	150	-854	70	141	-284	638	586	590	229	139	123	322	349
10%	296	-45	716	757	930	845	990	926	413	350	429	531	470
20%	407	210	813	833	979	943	1,225	1,177	473	420	471	579	547
30%	449	287	885	915	1,108	1,070	1,559	1,509	569	469	525	626	614
40%	495	327	935	1,018	1,143	1,253	1,959	1,828	712	558	571	662	731
50%	545	350	964	1,092	1,272	1,429	2,487	2,128	917	616	600	694	801
60%	598	369	1,022	1,189	2,000	2,150	2,729	2,463	1,132	720	670	759	1,054
70%	635	397	1,081	1,297	2,664	3,335	3,108	2,724	1,257	813	770	887	1,252
80%	679	417	1,183	2,118	3,896	4,002	3,963	3,860	2,363	1,057	1,030	958	1,745
90%	748	463	1,910	4,399	7,173	6,760	6,440	6,947	3,790	2,395	1,155	1,153	2,670
Max	1,900	2,072	14,821	37,926	19,915	27,537	12,880	14,301	11,604	7,764	3,122	2,409	7,442
Avg	556	285	1,507	2,264	2,915	3,176	3,004	3,060	1,629	1,088	753	805	1,266
F. EBC2_LLT													
Min	147	-734	428	452	-296	638	569	573	121	102	122	320	336
10%	279	-33	787	720	916	845	840	912	400	344	421	521	470
20%	396	250	853	869	949	929	1,215	1,165	452	399	463	557	540
30%	427	318	900	940	1,031	1,052	1,567	1,348	511	438	486	599	600
40%	468	333	945	1,016	1,148	1,167	1,669	1,629	696	555	559	651	714
50%	530	361	972	1,127	1,257	1,364	2,372	2,196	880	605	599	687	787
60%	589	380	1,022	1,183	1,675	1,815	2,681	2,468	1,033	719	658	753	970
70%	623	411	1,080	1,302	2,467	3,085	3,140	2,584	1,255	799	731	814	1,230
80%	647	455	1,170	1,954	3,435	4,120	4,131	3,222	1,635	1,005	877	910	1,655
90%	737	507	1,687	3,595	5,772	7,262	6,816	6,420	2,362	1,711	1,112	1,124	2,517
Max	2,474	1,954	13,319	39,108	20,580	28,762	12,875	14,135	9,205	5,202	2,441	2,237	7,365
Avg	546	318	1,440	2,268	2,703	3,203	3,011	2,929	1,309	889	691	776	1,209

C.A.4.2.6 South Delta Exports

Table C.A-24 shows the CALSIM-simulated combined CVP and SWP south Delta exports for the six CALSIM cases, summarized as the monthly cumulative percentiles for the 1922–2003 sequence. For the four baseline cases, all of the Delta exports are pumped from the south Delta, and for the two PP cases, most of the south Delta pumping is reduced and most of the exports are diverted at the north Delta intakes.

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Table C.A-24 indicates that the EBC1 annual average south Delta exports were 5,144 taf/yr, with minimum annual exports of 2,538 taf/yr and maximum annual exports of 6,894 taf/yr. The EBC2 baseline average annual exports were 4,898 taf/yr, with minimum annual exports of 2,007 taf/yr and maximum annual exports of 6,887 taf/yr. The EBC2_ELT annual average exports were 4,728 taf/yr, and the EBC2_LLT annual average exports were 4,441 taf/yr. The reductions in the simulated south Delta exports for the ELT (-3.5%) and the LLT (-9.5%) cases compared to the EBC2 case were the result of climate change and increased water supply demands (reduced Delta inflows) as well as effects of sea level rise on increased Delta outflows necessary for X2 and salinity control at the EC compliance locations. The PP_ELT annual average south Delta exports were simulated to be 2,985 taf/yr, with a minimum south Delta export of 691 taf/yr and a maximum south Delta export of 5,339 taf/yr. The PP_LLT annual average south Delta exports were simulated to be 2,755 taf/yr, with a minimum south Delta export of 1,293 taf/yr and a maximum south Delta export of 5,228 taf/yr. The average reduction in south Delta exports with the PP_ELT was 42%, and the average reduction in south Delta exports with the PP_LLT was 46%.

The monthly patterns of south Delta exports are very important for evaluating fish entrainment impacts. The CALSIM model accounts for all D-1641 objectives and the 2008 USFWS BiOp and 2009 NMFS BiOp actions, as well as the Delta inflows to calculate the south Delta exports. The median exports for the EBC1 case were about 9,000 cfs in October–December. The median exports were about 6,500 cfs in January–March and were only about 1,500 cfs in April and May and about 4,500 cfs in June. The median exports were highest at about 11,500 cfs in July and August and were about 10,000 cfs in September.

The median south Delta exports for the EBC2 case (with Fall X2) were about 6,500 cfs in October and November and about 8,500 cfs in December. The median exports were about 6,500 cfs in January–March, were about 1,500 cfs in April and May, and were 3,750 cfs in June. The median exports were 11,500 cfs in July and August and were 9,250 cfs in September. The major changes from the EBC1 case to the EBC2 case were a reduction in the September exports of about 500 cfs and a reduction in October and November exports of about 2,750 cfs (when the higher outflows for Fall X2 requirements were simulated). The reduction in June exports of 500 cfs was simulated from the EBC1 to the EBC2 case. The median exports in the other months were similar.

The median south Delta exports for the PP_ELT case were about 6,000 cfs in October and November and about 7,500 cfs in December. The median exports were about 4,500 cfs in January and were 1,500 cfs in February and March. The median exports were about 2,500 cfs in April and May and about 1,750 cfs in June. The median exports were 4,725 cfs in July, 4,000 cfs in August, and 5,000 cfs in September. The median south Delta exports for the PP_LLT case were about 6,000 cfs in October, 5,250 cfs in November, and about 7,250 cfs in December. The median exports were about 2,500 cfs in January, 1,750 cfs in February, and 750 cfs in March. The median PP_LLT exports were about 2,000 cfs in April and May and about 1,500 cfs in June. The median exports were 4,000 cfs in July and August and 5,000 cfs in September. The frequency of the years when the south Delta exports were reduced to zero was about 20% in January, 40% in February and March, about 20% in April, and 10% in May.

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Table C.A-24. CALSIM-Simulated Monthly Distribution of South Delta Exports (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	3,267	2,071	3,456	1,006	1,100	1,100	800	1,143	1,347	1,169	900	3,643	2,538
10%	4,824	5,138	6,135	4,451	3,792	2,224	1,500	1,500	1,597	8,966	4,293	4,964	3,439
20%	6,135	6,284	7,095	5,065	4,972	4,506	1,500	1,500	2,764	10,393	8,947	8,199	4,540
30%	7,147	7,417	7,628	5,962	5,966	4,781	1,500	1,500	3,077	11,056	10,999	9,027	4,817
40%	7,716	8,401	8,013	6,366	6,600	5,572	1,639	1,500	3,503	11,280	11,381	9,432	5,110
50%	9,009	9,079	8,607	6,446	6,998	6,629	1,718	1,570	4,441	11,382	11,463	9,895	5,303
60%	9,618	10,144	9,216	6,799	7,715	7,395	1,845	1,676	5,128	11,425	11,554	10,347	5,542
70%	10,392	10,905	9,989	6,884	8,313	8,677	2,076	1,863	5,480	11,502	11,669	11,063	5,839
80%	10,967	10,917	11,242	7,753	9,371	9,145	2,287	2,336	7,351	11,557	11,685	11,137	6,094
90%	11,044	10,934	11,320	8,941	10,800	9,819	3,259	3,440	9,096	11,595	11,725	11,158	6,313
Max	11,067	10,944	11,902	12,720	12,733	11,870	8,861	10,527	11,244	11,733	11,751	11,302	6,894
Avg	8,389	8,488	8,747	6,627	7,105	6,562	2,076	2,188	4,844	10,650	10,084	9,328	5,144
B. PP_ELT													
Min	0	0	0	0	0	0	0	0	0	230	1,391	0	691
10%	3,047	4,074	1,782	0	0	0	0	0	355	1,476	2,877	4,052	2,160
20%	5,049	4,459	4,988	0	0	0	0	492	1,029	2,372	3,145	4,529	2,360
30%	5,353	5,235	6,340	1,824	0	0	1,510	1,398	1,480	2,632	3,437	4,687	2,558
40%	6,044	5,623	7,224	2,603	0	0	2,174	1,905	1,680	3,378	3,798	4,829	2,814
50%	6,280	6,032	7,551	4,479	1,540	1,660	3,166	2,230	1,847	4,728	4,006	5,052	3,000
60%	6,681	6,340	7,826	5,779	2,995	2,075	3,907	2,839	2,986	5,549	4,303	5,307	3,199
70%	6,830	6,597	8,379	6,323	4,120	3,034	4,134	3,744	3,424	6,379	5,093	5,483	3,342
80%	7,092	7,324	9,019	6,571	5,202	4,205	4,552	4,326	3,787	8,179	5,900	5,836	3,494
90%	7,441	7,998	10,028	6,881	6,486	4,704	5,104	5,062	5,158	9,869	7,246	6,245	3,789
Max	9,079	11,799	13,050	7,263	7,196	7,266	6,261	7,879	6,838	13,935	10,935	7,051	5,339
Avg	5,847	5,953	6,962	3,767	2,381	1,889	2,698	2,523	2,482	5,178	4,639	4,963	2,985
C. PP_LLT													
Min	0	0	0	0	0	0	0	0	0	0	1,696	0	1,293
10%	2,656	2,783	1,643	0	0	0	0	0	231	884	2,244	2,030	1,891
20%	3,629	4,151	4,118	0	0	0	0	496	686	1,617	2,976	3,767	2,119
30%	4,329	4,752	5,396	1,165	0	0	1,050	1,198	1,107	2,373	3,228	4,490	2,466
40%	5,446	4,880	6,684	1,623	0	0	2,016	1,746	1,406	3,236	3,530	4,769	2,673
50%	6,048	5,268	7,349	2,658	1,909	752	2,393	1,955	1,674	3,989	3,998	5,112	2,726
60%	6,375	5,611	8,134	4,301	3,381	2,018	3,323	2,370	1,799	4,746	4,303	5,495	2,893
70%	6,597	5,941	9,265	4,692	4,174	2,841	4,144	2,958	2,905	6,334	4,741	5,647	3,020
80%	6,894	6,294	10,882	6,338	5,166	3,528	4,633	4,184	3,348	7,095	5,653	5,955	3,236
90%	7,232	7,024	11,513	6,770	6,504	4,482	5,007	4,884	3,598	9,465	6,777	6,422	3,454
Max	9,129	13,203	13,200	7,171	8,739	5,611	6,390	6,433	5,854	13,334	14,039	8,608	5,288
Avg	5,360	5,153	7,127	3,047	2,458	1,659	2,520	2,242	1,917	4,707	4,477	4,781	2,752

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	3,211	2,600	3,865	1,100	1,167	1,100	900	1,100	1,277	1,051	900	3,673	2,007
10%	4,544	3,531	6,383	4,370	3,744	2,248	1,500	1,500	1,471	7,830	3,693	4,395	3,424
20%	5,228	4,342	7,220	5,044	4,901	4,470	1,500	1,500	2,426	10,045	8,218	6,304	4,185
30%	5,725	5,129	7,835	5,851	5,723	4,745	1,500	1,500	3,104	10,729	10,721	7,593	4,595
40%	6,075	5,612	8,156	6,319	6,468	5,630	1,633	1,500	3,543	11,280	11,409	8,842	4,744
50%	6,346	6,362	8,770	6,569	6,693	6,634	1,712	1,514	3,831	11,376	11,619	9,262	4,971
60%	6,718	6,780	9,969	6,770	7,609	7,266	1,862	1,630	5,150	11,515	11,746	9,822	5,269
70%	7,317	8,243	10,585	6,881	7,940	8,645	2,021	1,782	5,502	11,574	11,780	10,517	5,623
80%	8,471	10,013	11,622	7,868	9,357	9,295	2,239	2,265	7,204	11,605	11,780	11,224	5,947
90%	9,449	11,280	11,669	9,129	10,514	9,956	3,250	3,421	9,749	11,605	11,780	11,280	6,185
Max	11,280	11,280	12,278	13,100	13,100	12,161	8,851	10,518	11,280	11,780	11,780	11,280	6,887
Avg	6,744	6,777	9,029	6,654	7,055	6,639	2,105	2,219	4,820	10,446	9,885	8,640	4,898
E. EBC2_ELT													
Min	1,544	1,891	2,782	900	1,307	1,100	900	900	1,005	900	900	2,823	1,713
10%	3,982	4,408	5,532	4,242	3,744	2,158	1,482	1,500	1,442	6,668	2,184	4,457	3,186
20%	4,490	4,791	7,169	5,086	4,846	4,315	1,500	1,500	1,680	7,948	7,668	4,818	3,915
30%	5,077	5,135	7,551	6,033	5,647	4,576	1,500	1,500	2,856	9,231	8,346	6,661	4,283
40%	5,455	5,771	7,953	6,409	6,599	5,324	1,650	1,517	3,202	9,994	10,848	8,467	4,397
50%	5,798	6,013	8,402	6,586	6,807	6,490	1,768	1,647	3,723	10,880	11,495	8,952	4,837
60%	6,115	6,769	9,766	6,784	7,651	7,173	1,929	1,769	5,081	11,137	11,630	9,405	5,158
70%	6,371	7,810	10,453	6,933	8,265	8,641	2,164	1,932	5,316	11,328	11,780	10,362	5,470
80%	6,702	9,020	11,545	8,171	9,386	9,396	2,490	2,336	5,904	11,570	11,780	11,098	5,599
90%	8,360	10,853	11,727	9,330	10,454	10,760	3,505	3,666	8,437	11,605	11,780	11,280	5,995
Max	11,280	11,280	12,278	13,100	13,100	12,161	8,851	10,777	11,280	11,621	11,780	11,280	6,977
Avg	5,890	6,753	8,812	6,720	7,148	6,588	2,181	2,307	4,420	9,652	9,433	8,326	4,728
F. EBC2_LLT													
Min	546	1,846	82	1,500	900	959	900	846	760	57	580	2,841	1,520
10%	2,524	3,447	4,120	4,485	3,337	2,149	1,355	1,500	1,480	3,590	3,451	4,333	2,831
20%	3,653	4,479	6,159	4,975	4,369	3,179	1,500	1,500	1,623	5,754	6,529	4,778	3,586
30%	4,160	4,874	7,220	5,697	5,484	4,563	1,597	1,500	2,362	8,258	7,926	5,574	3,825
40%	4,589	5,095	7,903	6,241	6,232	5,233	1,706	1,591	3,007	8,759	9,579	6,377	4,324
50%	4,944	5,660	8,243	6,521	6,655	6,562	1,805	1,686	3,544	9,671	10,931	7,588	4,607
60%	5,413	6,612	9,088	6,756	7,269	7,265	2,069	1,785	4,133	10,396	11,460	8,777	4,841
70%	5,780	7,132	10,518	6,860	8,229	8,209	2,219	1,961	5,105	10,844	11,672	9,392	5,081
80%	6,235	8,458	10,963	7,805	9,253	9,203	2,472	2,356	5,616	11,440	11,780	11,092	5,355
90%	6,644	11,280	11,705	9,581	10,513	10,471	3,606	3,385	6,163	11,605	11,780	11,280	5,735
Max	11,280	11,280	12,278	13,100	13,100	12,161	8,851	10,670	11,280	11,780	11,780	11,366	7,207
Avg	4,938	6,348	8,358	6,562	6,901	6,406	2,235	2,303	3,934	8,751	9,071	7,681	4,441

Draft

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C.A.4.2.7 Old and Middle River Flows

The reverse OMR flow restrictions (i.e., maximum negative flow) are adaptive management rules. The CALSIM modeling assumed that some OMR restrictions would apply for each of the applicable months (December–June). These assumed restrictions generally were held constant for each of the CALSIM cases. Because south-of-Delta pumping comes from the head of Old River (described above) or from OMR (as reverse flow), the reverse OMR flow restrictions effectively limit south Delta pumping as:

South Delta pumping limit (cfs) = reverse OMR limit (cfs) + head of Old River flow (cfs)

Some flow (about 35% of the monthly net Delta depletion) should be subtracted from the pumping limit to account for CCWD diversions and agricultural diversions in the south Delta.

Table C.A-25 shows the monthly distribution of the assumed OMR flow restrictions for each of the six CALSIM cases. The December limits would apply to just 2 weeks and the CALSIM model inputs specified a limit of 5,781 cfs in about 30% of the years. The assumed January limits were -5,000 cfs in about 40% of the years; 4,771 cfs in about 20% of the years; 3355 cfs in about 20% of the years; and 2,823 cfs in 20% of the years. The assumed February limits were -5,000 cfs in about 60% of the years; -3,500 cfs in about 20% of the years; about -2750 cfs in 10% of the years; and about -1,500 cfs in 10% of the years. The frequency of assumed restrictions of 5,000 cfs, 3,500 cfs, 2,500 cfs, and 1,250 cfs (the four named flows in the 2008 USFWS BiOp and 2009 NMFS BiOp) was arbitrary, but the CALSIM model inputs assumed -5,000 cfs would be the most frequent limit. The -5,000 cfs limit applied to 40% of the January values, 60% of the February values, 50% of the March values, 60% of the April values, 50% of the May values, and 50% of the June values.

The magnitude of the water supply reductions cannot be simulated accurately with CALSIM because the limits will be adaptively specified based on real-time monitoring of fish and turbidity and temperature conditions. The assumed restrictions provide a representative simulation compared to D-1641 conditions without any OMR restrictions. The OMR restriction of -5,000 cfs for 6 months (January–June) would allow exports of 1,800 taf. If the OMR restriction was reduced to -2,500 cfs for the 6 months, a total of 900 taf could be pumped from the south Delta. This uncertainty in the potential south Delta exports is a consequence of the adaptive management framework for the 2008 USFWS BiOp and 2009 NMFS BiOp actions regarding OMR flow.

Table C.A-26 shows CALSIM-simulated combined OMR flows for the six CALSIM cases, summarized as the monthly cumulative percentiles for the 1922–2003 sequence. Positive flow is north from the export pumping plants near Tracy toward the estuary. Because negative OMR flow is toward the south Delta pumps, the greatest negative values indicate higher pumping. The minimum values indicate the maximum pumping from the central Delta. For example, the minimum October and November OMR flows for the EBC1 case were -10,000 cfs. The October and November median OMR flows were -8,000 cfs, and the maximum October and November OMR flows were -3,000 cfs and -2,000 cfs. This indicates that reverse OMR flows were high in October and November. The minimum December OMR flow was -9,600 cfs, but the median December was -5,871 cfs (the assumed OMR limit in 30% of the years). This suggests that the OMR limits were reducing the December exports to this limit in several of the years. The minimum OMR flow in January–March and June were -5,000 cfs because the assumed OMR limits were restricting pumping to this limit in many of the years in these months. The minimum OMR flows in April and May were higher than the -5,000 cfs limit because the NMFS exports/San Joaquin River limits that apply in April and May were reducing the exports more

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than the OMR limits. The OMR flows in July–September were very high, with minimum flows of -11,000 cfs to -10,000 cfs and median OMR flows of -10,000 cfs to -9,000 cfs.

Table C.A-26 indicates that the PP_ELT and PP_LLT cases often would shift pumping from the south Delta to the north Delta intakes, and thereby increase the OMR flows. The median OMR flows for the PP_ELT case and the PP_LLT case were about 2,000 cfs higher in October and November, about the same in December, 2,000 cfs higher in January, 5,000 cfs higher in February, 3,500 cfs higher in March, 1,500 cfs higher in June, 6,000 cfs higher in July, 6,500 cfs in August, and 4,500 cfs higher in September.

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Table C.A-25. CALSIM-Simulated Monthly Distribution of Old and Middle River Flow (cfs)

Note: negative values are moving toward south Delta exports.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	-10,083	-10,146	-9,616	-5,000	-5,000	-5,000	-1,399	-1,769	-5,000	-11,487	-11,104	-10,072	-4,702
10%	-9,984	-9,897	-9,357	-5,000	-5,000	-5,000	-1,006	-1,150	-5,000	-11,263	-10,976	-9,914	-4,479
20%	-9,702	-9,810	-8,916	-5,000	-5,000	-5,000	-410	-702	-5,000	-11,166	-10,850	-9,742	-4,344
30%	-9,226	-9,629	-7,836	-5,000	-5,000	-5,000	-208	-495	-5,000	-11,117	-10,762	-9,588	-4,254
40%	-8,610	-8,782	-7,025	-4,898	-4,780	-4,537	182	-184	-4,950	-10,955	-10,588	-9,205	-4,148
50%	-8,044	-8,183	-5,871	-4,710	-4,165	-3,645	675	74	-3,500	-10,680	-10,400	-8,899	-4,014
60%	-6,974	-7,412	-5,871	-3,355	-3,500	-3,500	1,053	516	-3,500	-10,164	-10,278	-8,430	-3,728
70%	-6,480	-6,536	-5,871	-3,355	-2,776	-2,024	1,450	685	-3,500	-9,354	-9,737	-8,115	-3,393
80%	-5,641	-5,725	-5,729	-2,823	-2,268	-1,501	1,707	1,036	-2,223	-8,732	-7,732	-7,143	-3,068
90%	-4,606	-4,615	-4,552	-2,636	-742	-288	2,990	2,088	-1,975	-6,611	-4,516	-4,491	-2,419
Max	-3,179	-1,923	5,341	27,085	12,907	24,802	6,283	5,987	3,088	-11	-1,146	-3,489	2,222
Avg	-7,568	-7,592	-6,513	-3,449	-3,158	-2,758	843	353	-3,780	-9,715	-9,283	-8,236	-3,687
B. PP_ELT													
Min	-8,381	-10,749	-10,247	-5,000	-5,000	-5,000	-3,500	-3,413	-5,000	-13,560	-10,352	-5,771	-4,480
10%	-6,657	-7,289	-8,431	-5,000	-4,638	-3,500	-2,627	-2,818	-3,774	-9,640	-7,076	-5,307	-3,165
20%	-6,336	-6,485	-7,364	-5,000	-3,500	-2,771	-2,300	-2,556	-3,500	-7,460	-5,064	-5,115	-2,810
30%	-6,114	-5,868	-6,691	-5,000	-2,621	-1,566	-2,072	-1,700	-3,272	-5,675	-4,497	-4,956	-2,565
40%	-5,992	-5,594	-6,397	-4,086	-1,526	-1,150	-1,753	-1,230	-2,469	-5,324	-4,066	-4,721	-2,445
50%	-5,724	-5,334	-5,871	-2,823	1,028	1	-1,263	-1,150	-2,162	-4,359	-3,881	-4,563	-2,119
60%	-5,313	-5,012	-5,871	-1,944	1,811	1,539	-1,150	-1,150	-2,017	-3,359	-3,609	-4,356	-1,885
70%	-4,866	-4,673	-5,025	831	2,789	3,227	-127	-572	-1,735	-2,951	-3,353	-4,256	-1,609
80%	-4,660	-4,098	-3,183	2,408	4,524	4,279	2,557	1,178	-1,331	-2,268	-3,259	-4,163	-663
90%	-3,038	-3,741	1,248	6,200	8,167	7,892	6,191	6,093	-467	-1,974	-2,939	-3,978	121
Max	1,538	3,918	16,818	42,624	22,272	31,220	13,229	13,500	10,449	2,168	-1,830	1,842	7,191
Avg	-5,274	-5,266	-4,766	-662	1,327	1,622	218	104	-1,834	-4,959	-4,394	-4,351	-1,721
C. PP_LLT													
Min	-8,233	-12,201	-10,743	-5,000	-5,000	-4,363	-3,384	-3,500	-5,000	-13,007	-13,154	-6,270	-4,472
10%	-6,589	-6,383	-9,809	-5,000	-5,000	-2,823	-2,736	-2,646	-3,500	-9,181	-6,030	-5,634	-2,710
20%	-6,177	-5,536	-9,072	-4,194	-3,500	-2,214	-2,319	-1,698	-3,500	-6,229	-5,065	-5,217	-2,449
30%	-6,003	-5,290	-7,745	-2,888	-2,621	-1,269	-1,988	-1,150	-2,337	-5,526	-4,386	-4,959	-2,317
40%	-5,704	-5,019	-6,053	-2,802	-1,249	-629	-1,519	-1,150	-2,057	-4,919	-4,087	-4,773	-2,255
50%	-5,357	-4,728	-5,871	-1,133	516	9	-1,150	-1,081	-1,886	-4,250	-3,809	-4,612	-2,015
60%	-4,903	-4,495	-5,114	-611	1,550	1,200	-427	-652	-1,664	-3,679	-3,445	-4,382	-1,675
70%	-4,007	-4,290	-3,866	712	2,581	3,241	1,193	-152	-1,216	-2,772	-3,011	-4,171	-1,208
80%	-3,435	-3,817	-2,466	2,377	3,934	4,332	2,749	1,090	-422	-2,054	-2,808	-3,641	-637
90%	-2,306	-2,512	-141	5,473	7,178	7,874	6,600	5,383	411	-1,465	-2,494	-2,059	-137
Max	-193	3,462	15,144	43,736	23,131	32,580	13,196	13,338	8,050	-983	-2,111	1,707	6,573
Avg	-4,854	-4,555	-5,046	-13	1,049	1,844	379	246	-1,605	-4,699	-4,261	-4,214	-1,568

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D. EBC2													
Min	-10,349	-10,493	-10,021	-5,000	-5,000	-5,000	-1,393	-1,754	-5,000	-11,752	-11,299	-10,386	-4,522
10%	-8,167	-9,916	-9,687	-5,000	-5,000	-5,000	-1,008	-1,150	-5,000	-11,363	-11,173	-9,992	-4,245
20%	-7,467	-8,671	-9,164	-5,000	-5,000	-5,000	-532	-681	-5,000	-11,327	-11,080	-9,579	-4,112
30%	-6,488	-7,274	-8,513	-5,000	-5,000	-5,000	-219	-516	-5,000	-11,105	-10,899	-9,250	-3,989
40%	-5,877	-6,125	-7,585	-4,710	-4,947	-4,738	152	-232	-4,666	-10,811	-10,696	-8,787	-3,855
50%	-5,663	-5,634	-6,406	-4,710	-4,143	-3,790	681	122	-3,500	-10,507	-10,389	-8,361	-3,704
60%	-5,489	-5,039	-5,871	-3,355	-3,500	-3,500	1,046	381	-3,500	-10,030	-10,220	-7,898	-3,559
70%	-5,136	-4,600	-5,871	-3,355	-2,776	-2,823	1,445	630	-3,500	-9,410	-9,791	-6,867	-3,271
80%	-4,764	-3,692	-5,871	-2,823	-2,268	-1,506	1,710	988	-2,314	-8,358	-7,568	-5,564	-3,009
90%	-4,134	-3,157	-4,425	-2,823	-1,151	-781	2,947	1,943	-2,033	-6,433	-3,876	-4,070	-2,328
Max	-3,157	-2,222	5,490	24,928	14,644	24,301	4,951	3,952	1,518	-1,478	-1,306	-2,947	1,307
Avg	-6,019	-5,990	-6,768	-3,504	-3,188	-2,855	799	267	-3,761	-9,603	-9,184	-7,691	-3,485
E. EBC2_ELT													
Min	-10,424	-10,543	-9,883	-5,000	-5,000	-5,000	-1,960	-1,711	-5,000	-11,744	-11,328	-10,339	-4,481
10%	-7,064	-9,164	-9,579	-5,000	-5,000	-5,000	-1,150	-1,373	-5,000	-11,256	-11,173	-9,960	-4,116
20%	-6,015	-7,870	-8,944	-5,000	-5,000	-5,000	-827	-1,117	-5,000	-10,962	-11,028	-9,707	-3,943
30%	-5,722	-6,996	-8,428	-5,000	-5,000	-5,000	-511	-711	-5,000	-10,694	-10,863	-9,018	-3,805
40%	-5,494	-6,062	-6,877	-4,710	-4,801	-4,226	-207	-445	-3,774	-10,236	-10,712	-8,412	-3,707
50%	-5,267	-5,222	-5,871	-4,710	-3,631	-3,500	659	207	-3,500	-9,745	-10,399	-8,101	-3,612
60%	-4,867	-5,068	-5,871	-3,355	-3,500	-3,489	956	366	-3,500	-9,238	-9,751	-7,493	-3,385
70%	-4,426	-4,688	-5,871	-3,355	-2,776	-2,823	1,412	620	-3,138	-8,458	-8,012	-6,007	-3,096
80%	-4,024	-4,215	-5,529	-2,823	-2,268	-1,328	1,814	1,244	-2,309	-7,667	-7,427	-4,368	-2,730
90%	-3,437	-4,007	-3,708	-1,955	-235	-759	3,106	2,493	-2,022	-6,071	-2,887	-3,950	-2,302
Max	-1,765	-1,223	8,920	30,312	16,257	25,714	5,298	4,252	1,439	-1,851	-1,436	-2,692	1,381
Avg	-5,248	-5,970	-6,464	-3,373	-3,006	-2,691	715	262	-3,632	-9,110	-8,861	-7,423	-3,321
F. EBC2_LLT													
Min	-8,830	-10,393	-9,883	-5,000	-5,000	-5,000	-1,823	-1,802	-5,000	-11,763	-11,270	-10,442	-4,204
10%	-6,053	-9,876	-9,564	-5,000	-5,000	-5,000	-1,107	-1,325	-5,000	-10,857	-11,161	-10,128	-3,984
20%	-5,600	-7,061	-9,001	-5,000	-5,000	-5,000	-796	-1,150	-5,000	-10,454	-11,028	-9,430	-3,812
30%	-5,268	-6,432	-8,234	-4,794	-5,000	-5,000	-521	-920	-4,442	-10,162	-10,785	-8,480	-3,610
40%	-4,939	-6,103	-6,489	-4,710	-4,170	-3,790	-207	-447	-3,500	-9,931	-10,493	-7,916	-3,456
50%	-4,571	-5,116	-5,871	-4,477	-3,527	-3,500	372	-3	-3,500	-9,401	-9,971	-6,749	-3,284
60%	-4,105	-4,541	-5,871	-3,355	-3,500	-2,823	725	291	-3,500	-8,474	-8,952	-5,693	-3,173
70%	-3,793	-4,342	-5,594	-3,355	-2,750	-1,969	1,373	497	-2,886	-7,737	-7,548	-4,930	-2,823
80%	-3,115	-4,052	-4,118	-2,823	-2,233	-1,150	1,932	953	-2,071	-6,289	-6,581	-4,340	-2,631
90%	-2,306	-2,932	-3,109	-1,903	-652	-514	3,344	2,437	-2,019	-3,901	-3,487	-3,948	-1,967
Max	-837	-1,722	6,559	31,614	15,185	25,900	5,269	5,017	-967	-1,100	-1,187	-2,699	1,086
Avg	-4,427	-5,636	-6,155	-3,228	-2,964	-2,487	659	155	-3,504	-8,473	-8,604	-6,868	-3,122

Draft

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Table C.A-26. CALSIM-Simulated Monthly Cumulative Distribution of Required Minimum (Maximum Reverse) Old and Middle River Flow for 1922–2003

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
A. EBC1												
Min	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
10%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
20%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
30%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
40%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
50%	-15,000	-15,000	-15,000	-4,710	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
60%	-15,000	-15,000	-15,000	-4,710	-5,000	-4,516	-5,000	-3,500	-3,500	-15,000	-15,000	-15,000
70%	-15,000	-15,000	-5,871	-3,355	-3,527	-3,500	-3,500	-3,500	-3,500	-15,000	-15,000	-15,000
80%	-15,000	-15,000	-5,871	-3,355	-3,500	-3,500	-3,500	-3,500	-3,500	-15,000	-15,000	-15,000
90%	-15,000	-15,000	-5,871	-2,823	-2,750	-1,734	-1,150	-1,150	-1,998	-15,000	-15,000	-15,000
Max	-15,000	-15,000	-5,871	-2,823	-1,531	-1,150	-1,150	-1,150	-1,711	-15,000	-15,000	-15,000
B. PP_ELT												
Min	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
10%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
20%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
30%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
40%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-3,500	-3,500	-15,000	-15,000	-15,000
50%	-15,000	-15,000	-15,000	-4,710	-5,000	-5,000	-5,000	-3,500	-3,500	-15,000	-15,000	-15,000
60%	-15,000	-15,000	-15,000	-4,710	-5,000	-3,839	-3,500	-3,500	-3,500	-15,000	-15,000	-15,000
70%	-15,000	-15,000	-5,871	-3,355	-3,500	-3,500	-3,500	-3,500	-3,500	-15,000	-15,000	-15,000
80%	-15,000	-15,000	-5,871	-3,355	-3,500	-3,113	-3,500	-1,150	-2,097	-15,000	-15,000	-15,000
90%	-15,000	-15,000	-5,871	-2,823	-2,750	-1,328	-1,150	-1,150	-2,017	-15,000	-15,000	-15,000
Max	-15,000	-15,000	-5,871	-2,823	-1,249	-1,150	-1,150	-1,150	-1,618	-15,000	-15,000	-15,000
C. PP_LLT												
Min	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
10%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
20%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
30%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
40%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-3,500	-3,500	-15,000	-15,000	-15,000
50%	-15,000	-15,000	-15,000	-4,710	-5,000	-5,000	-3,500	-3,500	-3,500	-15,000	-15,000	-15,000
60%	-15,000	-15,000	-15,000	-4,710	-5,000	-3,548	-3,500	-3,500	-3,500	-15,000	-15,000	-15,000
70%	-15,000	-15,000	-5,871	-3,355	-3,500	-3,500	-3,500	-1,195	-2,308	-15,000	-15,000	-15,000
80%	-15,000	-15,000	-5,871	-3,355	-2,931	-3,016	-3,500	-1,150	-2,064	-15,000	-15,000	-15,000
90%	-15,000	-15,000	-5,871	-2,823	-2,268	-1,328	-1,150	-1,150	-2,021	-15,000	-15,000	-15,000
Max	-15,000	-15,000	-5,871	-2,823	-1,249	-1,150	-1,150	-1,150	-1,281	-15,000	-15,000	-15,000

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
D. EBC2												
Min	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
10%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
20%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
30%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
40%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
50%	-15,000	-15,000	-15,000	-4,710	-5,000	-5,000	-5,000	-3,500	-3,500	-15,000	-15,000	-15,000
60%	-15,000	-15,000	-15,000	-4,710	-5,000	-4,516	-5,000	-3,500	-3,500	-15,000	-15,000	-15,000
70%	-15,000	-15,000	-5,871	-3,645	-3,527	-3,500	-3,500	-3,500	-3,500	-15,000	-15,000	-15,000
80%	-15,000	-15,000	-5,871	-3,355	-3,500	-3,500	-3,500	-3,500	-3,500	-15,000	-15,000	-15,000
90%	-15,000	-15,000	-5,871	-2,823	-2,750	-2,024	-1,150	-1,150	-2,069	-15,000	-15,000	-15,000
Max	-15,000	-15,000	-5,871	-2,823	-1,531	-1,150	-1,150	-1,150	-1,801	-15,000	-15,000	-15,000
E. EBC2_ELT												
Min	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
10%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
20%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
30%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
40%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
50%	-15,000	-15,000	-15,000	-4,710	-5,000	-5,000	-5,000	-3,500	-3,500	-15,000	-15,000	-15,000
60%	-15,000	-15,000	-15,000	-4,710	-5,000	-3,839	-3,500	-3,500	-3,500	-15,000	-15,000	-15,000
70%	-15,000	-15,000	-5,871	-3,645	-3,527	-3,500	-3,500	-3,500	-3,500	-15,000	-15,000	-15,000
80%	-15,000	-15,000	-5,871	-3,355	-3,500	-3,500	-3,500	-1,229	-2,315	-15,000	-15,000	-15,000
90%	-15,000	-15,000	-5,871	-2,823	-2,750	-2,024	-1,150	-1,150	-2,051	-15,000	-15,000	-15,000
Max	-15,000	-15,000	-5,871	-2,823	-1,249	-1,150	-1,150	-1,150	-1,788	-15,000	-15,000	-15,000
F. EBC2_LLT												
Min	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
10%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
20%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
30%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-5,000	-5,000	-15,000	-15,000	-15,000
40%	-15,000	-15,000	-15,000	-5,000	-5,000	-5,000	-5,000	-3,500	-3,500	-15,000	-15,000	-15,000
50%	-15,000	-15,000	-15,000	-4,710	-5,000	-5,000	-5,000	-3,500	-3,500	-15,000	-15,000	-15,000
60%	-15,000	-15,000	-15,000	-4,710	-5,000	-3,790	-3,500	-3,500	-3,500	-15,000	-15,000	-15,000
70%	-15,000	-15,000	-5,871	-3,355	-3,500	-3,500	-3,500	-3,500	-3,500	-15,000	-15,000	-15,000
80%	-15,000	-15,000	-5,871	-3,355	-3,500	-3,016	-3,500	-1,150	-2,163	-15,000	-15,000	-15,000
90%	-15,000	-15,000	-5,871	-2,823	-2,750	-1,328	-1,150	-1,150	-2,051	-15,000	-15,000	-15,000
Max	-15,000	-15,000	-5,871	-2,823	-1,249	-1,150	-1,150	-1,150	-1,667	-15,000	-15,000	-15,000

Draft

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C.A.4.2.8 North Delta Intake Diversions

Table C.A-27 shows the CALSIM-simulated Sacramento River diversions into the proposed north Delta intakes, located along the Sacramento River between Freeport and Hood. There are no existing intakes at these locations, so the four baseline cases have no north Delta intake diversions. Although the intakes have a combined capacity of 15,000 cfs, the simulated north Delta diversions for the PP_ELT and PP_LLT cases are generally less than 5,000 cfs. The north Delta diversions are limited by the monthly inflow hydrology and the applicable D-1641 objectives that require a minimum Delta outflow. The maximum E/I ratio for the total south Delta pumping was assumed not to apply to the north Delta diversions. In addition, the proposed operating rules include monthly minimum bypass flows for the north Delta intakes to reduce the effects of these diversions on Sacramento River fish.

Table C.A-27 indicates that for the PP_ELT and PP_LLT cases, the simulated north Delta diversions would be very similar. Although the Sacramento River inflow is slightly different for each month of the 82-year sequence, the distribution of monthly flows is nearly identical (Table C.A-19). Some north Delta diversions were simulated in almost every month. However, the CALSIM-simulated north Delta diversions were 0 cfs in October for about 30% of the years for the ELT case and for about 70% of the years for the LLT case, and were 0 cfs in November for 10% of the years for the ELT case and for 20% of the years for the LLT case. The 10% cumulative diversions in December–June were about 500 cfs, which was the result of the low-level pumping (3% on Sacramento River flow) allowed in these months. For the ELT case, the median diversions were 1,700 cfs in October; 2,500 cfs in November; 1,000 cfs in December; 3,000 cfs in January; 6,500 in February; 7,000 cfs in March; 2,750 in April; 2,250 in May; 3,750 in June; 2,300 in July; and 3,000 cfs in August and September. The PP_LLT monthly median diversions were very similar.

Overall, the average annual north Delta diversion was 2,928 taf/yr for the PP_ELT case and was 2,704 taf/yr for the PP_LLT case. The major limit on the north Delta diversions was the assumed bypass flows that govern the north Delta diversions.

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Table C.A-27. CALSIM-Simulated Monthly Distribution of North Delta Diversions (cfs) near Hood

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1, EBC_2, EBC_ELT, EBC_LLT													
Min	0	0	0	0	0	0	0	0	0	0	0	0	0
10%	0	0	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	0	0	0	0
40%	0	0	0	0	0	0	0	0	0	0	0	0	0
50%	0	0	0	0	0	0	0	0	0	0	0	0	0
60%	0	0	0	0	0	0	0	0	0	0	0	0	0
70%	0	0	0	0	0	0	0	0	0	0	0	0	0
80%	0	0	0	0	0	0	0	0	0	0	0	0	0
90%	0	0	0	0	0	0	0	0	0	0	0	0	0
Max	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	0	0	0	0	0	0	0	0	0	0	0	0	0
B. PP_ELT													
Min	0	0	0	0	493	527	31	222	0	0	0	0	182
10%	0	0	567	684	783	701	638	538	653	101	115	88	621
20%	0	48	725	834	1,142	1,439	715	624	772	643	522	1,599	1,220
30%	0	684	785	1,012	2,351	3,879	1,141	724	1,506	1,261	1,301	2,096	1,570
40%	610	2,237	919	1,579	5,163	5,576	1,752	1,152	2,610	1,898	2,507	2,486	2,228
50%	1,719	2,509	1,069	2,971	6,485	7,049	2,818	2,271	3,734	2,322	3,140	2,983	2,665
60%	2,044	3,361	1,564	5,850	8,536	8,188	3,999	4,316	4,951	2,832	3,633	3,540	3,592
70%	2,344	4,296	2,405	9,140	9,321	8,637	6,827	6,939	6,262	3,439	4,000	4,189	4,175
80%	2,761	5,009	6,592	11,164	10,238	9,353	8,400	9,798	7,650	3,840	4,693	5,139	4,730
90%	5,257	7,015	10,907	12,831	10,886	9,662	10,158	11,910	10,073	5,382	5,596	6,313	5,465
Max	10,565	14,442	13,603	14,525	14,547	13,756	12,212	13,160	13,949	11,383	7,952	10,374	6,123
Avg	1,962	3,071	3,100	5,475	6,387	6,161	4,330	4,597	4,594	2,595	2,972	3,452	2,928
C. PP_LLT													
Min	0	0	0	0	0	484	238	0	272	0	0	0	136
10%	0	0	247	0	785	702	680	529	651	126	0	112	557
20%	0	0	721	760	1,141	1,042	778	731	782	313	190	230	863
30%	0	1,034	840	873	2,305	3,668	1,248	799	1,265	871	417	822	1,216
40%	0	1,368	918	1,263	5,253	5,215	2,038	1,463	2,142	1,137	1,208	1,853	1,852
50%	0	2,060	1,034	2,961	7,027	6,722	3,381	2,090	3,359	1,427	2,262	2,355	2,475
60%	0	2,809	1,291	5,962	8,964	8,540	4,047	4,089	4,650	1,959	3,391	2,727	3,183
70%	0	3,566	1,917	8,569	10,034	9,202	7,211	7,209	5,501	2,396	3,645	3,350	3,990
80%	48	5,187	5,103	11,585	10,675	9,667	8,803	9,146	6,900	3,194	4,036	4,181	4,571
90%	2,155	7,484	9,098	13,955	13,439	10,216	10,203	11,160	11,284	4,552	4,846	5,311	5,090
Max	9,938	11,472	14,035	14,524	14,547	14,575	12,209	12,265	13,225	6,874	7,174	10,195	6,159
Avg	626	2,927	2,771	5,465	6,695	6,296	4,548	4,460	4,384	1,957	2,356	2,553	2,704

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C.A.4.2.9 Sutter Slough and Steamboat Slough Flows

Table C.A-28 shows the calculated Sacramento River diversions into Sutter and Steamboat Sloughs. These two channels rejoin the Sacramento River near Rio Vista. These natural channels each divert about 20% of the Sacramento River flow. The CALSIM model has taken the tidal hydraulic flow results from the DSM2 model and used a simplified equation to estimate these diversion flows. The flow equations shift slightly if DCC is closed because the tidal elevations in the Sacramento River are slightly increased upstream of the DCC when it is closed. The DSM2 results indicate that the Sutter Slough flow is higher than the Steamboat Slough flow. The DSM2 flow splits for a range of Sacramento River at Freeport flows are given in Table C.A-19.

Table C.A-29 gives the Sutter Slough and Steamboat Slough diversions that reflect the Sacramento River flow and the operation of the DCC gates. The fraction of the Sacramento River flow increases by 8% when the DCC is closed for fish protection or flood control. For the EBC1 case, the median diversion flows reflect the median Sacramento River flows. The median diversion flow was 3,500 cfs in October, 4,500 cfs in November, and 6,500 cfs in December. The median diversion flow was 10,500 cfs in January, 15,500 cfs in February, and 12,500 cfs in March. The median diversion flow was 6,500 cfs in April, 5,500 cfs in May, and 4,500 cfs in June. The median diversion flow was 7,000 cfs in July, 5,500 cfs in August, and 4,000 cfs in September. The monthly median diversion flows into Sutter and Steamboat Sloughs were similar for the three EBC2 baseline cases because the Sacramento River flows were similar for these three EBC2 baseline cases.

The calculated monthly median diversion flows into Sutter and Steamboat Sloughs for the PP_ELT case was 3,500 cfs in October and November; 7,000 cfs in December; 9,000 cfs in January; 11,500 cfs in February; 8,000 cfs in March; 5,500 cfs in April; about 5,000 cfs in May, June, and July; and about 3,000 cfs in August and September. The median diversions into Sutter and Steamboat Sloughs were similar for the PP_LLT case. The median diversion flows for the PP cases were generally lower than the monthly diversions for the baseline cases because the Sacramento River flow would be reduced by the north Delta diversions. The median diversions in October, April, May, and June were about the same for the baseline and the PP cases. The median diversions were reduced by 1,000 cfs in November, July, and September. The median diversions were reduced by 2,000 cfs in January and August. The median diversions were reduced by 4,000 cfs in February and March. The reductions in the Sutter and Steamboat Slough diversions were about 40% of the simulated north Delta intake diversions. The annual average diversions into Sutter and Steamboat Slough were about 6,500 taf/yr (42% of the Sacramento River flow at Freeport) for the EBC1 and EBC2 baseline cases, and were reduced to about 5,500 taf/yr (36% of the Sacramento River flow at Freeport) for the two PP cases.

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Table C.A-28. CALSIM-Simulated Monthly Distribution of Steamboat Slough and Sutter Slough Flow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	1,280	1,933	1,832	2,515	2,988	2,677	2,629	1,464	2,286	2,293	1,762	1,801	2,093
10%	2,011	2,557	3,392	5,040	5,289	4,555	3,649	3,146	3,161	4,833	3,001	2,159	3,126
20%	2,571	3,130	4,300	5,470	6,200	6,360	4,363	3,772	3,734	5,908	4,342	3,392	4,004
30%	2,861	3,623	5,023	6,602	8,422	8,270	4,703	4,176	4,021	6,739	5,101	3,805	4,412
40%	3,227	3,877	5,891	8,525	11,644	9,779	5,371	4,725	4,166	6,899	5,294	4,115	4,830
50%	3,493	4,429	6,616	10,787	15,567	12,506	6,821	5,551	4,440	6,998	5,490	4,300	5,316
60%	3,715	4,873	7,772	13,846	20,561	15,733	8,829	6,216	4,668	7,200	5,609	4,503	7,175
70%	4,278	5,493	10,552	17,940	24,517	20,324	10,096	8,029	5,250	7,602	5,806	4,662	8,318
80%	4,883	6,448	16,912	26,390	29,413	25,060	18,101	12,488	7,529	8,106	6,080	5,918	9,096
90%	5,937	11,108	24,360	30,586	33,028	29,302	23,845	19,737	11,753	8,512	6,265	6,943	10,819
Max	15,051	25,875	36,912	37,792	37,192	39,438	34,694	28,168	29,062	11,501	7,258	12,034	15,921
Avg	3,929	5,786	10,456	14,739	17,304	15,169	10,351	8,359	6,139	6,964	5,157	4,607	6,552
B. PP_ELT													
Min	2,227	2,611	2,579	2,792	3,218	3,549	3,169	1,993	2,986	2,974	2,087	2,199	2,589
10%	2,775	2,727	3,931	5,270	5,279	4,805	4,250	3,510	3,834	3,361	2,967	2,868	3,299
20%	2,928	3,178	4,783	5,786	6,280	5,835	4,592	4,138	4,222	3,711	3,066	2,908	3,690
30%	3,171	3,299	5,290	6,628	7,214	6,851	5,024	4,326	4,545	3,868	3,134	2,934	3,861
40%	3,451	3,352	6,110	8,077	8,693	7,298	5,328	4,707	4,665	4,491	3,269	2,946	4,170
50%	3,462	3,378	7,043	9,015	11,493	8,104	5,667	4,985	4,747	5,469	3,391	2,958	4,589
60%	3,474	3,578	8,080	10,686	16,703	9,597	6,611	5,407	4,908	5,947	3,461	2,966	5,630
70%	3,484	4,105	9,360	14,580	19,471	15,252	8,466	5,757	4,997	6,192	3,626	2,976	6,497
80%	3,500	4,702	12,190	21,783	25,943	21,007	10,457	6,790	5,355	6,448	3,912	2,987	6,949
90%	4,413	8,056	21,386	25,501	30,108	26,849	18,587	12,236	5,786	7,661	4,890	3,166	8,578
Max	10,800	22,991	35,701	33,827	35,367	36,597	31,625	23,168	19,931	11,909	6,404	5,168	12,460
Avg	3,607	4,706	9,727	12,578	14,741	12,227	8,442	6,582	5,118	5,463	3,640	3,015	5,402
C. PP_LLT													
Min	2,154	2,415	2,689	2,729	3,551	3,469	3,606	2,095	3,320	3,426	3,089	2,856	2,583
10%	3,045	3,147	4,135	5,674	5,521	5,067	4,782	3,731	4,263	3,602	3,280	3,151	3,569
20%	3,737	3,415	5,400	6,398	6,773	5,944	5,046	4,543	4,640	4,173	3,361	3,236	4,051
30%	3,821	3,508	6,235	7,573	7,774	7,071	5,589	5,034	4,857	4,554	3,416	3,262	4,295
40%	4,710	3,565	6,727	8,668	8,766	7,572	5,911	5,279	5,103	5,339	3,592	3,280	4,609
50%	5,749	3,622	7,663	9,727	11,159	8,403	6,353	5,556	5,267	5,762	3,762	3,300	4,984
60%	6,432	3,647	8,378	10,665	16,208	10,172	6,973	5,755	5,443	6,266	3,996	3,310	5,982
70%	7,553	3,661	9,780	14,516	18,684	15,224	8,276	6,162	5,833	6,799	4,232	3,362	6,903
80%	8,272	3,916	12,617	22,412	26,344	20,907	10,832	6,818	6,418	7,325	4,572	3,532	7,353
90%	9,412	8,465	19,502	27,063	30,746	27,120	18,799	9,325	6,731	7,985	5,134	3,937	8,761
Max	13,039	22,347	36,349	34,468	37,048	36,662	32,089	19,802	17,281	12,404	8,442	5,550	11,993
Avg	6,020	4,567	9,811	13,047	15,162	12,533	8,790	6,456	5,525	5,911	4,072	3,447	5,735

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	1,291	1,448	2,033	3,721	3,088	2,760	2,479	1,521	2,317	2,225	1,703	1,882.	1,929
10%	2,077	2,291	3,228	4,906	5,087	4,464	3,560	2,937	3,320	4,722	2,647	2,058	3,088
20%	2,580	2,903	4,388	5,564	6,327	5,942	4,305	3,640	3,652	5,683	4,415	3,171	3,910
30%	2,645	3,574	5,128	6,477	7,862	8,480	4,615	4,076	3,983	6,457	4,946	3,691	4,381
40%	2,852	4,432	5,595	8,483	10,819	9,744	5,282	4,632	4,180	6,892	5,221	4,010	4,755
50%	3,349	5,493	6,428	10,070	15,586	11,402	6,875	5,451	4,472	7,081	5,411	4,515	5,285
60%	3,619	6,092	7,796	12,183	20,556	15,530	9,102	6,149	4,786	7,210	5,704	7,334	7,237
70%	3,778	7,367	10,071	18,093	23,255	19,505	10,665	7,820	5,273	7,647	5,838	8,534	8,523
80%	4,249	8,151	15,631	26,434	29,164	25,125	18,178	12,495	7,429	8,209	5,963	12,438	9,539
90%	5,614	9,755	23,660	30,104	32,894	29,3723	23,942	19,593	11,723	8,710	6,353	13,448	11,183
Max	15,323	26,104	36,936	37,847	37,251	39,4812	34,798	28,023	28,860	9,097	7,081	14,414	15,601
Avg	3,655	6,264	10,124	14,489	17,068	14,976	10,351	8,230	6,116	6,889	5,097	6,705	6,609
E. EBC2_ELT													
Min	1,132	1,488	2,087	2,486	2,699	2,808	2,542	1,589	2,357	2,2523	1,641	1,156	1,914
10%	1,965	2,319	3,237	5,015	5,101	4,434	3,717	3,219	3,2212	4,3467	2,566	1,992	3,103
20%	2,618	2,691	4,331	5,633	6,311	5,955	4,120	3,796	3,733	5,553	4,353	2,524	3,828
30%	2,680	3,801	5,227	6,727	7,734	8,355	4,513	4,029	3,978	6,195	4,606	3,259	4,218
40%	2,825	4,404	5,652	8,365	10,857	9,627	5,268	4,300	4,145	6,611	5,103	3,797	4,776
50%	3,492	5,320	6,361	10,347	16,168	11,488	6,562	4,831	4,390	7,133	5,372	4,228	5,230
60%	3,953	6,508	7,818	12,174	22,065	15,589	8,855	5,270	4,543	7,540	5,683	7,611	7,745
70%	4,293	7,056	10,331	18,241	23,646	20,068	10,413	6,647	4,738	8,506	5,836	8,048	8,631
80%	4,671	8,109	16,910	27,566	30,495	26,748	16,980	11,287	5,742	8,756	5,991	12,415	9,639
90%	5,274	9,872	24,886	31,450	34,120	29,976	24,093	17,066	7,466	9,002	6,139	13,441	11,158
Max	15,532	27,642	39,424	38,050	37,923	39,123	36,146	27,590	25,529	9,153	6,831	13,782	14,916
Avg	3,666	6,237	10,512	14,894	17,701	15,263	10,327	7,760	5,474	6,976	4,966	6,562	6,631
F. EBC2_LLT													
Min	1,359	1,298	2,074	2,093	2,433	2,799	2,809	1,380	2,630	2,292	2,135	1,206	2,178
10%	2,068	2,206	3,064	5,051	5,173	4,769	3,976	3,262	3,582	4,023	2,726	2,087	3,070
20%	2,734	2,673	4,428	5,775	6,926	6,542	4,526	3,769	3,988	5,526	4,350	2,258	3,884
30%	3,419	3,404	5,376	7,721	8,367	8,282	4,655	4,384	4,342	6,499	4,843	2,721	4,385
40%	3,857	4,392	5,660	9,146	11,094	9,683	5,017	4,540	4,568	7,288	5,301	3,360	4,775
50%	4,162	5,414	6,560	10,482	16,416	11,708	6,442	4,869	4,697	7,832	5,534	4,243	5,226
60%	4,422	6,176	8,127	12,370	21,452	15,382	8,921	5,202	5,092	8,297	5,713	8,152	7,801
70%	4,764	7,109	9,842	19,452	24,862	20,958	10,458	6,618	5,576	8,615	5,870	8,784	8,730
80%	4,898	7,890	14,839	27,615	31,979	27,174	17,862	9,882	5,951	8,880	6,086	12,469	9,642
90%	5,909	9,535	23,649	32,177	34,507	31,242	23,827	13,425	6,948	9,098	6,291	13,476	11,156
Max	13,801	26,069	39,794	39,528	39,327	38,909	36,366	24,077	22,766	11,589	7,211	14,634	14,106
Avg	4,140	5,971	10,182	15,313	18,082	15,585	10,389	7,097	5,422	7,232	5,147	6,544	6,676

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Table C.A-29. DSM2-Simulated Diversions from the Sacramento River into Sutter Slough and Steamboat Slough for a range of Sacramento River Flows with the Delta Cross Channel Open and Closed

Freeport Flow (cfs)	Sutter Slough Flow		Steamboat Slough Flow		Sutter and Steamboat Slough Percentage of Freeport Flow	
	DCC Open	Closed	DCC Open	Closed	DCC Open	Closed
10,000	1,896	2,435	1,107	1,349	30%	38%
20,000	4,384	5,143	2,753	3,627	36%	44%
30,000	6,872	7,851	4,399	5,905	38%	46%
40,000	9,360	10,559	6,045	8,183	39%	47%
50,000	11,848	13,267	7,691	10,461	39%	47%
60,000	14,336	15,975	9,337	12,739	39%	48%
70,000	16,824	18,683	10,983	15,017	40%	48%
80,000	19,312	21,391	12,629	17,295	40%	48%

C.A.4.2.10 Delta Cross Channel and Georgiana Slough Flows

The DCC diversions and the Georgiana Slough diversions are similar to the Sutter Slough and Steamboat Slough diversions. They each divert about 20% of the Sacramento River flow when the DCC is open. However, the DCC can be closed and this will increase the fraction of the Sacramento River flow diverted into Georgiana Slough, as discussed above for the Sutter Slough and Steamboat Slough diversions. About 40% of the Sacramento River flow is diverted into DCC and Georgiana Slough when the DCC gates are opened, and about 25% is diverted into Georgiana Slough when the DCC gates are closed. For the PP cases, the Sacramento River flow is reduced, so the resulting DCC and Georgiana Slough diversions are reduced correspondingly. D-1641 objectives and the 2009 NMFS BiOp require the DCC to be closed generally from November to June. The preliminary proposal would include this DCC closure criteria.

Table C.A-30 shows the CALSIM-calculated Sacramento River diversions into DCC and Georgiana Slough for the six CALSIM cases. The EBC1 median flows were about 5,000 cfs for October–March; about 2,500 cfs in April and May; 5,500 cfs in June; about 7,000 cfs in July and August; and 6,000 cfs in September. The monthly median flows were similar for the EBC2 baselines because the Sacramento River flows were similar, and the DCC closure was the same for each of the baseline cases. The PP cases had reduced monthly median diversion flows because the north Delta intakes reduced the Sacramento River flow, just as described for the Sutter and Steamboat Slough diversions. The annual average diversions into the DCC and Georgiana Slough were about 3,750 taf/yr (24% of the Sacramento River flow at Freeport) for the EBC1 and EBC2 baseline cases, and were reduced to about 3,150 taf/yr (21% of the Sacramento River flow at Freeport) for the two PP cases.

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Table C.A-30. CALSIM-Simulated Monthly Distribution of Delta Cross Channel and Georgiana Slough Flow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	2,885	2,961	2,737	1,820	1,946	1,864	1,851	1,540	4,113	4,217	4,140	4,169	2,453
10%	3,749	3,374	3,123	2,494	2,560	2,365	2,123	1,989	4,614	6,316	5,018	4,379	2,813
20%	4,084	3,467	3,312	2,609	2,803	2,846	2,313	2,156	5,025	6,940	5,969	5,234	3,124
30%	4,326	3,693	3,429	2,911	3,396	3,355	2,404	2,263	5,138	7,650	6,507	5,497	3,255
40%	4,703	3,899	3,621	3,424	4,255	3,758	2,582	2,410	5,298	7,777	6,643	5,740	3,413
50%	4,843	4,012	3,794	4,027	5,302	4,485	2,969	2,630	5,455	7,851	6,782	5,929	3,550
60%	4,993	4,208	3,963	4,843	6,634	5,346	3,505	2,808	5,529	7,978	6,867	6,032	3,924
70%	5,170	4,338	4,284	5,935	7,689	6,571	3,843	3,291	5,717	8,196	7,006	6,177	4,304
80%	5,366	4,557	5,661	8,189	8,995	7,834	5,978	4,481	6,018	8,614	7,201	6,484	4,429
90%	5,522	4,902	7,647	9,308	9,960	8,966	7,510	6,414	7,512	8,909	7,332	7,678	4,829
Max	6,244	8,052	10,996	11,230	11,070	11,669	10,404	8,663	8,902	9,311	8,036	9,329	5,494
Avg	4,719	4,141	4,565	5,081	5,765	5,196	3,910	3,379	5,670	7,744	6,547	5,986	3,785
B. PP_ELT													
Min	1,738	1,837	2,663	1,734	1,848	1,935	1,834	1,522	4,019	4,159	3,735	3,815	2,341
10%	2,967	2,738	3,054	2,393	2,396	2,270	2,122	1,925	4,569	4,600	4,368	4,297	2,498
20%	3,811	3,132	3,169	2,530	2,662	2,544	2,213	2,092	4,819	4,900	4,439	4,325	2,703
30%	4,230	3,281	3,256	2,754	2,910	2,814	2,328	2,142	4,992	5,012	4,488	4,344	2,804
40%	4,593	3,337	3,388	3,140	3,304	2,933	2,409	2,243	5,105	5,249	4,585	4,353	2,873
50%	4,719	3,497	3,549	3,389	4,049	3,147	2,499	2,317	5,151	6,151	4,673	4,361	2,987
60%	4,726	3,680	3,657	3,834	5,434	3,544	2,750	2,430	5,237	6,456	4,723	4,367	3,175
70%	4,734	3,690	4,000	4,870	6,171	5,049	3,243	2,523	5,314	6,678	4,842	4,374	3,438
80%	4,741	3,726	4,724	6,786	7,892	6,579	3,773	2,797	5,499	6,847	5,047	4,382	3,547
90%	4,802	4,128	6,680	7,775	9,000	8,133	5,935	4,246	5,780	7,738	5,752	4,511	3,802
Max	6,181	7,107	10,488	9,989	10,399	10,726	9,404	7,154	7,444	8,938	6,841	5,952	4,655
Avg	4,318	3,528	4,165	4,337	4,913	4,244	3,237	2,742	5,210	6,083	4,852	4,402	3,140
C. PP_LLT													
Min	1,814	1,851	2,681	1,666	1,882	1,860	1,896	1,499	4,031	4,211	4,219	4,054	2,286
10%	3,669	2,500	3,068	2,440	2,400	2,281	2,206	1,929	4,629	4,573	4,353	4,262	2,558
20%	3,954	3,106	3,160	2,631	2,729	2,511	2,275	2,143	4,868	4,861	4,410	4,322	2,700
30%	4,198	3,292	3,276	2,940	2,993	2,808	2,418	2,272	5,006	5,232	4,449	4,340	2,765
40%	4,343	3,369	3,502	3,228	3,254	2,940	2,503	2,336	5,162	5,788	4,573	4,353	2,944
50%	4,622	3,553	3,630	3,506	3,883	3,158	2,619	2,409	5,266	6,080	4,692	4,367	3,053
60%	4,728	3,659	3,798	3,753	5,211	3,624	2,782	2,462	5,378	6,447	4,857	4,373	3,330
70%	4,989	3,676	4,267	4,766	5,863	4,953	3,125	2,569	5,591	6,773	5,023	4,410	3,458
80%	5,243	3,688	4,832	6,843	7,878	6,448	3,797	2,741	5,937	7,152	5,262	4,530	3,582
90%	6,000	3,703	6,078	8,067	9,036	8,082	5,893	3,401	6,167	7,580	5,658	4,815	3,801
Max	8,669	6,826	10,510	10,015	10,693	10,592	9,389	6,157	6,941	9,077	7,986	5,951	4,778
Avg	4,745	3,413	4,188	4,380	4,936	4,245	3,260	2,646	5,339	6,125	4,910	4,470	3,178

Draft

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	2,883	2,340	2,827	2,142	1,973	1,886	1,811	1,555	4,133	4,469	4,099	4,225	2,379
10%	3,807	3,320	3,130	2,458	2,506	2,340	2,099	1,933	4,666	6,238	4,767	4,298	2,713
20%	4,225	3,429	3,336	2,634	2,837	2,734	2,298	2,120	4,950	6,919	6,021	4,516	3,085
30%	4,459	3,623	3,439	2,877	3,247	3,411	2,381	2,237	5,181	7,468	6,397	4,737	3,252
40%	4,722	3,726	3,741	3,412	4,035	3,749	2,559	2,385	5,310	7,776	6,592	4,848	3,399
50%	4,776	3,902	3,848	3,836	5,307	4,191	2,983	2,604	5,371	7,910	6,726	5,194	3,579
60%	4,890	4,051	3,952	4,399	6,633	5,292	3,577	2,790	5,541	8,001	6,934	5,590	4,059
70%	5,133	4,174	4,177	5,976	7,353	6,352	3,994	3,235	5,806	8,311	7,029	5,825	4,218
80%	5,300	4,589	5,319	8,201	8,929	7,851	5,999	4,482	6,080	8,710	7,118	6,261	4,341
90%	5,469	4,817	7,461	9,180	9,924	8,985	7,536	6,376	7,432	9,065	7,394	8,357	4,805
Max	5,653	8,113	11,002	11,245	11,086	11,681	10,432	8,624	8,848	9,339	7,910	9,140	5,625
Avg	4,709	4,022	4,509	5,014	5,702	5,144	3,910	3,345	5,662	7,774	6,504	5,713	3,743
E. EBC2_ELT													
Min	2,363	2,983	2,834	1,802	1,858	1,887	1,817	1,564	4,133	4,460	4,030	3,688	2,222
10%	3,809	3,313	3,087	2,473	2,496	2,319	2,129	1,996	4,683	5,935	4,681	4,249	2,693
20%	4,246	3,347	3,335	2,637	2,817	2,723	2,236	2,150	4,921	6,784	5,939	4,421	3,011
30%	4,522	3,475	3,406	2,927	3,194	3,359	2,340	2,211	5,093	7,236	6,117	4,652	3,159
40%	4,739	3,668	3,609	3,362	4,023	3,697	2,540	2,283	5,230	7,528	6,467	4,756	3,346
50%	4,762	3,762	3,837	3,888	5,432	4,191	2,883	2,424	5,304	7,896	6,656	4,888	3,456
60%	4,817	3,920	3,967	4,373	6,998	5,279	3,492	2,541	5,471	8,183	6,875	5,449	4,026
70%	5,057	4,026	4,192	5,983	7,417	6,468	3,905	2,906	5,541	8,863	6,983	5,694	4,227
80%	5,321	4,353	5,629	8,457	9,235	8,240	5,648	4,137	5,686	9,039	7,092	7,456	4,412
90%	5,431	4,631	7,746	9,488	10,197	9,097	7,536	5,671	6,514	9,212	7,196	8,317	4,815
Max	6,151	8,477	11,604	11,239	11,206	11,524	10,734	8,464	7,945	9,318	7,684	9,340	5,715
Avg	4,701	3,937	4,585	5,095	5,839	5,192	3,882	3,201	5,457	7,786	6,371	5,672	3,725
F. EBC2_LLT													
Min	3,025	2,878	2,801	1,676	1,766	1,862	1,865	1,488	4,182	4,182	4,351	3,702	2,409
10%	3,743	3,206	3,081	2,457	2,489	2,382	2,173	1,985	4,580	5,470	4,763	4,260	2,673
20%	3,963	3,337	3,283	2,648	2,951	2,850	2,318	2,118	5,106	6,600	5,897	4,381	2,984
30%	4,210	3,400	3,373	3,161	3,331	3,309	2,352	2,280	5,292	7,376	6,241	4,465	3,148
40%	4,428	3,558	3,609	3,537	4,051	3,679	2,448	2,322	5,474	7,879	6,561	4,666	3,308
50%	4,725	3,690	3,778	3,890	5,455	4,213	2,824	2,408	5,547	8,221	6,724	4,796	3,540
60%	4,808	3,722	3,928	4,388	6,784	5,182	3,478	2,496	5,744	8,600	6,848	4,985	3,904
70%	5,049	3,826	4,162	6,256	7,684	6,653	3,883	2,870	5,919	8,863	6,958	5,489	4,298
80%	5,362	4,007	5,039	8,410	9,561	8,293	5,836	3,731	6,284	9,049	7,109	6,526	4,387
90%	5,713	4,478	7,363	9,613	10,228	9,367	7,410	4,666	6,588	9,198	7,252	8,703	4,856
Max	6,243	8,002	11,623	11,553	11,500	11,390	10,719	7,476	8,427	9,307	7,894	9,396	5,543
Avg	4,644	3,785	4,457	5,164	5,895	5,236	3,865	2,996	5,693	7,826	6,453	5,511	3,713

Draft

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C.A.4.2.11 Sacramento River at Rio Vista Flows

The Sacramento River flow at Rio Vista includes the Yolo Bypass inflow and most of the Sacramento River flow at Freeport, except the diversions into DCC and Georgiana Slough (to the central Delta) and the simulated diversions at the proposed north Delta intakes. The diversions into Sutter and Steamboat Sloughs rejoin the Sacramento River at Cache Slough, just upstream of Rio Vista. There are D-1641 minimum flows required at Rio Vista for attraction flows for upstream migration of Chinook salmon in the months of September–December. The Rio Vista minimum flows of 3,000 cfs to 4,500 cfs are the same as the minimum Delta outflows specified in these months (depends on water year type).

Table C.A-31 shows the CALSIM-simulated monthly distribution of Sacramento River flows at Rio Vista for the six CALSIM cases. The minimum flows in September–December were generally satisfied. The EBC1 monthly median flows were about 5,500 cfs in October; 7,500 cfs in November; 12,500 in December; 22,000 in January; 29,000 cfs in February; 23,000 cfs in March; 13,000 cfs in April; 10,000 cfs in May; 6,500 cfs in June; 10,500 cfs in July; 8,500 in August; and 6,500 cfs in September. The median flows at Rio Vista for the three EBC2 baselines were similar because the Yolo Bypass and Sacramento River inflows were generally the same. The median monthly Rio Vista flows were reduced in the months when the north Delta intake diversions were simulated for the PP cases. The reduced Rio Vista flows were generally about the same as the north Delta intake diversions. The annual average Sacramento River at Rio Vista flows were about 14,000 taf/yr for the EBC1 and EBC2 baseline cases, and were reduced to about 12,000 taf/yr for the two PP cases.

Admin Draft

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Table C.A-31. CALSIM-Simulated Monthly Distribution of Sacramento River at Rio Vista Flow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	1,886	3,500	3,502	5,564	6,267	5,655	5,503	3,348	3,078	2,754	2,155	2,915	3,708
10%	3,001	4,434	6,359	10,027	10,247	8,838	7,354	6,231	4,566	7,121	4,307	3,160	5,767
20%	4,025	5,420	7,555	11,049	12,157	12,278	8,593	7,273	5,512	8,938	6,731	5,346	7,179
30%	4,588	6,275	9,181	12,986	16,527	15,820	9,220	7,978	5,929	10,301	7,939	5,956	8,008
40%	5,036	6,814	11,019	16,477	21,293	18,694	10,235	8,800	6,213	10,648	8,257	6,452	8,869
50%	5,561	7,639	12,714	22,123	29,290	23,309	12,956	10,308	6,675	10,792	8,620	6,788	9,880
60%	5,909	8,471	15,982	27,579	43,453	29,789	17,274	11,759	7,116	11,101	9,006	7,028	14,561
70%	7,191	9,775	21,708	42,309	53,726	39,795	19,709	14,689	8,022	11,803	9,233	7,357	17,864
80%	8,600	11,986	34,505	57,830	65,720	50,899	34,809	22,873	11,770	12,820	9,563	9,431	20,767
90%	10,658	21,055	58,431	89,778	103,696	75,988	50,541	35,324	20,345	13,318	10,087	11,399	25,223
Max	34,464	58,499	121,603	200,709	188,081	189,583	102,504	58,232	54,239	20,228	11,851	21,771	42,211
Avg	6,667	10,793	22,749	37,268	44,541	36,084	21,333	15,456	9,847	10,739	8,052	7,348	13,853
B. PP_ELT													
Min	2,238	3,350	3,595	5,062	5,793	6,253	5,505	3,347	3,000	3,000	1,957	2,175	3,714
10%	3,000	3,500	6,173	9,532	9,378	8,421	7,274	5,869	4,374	3,263	3,000	3,000	5,051
20%	4,000	4,500	7,765	10,723	11,663	10,750	8,021	6,940	5,059	3,676	3,000	3,000	5,783
30%	4,000	4,500	8,934	12,543	13,887	12,578	8,712	7,338	5,583	3,974	3,030	3,000	6,309
40%	4,000	4,500	10,977	15,492	17,447	14,324	9,140	7,894	5,766	5,255	3,246	3,000	7,239
50%	4,000	4,651	12,400	18,746	24,350	16,779	10,389	8,391	5,927	6,839	3,513	3,000	8,316
60%	4,000	5,216	15,681	24,668	38,804	22,282	12,674	9,302	6,136	7,579	3,615	3,000	11,318
70%	4,000	6,165	18,433	35,888	48,373	34,378	15,229	9,924	6,396	7,989	3,977	3,000	14,235
80%	4,732	7,894	31,887	55,346	66,173	46,527	24,848	12,391	6,771	8,553	4,483	3,000	17,574
90%	5,884	14,038	53,573	86,259	106,276	72,095	43,663	22,440	7,729	10,743	6,087	3,376	23,428
Max	21,360	55,327	144,762	207,924	206,923	197,048	99,832	42,516	35,049	19,901	9,347	6,866	37,891
Avg	4,619	7,808	22,397	35,738	42,821	32,261	18,201	11,332	6,590	6,737	3,988	3,147	11,723
C. PP_LLT													
Min	1,651	2,730	3,500	4,619	6,055	5,897	5,899	3,175	3,138	3,000	3,000	2,979	3,410
10%	3,000	4,286	5,838	9,839	9,447	8,523	8,016	5,869	4,500	3,002	3,000	3,000	5,323
20%	4,000	4,500	8,480	11,473	11,959	10,419	8,390	7,272	5,135	3,761	3,000	3,000	6,062
30%	4,064	4,500	9,739	14,267	14,141	12,643	9,374	8,116	5,522	4,520	3,000	3,000	6,801
40%	5,685	4,500	10,832	16,933	17,053	14,143	9,784	8,561	5,906	5,892	3,300	3,000	7,423
50%	8,247	4,500	13,027	19,835	23,004	17,154	10,917	9,131	6,288	6,496	3,601	3,000	8,289
60%	9,594	4,500	15,005	23,273	36,659	22,504	12,894	9,335	6,486	7,339	4,022	3,000	11,590
70%	10,978	4,788	17,981	32,532	46,858	34,528	14,586	10,019	7,046	8,344	4,315	3,121	14,528
80%	12,878	5,529	29,328	58,839	68,821	49,701	23,933	11,573	8,102	9,206	4,937	3,439	17,273
90%	14,997	14,976	54,224	81,120	111,339	73,917	44,226	18,721	8,712	10,799	5,791	4,140	23,821
Max	22,058	50,980	145,807	215,149	213,018	203,006	98,781	33,529	29,681	20,238	11,539	6,794	37,329
Avg	8,566	6,898	21,019	36,443	43,660	32,895	18,291	10,641	6,657	6,842	4,142	3,329	11,950

Draft

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	2,007	2,570	3,862	7,649	6,513	5,829	5,250	3,465	3,147	2,651	2,066	3,000	3,423
10%	3,024	3,955	5,903	9,924	10,205	8,748	7,125	5,881	4,830	6,804	3,737	3,000	5,695
20%	4,000	4,962	8,024	10,926	12,585	11,664	8,411	6,941	5,320	8,562	6,860	4,858	7,011
30%	4,000	6,617	9,347	12,810	15,036	16,139	9,174	7,731	5,929	9,835	7,712	5,703	7,975
40%	4,615	7,826	10,902	16,911	20,838	18,176	10,062	8,667	6,251	10,643	8,115	6,337	8,825
50%	5,268	9,910	12,320	20,033	28,657	22,204	13,022	10,152	6,698	10,880	8,603	7,169	9,882
60%	5,714	10,745	14,961	26,991	42,214	28,753	17,391	11,555	7,382	11,179	8,936	11,900	14,849
70%	6,258	13,348	19,577	40,749	50,509	38,838	20,760	14,379	7,956	12,113	9,185	13,975	18,123
80%	7,050	15,113	32,603	57,266	65,279	51,206	34,885	22,814	11,598	13,133	9,426	22,294	21,526
90%	10,061	18,817	57,707	88,025	103,500	73,374	50,509	35,337	20,272	13,721	10,088	24,150	25,733
Max	31,273	59,175	121,584	200,995	185,324	189,718	102,798	58,077	53,639	14,329	11,306	25,869	41,554
Avg	6,097	11,748	21,806	36,610	43,759	35,567	21,360	15,217	9,795	10,575	7,930	11,386	13,907
E. EBC2_ELT													
Min	1,738	2,673	3,831	5,404	5,764	5,973	5,291	3,522	3,147	2,630	1,985	2,071	3,415
10%	3,000	3,941	5,817	9,977	9,890	8,652	7,268	6,213	4,594	6,059	3,573	3,000	5,658
20%	4,000	4,606	8,223	10,967	12,441	11,511	8,002	7,175	5,370	8,186	6,476	3,769	6,821
30%	4,000	6,822	9,374	12,949	14,776	16,104	8,632	7,669	5,859	9,332	7,052	5,052	7,647
40%	4,218	7,717	10,433	16,333	21,187	17,744	9,949	8,035	6,126	10,076	7,857	5,956	8,706
50%	5,386	9,660	12,305	19,984	30,490	22,134	12,343	9,143	6,457	10,941	8,291	6,732	9,923
60%	6,245	11,948	14,957	26,288	44,581	28,526	16,762	10,099	6,732	11,687	8,877	12,371	15,146
70%	7,051	12,900	20,684	44,316	53,380	38,914	20,608	13,021	7,051	13,009	9,156	13,088	18,706
80%	7,872	15,099	33,978	57,723	73,141	54,069	33,370	21,362	8,813	13,588	9,459	22,067	21,958
90%	8,969	18,836	61,595	92,972	112,189	75,688	50,577	32,872	11,854	13,991	9,698	23,957	27,217
Max	31,651	64,164	152,014	217,257	208,215	202,239	108,480	51,524	45,539	14,302	10,688	24,672	42,242
Avg	6,058	11,671	23,283	38,556	46,674	36,744	21,306	14,232	8,525	10,604	7,610	11,025	14,167
F. EBC2_LLT													
Min	2,054	2,203	3,747	4,584	5,077	5,810	5,606	3,040	3,458	2,630	2,724	2,012	3,763
10%	3,000	3,694	5,397	9,798	9,855	9,118	7,592	6,149	5,228	5,477	3,711	3,000	5,521
20%	4,046	4,500	8,428	11,289	13,038	12,416	8,449	7,162	5,899	8,204	6,458	3,182	6,820
30%	5,282	5,790	9,487	14,561	15,634	15,781	8,874	8,045	6,335	9,620	7,345	4,011	7,813
40%	5,983	7,640	10,484	17,235	20,876	17,885	9,340	8,370	6,673	11,097	8,032	5,126	8,719
50%	6,615	9,360	12,383	20,080	30,201	22,183	12,040	8,895	7,001	11,911	8,420	6,600	9,667
60%	7,110	11,182	15,046	26,404	42,840	28,301	16,992	9,460	7,582	12,637	8,842	12,902	15,346
70%	7,768	12,825	18,736	42,481	55,842	41,531	19,769	12,500	8,345	13,227	9,037	14,195	18,575
80%	8,509	14,404	31,341	60,673	78,156	56,637	32,223	17,879	9,056	13,671	9,462	22,074	21,666
90%	10,453	18,050	55,501	93,523	115,116	79,910	52,612	28,178	10,565	14,010	10,001	23,967	27,183
Max	27,152	56,077	153,587	227,372	216,683	208,184	107,403	43,133	40,250	19,877	14,084	25,868	41,434
Avg	6,858	10,946	21,753	39,721	47,675	37,655	21,211	12,833	8,257	10,921	7,806	10,896	14,179

Administrative Draft

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C.A.4.2.12 Threemile Slough Flows

Threemile Slough is a natural channel connecting the Sacramento River near Decker Island, about 5 miles downstream of Rio Vista, to the San Joaquin River near Bradford Island, about 10 miles upstream of Antioch. Because the Sacramento River channel is shorter and deeper than the San Joaquin River channel, flood tide (rising tide) reaches Threemile Slough first on the Sacramento River side and the flood-tide flow is from the Sacramento River to the San Joaquin River. The Threemile Slough tidal flows are quite high (25,000 cfs), but the net flows generally range from about 1,000 cfs to 3,000 cfs from the Sacramento River to the San Joaquin River. The DSM2 model results indicate that the Threemile Slough flow depends on the Rio Vista flow and the calculated San Joaquin River flow (estimated as the Delta outflow minus the Rio Vista flow). This San Joaquin River flow has been called QWEST in the DAYFLOW data file of historical daily Delta flows. Threemile Slough flow can be calculated as:

Threemile Slough Flow (cfs) = 1,250 + 0.03 x Rio Vista Flow (cfs) – 0.16 (Outflow – Rio Vista Flow)

The Threemile Slough flow is almost always positive, except when the San Joaquin River flow is quite high (more than 5x the Rio Vista flow). When the DCC is closed and exports are higher than the sum of the San Joaquin River inflow and the Georgiana Slough diversions, a reverse San Joaquin River flow may be caused at Antioch (Rio Vista flow is greater than Delta outflow). These periods of reverse San Joaquin River flow will increase the Threemile Slough flow. The Threemile Slough flow is normally a net movement of water from the Sacramento River to the San Joaquin River that continues to the Delta outflow past Antioch.

Table C.A-32 shows the CALSIM-calculated monthly distributions of Threemile Slough flows from the Sacramento River to the San Joaquin River for the six CALSIM cases. The EBC1 monthly median Threemile Slough flows were about 1,500 cfs from October to March, about 750 cfs in April and May, 1,250 in June, and 2,000 cfs in July–September. The Threemile Slough flows were similar for the three EBC2 baselines. The Threemile Slough flows were reduced slightly in the PP cases because the Rio Vista flows were reduced by the north Delta intake diversions. The annual average Threemile Slough flows were about 1,000 taf/yr for the EBC1 and EBC2 baseline cases and were reduced to about 750 taf/yr for the two PP cases.

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Table C.A-32. CALSIM-Simulated Monthly Distribution of Threemile Slough flow (cfs) from Sacramento River to San Joaquin River

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	1,128	-256	-1,157	-5,498	-2,302	-4,224	-1,863	-2,507	-2,011	-939	556	878	-800
10%	1,340	1,355	1,529	924	477	349	-639	-705	626	1,339	1,472	1,340	717
20%	1,375	1,535	1,703	1,250	1,068	1,102	167	162	858	1,767	1,807	1,627	931
30%	1,482	1,615	1,807	1,442	1,223	1,247	360	521	1,084	2,004	1,954	1,745	1,023
40%	1,567	1,758	1,979	1,492	1,395	1,326	484	638	1,170	2,159	2,119	1,814	1,074
50%	1,667	1,852	2,039	1,630	1,481	1,417	611	798	1,223	2,223	2,210	1,889	1,127
60%	1,725	1,983	2,103	1,722	1,588	1,523	843	946	1,282	2,315	2,264	1,917	1,152
70%	1,895	2,045	2,277	1,778	1,659	1,580	909	1,077	1,373	2,372	2,319	1,965	1,227
80%	2,113	2,232	2,392	1,801	1,755	1,736	1,080	1,191	1,386	2,457	2,338	1,992	1,257
90%	2,236	2,337	2,552	1,855	1,844	1,848	1,267	1,344	1,433	2,499	2,374	2,023	1,285
Max	2,858	2,677	2,697	2,770	3,505	2,140	1,346	1,527	1,661	2,584	2,426	2,245	1,348
Avg	1,728	1,830	1,938	1,405	1,298	1,199	487	584	1,079	2,018	2,041	1,793	1,052
B. PP_ELT													
Min	-295	-2,158	-2,710	-8,509	-3,719	-5,082	-3,068	-4,028	-3,306	-1,390	615	-489	-1,662
10%	1,101	1,327	634	-483	-1,648	-1,329	-1,155	-1,346	-41	723	1,180	1,190	195
20%	1,276	1,355	1,550	358	-300	-102	151	432	763	1,111	1,218	1,340	496
30%	1,370	1,385	1,718	1,005	184	138	623	824	948	1,180	1,260	1,340	675
40%	1,370	1,385	1,869	1,324	631	498	875	1,062	1,019	1,232	1,277	1,340	809
50%	1,370	1,385	1,932	1,419	910	921	1,039	1,118	1,110	1,308	1,306	1,340	934
60%	1,370	1,442	2,030	1,622	1,245	1,193	1,161	1,208	1,142	1,427	1,340	1,340	984
70%	1,370	1,536	2,101	1,748	1,417	1,289	1,213	1,256	1,185	1,541	1,400	1,340	1,021
80%	1,370	1,722	2,187	1,781	1,607	1,456	1,320	1,323	1,223	1,816	1,498	1,340	1,078
90%	1,560	1,905	2,365	1,818	1,759	1,576	1,420	1,407	1,302	2,178	1,766	1,355	1,107
Max	2,176	2,760	2,757	1,923	2,337	1,849	1,576	1,691	1,447	3,747	2,386	1,514	1,350
Avg	1,342	1,439	1,641	954	539	469	621	598	783	1,393	1,387	1,257	753
C. PP_LLT													
Min	-355	-1,743	-2,863	-8,533	-3,797	-5,379	-3,069	-3,983	-3,083	262	1,124	-294	-1,565
10%	920	1,010	895	-185	-843	-1,228	-1,265	-1,179	-211	1,009	1,178	934	210
20%	1,146	1,340	1,275	378	-75	-214	32	375	643	1,073	1,180	1,166	550
30%	1,193	1,385	1,463	1,007	183	137	503	630	801	1,180	1,243	1,279	673
40%	1,253	1,385	1,635	1,083	556	669	947	995	938	1,204	1,261	1,340	834
50%	1,340	1,385	1,884	1,179	1,064	969	1,094	1,142	1,044	1,279	1,298	1,340	882
60%	1,396	1,385	2,043	1,370	1,239	1,139	1,143	1,208	1,118	1,391	1,337	1,340	931
70%	1,479	1,385	2,133	1,491	1,438	1,257	1,221	1,258	1,169	1,474	1,375	1,340	979
80%	1,608	1,439	2,395	1,647	1,633	1,348	1,289	1,310	1,202	1,624	1,432	1,340	1,003
90%	1,805	1,790	2,537	1,776	1,758	1,437	1,407	1,379	1,271	1,958	1,657	1,409	1,052
Max	2,106	3,056	2,811	2,208	2,478	1,842	1,600	1,564	1,530	3,657	2,649	1,602	1,346
Avg	1,326	1,340	1,668	839	627	444	605	608	802	1,387	1,376	1,238	742

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	921	-173	-815	-5,117	-2,587	-4,128	-1,763	-2,127	-1,753	-1,668	821	411	-695
10%	1,127	1,035	1,426	924	527	451	-635	-691	631	1,227	1,246	1,340	720
20%	1,264	1,270	1,715	1,212	1,078	1,156	168	173	881	1,681	1,772	1,369	933
30%	1,306	1,385	1,875	1,433	1,222	1,268	358	534	1,105	1,994	1,979	1,617	1,006
40%	1,340	1,469	2,003	1,494	1,374	1,363	479	650	1,156	2,085	2,116	1,705	1,046
50%	1,370	1,563	2,073	1,575	1,490	1,423	608	805	1,229	2,178	2,182	1,872	1,095
60%	1,413	1,659	2,121	1,686	1,612	1,562	838	989	1,270	2,272	2,262	1,947	1,134
70%	1,491	1,855	2,261	1,772	1,676	1,651	910	1,089	1,341	2,355	2,323	2,004	1,187
80%	1,640	2,045	2,409	1,794	1,758	1,760	1,107	1,180	1,395	2,422	2,357	2,317	1,221
90%	1,897	2,292	2,601	1,841	1,831	1,843	1,263	1,334	1,439	2,512	2,398	2,667	1,259
Max	2,790	2,693	2,852	2,784	3,422	2,094	1,346	1,472	1,621	2,590	2,456	2,935	1,341
Avg	1,462	1,615	1,967	1,408	1,293	1,219	495	599	1,085	1,977	2,026	1,868	1,028
E. EBC2_ELT													
Min	750	-391	-1,753	-6,355	-2,667	-4,117	-1,627	-2,331	-1,703	-523	985	542	-694
10%	1,065	1,201	1,389	931	437	513	-693	-756	838	1,391	1,205	1,340	705
20%	1,135	1,355	1,653	1,236	1,057	1,171	171	194	1,002	1,700	1,764	1,343	916
30%	1,215	1,386	1,819	1,376	1,128	1,270	392	530	1,112	1,826	1,877	1,491	998
40%	1,274	1,449	1,966	1,491	1,363	1,353	513	680	1,163	1,931	2,060	1,694	1,034
50%	1,340	1,515	2,075	1,584	1,499	1,423	615	773	1,229	2,053	2,173	1,815	1,078
60%	1,370	1,714	2,147	1,730	1,571	1,537	866	1,015	1,275	2,161	2,228	1,899	1,115
70%	1,370	1,837	2,255	1,780	1,676	1,610	1,047	1,134	1,309	2,235	2,316	2,004	1,183
80%	1,465	1,921	2,384	1,813	1,764	1,689	1,174	1,284	1,362	2,341	2,360	2,313	1,200
90%	1,554	2,223	2,484	1,841	1,855	1,833	1,272	1,359	1,411	2,399	2,400	2,697	1,245
Max	2,803	2,757	2,732	2,928	3,492	2,188	1,350	1,454	1,633	2,547	2,435	2,863	1,311
Avg	1,339	1,625	1,906	1,393	1,265	1,206	525	578	1,119	1,948	2,007	1,829	1,012
F. EBC2_LLT													
Min	553	49	-1,040	-6,395	-2,415	-4,215	-1,717	-2,599	-784	628	920	460	-617
10%	903	1,113	1,306	899	530	433	-781	-616	953	1,276	1,275	1,277	715
20%	990	1,313	1,432	1,181	1,093	1,144	159	309	1,078	1,525	1,600	1,341	893
30%	1,068	1,384	1,656	1,382	1,186	1,233	408	571	1,136	1,693	1,817	1,406	948
40%	1,132	1,394	1,844	1,497	1,323	1,307	584	721	1,172	1,790	2,048	1,596	1,020
50%	1,208	1,571	2,018	1,621	1,450	1,380	727	775	1,200	1,979	2,126	1,713	1,059
60%	1,306	1,625	2,095	1,712	1,552	1,492	943	1,115	1,226	2,067	2,208	1,861	1,091
70%	1,379	1,749	2,245	1,759	1,665	1,601	1,092	1,202	1,266	2,170	2,279	1,968	1,136
80%	1,457	1,849	2,357	1,792	1,780	1,727	1,153	1,293	1,316	2,232	2,325	2,186	1,181
90%	1,530	2,263	2,480	1,825	1,899	1,803	1,277	1,365	1,382	2,427	2,397	2,471	1,207
Max	2,463	2,770	2,713	3,408	3,458	2,444	1,357	1,468	1,565	3,253	2,442	2,815	1,352
Avg	1,229	1,595	1,845	1,377	1,294	1,189	544	629	1,129	1,888	1,972	1,760	994

Administrative Draft

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C.A.4.2.13 San Joaquin River at Antioch Flows

Table C.A-33 shows the CALSIM-calculated San Joaquin River flow at QWEST. The San Joaquin River at Antioch flow can be calculated by adding the Threemile Slough flow to the QWEST value. The San Joaquin River at Antioch flow is generally positive, but it may be reversed during periods with high exports (and reversed OMR flow) during the summer and fall period (without OMR restrictions). The San Joaquin River flow at Antioch may be important for various estuarine habitat, entrainment, and adult attraction flow effects on fish.

Table C.A-33 indicates that the median QWEST flows for the EBC1 baseline were reversed at -1,500 cfs in October and -2,000 cfs in November and December. The monthly median QWEST flows were about 2,000 cfs in January; 4,500 cfs in February; 3,500 cfs in March; 6,500 cfs in April; 5,500 cfs in May; and 1,500 cfs in June. The median monthly flows were reversed at -3,500 cfs in July; -4,000 cfs in August; and -2,500 cfs in September. The QWEST flows are similar to the OMR flows because they can be reversed by high south-Delta pumping. Table C.A-33 indicates that the QWEST flows were increased in the PP cases because the reduction in south Delta exports will increase OMR and increase QWEST by the same amount. For the PP cases the monthly median flows were about 0 cfs in October and November and were reversed at -2,000 cfs only in December. The QWEST flows were about 1,500 cfs in January; 8,500 cfs in February; 6,500 cfs in March; 3,000 cfs in April; 2,500 cfs in May and June; 1,000 cfs in July; 500 cfs in August; and 150 cfs in September. The summer periods of reverse QWEST generally were eliminated by the proposed north Delta intake diversions.

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Table C.A-33. CALSIM-Simulated Monthly Distribution of San Joaquin River at Antioch Flow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	-5,298	-6,080	-6,428	-2,619	-1,870	-1,382	882	-278	-1,013	-5,954	-5,330	-3,800	-1,411
10%	-4,025	-4,270	-5,217	-1,462	-638	-134	1,640	856	445	-5,510	-4,896	-3,308	-774
20%	-3,587	-3,845	-4,815	-1,182	455	920	2,860	2,007	669	-5,287	-4,792	-3,115	-467
30%	-2,686	-3,098	-3,767	-434	1,506	1,731	3,989	2,429	753	-4,510	-4,628	-2,932	-88
40%	-1,770	-2,788	-2,921	830	3,252	2,746	5,535	3,737	1,087	-4,187	-4,438	-2,751	263
50%	-1,404	-2,328	-2,210	2,041	4,843	3,567	6,862	5,648	1,607	-3,555	-4,182	-2,438	607
60%	-921	-1,860	-1,549	3,554	6,850	4,490	8,564	6,656	2,009	-2,996	-3,709	-2,009	1,377
70%	-379	-1,212	-893	6,447	10,122	7,013	10,193	7,735	2,429	-2,291	-2,751	-1,524	2,402
80%	52	-735	1,548	10,964	12,179	11,288	13,258	9,886	4,693	-1,488	-2,047	-395	3,435
90%	93	1,219	7,072	16,469	19,289	17,797	21,124	19,298	8,234	1,169	49	127	5,294
Max	1,188	20,239	34,937	79,644	46,563	69,293	36,954	32,516	28,900	17,761	6,472	4,731	18,570
Avg	-1,667	-1,603	-86	5,921	7,978	7,089	8,874	7,227	3,198	-2,491	-3,210	-1,874	1,744
B. PP_ELT													
Min	-3,308	-5,591	-6,353	-2,741	-1,635	-1,718	-34	-404	177	-11,583	-4,488	-726	-1,224
10%	-759	-2,552	-4,128	-1,633	-670	449	507	695	1,010	-3,149	-1,798	-53	-28
20%	17	-1,730	-3,526	-1,289	758	1,157	1,478	810	1,425	-1,418	-442	103	130
30%	50	-808	-2,843	-356	2,165	1,919	1,803	1,416	1,859	-7	165	115	489
40%	67	-188	-2,632	659	4,737	3,067	2,428	1,888	2,138	573	267	131	725
50%	78	-55	-2,338	1,609	8,716	6,493	3,089	2,338	2,337	1,043	563	139	1,667
60%	95	4	-1,646	4,434	11,678	9,737	4,447	3,103	2,692	1,267	665	144	2,854
70%	111	41	-846	10,647	16,679	12,866	7,698	4,518	3,282	1,514	749	152	3,866
80%	635	68	2,354	14,618	20,047	18,845	12,235	7,106	4,288	2,000	992	161	6,245
90%	1,569	626	13,788	27,337	32,626	25,003	22,204	20,417	9,924	4,340	1,228	936	9,081
Max	10,640	31,527	50,400	99,817	57,988	76,059	45,694	38,131	33,568	17,623	4,754	12,296	23,150
Avg	356	275	1,698	8,450	12,395	10,927	7,445	6,362	4,430	662	118	677	3,214
C. PP_LLT													
Min	-1,917	-7,570	-6,989	-1,752	-1,860	-1,706	-154	-208	-153	-10,953	-6,362	-1,160	-1,217
10%	-397	-1,427	-5,852	-392	-525	826	966	833	1,008	-1,752	-900	-63	397
20%	38	-159	-4,914	684	813	1,639	1,556	1,253	1,857	-611	-43	100	632
30%	121	-31	-3,436	1,875	2,050	2,504	1,890	1,605	2,107	201	216	127	934
40%	442	27	-2,456	2,628	3,549	3,438	2,521	1,909	2,411	998	423	139	1,157
50%	777	46	-1,368	3,280	8,321	5,798	2,862	2,365	2,658	1,254	628	144	1,712
60%	1,228	81	-59	4,246	12,151	8,587	4,581	3,175	3,396	1,330	741	157	2,768
70%	1,571	102	677	10,106	16,927	13,473	7,797	5,927	4,177	1,880	866	639	4,571
80%	2,162	847	3,382	15,258	19,702	18,187	12,285	7,313	5,203	2,261	1,205	1,217	5,833
90%	3,425	2,591	11,383	25,358	32,256	27,623	21,481	18,012	11,532	2,847	1,228	2,702	8,317
Max	10,842	28,117	46,746	101,321	60,420	79,033	45,503	37,888	29,402	7,293	1,575	10,606	22,438
Avg	1,194	733	1,276	9,300	12,002	11,203	7,568	6,167	4,327	723	213	827	3,322

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	-6,180	-5,199	-7,468	-2,448	-1,906	-1,687	878	14	-714	-6,057	-5,488	-5,705	-1,162
10%	-2,189	-3,967	-5,517	-1,405	-693	-494	1,637	851	420	-5,533	-5,071	-4,295	-536
20%	-1,110	-2,411	-4,969	-1,074	401	683	2,941	1,835	623	-4,705	-4,948	-3,500	-113
30%	-519	-1,477	-4,331	-36	1,555	1,713	3,959	2,461	805	-4,405	-4,727	-3,149	170
40%	32.1	-770	-3,355	833	2,853	2,521	5,512	3,568	1,250	-3,878	-4,377	-2,766	483
50%	66.9	-238	-2,627	2,108	4,598	3,540	6,972	5,588	1,723	-3,146	-3,973	-2,300	755
60%	335.7	284	-1,592	3,577	6,632	4,501	8,148	6,635	2,042	-2,762	-3,622	-1,735	1,318
70%	681.3	643	-803	6,025	9,610	6,828	10,182	7,630	2,423	-2,308	-2,941	-441	2,373
80%	1,025	1,373	1,220	11,069	12,477	10,569	13,277	10,302	4,447	-737	-1,861	126	3,681
90%	1,805	3,056	7,393	16,732	19,596	15,716	21,164	19,159	8,057	1,296	923	236	5,532
Max	3,130	19,841	35,058	77,316	48,365	68,720	36,927	30,067	26,951	21,154	4,796	8,055	17,794
Avg	-111	-76.1	-442	5,779	7,862	6,859	8,830	7,084	3,144	-2,267	-3,142	-1,595	1,900
E. EBC2_ELT													
Min	-4,695	-5,327	-6,309	-2,651	-1,911	-1,710	860	148	-866	-5,689	-5,372	-5,305	-872
10%	-650	-3,350	-5,305	-1,530	-592	220	1,623	805	534	-4,727	-5,153	-4,417	-377
20%	-10	-2,388	-4,716	-1,121	379	958	2,252	1,110	760	-4,110	-4,926	-3,349	-10
30%	63	-1,440	-4,217	-44	1,664	1,410	3,422	2,247	1,084	-3,836	-4,762	-2,803	258
40%	78	-583	-3,181	737	2,792	2,305	4,902	3,328	1,273	-3,261	-4,127	-2,359	514
50%	322	-58	-2,222	2,012	4,730	3,422	6,602	5,146	1,526	-2,533	-3,944	-1,696	841
60%	1,086	64	-1,315	3,499	7,339	4,855	7,939	6,250	1,938	-1,858	-3,392	-962	1,510
70%	1,437	258	-369	6,079	11,418	6,674	10,006	7,274	2,274	-1,508	-2,334	-69	2,678
80%	1,923	823	1,534	11,084	13,062	11,345	13,504	9,463	3,241	-508	-1,806	122	4,036
90%	2,488	2,513	7,596	17,405	22,122	17,243	20,518	18,537	6,186	903	1,571	1,042	6,054
Max	4,487	22,144	43,114	88,104	52,396	71,000	38,312	30,323	25,113	13,138	2,298	6,903	17,916
Avg	653	-154	216	6,234	8,579	7,166	8,632	7,033	2,697	-2,078	-3,080	-1,421	2,054
F. EBC2_LLT													
Min	-2,655	-5,440	-6,171	-1,940	-1,621	-1,660	893	-65	-359	-8,470	-5,409	-5,002	-619
10%	-99	-4,002	-5,263	-1,466	-415	325	1,683	1,067	763	-4,731	-5,169	-3,365	-123
20%	204	-1,757	-4,785	-933	670	1,010	2,390	1,238	1,158	-3,919	-4,725	-2,932	120
30%	526	-1,215	-3,802	47	2,109	1,649	3,207	1,833	1,449	-3,083	-4,405	-2,221	599
40%	933	-496	-2,314	751	2,975	2,685	4,345	3,089	1,741	-2,536	-4,026	-1,460	732
50%	1,362	16	-1,377	2,361	4,763	3,359	6,272	4,620	1,969	-1,956	-3,687	-1,235	1,022
60%	1,883	110	-265	4,004	7,594	5,192	7,322	5,854	2,196	-1,237	-3,120	-667	1,596
70%	2,484	543	485	6,290	11,042	7,150	9,859	6,388	2,366	-421	-1,765	-61	2,881
80%	2,782	1,207	1,641	11,699	13,190	10,839	13,494	9,094	2,673	547	-550	115	3,753
90%	3,258	2,512	7,064	17,461	21,369	17,646	20,218	16,434	3,752	1,637	862	925	5,843
Max	5,460	17,876	38,836	90,254	52,773	72,724	38,129	30,692	17,283	5,196	2,771	7,774	17,279
Avg	1,490	-100	312	6,553	8,587	7,442	8,497	6,449	2,581	-1,644	-2,830	-1,015	2,167

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C.A.4.2.1 Delta Outflow

The CALSIM-simulated Delta outflow is the sum of all of the upstream and Delta operations and is the major link with salinity in the Delta and with the X2 position. D-1641 has specified Delta outflow in all months; during the February–June period, the required Delta outflow is calculated from the required number of days that X2 must be downstream of the three EC measurements locations (Collinsville at 81 kilometers [km], Chipps Island at 75 km, and Port Chicago at 64 km). The CALSIM model uses information from the DSM2 modeling results in a monthly calculation that uses ANN to determine the outflow necessary to satisfy the X2 and EC objectives at Emmaton and Jersey Point.

A more basic relationship between Delta outflow and X2 is the original equation that estimates X2 from the daily or monthly outflow sequence. All of these estimation techniques are somewhat uncertain because the Delta outflow is itself estimated from upstream flows and assumed Delta depletions. For example, D-1641 allows the *X2 at Collinsville* objective to be satisfied by an estimated Delta outflow of 7,100 cfs. The *X2 at Chipps Island* objective can be satisfied by an estimated Delta outflow of 12,400 cfs, and the *X2 at Port Chicago* (Roe Island) objective can be satisfied by an estimated Delta outflow of 29,200 cfs. The CALSIM model calculates the required minimum Delta outflow necessary to meet all of the salinity, X2, and outflow requirements. It provides this monthly estimate of minimum required Delta outflow as an output parameter. Delta outflow requirements often limit the Delta exports, so the simulated Delta outflow for many months is equal to the minimum Delta outflow requirement for each month.

Table C.A-34 shows the CALSIM calculated minimum Delta outflow requirements for the combination of D-1641 outflow, X2, and salinity objectives. For the EBC1 case, the required outflows in October–January and July–September reflect the D-1641 monthly outflow objectives, distributed by water year types. The February–June required outflows include the X2 equivalents. Many of the monthly X2 equivalents are around 7,100 cfs, assumed to maintain X2 at Collinsville, and many months have X2 equivalents of about 12,500 cfs, assumed to maintain X2 at Chipps Island. For reference, the annual average outflow required for the EBC1 baseline case was 4,250 taf/yr.

The EBC2 baselines had higher annual average required outflows of about 5,000 taf/yr for EBC2, about 5,250 taf/yr for EBC2_ELT, and about 5,750 taf/yr for EBC2_LLT. The EBC2 baselines include the USFWS Fall X2 requirements in September–November following above normal (X2 near Collinsville) and wet (X2 near Chipps Island) years. The required outflows in September were raised from 3,000 cfs to between 11,000 cfs and 22,000 cfs in about 40% of the years. The required outflows in October were raised from 4,000 cfs to between 6,000 cfs and 11,000 cfs in about 40% of the years. The required outflows in November were raised from 4,500 cfs to between 10,000 cfs and 16,000 cfs in about 40% of the years. This raised the annual average required outflow by about 750 taf/yr. The EBC2_ELT and the EBC_LLT baseline cases had even higher required minimum outflows, caused apparently by changes in the X2 equivalents calculated by the CALSIM (ANN). The annual average required outflow for the EBC2_ELT case was 5,250 taf/yr, and the annual average required outflow for the EBC2_LLT case was 5,750 taf/yr.

Table C.A-35 shows the CALSIM-simulated monthly cumulative distributions of Delta outflow for the six CALSIM cases. The minimum monthly outflows reflect the critical year required outflow or the minimum X2 outflow (ANN) equivalents for the months of February–June. The minimum October outflow was 3,000 cfs (critical year requirement), and most (60%) of the years had an October outflow of 4,000 cfs. Only a few Octobers had any excess outflow (above requirements of 4,000 cfs), although there was one year with 30,000 cfs outflow in October. The 90% cumulative October

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outflow was 6,761 cfs. The 10% November outflow was 3,500 cfs (critical year requirement), and the 30% distribution outflow was 4,500 cfs. The other years had slightly more outflow than the D-1641 outflow requirements, but the CALSIM model (ANN) may have estimated that the salinity objectives at Emmaton, Jersey Point, or at Rock Slough required more outflow.

The monthly median outflow for the EBC1 case was 4,000 cfs in October; 5,000 cfs in November; 8,000 cfs in December; 22,000 cfs in January; 36,500 cfs in February; 27,000 cfs in March; 19,000 cfs in April; 16,000 cfs in May; 7,000 cfs in June; 8,000 cfs in July; 4,000 cfs in August; and 3,600 cfs in September. About half of the months had Delta outflow exceeding the outflow requirements, but the outflow in most of these months likely was controlled by the maximum allowed E/I ratio.

Figure C.A-32 shows the monthly CALSIM-simulated Delta outflows for the EBC1 and the PP_ELT and PP_LLT cases for the 1922–2003 sequence. There were many months with more than 50,000 cfs outflow, but the scale has been reduced to focus on the relatively low Delta outflow periods. The variations in the Delta outflow are quite large within each year, so it is difficult to determine any differences when looking at the entire monthly sequence. Figure C.A-33 shows the monthly CALSIM-simulated Delta outflows for the EBC1 and the PP_ELT and PP_LLT cases for the 1994–2003 sequence. For this relatively wet period, the reductions in Delta outflow from the EBC1 (green line) to the PP cases (blue and red lines) can be identified. Generally the sequence of Delta outflow can be tracked easily from the variation in the Delta inflows to the required Delta outflow and the allowable exports each month.

The CALSIM modeling tool performs all of these checks and tracking functions for each designated case. Determining the potential effects of these monthly flow changes on various habitat conditions for Delta fish is the major goal of the preliminary proposal effects analysis. The CALSIM model provides an estimate of the end of month X2 position (kilometers [km] from Golden Gate), as described below.

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Table C.A-34. CALSIM-Simulated Monthly Distribution of Delta Outflow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	3,000	3,500	3,500	4,500	7,407	6,219	6,426	4,000	4,000	4,000	3,000	3,000	3,639
10%	3,815	4,500	4,500	8,619	9,530	9,613	9,640	7,100	5,156	4,293	4,000	3,000	5,253
20%	4,000	4,500	5,010	9,879	13,526	12,657	11,153	8,682	6,248	5,000	4,000	3,000	6,471
30%	4,000	4,500	5,232	12,749	16,681	16,684	12,930	10,240	6,713	5,000	4,000	3,078	7,599
40%	4,000	4,778	6,383	17,219	23,683	22,158	15,325	12,419	7,100	6,500	4,000	3,411	8,722
50%	4,000	5,088	8,086	22,361	36,554	26,890	18,921	15,899	7,243	8,000	4,000	3,610	10,486
60%	4,014	5,786	11,294	31,168	51,454	34,199	26,270	19,254	8,081	8,000	4,000	3,872	16,191
70%	4,377	6,269	18,041	47,109	63,643	47,157	29,363	21,788	10,503	8,000	4,452	4,081	19,667
80%	4,625	7,626	35,260	67,477	77,261	62,997	49,728	30,110	14,841	8,751	4,746	7,970	24,098
90%	6,761	16,840	66,009	106,897	123,455	92,083	69,029	54,215	30,492	11,024	5,688	10,154	31,813
Max	30,878	78,878	156,563	280,515	226,138	259,340	139,460	84,439	72,462	37,702	16,427	25,677	60,779
Avg	4,931	9,193	22,714	43,289	52,594	43,172	30,099	22,517	12,765	7,951	4,618	5,334	15,533
B. PP_ELT													
Min	3,000	3,500	3,500	5,034	6,776	6,785	6,897	4,000	4,000	4,000	3,000	3,000	3,944
10%	4,000	3,500	4,500	7,970	8,927	9,013	8,725	7,100	5,938	4,000	3,500	3,000	4,886
20%	4,000	4,500	4,921	9,600	12,209	12,166	9,565	7,703	7,100	5,000	3,500	3,000	5,869
30%	4,000	4,500	6,123	12,558	15,921	14,889	10,073	8,445	7,288	5,000	3,758	3,000	6,689
40%	4,000	4,500	7,533	16,119	21,237	18,800	11,153	10,008	7,555	6,500	4,000	3,000	8,169
50%	4,000	4,500	8,867	21,277	36,181	24,828	12,470	11,352	8,086	8,000	4,000	3,000	9,280
60%	4,023	4,500	11,813	29,490	52,663	33,240	17,916	12,229	8,440	8,000	4,000	3,000	14,203
70%	4,582	4,500	16,276	44,117	64,355	43,585	22,612	13,581	9,030	8,000	4,000	3,000	18,715
80%	5,101	5,551	31,713	75,396	88,665	69,447	40,645	18,587	9,920	8,298	4,000	3,000	24,220
90%	6,287	14,560	67,842	116,110	146,559	92,822	61,901	39,902	16,007	9,495	4,000	3,677	31,035
Max	20,244	86,999	195,186	307,902	259,020	273,570	145,536	79,618	60,693	21,795	7,529	19,023	61,041
Avg	4,910	8,091	24,149	44,290	55,297	43,191	25,542	17,532	10,743	7,104	3,882	3,692	14,875
C. PP_LLT													
Min	3,000	3,500	3,500	5,763	7,266	7,239	7,100	4,002	4,000	4,000	3,000	3,000	4,376
10%	3,427	4,500	4,503	10,702	10,718	9,537	9,730	7,108	6,604	5,000	3,521	3,000	5,800
20%	4,760	4,500	4,979	13,393	12,184	12,647	10,238	8,872	7,112	5,000	4,000	3,000	6,427
30%	6,505	4,500	5,863	15,601	16,770	15,878	11,066	10,081	7,413	5,053	4,000	3,000	7,266
40%	8,556	4,500	7,526	19,204	20,929	18,480	11,915	10,719	8,444	6,500	4,000	3,000	8,721
50%	9,234	4,500	9,219	22,074	35,855	24,486	13,037	11,400	9,290	8,000	4,000	3,000	9,875
60%	11,414	4,500	11,852	25,970	48,563	32,147	18,173	11,898	10,164	8,000	4,000	3,277	14,098
70%	12,130	4,664	17,267	43,517	62,521	43,351	22,536	15,356	10,871	8,311	4,010	3,869	19,065
80%	13,610	6,968	29,142	75,744	89,737	69,098	38,660	19,347	11,466	8,990	4,353	4,638	24,453
90%	14,904	12,217	66,632	108,004	144,665	98,077	60,728	30,910	17,756	10,219	4,774	6,192	31,246
Max	23,763	79,242	192,577	316,632	261,645	282,502	144,293	68,134	53,012	11,991	5,335	14,811	59,767
Avg	9,698	7,629	22,347	45,847	55,743	44,102	25,754	16,646	10,706	7,271	4,132	4,028	15,210

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	3,000	3,500	3,500	5,749	7,489	6,219	6,141	4,000	4,000	4,000	3,158	3,000	3,832
10%	3,427	4,500	4,500	8,921	9,063	9,320	9,673	7,100	5,313	4,474	4,000	3,000	5,379
20%	4,000	4,500	4,524	10,135	13,351	12,758	10,732	8,516	6,478	5,000	4,000	3,000	6,558
30%	4,000	4,809	4,926	12,765	16,003	16,974	12,574	10,013	6,875	5,168	4,000	3,013	7,515
40%	4,000	5,817	6,055	17,435	22,895	21,291	14,695	11,784	7,100	6,500	4,000	3,178	8,611
50%	4,403	10,313	7,696	21,730	35,578	26,801	18,804	15,655	7,249	8,000	4,000	3,621	10,555
60%	6,094	11,250	11,211	28,909	51,065	33,865	26,521	18,527	8,609	8,000	4,004	11,563	16,780
70%	7,500	13,789	14,983	47,511	59,259	46,311	29,034	21,619	10,669	8,339	4,562	18,438	20,609
80%	7,813	15,313	30,377	67,227	76,708	62,797	49,905	30,014	14,454	9,321	4,768	19,375	25,247
90%	8,438	16,250	65,429	106,860	122,549	86,087	69,025	53,820	29,889	11,201	5,363	20,156	32,140
Max	27,510	79,161	156,667	278,473	220,864	258,901	139,734	84,164	71,767	34,893	14,665	22,592	59,348
Avg	5,914	11,671	21,411	42,487	51,697	42,427	30,085	22,139	12,661	8,014	4,565	9,658	15,743
E. EBC2_ELT													
Min	3,000	3,500	3,500	5,615	7,487	7,239	6,778	4,000	4,000	4,000	3,000	3,000	3,976
10%	3,384	3,612	4,500	8,950	8,915	9,306	9,673	7,258	5,625	4,581	4,000	3,000	5,480
20%	4,000	4,500	4,500	10,176	12,891	12,032	10,139	8,185	6,531	5,000	4,000	3,000	6,536
30%	4,000	4,500	4,727	12,862	15,870	17,468	12,026	9,319	6,939	5,134	4,000	3,000	7,356
40%	4,000	6,044	5,486	17,592	22,702	20,534	15,196	11,075	7,100	7,047	4,000	3,000	8,815
50%	5,425	9,844	8,666	21,342	35,846	25,701	18,708	13,911	7,243	8,000	4,000	3,659	10,639
60%	6,875	10,156	11,062	28,569	53,596	33,360	25,241	16,660	7,743	8,000	4,033	11,094	16,897
70%	9,375	13,732	15,354	49,661	66,028	46,531	28,968	19,798	8,561	9,332	4,259	18,124	20,744
80%	9,688	14,596	33,261	73,247	90,046	68,165	46,063	27,652	10,535	11,102	4,530	19,063	25,305
90%	10,156	15,000	73,195	112,525	137,572	87,794	68,921	48,602	20,916	12,661	5,075	19,375	33,440
Max	27,880	86,453	195,153	305,523	248,113	273,702	146,802	79,224	61,582	22,296	8,687	20,156	60,157
Avg	6,638	11,515	23,546	44,889	55,330	43,911	29,833	21,103	10,945	8,232	4,308	9,473	16,157
F. EBC2_LLT													
Min	3,233	3,500	3,861	4,500	6,657	7,239	7,100	4,000	4,000	4,000	3,000	3,000	4,320
10%	4,759	3,797	4,500	8,788	9,816	9,729	9,920	7,100	6,563	5,000	4,000	3,000	5,918
20%	5,716	4,500	4,788	10,492	12,609	12,686	10,555	9,633	7,100	5,341	4,000	3,000	6,712
30%	6,802	4,500	5,406	14,136	18,250	17,140	11,496	10,183	7,280	6,500	4,000	3,000	7,772
40%	7,309	5,228	7,301	18,238	22,738	19,077	14,880	11,071	8,122	7,694	4,000	3,000	9,095
50%	7,813	10,415	9,156	21,903	37,339	25,784	18,283	12,806	8,336	8,520	4,112	3,430	10,721
60%	8,125	10,938	11,224	28,863	52,213	33,466	24,609	14,355	8,824	10,120	4,610	11,875	16,888
70%	10,625	12,916	16,406	45,305	65,220	49,860	29,321	18,506	10,285	10,846	5,209	18,750	21,041
80%	10,938	14,371	31,145	75,522	92,657	70,864	44,550	25,327	11,153	12,889	5,562	20,781	25,441
90%	11,250	15,469	68,771	106,597	136,295	93,304	68,474	39,949	19,300	13,586	6,209	21,250	33,486
Max	24,664	74,097	192,448	317,787	253,373	281,371	145,542	68,558	53,980	18,471	6,995	21,875	58,712
Avg	8,276	10,844	22,113	46,372	56,338	45,097	29,603	19,121	10,560	8,984	4,754	9,754	16,282

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Table C.A-35. CALSIM-Simulated Monthly Distribution of X2 (km)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
A. EBC1													
Min	67.1	51.7	47.3	47.2	47.2	47.2	47.3	48.5	49.1	56.2	66.0	63.5	54
10%	80.3	72.8	53.1	48.2	47.7	48.2	49.6	52.5	58.9	72.8	82.4	81.4	66
20%	86.0	83.7	64.5	49.6	48.1	49.4	53.6	59.6	66.5	77.0	83.4	85.4	68
30%	89.3	87.0	73.5	56.0	51.3	53.3	58.6	62.1	71.8	78.5	84.6	88.2	71
40%	90.3	88.4	81.1	66.1	53.2	57.1	60.4	64.2	75.0	79.9	85.0	88.5	73
50%	90.7	89.5	85.5	69.2	58.4	59.8	63.7	66.9	76.9	81.3	85.7	89.0	76
60%	91.1	90.3	87.1	72.9	63.7	63.3	66.7	71.1	79.6	82.2	86.0	89.2	78
70%	91.3	90.9	88.8	80.1	67.1	65.1	69.1	74.6	81.0	84.6	86.7	89.6	80
80%	91.7	91.2	89.8	83.0	72.2	73.1	72.6	77.5	81.4	85.4	87.3	89.9	81
90%	93.0	92.1	90.6	84.8	77.9	75.7	76.6	80.9	83.2	86.4	89.7	91.7	84
Max	94.7	93.9	92.2	89.7	86.9	83.3	83.2	87.4	90.5	91.2	91.5	92.6	89
Avg	88.5	86.3	77.9	67.6	60.7	60.7	63.4	67.5	74.6	80.4	85.2	86.4	75
B. PP_ELT													
Min	72.8	52.2	47.7	47.6	47.6	47.7	47.7	49.3	51.0	62.3	74.7	71.4	56.8
10%	86.6	78.5	53.5	48.8	48.0	48.5	50.7	54.1	65.2	75.8	84.1	88.1	68.0
20%	88.3	87.2	64.4	51.4	48.6	50.0	56.6	64.8	74.0	79.5	84.5	88.7	70.0
30%	89.4	88.1	75.4	56.5	52.0	54.3	61.9	67.0	76.0	80.2	85.2	89.5	72.4
40%	90.0	89.0	81.9	67.6	55.1	58.6	65.0	71.3	77.6	80.9	85.4	89.7	75.3
50%	90.3	89.3	85.4	72.9	60.5	62.7	69.0	74.8	78.8	81.5	85.9	90.0	78.3
60%	90.6	89.9	86.7	75.2	65.5	66.6	71.7	76.5	80.4	82.0	87.1	90.4	79.3
70%	90.9	90.1	87.8	79.2	70.3	68.2	73.7	79.1	81.3	84.5	87.7	90.8	81.3
80%	91.1	90.4	89.0	82.4	74.2	73.1	74.9	80.6	82.4	85.1	88.9	91.6	82.8
90%	91.4	90.9	89.9	84.7	79.1	77.3	79.5	82.2	83.7	87.2	90.7	92.4	84.5
Max	93.1	92.6	92.4	90.1	86.8	82.3	83.2	87.1	90.2	90.5	92.1	93.5	87.8
Avg	89.0	86.8	78.3	68.3	62.1	62.4	66.7	71.8	77.0	81.6	86.5	88.5	76.6
C. PP_LLT													
Min	73.8	54.6	48.8	48.7	48.7	48.7	49.0	51.6	54.8	69.9	83.4	79.3	61
10%	80.7	80.3	57.8	50.5	49.4	49.8	52.0	58.0	66.9	78.7	85.2	88.9	69
20%	82.5	83.3	68.9	52.7	50.1	51.5	57.5	66.1	74.8	80.5	85.7	89.6	72
30%	83.9	83.9	78.4	58.0	53.3	55.7	63.0	70.3	78.2	80.8	85.9	90.0	74
40%	84.6	85.0	82.7	69.6	57.7	60.9	66.8	73.1	79.8	82.0	86.2	90.3	76
50%	86.1	85.7	85.0	73.6	60.6	64.8	69.4	77.9	80.4	83.4	87.1	90.6	78
60%	87.1	87.2	87.3	76.5	66.0	66.8	71.8	78.8	81.2	84.4	88.0	90.8	80
70%	88.5	88.0	88.7	78.6	71.9	69.7	74.8	79.7	82.1	85.8	88.9	91.2	81
80%	89.1	89.7	89.4	81.2	75.4	74.4	76.6	80.4	83.5	86.8	89.6	91.6	83
90%	90.4	90.6	90.1	82.4	79.7	79.2	80.2	84.0	85.8	88.8	90.9	91.9	85
Max	92.4	94.3	91.6	90.1	85.7	83.5	84.5	89.1	92.1	91.6	91.9	92.7	88
Avg	85.7	85.1	79.7	68.9	63.2	63.8	68.0	73.7	78.9	83.2	87.5	89.2	77

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	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
D. EBC2													
Min	67.3	51.7	47.3	47.2	47.2	47.2	47.3	48.5	49.3	57.1	67.3	65.8	55
10%	73.9	72.9	53.1	48.3	47.7	48.2	49.6	52.6	59.2	73.1	82.6	74.0	64
20%	74.0	74.0	63.1	49.8	48.3	49.6	53.7	59.5	66.7	77.3	83.8	74.0	67
30%	74.1	75.8	70.8	55.2	51.4	54.0	58.6	62.1	72.0	78.6	84.5	74.1	69
40%	81.0	80.9	78.7	64.6	54.0	57.1	60.6	64.9	75.0	79.7	84.9	81.0	71
50%	90.4	81.1	80.7	70.1	58.6	60.2	64.0	67.1	76.9	81.1	85.6	88.6	75
60%	91.1	89.5	83.0	72.7	64.0	63.1	67.2	71.4	80.0	81.9	86.0	89.3	78
70%	91.4	90.8	85.8	79.7	67.3	64.8	69.0	75.5	81.0	84.6	86.7	89.7	79
80%	91.7	91.4	88.7	82.0	72.8	73.4	73.4	78.0	81.7	85.1	87.4	90.2	81
90%	92.7	91.8	90.7	84.7	76.9	75.7	77.2	81.0	83.2	86.4	88.9	91.5	83
Max	94.6	93.4	92.2	87.2	83.2	82.3	82.5	87.2	90.2	90.9	90.8	92.4	88
Avg	84.1	82.3	76.3	67.4	60.8	61.0	63.6	67.8	74.7	80.4	85.2	82.5	74
E. EBC2_ELT													
Min	69.5	52.4	47.8	47.6	47.6	47.7	47.9	49.8	51.5	62.1	73.6	70.9	57
10%	73.9	73.9	53.0	49.3	48.2	49.1	50.2	53.0	62.6	74.4	82.1	74.0	65
20%	74.0	74.1	61.9	51.1	49.5	50.6	53.5	59.6	69.5	76.8	82.8	74.0	67
30%	74.1	75.1	71.3	56.3	52.0	53.9	58.3	63.9	74.2	77.3	84.1	74.1	69
40%	81.0	80.9	80.4	66.5	55.4	58.1	61.7	66.6	76.7	78.1	84.6	81.0	72
50%	90.2	81.1	81.4	71.0	58.6	60.1	66.2	70.7	77.7	80.4	84.8	88.7	75
60%	91.0	89.2	83.3	73.6	64.9	65.1	67.5	74.0	80.5	81.6	85.4	89.7	78
70%	91.4	90.9	84.8	79.6	69.2	66.5	70.0	77.1	81.2	84.3	86.8	90.3	79
80%	91.8	91.4	89.9	82.2	73.5	73.7	74.4	79.3	81.9	84.8	87.5	90.7	81
90%	93.0	92.6	90.9	84.1	77.7	76.6	78.4	81.1	83.3	86.1	89.7	91.7	83
Max	93.9	94.4	93.6	90.4	87.0	82.7	83.1	87.6	90.2	90.8	90.9	92.6	88
Avg	84.1	82.3	76.6	67.9	61.7	61.9	64.6	68.9	75.9	80.3	85.1	82.7	74
F. EBC2_LLT													
Min	72.2	55.4	50.0	49.6	49.6	49.5	50.0	53.1	55.7	71.4	81.2	73.9	60.8
10%	74.0	74.0	56.7	52.1	50.6	51.2	52.8	57.1	66.1	75.5	83.3	74.0	67.3
20%	74.0	75.0	65.1	53.8	51.8	52.8	57.0	63.6	72.7	76.6	83.9	74.0	69.0
30%	74.1	76.5	74.3	59.0	54.7	56.3	60.5	66.6	75.4	77.2	84.3	74.1	71.0
40%	81.0	80.9	81.2	67.1	58.2	60.4	64.2	70.0	77.6	78.2	84.9	81.0	72.5
50%	87.6	81.1	82.7	72.5	60.4	62.9	67.0	72.1	79.1	80.4	85.6	89.2	76.3
60%	88.9	88.6	84.2	75.0	66.0	66.3	69.3	75.1	80.6	83.2	86.1	90.2	79.1
70%	89.3	89.6	86.7	80.1	69.8	68.0	72.7	78.5	81.5	84.3	86.9	90.8	80.1
80%	90.7	90.3	88.5	82.7	74.7	73.9	75.6	79.2	82.2	85.2	87.9	91.8	81.7
90%	92.1	92.2	90.4	85.4	80.5	78.4	79.0	82.9	84.6	87.6	89.8	92.4	84.7
Max	94.6	94.7	94.0	90.4	87.3	83.8	84.6	88.7	90.9	90.9	92.1	94.3	88.2
Avg	83.7	82.7	78.2	69.4	63.5	63.7	66.5	71.4	77.6	80.8	85.8	83.4	75.6

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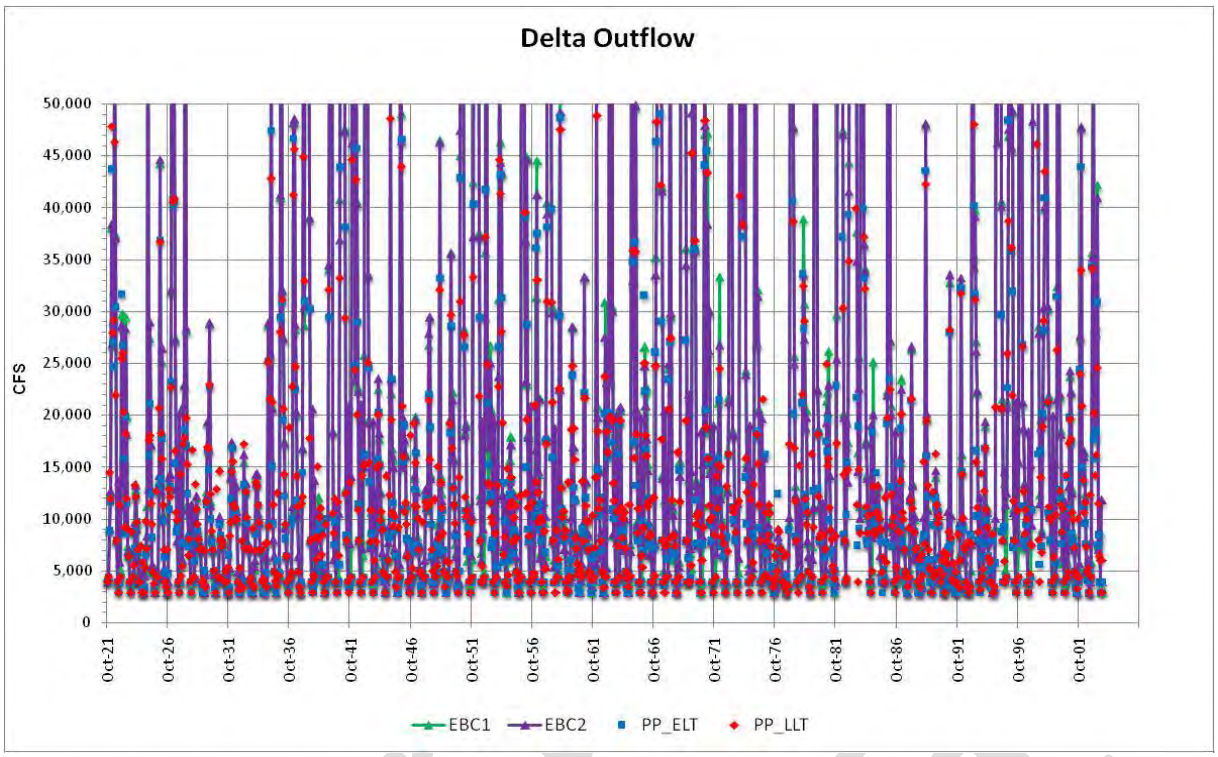

Figure C.A-32. CALSIM-Simulated Monthly Delta Outflow for WY 1922–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

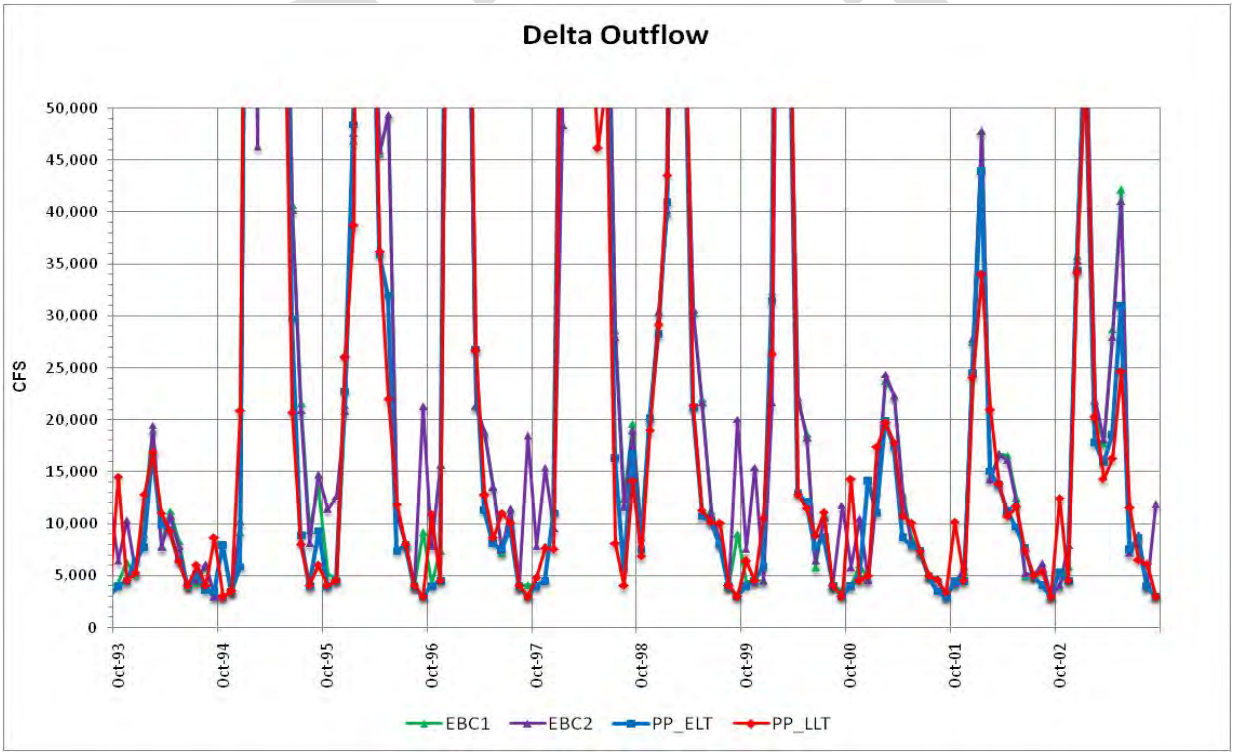

Figure C.A-33. CALSIM-Simulated Monthly Delta Outflow for WY 1994–2003 for the EBC1 and EBC2 Baselines and PP_ELT and PP_LLT Cases

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C.A.5 Hydrodynamic and Salinity Modeling—Results

The objective of the DSM2 modeling analysis was to determine the changes in Delta tidal hydrodynamics and salinity caused by the preliminary proposal. Six simulations were conducted to also evaluate the likely effects of future sea level rise on Delta tidal flows and salinity. The ELT baseline and PP_ELT cases assumed 6 inches of sea level rise, while the LLT baseline and PP_LLT cases assumed 18 inches of sea level rise. The PP was simulated only for the ELT and LLT periods. As described above, two existing baselines were simulated with (EBC2) and without (EBC1) the Fall X2 requirements of the 2008 USFWS BiOp.

The DSM2 model inputs and geometry files were adjusted for each of the six cases. The new intakes were added to the Sacramento River upstream of Sutter Slough; the additional areas of tidal habitat were added to appropriate locations for the PP_ELT (25,000 acres) and the PP_LLT (65,000 acres) cases. Some of the existing gates and barriers were modified for the PP cases. The PP simulations assume that the Suisun Marsh salinity control radial gates on Montezuma Slough would remain open all year long to allow full connection with tidal restoration areas in Suisun Marsh (this had a salinity effect in the fall months of some years when the gates were operated in the baseline cases). The south Delta agricultural (water level control) barriers were not installed for the PP cases to enhance tidal flows in the proposed restoration areas.

C.A.5.1 Changes in Martinez Boundary Conditions

Each of the DSM2 modeling cases for the 1976–1991 simulation period had different inflows, exports, and Delta outflows, based on the CALSIM monthly results for each case. Daily flows were estimated from the combination of historical inflows and the CALSIM monthly results. The model cases combined the effects of four different changes: (1) sea level rise, (2) expanded tidal habitat restoration areas, (3) diversions at the north Delta intakes, and (4) changes in inflows and outflow.

Figure C.A-34 shows that the assumed sea level rise at Martinez was a simple constant shift, and was nearly identical to the assumed sea level rise at the Golden Gate. The UnTRIM 3-D Bay-Delta model results indicated a very small increase in tidal amplitude (1% for 18 inches of sea level rise) and a slightly lower mean tide (-0.1 feet) than assumed at the ocean boundary. Figure C.A-34 presents a sample of the Martinez boundary stage applied for the EBC2, EBC2_ELT, and EBC2_LLT simulations. For the PP conditions, which include the addition of tidal restoration areas throughout the Delta, the net effect on Martinez tide also included tidal muting (reduced amplitude) of about 5% for the full 65,000 acres of additional tidal restoration. The RMA 2-D Bay-Delta model indicated that the tidal flows at Martinez would increase slightly (2%), although the tidal amplitude would be reduced by 5%. These effects of sea level rise and tidal habitat expansion on the tidal fluctuations and tidal flows at the Martinez boundary are relatively small.

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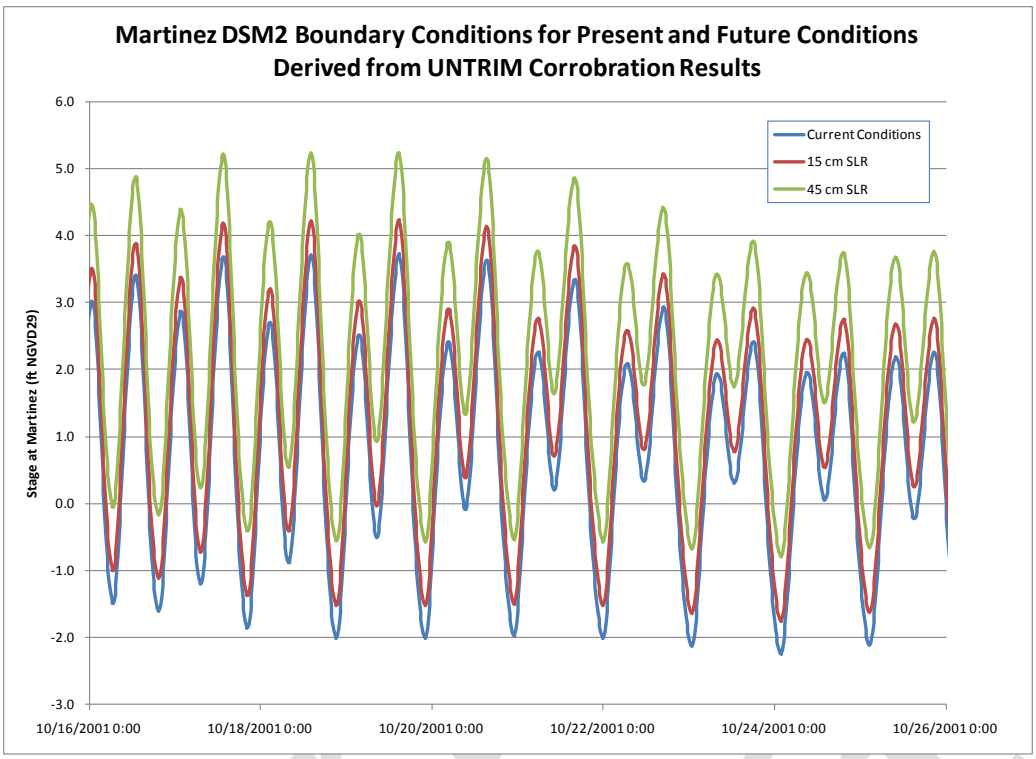

Figure C.A-34. Martinez Boundary Tidal Elevation Variation with Sea Level Rise (ELT and LLT)

The average flow in the Sacramento River for the simulation period of WY 1976–1991 was 20,864 cfs for the EBC1 and EBC2 cases, based on the CALSIM results for the same period. The Sacramento River inflows were reduced slightly (1%) for the ELT and LLT cases because of assumed climate change effects on runoff, and were reduced by about 5% because of the additional spills into the Yolo Bypass (Fremont Weir gate) for the PP cases. The average flow in the Yolo Bypass was about 3,600 cfs for the EBC1 and EBC2 cases and increased by about 15% for the ELT and LLT cases (4,200 cfs) from increased high flows with climate change, and increased an additional 15% with the Fremont Weir notch for the PP cases (4,800 cfs). The average flow in the San Joaquin River was about 5,100 cfs for the EBC1 and EBC2 cases, and the average flow was within 1% of the baseline (EBC1 and EBC2) for the ELT and LLT cases. The San Joaquin River inflow did not change with the preliminary proposal.

The south Delta exports and diversions into the north Delta intakes were specified from the CALSIM results for the six cases. The Delta diversions and agricultural return flows (drains) were the same for the six cases, although some agricultural diversions and drainage might be reduced with tidal habitat restoration (not simulated). The average north Delta intake diversions were 3,251 cfs in the PP_ELT case and 2,928 cfs in the PP_LLT scenario. The average south Delta exports were about 6,500 cfs for the EBC1 and EBC2 cases and were reduced to 4,046 cfs for the PP_ELT and 3,821 cfs for the PP_LLT cases.

Delta outflow was calculated in the DSM2 model, but averaged over a monthly time period the DSM2 outflow will be identical to the CALSIM-simulated outflow for the six cases. Because each of the six cases had a different sequence of Delta outflow, the salinity differences calculated for the six cases will be dominated by the CALSIM-simulated outflow differences; the much smaller effects from sea level rise and tidal habitat restoration will be difficult to evaluate.

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Boundary EC values (salinity) at Vernalis were calculated by the CALSIM model, and were slightly different for the six cases. The Sacramento River and Yolo Bypass EC was assumed to be a constant of 175 µS/cm for all cases. The Cosumnes and Mokelumne River EC was assumed to be a constant of 150 µS/cm.

The salinity boundary conditions at Martinez were adjusted for each DSM2 case. The 3-D UnTRIM model of the San Francisco Bay and Delta and the 2-D RMA Bay-Delta Model were used to develop adjustments for the Martinez EC boundary conditions (Table C.A-36). The RMA modeling suggested that the tidal habitat expansion would have almost no effects on the EC at Martinez. The UnTRIM model suggested that sea level rise would add about 1,000–1,500 µS/cm to the Martinez EC, for the full range of Martinez EC values. The daily average Martinez EC is about 30,000 µS/cm during low outflow of about 3,000 cfs and is reduced to about 10,000 µS/cm when the outflow is about 25,000 cfs. The EC increment from 18 inches (45 cm) of sea level rise would be 1,500 µS/cm at higher flows of 25,000 cfs and would be about 1,100 µS/cm higher at low outflow of 3,000 cfs. The EC increment from sea level rise therefore was estimated to be about 5% at the highest EC values and about 15% at the lowest EC values.

Table C.A-36. Adjustments to Baseline EC at Martinez for DSM2 Modeling of Preliminary Proposal Cases

	Martinez EC (µS/cm)	
Scenario	**Correlation**	**Lag (min)**
NT (14,000ac)	Y = 1.001 * X + 191.5	8
ELT (25,000ac)	Y = 0.999 * X + 114.7	10
LLT (65,000ac)	Y = 0.996 * X + 68.2	13
15cm SLR	Y = 0.9954* X + 556.3	0
45cm SLR	Y = 0.98* X + 1778.9	-2
ELT (25,000ac &15cm SLR)	Y = 0.999 * X + 357.78	9
LLT (65,000ac & 45cm SLR)	Y = 1.002 * X + 1046.3	11
X = Baseline Martinez EC. Y = Scenario Martinez EC. SLR = sea level rise.		

C.A.5.2 Changes in Tidal Elevations

The preliminary proposal tidal habitat restoration would increase the mean higher high water (MHHW) water surface area of the Delta and Suisun Bay (upstream of Martinez) from about 90,000 acres to 140,000 acres (+55% increase). The existing mean lower low water (MLLW) water surface area would increase from about 85,000 acres to 115,000 acres (+35% increase). The MHHW volume upstream of Martinez would increase from about 1,500,000 af to about 1,900,000 af (+25%) and the MLLW volume would increase from 1,000,000 af to about 1,150,000 af (+15%) with the simulated preliminary proposal tidal habitat restoration (based on the RMA model results). The RMA model and the DSM2 model indicated this would cause substantial tidal muting (reduced tidal amplitude) in many Delta locations. Reduced tidal amplitudes could alter the tidal flows into the major channel diversions and could reduce the net diversion flow as a percentage of the net flow upstream of the diversion.

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The additional tidal habitat would cause tidal muting (reduced tidal amplitude) throughout the Delta. Figure C.A-35 shows a longitudinal transect along the Sacramento River of the minimum average (10% cumulative) water levels for the six cases. Figure C.A-36 shows the longitudinal transect along the San Joaquin River of the minimum average (10% cumulative) water levels for the six cases. Near Martinez (River Kilometer 54), the changes in water level from baseline are approximately +0.5 and +1.5 feet, respectively, corresponding to the sea level rise boundary conditions applied at the western boundary in DSM2. Without the tidal habitat restoration included in the preliminary proposal, the minimum water levels would be raised uniformly along the Sacramento and San Joaquin Rivers. Only at the upstream end of the tidal influence are the tidal levels more controlled by the river geometry, so the sea level rise increases in minimum elevation are less. The PP simulations show increased minimum elevations caused by the tidal damping that results from the tidal habitat restoration. The PP simulations indicate that the maximum elevations are reduced by the tidal habitat restoration. The average tidal muting (reduction in high tide elevation) was about 0.3 feet for the ELT (25,00 acres) and the average tidal muting was about 0.5 feet for the LLT (65,000 acres) along the Sacramento and San Joaquin River channels (not shown here).

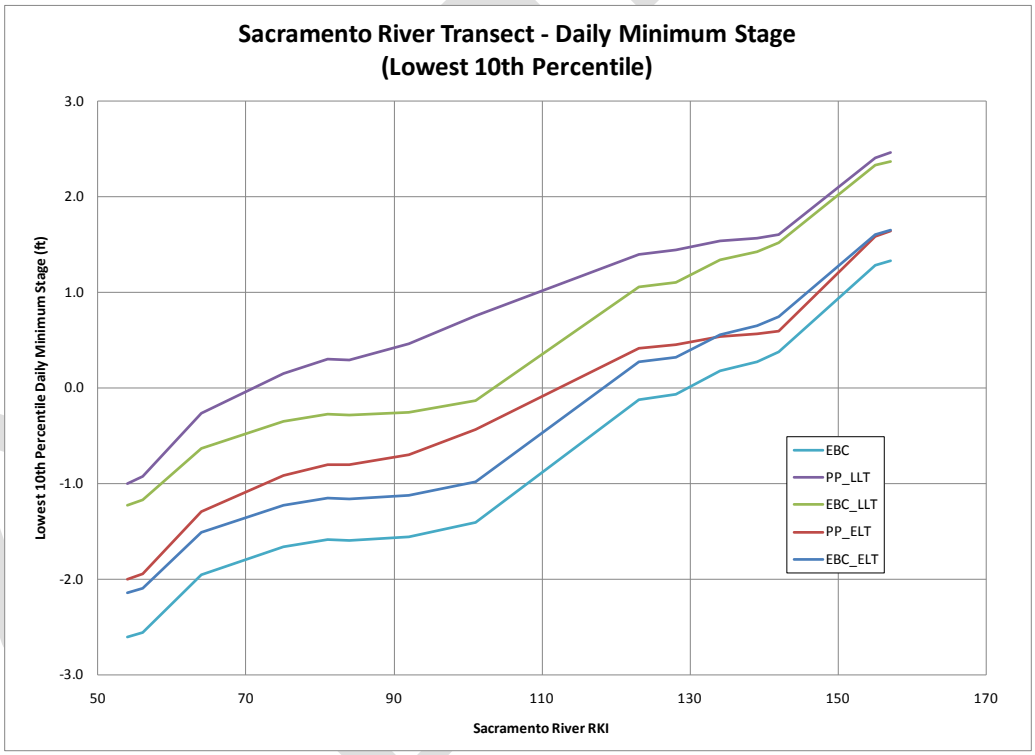

Figure C.A-35. Daily Minimum Stage Transect in Sacramento River, Lowest 10th Percentile

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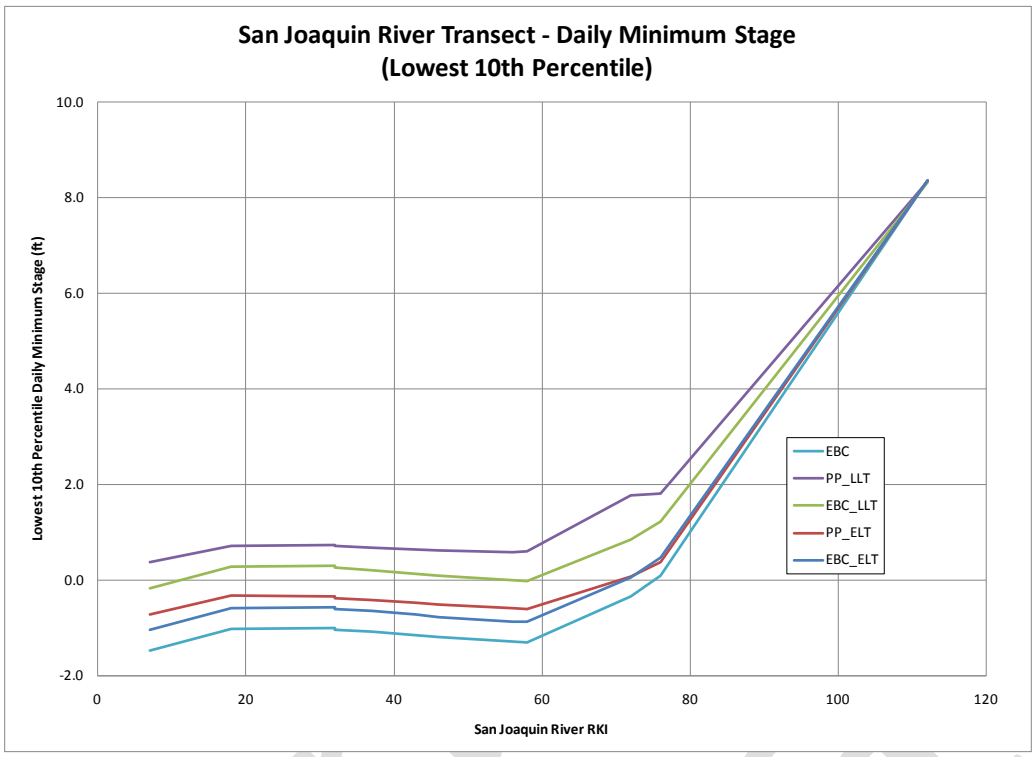

Figure C.A-36. Daily Minimum Stage Transect in San Joaquin River, Lowest 10th Percentile

C.A.5.3 Changes in DSM2-Simulated Channel Flow Diversions

The DSM2 daily flow results were used to demonstrate the shifts in the major flow diversion relationships (diversion flow as a fraction of upstream river flow) along the Sacramento River and along the San Joaquin River. The DSM2-simulated changes in these flow diversions (flow splits) for the PP cases were caused by the combined effects of sea level rise and tidal habitat expansion (restoration). For this section. the EBC1 daily average flows were compared to the PP_LLT daily average flows. The DSM2 simulation included the 1976–1991 period, but only daily flows for water years 1977 and 1978 are shown on the graphs (these years included the full range of daily flows). These flow-diversion relationships are described in greater detail because the flow splits and flow pathways through the Delta channels provide the foundation for evaluating effects of the Delta channel flows on fish migrating through the Delta and on the movement of larval and juvenile fish within the Delta.

C.A.5.3.1 Changes in Sacramento River Flow Diversions

Figure C.A-37 shows the Sutter Slough diversions as a function of the Sacramento River flow above Sutter Slough. The daily average flows and percent of flow diverted for WY 1977 and 1978 are shown. For all baseline cases this is the flow at Freeport; for the PP cases this would be the flow after the north Delta intake diversions. At Sacramento River flows of greater than 25,000 cfs, the DCC is closed, and the Sutter Slough flow is about 27% of the Sacramento River flow. The tidal flow variations at a Sacramento River flow of 25,000 cfs are weak, and this junction behaves as a river channel split. At a Sacramento River flow of 60,000 cfs, the Sutter Slough diversion flow would be about 16,000 cfs. At flows below 25,000 cfs, there are two cases; with the DCC closed the Sutter Slough diversion is slightly higher than when the DCC gates are open. The percentage of the

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Sacramento River flow diverted into Sutter Slough declines at river flows of less than 15,000 cfs; the percentage diverted is 22% at a low Sacramento River flow of 5,000 cfs. When the DCC gates are open, the percentage of the river flow diverted increased from 18% at a river flow of 5,000 cfs to about 22% at a river flow of about 20,000 cfs.

The effects of the preliminary proposal were simulated to slightly increase the Sutter Slough diversion, from about 27% to about 28.5% at river flows of greater than 25,000 cfs (when the DCC gates are closed). The percentage diverted was simulated to increase more at lower flows; the diversion was 30% of the river flow at a flow of 15,000 cfs and was 40% at a river flow of 5,000 cfs. This was apparently the result of tidal habitat expansion in the Cache Slough region that muted the tidal elevations in Sutter Slough and thereby increased the average daily diversion flow from the Sacramento River (elevations were not muted by as much).

Figure C.A-38 shows the DSM2-simulated Steamboat Slough diversions as a function of the Sacramento River flow upstream of Sutter Slough (Freeport). The EBC1 baseline Steamboat Slough diversion was about 20% for river flows of greater than 25,000 cfs when the DCC gates were closed. The baseline Steamboat Slough diversion percentage decreased at lower river flow and was about 15% at a low river flow of 5,000 cfs. The diversion flow was reduced by about 5% of the river flow when the DCC gates were open; the Steamboat Slough diversion was about 15% at a river flow of 20,000 cfs and was about 10% at a river flow of 5,000 cfs. The DSM2-simulated changes for the PP_LLT case were relatively small. The effects of opening the DCC gates were less than for the baseline diversions, so the Steamboat Slough diversion percentage remained 1–2% higher than the baseline at these relatively low river flows of 5,000 cfs to 20,000 cfs.

Figure C.A-39 shows the DSM2-simulated DCC diversion as a function of the Sacramento River flow upstream of the DCC (at Locke). The EBC1 baseline DCC diversion was about 40% for river flows of 5,000 cfs to 12,500 cfs (highest river flow while open). The highest DCC diversion was therefore about 5,000 cfs. The DSM2-simulated DCC diversions would be reduced for the PP_LLT to about 30–35% of the river flow above the DCC.

Figure C.A-40 shows the corresponding Georgiana Slough diversion as a function of the Sacramento River flow above the DCC. When the DCC was closed (above a flow of about 12,500 cfs at DCC) the Georgiana Slough diversion was about 30% of the river flow. The Georgiana Slough diversion increased at lower flows when the DCC was closed, to about 40% when the river flow was 7,000 cfs and to 50% when the river flow was 3,000 cfs. When the DCC gates were open, the baseline Georgiana Slough diversion was reduced by about 10% of the river flow, to about 22% at a flow of 12,500 cfs and about 30% at a river flow of 5,000 cfs. The DSM2-simulated Georgiana Slough diversion was reduced slightly with the preliminary proposal at lower river flows. The PP_LLT diversion percentage was 40% at a river flow of 5,000 cfs and about 30% at a river flow of 10,000 cfs. The Georgiana Slough diversion was about the same for river flows greater than 15,000 cfs (DCC closed).

Figure C.A-41 shows the DSM2-simulated combined Sutter and Steamboat Slough diversions as a function of the Sacramento River flow upstream of Sutter Slough for the EBC1 and PP_LLT cases. The simulated diversions for the PP case were slightly increased at higher flows when the DCC gates were closed, and were increased by about 5–10% of the river flow when the river flow was less than 20,000 cfs with the DCC open or closed. Figure C.A-42 shows the DSM2-simulated combined DCC and Georgiana Slough diversions as a function of the Sacramento River flow above Sutter Slough (Freeport for baselines). At low river flows when the DCC is open, the combined DCC and Georgiana

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Slough diversion is 50% at a flow of 5,000 cfs and 40% at a flow of 20,000 cfs. The Georgiana Slough diversion was about 30% with a river flow of 5,000 cfs and 20% at a river flow of 15,000 cfs; it decreased to 15% at a river flow of 50,000 cfs. The simulated diversions for the PP case were reduced at the lower river flows. The diversions with the DCC open were about 30% of the river flow. The Georgiana Slough diversion with the DCC gates closed was reduced from 30% to 20% of the river flow at a flow of 5,000 cfs, but was similar to the baseline diversion of about 15% for river flows of 50,000 cfs.

Figure C.A-43 shows the DSM2-simulated average daily diversions in Threemile Slough for the EBC1 and PP_LLT cases. The Threemile Slough flow from the Sacramento River to the San Joaquin River did not change appreciably with the preliminary proposal. The tidal flows in Threemile Slough were reduced because of the general tidal muting within the Delta that was the result of the increase tidal habitat (i.e., restoration) simulated for the PP_LLT.

Flow in Montezuma Slough, on average, is from the Sacramento River into Montezuma Slough and Suisun Marsh. The Montezuma flow is about 1% of Delta outflow. Operation of the Montezuma Slough Salinity Control Gate increases the diversion by a constant daily flow of about 2,000 cfs (when it is operated during October–March of some years). The net diversion flow was not increased by sea level rise or tidal habitat restoration but was reduced with the PP because the Montezuma Slough Salinity Control Gate was not operated, to allow full tidal exchange into Suisun Marsh.

C.A.5.3.2 Changes in San Joaquin River Diversions

Figure C.A-44 shows the DSM2-simulated changes in the Old River diversion from the San Joaquin River near Mossdale for the EBC1 and PP_LLT cases. The flow diversion is about 50% of the San Joaquin River at Mossdale flow. The Old River diversion flow is shown as a function of the San Joaquin River flow at Vernalis. The DSM2 model simulated the Paradise Cut flood bypass diversion upstream of Mossdale for flows greater than 17,500 cfs. The resulting Old River diversion was about 7,500 cfs when the Vernalis flow was 15,000 cfs, and was about 10,000 cfs when the Vernalis flow was 25,000 cfs because about half of the Vernalis flow greater than 17,500 cfs was diverted into Paradise Cut. The only simulated difference for the PP case was at flows less than 5,000 cfs. The baseline cases assumed that a rock barrier would be installed in October and November to increase flows at Stockton to improve adult Chinook migration success, but the rock barrier was assumed not to be installed for the PP case because of the tidal habitat restoration in the south Delta. Therefore, the PP case showed increased Old River diversions in these months. The overall effects of the preliminary proposal on these Sacramento and San Joaquin diversion flows were relatively small compared to the large increase in tidal habitat from sea level rise and restoration efforts. The daily net average flows and average flow splits (pathways) would not be greatly changed by the PP case.

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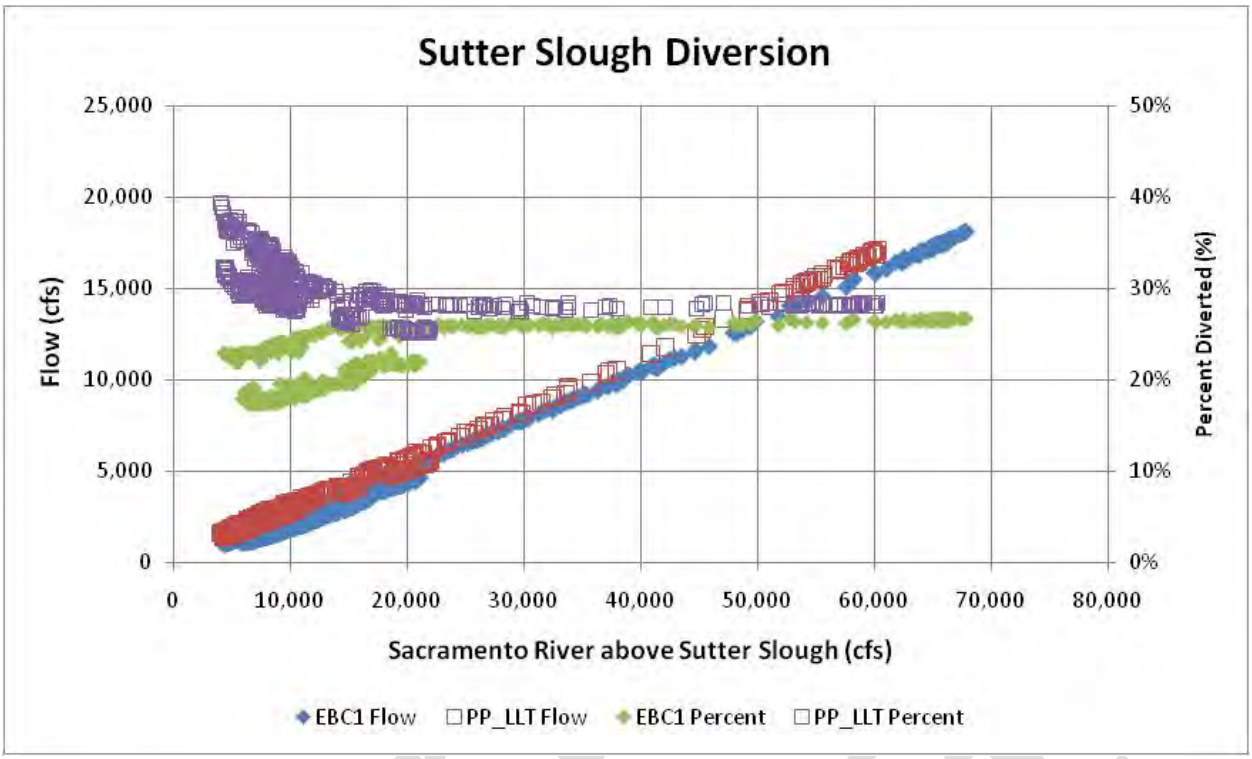

Figure C.A-37. DSM2-Simulated Sutter Slough Diversion from the Sacramento River for EBC1 and PP_LLT Cases

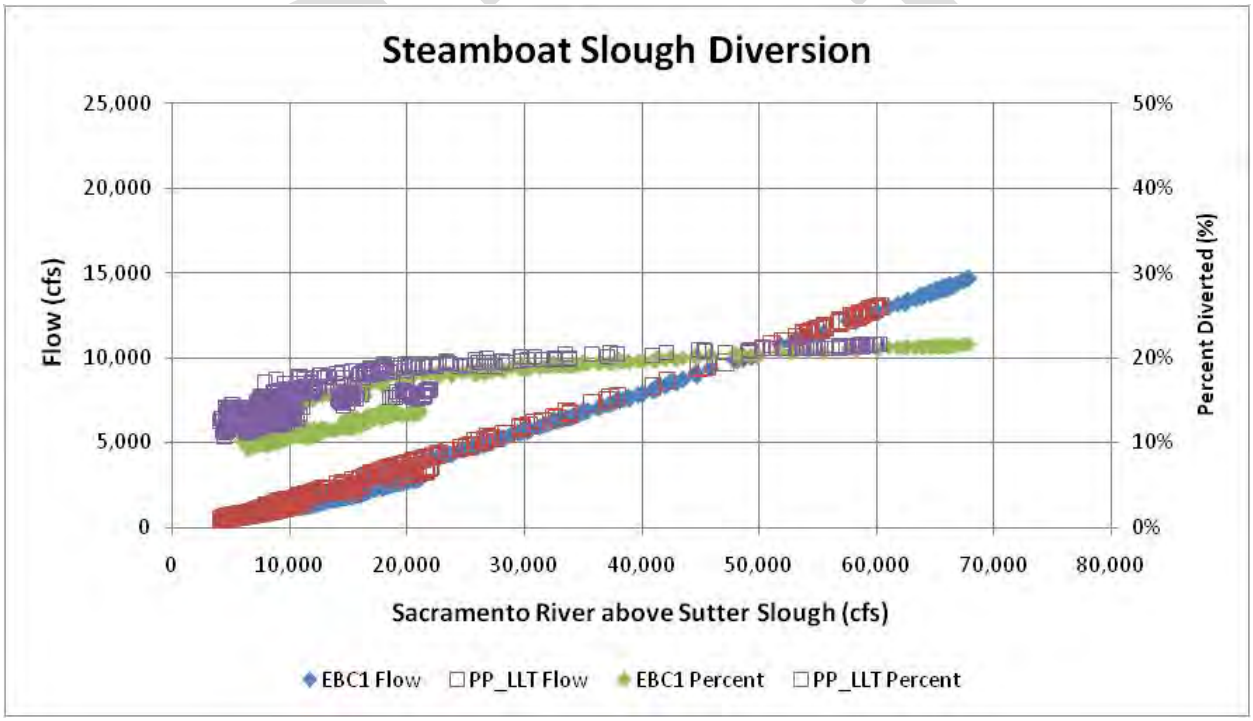

Figure C.A-38. DSM2-Simulated Steamboat Slough Diversion from the Sacramento River for EBC1 and PP_LLT Cases

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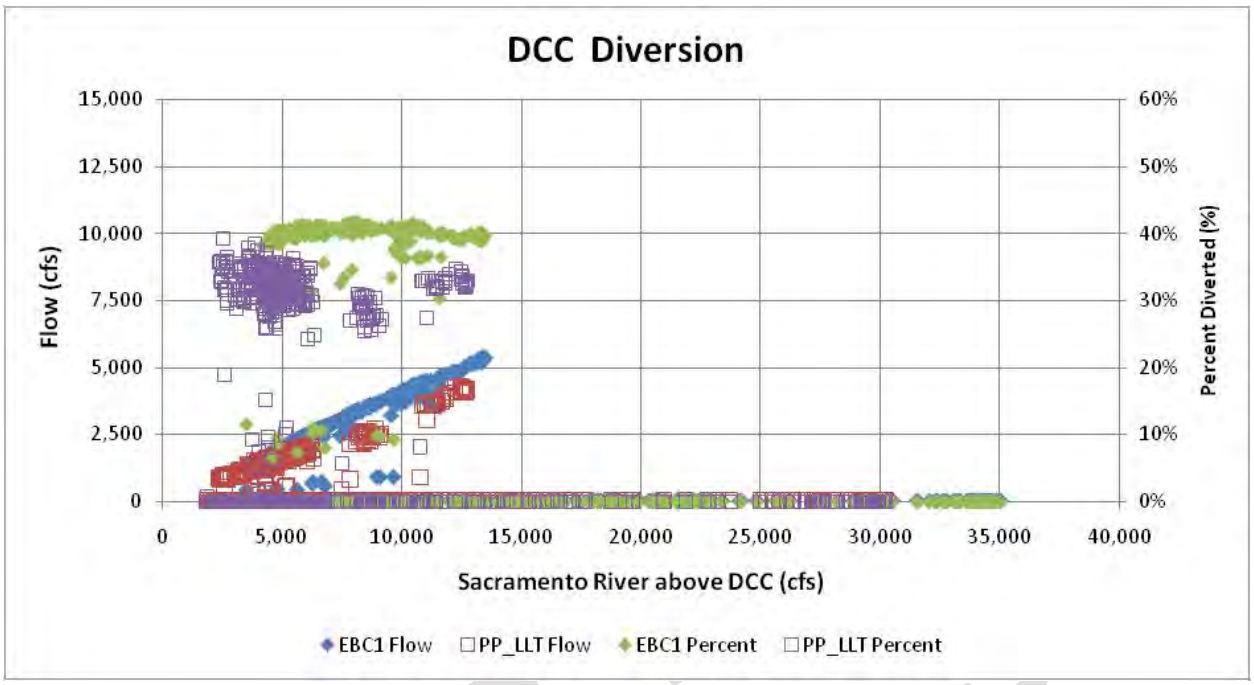

Figure C.A-39. DSM2-Simulated Delta Cross Channel Diversion from the Sacramento River for EBC1 and PP_LLT Cases

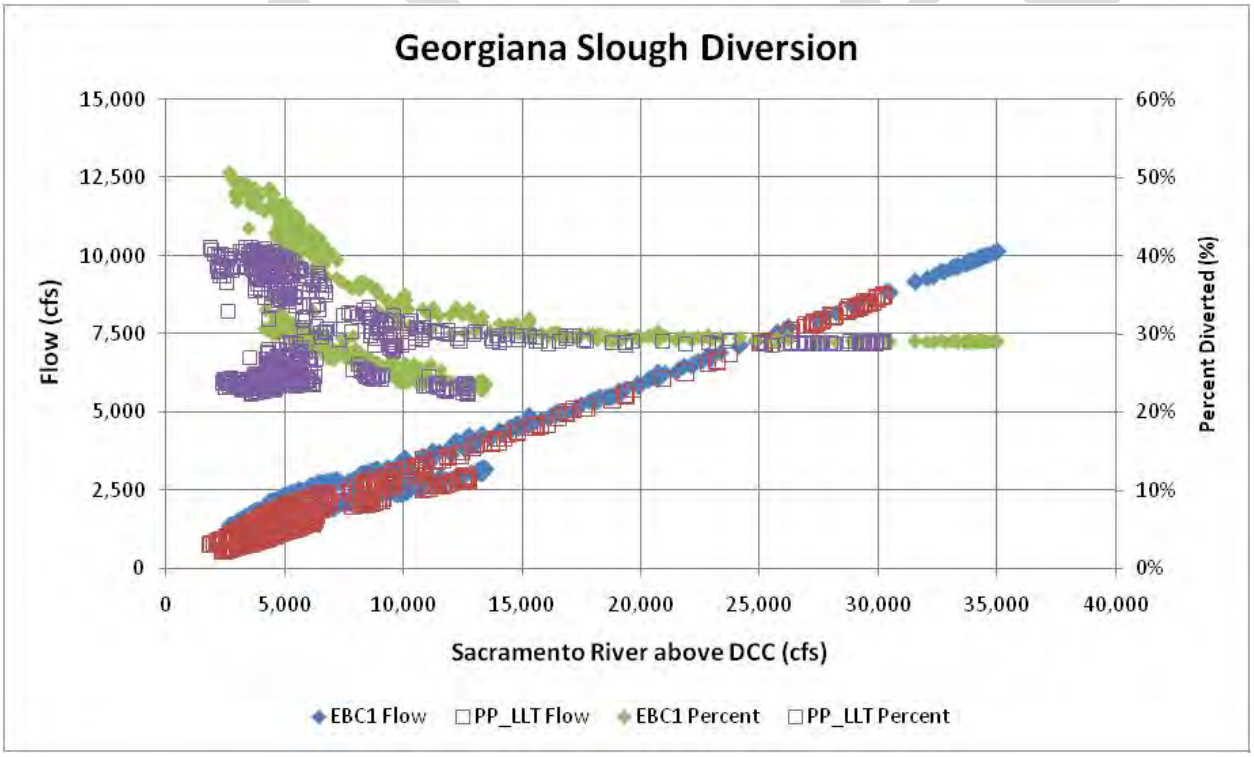

Figure C.A-40. DSM2-Simulated Georgiana Slough Diversion from the Sacramento River for EBC1 and PP_LLT Cases

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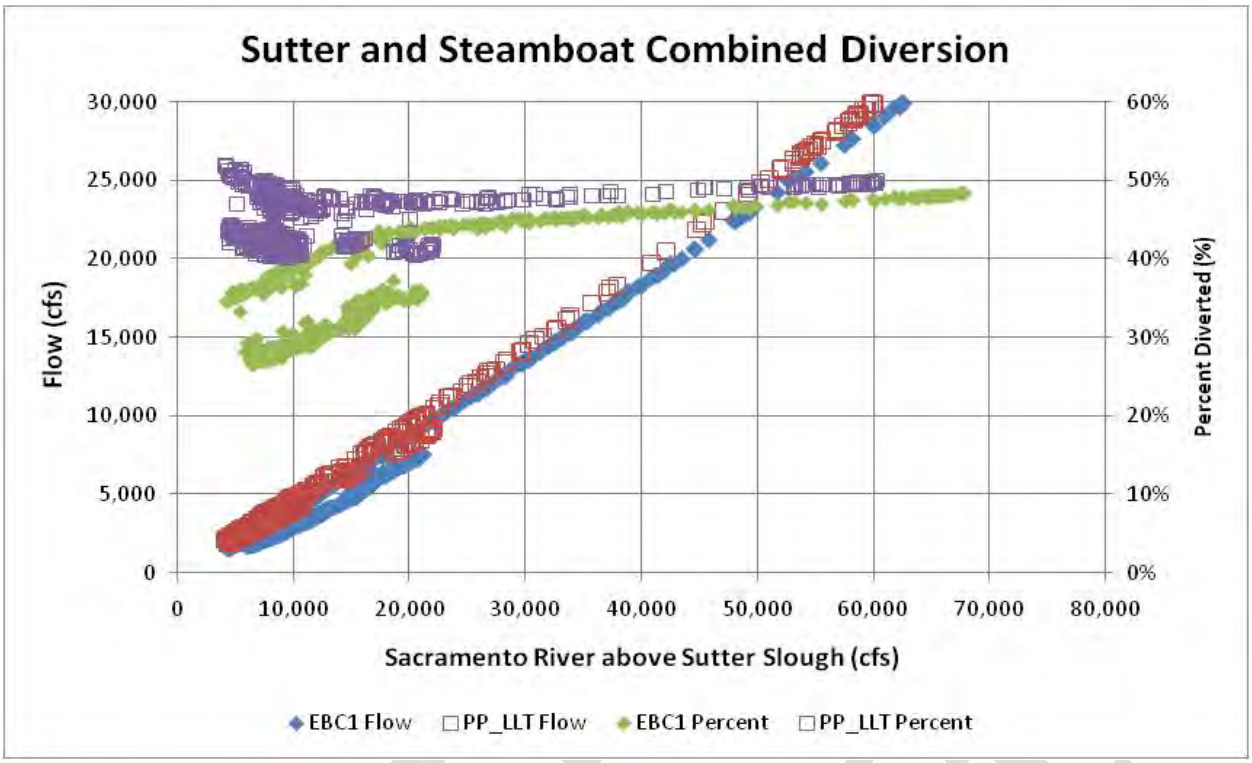

Figure C.A-41. DSM2-Simulated Combined Sutter and Steamboat Slough Diversion (and percentage) from the Sacramento River for EBC1 and PP_LLT Cases

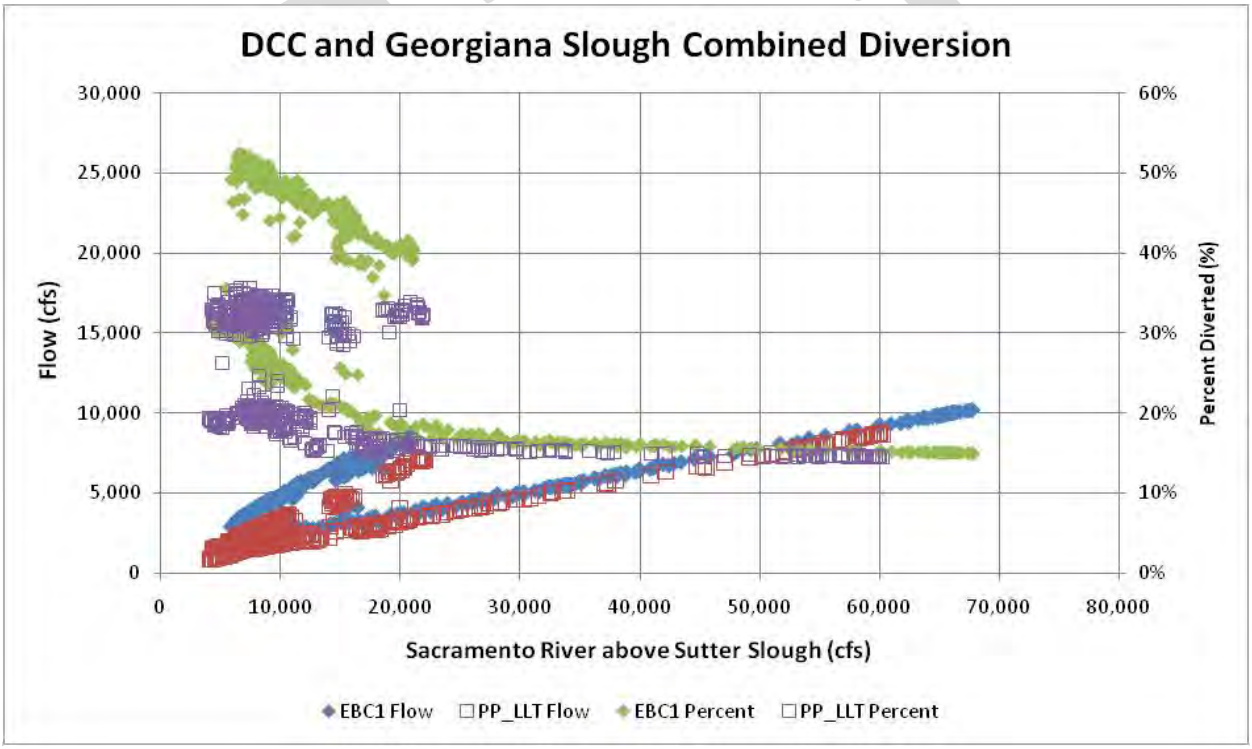

Figure C.A-42. DSM2-Simulated Combined Delta Cross Channel and Georgiana Slough Diversion (and percentage) as a Function of the Sacramento River Flow above Sutter Slough) for EBC1 and PP_LLT Cases

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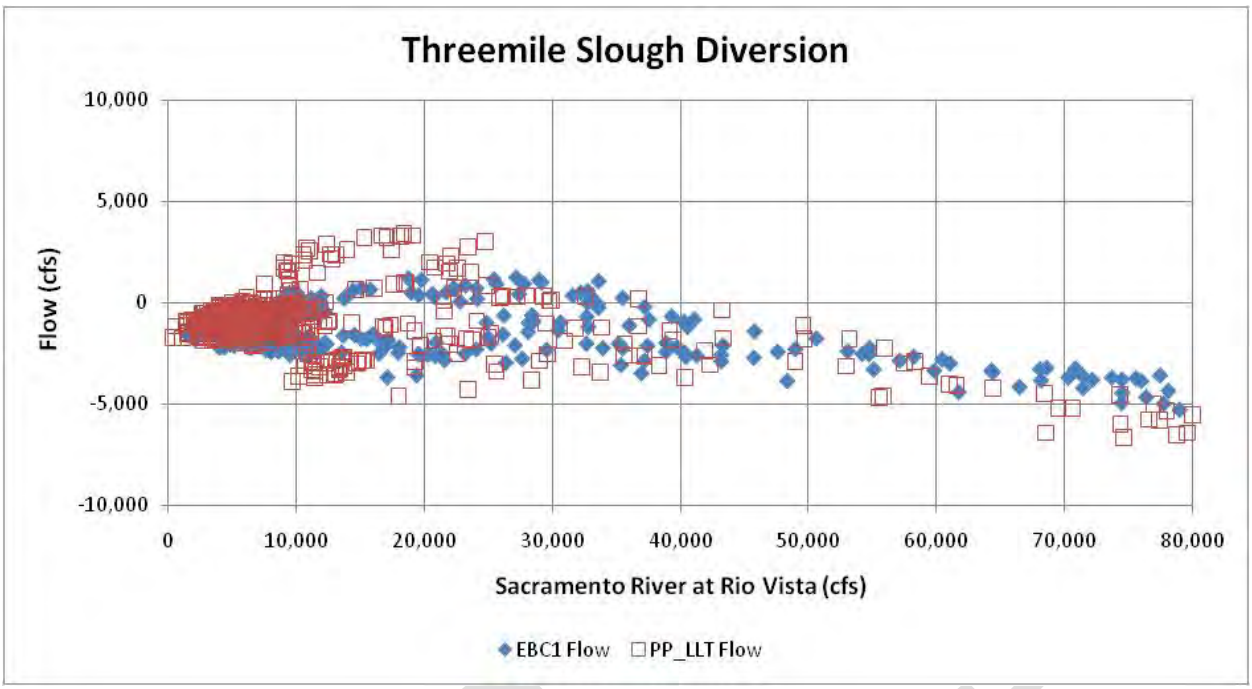

Figure C.A-43. DSM2-Simulated Threemile Slough Diversion (negative is from Sacramento to San Joaquin River) as a Function of the Sacramento River Flow at Rio Vista for EBC1 and PP_LLT Cases

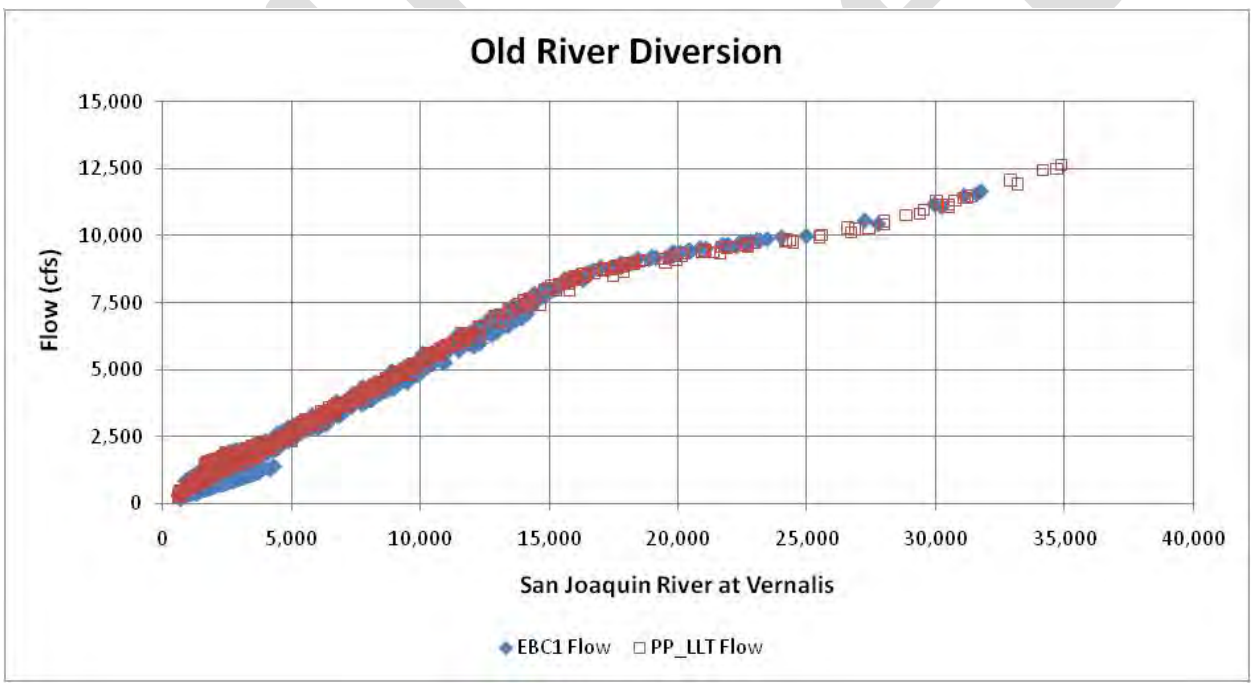

Figure C.A-44. DSM2-Simulated Old River Diversion from the San Joaquin River as a Function of the San Joaquin River Flow at Vernalis for EBC1 and PP_LLT Cases

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C.A.6 DSM2-Simulated Changes in Salinity

The DSM2 modeled salinity is a direct function of the specified outflow, taken from the CALSIM-simulated Delta outflow for each case. The Martinez EC boundary was calculated using the DSM2-preprocessor that uses the historical EC measurements and the adjustments in outflow, along with the added effects of sea level rise and tidal habitat restoration to estimate the adjusted EC values. The upstream salinity in the Delta channels calculated by DSM2 is a direct function of the tidal flows (which are largely unchanged) and the simulated tidal mixing within the existing channels, with or without the additional tidal habitat areas. Most of the differences in salinity at upstream Delta locations are caused by the CALSIM-simulated outflow changes, with relatively small adjustments for sea level rise and tidal habitat restoration. The major differences in the DSM2 salinity results are caused by the different assumed Delta outflow sequences. The small effects of sea level rise and tidal habitat restoration cannot easily be identified from the monthly EC results, because the outflow changes between the cases were relatively large.

Figure C.A-45 shows the DSM2-simulated monthly EC at Collinsville for the six DSM2 cases. The seasonal changes in salinity at Collinsville ranged from less than 1,000 µS/cm to about 10,000 µS/cm in almost every year. The salinity at Collinsville was about 30% of the assumed EC at Martinez (maximum of about 35,000 µS/cm during low-outflow periods). The X2 location would be at Collinsville (KM 81) when the EC was about 2,500 µS/cm. The X2 location was generally upstream of Collinsville (EC was greater than 2,500 µS/cm) in the summer and fall, and downstream of Collinsville in the winter months.

Figure C.A-46 shows the DSM2-simulated monthly EC at Emmaton for the six DSM2 cases. The seasonal changes in salinity at Emmaton ranged from less than 250 µS/cm to about 3,500 µS/cm in almost every year. The salinity at Emmaton was about 35% of the salinity at Collinsville.

Figure C.A-47 shows the DSM2-simulated monthly EC at Jersey Point for the six DSM2 cases. The seasonal changes in salinity at Jersey Point ranged from less than 250 µS/cm to about 2,500 µS/cm in almost every year. The salinity at Jersey Point was about 25% of the salinity at Collinsville.

Figure C.A-48 shows the DSM2-simulated monthly EC at Rock Slough (Old River at Rock Slough) for the six DSM2 cases. The seasonal changes in salinity at Rock Slough ranged from less than 250 µS/cm to about 1,000 µS/cm in almost every year. The salinity at Rock Slough was about 10% of the salinity at Collinsville, and about 40% of the salinity at Jersey Point.

The changes in EC at each of these stations were caused by changes in outflow. Because three of the baseline cases (EBC2, EBC2-ELT and EBC2_LLT) assume that the Fall X2 requirements of the 2008 USFWS BiOp would be satisfied in the fall of 1978, 1980, 1983, 1984, and 1986 (5 of the 16 years simulated), while the PP cases assume that the Fall X2 requirements would not be necessary, the PP cases show much higher EC in the months of September–November of these years at each station.

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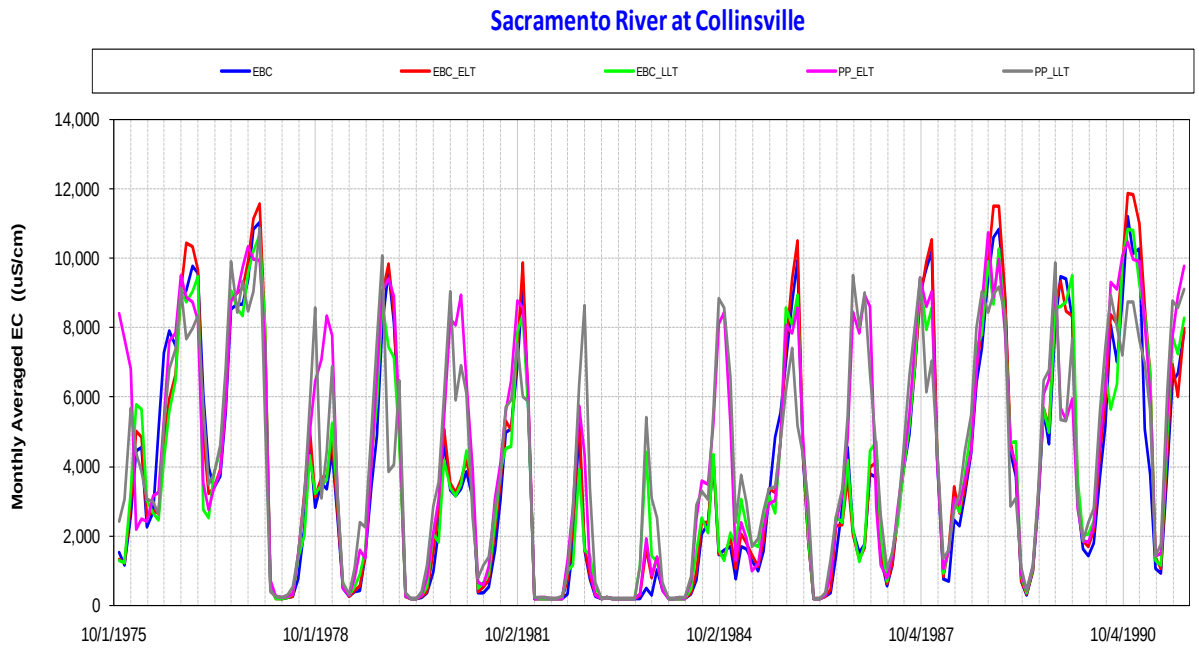

Figure C.A-45. Monthly EC at Collinsville for WY 1976–1991 for the Six DSM2 Cases

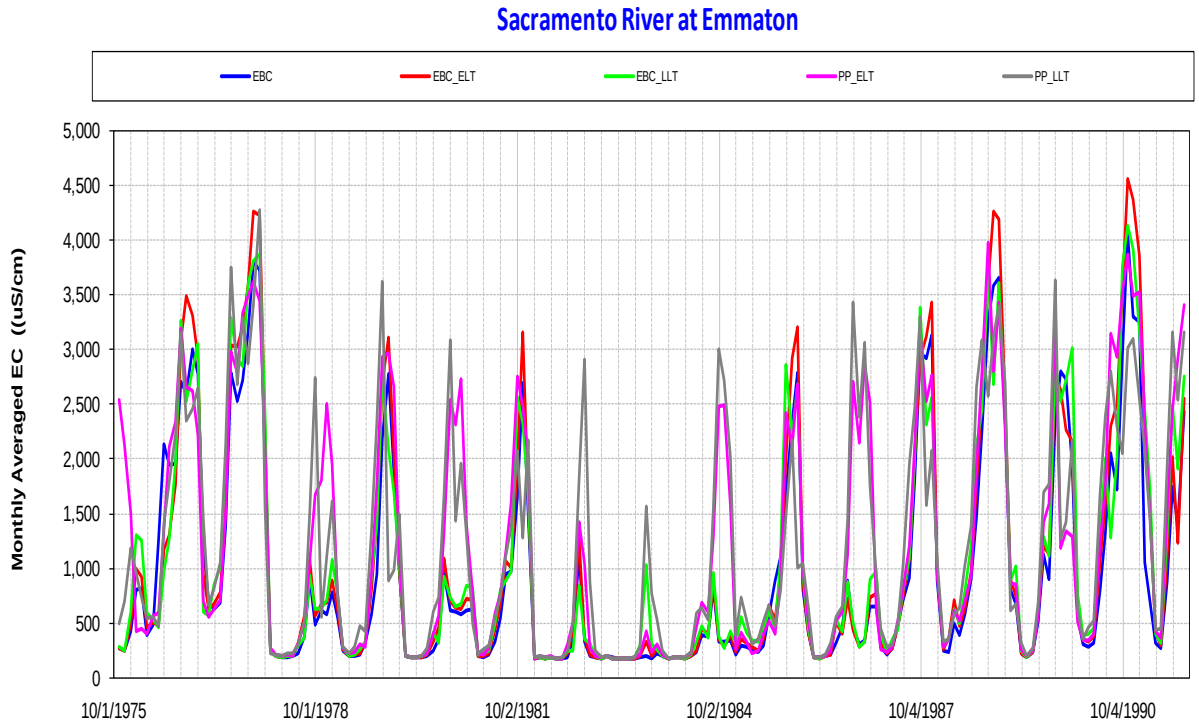

Figure C.A-46. Monthly EC at Emmaton for WY 1876–1991 for the Six DSM2 Cases

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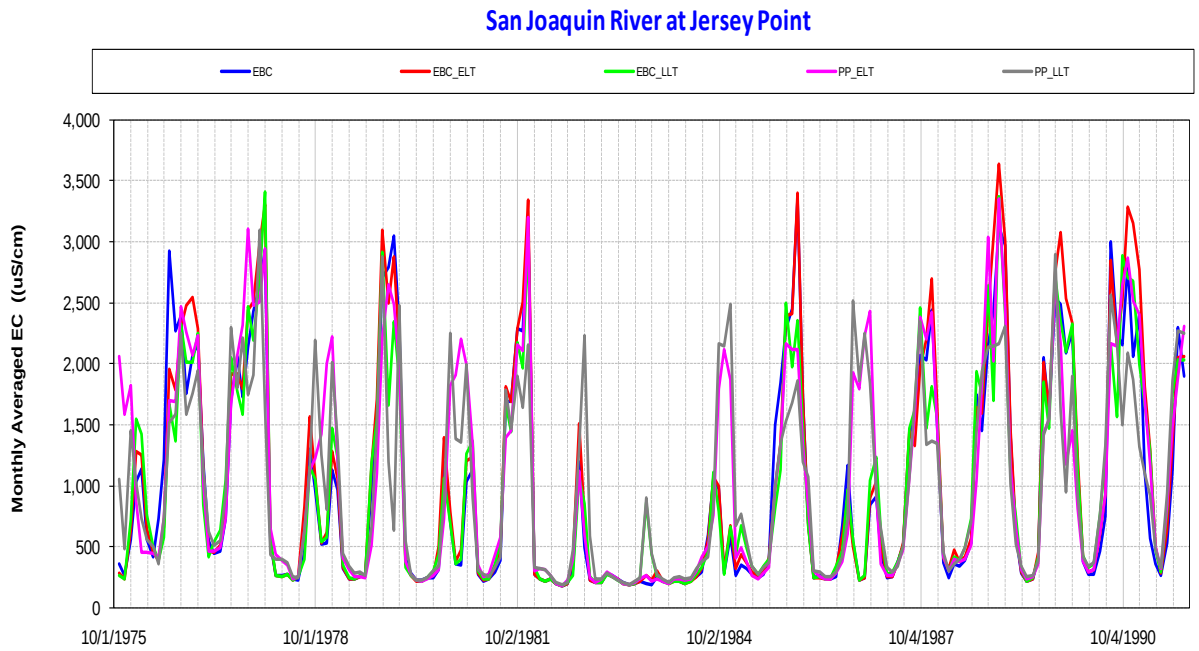

Figure C.A-47. Monthly EC at Jersey Point for the Six DSM2 Cases

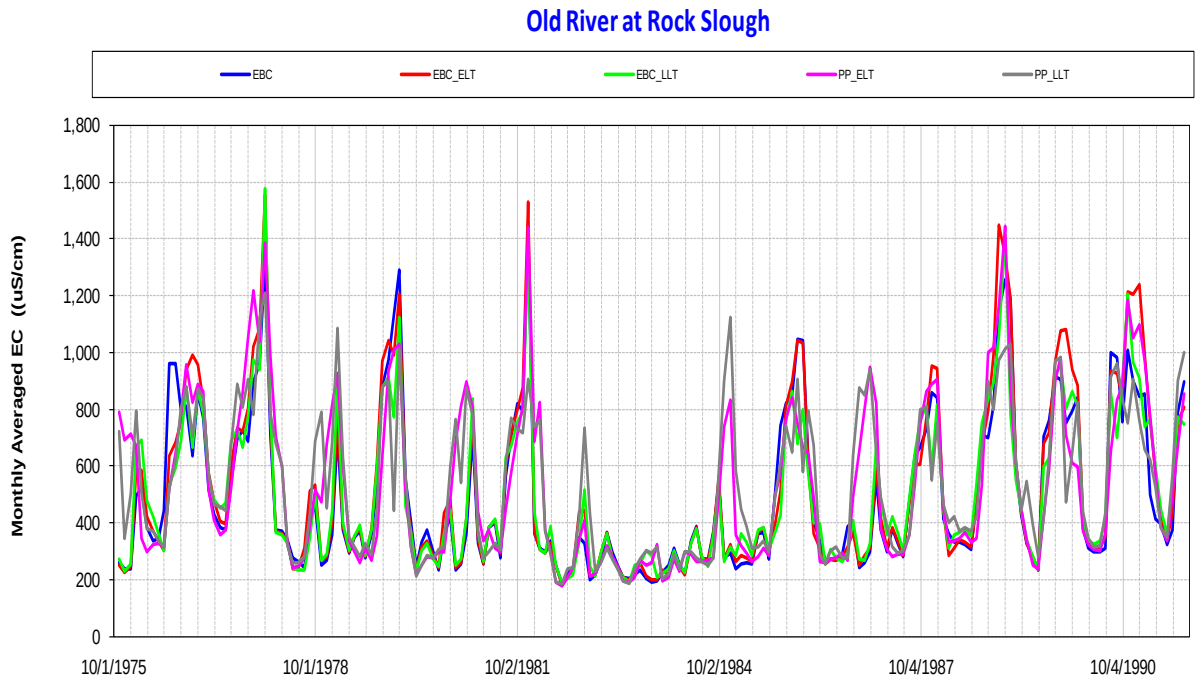

Figure C.A-48. Monthly EC at Old River at Rock Slough for the Six DSM2 Cases

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The export flow-weighted average EC for SWP, CVP, and CCWD exports was calculated for each of the scenarios. Table C.A-37 provides a summary of the average export flow-weighted EC concentration at SWP, CVP, and CCWD export facilities for the six cases. The export flow-weighted average EC at Banks pumping plant was reduced slightly in the future baseline conditions scenarios (by 0.4% for EBC2_ELT conditions and by 2.7% for EBC2_LLT conditions). At Jones pumping plant, the export flow-weighted average EC was increased by 2.4% at 2025 and decreased by 0.9% at 2060. CCWD export water quality increases by 3.1% at 2025 and 3.3% at 2060.

Table C.A-37. Summary of Average Export-Weighted EC at South Delta Exports

Location	EBC	EBC_ELT	EBC_LLT	PP_ELT	PP_LLT
Average Export-Weighted EC (in µmhos/cm)					
Banks PP Exports	461.6	456.6	449.1	380.8	378.3
Jones PP Exports	510.4	522.5	506.0	432.4	418.1
CCWD Exports (RS, OR, and VC)	426.4	439.6	440.6	442.2	463.7
Percent Change from EBC					
Banks PP Exports		-0.4	-2.7	-17.5	-18.0
Jones PP Exports		2.4	-0.9	-15.3	-18.1
CCWD Exports (RS, OR, and VC)		3.1	3.3	3.7	8.7

PP = pumping plant.
EC = electrical conductivity.
RS = Rock Slough.
OR = Old River.
VC = Victoria Canal.
µmhos/cm = micro ohms per centimeter.

The PP simulations reduced the export flow-weighted EC at Banks pumping plant and Jones pumping plant because about half of the exports were diverted at the north Delta intakes. The Banks average EC was reduced by 17.5% for the PP_ELT and by 18% for the PP_LLT. The average Jones pumping plant EC was reduced by 15.3% for the PP_ELT and by 18.1% for the PP_LLT. The average CCWD EC was increased by 3.7% for the ELT and by 8.7% for the LLT. Because the lowest possible export EC value would be 175 µS/cm (Sacramento River salinity), the maximum improvement in export salinity would be to reduce all "excess" salinity from the San Joaquin River, agricultural drainage, and seawater intrusion. Using a minimum possible EC of 175 µS/cm, the percentage improvement in export salinity was about 27% for both the SWP and CVP Delta exports. This reduction in the export salinity would be substantial, but these DSM2 results demonstrate the fact that "dual conveyance" operations of the preliminary proposal would allow a considerable portion of the San Joaquin River salt and substantial seawater intrusion to reach the south Delta exports.

The DSM2 model does not simulate the X2 position directly. The X2 position must be calculated (interpolated) from the daily EC at Martinez (KM 54), Port Chicago (KM 65), Chipps Island (KM 74), Collinsville (KM 81), Emmaton (KM 91), and Rio Vista (km 101). The X2 position is assumed to be the location of the daily average EC of 2,500 µS/cm. The X2 position is completely dependent on the monthly outflow sequence for the six cases.

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C.A.6.1 DSM2-Simulated Changes in Outflow-Salinity and Outflow-X2 Relationships

The salinity gradient within the San Francisco Bay-Delta estuary depends on the Delta outflow (i.e., estuary freshwater inflow). The salinity changes most dramatically with a change in Delta outflow at the upstream end of the estuary (upstream of Martinez). The relationship between Delta outflow and salinity is generally described with the outflow-X2 equation. X2 is defined as the upstream distance from the Golden Gate Bridge (km) of the 2 ppt bottom salinity and is used as an index of the upstream extent of seawater intrusion into Suisun Bay and the Delta. But the entire salinity gradient is shifted downstream with increasing Delta outflow.

The measured daily average salinity (EC) at a fixed monitoring station (e.g., Martinez, Port Chicago, Chipps Island, Collinsville, Emmaton) shows a decreasing pattern of EC with increased outflow (i.e., negative exponential relationship). The relationships between outflow and salinity at each station or between outflow and X2 provide the basis for managing Delta outflow for salinity control. The relationships between outflow and salinity or between outflow and X2 which are assumed in CALSIM (ANN) or are simulated in DSM2 are very important for determining the required Delta outflow necessary to meet the D-1641 X2 and EC objectives. This section reviews the CALSIM and DSM2 model results for X2 and for EC at the salinity compliance locations (Emmaton and Jersey Point). A comparison of the EBC1 and EBC2 cases with the EBC2_LLT and PP_LLT cases will identify the assumed changes from sea level rise and from the tidal habitat expansion (restoration).

Because the DSM2 model downstream boundary is at Martinez, the effects of sea level rise and habitat expansion on salinity must be included in the assumed boundary conditions for salinity specified at Martinez for each of the BDCP cases. The effects of sea level rise were determined from the RMA Bay-Delta and UNTRIM Bay-Delta models and applied as adjustments to the boundary conditions that were estimated from the CALSIM calculated Delta outflow (different from historical outflow) and the tidal pattern of historical EC measured at Martinez. The DSM2 dispersion coefficients were also increased to account for increased tidal mixing of Martinez boundary EC. The DSM2 EC results can be compared to determine if a shift in the outflow-EC or outflow-X2 relationships were simulated between the existing conditions and the LLT conditions (with 1.5 feet of sea level rise).

The Martinez EC boundary conditions were adjusted for each DSM2 case to match the monthly outflow calculated by the CALSIM model for each BDCP case. This adjustment in the Martinez EC to match the different CALSIM outflows was generally much greater than the previously simulated EC effects from sea level rise (using the UnTRIM model) or tidal habitat restoration (using the RMA Bay-Delta model). Therefore, it is difficult to identify the effects of sea level rise or tidal habitat restoration from the direct comparison of the monthly EC simulated for the six BDCP cases. The changes in the monthly simulated EC values for the six BDCP cases were dominated by the different monthly outflow sequences. Therefore, the relationship between Delta outflow and simulated EC were compared to determine how much of a shift in the outflow-EC or outflow-X2 equations resulted from the combination of sea level rise and tidal habitat restoration.

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C.A.6.2 San Francisco Estuary Salinity Gradient

The salinity gradient in the San Joaquin River estuary can be approximated as a logistical (shape) relationship because the salinity at the downstream end (Golden Gate) will remain at ocean salinity (32 practical salinity units [psu], about 47,500 µS/cm) while the salinity at the upstream end (Rio Vista at 100 km) will remain fresh (0.1 psu, about 200 µS/cm). There will be salinity stratification at higher outflows, with fresh water remaining near the surface, but the depth averaged salinity can be approximated with the patterns shown in Figure C.A-49.

Figure C.A-49 shows the calculated salinity gradient in the estuary between 0 km and 100 km for a range of outflows from 3,000 cfs to about 30,000 cfs. The outflow was selected as increments of 1.55x to show that the calculated X2 position (about 3,000 µS/cm) is moved 5 km downstream for each 55% increase in outflow. The X2 positions is moved downstream 1 km for each 9% increase in outflow, because $(1.09)^5$ is equal to 1.55.

Figure C.A-50 shows the calculated salinity gradient in the estuary between 50 km and 100 km for a range of outflows from 3,000 cfs to about 30,000 cfs. This shows that the Martinez EC (at 55 km) is reduced nearly linearly for each outflow increase of 55%. The calculated Martinez EC was about 24,500 µS/cm with an outflow of 3,000 cfs, and was about 7,500 µS/cm with an outflow of about 28,000 cfs. The EC was reduced by about 17,000 µS/cm for five outflow increases of 55% each, so the EC was reduced by an average of about 3,400 µS/cm for each 55% increase in outflow (corresponding to an X2 shift of 5 km). The EC at upstream locations are generally related to both the Martinez EC and the outflow, because they are located at specific distances along the EC gradient. The logistical equation used to estimate the salinity gradient was originally identified from the USGS boat surveys of salinity and other water quality parameters. The approximate logistic equation (Unger 1994) was:

$$\text{EC } (\mu S/cm) \text{ at Distance Z (km)} = 48{,}000 \,/\, [1 + 510 \times \exp(-7 \times (1.5 - \text{Distance Z/X2}))]$$

The X2 location must be estimated from the steady-state monthly X2 equation which is:

$$\text{X2 (km)} = 181.8 - 26.26 \times \text{Log[outflow(cfs)]}$$

The logistic coefficients have been selected so that when the distance Z is X2, and the ratio of Z/X2 is 1.0, the EC will be 2,927 µS/cm. This equation can only capture the basic estuarine gradient, and assumes that Delta outflow has been steady (constant) for long enough to fully establish this equilibrium salinity gradient. This equation applies to daily average salinity only. The actual salinity will move upstream and downstream by several kilometers (5 km at Martinez, 10 km at Chipps Island) during each tidal cycle. This movement of the salinity gradient causes the maximum EC at Martinez to be about 7,500 µS/cm higher than the average EC and the minimum EC to be about 7,500 µS/cm lower when the average Martinez EC is greater than 15,000 µS/cm (at relatively low Delta outflow). As with Martinez, there is a wide range of salinity within each tidal cycle at any given fixed location in the estuary.

C.A.6.3 DSM2 Outflow-Salinity Relationship at Martinez

The most important outflow-salinity relationship in the DSM2 model is the Martinez Boundary EC that was estimated (with a modified G-model formulation) from the CALSIM outflow values for each of the six BDCP cases. If a higher EC was estimated for the LLT cases (1.5 feet of sea level rise) with the same Delta outflow, this would represent the assumed effect of sea level rise on increasing EC at

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Martinez (because the San Francisco Bay depth was increased). The UnTRIM Bay-Delta model study for 2002 historical conditions estimated that the Martinez EC would increase by about 1,500 µS/cm (0.7 psu) for all Delta outflows observed during 2002. The DSM2 Martinez boundary EC values were therefore shifted by about 1,500 µS/cm for the full range of outflow. The DSM2 model results will indicate how this increased EC was tidally mixed upstream into the Delta.

Figure C.A-51 shows the monthly Martinez EC values (DSM2 monthly average EC) plotted against the monthly Delta outflow for the six BDCP cases. The Martinez EC ranged from about 30,000 µS/cm at the lowest Delta outflow of 3,000 cfs to about 10,000 µS/cm at an outflow of about 100,000 cfs. There is considerable scatter in this relationship because when the outflow was high in one month and is reduced in the next, the monthly EC will remain lower than expected for steady outflow. When the outflow was low and is increased, the monthly EC will remain higher than expected for steady outflow. The G-model formulation calculates the effective Delta outflow (i.e., a moving average) and estimates the steady state outflow-EC relationship as a negative exponential equation.

A two or three month moving average outflow is generally close to the effective Delta outflow. Figure C.A-52 shows the monthly Martinez EC values for the six cases as a function of the effective Delta outflow, calculated using a G-model averaging coefficient of 4,000 cfs/month. The DSM2 values for the Martinez EC are quite accurately described by the negative exponential equation (coefficients given in Table C.A-38) once the effective outflow is calculated. The DSM2 EC values are generally above the G-model curve and within 2,500 µS/cm of the G-model curve.

The main purpose for this comparison is to determine if the DSM2 model EC results for the PP_LLT conditions (with sea level rise and full tidal habitat restoration) showed any large changes in the outflow-salinity relationship when compared to the existing conditions simulations. Figure C.A-53 shows the DSM2 simulated Martinez EC for the two existing conditions baselines EBC1 and EBC2. The monthly average EC follows the negative exponential estimate quite closely. Figure C.A-54 shows the DSM2 simulated Martinez EC for the EBC2_LLT and PP_LLT. The EBC2_LLT includes the effects of 1.5 feet of sea level rise, but no tidal restoration. The PP_LLT included the effects of sea level rise and full tidal habitat restoration. As anticipated from the previous UnTRIM and RMA modeling, the DSM2 Martinez EC values were generally about 2,500 µS/cm higher than the existing Martinez EC values at the same effective Delta outflow. For example, the existing conditions Martinez EC values are between 15,000 µS/cm and 17,500 µS/cm for an effective outflow of about 10,000 cfs. The LLT simulations indicate that the EC was increased to between 17,500 µS/cm and 20,000 µS/cm for the same effective outflow of about 10,000 cfs.

C.A.6.4 DSM2 Simulated EC in Suisun Bay

Figure C.A-55 shows the monthly EC simulated with DSM2 at Martinez, Port Chicago, Chipps Island, and Collinsville for the EBC1 case for WY 1976–1991. The Martinez EC values fluctuated from 250 µS/cm at high outflow to 25,000 µS/cm at low outflow. Each year is similar, but the wet years have low EC values for more months, and the EC values at Martinez do not approach the freshwater minimum EC of 250 µS/cm in every year. The EC at upstream stations was always lower than the Martinez EC, but the ratio between these EC values was reduced at higher outflows because the X2 location moves downstream past the upstream stations, and the relative position of the upstream stations on the salinity gradient curve (Figure C.A-49 and Figure C.A-50) changes. The highest EC values correspond to the fall months with lowest outflow.

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Figure C.A-56 shows the monthly EC simulated at Martinez, Port Chicago, Chipps Island, and Collinsville for the EBC2 case for WY 1976–1991. The EBC2 case includes the Fall X2 requirements, so in about half of the years the EC was reduced in the months of September-November to maintain X2 at Collinsville or Chips Island. The Chipps Island EC of about 3,000 µS/cm indicates a wet year, while Collinsville EC of about 3,000 µS/cm indicates an above normal year. The monthly EC pattern for the remainder of the years was very similar to the EBC1 case. Figure C.A-57 shows the monthly EC values for the EBC2_ELT case, which included 0.5 feet of sea level rise but no tidal habitat restoration. Figure C.A-58 shows the monthly EC values for the EBC2_LLT case which included 1.5 feet of sea level rise but no tidal habitat restoration. The EBC2_ELT and EBC2-LLT cases were similar to the EBC2 case, although there were many months with slightly different Delta outflows calculated with CALSIM.

Figure C.A-59 shows the monthly EC values for the PP_ELT case, which included 0.5 feet of sea level rise and 25,000 acres of tidal habitat restoration. Figure C.A-60 shows the monthly EC values for the PP_LLT case which included 1.5 feet of sea level rise and the full tidal habitat restoration of 65,000 acres. Careful inspection of these six figures will reveal many small differences caused by the slightly different monthly CALSIM outflows used in the DSM2 modeling of each case. The differences in the fall months of those years with X2 requirements in the EBC2 cases are more easily recognized. These graphs summarize the DSM2 simulations of the salinity intrusion into the Delta. The major factor controlling Delta salinity is always the effective Delta outflow. The average salinity values at each station for these six cases are very similar, because the basic sequence of Delta outflow is very similar, and is determined by the required Delta outflow and the Delta inflow variations from wet years to dry years. The largest differences in monthly EC values were seen between the EBC1 and the PP_ELT and PP_LLT cases, which did not have any Fall X2 requirements (higher outflow), and the three EBC2 cases which did have Fall X2 requirements (lower outflow).

C.A.6.5 DSM2 Simulated Salinity at Collinsville

The combined effects of sea level rise and tidal habitat restoration on Delta salinity were simulated to be relatively small compared to the salinity variations caused by tidal flows and by changes in Delta outflow. The seawater intrusion effects can be shown by comparing the simulated outflow-salinity curve (G-model) at Collinsville, which is the most upstream of the three X2 stations for regulated outflow. The outflow is regulated in the February-June period to maintain X2 at or downstream of Collinsville. Therefore, the Collinsville EC is expected to be less than 3,000 µS/cm in these months.

Figure C.A-61 shows the monthly Collinsville EC values for the six cases as a function of the monthly Delta outflow. There is considerable scatter in this relationship because the monthly outflow may not be the steady-state outflow for the salinity gradient if the outflow has changed substantially. Figure C.A-62 shows the monthly Collinsville EC values for the six cases as a function of the effective Delta outflow, calculated using a G-model averaging coefficient of 4,000 cfs/month. The DSM2 values for the Collinsville EC were well described by the negative exponential equation (coefficients given in Table C.A-38) with the effective outflow (calculated). The DSM2 EC values were generally above the G-model curve but within 2,500 µS/cm of the curve. The Collinsville EC was simulated to be less than 2,500 µS/cm at an outflow of 10,000 cfs.

Figure C.A-63 shows the DSM2 simulated Collinsville EC for the two existing conditions baselines EBC1 and EBC2. The monthly average EC follows the negative exponential estimate quite closely. Figure C.A-64 shows the DSM2 simulated Collinsville EC for the EBC2_LLT and PP_LLT. The

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EBC2_LLT includes the effects of 1.5 feet of sea level rise, but no tidal restoration. The PP_LLT included the effects of sea level rise and full tidal habitat restoration. As anticipated from the Martinez results, the DSM2 Collinsville EC values were generally about 1,000–2,000 µS/cm higher than the existing Collinsville EC values at the same effective Delta outflow. For example, the existing conditions Collinsville EC values were between 3,000 and 5,000 µS/cm for an effective outflow of about 7,500 cfs. The LLT simulations indicate that the EC was increased to between 4,000 µS/cm and 6,000 µS/cm for the same effective outflow of about 7,500 cfs.

C.A.6.6 Effects on Increased Salinity on X2

The major effect of increased salinity in Suisun Bay caused by sea level rise and tidal habitat restoration will be that the X2 location would be shifted upstream for a given effective Delta outflow, and that more outflow would be required to maintain the X2 at Chipps Island or Collinsville. Figure C.A-50 (and the X2 equation) indicates that the salinity at Collinsville (81 km) or Chipps Island (75 km) is reduced by about 2,000 µS/cm for each 55% increase in flow, which also moves X2 downstream 5 km. The simulated increase in salinity (EC) at Chipps Island and Collinsville was generally between 1,000 µS/cm and 2,000 µS/cm for the same effective Delta outflow.

Figure C.A-63 and Figure C.A-64, show the outflow-EC relationship at Collinsville. The DSM2-simulated existing conditions salinity at Collinsville was about 3,250 µS/cm (assumed equivalent to X2) with an outflow of about 7,500 cfs (Figure C.A-63). The DSM2-simulated salinity at Collinsville was increased to about 5,000 µS/cm with an outflow of 7,500 cfs for the PP_LLT case (Figure C.A-64). The simulated Collinsville EC was about 3,250 µS/cm (assumed equivalent to X2) with an outflow of about 9,000–10,000 cfs.

The previous UnTRIM and RMA Bay-Delta modeling results and the DSM2 modeling results for the BDCP cases suggest that the combined effects of sea level rise and tidal habitat restoration in the LLT timeframe will cause the salinity gradient to move about 3–5 km further upstream during relatively low flow periods.

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Table C.A-38. Estimated X2 and Salinity (EC) at Delta Locations for Various Effective Delta Outflows

Negative Exponential Estimates derived from 1976–1991 Historical EC and Delta outflow
EC (µS/cm) = minimum (175) + constant x exp [factor x outflow (cfs)]

Delta Outflow	X2	Martinez	Port Chicago	Chipps Island	Collinsville	Antioch	Jersey Point	Emmaton	Rio Vista	Rock Slough
Constant		27,000	32,000	30,000	25,000	20,000	15,000	20,000	10,000	5,000
Factor		-0.00006	-0.00010	-0.00025	-0.00030	-0.00035	-0.00050	-0.00050	-0.00040	-0.00050
2,500	92.6	24,239	25,072	16,208	11,959	8,487	4,498	5,980	3,829	1,683
3,000	90.5	23,552	23,856	14,321	10,314	7,149	3,547	4,713	3,162	1,366
3,500	88.7	22,886	22,700	12,656	8,898	6,025	2,807	3,725	2,616	1,119
4,000	87.2	22,239	21,600	11,186	7,680	5,082	2,230	2,957	2,169	927
4,500	85.9	21,611	20,554	9,890	6,631	4,290	1,781	2,358	1,803	777
5,000	84.7	21,002	19,559	8,745	5,728	3,625	1,431	1,892	1,503	660
5,500	83.6	20,411	18,612	7,735	4,951	3,068	1,159	1,529	1,258	570
6,000	82.6	19,837	17,712	6,844	4,282	2,599	947	1,246	1,057	499
6,500	81.7	19,281	16,855	6,057	3,707	2,206	782	1,025	893	444
7,000	80.8	18,740	16,041	5,363	3,211	1,876	653	854	758	401
7,500	80.0	18,216	15,266	4,751	2,785	1,599	553	720	648	368
8,000	79.3	17,707	14,529	4,210	2,418	1,366	475	616	558	342
8,500	78.6	17,213	13,827	3,733	2,102	1,171	414	535	484	321
9,000	78.0	16,734	13,160	3,312	1,830	1,007	367	472	423	306
9,500	77.3	16,269	12,526	2,940	1,596	869	330	423	374	293
10,000	76.8	15,818	11,922	2,613	1,395	754	301	385	333	284
10,500	76.2	15,380	11,348	2,323	1,221	657	279	355	300	276
11,000	75.7	14,955	10,802	2,068	1,072	576	261	332	273	270
11,500	75.2	14,543	10,282	1,842	944	507	248	314	251	266
12,000	74.7	14,142	9,788	1,644	833	450	237	300	232	262
12,500	74.2	13,754	9,318	1,468	738	402	229	289	217	260

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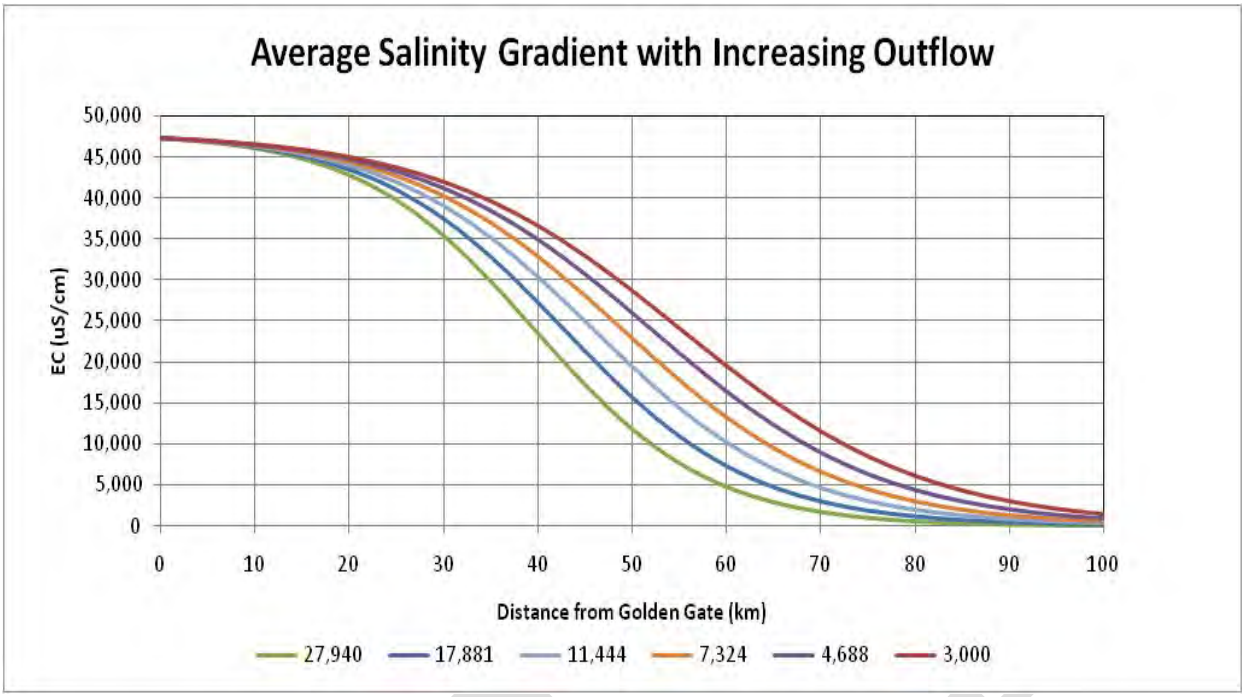

Figure C.A-49. Calculated EC Gradient in the SF Estuary between Golden Gate (0 km) and Rio Vista (100 km) with Increasing Delta Outflow

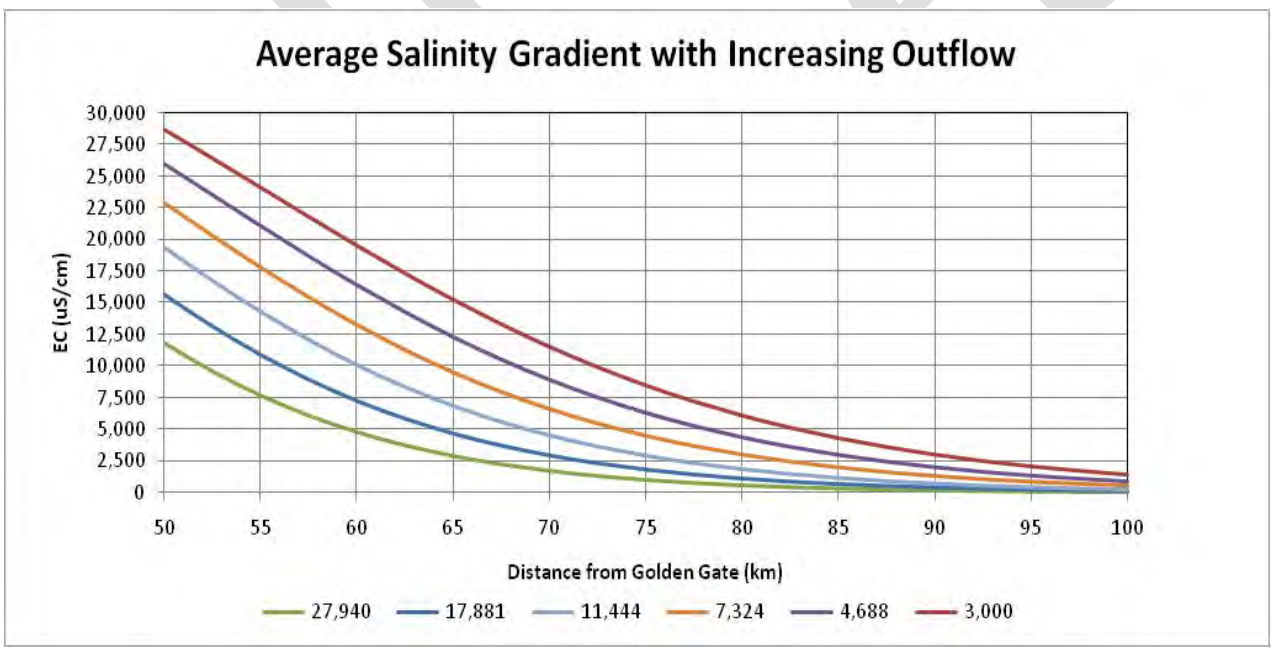

Figure C.A-50. Calculated EC Gradient in Suisun Bay and the Delta between Martinez (km 55) and Rio Vista (100 km) with Increasing Delta outflow

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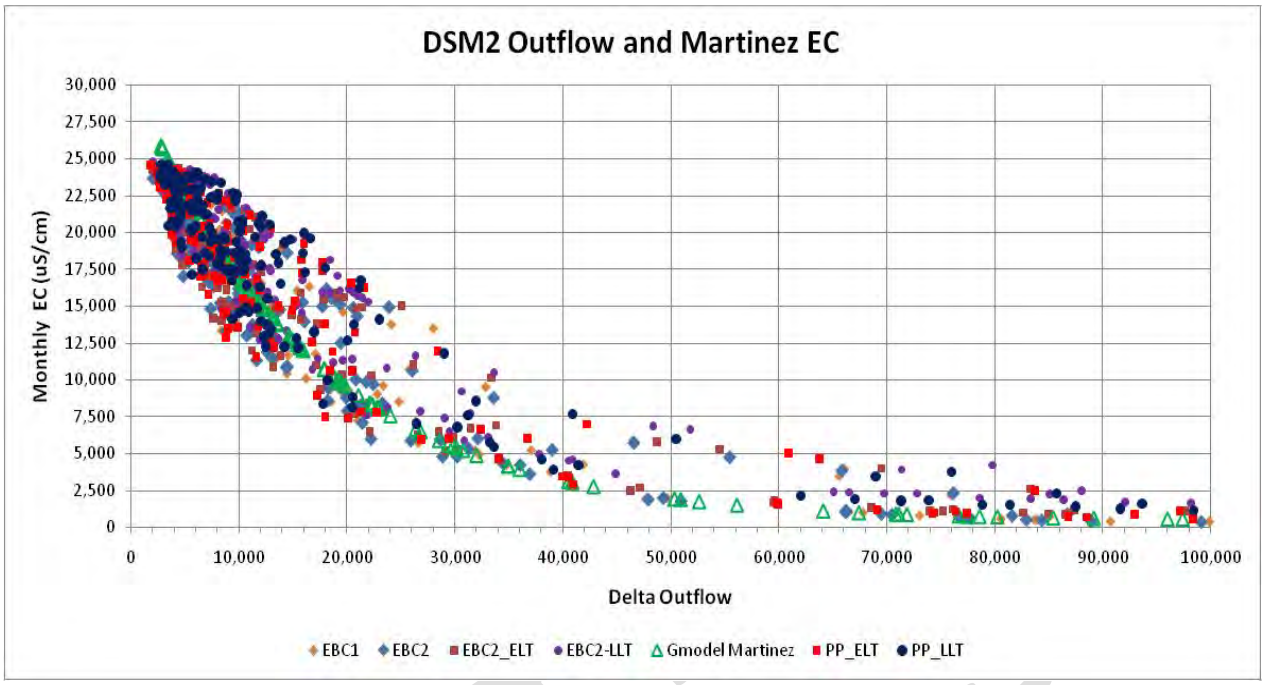

Figure C.A-51. Monthly Average EC at Martinez for the six BDCP Cases as a Function of Monthly Delta Outflow for WY 1976–1991

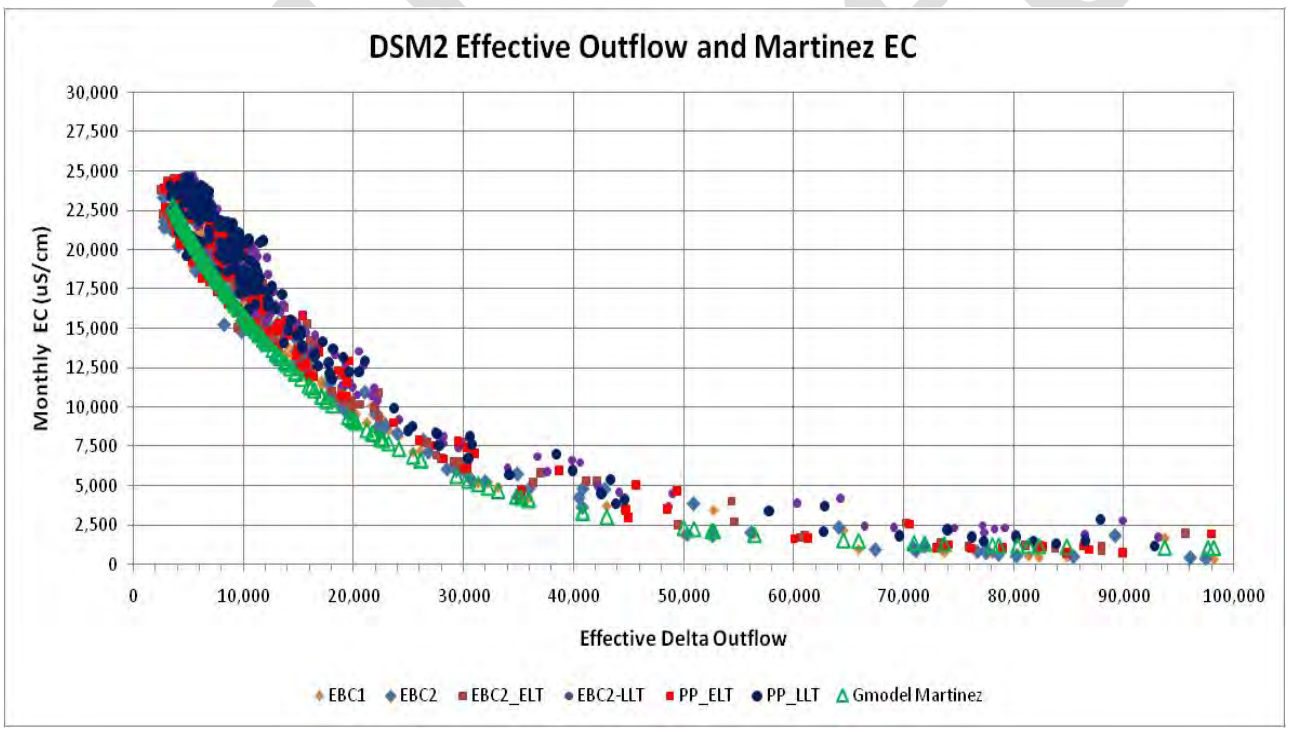

Figure C.A-52. Monthly Average EC at Martinez for the six BDCP Cases as a Function of Effective Delta Outflow (G-model) for WY 1976–1991

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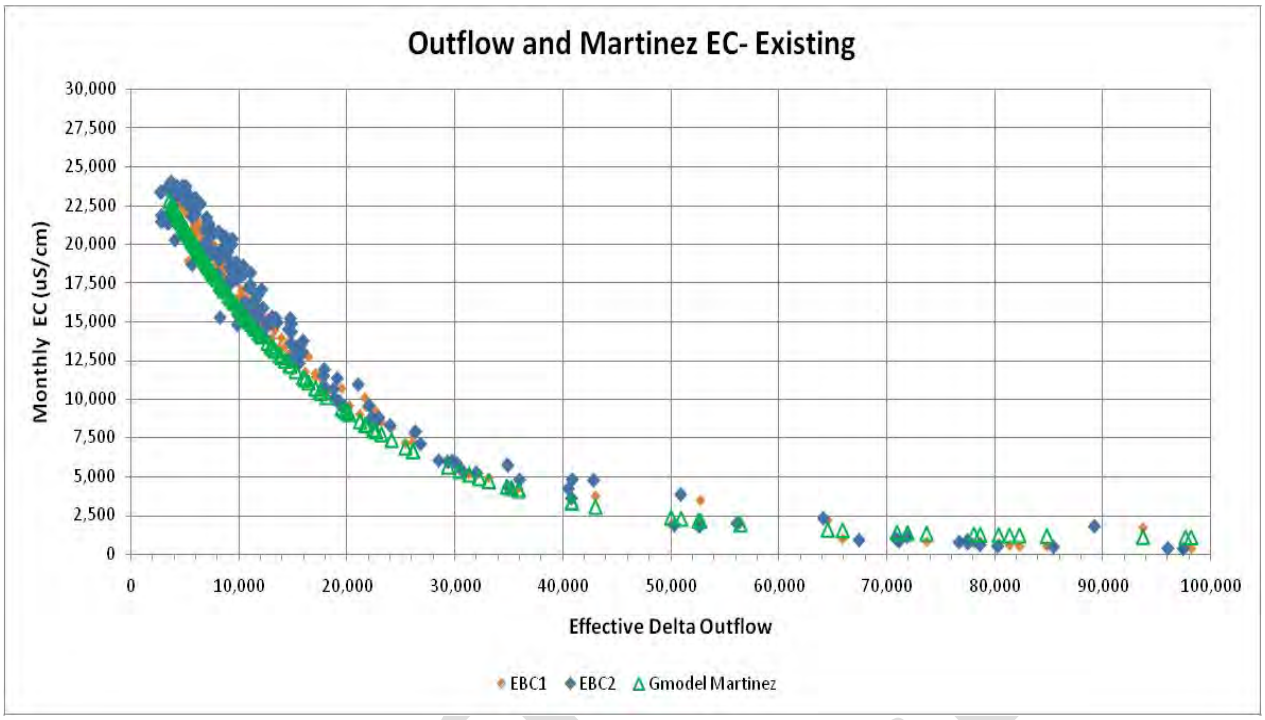

Figure C.A-53. Monthly EC at Martinez for the Existing Conditions Cases (EBC1 and EBC2) as a Function of Effective Delta Outflow for WY 1976–1991

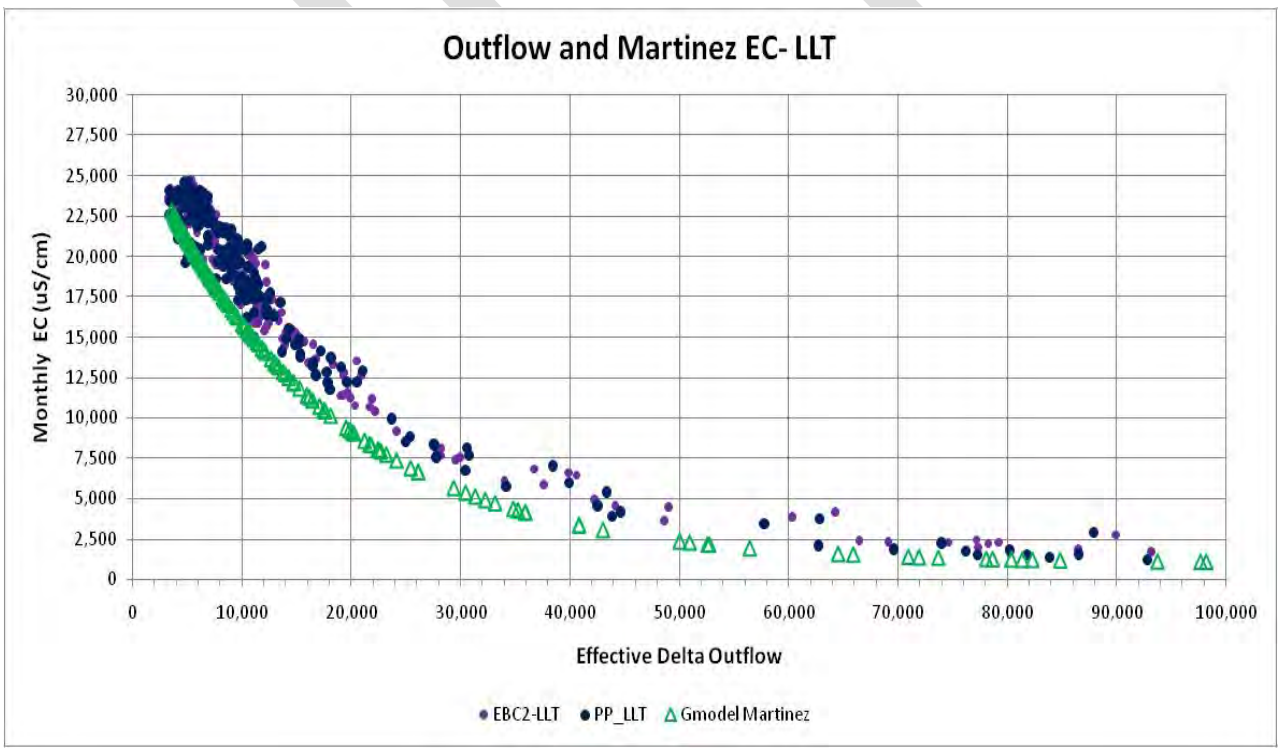

Figure C.A-54. Monthly EC at Martinez for the LLT Cases (EBC2_LLT and PP_LLT) as a Function of Effective Delta Outflow for WY 1976–1991

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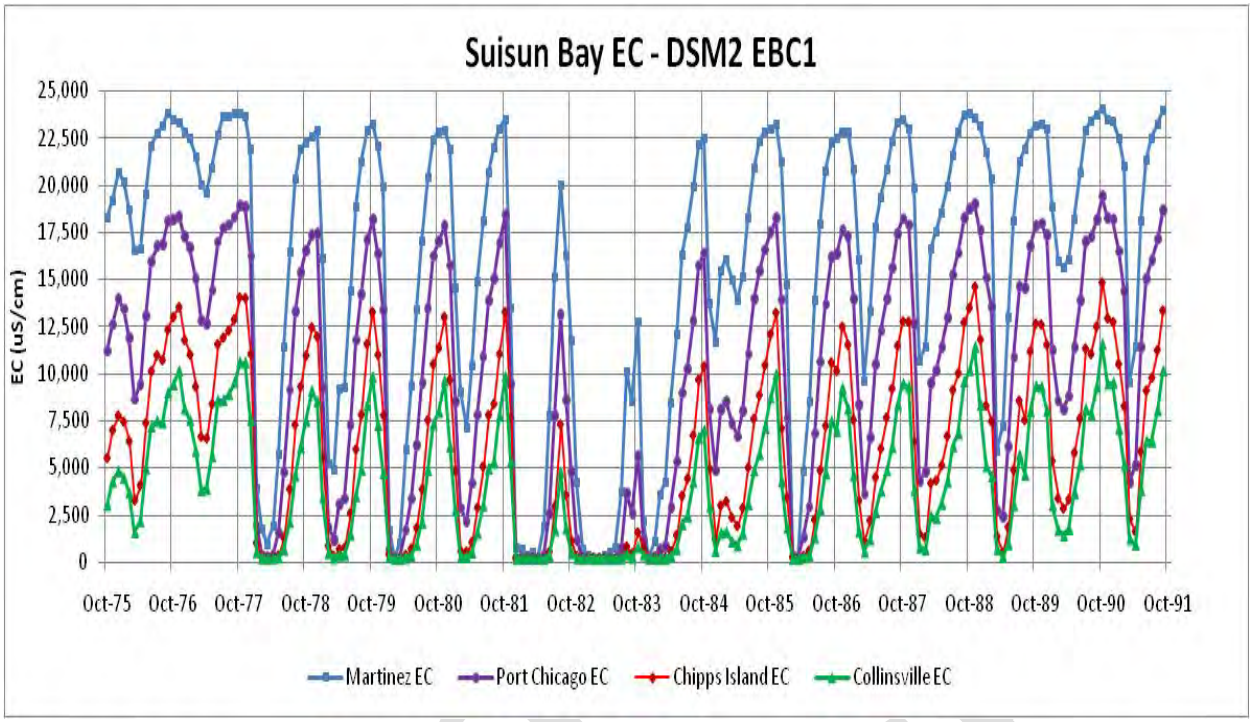

Figure C.A-55. DSM2-Simualted Monthly EC in Suisun Bay for the EBC1 Case for WY 1976–1991

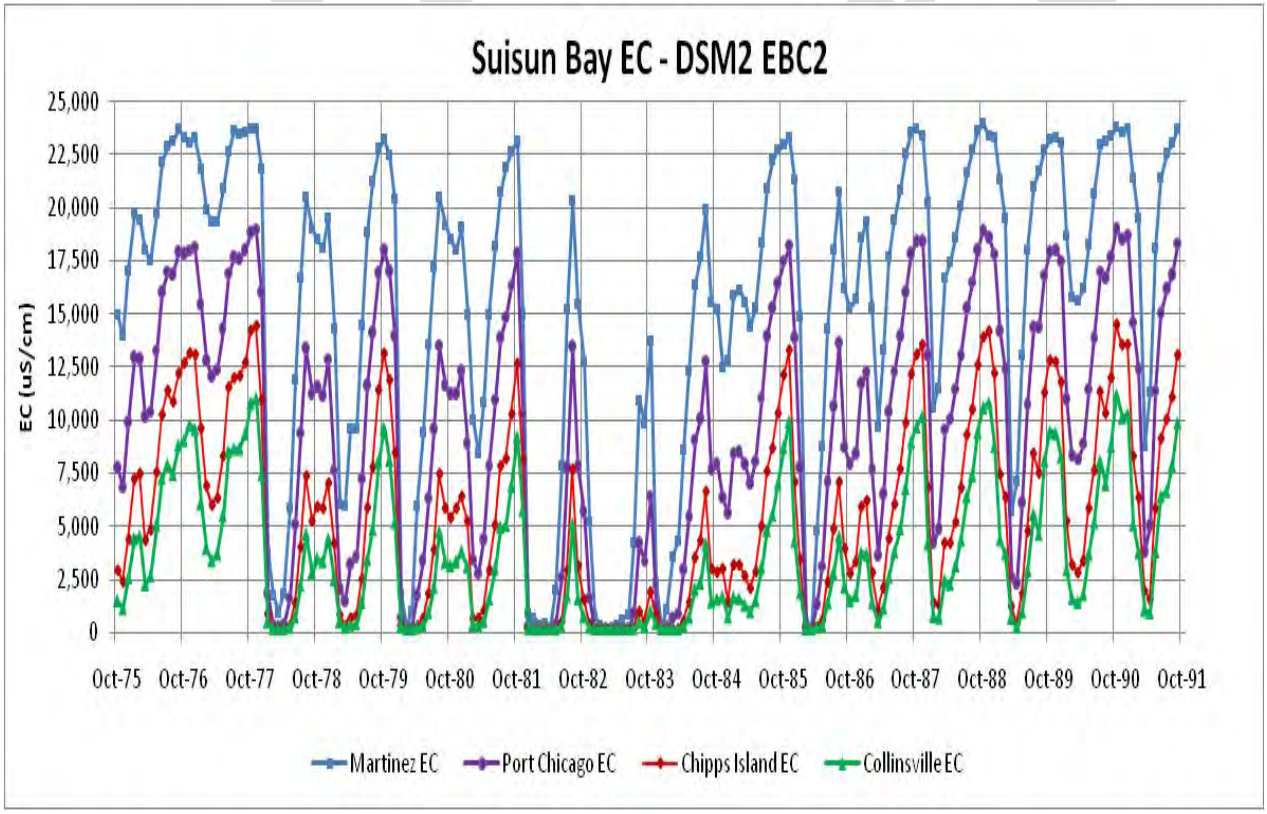

Figure C.A-56. DSM2-Simualted Monthly EC in Suisun Bay for the EBC2 Case for WY 1976–1991

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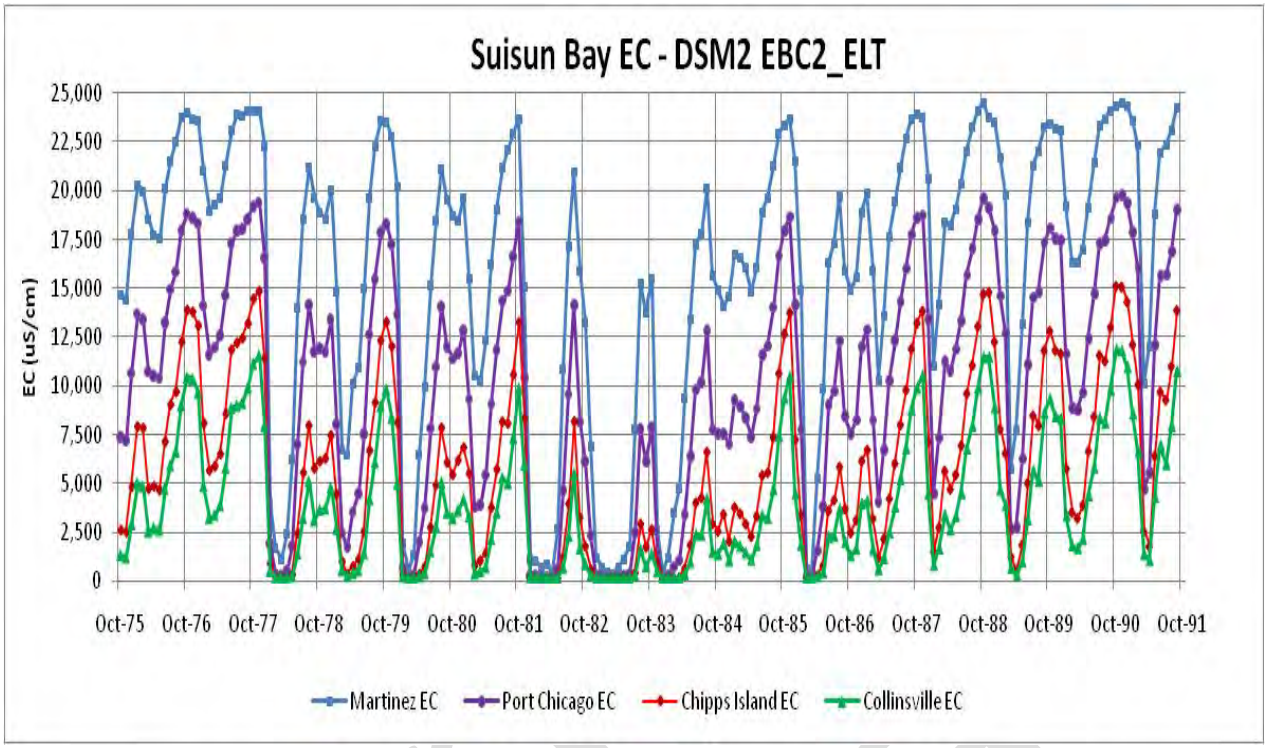

Figure C.A-57. DSM2-Simualted Monthly EC in Suisun Bay for the EBC2_ELT Case for WY 1976–1991

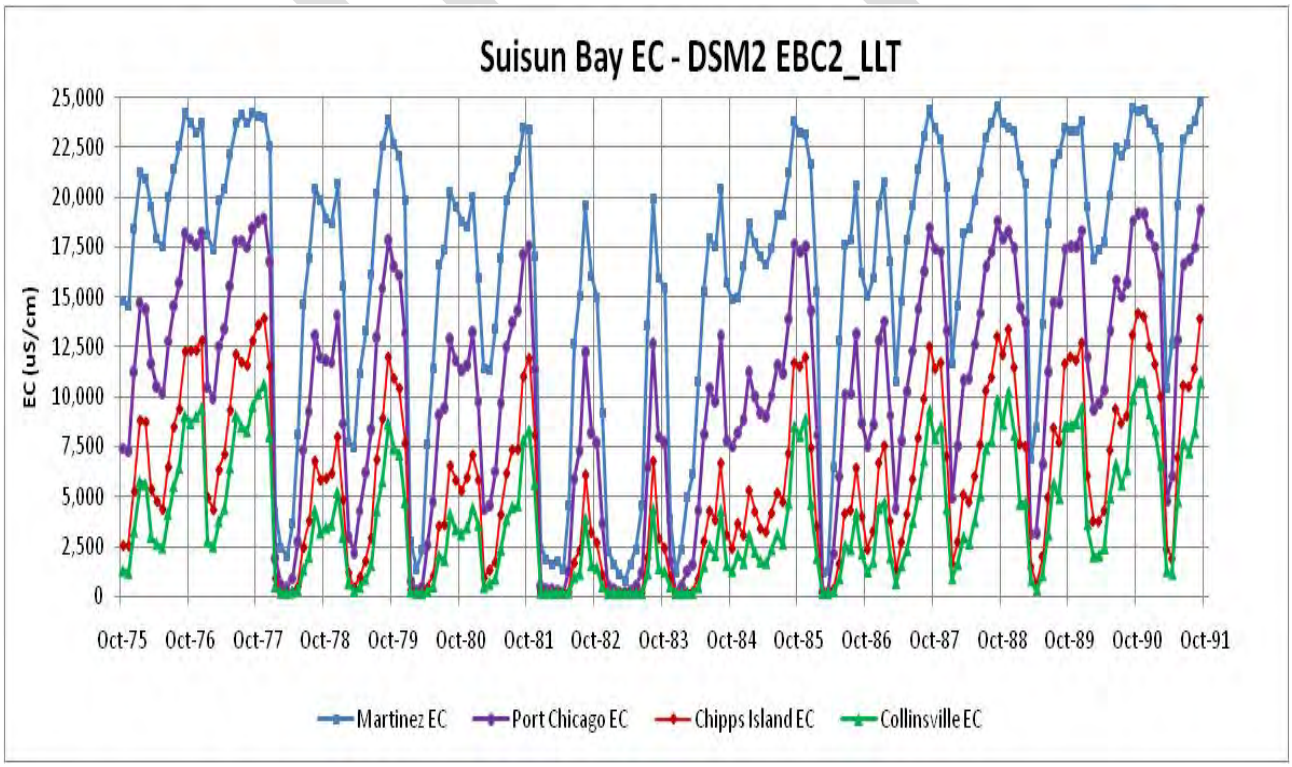

Figure C.A-58. DSM2-Simualted Monthly EC in Suisun Bay for the EBC2_LLT Case for WY 1976–1991

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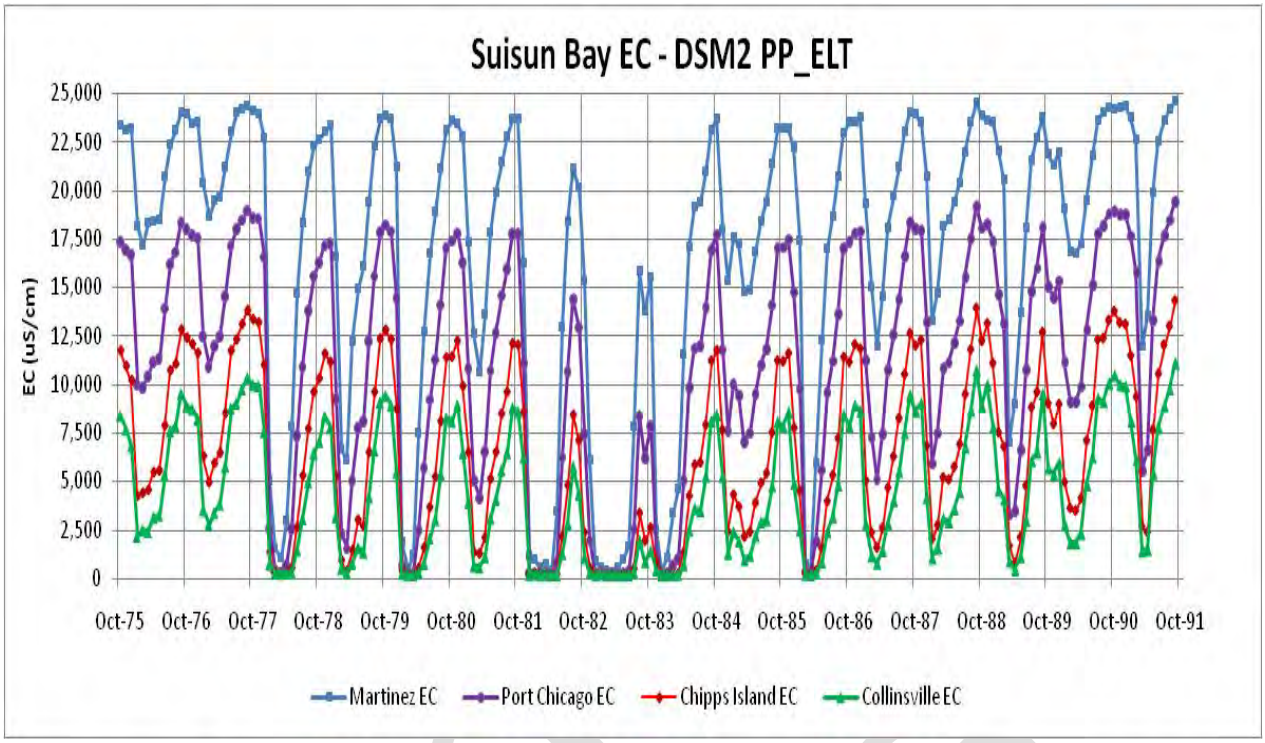

Figure C.A-59. DSM2-Simualted Monthly EC in Suisun Bay for the EBC2_LLT Case for WY 1976–1991

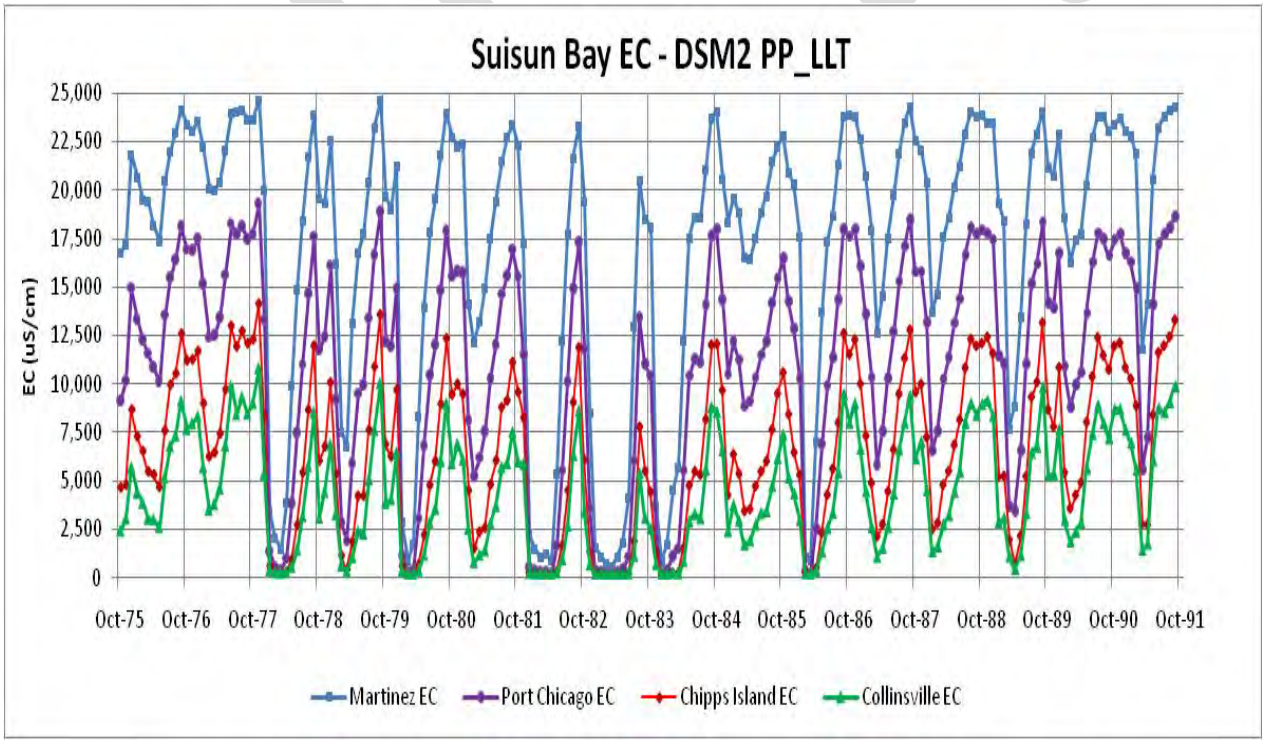

Figure C.A-60. DSM2-Simualted Monthly EC in Suisun Bay for the EBC2_LLT Case for WY 1976–1991

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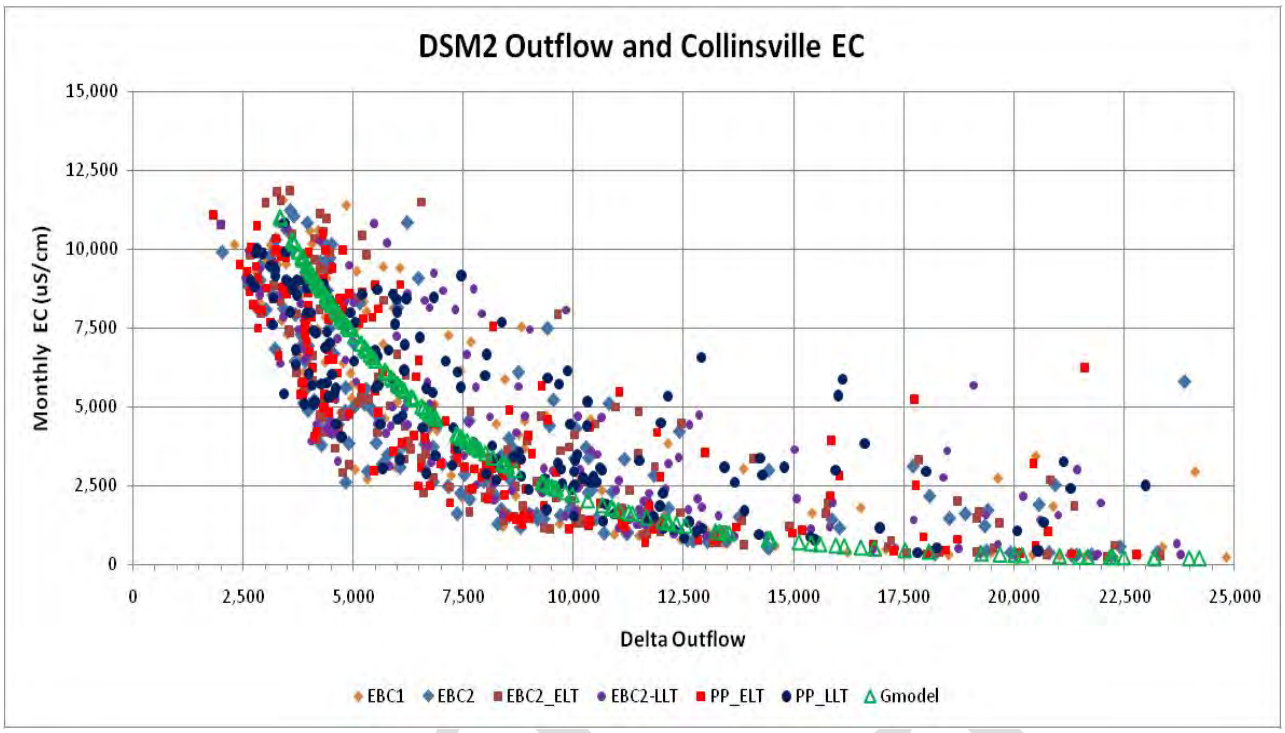

Figure C.A-61. Monthly Average EC at Collinsville for the six BDCP cases as a function of Monthly Delta Outflow for WY 1976–1991.

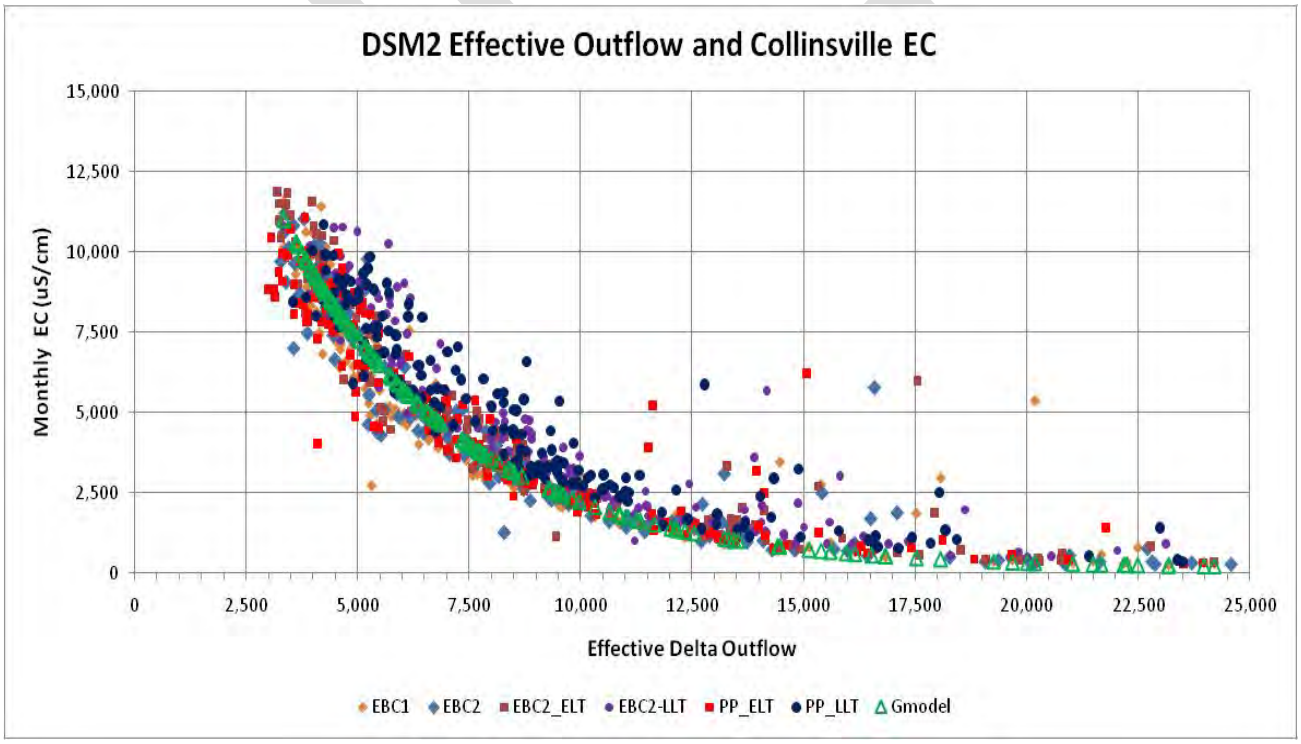

Figure C.A-62. Monthly Average EC at Collinsville for the six BDCP cases as a function of Effective Delta Outflow (G-model) for WY 1976–1991.

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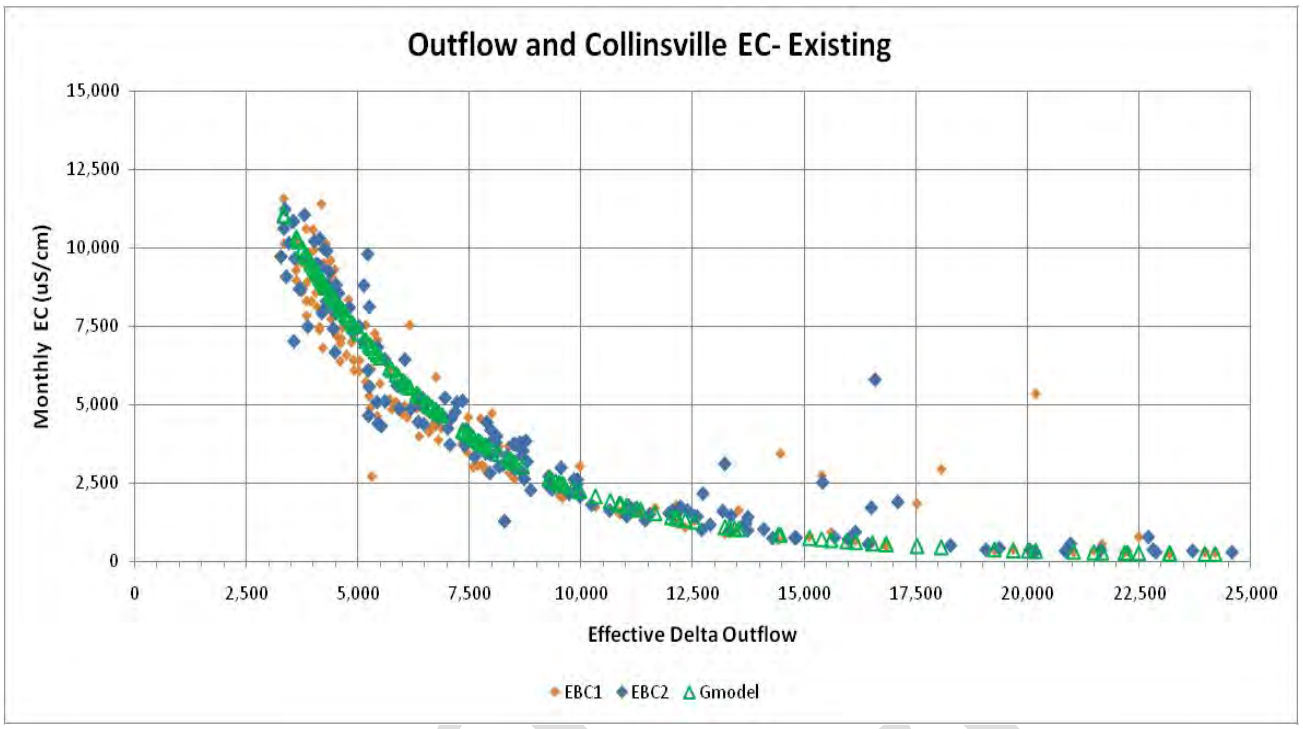

Figure C.A-63. Monthly EC at Collinsville for the Existing Conditions Cases (EBC1 and EBC2) as a Function of Effective Delta Outflow for WY 1976–1991

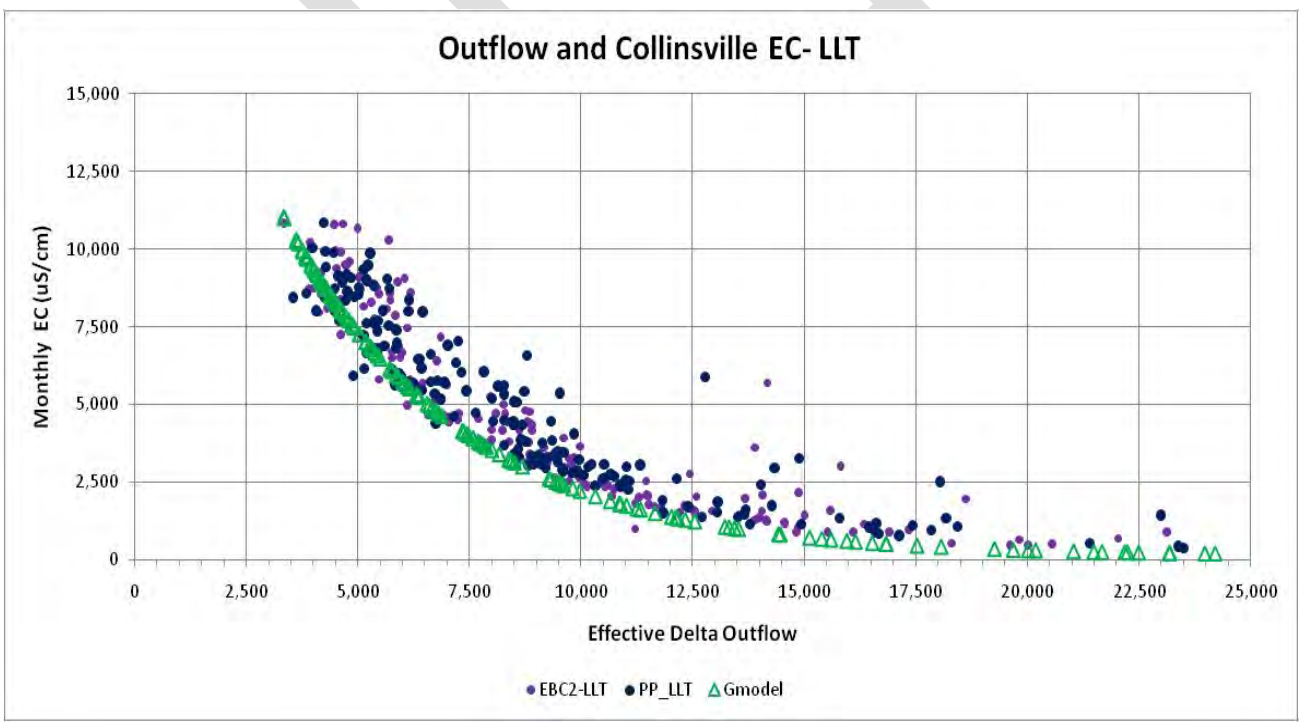

Figure C.A-64. Monthly EC at Collinsville for the LLT Cases (EBC2_LLT and PP_LLT) as a Function of Effective Delta Outflow for WY 1976–1991

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C.A.7 DSM2 Source Tracking Results

The Delta Inflow source-tracking analysis uses results from DSM2-QUAL to track the six Delta inflows as conservative (no sources or sinks) concentrations. The six Delta inflows are:

1. Sacramento River Inflow (Freeport)
2. Yolo Bypass Inflow (Cache Slough)
3. San Joaquin River Inflow (Vernalis)
4. Cosumnes and Mokelumne and Calaveras Rivers (Eastside)
5. Delta Runoff and Agricultural Drainage (Drains)
6. Martinez Boundary Water (flood tide) Inflow

Each of the six Delta inflows is tracked with a separate "source concentration" variable. Each inflow has a separate constant source concentration of 100. The inflow source concentration will be reduced if the inflow is diluted or diverted within the Delta channels. As the inflow water mixes with other water in the Delta, the inflow source concentration is reduced (diluted). If water is removed in agricultural diversions or exports, the concentration of water from each source also is removed, reducing the downstream source concentrations.

C.A.7.1 San Joaquin River Inflow

The San Joaquin River inflow provides a good example of this downstream source tracking through the Delta. Figure C.A-65 shows the CALSIM-simulated monthly San Joaquin River flow at Vernalis. The monthly San Joaquin River flows for the six cases were very similar, with some differences simulated by CALSIM for the ELT and the LLT cases. This inflow was tracked at several locations in the Delta to understand how the San Joaquin River inflow was distributed. The first channel diversion for the San Joaquin River inflow is at the head of Old River near Mossdale. About half the San Joaquin River flow is diverted into Old River and about half continues to Brandt Bridge and Stockton.

Figure C.A-66 shows the monthly percentage of the water at Brandt Bridge from the San Joaquin River inflow at Vernalis for the six cases. Usually the San Joaquin River inflow contributes 100% of the water at Brandt Bridge, but there are some summer months of dry years when the agricultural drainage contributes the "missing" 20% to 40% of the water that is not San Joaquin River inflow.

Figure C.A-67 shows the monthly percentage of the water at Stockton from the San Joaquin River inflow at Vernalis for the six cases. The San Joaquin River inflow often contributes 100% of the water at Stockton, but during the summer months of dry years the San Joaquin River contribution was reduced to less than 50% and the contribution from agricultural drainage, eastside streams, or the Sacramento River increases. As the San Joaquin River flow at Stockton decreases, tidal mixing of Sacramento River water upstream from Turner Cut can contribute a small percentage of the water upstream at Stockton.

Figure C.A-68 shows the San Joaquin River inflow contribution downstream of Turner Cut for the six cases. Because Sacramento River water that is diverted at the DCC or Georgiana Slough often moves upstream in the San Joaquin River between the Mokelumne River mouth and Turner Cut, the San Joaquin River inflow contribution was reduced to about 50% in many months. Only when the San

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Joaquin River flow is much higher than exports in high-flow months does the San Joaquin River inflow contribution to water downstream of Turner Cut remain greater than 90%.

Figure C.A-69 shows the San Joaquin River inflow contribution at Prisoners Point, just upstream of the Mokelumne River mouth. Almost all of the San Joaquin River inflow water has been diverted into Middle River through Columbia Cut or at the mouth of Middle River and does not reach Prisoners Point, unless the San Joaquin River inflow is very high. Figure C.A-70 shows the San Joaquin River inflow contribution at San Andreas Landing, downstream of the Mokelumne mouth. During most months, the Sacramento River water diverted to the Mokelumne River overwhelms the San Joaquin River inflow contribution. The maximum San Joaquin River inflow contribution was about 40% in a few high-inflow months (e.g., 1978, 1986). Figure C.A-71 shows the San Joaquin River inflow contribution at Jersey Point, just downstream of False River. The San Joaquin River inflow contributions are higher than they were at San Andreas Landing because during these high flow months, much of the San Joaquin River inflow diverted into Old River near Mossdale has moved past the CVP and SWP exports and is flowing through Franks Tract and False River to rejoin the San Joaquin River at Jersey Point. The peak San Joaquin River inflow contributions were about 60% in the highest San Joaquin River inflow months.

Figure C.A-72 shows the San Joaquin River inflow contribution at Chipps Island, downstream of the San Joaquin River confluence with the Sacramento River. The San Joaquin River inflow contributions were reduced further by the fraction of the Delta outflow from the Sacramento River and other inflow sources. The maximum San Joaquin River contribution at Chipps Island was about 10–20% in the months with highest San Joaquin River inflows compared to the other inflows. Most of the San Joaquin River inflow was diverted at the CVP and SWP south Delta pumping plants, and only in a few months does San Joaquin River inflow make it to Chipps Island and Suisun Bay. Most of the water at Chipps Island, however, is from the Sacramento and Yolo Bypass inflows. The PP cases had slightly increased San Joaquin River inflow contributions at Chipps Island because the south Delta pumping would be reduced, allowing more of the San Joaquin River inflow to reach Chipps Island. In the few months when San Joaquin River inflow made it to Chipps Island, the maximum San Joaquin River inflow contributions at Chipps Island for the PP_ELT and PP_LLT cases were about 10%. In these months of high San Joaquin River inflow, a greater fraction of the San Joaquin River will make it to Suisun Bay, but the San Joaquin River inflow will contribute less than 10% of the water in Suisun Bay. The source tracking of the San Joaquin River inflow can be used to determine how much of the monthly San Joaquin River flow makes it to Chipps Island. For this evaluation, the Chipps Island outflow is multiplied by the San Joaquin River contribution (%) to calculate the outflow (cfs) from the San Joaquin River. This San Joaquin River outflow is compared to the San Joaquin River inflow to estimate the fraction of the San Joaquin River inflow that was transported to Chipps Island.

The fraction of the monthly San Joaquin River inflow that was exported can be calculated in a similar way. The fraction of the San Joaquin River inflow being pumped at Banks is estimated by multiplying the San Joaquin River contribution (%) times the Banks pumping. Figure C.A-73 shows the San Joaquin River inflow contributions entering CCF and being exported at the Banks pumping plant. There is a wide range of San Joaquin River contributions at CCF, from less than 10% (during months with low San Joaquin River inflow) to almost 100% (during months with high San Joaquin River inflow or low Banks pumping). Figure C.A-74 shows the San Joaquin River inflow contribution at the Jones pumping plant and the DMC. There is always more of a San Joaquin River contribution at the CVP Jones pumping plant because the San Joaquin River water diverted into Old River and Grant Line Canal will preferentially enter the Jones pumping plant and will enter CCF only if there is additional San Joaquin River water. About half of the San Joaquin River inflow will flow past

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Stockton and then be diverted into Turner Cut or into Columbia Cut and the mouth of Middle River and then flow upstream in Middle River to the export pumps. This water from Middle River will preferentially enter CCF and the Banks pumping plant.

Only when the San Joaquin River inflow is greater than the combined south Delta export pumping will any San Joaquin River inflow move out of the south Delta channels and flow past Chipps Island to Suisun Bay. Figure C.A-75 shows the San Joaquin River inflow and the DSM2-simulated (i.e., source tracking) fraction of the San Joaquin River at the combined exports for EBC2 baseline case for 1976–1991. The calculated San Joaquin River inflow at the combined exports (i.e., minimum of San Joaquin River flow and exports) is shown for comparison. The DSM2 model source tracking indicates that some of the San Joaquin River flow is not reaching the exports and presumably is being diverted by the agricultural diversions. Figure C.A-76 shows the San Joaquin River inflow and the DSM2-simulated fraction of the San Joaquin River at Chipps Island for the EBC2 baseline case for 1976–1991. The calculated San Joaquin River inflow at Chipps Island (i.e., Delta outflow) is shown for comparison. The simple calculation (i.e., San Joaquin River inflow-exports) slightly overestimates the San Joaquin River inflow reaching Chipps Island. The San Joaquin River inflow can be simply divided between the south Delta exports and Delta outflow, with some portion of the San Joaquin River inflow diverted during the summer period of high agricultural diversions.

C.A.7.2 Martinez Boundary Water Tracking

The water and salt that enter Suisun Bay at the Martinez Boundary (during flood tide upstream flows) also were tracked by the DSM2 model. Figure C.A-77 shows the monthly Delta outflow and the San Joaquin River inflow contribution at Martinez for the baseline EBC2 case for WY 1976–1991. Outflow is less than 25,000 cfs in most months. Figure C.A-78 shows the DSM2-simulated contribution of water from the Martinez boundary (km 54) at Port Chicago (km 64) for the WY 1976–1991. The average Martinez water contribution is about 80–85% during months with low outflow (5,000 cfs). Comparison of the two figures indicates that an outflow of 50,000 cfs reduced the Martinez contribution to about 20%, an outflow of 100,000 cfs reduced the Martinez contribution to about 10%, and an outflow of 150,000 cfs reduced the Martinez contribution to about 0% at Port Chicago. The Martinez boundary water carries the Martinez salinity with it; the percentage of Martinez water at upstream Delta locations reflects the seawater intrusion effects caused by tidal mixing. During months with low outflow, the Port Chicago EC should be about 80% of the Martinez boundary EC. Figure C.A-79 shows the DSM2-simulated EC at Martinez and Port Chicago. The maximum monthly average Martinez EC was greater than 22,500 µS/cm, and the maximum monthly average Port Chicago EC was above 17,500 µS/cm (80% of the Martinez EC). Figure C.A-79 shows that an outflow of about 75,000 cfs would reduce the Martinez EC and the Port Chicago EC to less than 200 µS/cm (the assumed Sacramento River EC was 175 µS/cm).

Figure C.A-80 shows the DSM2-simulated contribution of water from the Martinez boundary (km 56) at Collinsville (km 81) for the WY 1976–1991. The maximum Martinez water contribution was about 50%, suggesting that the Collinsville EC would be about 50% of the Martinez EC. The maximum Martinez water contribution at Chipps Island (not shown) was about 65%. The simulated Martinez contributions are reduced at higher outflows. Figure C.A-81 shows the DSM2-simulated EC at Chipps Island and Collinsville. The maximum monthly average Chipps Island EC was about 15,000 µS/cm (65% of maximum Martinez EC) and the maximum average Collinsville EC was about 10,000 µS/cm (40% of maximum Martinez EC). The maximum Martinez water contribution at Emmaton was about 15%, and the maximum Martinez water contribution at Jersey Point was about

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10% (not shown) during months with low Delta outflow. Figure C.A-82 shows the DSM2-simulated EC at Emmaton and Collinsville. The maximum monthly average Emmaton EC was about 3,500 µS/cm (15% of maximum Martinez EC) and the maximum average Jersey Point EC was about 2,500 µS/cm (10% of maximum Martinez EC). These figures demonstrate that the seawater intrusion estimated from the source tracking and the EC simulations were consistent. The increased salinity during periods of low Delta outflow indicates the upstream movement of salinity and other water quality concentrations or floating particles (e.g., phytoplankton, zooplankton, larval fish) from the Martinez boundary.

Figure C.A-83 and Figure C.A-84 show the DSM2-simulated Martinez boundary water contributions at the SWP Banks and CVP Jones pumping plants for WY 1976–1991. The DSM2-simulated Martinez water contribution was generally similar for the SWP and CVP pumping and was greater than 1% in about half of the months. The maximum Martinez water contribution at the Banks pumping plant is generally a little higher than the contribution at the CVP Jones pumping plant because the CVP Jones pumping plant generally has a greater contribution from the San Joaquin River inflow. The maximum Martinez contribution at the SWP Banks pumping plant was about 3%, and the maximum contribution at the CVP Jones pumping plant was about 2%. Because the average Martinez EC was about 23,000 µS/cm in these low-outflow months, the contribution in the combined SWP and CVP exports can be estimated to be about 575 µS/cm (i.e., 0.025 x 23,000 = 575). The modeling results indicate that the Martinez water contribution (seawater intrusion) at the exports was primarily a function of Delta outflow and was not affected by south Delta export pumping. Therefore, because the PP cases did not increase the Delta outflow, there was no reduction in the simulated EC from Martinez (seawater intrusion contribution) at the south Delta pumping plants. The export EC was reduced by the north Delta intake diversions (Sacramento River EC of 175 µS/cm) but the export EC could have been reduced even more by slightly increased outflow (which would reduce the seawater intrusion contribution).

C.A.7.3 Agricultural Drainage Tracking

The DSM2 uses an input file (Delta Islands Consumptive Use [DICU]) that is used to simulate the agricultural diversions and seepage and drainage discharges that are located throughout the Delta. The DICU discharges from the islands to the channels are one of the sources tracked. For salinity simulations, the DICU discharges (drains) have assumed monthly EC values, which are highest in the winter. Seepage is assumed to be about 1 inch per acre for the Delta lowlands islands, and agricultural diversions are assumed to be 1.5 x the monthly irrigation ET, so the drainage in the summer is about 50% of the irrigation demand, or about 33% of the agricultural diversions. The salinity of these summer return flows might be as low as the channel EC, but DICU uses fixed monthly values regardless of the channel (diversion) EC. The DICU does not calculate a salt balance for each island.

The DICU discharges include runoff from rainfall, seepage, and irrigation return flow, as well as some leaching water assumed to be applied and drained after a month from some islands in the winter is tracked. Therefore, although agricultural drainage water is tracked in DSM2, it is difficult to estimate the salinity or other constituent concentration (e.g., dissolved organic carbon [DOC], nutrients) of this drainage water. The agricultural diversions are assumed to remove water from the Delta channels, although 33% of this diversion and most of the seepage flow will be returned to the Delta channels as drainage. Nevertheless, the source tracking of agricultural drainage provides a

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useful general pattern of influence from these internal Delta sources of water (from runoff, seepage, and agricultural diversion return flow).

Figure C.A-85 and Figure C.A-86 show the DSM2-simulated agricultural drainage source contributions at the SWP Banks the CVP Jones Pumping Plants for WY 1976–1991 for the six cases. The drainage source contribution was a maximum of about 20–25% in the summer months of most years. The drainage contributions were about the same in the SWP and CVP exports. The lowest drainage contribution in the winter months was about 5%. The highest drainage contribution of about 25% was simulated in months with low export pumping. The drainage contributions were higher in months with reduced export pumping, because the summer drainage flows were constant from year to year, while the channel flows to the exports (i.e., reverse OMR flow, Grant Line Canal) were lower in months with reduced pumping. The PP cases had higher drainage contributions at the south Delta pumps in months when the north Delta intake diversions allowed the south Delta pumping to be reduced. Therefore, the effects of reduced pumping on water quality at the south Delta pumps are based on these counteracting effects (lower San Joaquin River contributions but higher agricultural drainage contributions).

Figure C.A-87 and Figure C.A-88 show the DSM2-simulated drainage source contributions in the Sacramento River at Emmaton and in the San Joaquin River at Jersey Point for WY 1976–1991 for the six cases. The average simulated drainage contribution at Jersey Point ranged from about 2% in the winter to about 7% in the summer of most years. The average simulated drainage contribution at Emmaton ranged from about 1% in the winter to about 5% in the summer of most years. The PP cases showed slightly higher drainage contributions at Jersey Point in some of the years, caused by the reduced south Delta export pumping that currently removes a major portion of the south Delta drainage flows.

C.A.7.4 Yolo Bypass Inflow Tracking

The Yolo Bypass inflow enters the Delta at Cache Slough near Rio Vista. Figure C.A-89 and Figure C.A-90 show the DSM2-simulated Yolo Bypass contribution in the Sacramento River at Emmaton and in the San Joaquin River at Jersey Point for WY 1976–1991 for the six cases. The only way for Yolo Bypass water to reach Jersey Point is to tidally mix through Threemile Slough or to tidally mix upstream from the confluence. Presumably the upstream movement from the confluence is limited because the Yolo Bypass inflow is large only during high outflow months. The Yolo Bypass inflow source tracking results provide a method for estimating the exchange of Sacramento and San Joaquin River water through Threemile Slough. The results indicate that a maximum of about 5–10% of the Yolo Bypass inflow moves through Threemile Slough to the San Joaquin River at Jersey Point. Because the average tidal flow in Threemile Slough is about 30,000 cfs, the flood tide volume is about 15,000 af, representing an equivalent transfer flow of about 7,500 cfs (25% of the maximum tidal flow). This would be 10% of a Yolo Bypass inflow of 75,000 cfs and about 5% of a Yolo Bypass inflow of 150,000 cfs.

C.A.7.5 Sacramento and Eastside River Tracking

Because the Sacramento River and the Yolo Bypass and the eastside rivers (Cosumnes, Mokelumne, and Calaveras) have low salinity and generally low concentrations of other constituents, the source tracking results for these three major sources were assumed to contribute the remaining water at all Delta locations. Tracking the San Joaquin River inflow, the Martinez boundary water and the agricultural drainage water will identify the contribution of water with increased salinity and

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increased concentrations of other constituents. The source tracking results therefore provide a general method for estimating likely changes in water quality concentrations at various Delta locations resulting from changes in the Delta inflows and south Delta exports that may be caused by the preliminary proposal operations.

The general method can be described for salinity (EC), although EC is already included in DSM2 modeling. The general water quality analysis requires an assumed baseline concentration. The baseline EC value of 175 µS/cm is used for the Sacramento and Yolo Bypass inflows. The eastside rivers use a value of 150 µS/cm. The increased EC at the exports caused by the San Joaquin River source, the drainage source, and the Martinez source would be calculated as the contribution from these sources times the incremental EC from these sources.

> Increased EC (µS/cm) = San Joaquin River contribution (%)/100 x San Joaquin River EC increment (µS/cm) + Drain contribution (%)/100 x Drain EC increment + Martinez contribution (%)/100 x Martinez EC increment (µS/cm)

The incremental EC (or the incremental concentration) is the measured San Joaquin River EC or drainage EC or Martinez EC minus the assumed baseline Sacramento River EC (or concentration). As can be seen in the figures shown in this section, the changes in the San Joaquin River contributions will depend on the San Joaquin River inflow. The changes in the drainage contributions will depend most strongly on the south Delta pumping, and the changes in the Martinez contributions will depend on the Delta outflow. The general effects of monthly changes in Delta inflows, south Delta export pumping, and Delta outflow on salinity and other water quality concentrations therefore can be generally understood from this analysis of source tracking.

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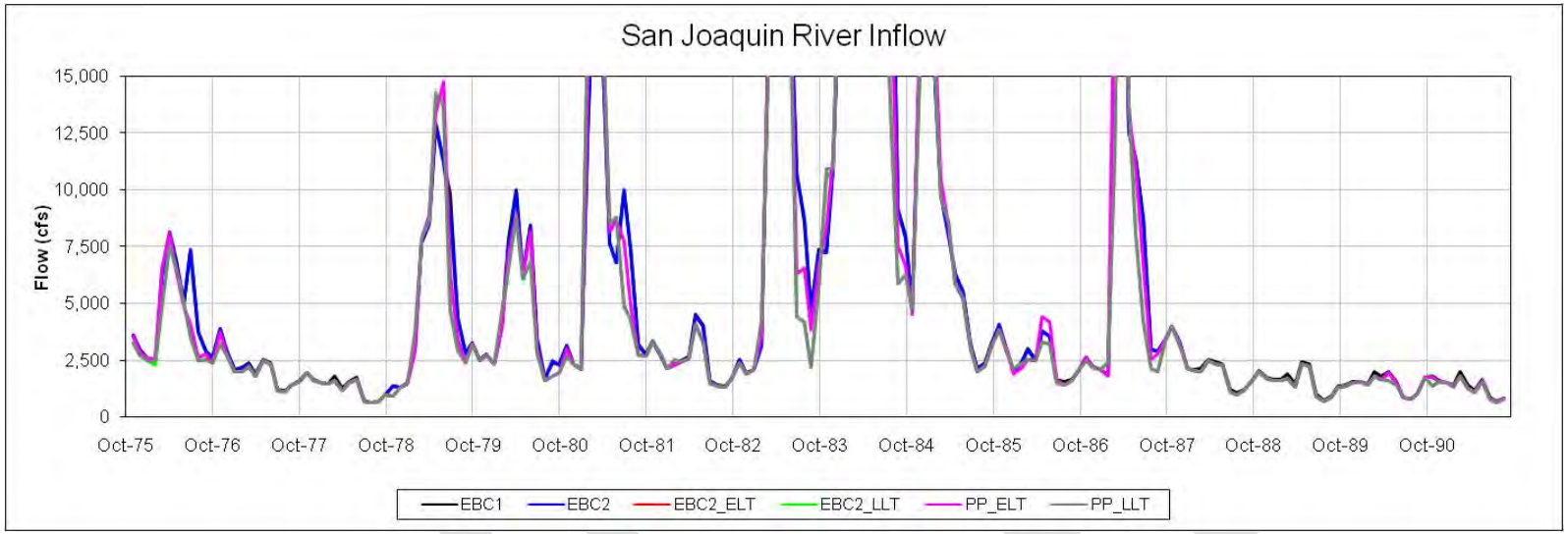

Figure C.A-65. Monthly CALSIM-Simulated San Joaquin River Inflow at Vernalis for WY 1976–1991

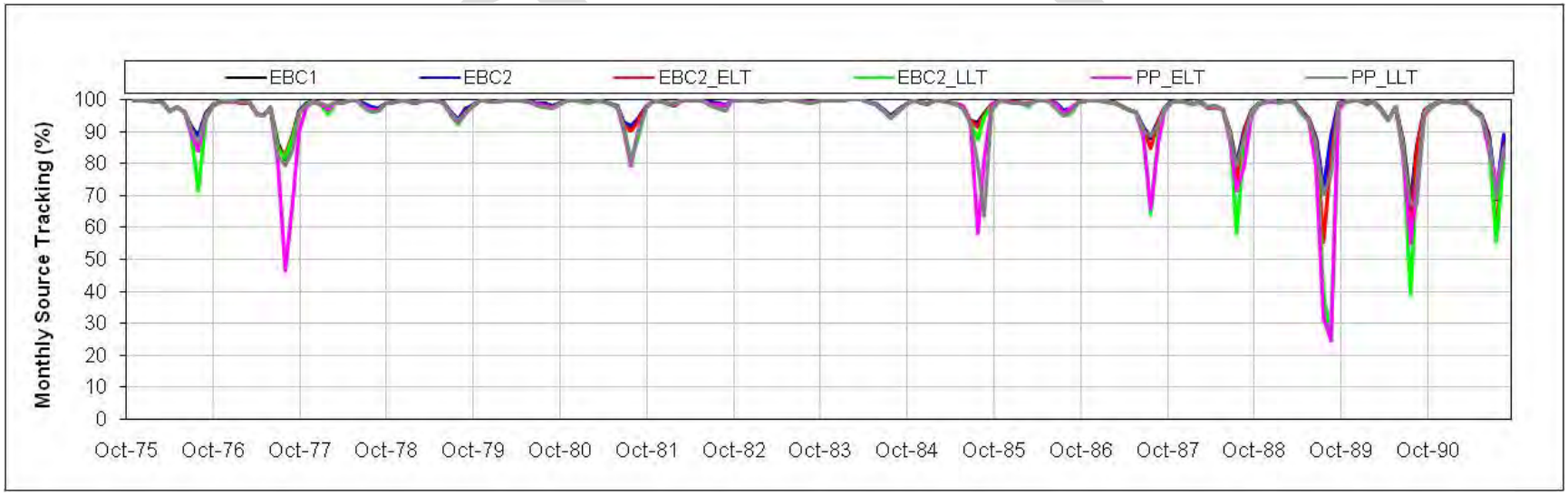

Figure C.A-66. DSM2-Simulated Monthly Source Tracking of San Joaquin River Inflow at Brandt Bridge for WY 1976–1991

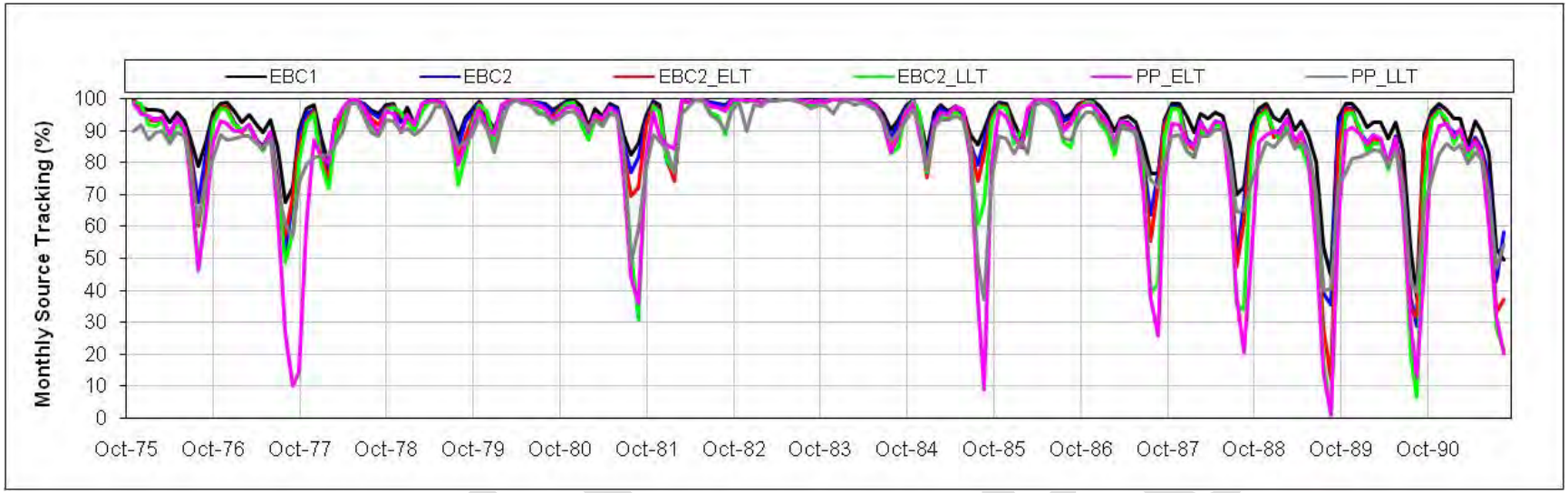

Figure C.A-67. DSM2-Simulated Monthly Source Tracking of San Joaquin River Inflow at Stockton for WY 1976–1991

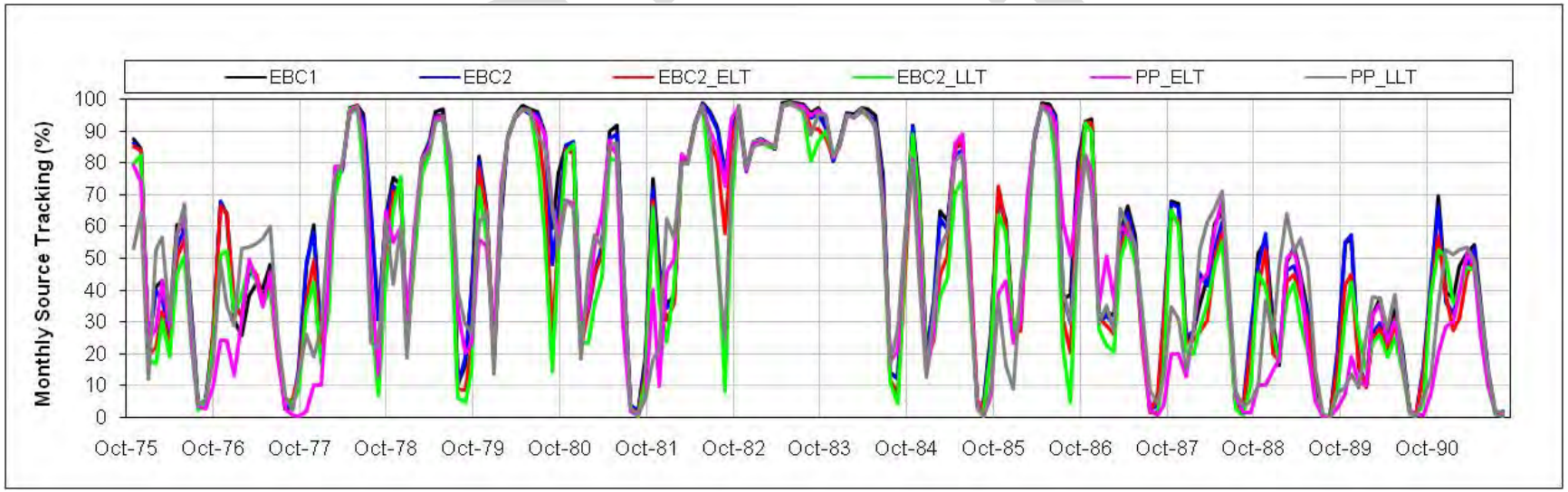

Figure C.A-68. DSM2-Simulated Monthly Source Tracking of San Joaquin River Inflow Downstream of Turner Cut for WY 1976–1991

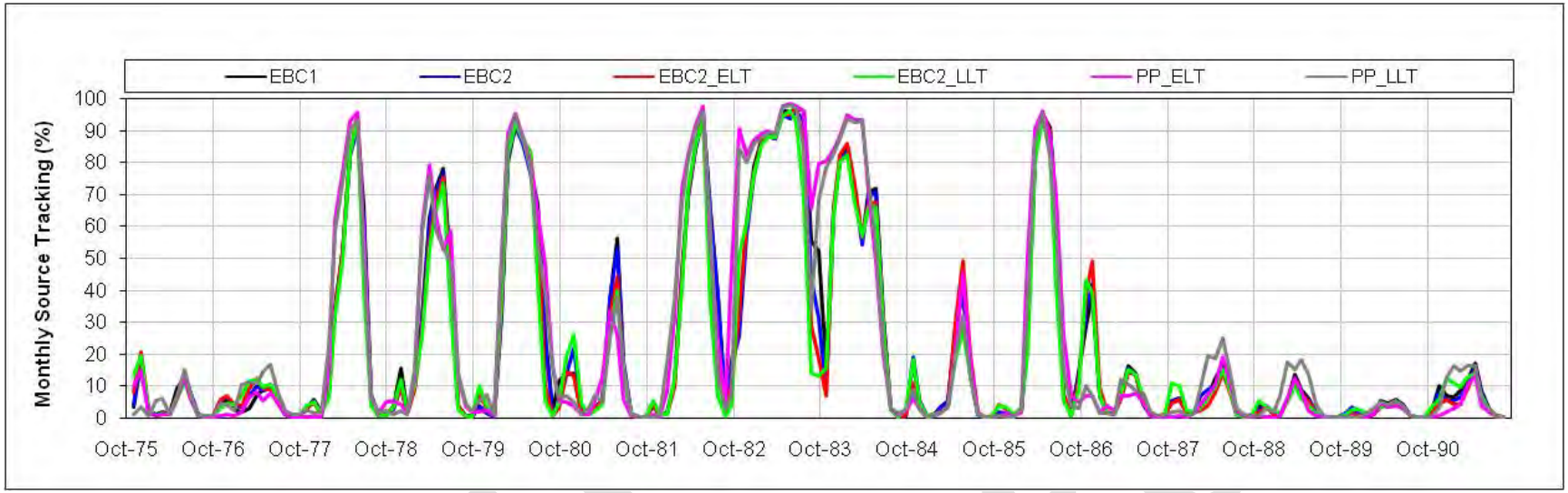

Figure C.A-69. DSM2-Simulated Monthly Source Tracking of San Joaquin River Inflow at Prisoners Point for WY 1976–1991

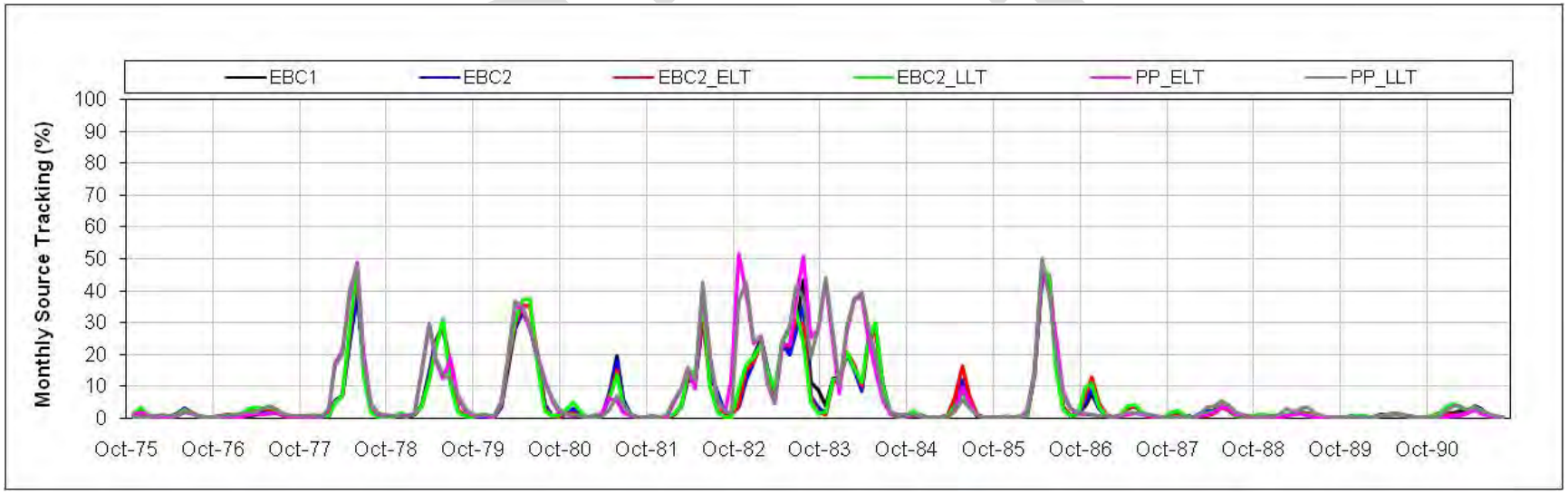

Figure C.A-70. DSM2-Simulated Monthly Source Tracking of San Joaquin River Inflow at San Andreas Landing for WY 1976–1991

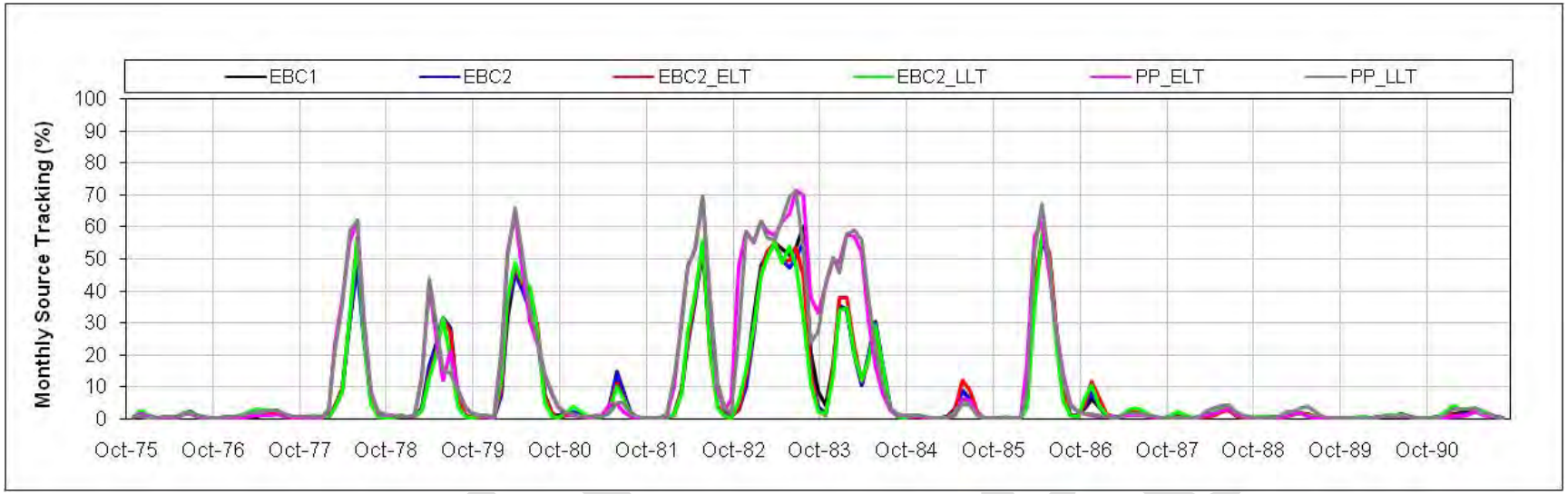

Figure C.A-71. DSM2-Simulated Monthly Source Tracking of San Joaquin River Inflow at Jersey Point for WY 1976–1991

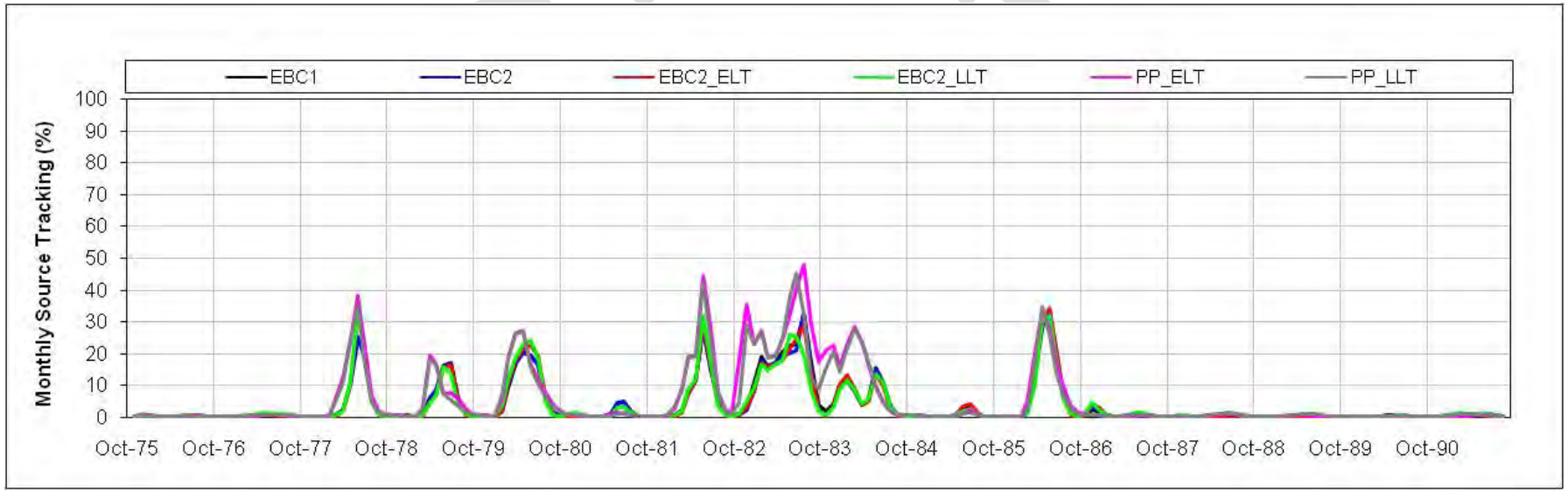

Figure C.A-72. DSM2-Simulated Monthly Source Tracking of San Joaquin River Inflow at Chipps Island for WY 1976–1991

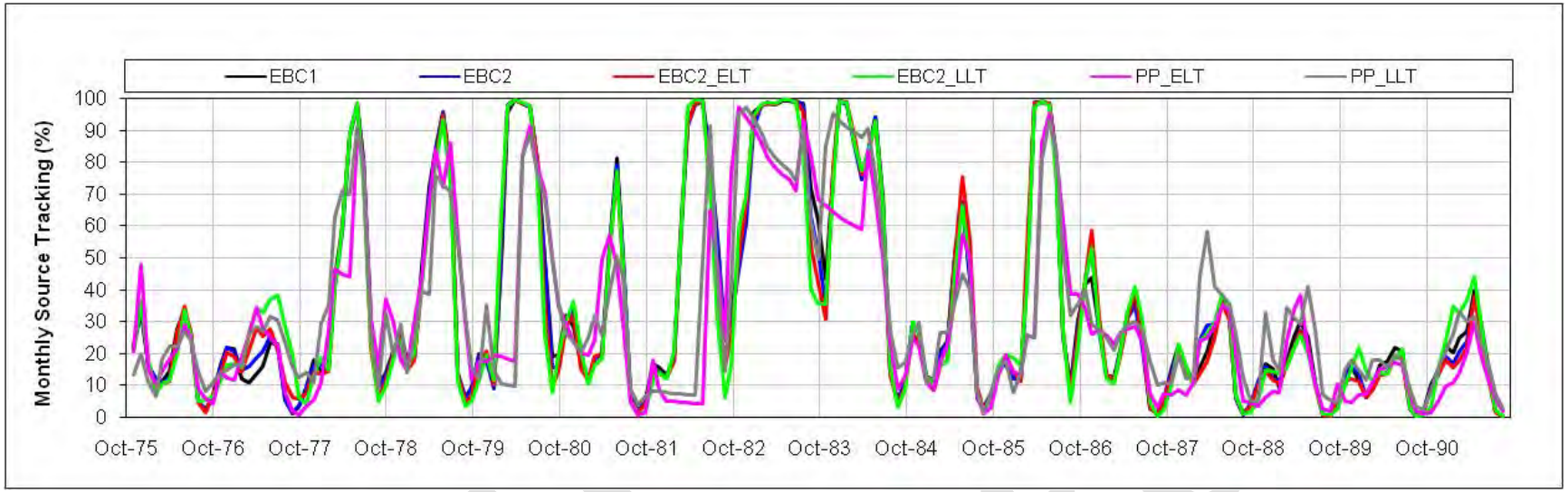

Figure C.A-73. DSM2-Simulated Monthly Source Tracking of San Joaquin River Inflow at Clifton Court Forebay for WY 1976–1991

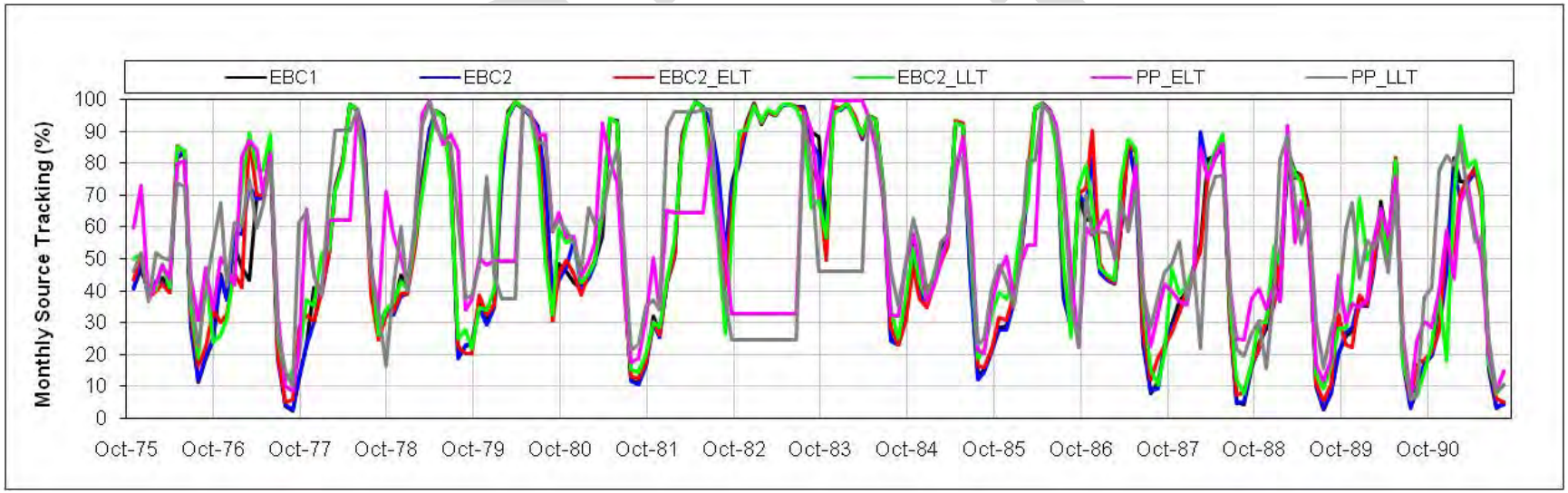

Figure C.A-74. DSM2-Simulated Monthly Source Tracking of San Joaquin River Inflow at Jones Pumping Plant for WY 1976–1991

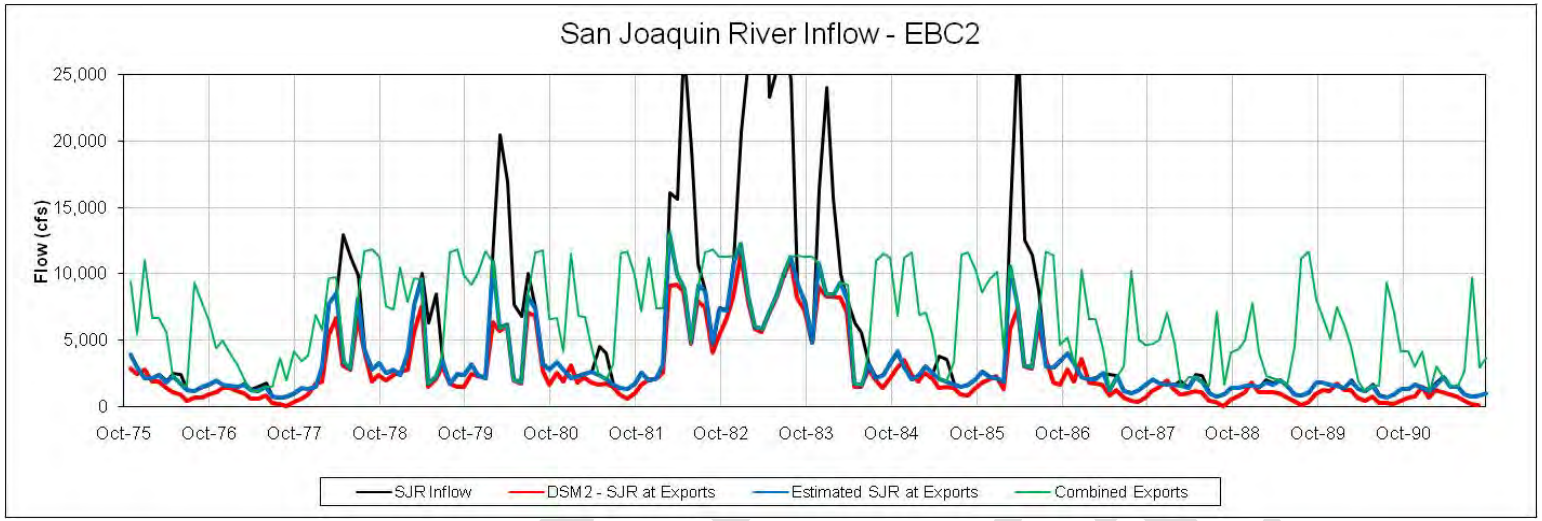

Figure C.A-75. DSM2-Simulated and Estimated Monthly San Joaquin River Inflow at CVP Jones and SWP Banks Pumping Plants for EBC2 Case for 1976–1991

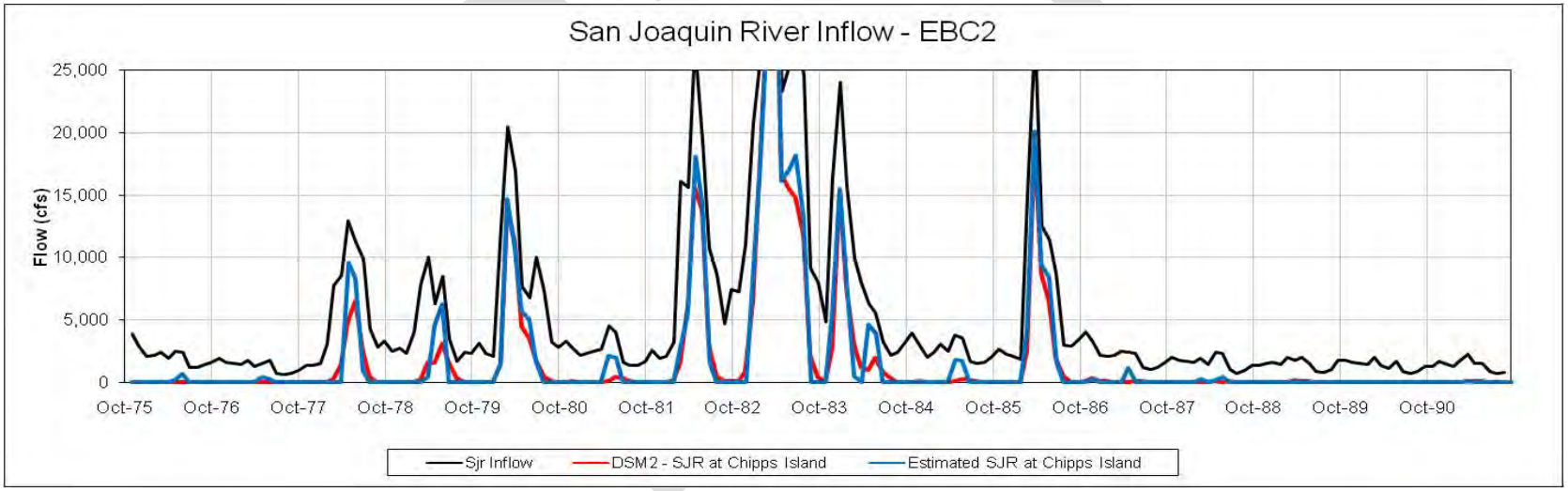

Figure C.A-76. DSM2-Simulated and Estimated Monthly San Joaquin River Inflow at Chipps Island (Delta Outflow) for EBC2 Case for 1976–1991

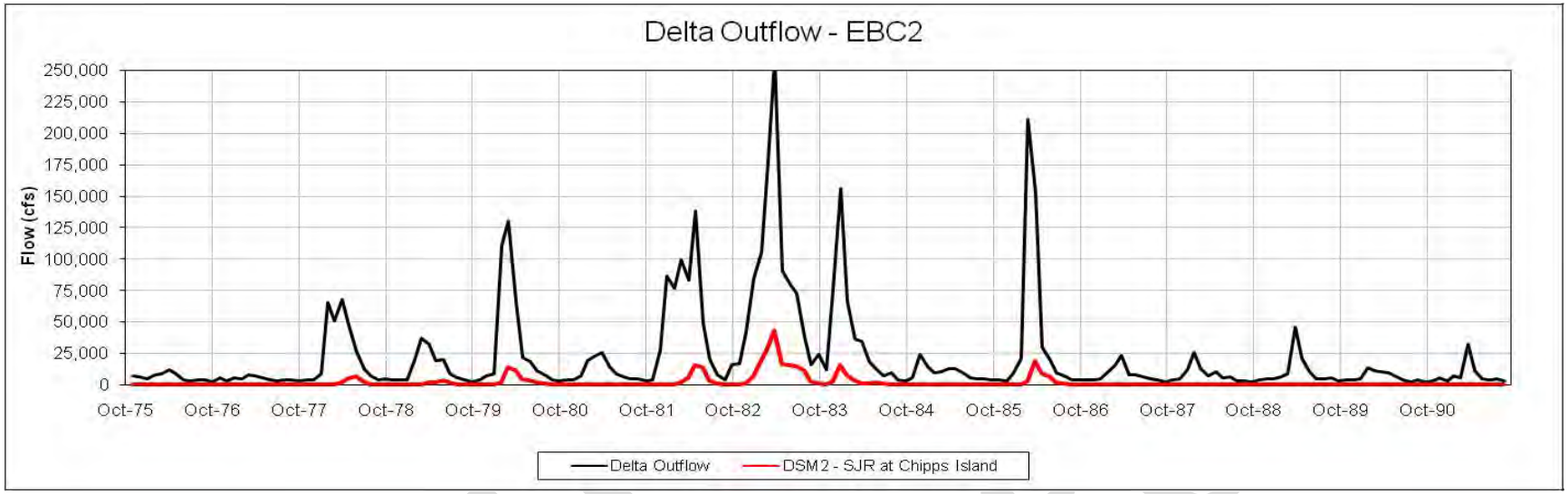

Figure C.A-77. DSM2-Simulated Delta Outflow and the San Joaquin River Flow at Martinez for the EBC2 Case for WY 1976–1991

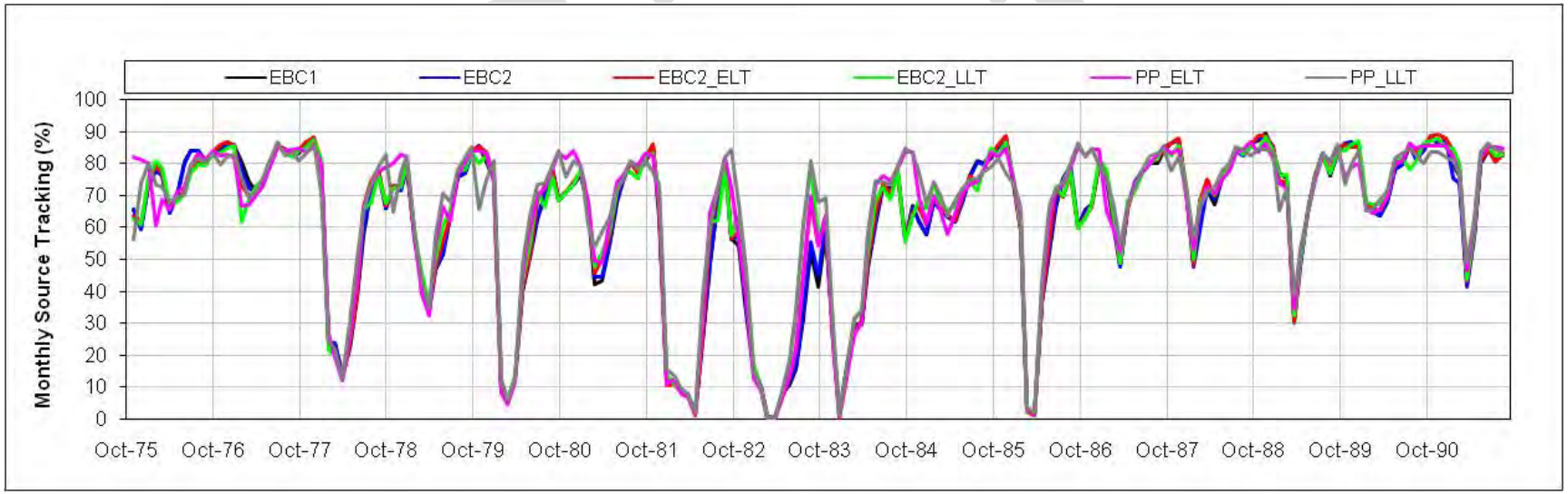

Figure C.A-78. DSM2-Simulated Monthly Source Tracking of Martinez Boundary Water (flood tide) at Port Chicago for WY 1976–1991

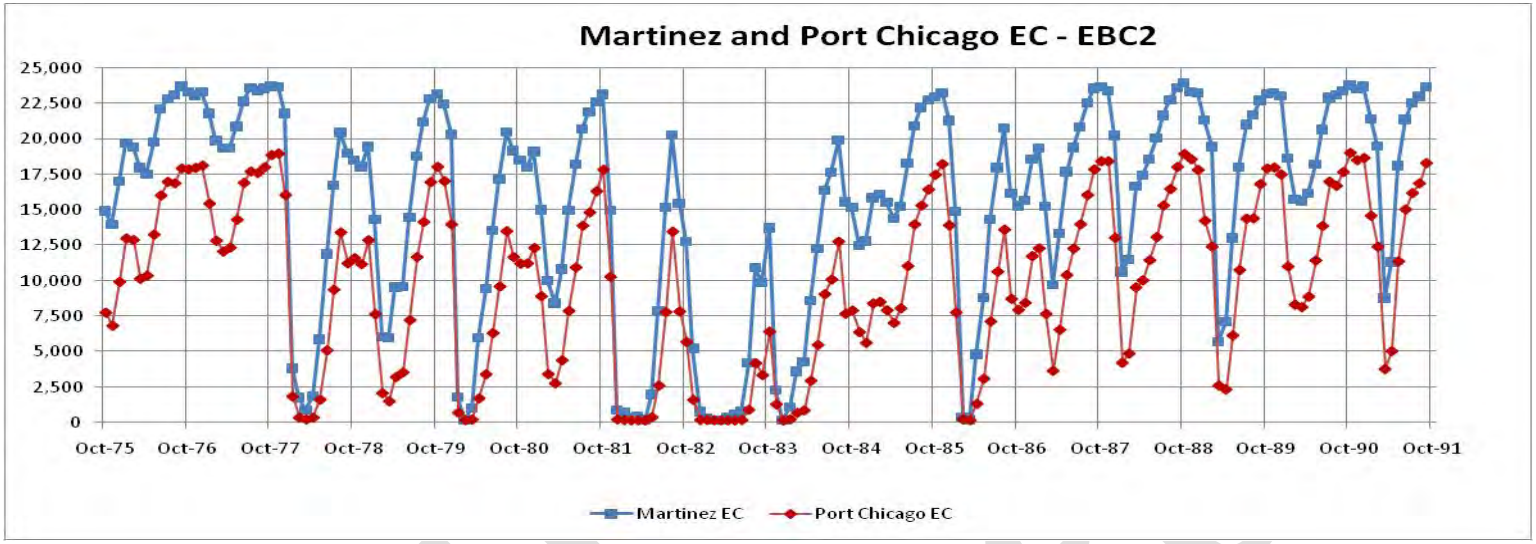

Figure C.A-79. DSM2-Simulated Monthly EC at Martinez (km 54) and Port Chicago (km 64) for WY 1976–1991

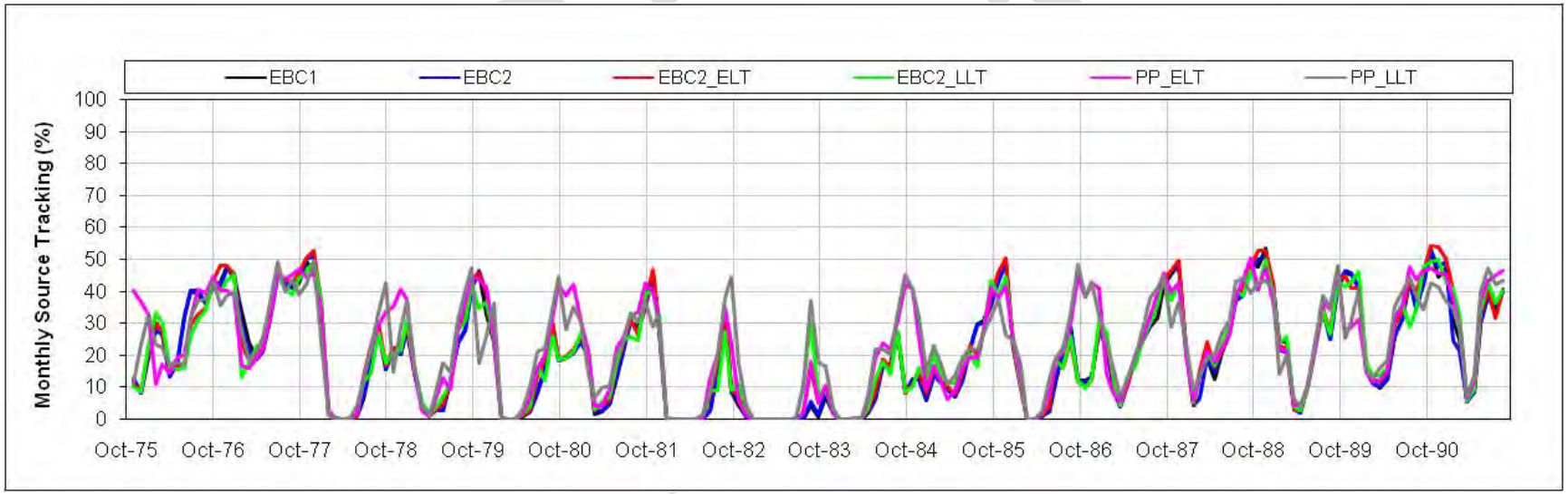

Figure C.A-80. DSM2-Simulated Monthly Source Tracking of Martinez Boundary Water (flood tide) at Collinsville (km 81) for WY 1976–1991

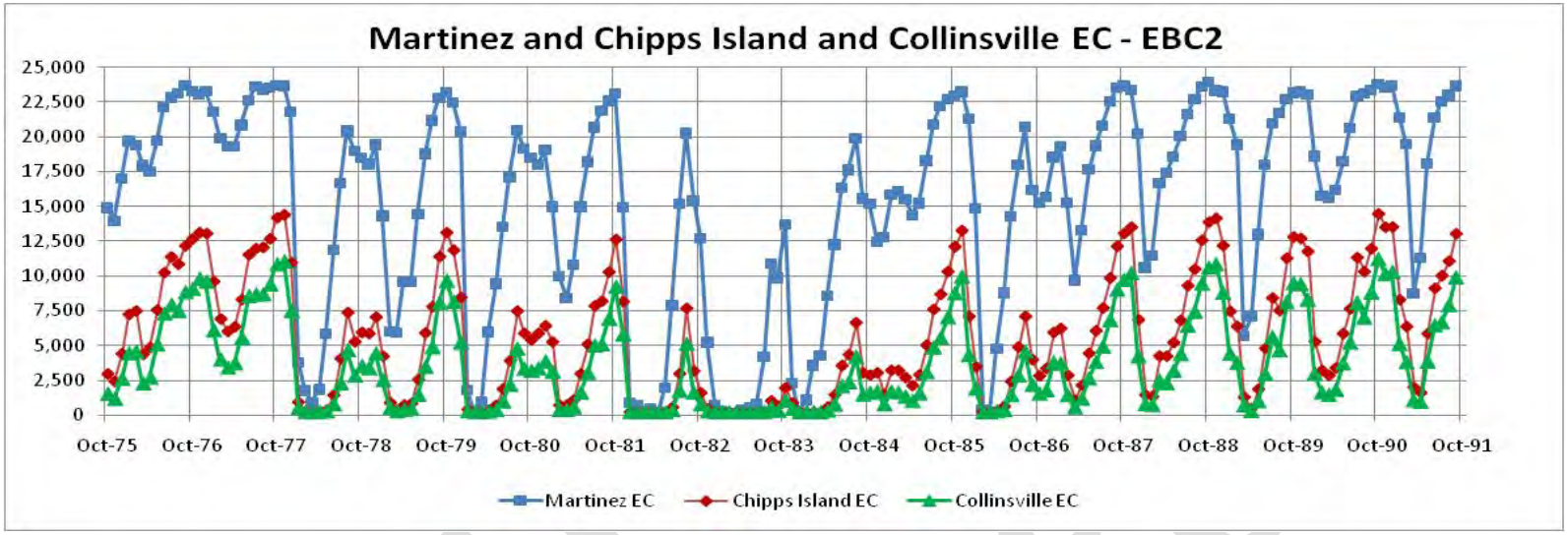

Figure C.A-81. DSM2-Simulated Monthly Source Tracking of Martinez Boundary Water (flood tide) at Emmaton (km 92) for WY 1976–1991

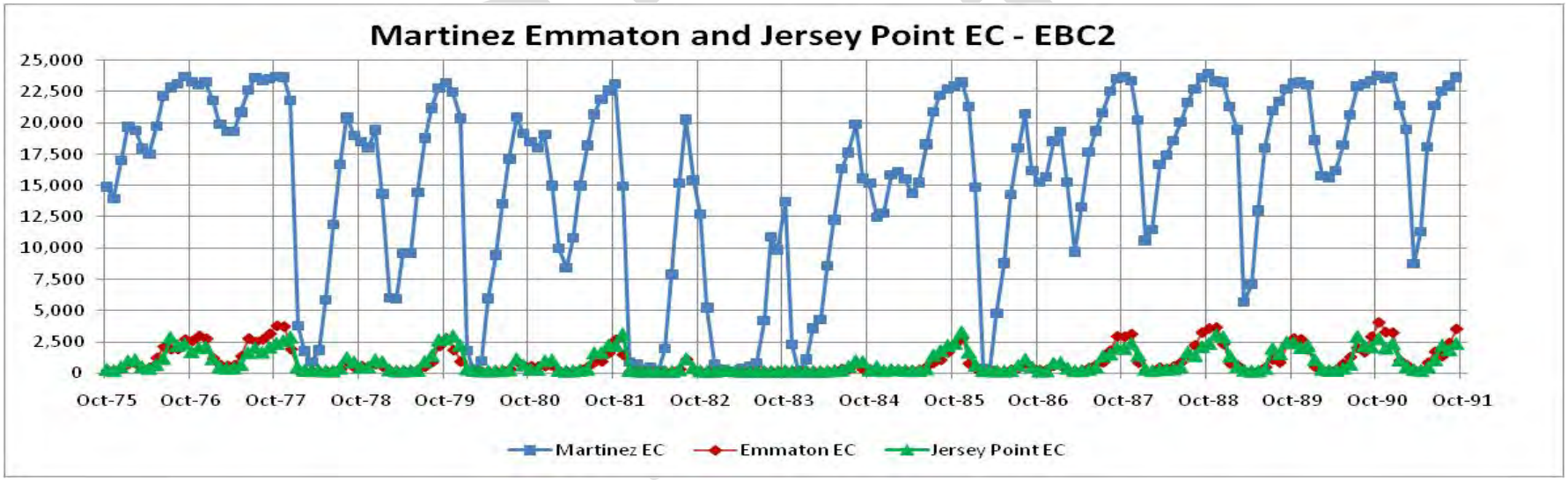

Figure C.A-82. DSM2-Simulated Monthly Source Tracking of Martinez Boundary Water (flood tide) at Jersey Point (km 98) for WY 1976–1991

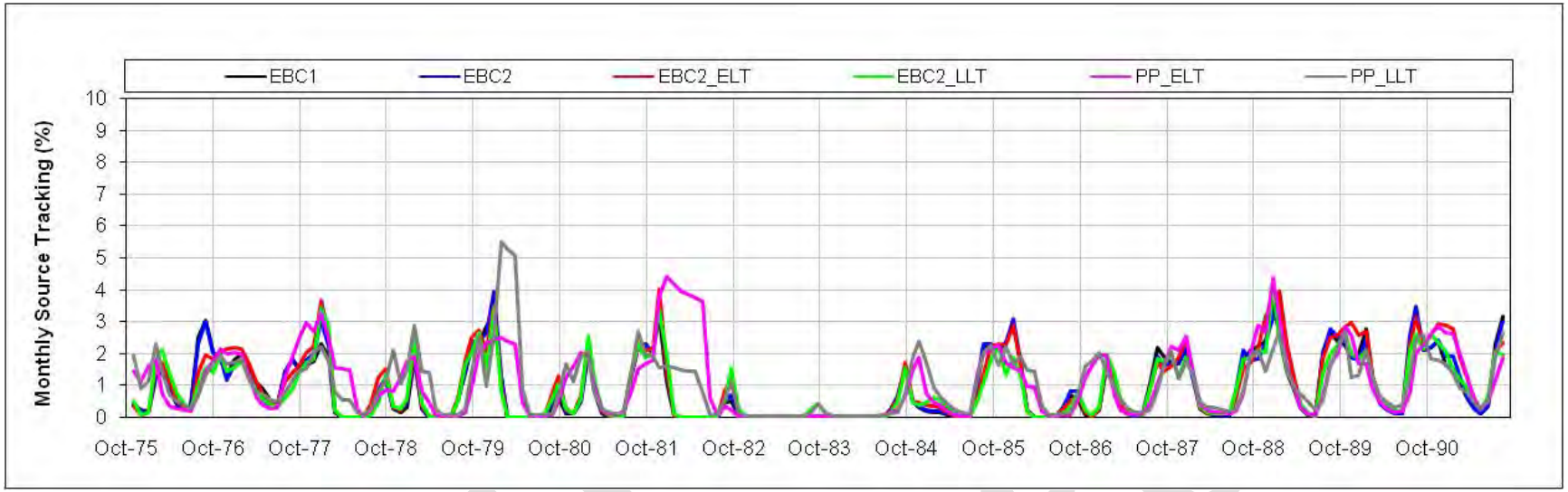

Figure C.A-83. DSM2-Simulated Monthly Source Tracking of Martinez Boundary Water (flood tide) at Clifton Court Forebay for WY 1976–1991

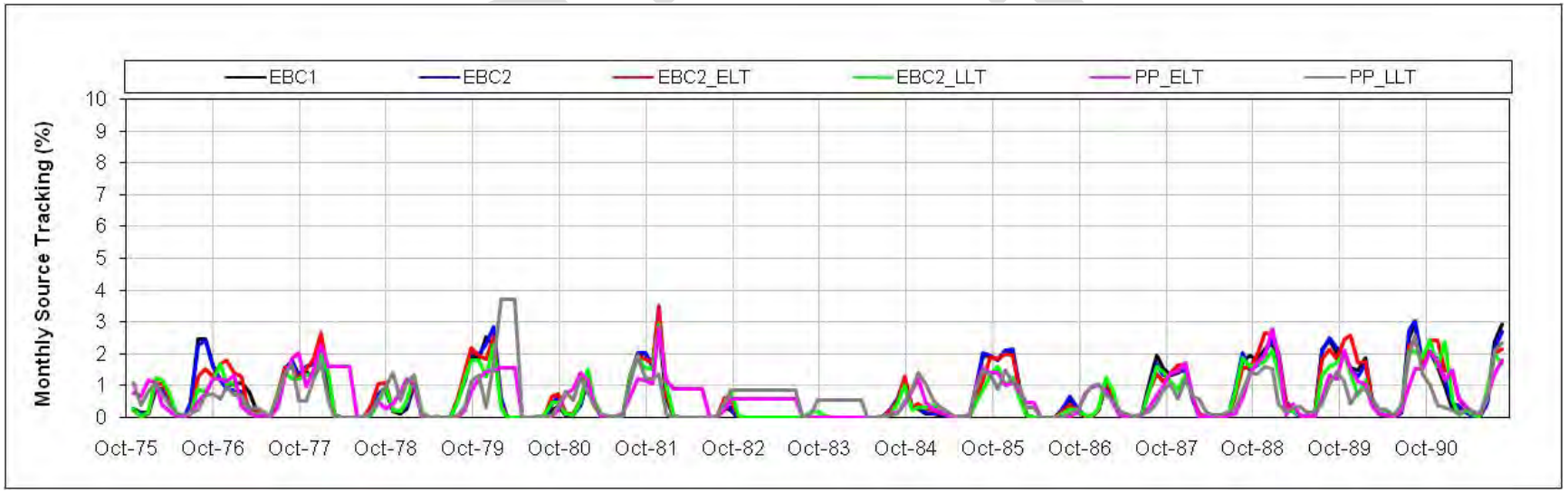

Figure C.A-84. DSM2-Simulated Monthly Source Tracking of Martinez Boundary Water (flood tide) at Jones Pumping Plant for WY 1976–1991

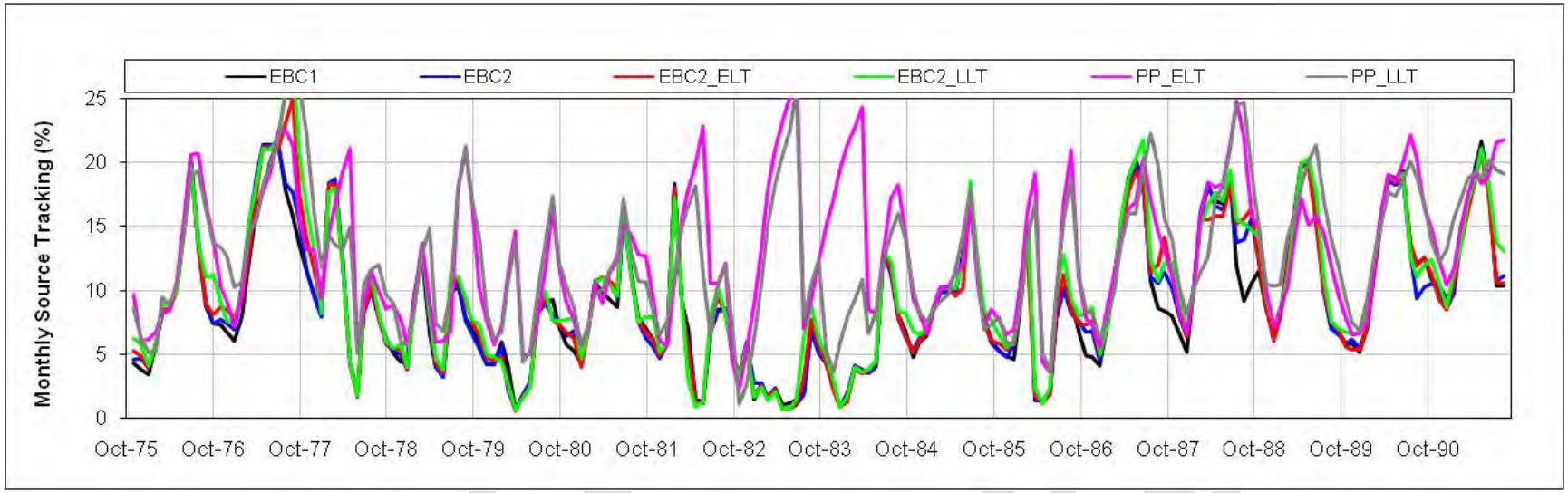

Figure C.A-85. DSM2-Simulated Monthly Source Tracking of Delta Runoff and Agricultural Drainage at Clifton Court Forebay for WY 1976–1991

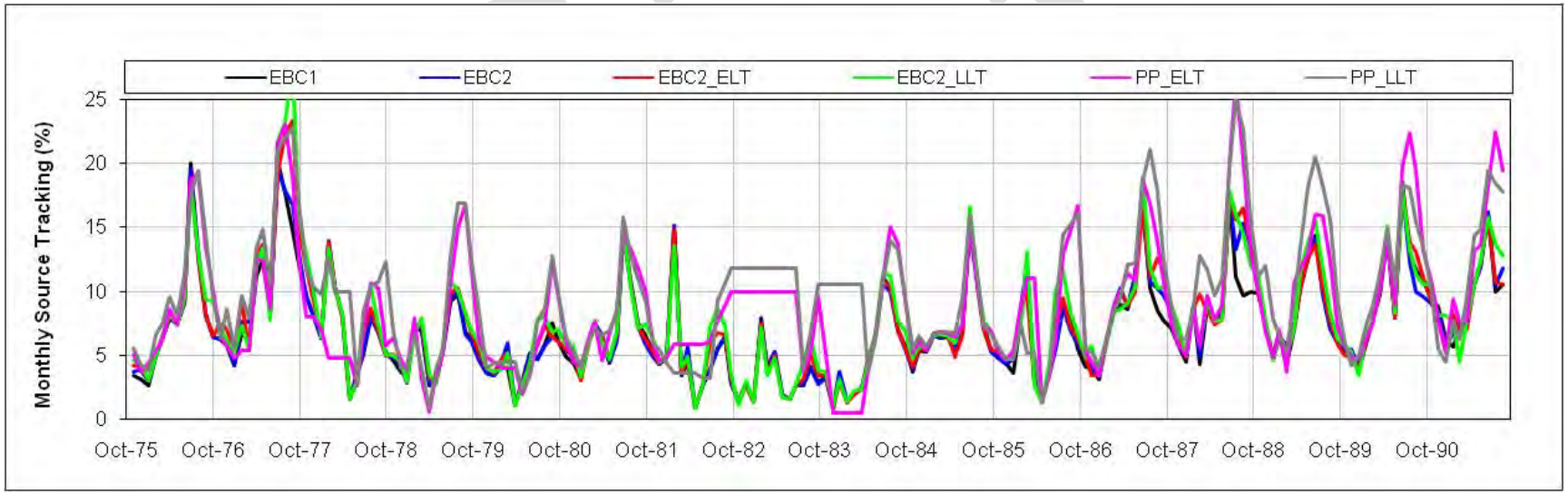

Figure C.A-86. DSM2-Simulated Monthly Source Tracking of Delta Runoff and Agricultural Drainage at Jones Pumping Plant for WY 1976–1991

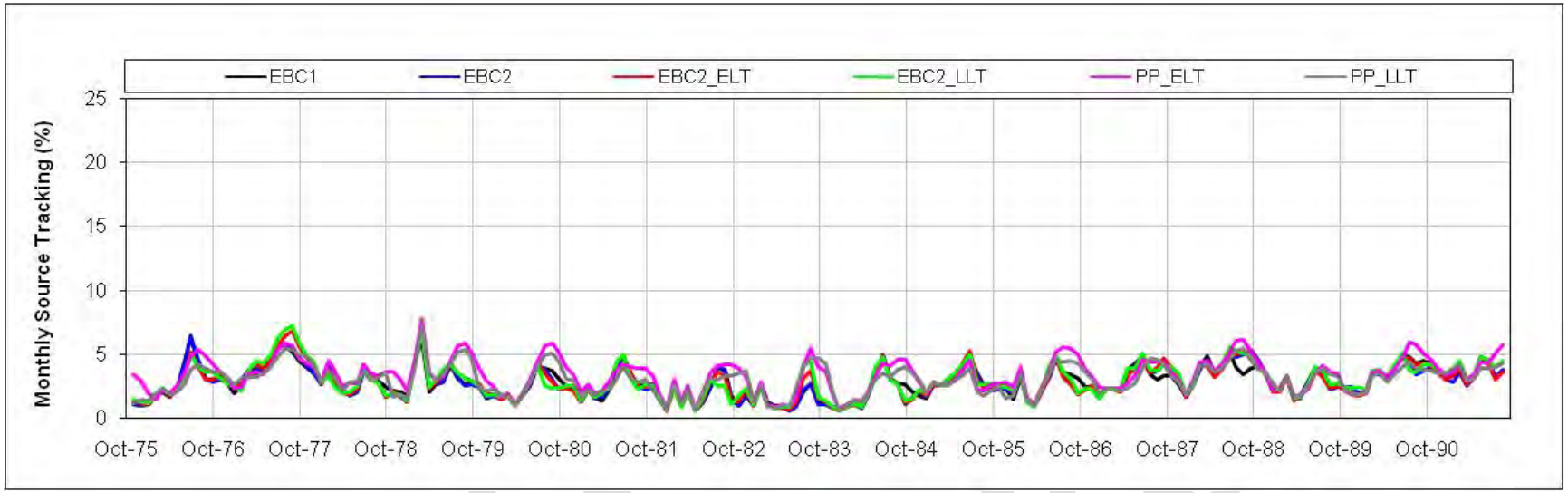

Figure C.A-87. DSM2-Simulated Monthly Source Tracking of Delta Runoff and Agricultural Drainage at Emmaton for WY 1976–1991

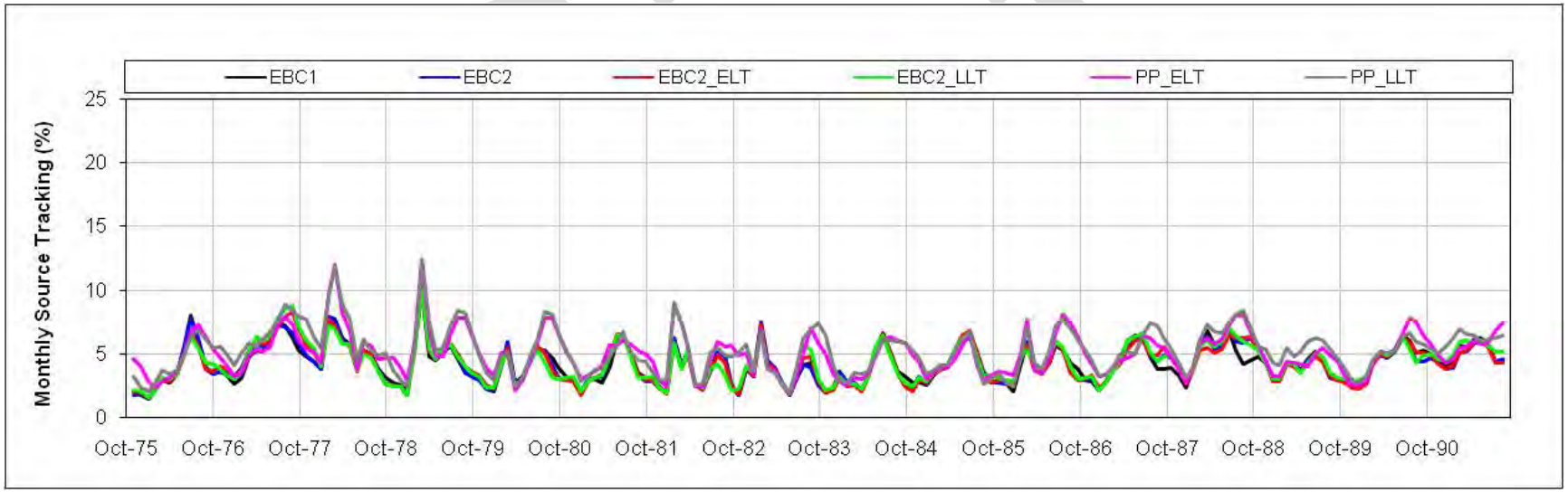

Figure C.A-88. DSM2-Simulated Monthly Source Tracking of Delta Runoff and Agricultural Drainage at Jersey Point for WY 1976–1991

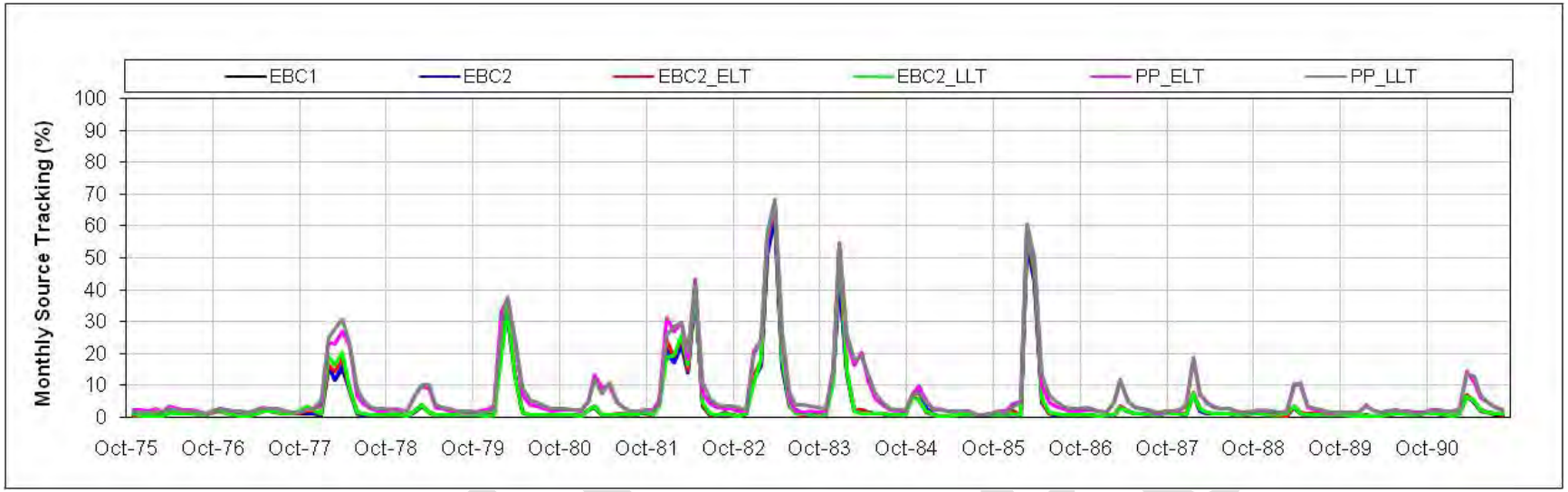

Figure C.A-89. DSM2-Simulated Monthly Source Tracking of Yolo Bypass Inflow at Emmaton for WY 1976–1991

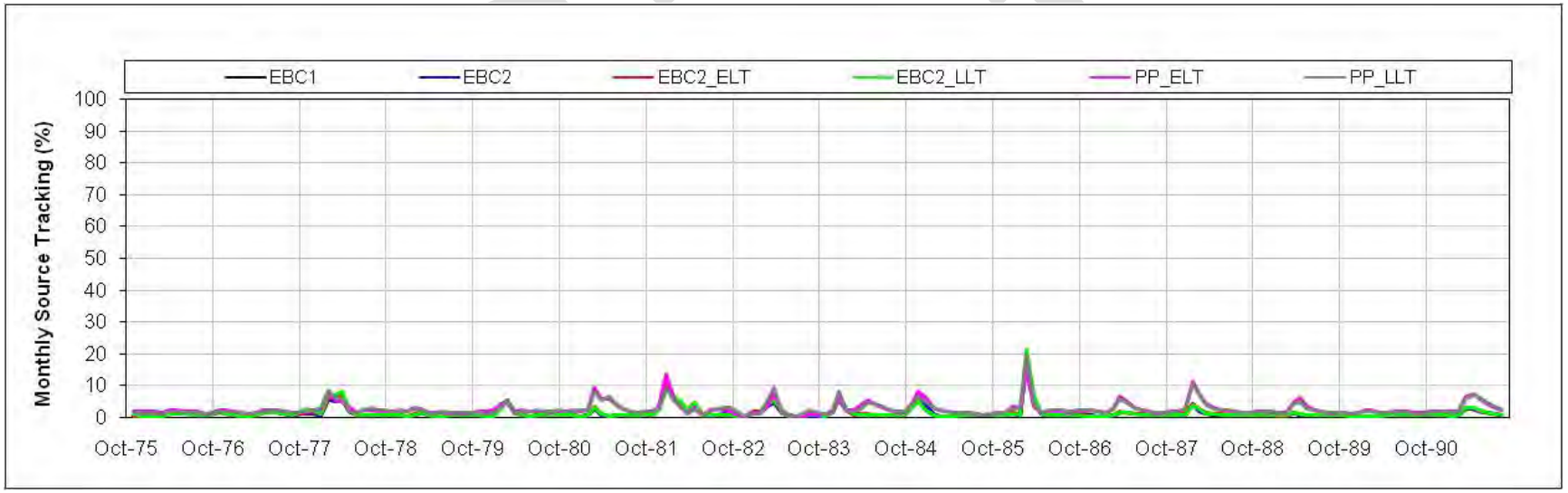

Figure C.A-90. DSM2-Simulated Monthly Source Tracking of Yolo Bypass Inflow at Jersey Point for WY 1976–1991

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C.A.8 DSM2 Particle Tracking and Fate—Results

DSM2-PTM simulates the transport of particles based on the simulated tidal flows and assumed vertical and lateral velocity gradients. The average velocity in each 1-D channel segment is used to approximate the 3-D location of individual particles. The PTM module uses geometry files, velocity, flow, and stage output from the HYDRO module to monitor the location of each individual particle using assumed vertical and lateral velocity profiles and specified random movement to simulate mixing. The location of a particle in a channel is determined as the distance from the downstream end of the channel segment (x), the distance from the centerline of the channel (y), and the distance above the channel bottom (z). Particle tracking has been used for visualization of tidal flow transport patterns and evaluation of larval and juvenile fish movement and entrainment.

The longitudinal distance traveled by a particle is determined from a combination of the tidal flow and assumed lateral and vertical velocity profiles in each channel. The transverse velocity profile simulates the effects of channel shear that occurs along the sides of a channel. The result is varying velocities across the width of the channel. The vertical velocity profile shows that particles located near the bottom of the channel move more slowly than particles located near the surface. The model uses a logarithmic vertical velocity profile. Particles also move because of random mixing. The mixing rates (i.e., distances) are a function of the water depth and the velocity in the channel. High velocities and deeper water result in greater mixing. Particles entering exports or agricultural diversions are considered lost from the system, and their fate is recorded. Once particles pass the Martinez boundary, they have no opportunity to return to the Delta.

Representative months (24) were selected from the CALSIM simulation period (WY 1922–2003) for PTM simulations that included a full range of Sacramento River at Freeport and San Joaquin River at Vernalis inflows as shown in Figure C.A-91. The selected PTM months had evenly distributed E/I ratios between 0.1 and 0.6 as shown in Figure C.A-92. PTM simulations were performed to determine the fate of particles released from 39 Delta locations (shown in Figure C.A-93) after 30 days. The locations matched the 20 mm delta smelt survey stations and other locations such as the San Joaquin River at Mossdale and the Cache Slough region. Four thousand particles were inserted at the identified locations on the first day of the selected month. The fates of the inserted particles were tracked for 30 days (or longer). Particles could be tracked at various Delta channels (intermediate fate) or to the individual diversions or to outflow (ultimate fate). Spatial plots of the percentage of particles with a specified fate (e.g., entrainment in south Delta exports) were prepared as shown in Figure C.A-94. Graphs showing the relationship of particle fate over the range of a selected hydrologic variable (e.g., OMR flows, E/I ratio) also were prepared to evaluate the possible movement of larval or juvenile fish released from a given location, as shown in Figure C.A-95.

Location is one of the primary factors controlling the risk of entrainment. For a specified Delta location, the south Delta exports, reverse OMR flow, Delta outflow, and the E/I ratio are the most useful flow variables for characterizing the entrainment risk or the fraction of particles reaching Chipps Island within a month. The entrainment results can be summarized for the major Delta regions with separate plots. This is similar to the presentation of entrainment as a function of the E/I ratio that was described and discussed by Kimmerer and Nobriga (2008). The effects of entrainment of fish are described in Appendix 5.B.

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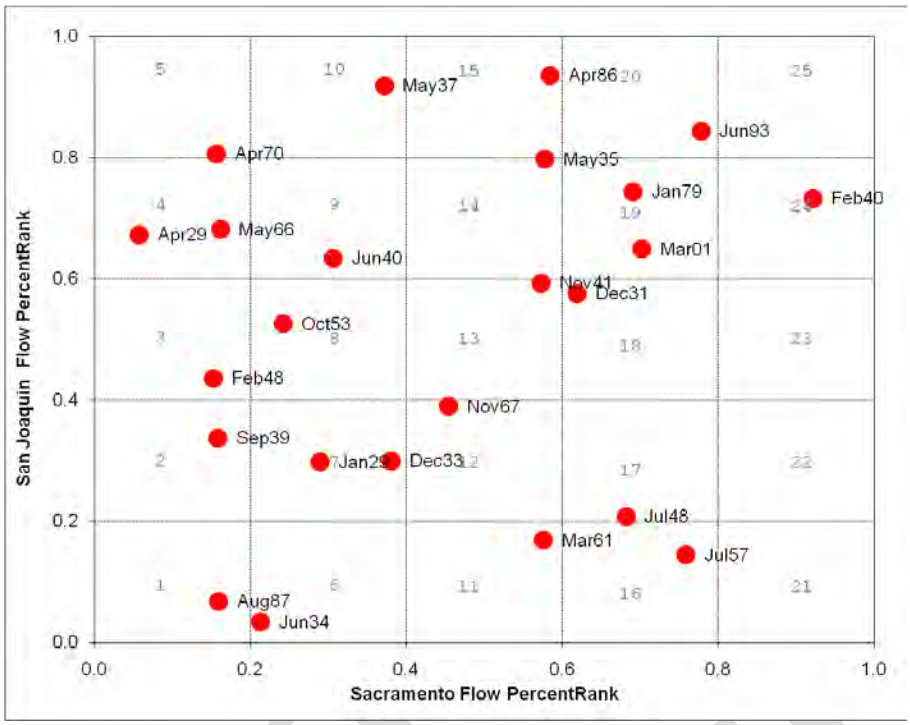

Figure C.A-91. Selected PTM Insertion Periods Plotted on the Sacramento River and San Joaquin River Inflow Hydrology Bins with Month and Year Identified for Each Insertion Period

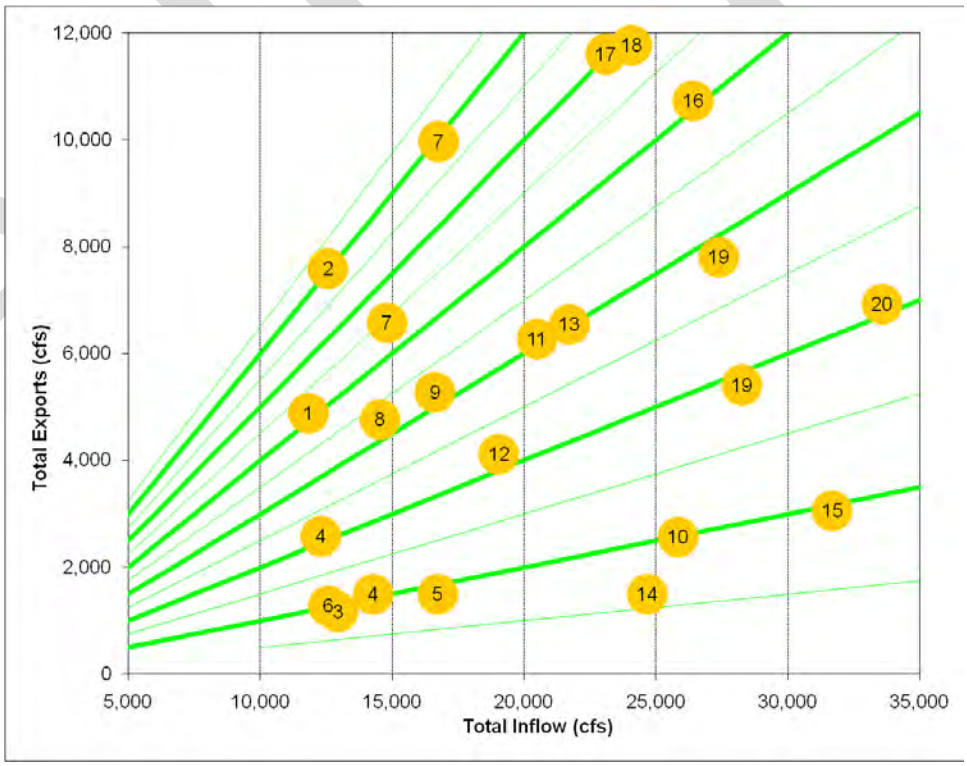

Figure C.A-92. Selected PTM Insertion Periods Plotted on the E/I Ratio Plot with the Hydrology Bin for Each Period Identified

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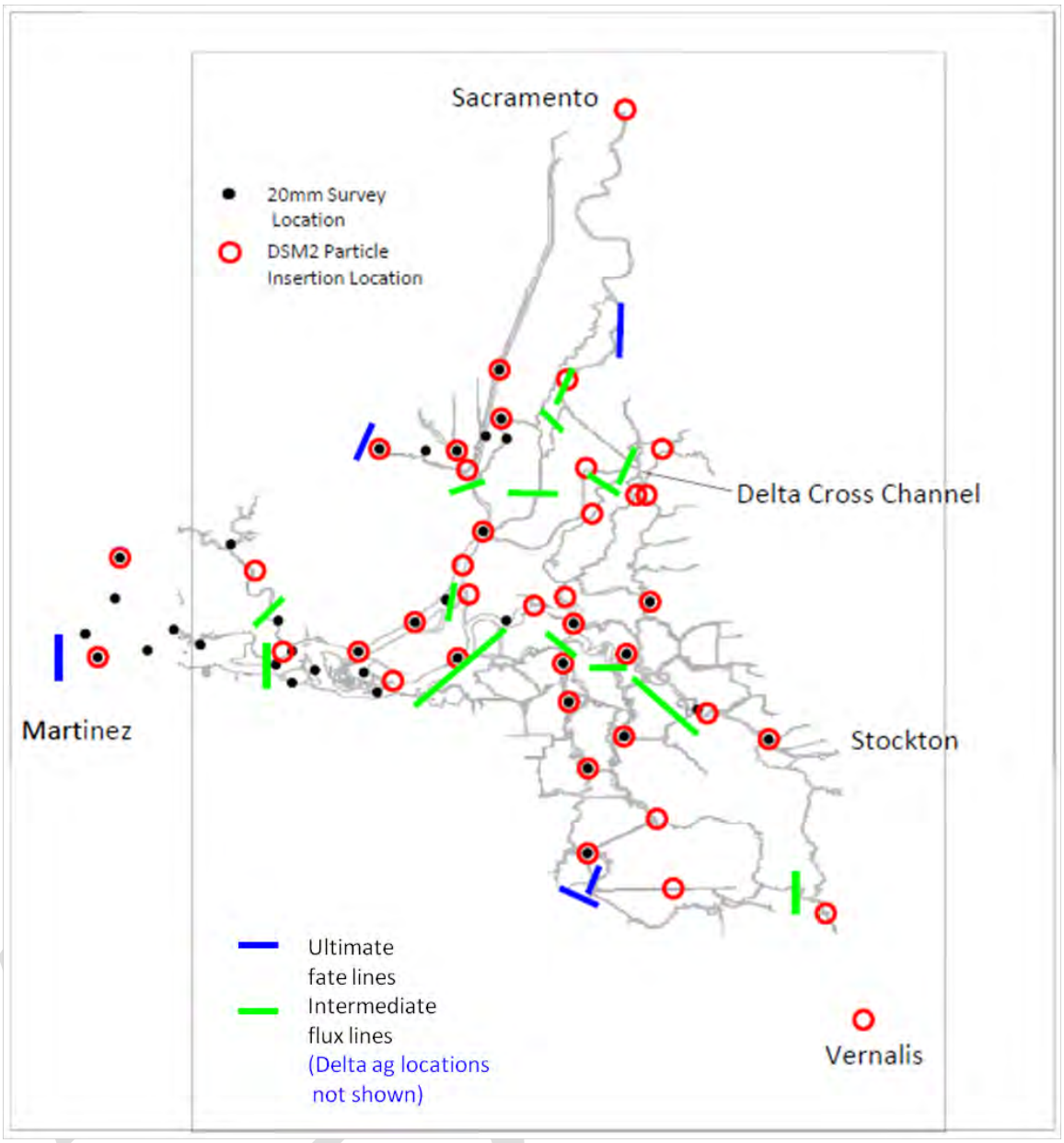

Figure C.A-93. Particle Insertion and Tracking Locations for Residence Time and Fate Computations

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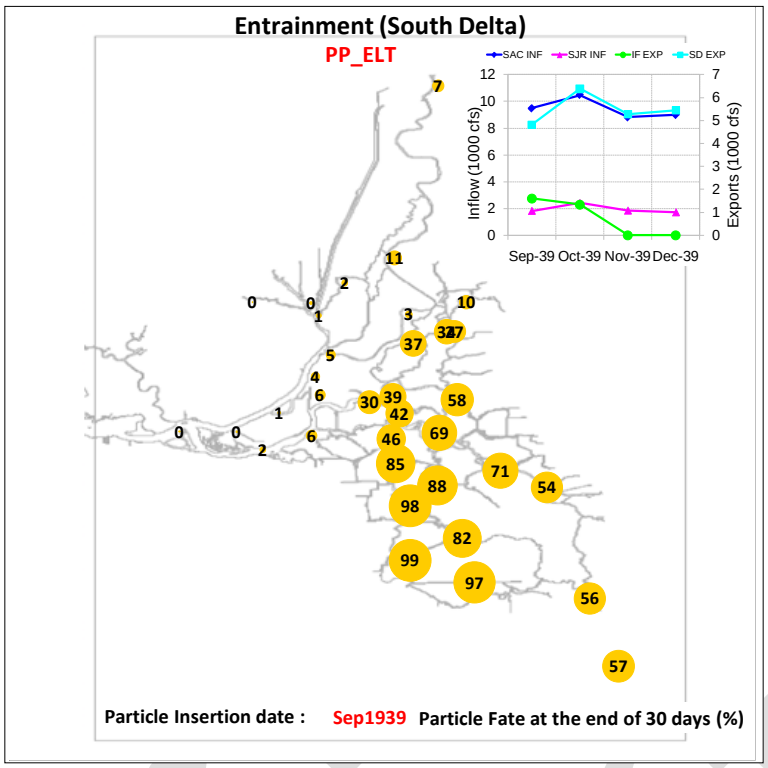

Figure C.A-94. An Example Spatial Plot Showing the Percent Entrainment for Particles Released at Various Locations in the Delta at the End of 30 Days after Insertion

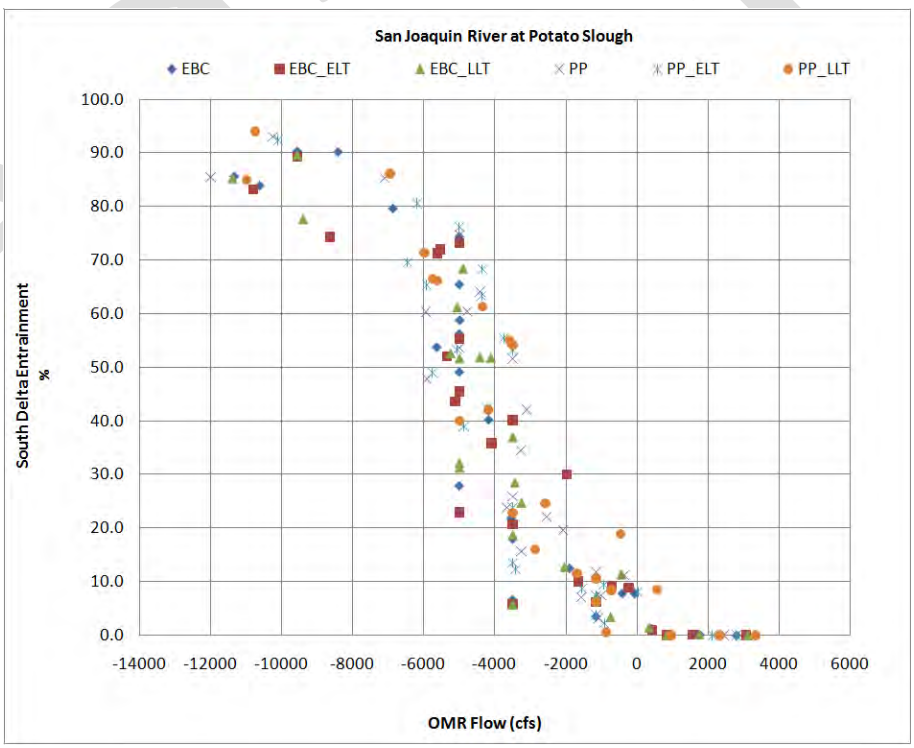

Figure C.A-95. Example Graph Showing the Relationship between the Percent Entrainment and Old and Middle River Flow (cfs) for Particles Inserted in the San Joaquin River at Potato Slough

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C.A.8.1 San Joaquin River Inflow Entrainment

San Joaquin River inflow (Vernalis or Mossdale) is most likely to be entrained at the south Delta exports. About half of the San Joaquin River inflow is diverted into Old River downstream of Mossdale, and the remainder moves past Stockton but then can be diverted from the San Joaquin River into Turner Cut or other channels connecting to Middle River or Old River. Unless the export pumping is less than the San Joaquin River inflow, most of the San Joaquin River inflow will be entrained.

Figure C.A-96 shows the PTM results for the percentage of particles released from Vernalis that were entrained at the south Delta pumps (after 30 days) for the 24 release conditions (months) for each of the six cases. The independent flow variable (x axis) is the total south Delta pumping (cfs). The percentage of the particles released from Vernalis that were entrained generally increased with export pumping, as might be expected. The maximum entrainment appears to increase rapidly with south Delta exports. About 50% of the Vernalis particles can be entrained with export pumping of 3,000 cfs. About 75% of the Vernalis particles can be entrained with export pumping of 5,000 cfs, and about 90% of the Vernalis particles can be entrained with export pumping of 10,000 cfs. But the percentage of Vernalis particles entrained was considerably less than this maximum value for several of the release cases. These variations must be explained by other flows in the south Delta. The most likely change in flow was the three cases in October and November. The head of Old River barrier was assumed to be installed in these months (unless the San Joaquin River flow was greater than 7,000 cfs). This would reduce the expected entrainment of the particles in the San Joaquin River inflow.

Figure C.A-97 shows the same PTM results for the percentage of Vernalis particles entrained at the south Delta pumps, but the independent variable is the San Joaquin River inflow. The percentage of Vernalis particles entrained increased rapidly as San Joaquin River inflow increased to 2,000 cfs. The export pumping must have been lower than the San Joaquin River inflow, or these particles likely would have been entrained at nearly 100%. A lower percentage of the Vernalis particles was entrained when the San Joaquin River inflow was higher because the export pumping was a lower fraction of the San Joaquin River inflow and some of the Vernalis particles were not entrained by south Delta pumping. The month with the highest San Joaquin River flows of 12,000 cfs resulted in low entrainment of 10% for all six cases, but the month with San Joaquin River inflows of about 10,000 cfs had more variable percentage entrainment, from 30% to 60%.

Figure C.A-98 shows the PTM results for the percentage of Vernalis particles entrained at the south Delta exports, with the independent variable being the ratio of the exports to the San Joaquin River inflow. A ratio of less than 1 indicates the exports were less than the San Joaquin River inflow, and the maximum entrainment would be equal to the export/San Joaquin River inflow ratio. But as the exports/San Joaquin River ratio increased to 2 or 3 or higher, most of the Vernalis particles were entrained at the south Delta exports.

Figure C.A-99 shows the PTM results for the percentage of Vernalis particles entrained as a function of the OMR flow. A positive OMR flow indicates that the export pumping is less than 50% of the San Joaquin River inflow. The negative OMR flow is approximately equal to the export pumping minus 50% of the San Joaquin River inflow. The south Delta exports and the OMR flow provide about the same resolution of the percentage of Vernalis particles entrained. The same cases with lower-than-expected entrainment are apparent in both graphs.

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Because particles are released on the first of the month, large variations in daily flows explain some of the differences in PTM entrainment compared to the monthly average flows. The entrainment of particles from Mossdale had nearly identical patterns with exports or with exports/San Joaquin River inflow to those shown for Vernalis.

C.A.8.2 Stockton Deep Water Ship Channel Entrainment

Figure C.A-100 through Figure C.A-103 show the same four graphs for entrainment of particles released from the Stockton Deep Water Ship Channel at Buckley Cove. Figure C.A-100 shows that the percent entrainment increases with south Delta export pumping, and that entrainment was 50% with pumping of 3,000 cfs and was 75% with pumping of 5,000 cfs. Some of the cases showed reduced entrainment, and these must be months with higher San Joaquin River inflows that move more of the particles released from Buckley Cove out of the influence of the south Delta pumping. Figure C.A-101 shows that entrainment was low for months with San Joaquin River inflow greater than 5,000 cfs. Figure C.A-102 shows that the entrainment of Buckley Cove particles reaches 90% at an export/San Joaquin River inflow ratio of about 2. This is about half the rate of entrainment of particles released from Vernalis because about half of the San Joaquin River inflow is diverted into Old River. The Buckley Cove particles are entrained as the other half of the San Joaquin River inflow is pulled through Turner Cut and other connections with Middle River toward the export pumping. Figure C.A-103 shows a very tight relationship between the entrainment of particles from Buckley Cove and OMR flow. There is no entrainment of Buckley Cove particles until the OMR flow is -1,000 cfs. The entrainment increased rapidly to 50% with OMR flow of -3,000 cfs. Entrainment was more than 75% with OMR flow of -5,000 cfs and was 95% with OMR flow of -10,000 cfs. There were fewer cases with lower-than-expected entrainment values for particles released at Buckley Cove. Very similar entrainment values were simulated for particles released at Rough and Ready Island in the Deep Water Ship Channel.

C.A.8.3 Central Delta Entrainment

Figure C.A-104 shows the relationship between the entrainment of particles from Potato Point (west end of Venice Island) and OMR flow. The reverse OMR flow is the portion of the south Delta exports not supplied directly from the Old River diversions from the San Joaquin River. There was no entrainment of Potato Point particles until the OMR flow was -1,000 cfs. The entrainment was 10% with OMR flow of -2,000 cfs and increased rapidly to 50% with OMR flow of -5,000 cfs. Entrainment was 80% with OMR flow of -8,000 cfs and was 90% with OMR flow of -10,000 cfs. There were some cases with lower-than-expected entrainment values for particles released at Potato Point. Similar entrainment values were simulated for particles released at other locations along the San Joaquin River between Buckley Cove and the mouth of the Mokelumne River. The percentage entrainment increased in a similar pattern with reverse OMR flow for particles released into Georgiana Slough, the Mokelumne River mouth or the North or South Fork Mokelumne River. The PTM results for each of these locations responded in a similar way to reverse OMR flow, which is a good indicator of the strength of the south Delta exports. The reverse OMR flows are distributed into the network of Old and Middle River channels that connect with the San Joaquin River channel.

Figure C.A-105 shows the relationship between the entrainment of particles from Franks Tract East (in Old River) and OMR flow. There was no entrainment of Franks Tract particles until the OMR flow was -1,000 cfs. The maximum entrainment was 20% with OMR flow of -2,000 cfs and increased to 50% with OMR flow of -4,000 cfs. Entrainment was 80% with OMR flow of -8,000 cfs and was 90%

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with OMR flow of -10,000 cfs. There were some cases with lower-than-expected entrainment values for particles released at Franks Tract East. Because the OMR flows were assumed to be -3,500 cfs or -5,000 cfs during the months of January–June of most years, a wide range of entrainment values was simulated with the PTM. The monthly entrainment ranged from 10% to 45% for months with OMR flows of -3,500 cfs and ranged from 25% to 65% for months with OMR flows of -5,000 cfs. Other factors, such as high San Joaquin River inflow and high Georgiana Slough flow, must account for the different PTM results with the same OMR flows. Both the San Joaquin River flow and the Georgiana Slough flow would allow more particles to escape from these central Delta locations. It is possible that another flow ratio, such as OMR flow to Antioch flow, might account for these variations in particle entrainment at the south Delta pumps.

Figure C.A-106 shows the relationship between the entrainment of particles from Threemile Slough and OMR flow. Threemile Slough connects the Sacramento River upstream of Emmaton with the San Joaquin River upstream of Jersey Point. The relationship indicates that there was no entrainment of Threemile particles until OMR flow was -3,000 cfs. The maximum entrainment was15% with OMR flow of -5,000 cfs (range of 0 to 20%) and was about 50% with OMR flow of -11,000 cfs. The variations in the PTM simulated percentage entrainment likely was caused by higher San Joaquin River flows (at Antioch), which allowed more of the released particles to be tidally transported downstream toward Chipps Island.

Figure C.A-107 shows the relationship between the entrainment of particles from the San Joaquin River at Dutch Slough (Big Break) and OMR flow. Dutch Slough supplies about 5% of the reverse OMR flow. The percentage entrainment of Big Break particles was much lower than the percentage entrainment from other locations upstream along the San Joaquin River because most of the reverse OMR flow is supplied from Middle River and Old River channels. The relationship indicates that there was no entrainment of Big Break particles until OMR flow was -5,000 cfs. The maximum entrainment increased with reverse OMR flow and was about 30% with OMR flow of -11,000 cfs.

C.A.8.4 Sacramento River Entrainment

Figure C.A-108 shows the percentage entrainment of particles released at Sacramento in the south Delta exports as a function of OMR flow. Because the DCC gates are closed or partially closed in more than half of the months (November–June), the fraction of the Sacramento River flow diverted into the central Delta is variable (20% to 40%). Although the Sacramento River flow varies greatly, the percentage of the Sacramento River flow that is entrained in the south Delta pumping depends most directly on the reverse OMR flow. The PTM results indicate that there was no entrainment of Sacramento River inflow particles until OMR flow was -2,000 cfs. The PTM-simulated percentage entrainment of Sacramento particles increased with a linear pattern to about 50% with OMR flow of -10,000 cfs. The maximum entrainment was 10% with OMR flow of -4,000 cfs and 30% with OMR flow of -6,000 cfs. The range of entrainment (30% to 50%) at higher reverse OMR flows (-8,000 cfs to -10,000 cfs) likely was caused by daily flow variations in the DSM2 simulations of river flows and exports that allowed more of the particles released on the first day to move toward Chipps Island than would be expected from the monthly flows. This relationship would apply to all particles released along the Sacramento River upstream of Sutter Slough. A similar pattern with a higher percentage entrainment would be simulated for release locations downstream of Sutter (or Steamboat) Slough because a higher fraction of the particles would be diverted into the DCC and/or Georgiana Slough.

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Figure C.A-109 shows the percentage entrainment of particles released in the Sacramento River at Ryde (downstream of Georgiana Slough) in the south Delta exports as a function of OMR flow. Because Ryde is downstream of Georgiana Slough, a smaller fraction of the particles is tidally transported upstream into Georgiana Slough. Most of these particles likely are transported through Threemile Slough to the San Joaquin River and then toward the south Delta exports as a function of reverse OMR. The entrainment relationship from Ryde is similar to the Threemile Slough entrainment (Figure C.A-106). The PTM results indicate that there was no entrainment of Ryde particles until OMR flow was -4,000 cfs. The PTM-simulated percentage entrainment of Ryde particles increased to about 25% with OMR flow of -10,000 cfs. The range of simulated entrainment was 10% to 25% for reverse OMR flows of -8,000 cfs to -10,000cfs. Daily flow variations in the DSM2 simulations are the most likely cause of these variations in PTM-simulated entrainment of particles released at Ryde. The PTM simulation of percentage entrainment of particles released from Rio Vista or from Cache Slough was very similar to the entrainment of particles from Ryde. The movement of particles from north Delta locations was controlled by the Threemile Slough tidal flows and then by the reverse OMR flows.

The PTM-simulated percentage entrainment of particles released from downstream of Antioch or Collinsville in Suisun Bay or Suisun Marsh was very low. For example, the percentage entrainment of particles released in the Sacramento River at Sherman Lake (confluence of Sacramento and San Joaquin Rivers) showed no entrainment until the OMR flow was -6,000 cfs and a maximum entrainment of 5% with OMR flow of -11,000 cfs. Particle entrainment (30 days) from locations in Suisun Bay or Suisun Marsh is much less than 1%.

C.A.8.5 Changes in Particle Tracking Model Results with the Preliminary Proposal

The PP cases include two major changes from the baseline conditions that will affect the PTM results. The first major PP change is the north Delta diversions, which would reduce the reverse OMR flows in some water year types. This would be a substantial change for entrainment from all Delta locations because the percentage entrainment in the south Delta exports is always a linear or logistical relationship with reverse OMR flow. This would allow the percentage entrainment in the south Delta exports of all particles released throughout the Delta to be reduced in these months. The reduction in the particle entrainment in the south Delta exports will depend on the release locations, as previously described. The second major PP change is the additional tidal habitat (restoration), which would cause tidal flows and the amplitude of tidal elevation fluctuations to be reduced. The DSM2 tidal modeling indicates that these effects of tidal muting will likely change some of the Delta channel flow diversions (e.g., DCC, Georgiana Slough, Threemile Slough, head of Old River), and this may change the simulated PTM entrainment from locations upstream of these flow diversions (Table C.A-39). These changes in tidal flows and diversion flows may shift the relationship between OMR flow and PTM entrainment.

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Table C.A-39. Comparison of Average Percentage Entrainment in South Delta Exports for the 24 Monthly Flow Conditions for the Six Preliminary Proposal Cases

Release Location	EBC1	EBC2	EBC2_ELT	EBC2_LLT	PP_ELT	PP_LLT
Sacramento	17.07	10.01	9.20	12.65	6.47	6.02
Georgiana	39.51	26.48	24.25	31.32	26.39	23.93
Ryde	6.86	3.25	3.31	4.69	2.77	2.67
Rio Vista	7.33	3.22	3.31	4.87	2.78	2.85
Threemile	15.71	8.06	7.76	11.09	5.39	5.04
Confluence	0.98	0.36	0.37	0.71	0.23	0.46
Vernalis	58.01	55.46	55.17	55.67	55.81	48.83
Buckley Cove	57.91	50.76	49.31	53.60	48.47	40.69
Potato Point	40.42	27.30	25.07	32.31	27.75	25.33
Grant Line Canal	87.16	86.71	87.52	87.05	87.13	82.66
Old River at Quimby Island	60.26	54.32	51.78	57.79	55.79	48.40
Franks Tract	45.10	34.59	32.21	39.61	34.21	28.32
Big Break	5.72	2.47	2.49	4.05	2.04	3.38

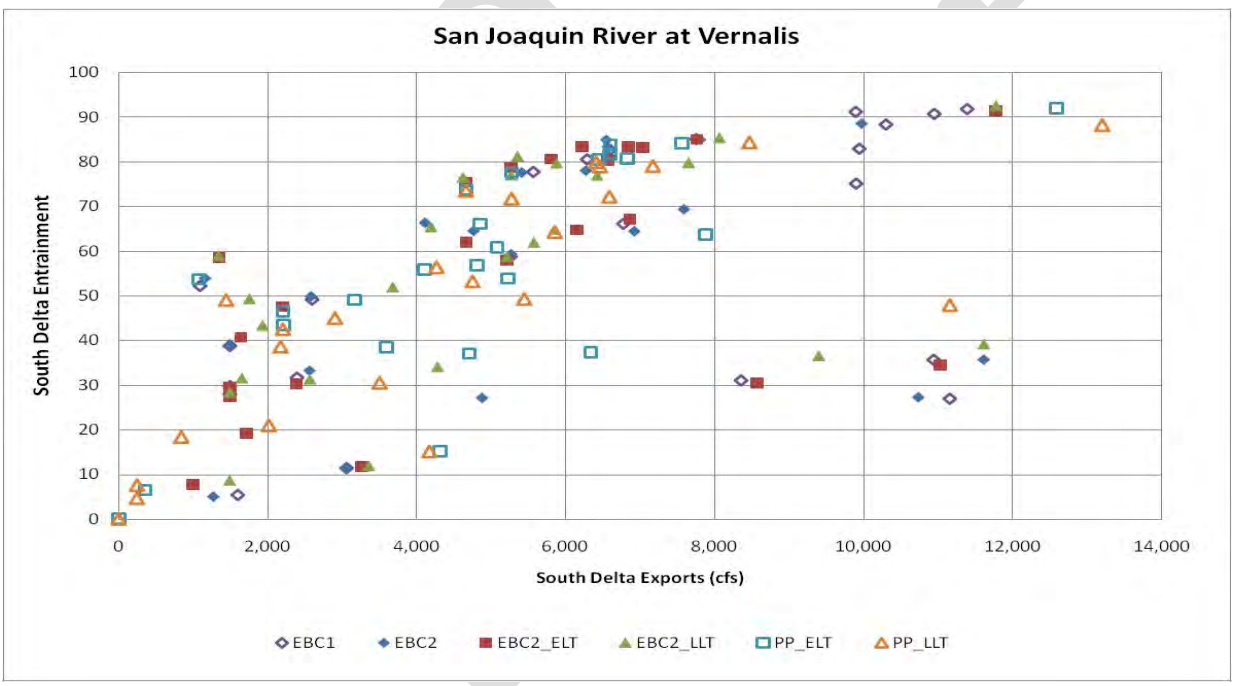

Figure C.A-96. Percentage of Particles Released from Vernalis Entrained (30 days) at South Delta Pumps as a Function of South Delta Pumping (cfs)

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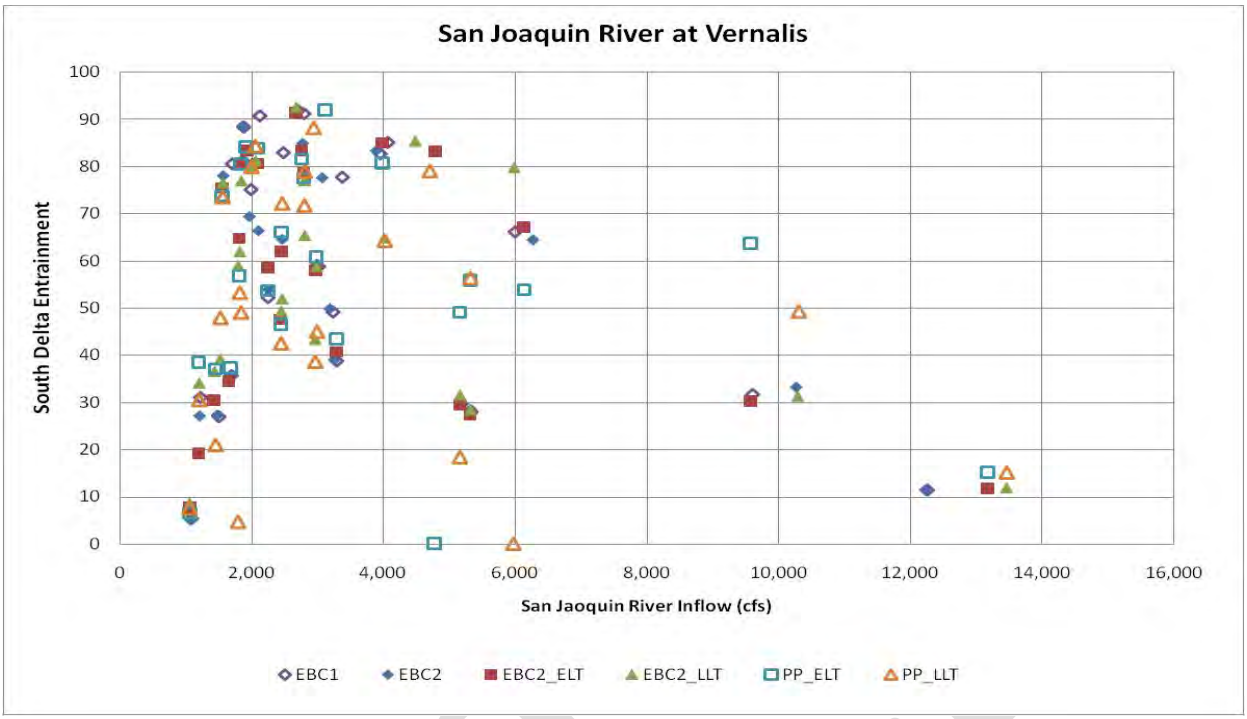

Figure C.A-97. Percentage of Particles Released from Vernalis Entrained (30 days) at South Delta Pumps as a Function of San Joaquin River Inflow (cfs)

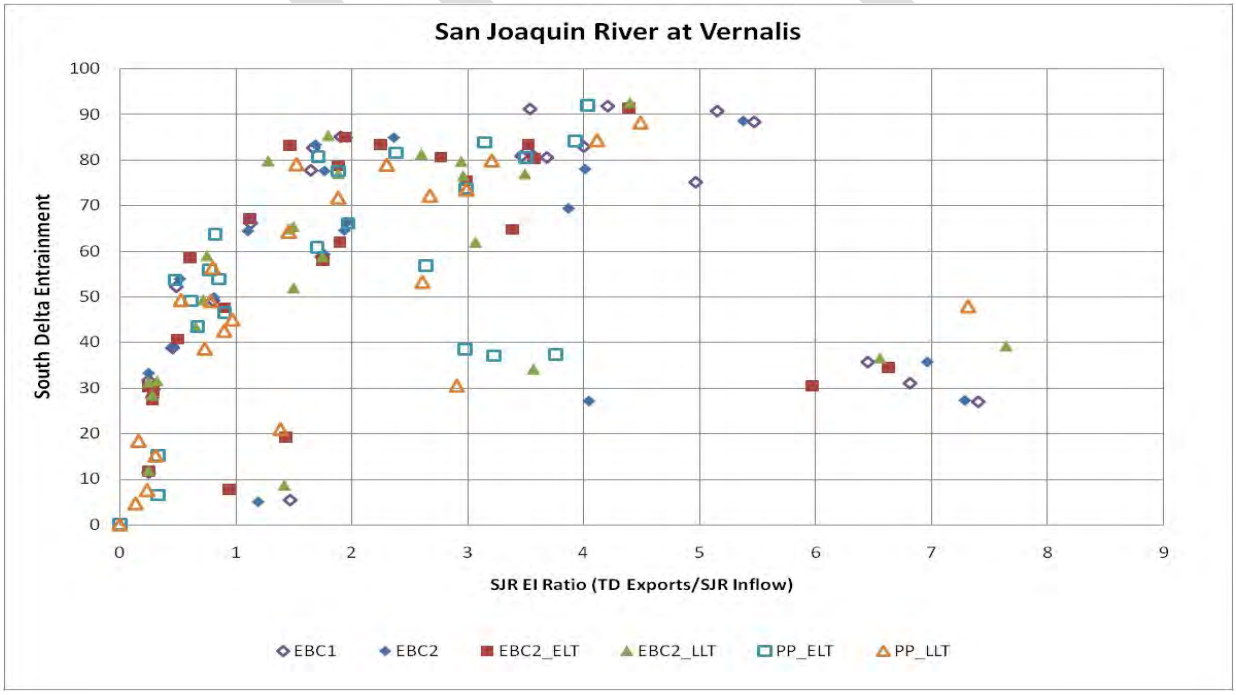

Figure C.A-98. Percentage of Particles Released from Vernalis Entrained (30 days) at South Delta Pumps as a Function of South Delta Exports/San Joaquin River Inflow Ratio

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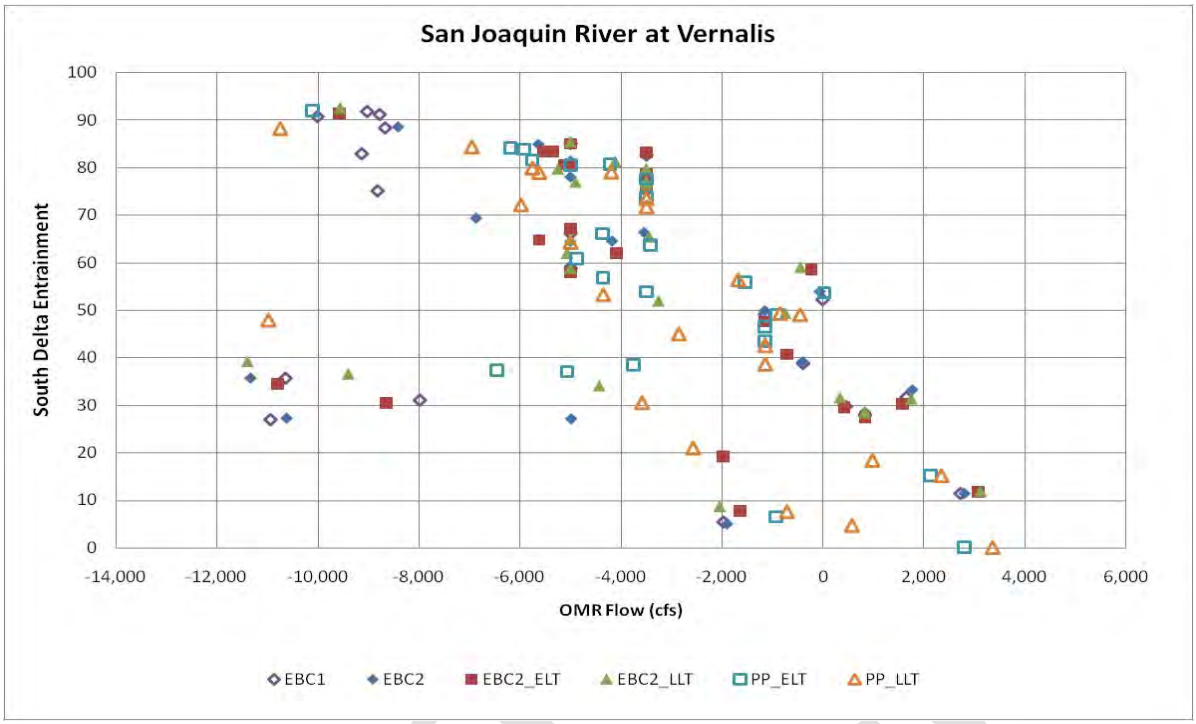

Figure C.A-99. Percentage of Particles Released from Vernalis Entrained (30 days) at South Delta Pumps as a Function of Old and Middle River (OMR) Flow (cfs)

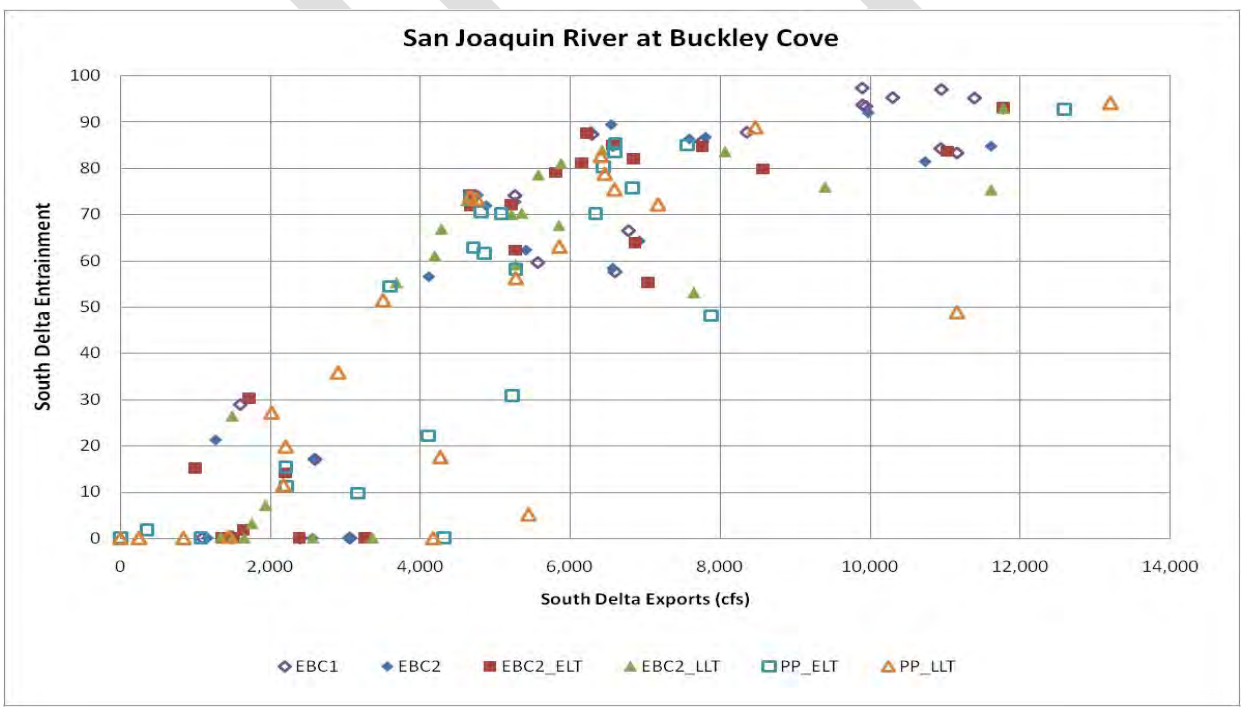

Figure C.A-100. Percentage of Particles Released from Buckley Cove Entrained (30 days) at South Delta Pumps as a Function of South Delta Pumping (cfs)

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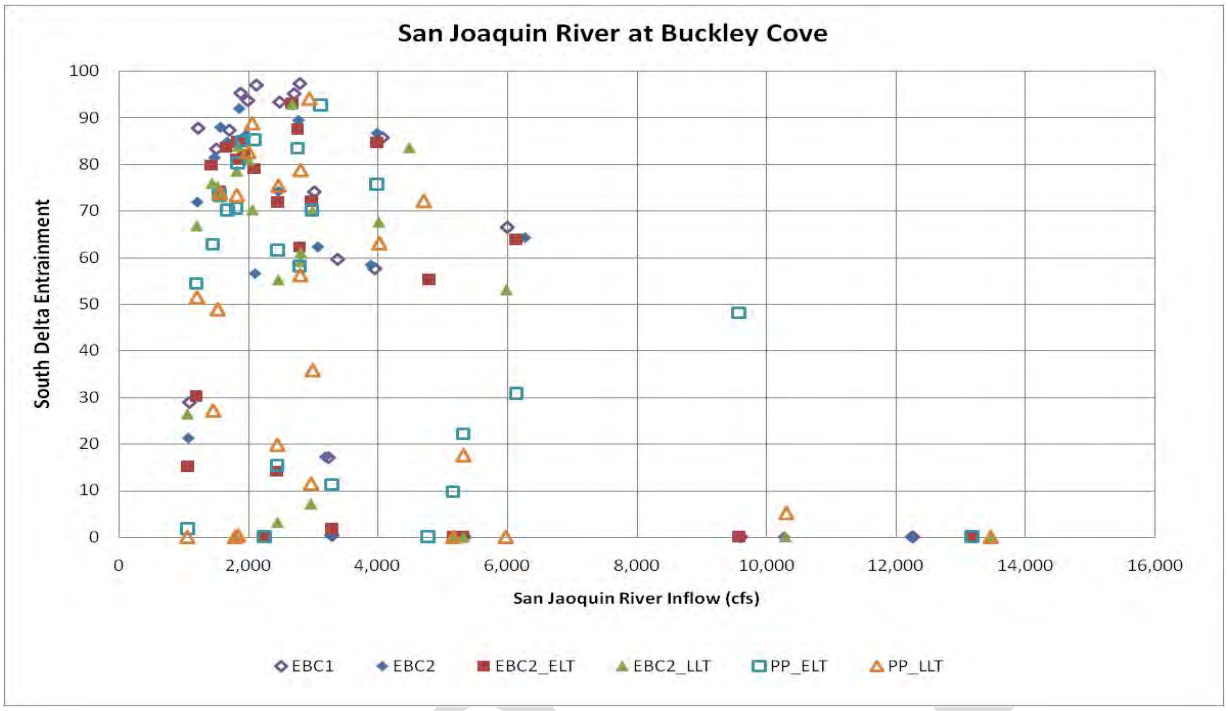

Figure C.A-101. Percentage of Particles Released from Buckley Cove Entrained (30 days) at South Delta Pumps as a Function of San Joaquin River Inflow (cfs)

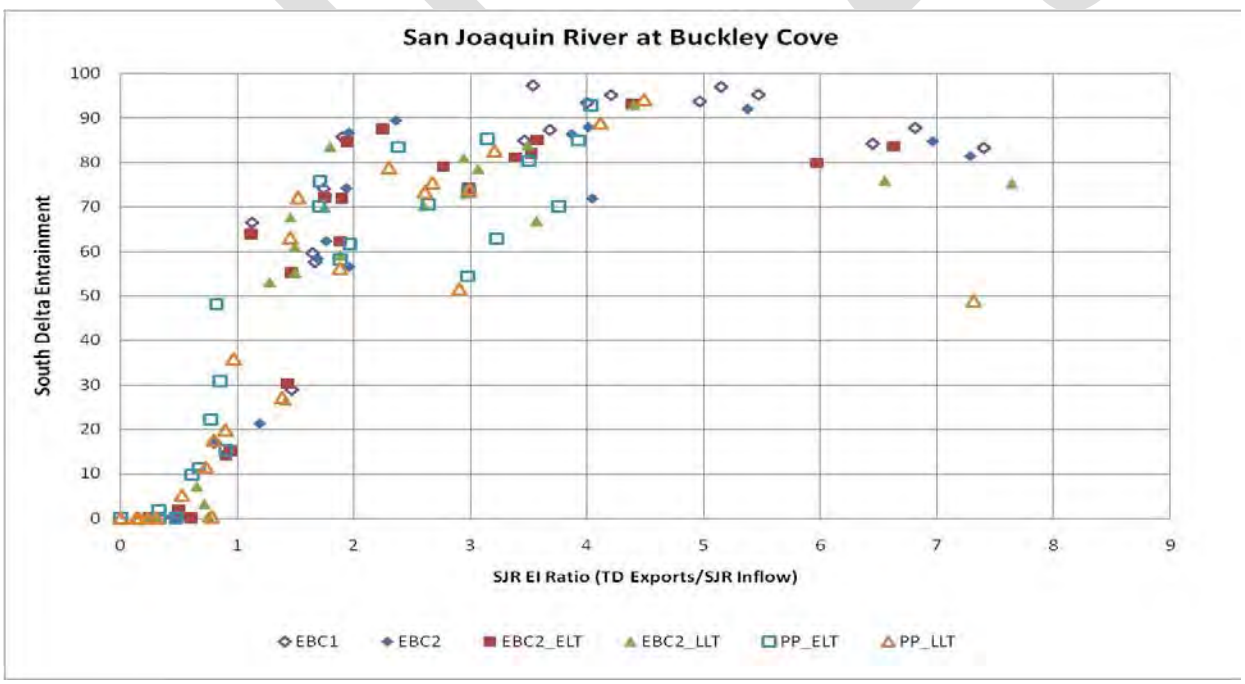

Figure C.A-102. Percentage of Particles Released from Buckley Cove Entrained (30 days) at South Delta Pumps as a Function of South Delta Exports/San Joaquin River Inflow Ratio

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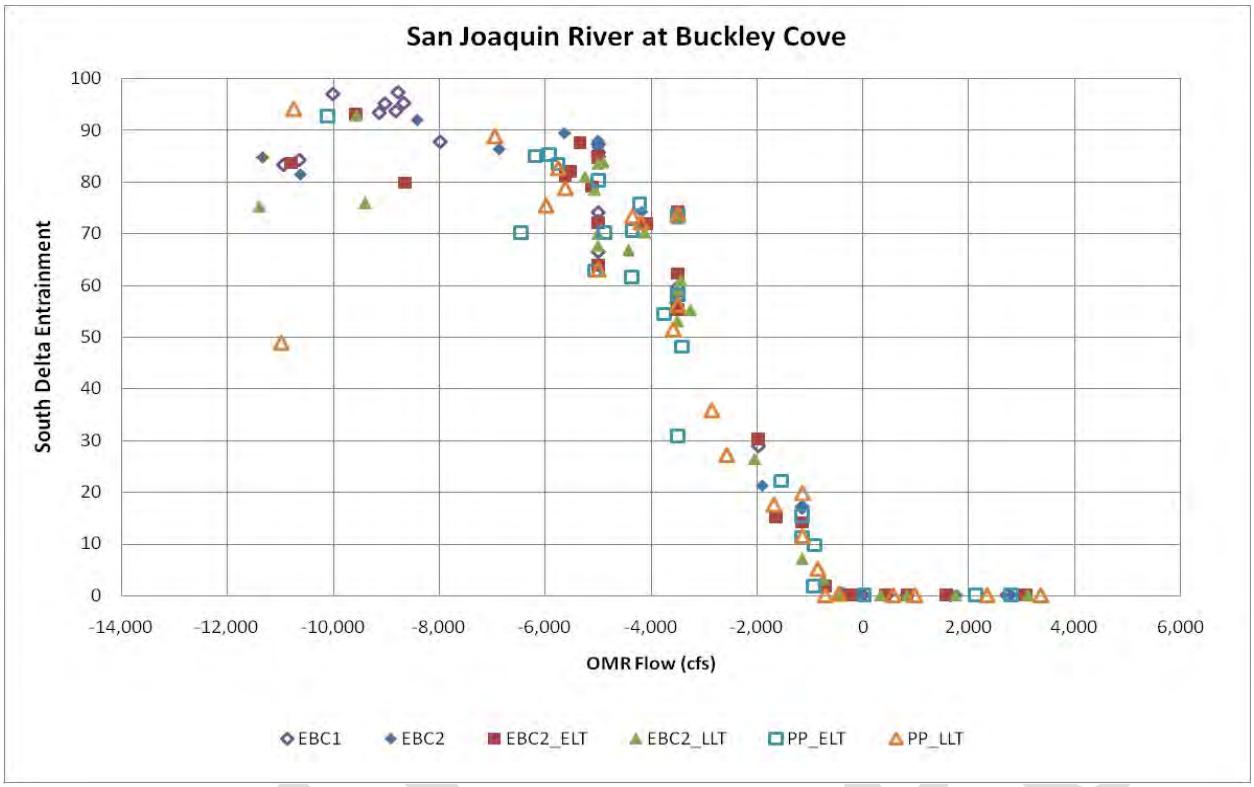

Figure C.A-103. Percentage of Particles Released from Buckley Cove Entrained (30 days) at South Delta Pumps as a Function of Old and Middle River (OMR) Flow (cfs)

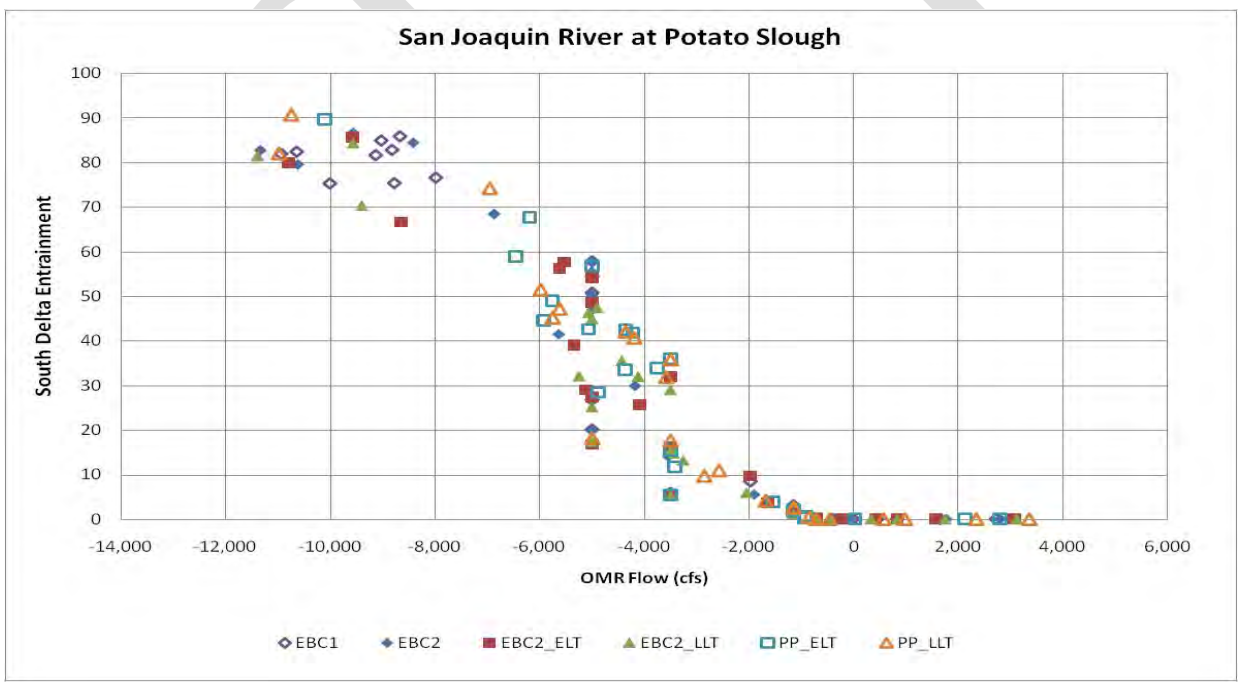

Figure C.A-104. Percentage of Particles Released from Potato Point Entrained (30 days) at South Delta Pumps as a Function of Old and Middle River Flow (cfs)

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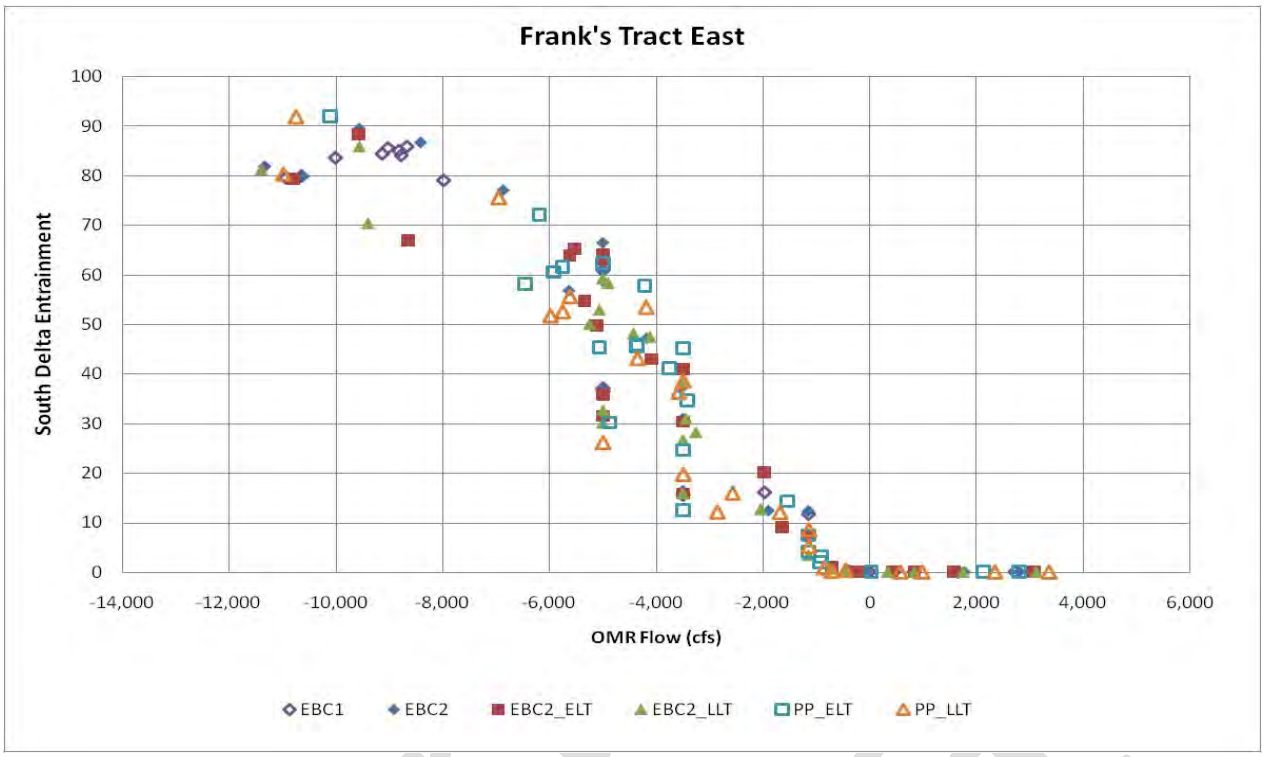

Figure C.A-105. Percentage of Particles Released from Franks Tract (East) Entrained (30 days) at South Delta Pumps as a Function of Old and Middle River Flow (cfs)

Figure C.A-106. Percentage of Particles Released from Threemile Slough Entrained (30 days) at South Delta Pumps as a Function of Old and Middle River Flow (cfs)

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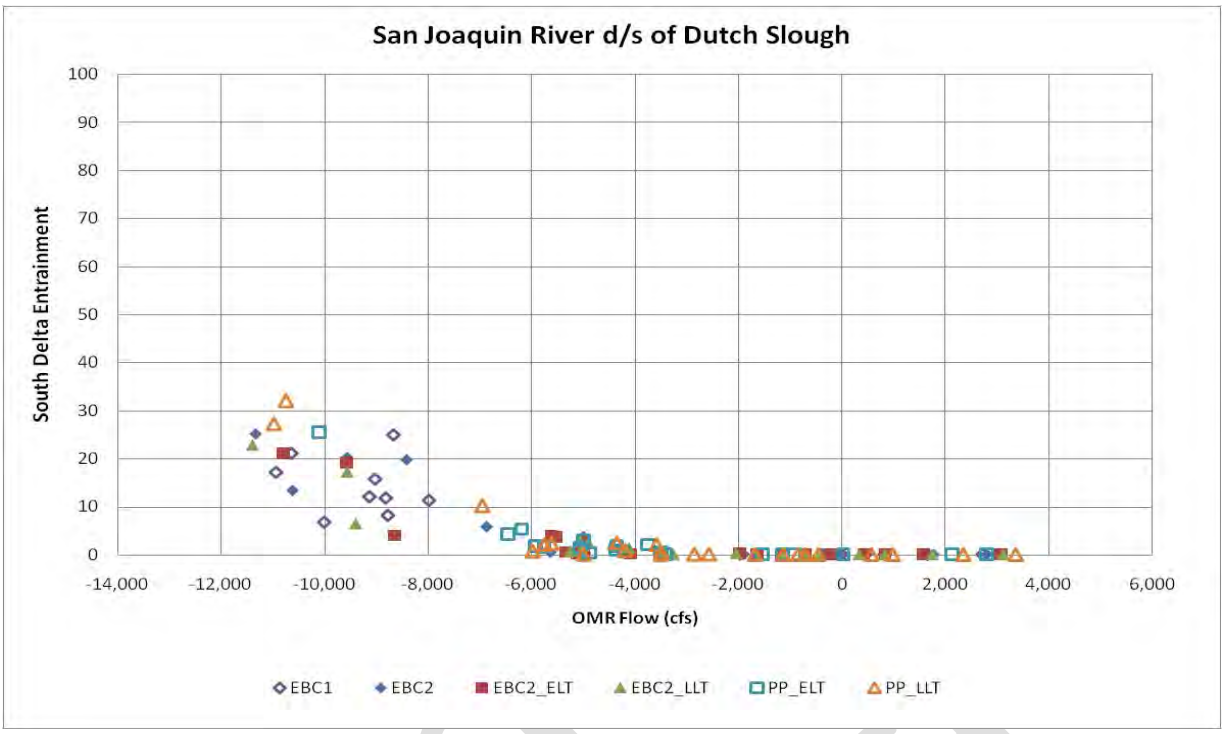

Figure C.A-107. Percentage of Particles Released from Big Break (near Antioch) Entrained (30 days) at South Delta Pumps as a Function of Old and Middle River Flow (cfs)

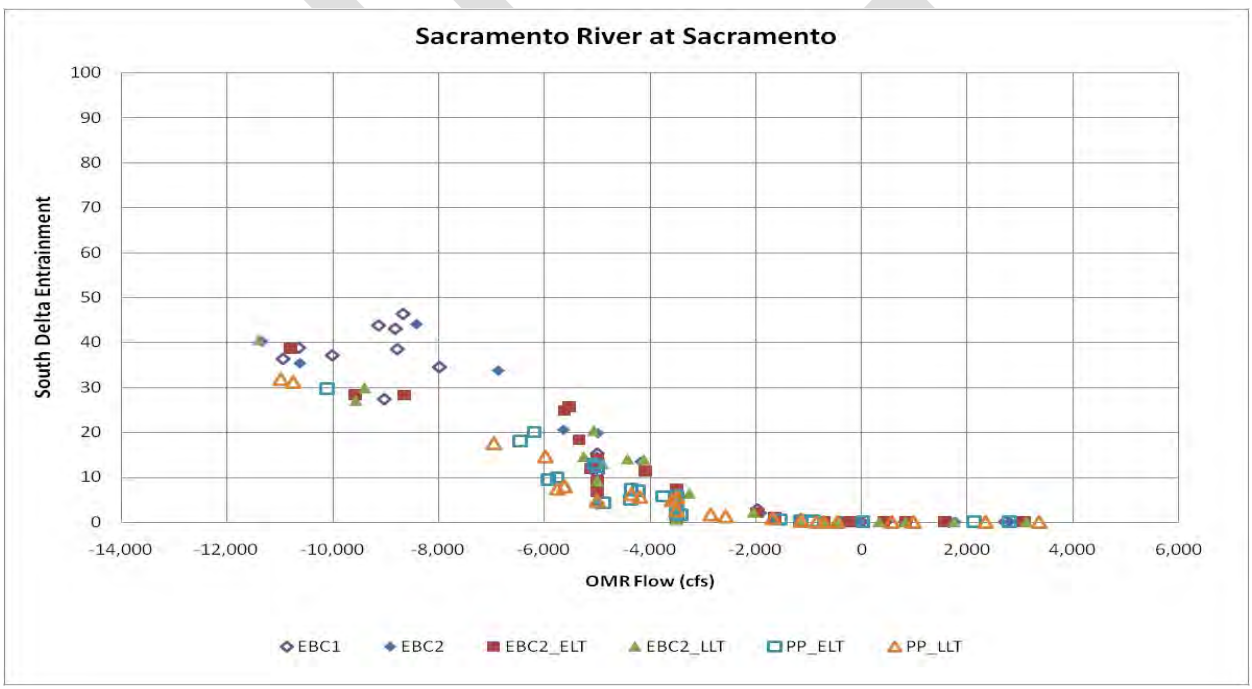

Figure C.A-108. Percentage of Particles Released from Sacramento River Inflow Entrained (30 days) at South Delta Pumps as a Function of Old and Middle River Flow (cfs)

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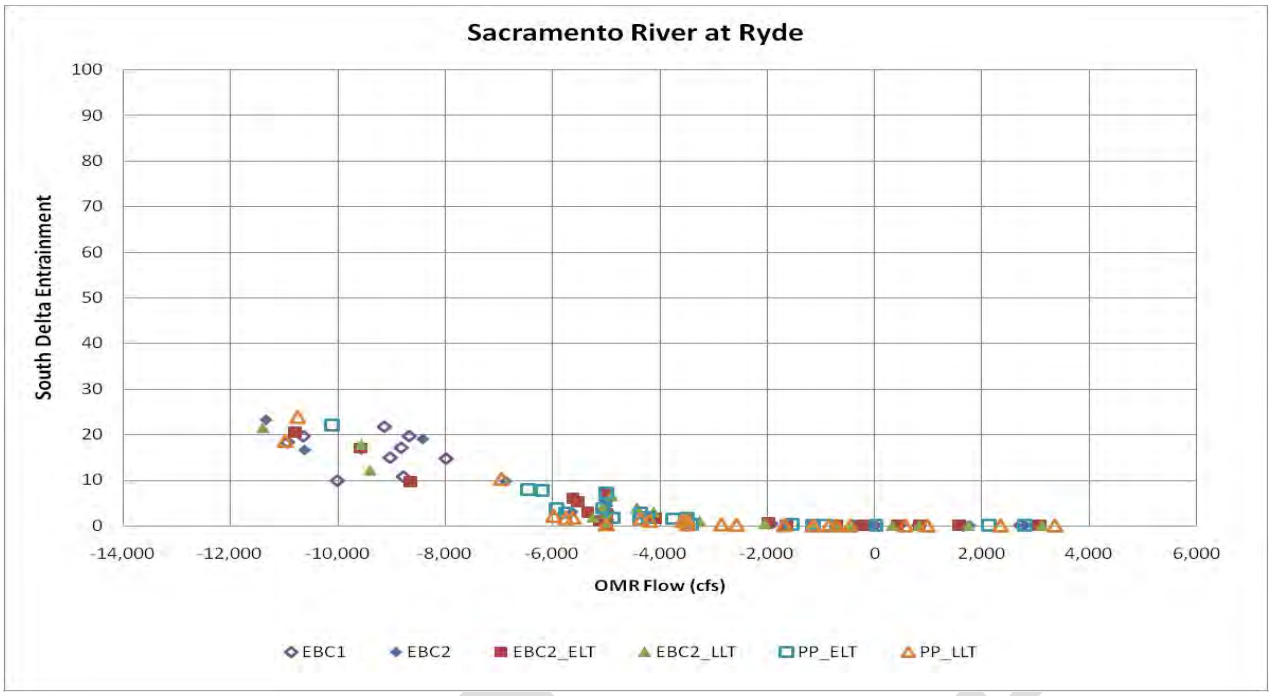

Figure C.A-109. Percentage of Particles Released from Sacramento River at Ryde (below Georgiana Slough) Entrained (30 days) at South Delta Pumps as a Function of Old and Middle River Flow (cfs)

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