CHAPTER VI. ENVIRONMENTAL EFFECTS OF IMPLEMENTING FLOW AND WATER OPERATION ALTERNATIVES

The purpose of this chapter is to evaluate and disclose the environmental effects of implementing the flow and water operation alternatives (flow alternatives) described in Chapter II.D. The flow alternatives implement the water quality objectives found in Table 3, page 19 of the 1995 Bay/Delta Plan. For the purposes of this analysis, flow objectives include Delta outflow and river flow objectives (flow objectives), salinity objectives in the Delta that occasionally control outflows, Vernalis salinity objectives, limits on exports and restrictions on Delta Cross Channel gate operations.

This chapter is divided into the following five sections: (A) background information on flow objectives, (B) environmental effects in the Delta, (C) environmental effects in upstream areas, (D) export areas, and (E) Friant service area.

A. BACKGROUND INFORMATION ON FLOW OBJECTIVES

Prior to the 1978 Bay/Delta Plan, salinity standards were adopted in the water quality control plans for the Delta to ensure adequate flow through the estuary for fish and wildlife. Salinity standards were used instead of flow objectives because methods had not been developed to quantify Delta inflow and outflow and because both flow and salinity are closely related to the health of aquatic resources in the Delta. The 1978 Bay/Delta Plan, however, included Delta outflow objectives and river flow objectives for the Sacramento River at Rio Vista. Then, as now, the principal purpose of the flow objectives was for fish and wildlife protection.

The objectives in the 1978 and 1991 Bay/Delta Plans were reviewed and updated in the 1995 Bay/Delta Plan. Two major features of the new Delta outflow objectives are that (1) they apply on a year-round basis, and (2) from February through June, they can be met either through Delta outflow or through compliance with specified salinity conditions at three locations in the Delta and Suisun Bay. Delta outflow and its related salinity values are included in the objectives because these parameters have been found to correlate with the abundance of certain estuarine resources (see Chapter IV, sections E.2 and E.3).

The river flow objectives in the 1995 Bay/Delta Plan for the Sacramento and San Joaquin rivers provide attraction and transport flows and suitable habitat for various life stages of aquatic organisms. River flows are measured at gages on the Sacramento and San Joaquin rivers at Rio Vista and Vernalis, respectively.

The 1995 Bay/Delta Plan also contains export limits to protect the habitat of estuarine-dependent species by reducing the entrainment of the various life stages of aquatic species by the major export pumps in the southern Delta. The export limits are expressed as a maximum percent of Delta inflow diverted.[1] CVP operations are further constrained in the 1995 Bay/Delta Plan by objectives that restrict the operation of the Delta Cross Channel gates. The

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[1] The method for calculating the percent of Delta inflow diverted is described on page II-11 of this report.

gates are required to be closed in the winter and spring to reduce the diversion of eggs, larvae, and smolts into the central Delta where survival is generally reduced.

Seven alternatives for achieving the flow objectives and the "no project alternative" are summarized in Chapter II, section E. The environmental effects of implementing the flow alternatives are evaluated in this chapter using a two step process. First, the base case and each of the seven alternatives were modeled to determine the river flows, Delta outflow, Delta salinity distribution and reservoir levels that will result from implementing each of the alternatives. For each of these factors, the alternatives were compared to the base case to evaluate changes in hydrology. The modeled hydrology was then compared to biological criteria for fish, other aquatic resources, vegetation and wildlife to evaluate the environmental effects of implementing each of the flow alternatives.

B. ENVIRONMENTAL EFFECTS IN THE DELTA

The evaluation of the environmental effects in the Delta is divided into the following subsections: (1) hydrology, (2) salinity, (3) fish and aquatic resources, (4) Delta vegetation and wildlife, (5) land use, and (6) recreation.

1. Hydrology

The principal factors affecting Delta hydrology are river inflow from the San Joaquin and Sacramento river systems, Delta outflow, exports and local diversions. Another comparatively small source of Delta inflow is from the streams draining the area immediately east of the Delta. Local diversions are assumed to be the same under all of the alternatives. Freeport is the measuring site for Delta inflow from the Sacramento River while Vernalis is the measuring site for Delta inflow from the San Joaquin River.

Because of tidal influence, outflow from the Delta cannot be measured directly. Thus, Delta outflow is estimated using the Net Delta Outflow Index. This index is described on page II-11 of this report.

Tables VI-1 through VI-12 list the base case monthly flows of the Sacramento River at Freeport, the San Joaquin River at Vernalis, total Delta inflow (which includes inflow from the San Joaquin and Sacramento rivers, and the eastside streams), Delta outflow, Delta export pumping and the export/inflow ratio for the 73-year period and critical period. Below the base case flows are the reductions and increases from the base case flows resulting from the seven flow alternatives. The bolded entries in the tables signify the highest flows among the seven alternatives for each month.

Table VI-1

Sacramento River Flow at Freeport, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	14,211	17,053	24,238	32,539	38,481	35,441	23,335	19,893	16,904	16,385	13,951	11,812

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-704	-43	-659	-690	85	220	267	-256	2,889	694	-1,616	167
3	-554	161	-481	-513	187	237	278	-269	2,367	365	-1,643	190
4	-556	158	-507	-515	175	241	276	-273	2,408	378	-1,647	185
5	***-315***	***706***	***10***	***-162***	***543***	***847***	345	***-171***	2,274	-861	-1,732	262
6	-572	-292	-1,090	-885	-379	12	198	-327	***3,461***	894	-1,255	***573***
7	-819	-366	-907	-888	-174	352	***1,092***	-831	3,394	923	-1,498	109
8	-736	-146	-793	-742	40	204	-31	-438	2,955	***1,007***	***-1,223***	222

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-2

Sacramento River Flow at Freeport, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	10,186	8,893	12,867	16,315	15,126	14,694	10,534	10,121	11,029	14,321	12,063	8,107

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1,227	350	-729	-697	-1,123	534	952	1,445	3,500	-681	***-1,838***	293
3	-1,248	468	-702	-656	-1,084	905	994	1,559	2,955	-671	-2,251	161
4	-1,250	462	-702	-656	-1,084	911	994	***1,566***	2,941	-678	-2,254	161
5	-1,060	***717***	***-293***	***-296***	***-640***	***1,456***	126	1,017	3,885	-1,622	-2,166	221
6	***-983***	398	-816	-865	-1,330	-54	1,067	1,519	***4,384***	-486	-2,546	***317***
7	-1,106	193	-697	-653	-1,081	271	***2,804***	437	3,750	-1,380	-2,265	238
8	-1,271	375	-743	-697	-1,168	201	387	966	4,000	***-186***	-1,961	118

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-3

San Joaquin River Flow at Vernalis, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	3,169	2,076	2,927	4,413	6,808	6,177	5,448	4,653	3,722	1,798	1,361	1,874

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-47	-68	-150	-217	-390	-83	356	719	93	178	236	-27
3	26	-94	-193	-335	-512	-89	389	774	785	552	417	-31
4	-1	-75	-174	-354	-532	-57	385	760	761	545	442	-12
5	***433***	-14	-161	-469	***387***	***729***	***2,360***	***2,144***	***926***	***1,728***	***523***	***97***
6	85	-43	-73	-54	-64	34	401	726	307	294	339	-19
7	358	***23***	***145***	***127***	95	64	-54	255	256	221	-22	-201
8	-140	22	-80	-261	-532	-73	645	1,063	306	200	164	-40

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-4

San Joaquin River Flow at Vernalis, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1,870	1,442	1,675	1,778	2,983	2,231	2,409	1,770	1,277	1,099	1,138	1,464

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	105	-131	-160	-108	-87	-30	210	781	-65	-132	-106	-74
3	151	-126	-154	-157	-416	-27	235	802	973	695	***551***	-31
4	165	-126	-154	-146	-253	-27	235	781	***1,001***	695	***551***	-31
5	***530***	***-5***	***-21***	***-11***	***221***	***782***	***1,661***	***1,564***	592	***1,240***	292	***160***
6	172	-134	-146	-106	-90	-30	199	776	286	411	426	-45
7	-21	-95	-43	-13	-2	70	103	344	197	223	-253	-237
8	-58	-106	-68	-105	-305	-5	433	936	194	152	-64	-69

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-5

Total Delta Inflow, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	18,019	20,328	32,458	47,069	58,534	50,483	34,350	26,372	22,014	19,312	16,354	14,552

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-775	-116	-814	-912	-309	114	571	378	2,866	749	-1,484	81
3	-542	64	-678	-851	-328	136	638	455	3,081	844	-1,285	125
4	-573	79	-685	-872	-360	170	629	432	3,092	844	-1,271	136
5	***76***	***658***	***-214***	***-706***	***850***	***1,757***	***2,986***	***2,296***	***3,777***	1,092	-1,274	228
6	-493	-338	-1,167	-943	-444	40	588	377	3,741	***1,159***	***-941***	***541***
7	-519	-350	-767	-765	-82	364	913	-775	3,382	862	-1,754	-224
8	-944	-129	-876	-1,006	-543	67	568	471	3,067	1,038	-1,164	163

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-6

Total Delta Inflow, Critical Period

Base Case Period Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	12,388	10,736	15,499	19,367	19,587	17,849	13,568	12,446	12,871	15,936	13,661	9,963

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1,152	216	-894	-816	-1,219	496	1,146	2,137	3,323	-941	-2,052	156
3	-1,125	345	-859	-819	-1,503	870	1,213	2,272	3,803	-105	-1,808	72
4	-1,113	336	-859	-808	-1,343	876	1,213	2,258	3,820	-112	-1,808	72
5	***-583***	***667***	***-317***	***-301***	***-414***	***2,385***	2,173	***3,137***	***5,315***	***-58***	***-1,807***	***399***
6	-825	272	-968	-976	-1,429	-95	1,249	2,263	4,619	-128	-2,163	245
7	-1,150	95	-743	-675	-1,086	336	***2,902***	709	3,860	-1,259	-2,602	-50
8	-1,359	269	-813	-810	-1,521	184	781	1,789	4,107	-119	-2,079	27

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-7

Delta Outflow, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	8,216	9,974	22,176	38,689	49,942	42,012	24,417	18,415	12,891	6,627	3,870	4,145

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-919	591	-252	-507	971	864	3,083	155	334	59	176	528
3	-753	734	-162	-493	945	854	3,122	185	474	60	181	563
4	-791	756	-151	-507	910	892	3,118	172	471	60	184	571
5	***-322***	***1,213***	***224***	***-412***	***1,928***	***2,321***	***4,576***	***1,267***	***948***	***140***	168	***691***
6	-1,105	172	-1,041	-1,516	1,382	1,220	3,090	126	916	69	***190***	468
7	-650	347	-293	-448	1,208	1,118	2,013	847	749	69	124	435
8	-1,132	569	-291	-645	772	896	4,020	913	469	57	160	536

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-8

Delta Outflow, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	5,708	3,050	5,998	10,604	8,443	8,118	8,190	4,800	4,228	3,973	4,842	2,650

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1,536	***1,767***	-377	-2,139	3,269	4,627	1,101	3,559	3,236	883	-957	379
3	-1,545	1,762	-379	-2,160	3,069	4,646	1,095	3,564	3,287	883	-957	384
4	-1,540	1,756	-379	-2,152	3,170	4,646	1,095	3,564	3,287	883	-957	384
5	-1,582	1,650	***-295***	***-1,927***	***3,614***	***4,760***	***1,308***	***3,868***	3,860	***883***	-1,067	***387***
6	-1,880	1,759	-401	-2,201	3,083	4,397	1,112	3,571	***3,930***	883	***-776***	384
7	***-1,373***	1,518	-342	-2,033	3,083	4,031	1,006	3,799	3,714	883	-1,129	379
8	-1,779	1,754	-349	-2,136	3,060	4,345	1,285	3,608	3,397	883	-830	385

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-9
Delta Exports, 73-Year Period

Base Case Average Monthly Exports (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	534	578	624	611	544	526	527	358	323	526	592	514

Change in Exports from the Base Case (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	9	-42	-34	-25	-72	-46	-149	14	150	42	-102	-27
3	13	-40	-31	-22	-72	-44	-147	17	155	48	-90	-26
4	13	-41	-33	-23	-71	-44	-148	16	155	48	-89	-26
5	24	-33	-27	-18	***-61***	***-34***	-94	***63***	***168***	58	-89	-28
6	***38***	***-31***	***-7***	***35***	-102	-72	-149	16	***168***	***67***	***-69***	***4***
7	8	-42	-29	-20	-73	-46	***-65***	-100	156	48	-115	-39
8	11	-42	-36	-22	-74	-51	-203	-24	154	60	-81	-22

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-10
Delta Exports, Critical Period

Base Case Average Monthly Exports (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	335	410	573	591	657	573	231	334	295	480	366	326

Change in Exports from the Base Case (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	24	-92	-32	82	-250	-254	2	-88	5	-112	-68	-13
3	26	-85	-30	83	-255	-232	7	-80	31	-61	-53	-18
4	26	-85	-30	83	-252	-232	7	-80	32	-61	-53	-18
5	***61***	***-59***	***-1***	***100***	***-224***	***-147***	51	***-45***	***87***	***-57***	***-47***	***1***
6	65	-89	-35	76	-252	-276	8	-80	41	-62	-86	-8
7	14	-85	-25	84	-233	-227	***113***	-190	8	-132	-91	-25
8	26	-89	-28	81	-256	-256	-28	-108	43	-61	-77	-21

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

The tables show that, of all the alternatives, Alternative 5 generally results in the highest river flows at Freeport and Vernalis. Notable exceptions to this trend include the Sacramento River at Freeport where the Alternative 5 flows are the lowest of the alternatives for June, July, and August over the 73-year period and the San Joaquin River at Vernalis where the Alternative 7 flows are the highest of the alternatives for November, December and January over the 73-year period.

In most months, Alternative 5 results in the highest total Delta inflow and Delta outflow of all the alternatives. However, Alternative 6 results in the highest total Delta inflow in July, August, and September over the 73-year period. The Delta outflow reported in Tables VI-7 and VI-8 meets the minimum required outflow objective in the 1995 Bay/Delta Plan for all seven alternatives.

Average monthly Delta export/inflow ratios for the alternatives are shown in Tables VI-11 and VI-12. For both the 73-year period average and critical period average, the alternatives are not significantly different from each other with respect to the average monthly export/inflow ratio achieved. The tables show that the average monthly export/inflow ratio achieved under the different alternatives is significantly lower than the objective for every month except June. This result is expected because the objective represents a maximum value and the monthly data are averages. Reviewing the entire data set, the export/inflow ratio limit is never violated in April, July or August for the entire 73-year period for Alternatives 2, 3, 4, 6, and 8, or in July and August for Alternatives 5 and 7. The environmental significance of the changes in Delta outflow and exports is described in the following section of this chapter.

Table V1-11

Delta Export/Inflow Ratio, 73-Year Period

Base Case Average Monthly E/I Ratio*

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.48	0.55	0.45	0.33	0.28	0.27	0.36	0.28	0.28	0.43	0.55	0.58

1995 WQCP Monthly E/I Objective

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.65	0.65	0.65	0.65	0.35**	0.35	0.35	0.35	0.35	0.65	0.65	0.65

Flow Alternatives Average Monthly E/I Ratio

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	0.52	0.50	0.44	0.35	0.21	0.22	0.22	0.24	0.32	0.43	0.48	0.55
3	0.52	0.50	0.44	0.35	0.21	0.22	0.22	0.25	0.32	0.43	0.49	0.55
4	0.52	0.50	0.44	0.35	0.21	0.22	0.23	0.25	0.32	0.43	0.49	0.55
5	0.52	0.49	0.44	0.34	0.21	0.22	0.24	0.26	0.32	0.44	0.50	0.55
6	0.54	0.51	0.46	0.38	0.20	0.21	0.23	0.25	0.32	0.44	0.50	0.57
7	0.51	0.50	0.44	0.35	0.22	0.22	0.28	0.16	0.32	0.43	0.47	0.54
8	0.52	0.49	0.44	0.35	0.21	0.22	0.19	0.22	0.32	0.44	0.49	0.55

*There is no E/I objective under D-1485

**Is increased to 0.45 if the Eight River Index for January is less than or equal to 1.0 MAF

Table V1-12

Delta Export/Inflow Ratio, Critical Period

Base Case Average Monthly E/I Ratio*

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.41	0.60	0.58	0.49	0.62	0.58	0.27	0.42	0.37	0.47	0.39	0.51

1995 WQCP Monthly E/I Objective

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.65	0.65	0.65	0.65	0.35**	0.35	0.35	0.35	0.35	0.65	0.65	0.65

Flow Alternatives Average Monthly E/I Ratio

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	0.49	0.45	0.58	0.59	0.39	0.29	0.25	0.25	0.28	0.33	0.32	0.49
3	0.50	0.46	0.58	0.59	0.39	0.30	0.26	0.26	0.30	0.36	0.34	0.48
4	0.50	0.46	0.58	0.59	0.39	0.30	0.26	0.26	0.30	0.36	0.34	0.48
5	0.52	0.48	0.59	0.59	0.40	0.34	0.28	0.28	0.33	0.38	0.35	0.50
6	0.53	0.45	0.58	0.59	0.39	0.28	0.26	0.26	0.29	0.36	0.30	0.49
7	0.48	0.47	0.58	0.59	0.40	0.31	0.34	0.16	0.27	0.30	0.30	0.48
8	0.51	0.45	0.58	0.59	0.39	0.29	0.22	0.24	0.31	0.36	0.29	0.48

* There is no E/I objective under D-1485

** Is increased to 0.45 if the Eight River Index for January is less than or equal to 1.0 MAF

2. Salinity

This section analyzes salinity conditions under the seven flow alternatives and the base case as modeled by DWRSIM and the DWR Delta Simulation Model, DWRDSM1. Two analyses are discussed below to illustrate the flow alternatives' effects on salinity in the Estuary. In the first analysis, the position of X2, the 2 parts per thousand (ppt) isohaline, for each of the flow alternatives is compared with the X2 position of the base case. In the second analysis, the electrical conductivity (EC) of each of the flow alternatives at stations throughout the Delta is compared to that of the base case.

a. **X2**. The significance of the changes in the X2 position is related to their effects on aquatic resources in the Delta. X2 is defined as the distance from the Golden Gate Bridge in kilometers (km) of the 2 part per thousand (ppt) isohaline at a depth of one meter from the bottom of the channel. Figure VI-1 shows the distance in kilometers from the Golden Gate Bridge along a path through the Bay/Delta. This figure can be used to locate the X2 position. The 1995 Bay/Delta Plan provides that the Delta outflow objectives are met from February through June if the location of the X2 isohaline is downstream of specified locations for a certain number of days per month. During the development of the X2 objectives, it was agreed that the 2-ppt salinity isohaline at the bottom of the water column could be represented by a specific conductance of 2.64 mmhos/cm at the surface. This conversion was made because the majority of the field salinity EC data are measured at the surface. These data are adjusted to 25°C to provide comparable data.

DWRSIM was used to determine the location of the X2 isohaline position for each of the seven flow alternatives and the base case. The model predicts the location of X2 as a function of the current and previous months' flows (see Chapter IV section A). Table VI-13 shows monthly average X2 positions for Alternative 1 for the 73-year period and the critical period as predicted by the model. The table also compares these monthly average X2 positions for the base case to the X2 positions for each of the other alternatives. Positive changes indicate westward movement of the X2 line, which is generally desirable for aquatic species in the Estuary; negative changes indicate a shift toward the Delta.

Some general observations regarding the position of X2 can be noted. Over the 73-year period, the X2 position for the flow alternatives moves slightly downstream as compared to the base case in November and December and from February through September. The greatest downstream movement occurs in April. X2 moves upstream in October and January. This upstream movement corresponds with a reduction in Delta outflow as compared to the base case (see Table VI-7). The same general trends are observed during the critical period, except that upstream movement of X2 also occurs in August. This corresponds to reduced critical period Delta outflow during August (see Table VI-8). Delta outflow in December for the critical period is also reduced from the base case; however, the X2 position is downstream of the base case. This is likely the result of antecedent conditions.

The effects of Alternatives 2, 3, 4, 7, and 8 on X2 are virtually indistinguishable from each other for both the 73-year period and the critical period. This is to be expected since monthly average Delta outflow varies little among these alternatives. The X2 position is farther downstream for all months under Alternative 5 than for any other alternative because of the higher outflow under this alternative. The X2 position is farther upstream in October through January under Alternative 6 than the other alternatives because higher exports associated with combined use of SWP and CVP points of diversion in the Delta result in lower Delta outflows during this period.

Figure VI - 1
X2 Location Map
Sacramento - San Joaquin Delta and San Francisco Bay

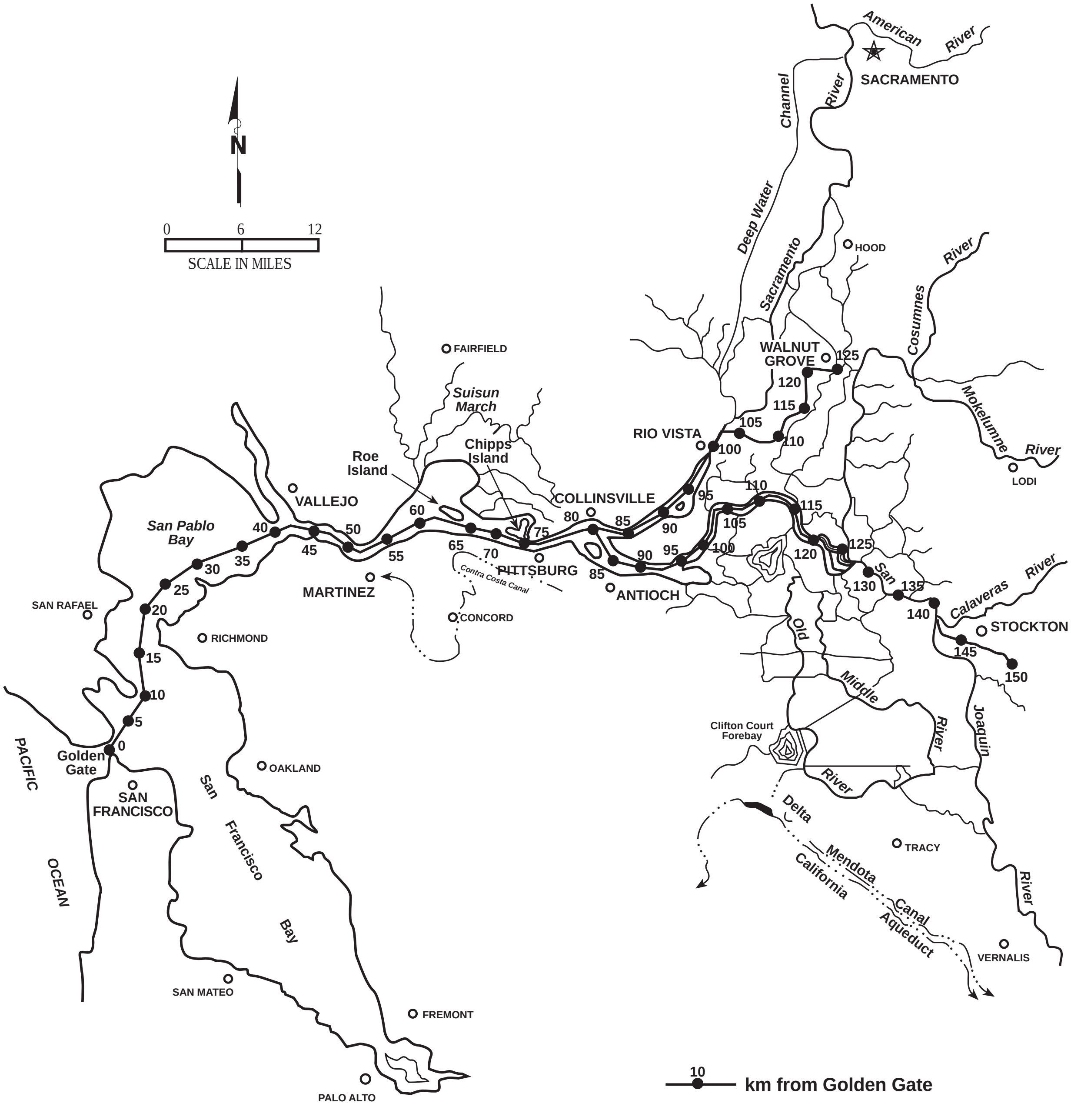


Table VI-13

Modeled Isohaline (X2) Position

73-Year Period Average Monthly X2 Position (km)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	83.0	82.4	77.4	70.4	66.4	66.1	70.8	73.3	76.6	80.9	85.7	88.1

Change in X2 Position from the Base Case (km)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-0.9	1.1	0.2	-0.5	1.1	1.4	3.0	1.9	2.5	1.5	1.0	1.5
Alt 3	-0.7	1.2	0.2	-0.5	1.2	1.5	3.1	1.9	2.5	1.5	1.0	1.5
Alt 4	-0.7	1.2	0.2	-0.5	1.2	1.5	3.1	1.9	2.5	1.5	1.0	1.6
Alt 5	-0.4	1.6	1.6	-0.2	1.5	2.0	3.7	2.7	3.0	1.6	1.1	1.4
Alt 6	-1.1	0.7	-0.3	-1.1	1.0	1.4	3.0	1.9	2.9	1.6	1.1	1.4
Alt 7	-0.7	0.9	0.1	-0.6	1.1	1.5	2.6	2.1	2.8	1.6	1.0	1.4
Alt 8	-1.0	1.1	0.2	-0.5	1.1	1.4	3.4	2.3	2.7	1.5	1.0	1.5

Critical Period Average Monthly X2 Position (km)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	85.4	88.8	84.9	79.1	79.8	82.6	81.1	83.5	85.9	87.3	85.9	90.0

Change in X2 Position from the Base Case (km)

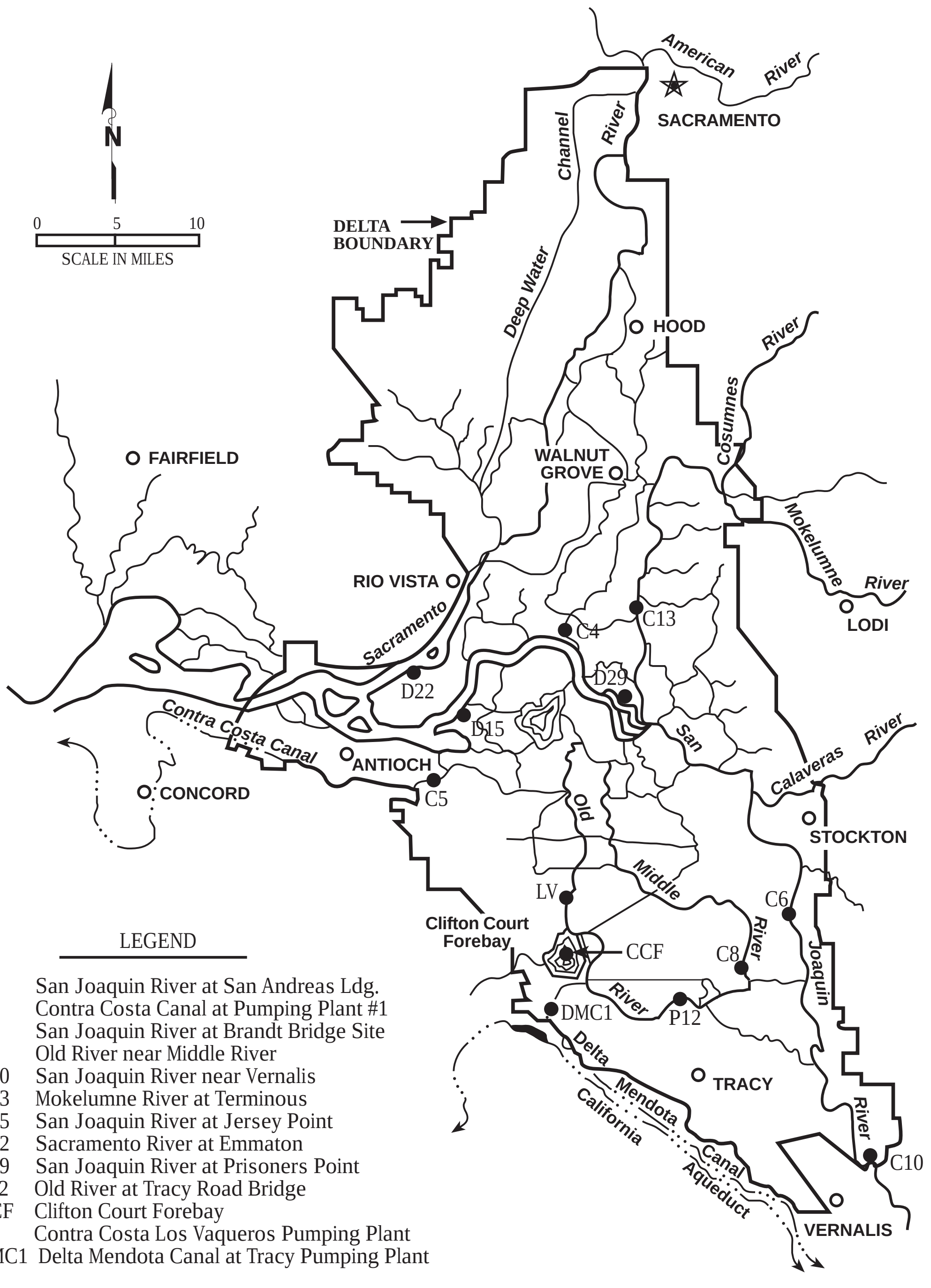
Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-2.3	2.6	0.3	-2.0	2.6	6.7	3.9	5.4	6.4	3.8	-0.5	0.9
Alt 3	-2.4	2.6	0.3	-2.0	2.5	6.7	3.9	5.4	6.4	3.8	-0.5	0.9
Alt 4	-2.4	2.6	0.3	-2.0	2.5	6.7	3.9	5.4	6.4	3.8	-0.5	0.9
Alt 5	-2.3	2.3	-0.1	-0.8	-3.2	8.0	6.1	6.3	7.5	3.9	-0.8	0.7
Alt 6	-3.0	2.6	0.2	-2.1	2.5	6.5	3.9	5.4	7.0	4.0	0.0	1.0
Alt 7	-2.0	2.4	0.2	-1.9	2.5	6.4	3.8	5.5	6.9	4.0	-0.7	0.8
Alt 8	-2.7	2.6	-0.2	-1.0	2.8	7.3	5.9	6.0	7.2	3.8	-0.4	0.9

Overall, the shift in X2 locations for all the flow alternatives in comparison to the base case is downstream and should have positive effects on aquatic resources. In October and January, the X2 position under the alternatives would be slightly eastward, but this limited shift in the X2 location is not significant and will not require mitigation.

b. **Electrical Conductivity Within the Delta**. DWRDSM was used to determine the effect of each of the eight flow alternatives on EC in the Delta. To estimate monthly average salinity in the Delta, DWRDSM (described in Chapter IV) uses the hydrology generated by DWRSIM studies of the base case and alternatives as input. Thus, the modeling assumptions for DWRSIM, discussed in Chapter IV, also apply to the salinity analysis. DWRDSM is not intended to provide absolute predictions of future Delta hydrodynamic and EC conditions; rather, the model is meant as a tool to compare Delta conditions under various alternative actions.

This analysis examines results of simulations at the following 13 locations shown on Figure VI-2 and listed in Table VI-14: Contra Costa Canal at Pumping Plant No. 1/Rock Slough; Contra Costa Los Vaqueros Intake; Banks Pumping Plant; Tracy Pumping Plant; Sacramento River at Emmaton; San Joaquin River at Jersey Point; South Fork of the Mokelumne River at Terminous; San Joaquin River at San Andreas Landing; San Joaquin River at Prisoners Point; San Joaquin River at Vernalis; San Joaquin River at Brandt Bridge

Figure VI-2
Delta Salinity Recording Stations



LEGEND

	C4	San Joaquin River at San Andreas Ldg.
	C5	Contra Costa Canal at Pumping Plant #1
	C6	San Joaquin River at Brandt Bridge Site
	C8	Old River near Middle River
	C10	San Joaquin River near Vernalis
	C13	Mokelumne River at Terminous
	D15	San Joaquin River at Jersey Point
	D22	Sacramento River at Emmaton
	D29	San Joaquin River at Prisoners Point
	P12	Old River at Tracy Road Bridge
*	CCF	Clifton Court Forebay
*	LV	Contra Costa Los Vaqueros Pumping Plant
*	DMC1	Delta Mendota Canal at Tracy Pumping Plant

* These stations are not Bay/Delta WQCP Monitoring Stations

Table VI-14
Salinity Recording Stations

Sacramento Valley 40-30-30 Index	San Joaquin Valley 60-20-20 Index
Contra Costa Canal Pumping Plant # 1	San Joaquin River at Vernalis
Contra Costa Los Vaqueros Intake	San Joaquin River at Brandt Bridge site
Banks Pumping Plant	Old River at Tracy Road Bridge
Tracy Pumping Plant	Old River near Middle River
Sacramento River at Emmaton	
San Joaquin River at Jersey Point	
South Fork Mokelumne River at Terminous	
San Joaquin River at San Andreas Landing	
San Joaquin River at Prisoners Point	

site; Old River at Tracy Road Bridge; and Old River near Middle River. Figures VI-3 through VI-22 show expected chloride concentrations for Contra Costa's Intakes and the Banks and Tracy pumping plants, under the seven flow alternatives and the base case for water years 1976 through 1991. Figures VI-23 through VI-63 show expected electrical conductivity (EC) at the remaining stations. Where possible, objectives are noted on the figures. EC objectives for stations in the south Delta are the same for all year types, while EC objectives at other stations change based on the year type. The first figure for each station shows the average EC (or chloride concentration) for wet years during the 16-year period, followed by above normal, below normal, dry, and critically dry years. Year types are based on the Sacramento Valley "40-30-30" classification system with the exception of the four Southern Delta Salinity stations, which are based on the San Joaquin Valley "60-20-20" hydrologic classification system. Below normal years under the San Joaquin 60-20-20 hydrologic classification system do not occur during the model study period (1976 – 1991). Consequently below normal year types are omitted for stations under the San Joaquin Valley 60-20-20 Index convention.

Modeled chloride concentrations at Contra Costa Canal Pumping Plant No. 1 are shown in Figures VI-3 through VI-7. A feature of these plots is that the maximum mean daily chloride objective is exceeded slightly in December of critically dry years under Alternatives 2 through 8. This is caused by differences between the methods used by DWRSIM and DWRDSM to calculate salinity or chloride concentrations. DWRSIM, the operations model, uses a relationship between outflow and salinity to determine concentrations of these parameters at selected western Delta stations, including the Contra Costa Pumping Plant. DWRSIM makes reservoir releases as necessary to meet the objectives at these locations and DWRSIM output indicates that these objectives are always met. The hydrology output from DWRSIM is used as input to DWRDSM, which uses a more complicated method for calculating salinity and chloride concentrations. The method used by DWRDSM considers other factors such as exports and tidal influence. Output from DWRDSM may show significant violations of salinity objectives. In summary, the DWRDSM output indicates a need for carriage water, but the DWRSIM model does not presently include a method for calculating carriage water. Although DWRDSM output predicts that salinity objectives at some locations will be violated, in actual operations, the projects would be operated to meet salinity and chloride objectives in the western Delta under all of the alternatives, and violations would not be expected to occur. Because of the conditions described above, salinity information depicted in Figures VI-3 through VI-67 is generally discussed relative to base case salinity, rather than to the objectives.

Figures VI-3 through VI-7 show predicted chloride concentrations for Contra Costa Canal at Pumping Plant No.1. The graphs show that chloride levels among Alternatives 2 through 8 increase relative to the base case in December of above normal years and in December, January, and February of both dry and critically dry years. Chloride levels among Alternatives 2 through 8 decrease in August and September of wet and above normal year types, in June through September of below normal and dry years, and in March through August of critically dry years. Chloride levels of Alternatives 2 through 8 are similar throughout the year, with the limited exception of Alternative 6 in some winter months in below normal years. At these times the chloride levels rise because of increased exports and decreased outflow associated with use of the combined points of diversion.

Figures VI-8 through VI-12 show predicted chlorides for Contra Costa Water District's Los Vaqueros Intake on Old River. The graphs show that chloride levels among Alternatives 2 through 8 are greater than the base case in December of above normal years and December, January and February of dry and critical years. Alternatives 2 through 8 are lower than the base case chlorides in September of above normal years; July, August and September of below normal and dry years, and June, July and August of critically dry years. Otherwise chloride levels are similar throughout the year.

Figures VI-13 through VI-17 and Figures VI-18 through VI-22 show predicted chlorides for the SWP Banks Pumping Plant and CVP Tracy Pumping Plant, respectively. The graphs show that chloride levels among Alternatives 2 through 8 are greater than base case chlorides in December of above normal years and December, January, and February of dry and critical years. Alternatives 2 through 8 are lower than the base case in July, August and September of below normal and dry years, and June, July, and August of critically dry years. Other differences are not significant.

Figures VI-23 through VI-27 show predicted salinity for the Sacramento River at Emmaton. Salinity for Alternatives 2 through 8 increases over the base case in October of wet years; decreases from June to December of below normal years and from April to September of dry years. In critically dry years salinity for Alternatives 2 through 8 is higher than the base case in August, October, December, and January but is lower from February to July.

Figures VI-28 through VI-32 show predicted salinities in the San Joaquin River at Jersey Point in the western Delta. Salinity levels under Alternatives 2 through 8 are higher than base case salinity in October of wet and above normal years and in January of dry and critically dry years. Salinity levels under Alternatives 2 through 8 are similar to or lower than the base case throughout the summer months in all year types.

Figures VI-33 through VI-47 show predicted central Delta salinities at Terminous, and the San Joaquin River at San Andreas Landing and Prisoners Point. The alternatives and the base case have very similar salinity conditions at Terminous on the South Fork of the

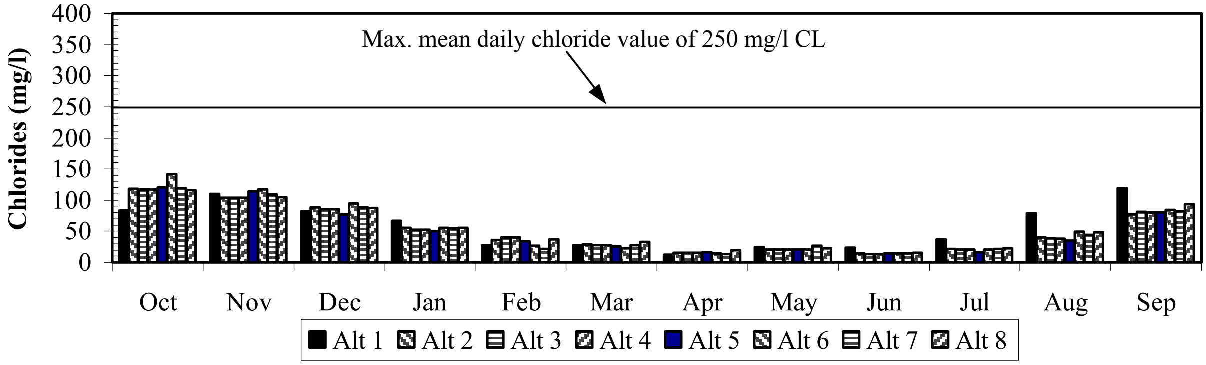
Mokelumne River. The salinity patterns at San Andreas and Prisoners Point are similar to the salinity patterns in the western Delta stations. Salinity at these stations increases relative to the base case in December of dry and critically dry years when the Delta Cross Channel is closed and exports are high. In the spring and summer, salinity decreases as outflow increases. The spring salinity decreases at these stations are not as pronounced as in the western Delta because the Delta Cross Channel gates are closed more often than under the base case.

Figures VI-48 through VI-63 show predicted salinity levels at the four southern Delta stations: San Joaquin River at Vernalis, and at Brandt Bridge, Old River at Tracy Road Bridge, and Old River near Middle River. The salinity objectives at Vernalis in the Bay/Delta Plan are 0.7 mmhos/cm from April through August and 1.0 mmhos/cm from September through March. The salinity requirement at Vernalis in D-1422 (base case) is 500 ppm (approximately 0.86 mmhos/cm). The exceedances of the objectives predicted by DWRDSM are not caused by the differences between DWRSIM and DWRDSM, as described above. Salinity conditions at Vernalis predicted by DWRSIM are boundary conditions in DWRDSM and are, therefore, the same in both models. DWRSIM makes releases from New Melones Reservoir to meet salinity objectives at Vernalis. When there is insufficient water in New Melones Reservoir to meet all of the demands, salinity objectives are violated. During the 16-year, 192-month period, Alternatives 2 and 5 exceed the monthly Vernalis salinity objective three times. Alternative 7 exceeds salinity objectives 23 times and Alternative 8 exceeds objectives 15 times. Flow Alternatives 3, 4 and 6 do not have any exceedances of the Vernalis salinity objective. Because of the difference in objectives at Vernalis between the base case and the seven alternatives, Vernalis salinity is generally higher in the summer for the base case than for the other alternatives. Alternative 7 exceeds Plan objectives at the four stations in August of dry and critically dry years. This is because, under the Letter of Intent, there is a 70 TAF cap on releases from New Melones Reservoir for salinity control. Alternative 8 exceeds Plan objectives in August of critically dry years because of New Melones Reservoir release limits for salinity control specified in the Stanislaus River Interim Operations Plan.

The model is not operated to require the release of higher dilution flows to meet salinity objectives at the other three southern Delta stations (Brandt Bridge, Old River at Tracy Bridge, and Old River near Middle River). Consequently, salinity at these stations exhibit a pattern similar to Vernalis salinity, but the objectives at these locations are exceeded more often than the Vernalis objectives, especially under dry conditions, because of the local water use and drainage patterns.

All four of the south Delta stations show Alternative 5 having the lowest salinity in July, except for Brandt Bridge in dry and critical years. Alternative 5 also tends to exhibit slightly lower salinity in the spring, although the decrease is small.

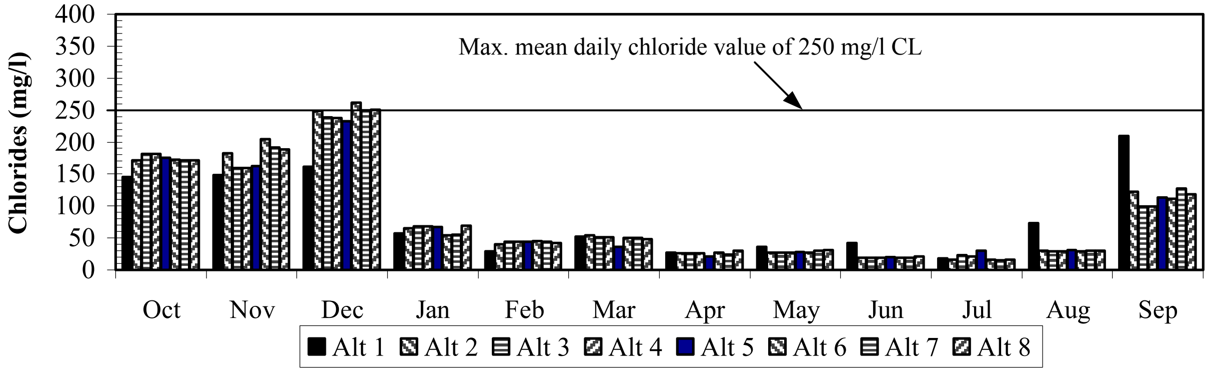
Figure VI-3
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Wet Years



For a Wet water year; 240 (66%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

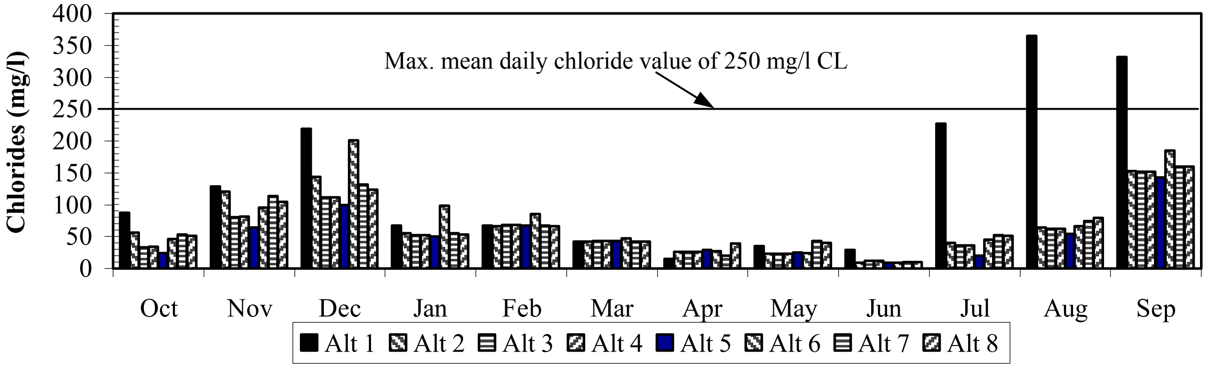
Figure VI-4
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Above Normal Years



For a Above Normal water year; 190 (52%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

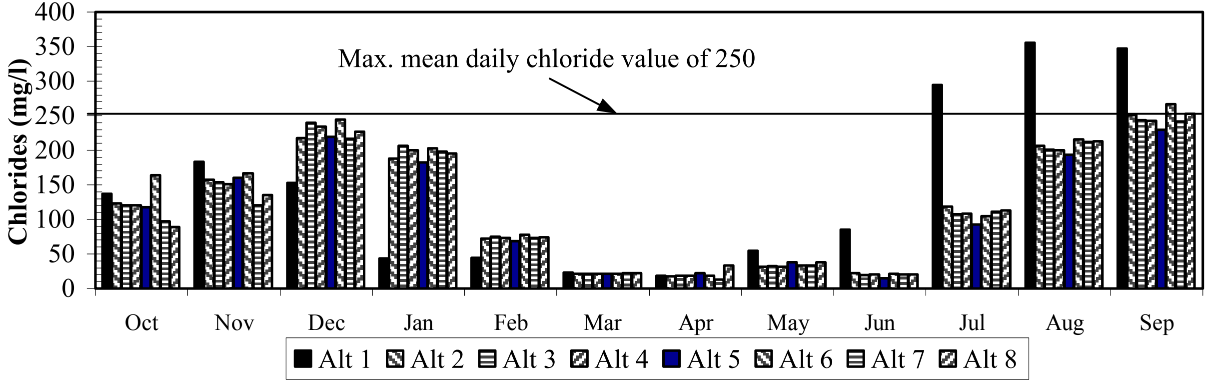
Figure VI-5
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Below Normal Years



For a Below Normal water year; 175 (48%) days <= 150 mg/l
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **below normal** year (1979)

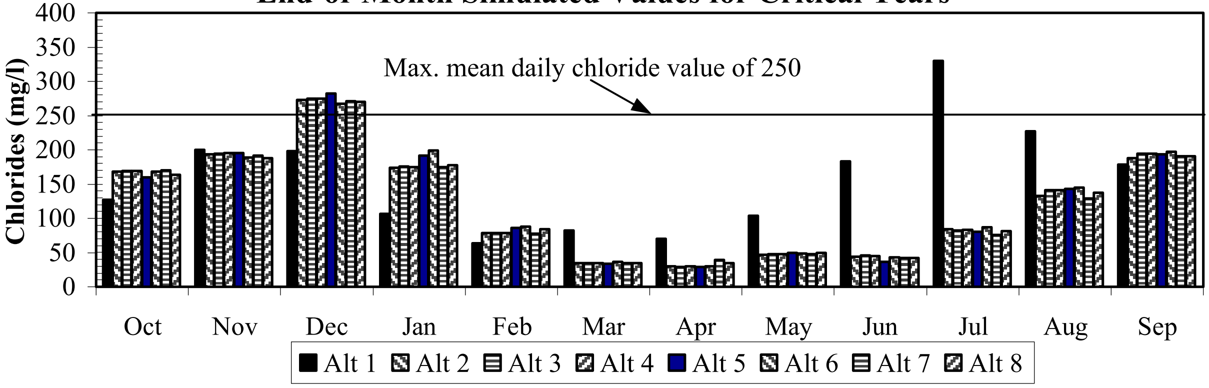
Figure VI-6
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Dry Years



For a Dry water year; 165 (45%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years
averaged (1981, 85, 87 & 89)

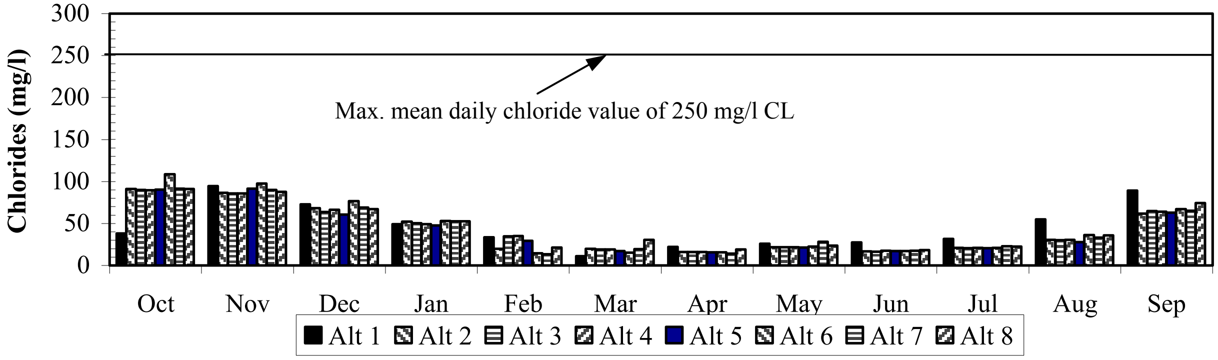
Figure VI-7
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Critical Years



For a Critical water year; 155 (42%) days <= 150 mg/l
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years
averaged (1976, 77, 88, 90 & 91)

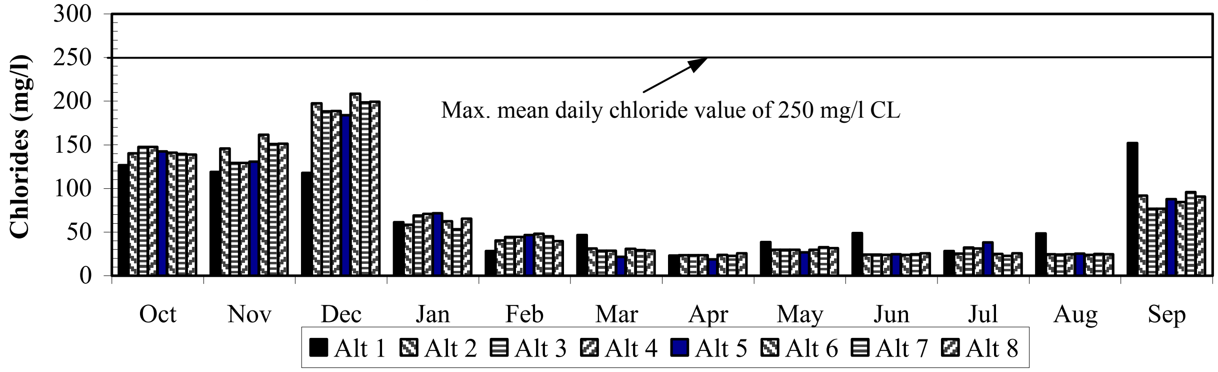
Figure VI-8
Salinity for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Wet Years



For a Wet water year; 240 (66%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years
averaged (1982, 83, 84 & 86)

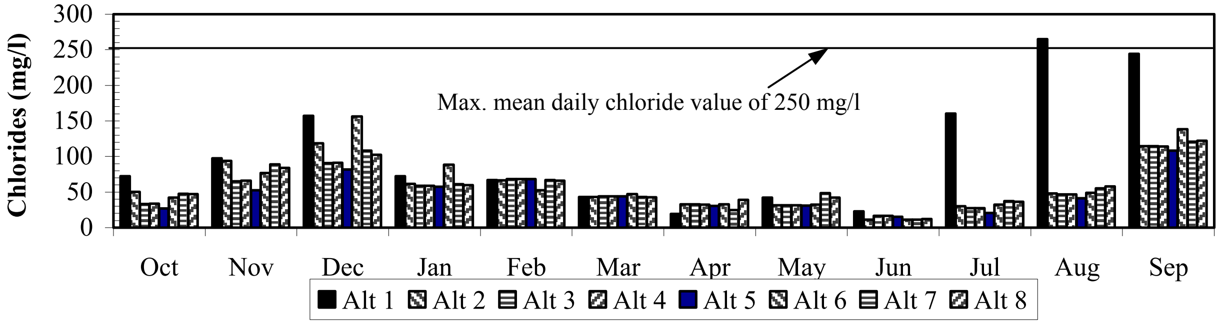
Figure VI-9
Salinity for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Above Normal Years



For a Above Normal water year; 190 (52%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal**
years averaged (1978 & 80)

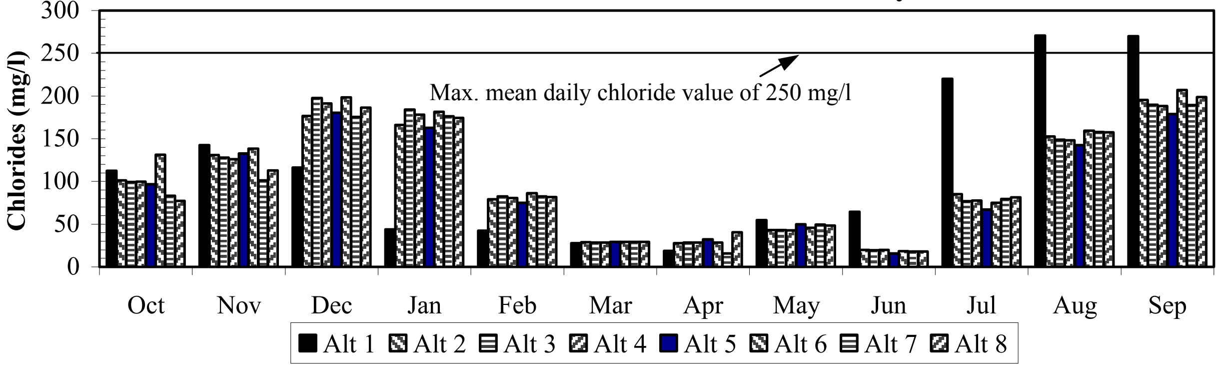
Figure VI-10
Salinity for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Below Normal Years



For a Below Normal water year; 175 (48%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30"
below normal year (1979)

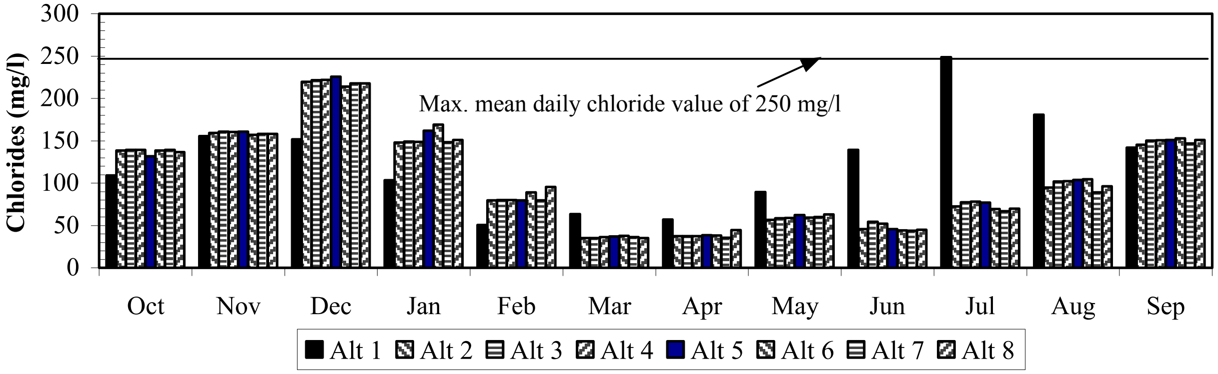
Figure VI-11
Salinity for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Dry Years



For a Dry water year; 165 (45%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

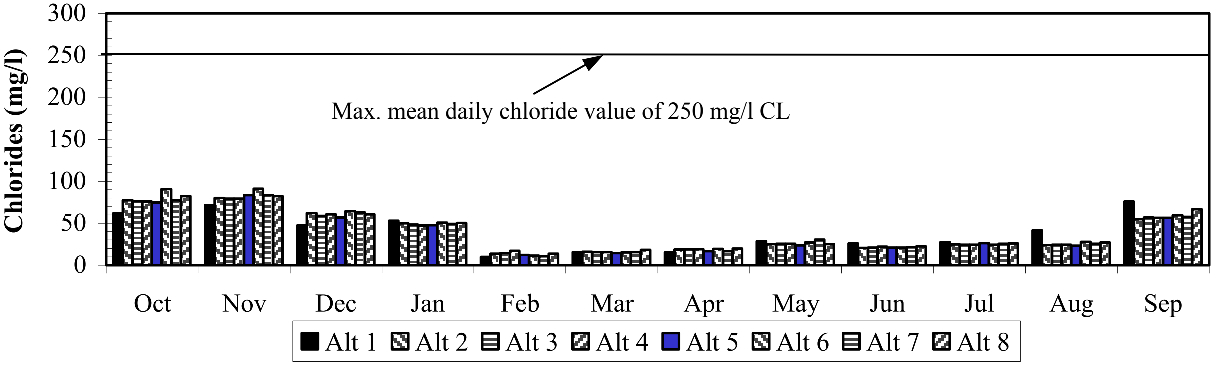
Figure VI-12
Salinity for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Critical Years



For a Critical water year; 155 (42%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

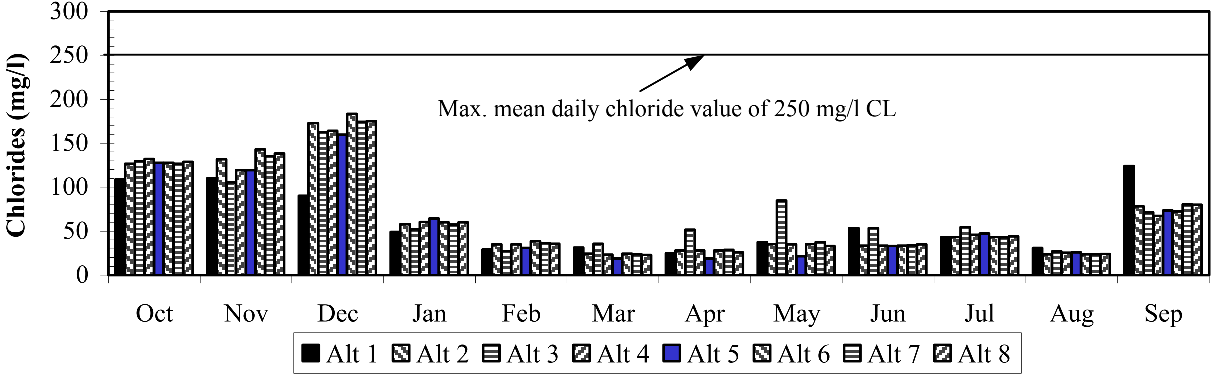
Figure VI-13
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Wet Years



For a Wet water year; 240 (66%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years
averaged (1982, 83, 84 & 86)

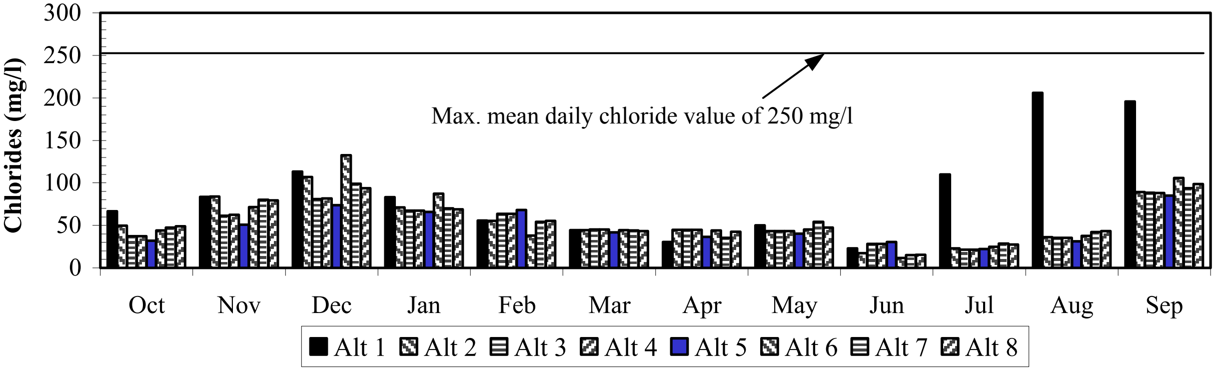
Figure VI-14
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Above Normal Years



For a Above Normal water year; 190 (52%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal**
years averaged (1978 & 80)

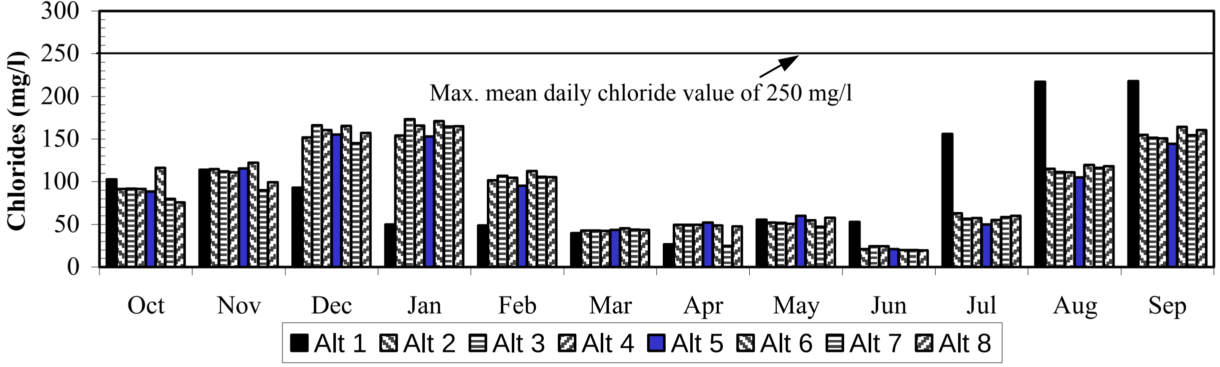
Figure V-15
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Below



For a Below Normal water year; 175 (48%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30"
below normal year (1979)

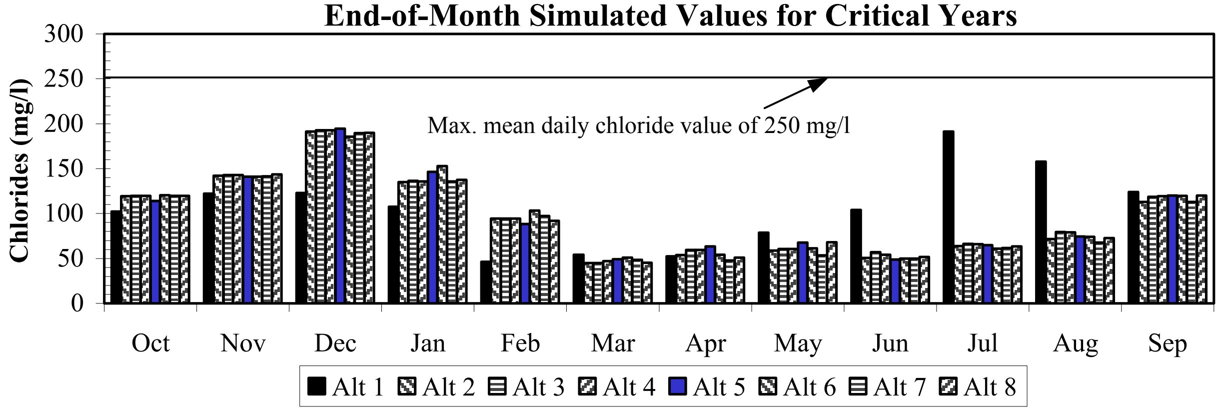
Figure VI-16
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Dry Years



For a Dry water year; 165 (45%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years
averaged (1981, 85, 87 & 89)

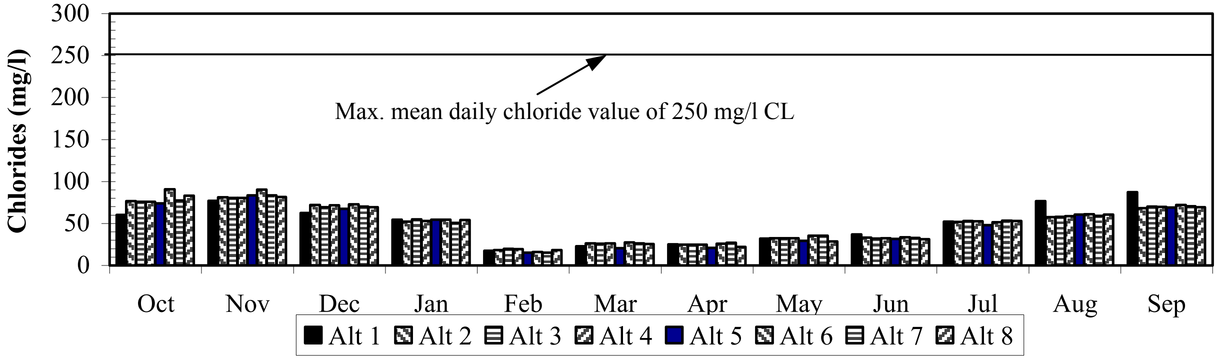
Figure VI-17
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Critical Years



For a Critical water year; 155 (42%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years averaged
(1976, 77, 88, 90 & 91)

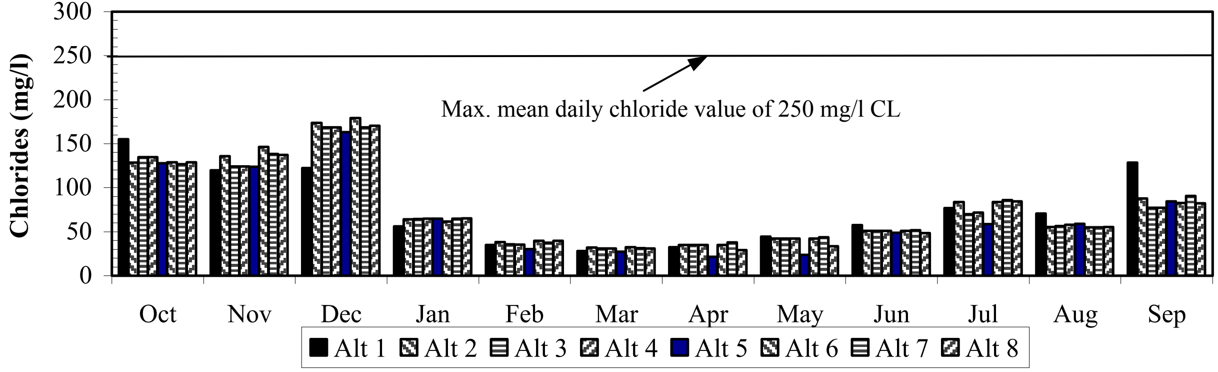
Figure VI-18
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Wet Years



For a Wet water year; 240 (66%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**wet** years
averaged (1982, 83, 84 & 86)

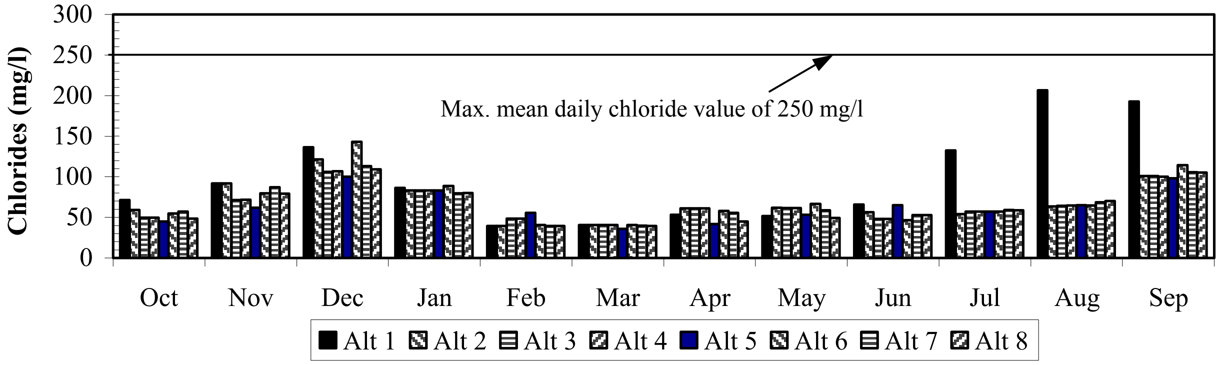
Figure VI-19
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Above Normal Years



For a Above Normal water year; 190 (52%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**above normal**
years averaged (1978 & 80)

Figure VI-20
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Below Normal Years



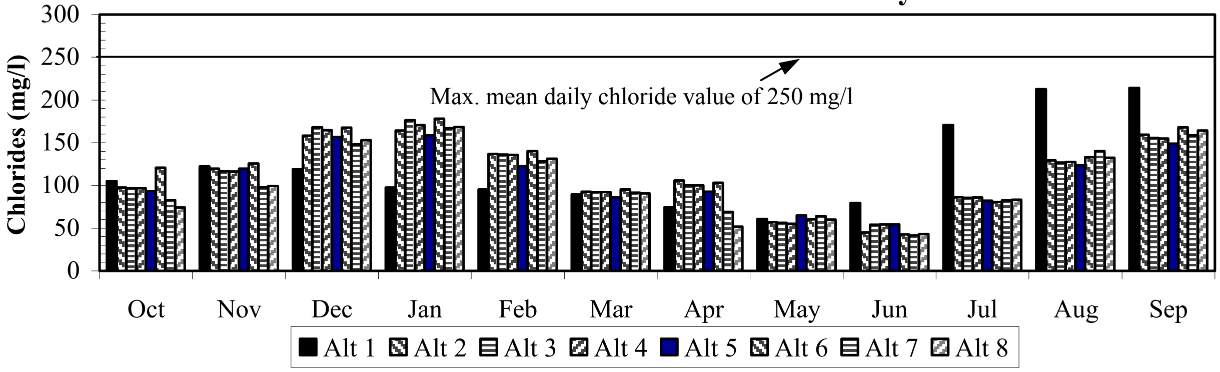
For a Below Normal water year; 175 (48%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30"
below normal year (1979)

Figure VI-21

Salinity for Tracy Pumping Plant

End-of-Month Simulated Values for Dry Years



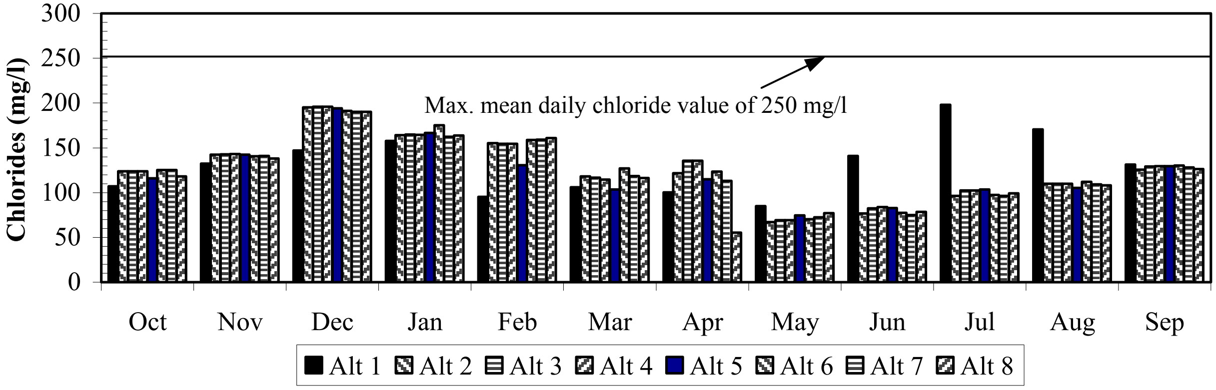
For a Dry water year; 165 (45%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**dry** years
averaged (1981, 85, 87 & 89)

Figure VI-22

Salinity for Tracy Pumping Plant

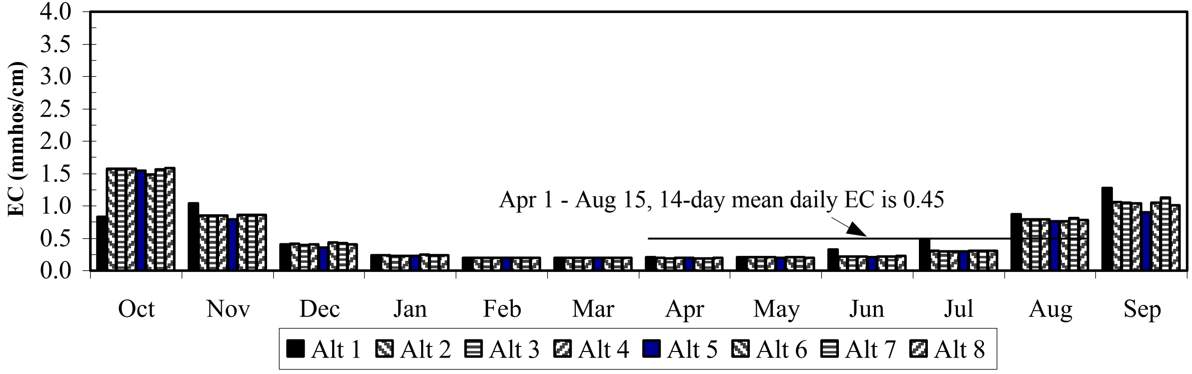
End-of-Month Simulated Values for Critical Years



For a Critical water year; 155 (42%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**critical** years averaged
(1976, 77, 88, 90 & 91)

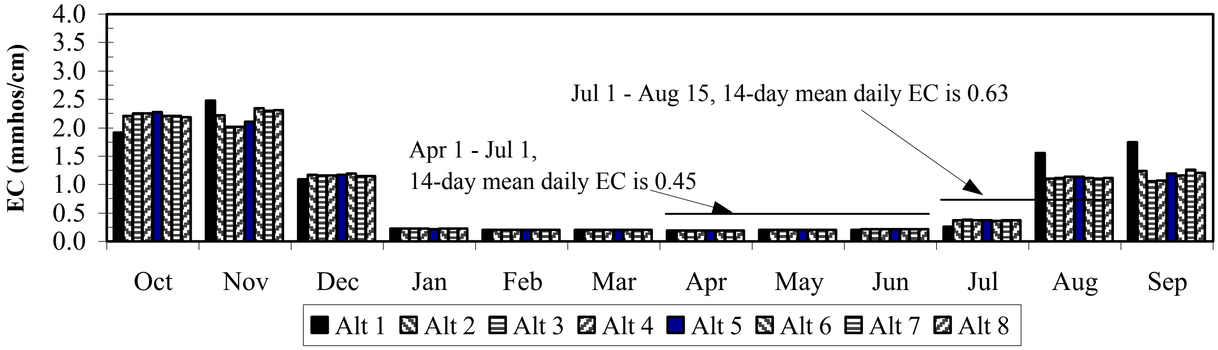
Figure VI-23
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Wet Years



Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

Salinity objectives are the same for D-1485 & Bay/Delta Plan

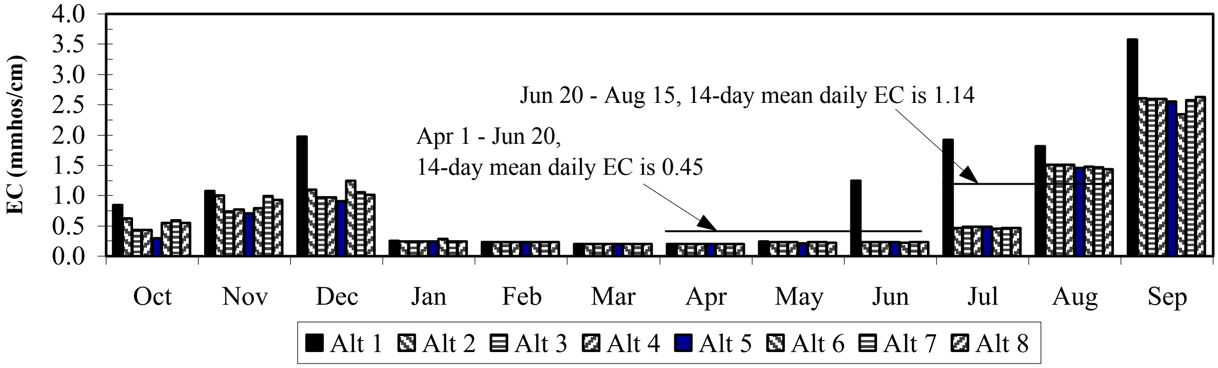
Figure VI-24
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Above Normal Years



Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

Salinity objectives are the same for D-1485 & Bay/Delta Plan

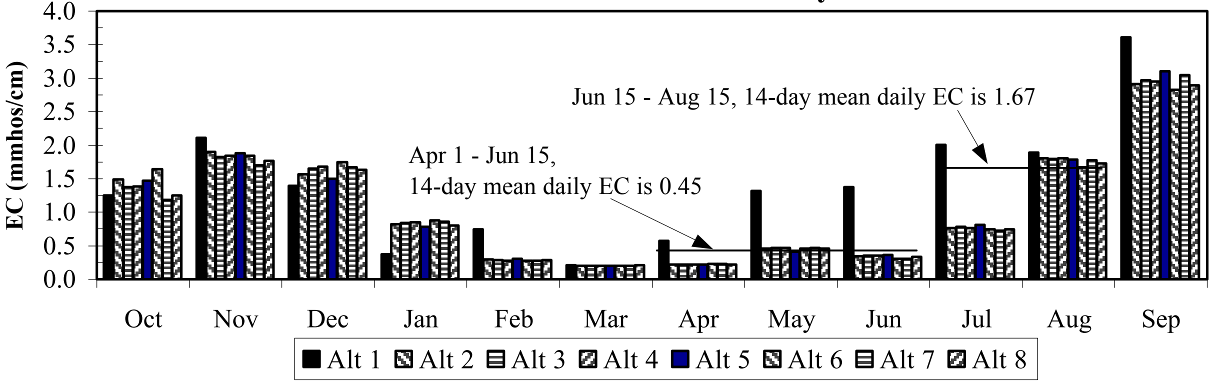
Figure VI-25
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Below Normal Years



Sacramento "40-30-30" **below normal** year (1979)

Salinity objectives are the same for D-1485 & Bay/Delta Plan

Figure VI-26
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Dry Years



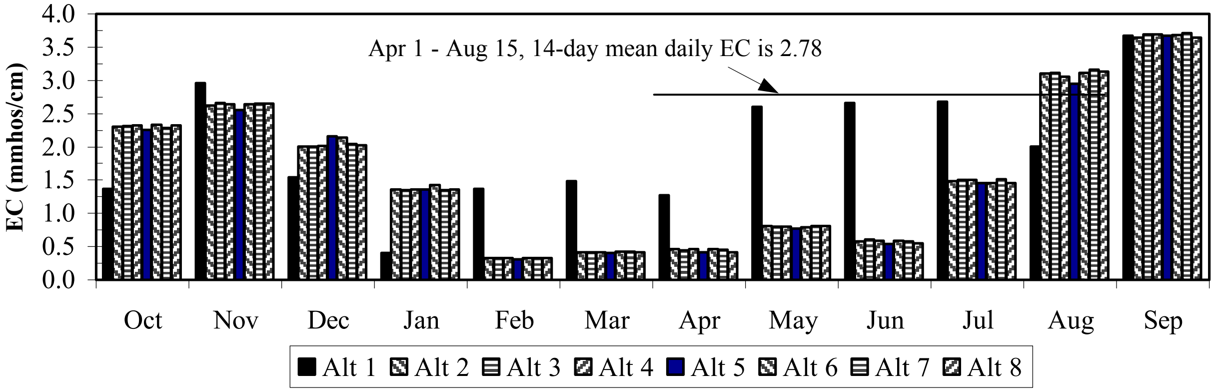
Jun 15 - Aug 15, 14-day mean daily EC is 1.67

Apr 1 - Jun 15,
14-day mean daily EC is 0.45

Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**dry** years
averaged (1981, 85, 87 & 89)

Figure VI-27
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Critical Years

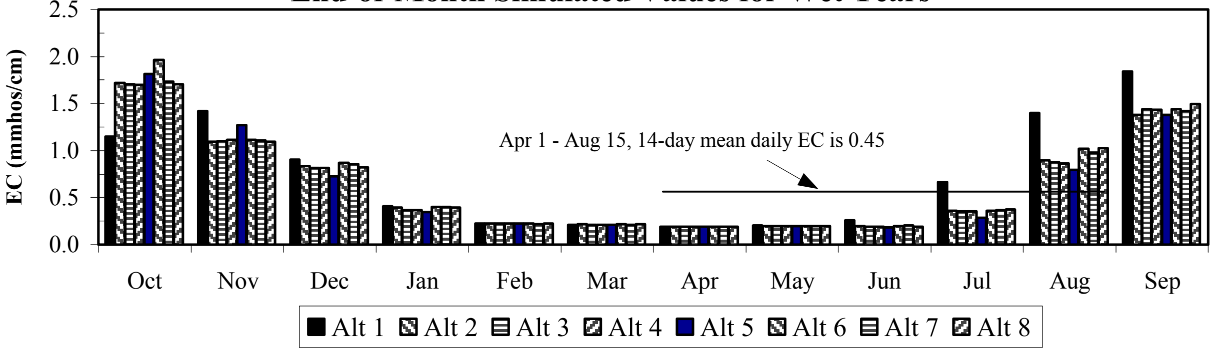


Apr 1 - Aug 15, 14-day mean daily EC is 2.78

Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**critical** years
averaged (1976, 77, 88, 90 & 91)

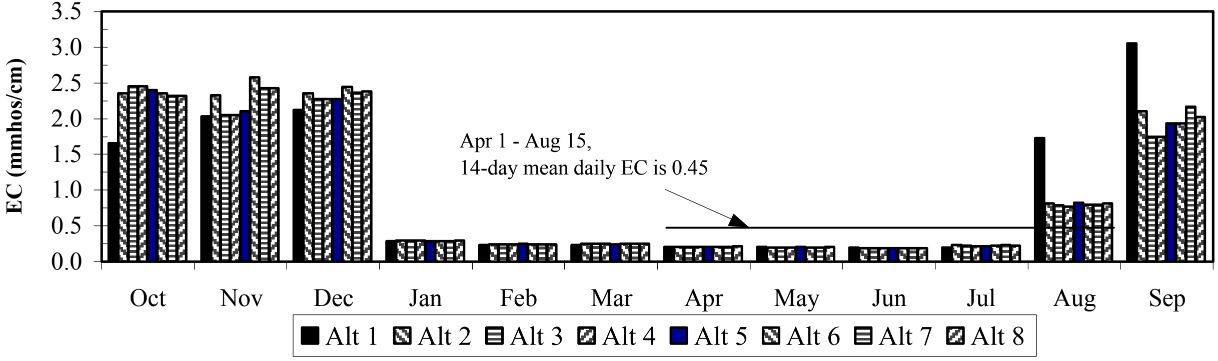
Figure VI-28
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Wet Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30 "**wet** years
averaged (1982, 83, 84 & 86)

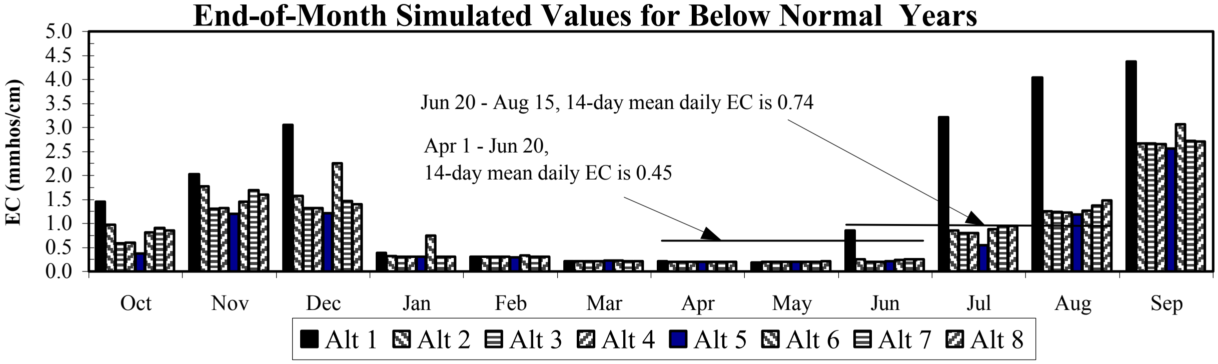
Figure VI-29
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Above Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30 "**above normal**
years averaged (1978 & 80)

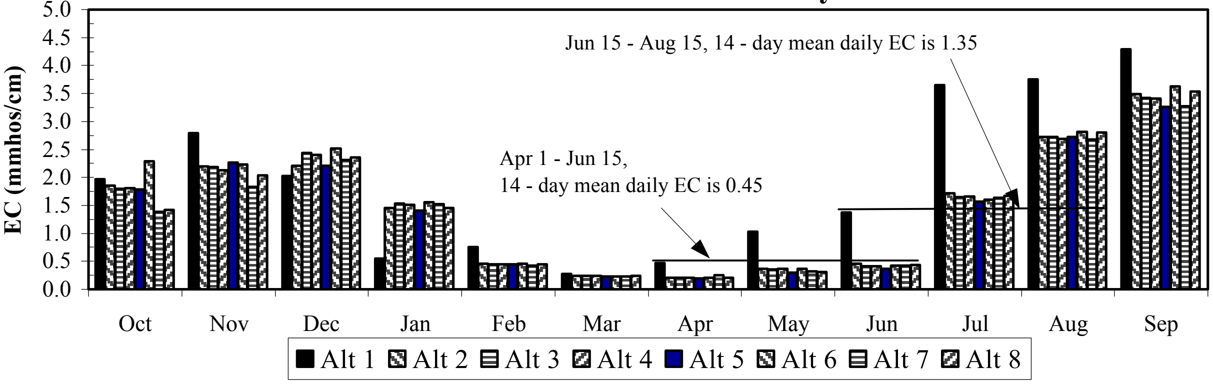
Figure VI-30
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Below Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30"
below normal year (1979)

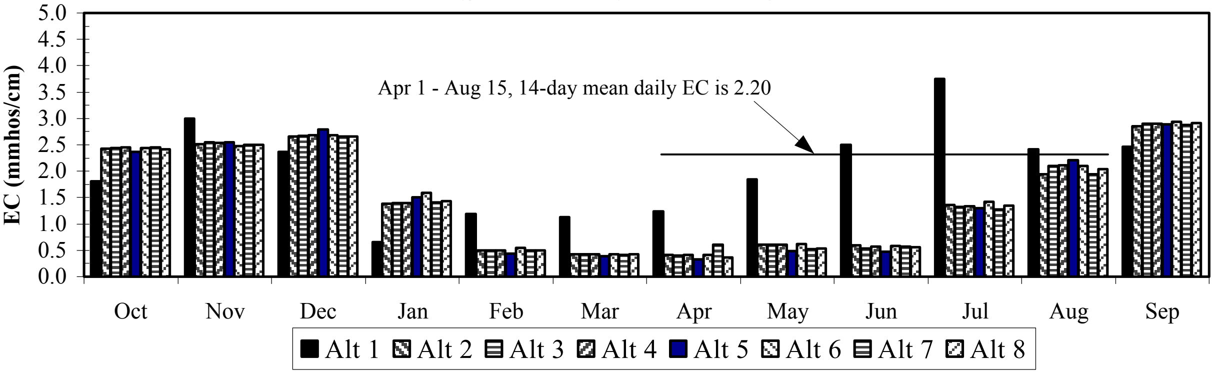
Figure VI-31
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Dry Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

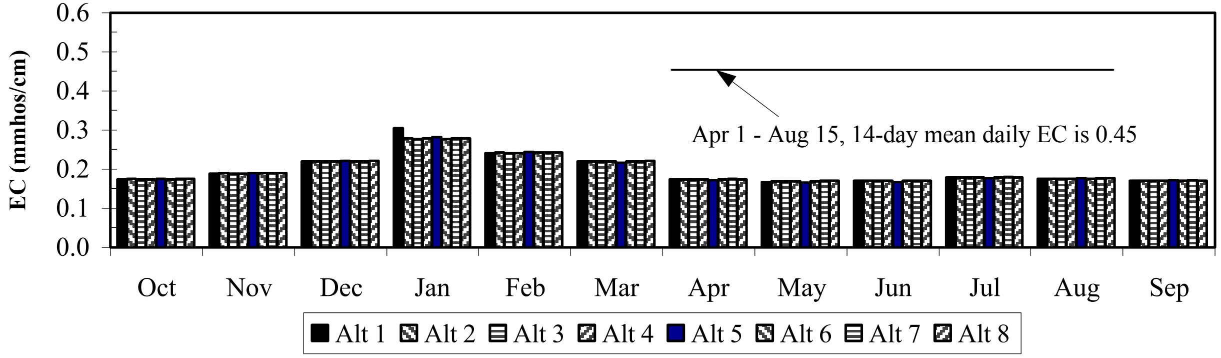
Figure VI-32
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Critical Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **critica**l years averaged (1976, 77, 88, 90 & 91)

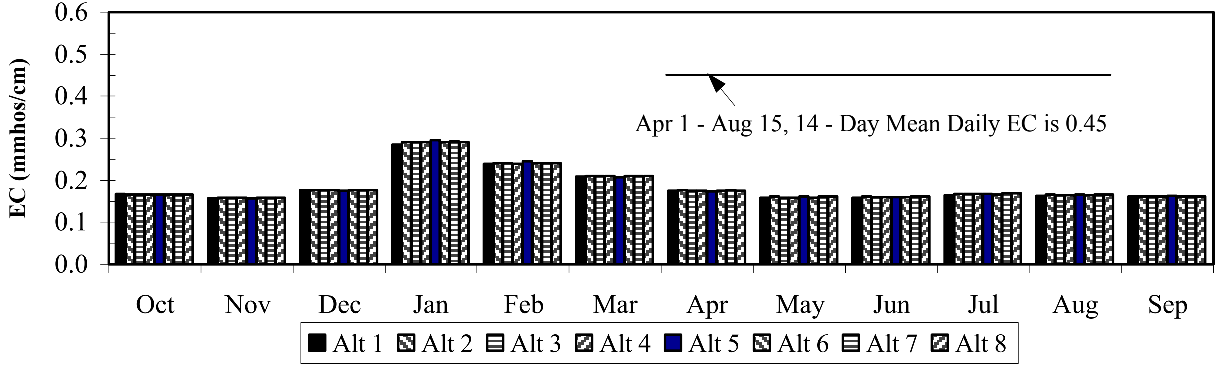
Figure VI-33
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Wet Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

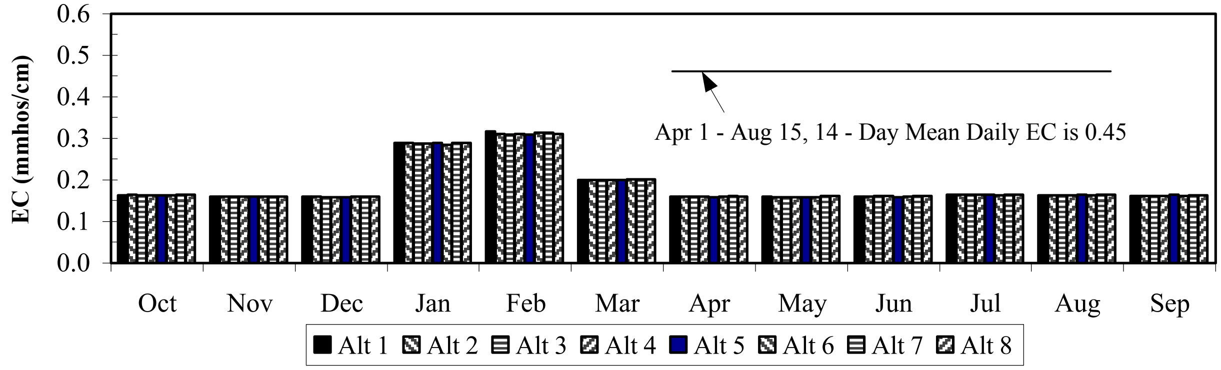
Figure VI-34
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Above Normal Years



Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

Salinity objectives are the same for D-1485 & Bay/Delta

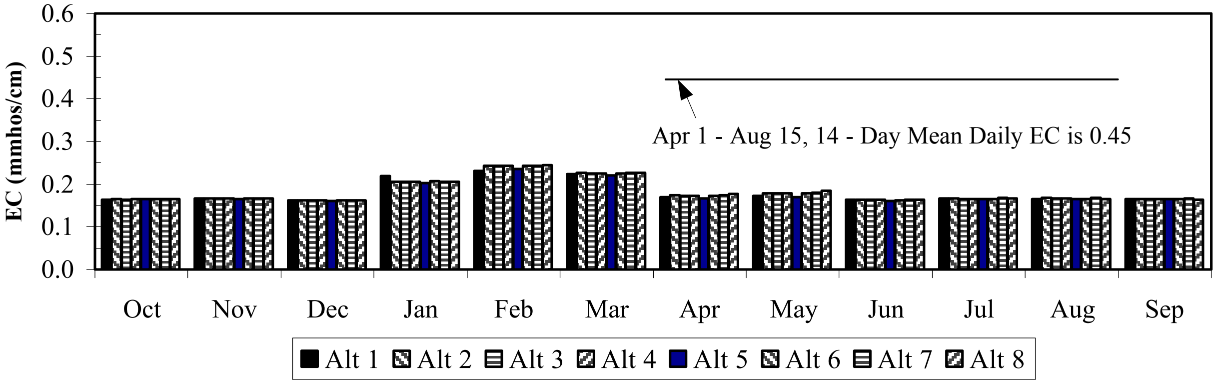
Figure VI-35
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Below Normal Years



Sacramento "40-30-30" **below normal** year (1979)

Salinity objectives are the same for D-1485 & Bay/Delta

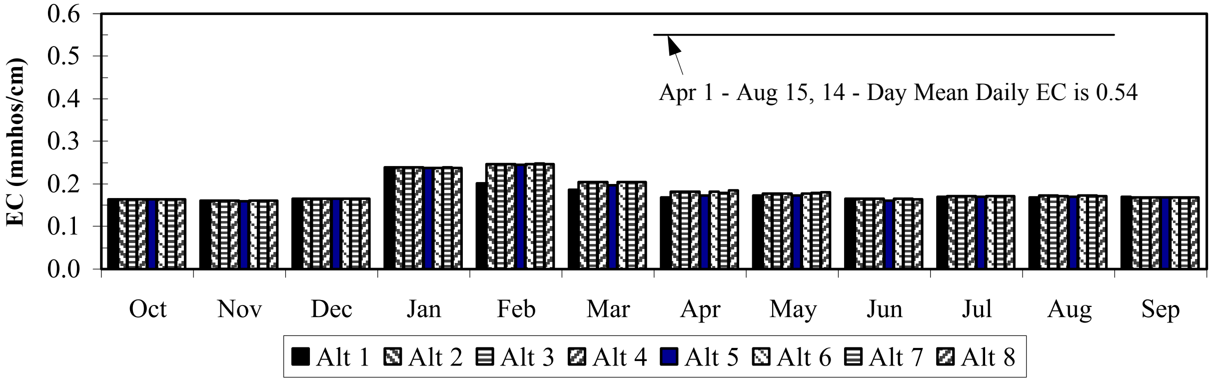
Figure VI-36
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Dry Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**dry** years averaged (1981, 85, 87 & 89)

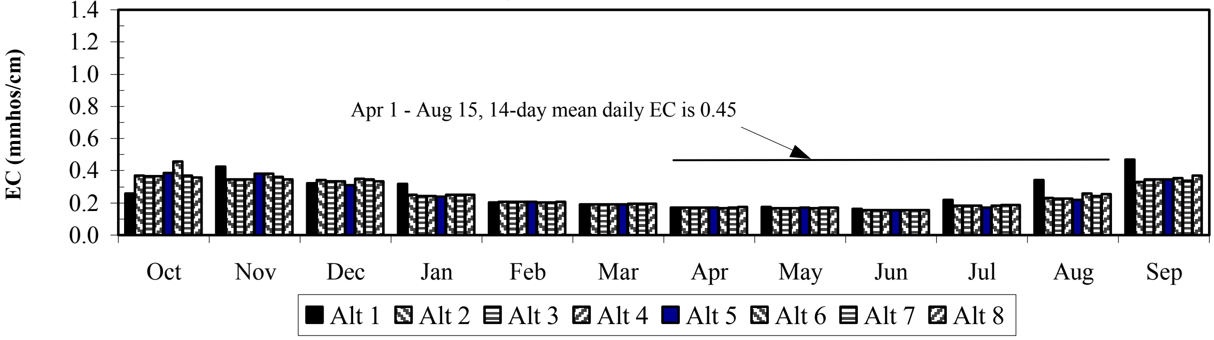
Figure VI-37
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Critical Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**critical** years averaged (1976, 77, 88, 90 &

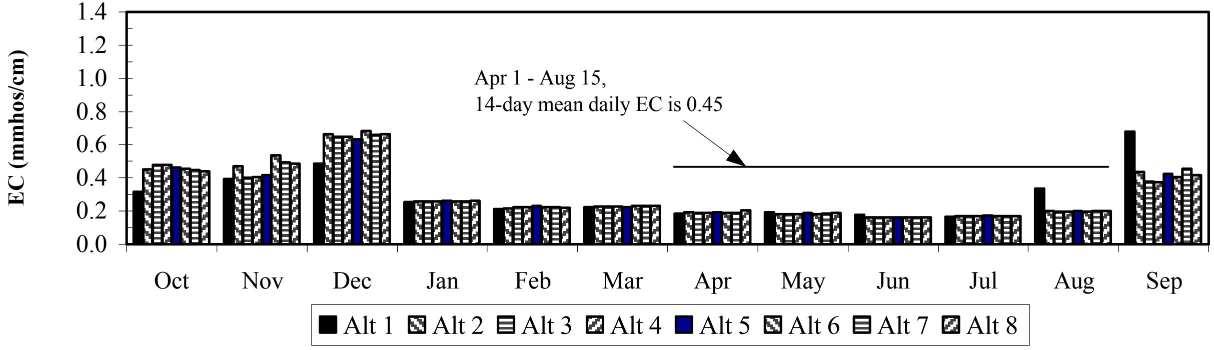
Figure VI-38
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Wet Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

Figure VI-39
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Above Normal Years

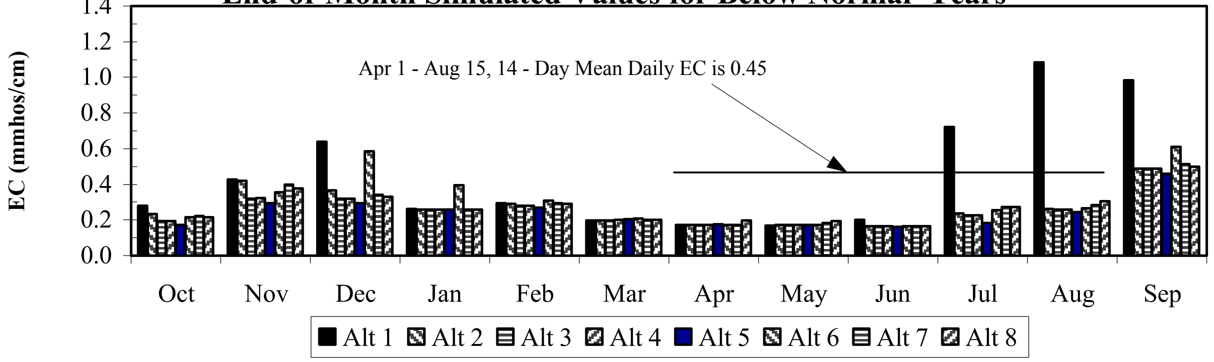


The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

Figure VI-40

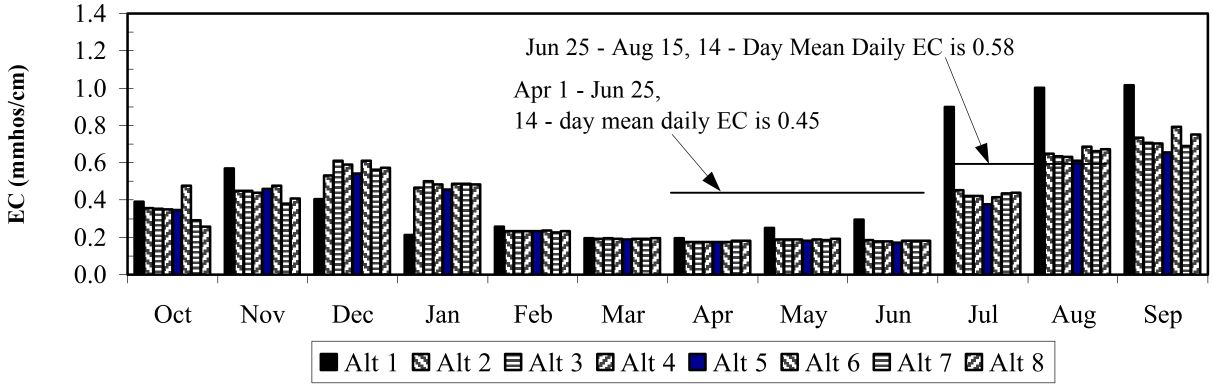
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Below Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **below normal** year (1979)

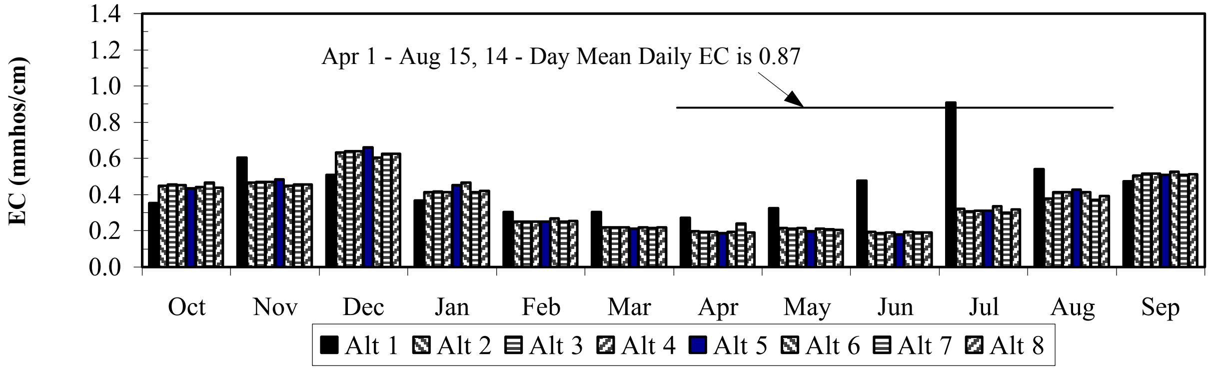
Figure VI-41
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Dry Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan.
The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **dry** years
averaged (1981, 85, 87 & 89)

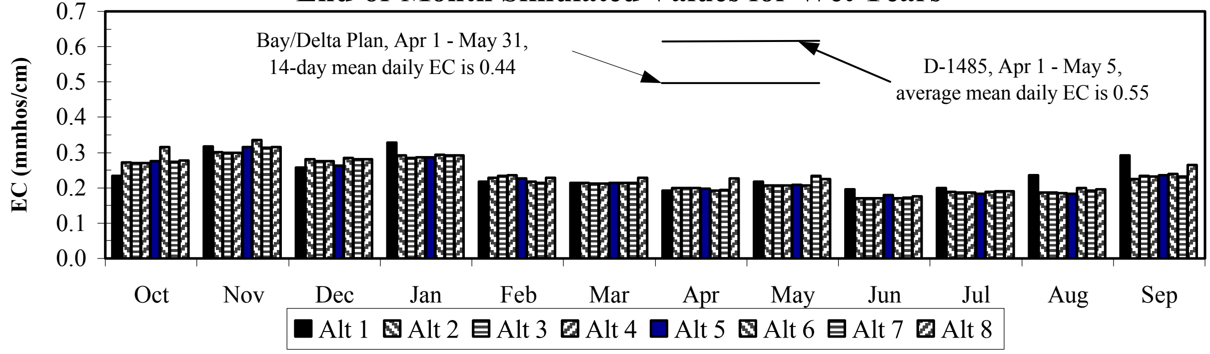
Figure VI-42
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Critical Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan.
The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **critical** years
averaged (1976, 77, 88, 90 & 91)

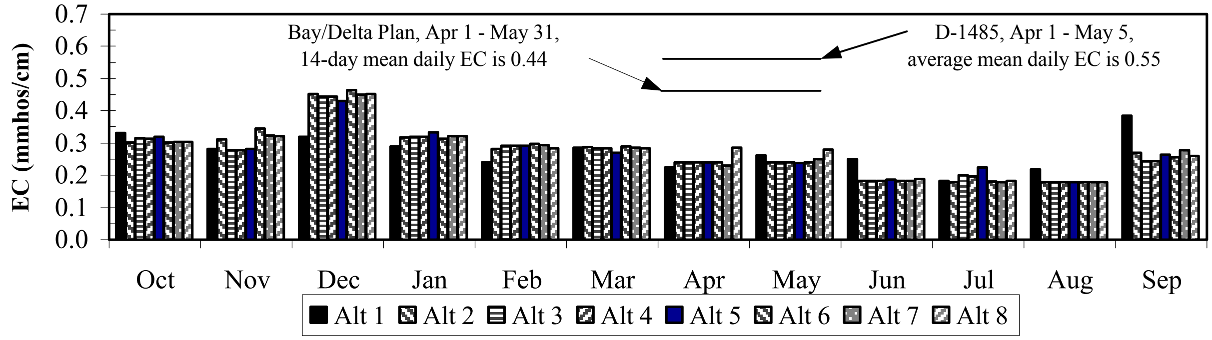
Figure VI-43
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Wet Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

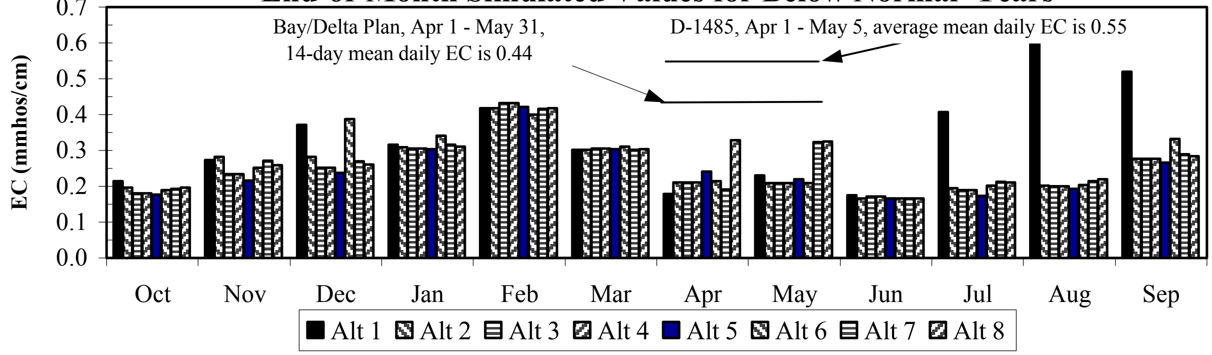
Figure VI-44
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Above Normal Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

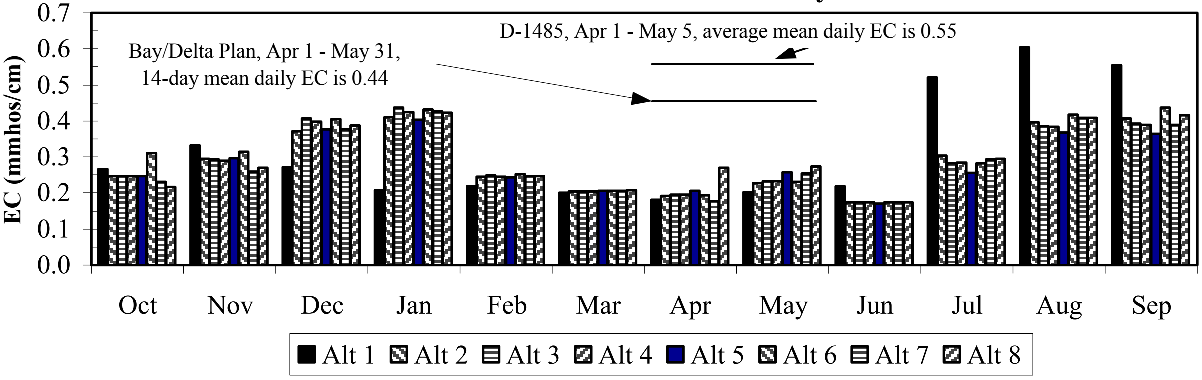
Figure VI-45
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Below Normal Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **below normal** year (1979)

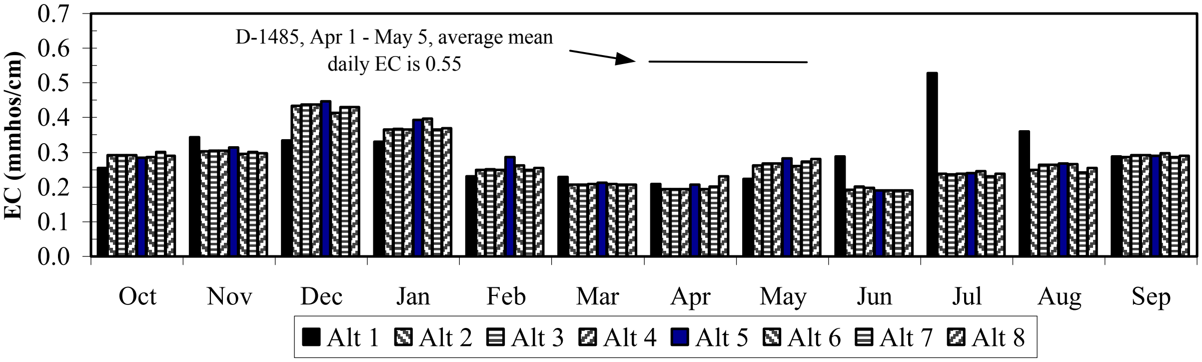
Figure VI-46
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Dry Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

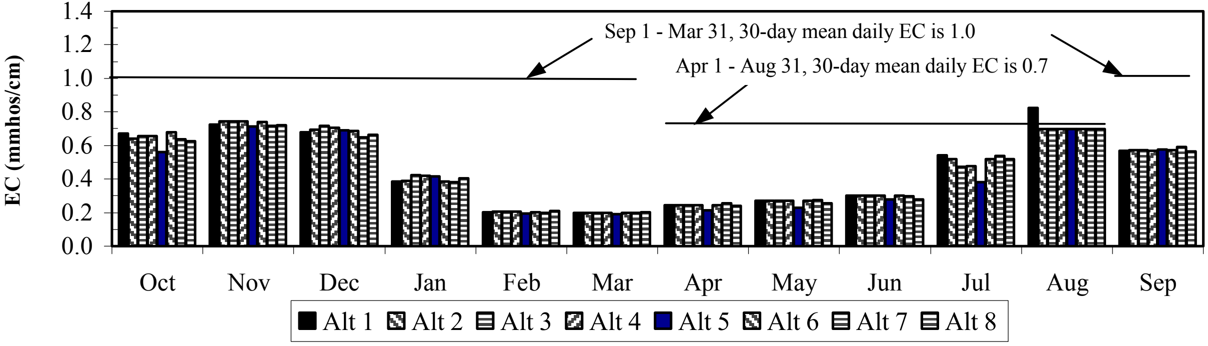
Figure VI-47
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Critical Years



The Bay/Delta Plan has no salinity objectives for critical years

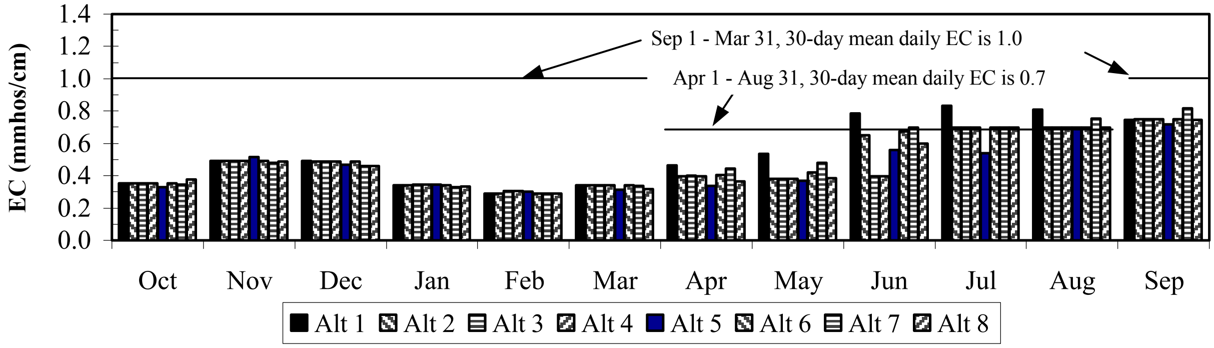
Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

Figure VI-48
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Wet Years



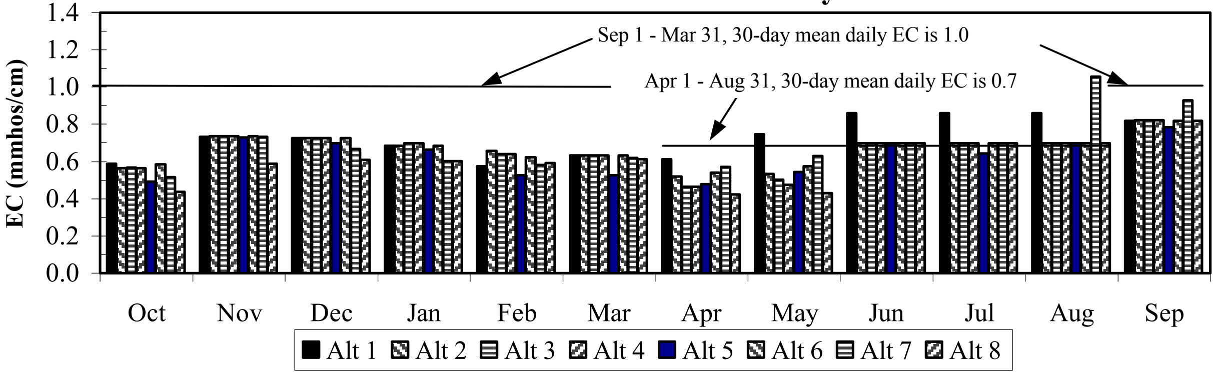
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure VI-49
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Above Normal Years



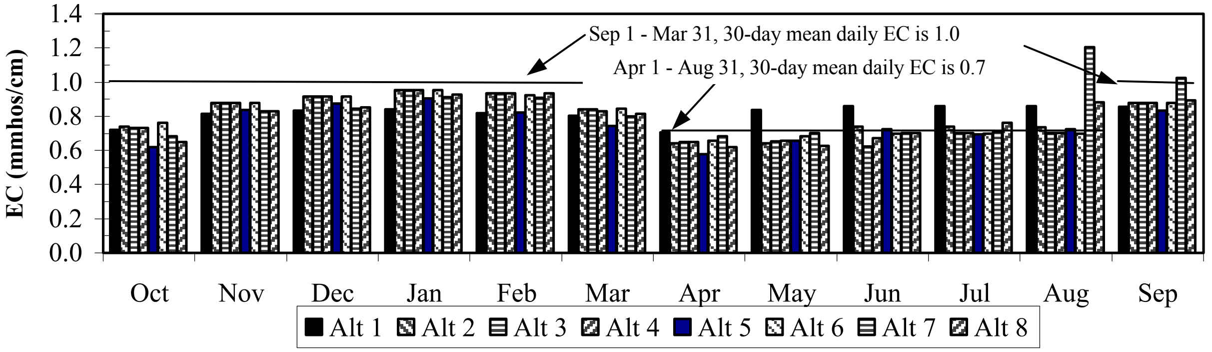
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" above normal years averaged (1979 & 84).

Figure VI-50
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Dry Years



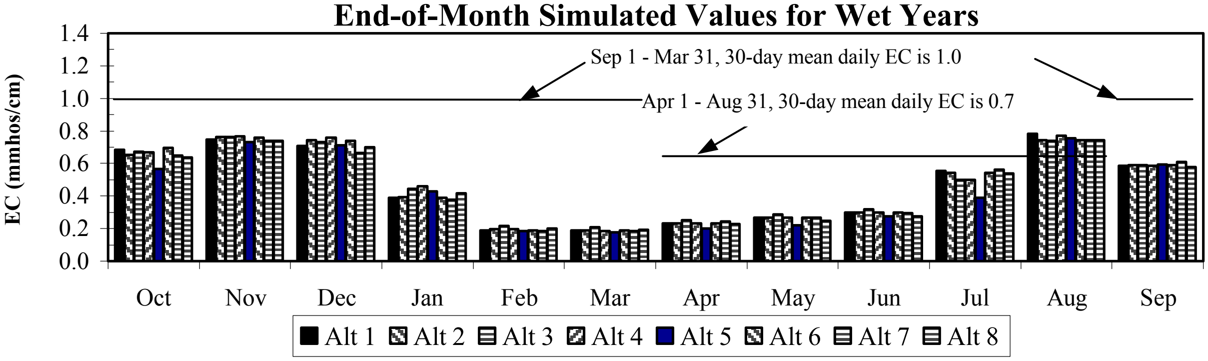
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure VI-51
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Critical Years



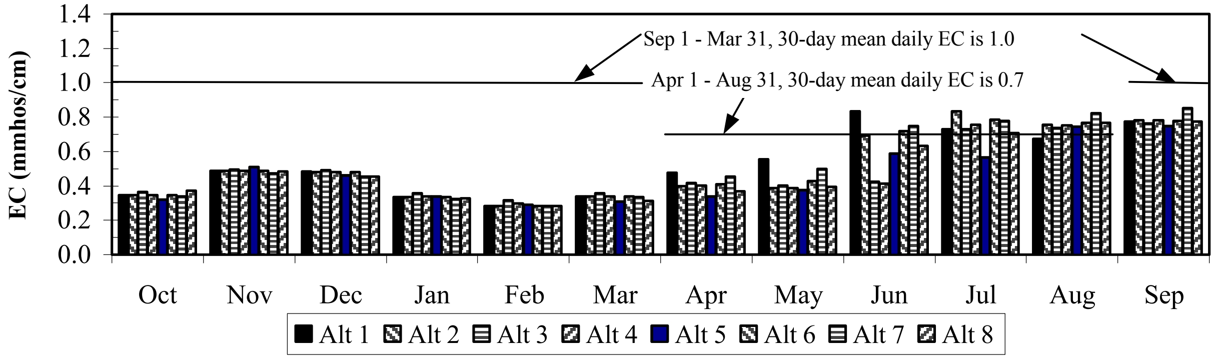
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

Figure VI-52
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Wet Years



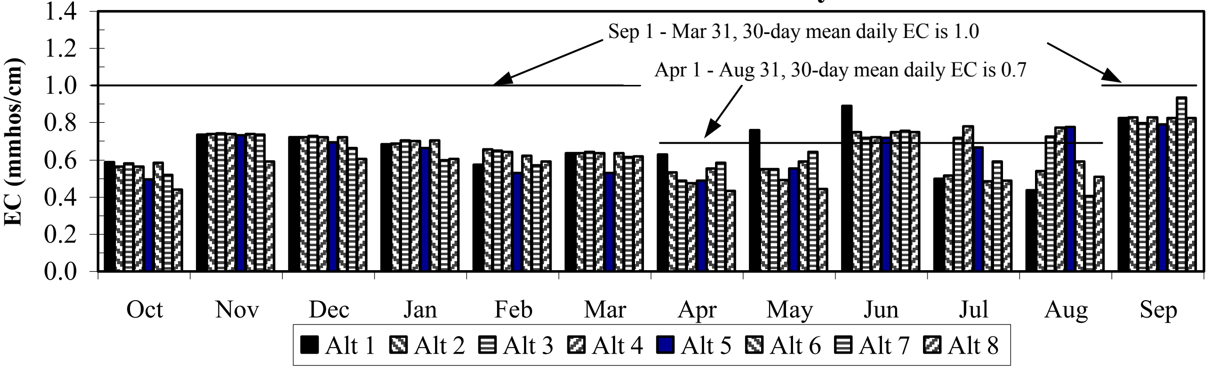
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure VI-53
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Above Normal Years



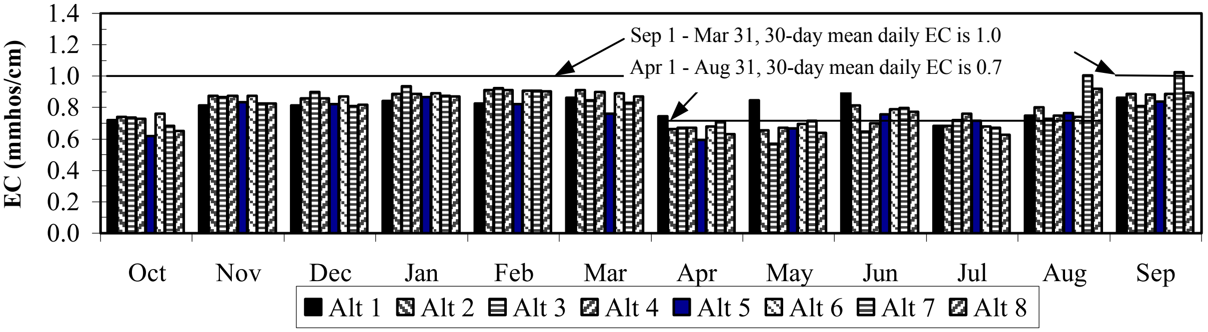
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" above normal years averaged (1979 & 84).

Figure VI-54
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Dry Years



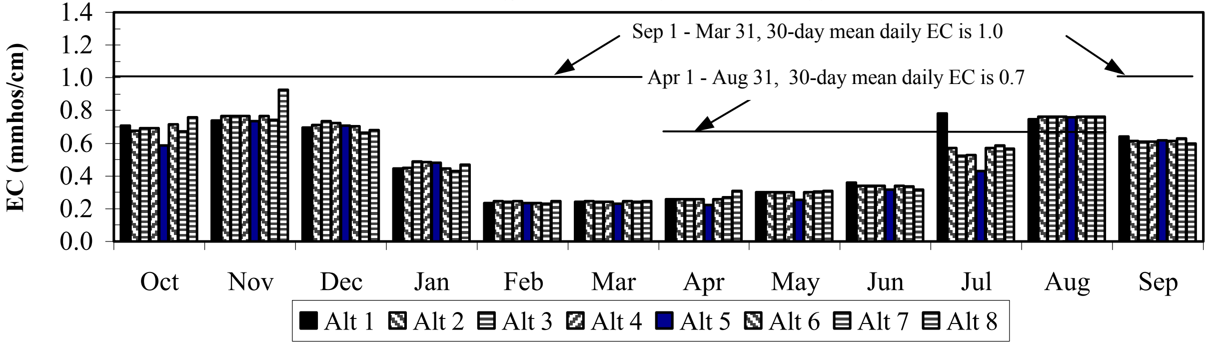
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure VI-55
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Critical Years



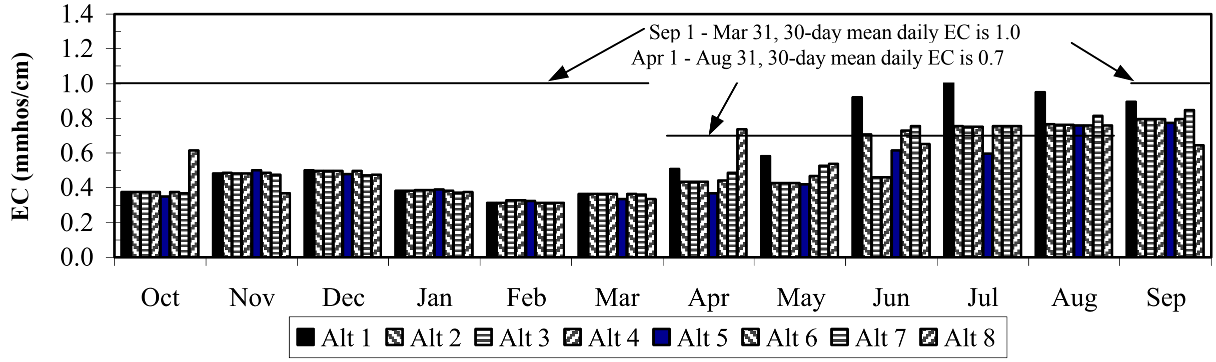
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

Figure VI-56
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Wet Years



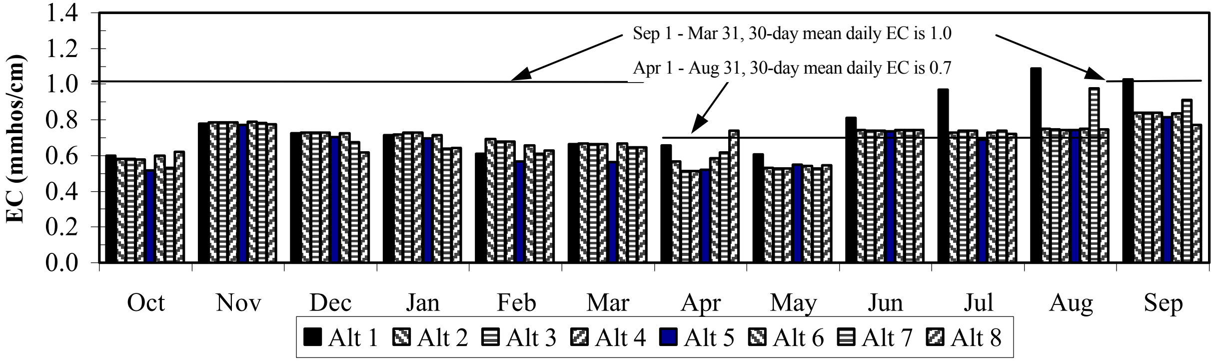
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure VI-57
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Above Normal Years



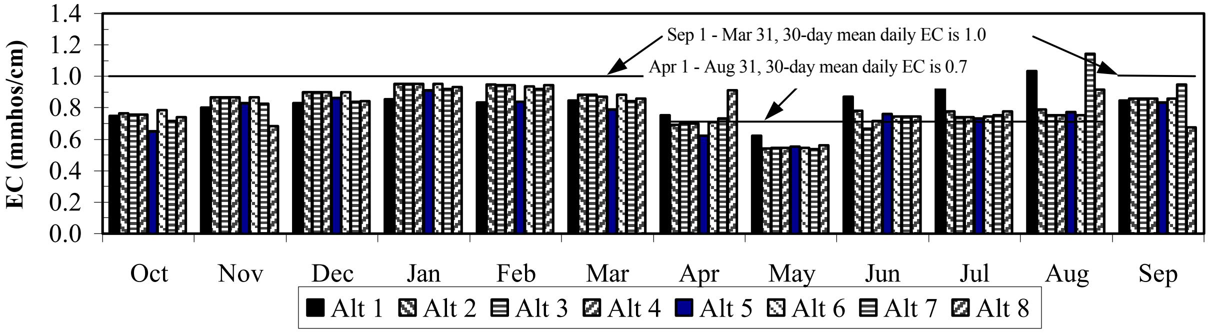
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" above normal years averaged (1979 & 84).

Figure VI-58
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Dry Years



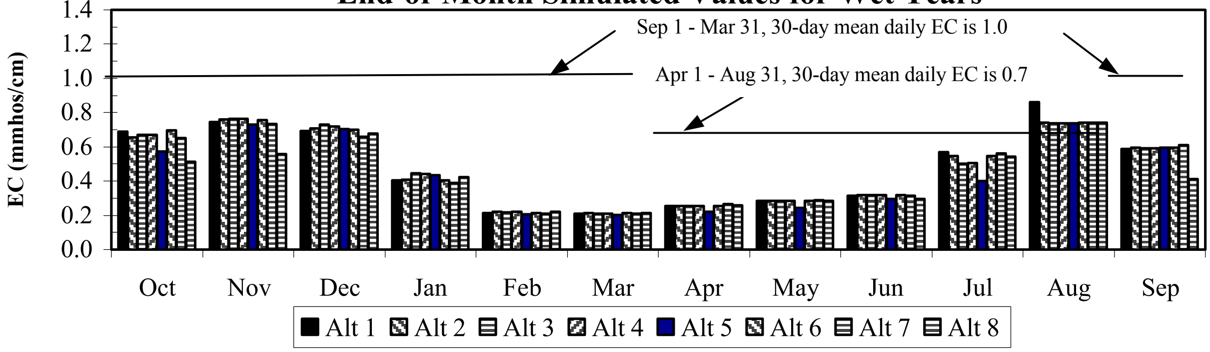
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure VI-59
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Critical Years



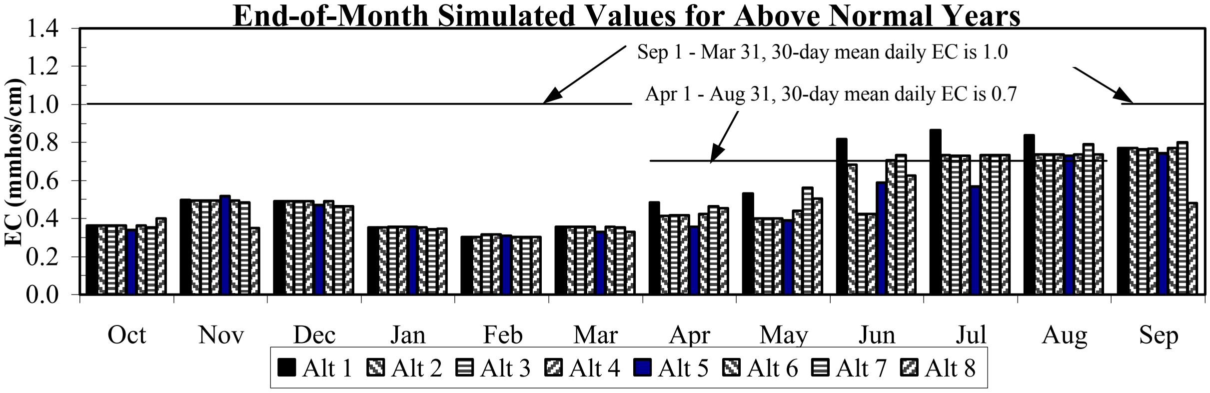
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

Figure VI-60
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Wet Years



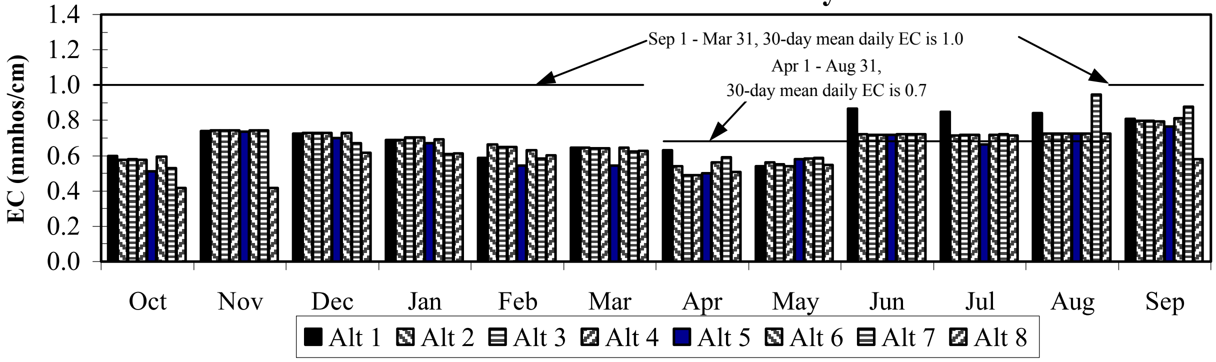
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure VI-61
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Above Normal Years



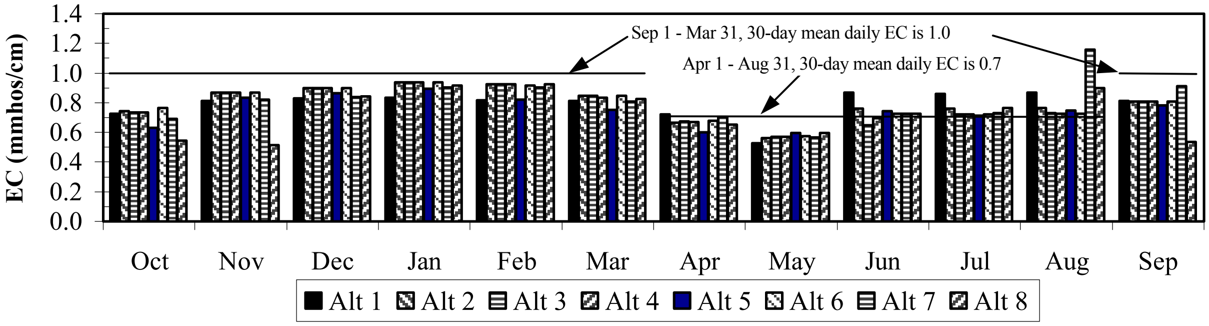
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" above normal years averaged (1979 & 84).

Figure VI-62
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Dry Years



Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure VI-63
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Critical Years



Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

In summary, the salinity conditions in the central and western Delta reflect the changes in outflow caused by implementation of the Bay/Delta Plan. The Bay/Delta Plan provides for higher outflows in spring and summer than the base case. These higher outflows deplete upstream reservoirs, which results in decreased outflows in some fall and winter months. Consequently, salinity conditions in the central and western Delta under the Bay/Delta Plan are generally better than or equivalent to the salinity conditions under the base case in the spring and summer but in some winter months salinity conditions decline in these locations in comparison to the base case. Nonetheless, water quality objectives will be met under all of the alternatives and the higher salinity conditions in some winter months will be offset by lower concentrations in the spring and summer. Therefore, there are no significant adverse salinity-related effects in the central and southern delta associated with implementation of the Bay/Delta Plan, and mitigation is not required. In addition, there is no clearly superior alternative among Alternatives 2 through 8 with respect to salinity conditions at these locations.

Salinity conditions in the southern Delta, while significantly affected by outflow conditions, are also significantly affected by salinity conditions in the San Joaquin River. The implementation of the Bay/Delta Plan will generally improve salinity conditions in the principal irrigation season (April to August) because the salinity objective is more restrictive than the salinity objective in the base case. Among Flow Alternatives 2 through 8, salinity conditions in the southern Delta are similar except with the exception of Flow Alternatives 7 and 8. For these alternatives, dilution water releases from New Melones Reservoir are capped and salinity will occasionally be higher than the other alternatives, especially in the late summer. For Alternative 7, salinity conditions will on occasion both exceed objectives and base case salinity conditions. This is a significant environmental effect. In the short term if this alternative is adopted, this significant effect cannot be mitigated. In the long-term, the water quality control actions described in Chapter VIII can be used as mitigation.

3. Fish and Aquatic Resources

The Bay/Delta Estuary is the largest estuarine system on the west coast of the United States and drains over 40 percent of California's land (SFEP 1992a). Estuaries are among the most productive ecosystems, supporting a wide range of fish and aquatic resources with their rich nutrients and diverse habitats. The estuary is a transition zone between the freshwater riverine and marine environments. Many of the organisms inhabiting this area have evolved special adaptations to cope with the variability in environmental conditions. The diverse assemblage of aquatic resources in the estuary is of great economic, aesthetic, and scientific value. A significant proportion of California's commercial fisheries depends on species that inhabit or migrate through the Estuary (USBR 1997a).

More than 130 species of fish inhabit the Bay/Delta Estuary for at least part of their life cycle (SFEP 1992a). Approximately ¼ of these species have been introduced. Some of the most abundant species (threadfin shad, white catfish, inland silverside, and striped bass) in the Delta were introduced from other areas (Herbold and Moyle 1989). Most historical introductions were intentional, for sportfishing, increased production, or control of other organisms. Recent introductions occurred primarily from ship ballast discharges.

a. General Factors. Significant population declines have occurred for many aquatic species in the Delta over the past few decades. Simultaneous declines of several species suggest overall impacts to the Estuary. The primary factors thought to significantly impact the Estuary and its inhabitants are: (a) reduced Delta outflow, (b) entrainment of organisms by export water pumps, (c) reverse flows in the Delta, (d) temperature fluctuations; (e) food limitations, (f) habitat loss; (g) introduced species, (h) harvest, and (i) contamination by pollutants. The relative magnitude of these factors and their complex interactions (synergistic or antagonistic) are not fully understood. The main factors are only briefly discussed here. A detailed discussion of these factors is available in the ER (SWRCB 1995).

Outflow. The seasonal pattern and annual volume of Delta outflow affects the abundance of many aquatic species dependent on the Delta. Outflow affects physical variables such as water temperature, salinity, pollutant concentrations, habitat availability for aquatic organisms, floodplain inundation, and the migration and transport of organisms through various life stages. Delta outflow affects both estuarine and anadromous species by altering the time required to move upstream or downstream and the availability of habitat. Transport time affects species that spawn upstream and depend on currents to carry their eggs and larvae to downstream nursery areas (SWRCB 1995). Generally, the higher the outflow, the farther downstream fish and invertebrates are dispersed (DFG 1993). Although fluctuations exist, outflow is generally highest from January to March and lowest from July through September. Flow during April, May, and June is particularly important to the reproductive success and survival of many estuarine species (SFEP 1992b). The reduction of spring outflows is considered to have adverse impacts on the aquatic resources. Monthly Delta outflow under the flow alternatives is shown in Tables VI-7 and VI-8. In general, Delta outflow is lower under Flow Alternatives 2 through 8 than in the base case in October through January. However, in the spring months, predicted outflow under Alternatives 2 through 8 is greater than outflow for the base case which may improve conditions for spawning and survival of aquatic resources in the estuary in this critical period.

Entrainment. Entrainment is broadly defined to include diversions of water that take, damage, or kill aquatic organisms (IEP 1996). Diversion of water and in-Delta pumping results in the entrainment and mortality of numerous aquatic organisms. In addition to the direct mortality that occurs with physical entrainment, losses are incurred through predation at intakes and fish salvage facilities, by the Delta fish salvage process itself (SWRCB 1995), and by removal from preferred habitat. Other factors that may influence entrainment are the type of diversion, the velocity caused by the diversion, type of screens or other protective devices, the time of year, and the species composition in the area. Smaller, less mobile organisms and critical life stages (eggs, larvae, and juveniles) of larger organisms are more susceptible to entrainment.

Sources of entrainment in the Delta include the SWP and the CVP export facilities and the approximately 1,800 other municipal, industrial, and agricultural diversions. Currently, SWP and CVP exports can reach approximately 10,000 cfs most of the year with higher levels possible in the winter. Agricultural diversions, which peak between April and August (with an estimated combined capacity of 4,000 cfs), may account for significant fish losses in localized areas of the Delta. Large numbers of fish including chinook salmon, striped bass, American shad, and delta smelt, are present during the diversion season. The majority of these diversions are not effectively screened.

Potential effects of entrainment vary among the flow alternatives. In general, flow alternatives with lower Delta outflow and higher exports have the highest entrainment potential. Over the 73-year period of record, exports are predicted to increase in May, June, July, and October under Alternatives 2 through 6; exports are predicted to increase in June, July, and October under Alternatives 7 and 8 compared to the base case. In critical years, exports are predicted to increase in April, June, and October under Alternatives 2 through 8 compared to the base case, except for Flow Alternative 8 in April. However, increased Delta outflows exceed these increased exports, except in October when Delta outflow decreases and exports increase. Alternatives 2 through 8 also have higher total outflow and lower total exports than the base case on an annual basis. Therefore, in general, these alternatives are not likely to result in significantly higher entrainment rates.

Reverse Flows. When SWP and CVP exports are high and Delta inflow is low, the net flow in the lower San Joaquin River and Delta channels south of the San Joaquin River are usually toward the southern Delta, rather than downstream towards Suisun Bay. Reverse flows may result in increased straying. Reverse flows may also carry eggs, larvae and young fish into the central and southern Delta, reducing survival because of poor rearing conditions, increased predation, and increasing vulnerability to entrainment at the export facilities and in local agricultural, municipal, and industrial diversions (SWRCB 1995).

Table VI-15 lists QWEST flows from the DWRSIM studies (QWEST is the net flow at Jersey Point on the San Joaquin River). To a certain extent, QWEST can be used as a measure of reverse flow conditions in Delta channels. As QWEST decreases, reverse flows in some Delta channels will increase. Model output indicates that predicted QWEST values for Alternatives 2 through 8 are generally higher than for the base case in February, March, and April, which may benefit aquatic resources in this important period. However, in the fall and winter months, November through January, QWEST is generally decreased under Alternatives 2 through 8 compared to the base case.

Table VI-15

QWest Flow

73-Year Period Annual Average (cfs)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	242	-1,134	785	4,357	7,402	6,367	3,334	3,539	3,245	-1,665	-3,111	-1,711
2	-185	-1,459	-126	3,704	7,587	6,355	4,595	2,820	1,057	-2,098	-1,792	-1,309
3	-126	-1,478	-220	3,567	7,473	6,330	4,625	2,861	1,579	-1,864	-1,769	-1,289
4	-164	-1,502	-188	3,555	7,448	6,365	4,621	2,851	1,547	-1,873	-1,764	-1,279
5	136	-1,580	-242	3,387	8,148	7,268	6,022	3,859	1,998	-916	-1,717	-1,215
6	-392	-1,678	-474	2,861	8,400	6,890	4,663	2,852	1,222	-2,229	-2,035	-1,656
7	239	-1,454	76	3,954	8,049	6,494	2,809	4,009	1,103	-2,252	-1,932	-1,362
8	-380	-1,399	-53	3,635	7,427	6,399	5,788	3,737	1,143	-2,321	-2,088	-1,340

Critical Period Annual Average (cfs)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	997	-927	-1,258	-361	-1,261	-1,244	2,717	425	-339	-2,769	-702	-399
2	309	-328	-2,670	-3,667	-73	331	532	-156	-65	-1,417	-360	-262
3	311	-423	-2,694	-3,722	-315	33	490	-251	387	-1,422	-74	-168
4	311	-426	-2,694	-3,716	-211	27	490	-256	399	-1,417	-74	-168
5	156	-717	-2,930	-3,776	-147	-325	1,465	525	286	-743	-235	-204
6	-214	-373	-2,627	-3,594	-82	610	448	-211	-17	-1,550	316	-276
7	381	-457	-2,664	-3,594	-301	-30	-1,168	957	230	-920	-237	-223
8	93	-359	-2,635	-3,667	-246	344	1,204	311	-266	-1,763	-153	-137

Temperature. Water temperature regimes affect migration, spawning, incubation success, growth, inter- and intra-specific competitive ability, and resistance to disease and parasites. Most successful fish spawning occurs within a narrow temperature range. Temperature variations outside this range may inhibit the development of eggs and sperm or reduce survival of eggs, larvae, and juvenile fish. Warmer water may result in emigration to areas of more suitable water temperature (Baxter 1960). The return to temperature regimes that existed under unimpaired conditions is, in general, beneficial to native organisms. Anadromous species depending on temperature to cue reproduction cycles are significantly affected by temperature changes. Of these, steelhead and chinook salmon have the lowest temperature requirements.

The effects of the flow alternatives on water temperature in the Delta are difficult to assess. In general, water temperatures in the Delta are affected primarily by ambient air temperatures. Minor temperature fluctuations in the Delta may be caused by the discharge of cooling water from power plants, release of warm water from reservoirs, changes in flow regimes, loss of stream side (riparian) vegetation, and climate changes (SWRCB 1995). The relative change in Delta outflow among the alternatives is low and is unlikely to result in detectable water temperature changes in the Delta. Flow Alternative 6, which recycles water, may increase San Joaquin River temperatures which may significantly affect migrating San Joaquin River salmon smolts. If this alternative were adopted, this significant effect could not be mitigated.

Food Limitation. Food supply affects the abundance of organisms at all trophic levels. Food may be limited in various ways, including decreased availability of nutrients, and decreased abundance and availability of preferred food items (SWRCB 1995). Studies have shown that small fish larvae are more susceptible to predation than large larvae. Thus, reduction in growth through food limitation may result in lower survival and recruitment even if larvae are not starving (IEP 1996). Introduction of species, such as the Asiatic clam, has increased competition for food and altered the food web. Increased flow increases habitat for food organisms in the Bay/Delta (USBR 1997a). Reduced diversions, in general, reduce the entrainment of food from the Delta.

The effects of the flow alternatives on available food supply are complex. However, the higher outflows and lower exports under Alternatives 2 through 8 compared to the base case in the spring months may increase available food supply in the Delta, because habitat for food organisms may be increased and entrainment of food organisms may be decreased.

Habitat Loss. Land reclamation and waterway modification have caused major ecological changes in the Estuary and throughout the Central Valley. These changes include the destruction of most tidal marshes in the Estuary and the seasonally flooded wetlands upstream of the Estuary (DFG 1993). Marsh and habitat losses are important factors that shape and control existing populations of organisms (SWRCB 1995). Losses of habitat have probably reduced the resilience of certain populations, resulting in decline of certain species. Reduced wetland habitat also reduces the buffering capacity of the area leading to more pollutants reaching the waterways. Urbanization increases the volume and decreases the runoff time of storm events, increasing the suspended solids load to the Estuary. The removal of riparian vegetation contributes to habitat loss. By maintaining bank stability, providing shade and instream cover for aquatic organisms, moderating water temperatures, contributing nutrients, and providing habitat diversity, riparian vegetation performs a variety of critical functions in stream ecosystems (USBR 1997a). The transformation of vast areas of freshwater marsh into cropland eliminated the contribution of marsh productivity to downstream food web organisms. Channelization has removed the shallow margins of most river channels, preventing the growth of submerged aquatic vegetation. Additionally, dredging and disposal of estuarine sediments temporarily increase turbidity and may disperse toxic pollutants and increase their availability to aquatic organisms (SWRCB 1995).

Flow changes due to implementation of the flow alternatives may result in slight changes in water elevations and wetted channel periphery in the Delta. Changes in wetted periphery may affect the availability of habitat for certain species of fish, such as Sacramento splittail, that depend on newly flooded areas for spawning and early rearing.

However, the project alternatives are not expected to have significant effects on available habitat. The alternatives will not result in direct loss of physical habitat. Changes in wetted channel periphery due to the flow changes are expected to be slight under the project alternatives compared to the base case. In the spring months, there may be a slight increase in wetted periphery and available habitat under Alternatives 2 through 8, since Delta outflow in February through June will be increased compared to the base case.

Introduced Species. The Bay/Delta Estuary is dominated by more than 150 introduced species of aquatic plants and animals (SWRCB 1995). Introduced species have caused major shifts in the food web dynamics that may drive some native species to extinction or inhibit recovery of depleted species (USFWS 1996). Many species were intentionally introduced to diversify the Estuary and control pests. Recent introductions have primarily occurred from ship ballast water. Competition for food and space, predation, habitat alteration, hybridization and pathogen transport are only a few of the adverse effects on the native species. More details are provided in the Environmental Report, Chapter V, page 22 (SWRCB 1995).

The flow alternatives are not expected to affect the introduction or propagation of introduced species. One of the primary introductions resulting in the food web shift, the Asiatic clam (*Potamocorbula amurensis*), may inhabit a smaller area with increased Delta outflow because of its preference for brackish waters, but there is no evidence that increased outflow will significantly affect abundance of the species.

Harvest. Over-exploitation of many Bay/Delta species, including mollusks, crustaceans, and fish, has contributed to their population declines. The number of spawning adults and the average age (potential fecundity) of the species are affected by harvest. Illegal harvest is of concern because of the difficulty in estimating the catch and the potential decrease in reproducing stocks. The flow alternatives will have no direct effects on harvest of Bay/Delta species.

Contaminants. Aquatic resources in the Bay/Delta may be affected by numerous sources of contaminants. Up to 40,000 tons of toxic pollutants enter the Estuary each year, mainly from non-point sources such as agricultural and urban runoff (SWRCB 1995). Other sources include municipal and industrial discharges, mine drainage, dredging, atmospheric deposition, accidental spills, leaks from waste disposal sites and marine vessel discharges (SFEP 1992a). Control of these sources requires full implementation and enforcement of existing regulatory controls and development of new initiatives to remediate existing conditions.

Pollutants are distributed in the Bay/Delta by a combination of physical, chemical, and biological processes (SFEP 1992a). Many contaminants naturally accumulate in the entrapment zone of the Estuary, which is preferred by many Delta organisms, increasing exposure. Some pollutants bioaccumulate in organisms by direct absorption or by ingestion of contaminated food. Bioconcentration can result in levels of pollutants accumulating in higher trophic levels.

Many pollutant-related effects in the Delta have been identified, although conclusive evidence quantifying these effects to individual populations and the whole aquatic community is hard to establish (SFEP 1992a). Toxic pollutants of particular concern are trace elements such as selenium, copper, cadmium, and chromium, organochlorine and other pesticides (DDT and Dioxin), and petroleum hydrocarbons like benzene and chrysene (USBR 1997a). Pesticides from urban and agricultural runoff are also of concern. Pollutant effects on organisms range from subtle physiological and reproductive changes to deformity and mortality (SWRCB 1995).

The flow alternatives do not directly affect contaminant input, concentrations, or effects. Flow alternatives may affect pollutant concentrations by altering dilution rates; however, changes in concentration are expected to be minor. Therefore, the alternatives are unlikely to have a significant effect on contaminant problems. No mitigation measures are required.

b. Impacts of Alternatives on Selected Species. The species discussed below are intended to be representative of the range of species present in the Bay/Delta system. They were selected because of their relative importance and the availability of data. Not all species have been as thoroughly studied as chinook salmon; these species are only qualitatively discussed. This section describes impacts to selected species in the Delta; section C describes impacts in upstream areas. Detailed descriptions of the selected species can be found in the Environmental Report (SWRCB 1995).

Salmon. Chinook salmon (*Onchorhynchus tshawytscha*), also called king salmon, has the broadest geographic range of the five Pacific salmon species and is the largest of the salmon species. Chinook salmon migrate to the ocean early in their life, mature in the ocean, and return inland as adults to spawn in freshwater streams (SWRCB 1995).

There are four distinct runs of chinook salmon in the Bay/Delta Estuary: spring, fall, late-fall, and winter. These runs are distinguished primarily by the time of entry into freshwater. Each run's migration pattern is different (identified in Chapter III, Table III-7). The winter-run chinook salmon are listed as endangered under both the state and federal endangered species acts. Spring-run chinook are listed as threatened under both the state and federal endangered species acts. Fall-run and late-fall run chinook are candidate species under the federal Endangered Species Act.

The CVP and SWP export facilities in the southern Delta adversely affect anadromous fish survival in the Delta through direct entrainment losses and indirect effects related to changes in the cycle, direction, and magnitude of flow in the Delta channels (USBR 1997a). Reduced inflow to the Delta in combination with increased diversions from the Delta have caused adverse impacts on anadromous and resident species by reducing net flow through the Delta and Delta outflow (USBR 1997a). Water diversions reduce survival of emigrating juvenile salmonids through direct losses at inadequately screened diversions and indirect losses associated with reduced stream flows. Fish losses at diversions result from injury, impingement, entrainment and predation. Higher flow rates through the Delta generally increase juvenile salmon survival by decreasing migration time, reducing exposure to diversions, and maintaining favorable water quality and habitat conditions during migration.

Fall-run and late fall-run chinook salmon juveniles are particularly vulnerable to entrainment related mortality at local diversions because the emigration period (April-June) coincides with the onset of the irrigation season (April-October). Losses are minimal during the summer from entrainment in irrigation diversions because most juveniles are not actively migrating during that period. Generally, most juvenile salmon salvaged in the spring at the Delta pumps are from the San Joaquin Basin. Salvage records from the SWP indicate salmon fry and smolts are entrained year-round but peak in the late winter and spring when the fall-run pass through the Delta. Losses of chinook salmon at the SWP and CVP Delta export facilities typically range from 400,000 to 800,000 fry and smolts per year. (USBR 1997d).

The USFWS salmon smolt survival model, described in Chapter IV, was used to evaluate the effects of the flow alternatives on survival of chinook salmon through the Delta. Survival indices for the following chinook salmon runs/lifestages were modeled:

- Sacramento River fall-run, late fall-run, and winter-run (smolts), and spring-run (young-of-the-year and yearlings)
- San Joaquin fall-run smolts (with and without the Head of Old River barrier)

The model formulas incorporate multiple-regression survival indices generated from coded-wire-tagged smolt survival studies. The models split the Sacramento and San Joaquin rivers into various reaches and use backward-stepping smolt mortality equations using selected environmental variables (flows, exports, and temperature) shown to affect smolt mortality in each reach. Both the Sacramento and San Joaquin models assume that smolts enter the various reaches of the model in the same proportion as flow. Water temperatures on the Sacramento River for November through March are assumed to be monthly constants of 53, 47, 47, 50 and 55 degrees, respectively. Historical temperature estimates from the USBR for both the San Joaquin and Sacramento rivers were used as input for April, May, and June. Survival indices were predicted over the hydrologic period of record (1922-1992). Model calculations are shown in Volume 2, Appendix 5.

Although none of the models predict absolute survival, they are a useful tool for obtaining a baseline index and comparing the effects of the alternatives. Given the fixed temperatures used in the models, the higher survival can be expected with higher flows, lower exports, and increased DCC closure.

Figures VI-64 through VI-70 show the predicted indices for through-Delta migration of each chinook salmon run by flow alternative and water year type. For all runs, predicted survival indices were generally higher in wetter water years. Indices predicted under Flow Alternatives 2 through 8, in general, were higher than in the base case.

For Sacramento River fall-run smolts (Figure VI-64), survival indices in a wet water year were similar in all of the flow alternatives and the base case. In all other water year types, survival indices for Flow Alternatives 2 through 8 were generally similar, and higher than in the base case.

For late fall-run smolts (Figure VI-65), predicted survival indices were higher under Flow Alternatives 2 through 8 than in the base case in all water year types. The difference between the flow alternatives and the base case increased in drier water years. Among the flow alternatives, survival indices were similar.

For winter-run smolts (Figure VI-66), survival indices were higher under Flow Alternatives 2 through 8 than in the base case in all water year types. The difference between the flow alternatives and the base case increased in drier water years. Among the flow alternatives, survival indices were similar.

For young-of-the-year spring-run (Figure VI-67), survival indices in wet, above normal, and below normal water years were similar in all of the flow alternatives and the base case. In dry and critical years, predicted survival indices under Flow Alternatives 2 through 8 were similar, and higher than in the base case.

For yearling spring-run (Figure VI-68), survival indices were higher under Flow Alternatives 2-8 than in the base case in all water year types. The difference between the flow alternatives and the base case increased in drier water years. Among the flow alternatives, survival indices were generally similar.

For San Joaquin fall-run (Figures VI-69 and VI-70), predicted survival indices were higher with the operation of the Head of Old River barrier than without the barrier, but the relationships between the flow alternatives and the base case were similar with and without the barrier. Predicted survival indices were higher under Flow Alternatives 2-8 than in the base case, except for Alternative 7 in a wet year. The difference between the flow alternatives and the base case generally increased in drier water years. Among the flow alternatives, Alternatives 5 and 8 were generally higher, and Alternative 7 lower, than the other alternatives.

While the smolt survival models indicate that factors such as flow, exports, barrier operations, and temperature affect smolt survival, other factors are likely to affect survival as well. These factors include contaminants, availability of suitable rearing habitat in the Delta, and introduced species impacts. Ocean harvest also has a significant effect on adult survival. The alternatives will not significantly affect these other factors. The general effects of the flow alternatives on contaminants and introduced species impacts are described previously in section B.3.a. The effects of the flow alternatives on the availability of rearing habitat for chinook salmon in the Delta could not be assessed directly, because the relationship between flow and rearing habitat availability has not been described.

Figure VI-64

Sacramento River Fall-Run Salmon Smolt Survival

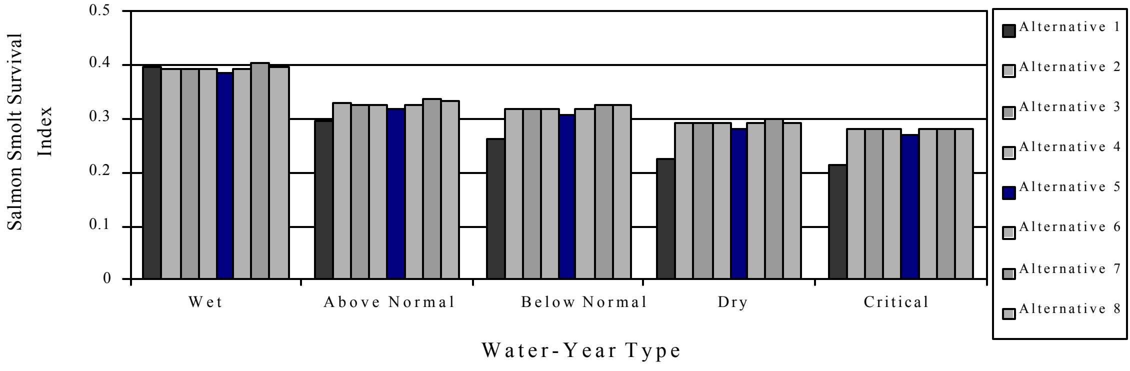


Figure VI-65
Sacramento River Late Fall-Run Salmon Smolt Survival Index

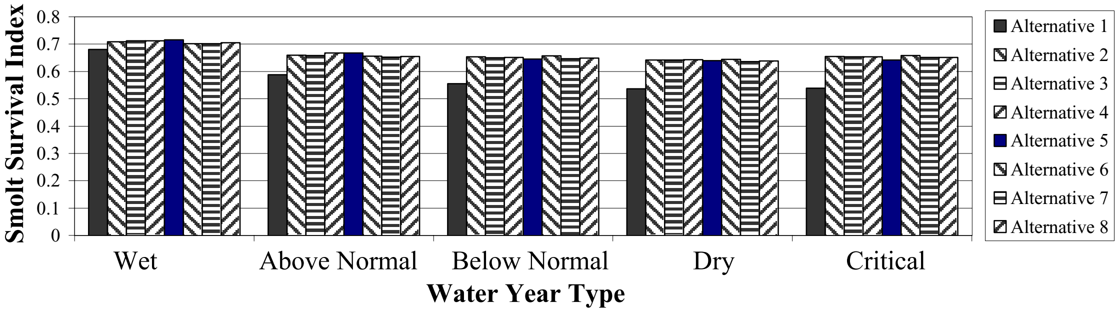


Figure VI-66
Sacramento River Winter Run Salmon Smolt Survival Index

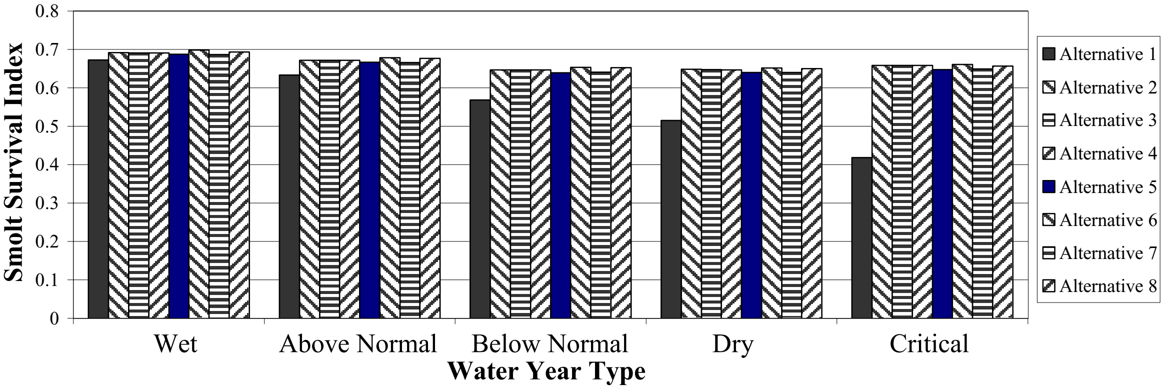


Figure VI-67
Sacramento River Young-of-the-Year Spring-Run Salmon
Smolt Survival Index

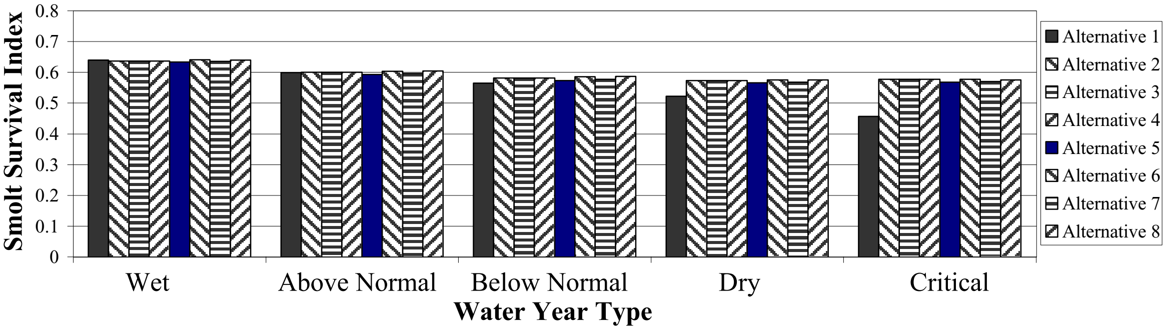


Figure VI-68
Sacramento River Yearling Spring-Run Salmon Survival Index

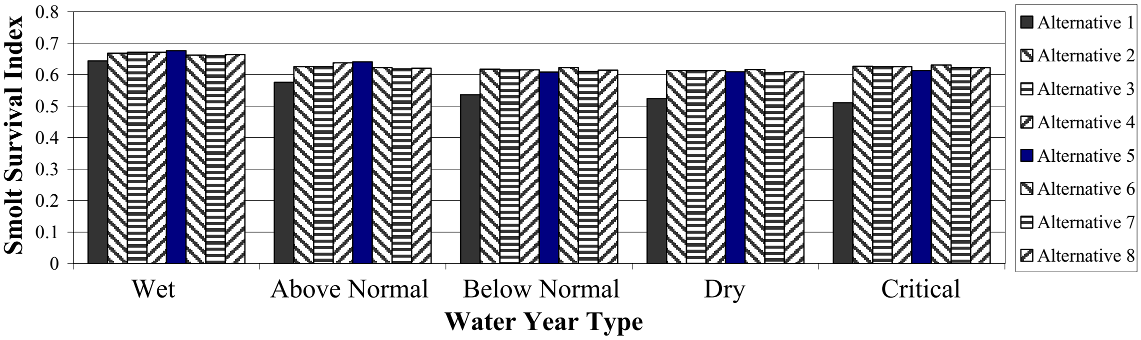


Figure VI-69
San Joaquin River Fall-Run Salmon Smolt Survival Index with Barrier

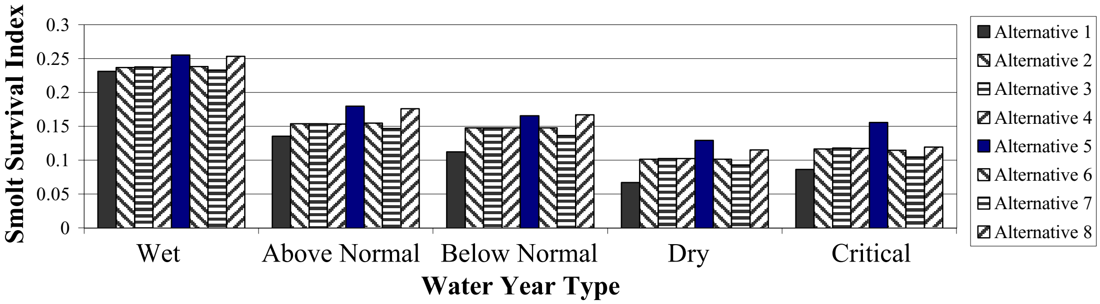
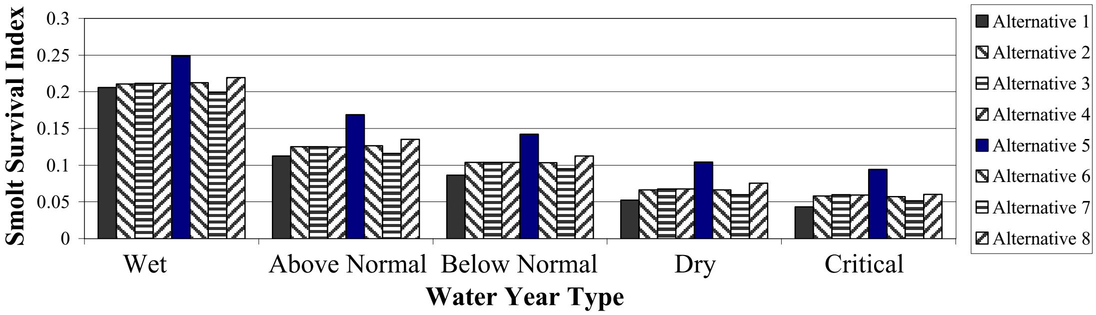


Figure VI-70
San Joaquin River Fall-Run Salmon Smolt Survival Index without Barrier



Recirculation under Flow Alternative 6 will increase the percentage of Sacramento River water that returns to the San Joaquin River. This may impact the imprinting of juvenile fall-run chinook salmon emigrating from the San Joaquin Basin in April and May. However, under current conditions, substantial quantities of Sacramento River water are imported into the San Joaquin basin. The significance of the potential impact of additional water imports is not known.

Steelhead. The flow alternatives have the potential to affect juvenile steelhead (*Onchorhynchus mykiss*) during the period of emigration through the Delta. Emigration through the Delta occurs from December through May, with peak migration occurring from February through April (DWR and USBR 1999). The primary factors affected by the flow alternatives that may affect survival of juvenile steelhead in the Delta are Delta inflows, exports, and closure of the Delta Cross Channel gates.

Operations of the CVP and SWP export facilities in the southern Delta may adversely affect steelhead survival in the Delta through direct entrainment losses and indirect effects related to changes in the cycle, direction, and magnitude of flow in the Delta channels (USBR 1997a). Reduced inflow to the Delta in combination with increased diversions may cause adverse impacts on anadromous species by reducing net flow through the Delta and Delta outflow (USBR 1997a). Higher flow rates through the Delta may generally increase steelhead survival by decreasing migration time, reducing exposure to diversions, and maintaining favorable water quality and habitat conditions during migration. Closure of the Delta Cross Channel gates may reduce entrainment of juvenile steelhead from the Sacramento River into the central Delta where survival may be lower.

In general, survival of juvenile steelhead emigrating through the Delta in the February through April period may improve under Flow Alternatives 2 through 8 compared to base case conditions. Delta inflow will generally be higher under Flow Alternatives 2 through 8 in March and April, but lower in February. Delta exports will be lower in the February through April period, except in April of critical water years. The DCC gates will be closed in the February through April period under Flow Alternatives 2 through 8 but the gates would be open most of this period under the base case condition.

Delta Smelt. Delta smelt (*Hypomesus transpacificus*) are small, annual, euryhaline fish that are endemic to the Sacramento-San Joaquin Delta Estuary (USBR 1997a). Delta smelt were once one of the most abundant fish species in the Delta, but their recent decline has led to the species being listed in 1993 as threatened under the state and federal Endangered Species Acts (USBR 1997a). Adults and older juveniles principally live in shallow water or near the surface in deeper water where they feed on zooplankton, particularly copepods. After release during spawning, delta smelt eggs sink toward the bottom and adhere to any available hard substrate (USBR 1997a). Little is known about the annual movement of smelt in the Bay/Delta. In some years, more fish are found in the north tributaries of the Estuary than in others.

Entrainment is another key factor in the decline of delta smelt. The primary mechanism for increased entrainment is low outflow and high exports, which shift the population closer to the diversions (IEP 1996). Entrainment is generally highest during drier years, suggesting that a greater proportion of smelt is entrained when the population is most sensitive. The entrainment of delta smelt by SWP and CVP pumps predominately affects spawning adults, larvae, and young juveniles. Prespawning adults and older juveniles inhabiting the western Delta and Suisun Bay are probably beyond the influence of the SWP and CVP pumps (USBR 1997a). Entrainment losses at agricultural diversions are unknown but are assumed to be significant because of the large number of diversions (1,800) and total diversion capacity (4,000 cfs). Diversions in the northern and central Delta where they are most abundant are likely the greatest source of entrainment (USFWS 1996).

Reduced Delta outflow also has a significant effect on delta smelt abundance (USBR 1997a). Outflow affects survival because smelt spawn in the Delta and young are transported to downstream nursery areas. High flows increase survival by dispersing smelt over a greater area of the Estuary, by increasing the available food supply, and by reducing vulnerability to predation, entrainment, and contaminant effects in upstream channels (DFG, 1993). However, extremely high Delta outflow, as in 1982-1983, may also affect delta smelt by flushing them out of the system. High February-June flows are thought to be necessary for transport of larval and juvenile smelt away from export areas in to productive rearing habitat (USFWS 1996). Increased exports and the associated adverse changes in the position of X2 and reductions in net westerly flows measured by QWEST in the spring months are important factors affecting delta smelt abundance. There is a weak positive correlation between abundance and the number of spring days that the entrapment zone remains in Suisun Bay (IEP 1996).

Contaminants have also been found to have potential population-level effects on delta smelt abundance. An inverse relationship between copper applications to rice fields and delta smelt midwater trawl abundance has been identified in a preliminary study (IEP 1996).

The USFWS issued a biological opinion to the SWP and the CVP that operation to the objectives in the Bay/Delta Plan would not cause jeopardy to delta smelt using the current facility configuration and operations (USFWS 1995). The requirements of this opinion are generally met with Alternatives 2 through 8, and improve conditions for delta smelt. The export and outflow differences among Flow Alternatives 2 through 8 are probably not large enough to cause a substantial effect on delta smelt populations. Flow Alternative 5 may be beneficial to delta smelt because of the higher Delta outflows.

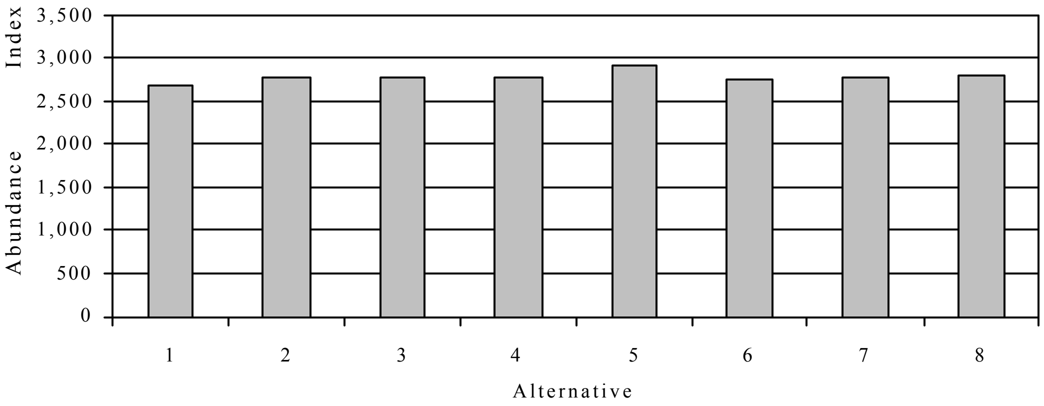
Longfin Smelt. Longfin smelt (*Spirinchus thaleichthys*) are a small planktivorous fish that can tolerate salinities ranging from fresh water to sea water and are an important component of the estuarine food chain in that they are eaten by predatory fish, birds, and marine mammals (BDOC 1993). Longfin smelt migrate from salt and brackish water to the Delta during the winter and spawning occurs in the Delta from December to April (Stevens 1983). They deposit adhesive eggs in fresh to brackish water over sandy-gravel substrates, rocks, or aquatic vegetation in channels of the eastern Estuary. Longfin smelt larvae are then transported to nursery areas by freshwater outflow (SWRCB 1995).

The factor most closely associated with the recent decline in the abundance of longfin smelt is the decrease in outflow during the winter and spring months when the smelt are spawning (SWRCB 1995). In low outflow conditions, adults must migrate further upstream to find suitable freshwater spawning habitat. Reverse flows, which draw freshwater from the Sacramento River, may entrain adults into the southern Delta where adults and their larvae are more vulnerable to entrainment in diversions and other causes of mortality (USBR 1997a). Adequate flow is crucial for the survival of longfin smelt because it provides an increased area of suitable brackish water rearing habitat.

A significant positive relationship exists for longfin smelt abundance and December to May Delta outflow (SWRCB 1995). Figure VI-71 shows the predicted abundance index for each of the flow alternatives, based on the outflow/abundance relationship. The indices predicted for Alternatives 2 through 8 are slightly higher than for Alternative 1, the base case. The indices for Flow Alternatives 2 through 8 are similar. Slightly higher outflow in Flow Alternative 5 resulted in a slightly higher index. The significance of these slight differences in predicted abundance indices is unknown.

Figure VI-71

Predicted Abundance Indices for Longfin Smelt



Sacramento Splittail. The Sacramento splittail (*Pogonichthys macrolepidotus*) are a highly fecund large minnow endemic to the Bay/Delta Estuary with a moderate tolerance for salt water (SWRCB 1995). Sacramento splittail can live 5-7 years and typically begin spawning at 2 years of age in areas of submerged vegetation in slow moving stretches of water. Hatched larvae remain in shallow, weedy areas until they move to deeper habitat in the late summer. Neomysis is the primary food for splittail, but they will opportunistically feed upon earthworms, clams, insect larvae, and other invertebrates. Splittail, in turn, are preyed upon by striped bass and other predatory fish in the Estuary (SWRCB 1995).

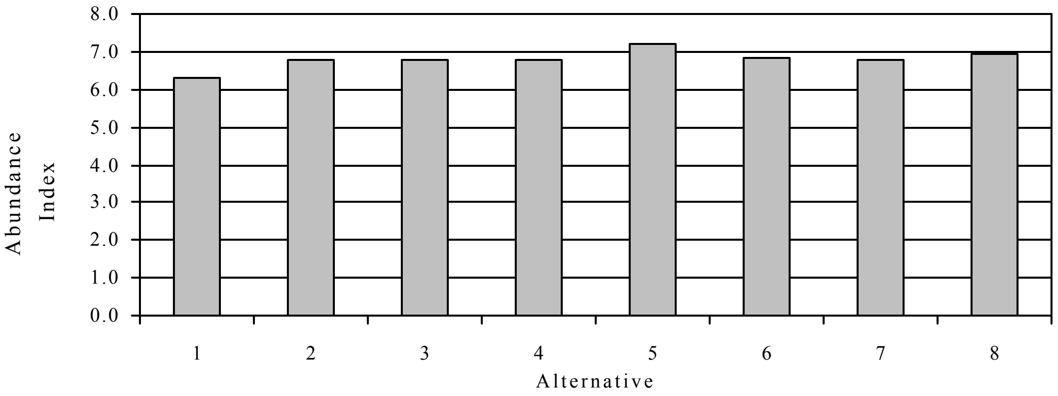
The flooding of spawning habitat and heavy feeding on terrestrial organisms prior to spawning are two mechanisms by which habitat conditions influence successful splittail reproduction (IEP 1996). The operation of upstream storage reservoirs and diversions, including SWP and CVP facilities, may adversely affect spawning by reducing freshwater flow and the availability of temporarily flooded habitat (USBR 1997a). Consequently, spawning adults are forced to use less favorable habitat, thereby decreasing reproductive success (USBR 1997a). Freshwater flow duration may be an important factor in determining egg and larval survival because larval splittail are commonly found in the shallow, weedy areas where spawning occurs. Additionally, reduced duration of flooding during spawning and early rearing may degrade conditions necessary for optimal egg and larval development, or may desiccate these habitats before larvae are able to move to other rearing areas.

Sacramento splittail are entrained in Delta water diversions. However, Sommer et al (1997) suggests that entrainment at the south Delta pumps does not have important effects on the population, although individual year classes may be impacted. Although adult splittail are entrained year-round, most adults are entrained between January and April, which coincides with the migration and spawning period. Juveniles account for the majority of splittail entrained and most of the juvenile entrainment occurs from April to August (USBR 1997a). Late winter and spring Delta diversions coincide with the splittail spawning period. Splittail are most abundant in the north and western Delta (USFWS 1996). Entrainment appears to be proportional to abundance (USFWS 1996).

A relationship exists between juvenile Sacramento splittail abundance and March to May Delta outflow (SWRCB 1995). Figure VI-72 shows the predicted abundance indices for each of the alternatives. The indices predicted for Alternatives 2 through 8 are slightly higher than Alternative 1, the base case. The indices for all of the flow alternatives are similar, particularly Alternatives 2, 3, 4, 6, and 7. Indices for Alternative 5 are slightly higher than for the other alternatives. Alternative 8 has the next highest index. The significance of these slight differences in predicted abundance indices is unknown.

Figure VI-72

Predicted Abundance Indices for Sacramento Splittail



Striped Bass. Striped bass (*Morone saxatilis*) flourished in the Bay/Delta Estuary after their introduction from their native Atlantic Coast estuaries in 1887. Within a decade, striped bass became established in the Bay/Delta Estuary and supported a large commercial fishery until 1935. At that time, the commercial fishery was outlawed and became exclusively a sport fishery (USBR 1997a). The annual catch reported for the sport fishery was larger than that for the commercial fishery. In 1955, catch in the annual sport fishery exceeded four million pounds (Skinner 1962). Sport fishery and mark-recapture data indicated the population plummeted from around three million fish in the early 1960's to approximately 1.7 million in the late 1960's (USBR 1997a). The population, estimated at 1,948,000 adults in 1967, eroded to approximately 574,000 in 1990 (DFG 1993). Slight recovery is evident in population estimates for 1994 (1,192,000 adults) and 1996 (775,000 adults).

Bay/Delta striped bass spend the majority of their lives in the Estuary and along the Pacific coast, within a few miles north and south of the Golden Gate. Once this anadromous fish reaches maturity it migrates upstream into fresh water to spawn in the spring. Approximately one-half to two-thirds of the striped bass spawn in the Sacramento River system with the remainder spawning in the lower San Joaquin River (SWRCB 1995). Most spawning occurs in moderately swift currents when the water is between 61 and 69 degrees. Striped bass spawn in small groups by releasing eggs and sperm simultaneously at the surface of main currents. Semi-buoyant eggs are carried downstream with the currents towards the Delta. Eggs hatch in two or three days and larvae begin feeding on small zooplankton after absorbing their yolk sacs. Upon reaching the western Delta, their primary rearing area, they are large enough to begin feeding on opossum shrimp (*Neomysis mercedis*). This remains a major food source until their second year when they become more opportunistic and feed on bay shrimp and small forage fish. In three or four years, bass reach maturity and migrate upstream to spawn. Striped bass may live for twenty or more years. Older and larger, which are more fecund, are no longer present in the Bay in great numbers. The majority of the adult population in the Bay/Delta is in the 4 to 7 year age classes.

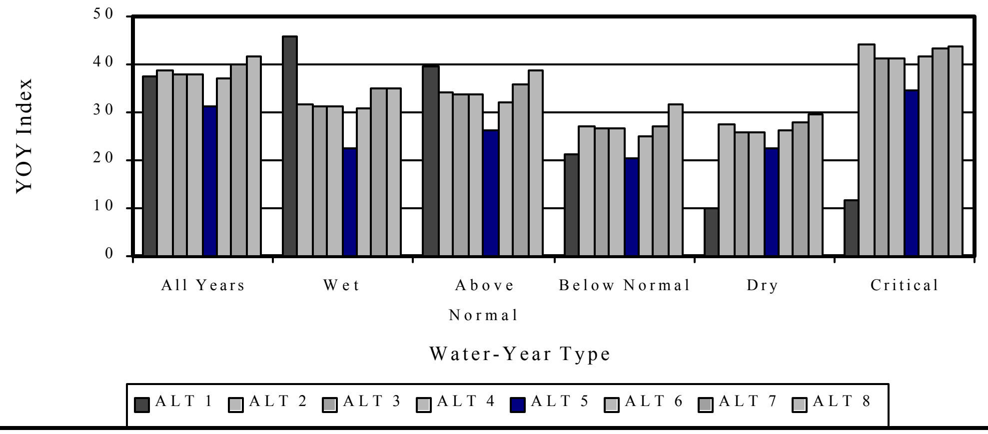
There are many possible factors contributing to the declining abundance of adult striped bass in the Bay/Delta Estuary including survival of critical life stages, entrainment in water diversions, food limitations, exposure to contaminants, and reduced habitat. Recent literature indicates that the population may also be affected by loss of older fish and declining carrying capacity (Kimmerer 1997).

Changes in flow and Delta exports due to the flow alternatives will primarily affect the young-of-the-year striped bass lifestage. The effects of the flow alternatives on young-of-the-year striped bass abundance were modeled using a multiple regression relating total young-of-the-year striped bass abundance at 38 mm. to the mean April to July San Joaquin River flow past Jersey Point, $\log_{10}$ net Delta outflow, and total Delta exports (including CVP, SWP, Contra Costa Canal, and miscellaneous Delta diversions) (Lee Miller, DFG, personal communication). The regression is described in Chapter IV; regression calculations are shown in Volume 2, Appendix 5.

Figure VI-73 shows the predicted young-of-the-year indices for the flow alternatives, by water year type and all years combined. The pattern of predicted indices among Flow Alternatives 2 through 8 was similar in each water year type. Indices for Alternatives 3, 4, and 6 were similar, and higher than for Alternative 5, but lower than for Alternatives 2, 7, and 8. Indices predicted for the base case varied significantly among water year types, being higher than Alternatives 2 through 8 in wet and above normal water years, but generally lower than Alternatives 2 through 8 in below normal, dry, and critical years.

Figure VI-73

Predicted Striped Bass Young-Of-Year Index



In all years combined, the predicted young-of-the-year index for the base case was similar to Alternatives 2, 3, 4, and 6, higher than Alternative 5, and lower than Alternatives 7 and 8. In general, Flow Alternative 5 may have a slight adverse impact on young-of-the-year abundance compared to the base case; Flow Alternatives 7 and 8 may result in slightly higher abundance than in the base case.

The observed differences in abundance indices are primarily due to changes in total Delta exports. Of the flow/export variables included in the regression, mean April – July total Delta exports had a dominant effect on the predicted abundance indices. In general, total exports were higher in this period under Alternative 5, and lower under Alternatives 7 and 8, than under Alternatives 2, 3, 4, and 6.

The predicted changes in young-of-the-year abundance under Alternative 5 may have a slight adverse impact on the adult striped bass population. Striped bass losses under Alternative 5 could be mitigated through funding of additional stocking.

American Shad. American shad (*Alosa sapidissima*) are members of the herring family. American shad are oceanic as adults except for a brief spawning run in fresh water (SWRCB 1995). River flow is the only factor known to correlate with American shad abundance. Higher flow probably improves attraction of upstream migrating adults (the number of adults spawning in a tributary is proportional to the amount of flow from that tributary), increases upstream spawning area, and improves rearing habitat (IEP 1996). Hypotheses explaining reduced abundance at lower Delta outflows include the following: (1) water velocities needed to suspend eggs and larvae off the bottom are reduced, increasing the likelihood that eggs and larvae will settle to the river bottom and die, (2) warmer water temperatures associated with lower river flows reduce survival of eggs and larvae, (3) eggs and larvae are more susceptible to exposure to toxic substances in the rivers and Delta, (4) a lower proportion of larvae are carried to the Delta, and (5) a higher proportion of larvae are drawn into the central and south Delta where vulnerability to entrainment is greater (USBR 1997a).

The survival of shad eggs is also closely associated with water temperature. Less than optimal water temperatures may cause poor development, reduced growth rates, and increased mortality of developing larvae (USBR 1997a). The optimum temperature range for spawning is 62-68°F, with mortality increasing with an increase in temperature, especially above 68°F (USBR 1997a).

High Delta outflow and reduced exports would be expected to minimize impacts. Flow Alternative 5 has the highest outflow but also has increased exports. Therefore, Delta conditions for survival of American shad may be similar under all of the alternatives.

Starry Flounder. The starry flounder (*Platichthys stellatus*) is a flatfish that feeds on benthic organisms. It is common downstream of the Delta in Suisun and San Pablo bays and lives on all types of substrates except rocky areas (Baxter 1960). The starry flounder is a euryhaline fish, which enables it to tolerate salinities ranging from nearly seawater to freshwater (Turner 1966), and may be found in the Bay during all stages of life (USBR 1997a).

Eggs, larvae, and small juveniles of the starry flounder are pelagic (open water) and primarily inhabit the upper water column (Hergessell 1993). Larval starry flounder consume phytoplankton and zooplankton. Juveniles smaller than four inches in length feed upon copepods and other small crustaceans. Larger juveniles and adults are benthic, and consume crustaceans such as *Crangon*, Dungeness crabs, worms, clams, and occasionally fish (USBR 1997a). Starry flounder are preyed upon by marine mammals and piscivorous birds. They are also prey of striped bass in both the fresh and marine waters of the Bay/Delta Estuary (DFG 1992b).

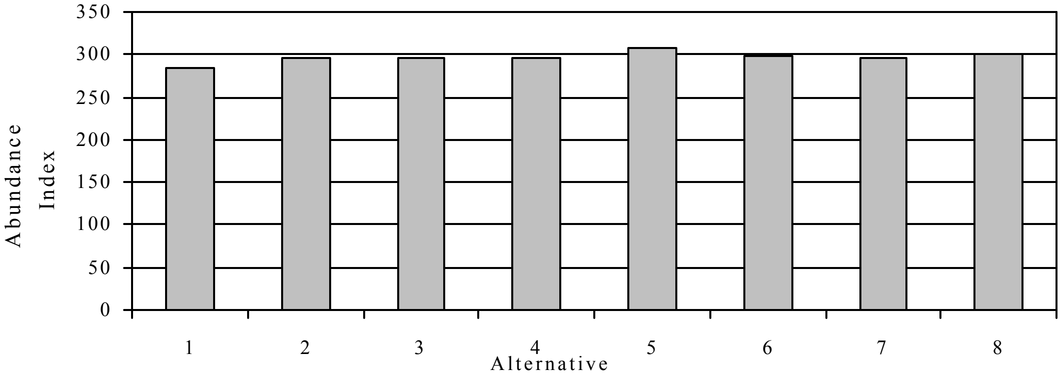
Outflow is an important factor in the survival of starry flounder. Starry flounder spawn in winter and early spring and abundance is correlated to outflow during the same period (DFG, 1993). Moderate to high outflow increases the amount of rearing habitat in San Pablo, Suisun, and Honker bays (IEP 1996). The amount and location of shallow, brackish water nursery habitat for recently settled and small juveniles is most important from March through June, which is also when most of the larvae and juvenile immigration occurs (SWRCB 1995). The quantity of this habitat is correlated with starry flounder abundance in the Estuary later in the year. In addition, gravitational circulation in the lower Estuary is strongly affected by freshwater flows and may aid in the immigration of young flounder into the estuarine nursery areas (IEP 1996).

The decline of starry flounder abundance in Suisun Bay principally reflects reduced production of young (SWRCB 1995). Other factors may include pollution and competition.

Abundance of starry flounder is strongly dependent on outflow. Exports do not have as strong an influence on abundance. Since most immigration occurs from March to June, outflow during this period is considered critical. Figure VI-74 shows abundance indices predicted for each flow alternative during that period. Indices for Alternatives 2, 3, 4, 6, and 7 are very similar and are slightly higher than for Alternative 1, the base case. The index for Alternative 5 is slightly higher due to higher flow. Alternative 8 has the second highest index. The significance of these slight differences in predicted abundance indices is not known.

Figure VI-74

Predicted Abundance Indices for One-Year-Old Starry Flounder



Crangon. *Crangon franciscorum*, commonly known as bay shrimp, is a type of caridean shrimp that seldom exceeds 70 mm in total length and dominates the smaller benthic fauna in the Bay/Delta Estuary (SWRCB 1995). *C. franciscorum* exhibits a response to outflow that may be attributed to two flow-related mechanisms. First, higher river inflows transport the small post-larval shrimp into the bay and disperse them into estuarine nursing areas. Second, higher river inflows reduce bay salinity and increase the amount of suitable nursery habitat for juvenile shrimp (SWRCB 1995).

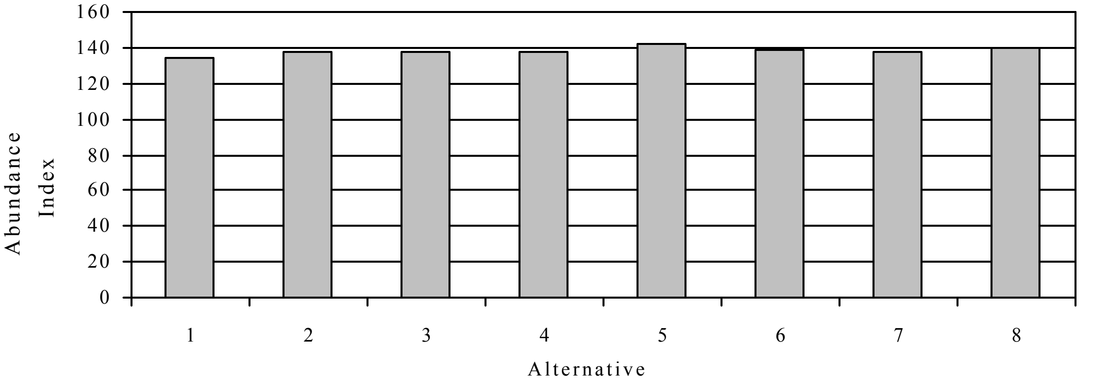
C. franciscorum spawn in the winter and early spring. Densities are correlated to outflow during this period (DFG 1993). In low flow years, the distribution of *C. franciscorum* is further upstream and exposes them to entrainment at the PG&E Delta power plants. Large numbers of *C. franciscorum* were entrained during a wet year and numbers may be substantially higher during dry years (IEP 1996). The species is also entrained at other diversions, including the SWP and CVP facilities. *C. franciscorum* populations may be adversely affected by lower phytoplankton food availability. The 1986 invasion of the Asiatic clam, *Potamocorbula amurensis*, has reduced chlorophyll *a* levels by a factor of 10 in Suisun Bay.

The amount of shallow, brackish water habitat seems to be a key population factor for this species. Shallow water habitat provides physical refuge for juvenile *C. franciscorum* from predators and adult shrimp, as *Crangon* are cannibalistic (IEP 1996).

A significant positive relationship exists between juvenile *C. franciscorum* abundance and March to May Delta outflow (SWRCB 1995). Figure VI-75 shows that the abundance indices predicted for all of the flow alternatives slightly exceed that of the base case. Among the flow alternatives, the indices are quite similar. Alternative 5 has a slightly higher index than the other alternatives that may be due to higher outflow. Alternative 8 has the next highest index. The significance of these slight differences in predicted abundance indices is not known.

Figure VI-75

Predicted Abundance Indices for Immature *Crangon Franciscorum*



Neomysis. *Neomysis mercedis*, a native mysid shrimp, is an important food source for many estuarine fish and feeds upon phytoplankton, rotifers, and copepods (SWRCB 1995). The life span, survival, size, and abundance of *Neomysis* are regulated by outflow, water temperature and food supply. The SWP and CVP pumps may export large numbers of *N. mercedis* in low outflow years when they are further upstream (SWRCB 1995). Food supply is probably the most important limiting factor for *N. mercedis.*, Abundance has decreased with the decline of phytoplankton (chlorophyll *a*) concentrations since the 1970s (Orsi and Mecum 1996). In recent years, the introduced *Acanthomysis* shrimp appears to be replacing *Neomysis* in certain areas/time periods.

Until 1986, a positive relationship existed between *N. mercedis* abundance and average March through November Delta outflow (SWRCB 1995). In recent years, *Neomysis* abundance has been significantly lower than predicted by that relationship. In general, increased flow and reduced diversions are believed to increase phytoplankton biomass, increase potential habitat, and push *Potamocorbula amurensis* populations farther downstream, reducing the competition for food. The flow alternatives, therefore, may have a slight beneficial effect on *Neomysis* abundance compared to the base case.

Copepods. Copepods are small crustaceans, many of which are planktonic. They feed upon a variety of diatoms, green and blue-green algae, and flagellated protozoans. Copepods, in turn, are the main food source for many small fish and other organisms in the Estuary and are an important link in many food webs. The abundance of copepods is closely linked with phytoplankton abundance and spring temperatures (USBR 1997a). A significant correlation between chlorophyll and copepod biomass has been found and may suggest food limitation, although this effect is specific to species, location, and time (IEP 1996).

A variety of copepod species inhabit the Delta. Complex interactions among native and recently introduced copepod species affect the overall abundance and biomass of copepods in the system. Entrainment in diversions and residence time are probably important factors affecting copepod abundance in the Delta. (IEP 1996).

Phytoplankton. Phytoplankton are very small, usually microscopic, algae that are suspended in the water column and drift with the currents. The major phytoplankton groups in the Bay/Delta Estuary are diatoms, dinoflagellates, and cryptomonads. As primary producers that convert solar energy into food through photosynthesis, phytoplankton comprise an essential part of the food web in the Estuary. Phytoplankton productivity, biomass, density, and species composition are influenced by several factors, including light, temperature, nutrients, residence time, inflow, and grazing by aquatic animals (SWRCB 1995).

Light limitation due to turbidity and depth affects phytoplankton growth rates in the Estuary (USBR 1997a). In general, phytoplankton are light limited due to the high turbidity in the Estuary. Net production is consistently negative in the channels of the Delta, where most phytoplankton occur in light-limited conditions below the surface. Only in the shoal areas, like those in Suisun Bay, where the phytoplankton cells are frequently mixed into the surface waters, can net production be positive; phytoplankton growth rate is about ten times higher in the shoals than the channels of Suisun Bay (SWRCB 1995). The introduction of the Asiatic clam, *Potamocorbula amurensis*, in 1986, however, has decreased chlorophyll *a* concentrations by a factor of 10 in Suisun Bay (SFED 1997).

Entrainment and Delta outflow are important to phytoplankton variability in the Delta (IEP 1996). Export pumping was negatively correlated with phytoplankton community composition and chlorophyll *a* concentration. Subsequently, it has been shown that diversions and Delta outflow together account for 86 percent of chlorophyll *a* concentrations in the entrapment zone (SWRCB 1995). Extremely high flows, however, may decrease phytoplankton biomass by flushing phytoplankton out of the estuary. Since freshwater flow influences the location of the entrapment zone, flow also becomes a crucial factor in the maintenance of an abundant population of phytoplankton. Consequently, habitat for phytoplankton in the Delta is greatly affected by exports and also by residence time, which varies with flow conditions (SWRCB 1995).

In general, flow alternatives with higher Delta outflow and lower exports are expected to be beneficial to phytoplankton.

c. Summary of Effects on Fish and Aquatic Resources. The major factors affecting aquatic resources in the Bay/Delta are reasonably well understood, although the interactions of these factors and the relative magnitude of the effects are still controversial. In general, the condition of aquatic resources in the Bay/Delta improves as the hydrologic regime moves towards unimpaired conditions. In general, habitat conditions under Flow Alternatives 2 through 8 are expected to improve for aquatic species compared to the base case. The primary factors affecting aquatic organisms that may be affected by the SWRCB in this proceeding include Delta outflow and exports.

In general, Flow Alternatives 2-8 result in lower exports in the spring months than in the base case, which may reduce entrainment and the adverse effects of reverse flows in the critical period for spawning, rearing, and outmigration of many aquatic species in the Delta. However, in some months, Alternatives 2 through 8 result in higher Delta exports and greater reverse flows than in the base case, which may result in increased entrainment of aquatic organisms at the Delta export facilities.

In the critical spring months, Delta outflow under Flow Alternatives 2 through 8 is greater than in the base case, which may improve conditions for spawning and survival of aquatic resources. However, in general, Delta outflow is lower under Alternatives 2 through 8 than in the base case in October through January.

In general, implementation of Flow Alternatives 2 through 8 is predicted to have slight beneficial effects on through-Delta survival of juvenile chinook salmon and steelhead, and on abundance of longfin smelt, Sacramento splittail, starry flounder, *Crangon franciscorum*, and *Neomysis*, compared to the base case.

Due to higher exports predicted in some of the spring months, young-of-the-year striped bass abundance is predicted to be lower under Alternative 5 than in the base case. Potential impacts on striped bass under Alternative 5 could be mitigated through additional stocking.

Recirculation under Flow Alternative 6 will increase the percentage of Sacramento River water that returns to the San Joaquin River. This may impact the imprinting of juvenile fall-run chinook salmon emigrating from the San Joaquin Basin in April and May. However, under current conditions, substantial quantities of Sacramento River water are imported into the San Joaquin basin. The significance of the potential impact of additional water imports is not known.

4. Vegetation and Wildlife

This section considers the potential impact that the flow alternatives might have on vegetation and wildlife within the Delta. The Delta consists of a mosaic of levied islands and open waterways. Of the total area, 72 percent is farmland on which a wide variety of crops are grown. Natural habitats comprise 12.6 percent of the total area and consist of freshwater and saline emergent marsh, riparian, and open water habitat (USBR 1997b). Wetlands within the interior Delta are dominated by freshwater plant species. A gradual transition from freshwater to brackish and then saline conditions occurs between Emmaton and Jersey Point on the Sacramento and San Joaquin rivers and Benicia further downstream. This salinity gradient results in a gradual shift in plant community species composition. Base assumptions in the analysis of impact are that (1) there will be no change in the amount of agricultural land in production, and (2) there will be no change in the extent, frequency, or intensity of levee maintenance.

Potential impacts to Delta vegetation and wildlife resulting from implementation of the flow alternatives are related to changes in river stage in the lower Sacramento and San Joaquin rivers, and changes in salinity caused by a new flow regime. Drought represented by low summer stages, and inundation mortality (high stages year-round) are the major impact mechanisms of river stage on riparian and wildlife habitat. Long-term changes in salinity could cause a gradual shift in the relative proportion of freshwater, brackish, and saltwater marsh within the estuary. Populations of wildlife species dependent on a particular habitat type might shift accordingly.

The effect of river stage changes is greatest at the upstream margins of the Delta and decreases with distance into the Delta. This is due to the tidal effects and the high volume of water in the Delta compared to the inflow. River stages have been calculated for the Sacramento River at Verona and the San Joaquin River at Vernalis in section C.3 of this chapter (see Tables VI-39 and VI-43). These sites are indicative of conditions at the upstream boundaries of the Delta. Reductions in river stage of less than 20 percent are considered to be less than significant in terms of impact on riparian and wetland habitat. At Vernalis, higher flows during the May to July period of dry years in Alternatives 3 and 4, and during the April to October period in all water year types in Alternative 5 produce a beneficial effect on riparian and wildlife habitat in the lower portion of the river and may also be beneficial in the Delta. On the Sacramento River at Verona there is a significant reduction in wet year flows from February to May for Alternative 5. This reduction should not adversely impact riparian vegetation under wet weather conditions.

The impact of the flow alternatives on salinity (expressed as electrical conductivity) and "X2" position (the 2 ppt isohaline) is discussed in section A.2 above. Salinity information for water years 1976 to 1992 was determined for the alternatives at representative points within the southern, central, and western Delta using the DWRDSM model. This information is presented in Figures VI-3 through VI-63. In general, salinity under the base case (Alternative 1) is greater than or equal to the other alternatives during the April to July period in the western and central Delta. Other months are variable. In the southern Delta, modeled salinity under the alternatives varies from just below the salinity objectives to greater than the objectives during the June to August period. In some instances, the alternatives exceed the base case.

Soil salinity tolerance ranges have been established for certain dominant wetland plant species (Jones & Stokes and EDAW 1975). Common freshwater plant species, such as cattail and tule, display a wide range in soil water salinity tolerance. The salinity changes predicted by the DWRDSM modeling are well within the tolerance ranges and therefore would not cause long term changes in plant species composition.

5. Land Use

This section considers the potential impact that the flow alternatives might have on patterns of land use within the Delta. The Delta is used primarily for agricultural purposes. The area, much of which is now below sea level, is interlaced with hundreds of miles of waterways and relies on more than 1,000 miles of levees for protection against flooding. A wide variety of crops are grown on more than 500,000 acres of rich farmland. Delta farmland is irrigated by water diverted from Delta channels under a combination of riparian and appropriative water rights.

Ambient water quality is the parameter that most directly affects irrigated agriculture in the Delta. Water availability is not a problem because most of the Delta has an elevation at or near sea level. The results of the DWRDSM salinity modeling are discussed in sections B.2. and B.4. above. Under all of the alternatives, water quality is adequate for agricultural uses in the western and central Delta. However, the modeling results indicate that salinity objectives in the southern Delta are not always met in the summer. Even with the long-standing water quality problem in the southern Delta, the basic agricultural use of the land has not changed. Implementation of the flow objectives will not worsen the problem. Thus, none of the alternatives are expected to change the current land uses in the Delta.

A number of appropriative water right holders identified in Table II-5 are located within the Delta. If diversions under their appropriative water rights were curtailed, they probably would continue to divert under riparian right if natural flow is available at the time, or seek contracts for project water. In either case, there likely would be no effect on water availability and land use practices resulting from implementation of the outflow alternatives.

6. Delta Recreational Impacts

Many water-dependent and water-enhanced activities occur in the Sacramento-San Joaquin Delta. Annual use is estimated at over 12 million visitor days. Boating and fishing, as separate activities, are the most important recreational activities, accounting for 17 percent and 15 percent of the recreational use in the region, respectively.

Closure of the Delta Cross Channel in some months, as required by the 1995 Bay/Delta Plan, will have adverse effects on boating in the Delta as it impedes navigation between the Sacramento and Mokelumne rivers. Under D-1485, the DCC gates are closed between January 1 and April 15, whenever Delta outflow exceeds 12,000 cfs. Additionally, between April 16 and May 31, gates may be closed up to 20 days (but no more than two out of four consecutive days) at the discretion of the DFG.

Under the plan, DCC gates are closed between February 1 and May 20. Additionally, between November 1 and January 31, gates are closed for up to a total of 45 days, as needed for protection of fish. Between May 21 and June 15, gates are closed for a total of 14 days, as needed for fish protection.

Sport fishing could be enhanced by improved water quality in the Delta. Fish populations in the Delta have been declining for a number of reasons. The flow objectives in each of the alternatives may stabilize or improve the fish populations in the Delta. An increase in game fish populations should result in increased sport fishing opportunities.

C. ENVIRONMENTAL EFFECTS IN UPSTREAM AREAS

The upstream areas considered in this evaluation include the Sacramento and San Joaquin river basins north and south of the Delta described in Chapter III of this report. The evaluation of the environmental effects in upstream areas is divided into the following subsections: (1) hydrology, (2) water temperature, (3) aquatic habitat, (4) vegetation and wildlife, (5) erosion, (6) land use, (7) urban development, (8) energy, (9) recreation, (10) aesthetics, (11) cultural resources, and (12) groundwater pumping.

1. Hydrology

Changes in river flows are evaluated in this section to provide a basis for evaluating the impacts of the flow alternatives on fish and aquatic resources and other flow dependent resources in the upstream areas. The points at which river flows are evaluated correspond to control points in the DWRSIM model. These points were selected to coincide with actual gauging stations or with points on the tributaries upstream of their confluence with the Sacramento or San Joaquin rivers.

Tables VI-16 through VI-31 list the modeled base case monthly flows for eight locations in the Sacramento/San Joaquin River system for the 73-year period and critical period. Below the base case flows are the changes in these flows from the base case that result from implementing the seven flow alternatives.

Table VI-16

Sacramento River Flow at Red Bluff, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	7,277	8,978	12,377	15,272	18,163	15,350	11,477	10,672	10,936	12,776	10,506	6,236

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	73	216	30	-126	60	127	16	**-190**	1,173	-565	-681	36
3	128	335	115	-75	120	154	31	-199	972	-787	-713	74
4	128	331	109	-75	124	128	36	-199	984	-764	-716	69
5	**344**	**615**	**272**	**145**	**312**	**279**	-1	-350	707	-1,458	-701	110
6	86	-40	-187	-255	-252	6	37	-269	**1,656**	**-486**	**-457**	**317**
7	-52	-18	-61	-208	-88	187	**358**	-417	1,584	-550	-569	23
8	99	174	37	-130	223	121	-68	-231	1,224	-523	-696	82

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-17

Sacramento River Flow at Red Bluff, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	4,793	4,790	6,785	6,904	6,948	6,470	6,907	7,604	8,252	9,739	9,772	5,191

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-79	50	-82	-84	-84	306	20	281	765	**993**	**-1,294**	117
3	-249	**246**	-41	-44	-42	385	207	**379**	480	454	-1,338	112
4	-249	212	-41	-44	-42	388	216	**379**	492	447	-1,341	112
5	-132	-21	**40**	**40**	**93**	**645**	294	103	957	-788	-1,356	**204**
6	**14**	72	-206	-209	-210	-149	196	277	**1,656**	867	-1,696	153
7	-272	-222	-166	-168	-168	52	**574**	195	1,289	570	-1,361	182
8	-158	8	-82	-84	-49	3	-2	257	988	981	-1,696	163

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-18
Sacramento River Flow at Verona, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	11,776	13,579	19,218	26,962	31,867	30,444	19,148	15,623	12,712	12,853	10,543	9,488

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-506	-12	-433	-547	92	152	233	-361	2,042	1,044	-1,260	-151
3	-373	174	-305	-437	172	162	274	-386	1,628	759	-1,245	-145
4	-373	170	-321	-438	161	145	275	-378	1,654	776	-1,250	-146
5	**11**	**835**	**248**	**-23**	**816**	**785**	553	**-65**	1,935	36	-1,015	**197**
6	-461	-165	-733	-650	-215	40	177	-474	**2,454**	1,164	-1,003	142
7	-623	-269	-651	-723	-168	238	**949**	-823	2,422	1,220	-1,121	-147
8	-568	-107	-583	-609	283	144	1	-527	2,087	**1,331**	**-872**	-69

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-19
Sacramento River Flow at Verona, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	8,494	7,232	9,837	13,840	12,231	12,084	8,111	7,686	8,336	10,246	9,066	7,032

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1,252	120	-252	-236	-213	520	746	980	1,411	604	-1,297	-240
3	-1,452	350	-220	-195	-174	536	978	1,096	1,005	430	-1,394	-379
4	-1,450	308	-220	-195	-174	542	984	1,096	1,022	414	-1,394	-379
5	**-1,145**	**439**	**9**	**36**	**79**	**1,197**	1,236	**1,362**	**2,978**	-318	**-812**	**-6**
6	-1,359	174	-380	-358	-339	62	743	1,003	2,227	941	-1,657	-339
7	-1,382	-244	-364	-317	-315	198	**2,409**	404	1,690	-58	-1,255	-267
8	-1,412	107	-260	-240	-172	169	271	496	1,659	**1,236**	-1,287	-344

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-20
Feather River Flow at Gridley, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	2,941	2,623	4,525	5,627	6,472	6,280	3,160	3,948	3,351	4,398	3,727	1,818

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-580	-226	-462	-421	32	25	220	**-171**	**868**	1,608	-576	-189
3	-501	-161	-419	-362	49	8	244	-188	654	1,545	-528	-221
4	-501	-160	-429	-362	34	17	241	-180	669	1,540	-531	-216
5	**-307**	**30**	**-113**	**-108**	**280**	**221**	71	-374	262	824	-615	**-28**
6	-544	-123	-544	-395	35	33	143	-205	798	1,649	-544	-175
7	-572	-249	-587	-516	-82	52	**592**	-406	838	1,771	-530	-171
8	-665	-277	-616	-477	10	21	72	-298	861	**1,853**	**-176**	-151

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-21

Feather River Flow at Gridley, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	2,841	1,868	2,496	1,185	1,522	1,645	1,661	1,789	3,018	4,382	2,486	1,556

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1,171	76	***-170***	-155	***-135***	212	731	706	648	-388	9	***-365***
3	-1,201	101	-178	-155	***-135***	149	773	720	526	-26	-51	-497
4	-1,196	98	-178	-155	***-135***	152	773	720	526	-35	-51	-497
5	***-921***	***284***	-378	-155	-379	***412***	555	223	564	-334	119	-375
6	-1,361	98	***-170***	-155	***-135***	212	552	***730***	574	70	46	-497
7	-1,103	-22	-197	-155	-153	149	***1,832***	214	398	-630	107	-452
8	-1,248	99	-177	-155	-145	170	278	243	***669***	***253***	***414***	-512

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-22

American River Flow at Nimbus Dam, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	2,159	2,696	3,651	4,374	5,145	4,001	3,695	3,359	3,895	3,513	2,763	1,898

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-196	-32	-227	-143	-7	68	34	104	846	-348	-360	316
3	-180	-12	-176	-76	18	76	5	118	738	-394	-402	333
4	-181	***-11***	-186	-78	18	97	2	104	754	-398	-400	329
5	***-110***	84	***-68***	***0***	***103***	***115***	-120	-5	533	-654	***-252***	***452***
6	-114	-129	-359	-235	-163	-27	20	***145***	***1,006***	***-269***	-254	429
7	-194	-98	-257	-163	-3	114	***141***	-8	973	-296	-398	252
8	-172	-41	-211	-136	49	63	-30	87	869	-323	-351	287

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-23

American River Flow at Nimbus Dam, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1,571	1,314	1,277	1,212	2,039	1,868	2,622	1,791	2,715	4,210	2,412	576

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	25	224	-483	-458	-907	21	210	460	2,087	-1,285	***-546***	526
3	199	123	-486	-458	-907	376	22	458	1,945	-1,106	-862	536
4	195	154	-486	-458	-907	***379***	14	465	1,916	-1,099	-862	533
5	***371***	***526***	***-85***	***-87***	***-463***	370	-918	-49	1,239	***-958***	-737	***707***
6	367	227	-442	-499	-991	-112	325	***514***	2,154	-1,429	-895	651
7	267	434	-336	-316	-760	75	***392***	33	2,063	-1,322	-1,009	497
8	136	268	-480	-462	-916	33	116	466	***2,339***	-1,426	-675	458

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-24
San Joaquin River Flow at Newman, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1,638	866	1,290	1,816	2,979	2,233	1,521	2,140	1,610	650	528	830

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-7	-4	-5	-3	-9	-4	-8	-6	-9	-8	-8	-11
3	-64	-46	-69	-66	-181	-30	204	283	181	159	44	-17
4	-35	-20	-38	-53	-114	20	69	143	179	161	53	2
5	***334***	***39***	-63	-41	***473***	***815***	***2,121***	***1,783***	***772***	***1,392***	***425***	***116***
6	152	-4	***-4***	***-2***	12	52	408	732	242	174	100	-8
7	-26	-22	-23	-33	-83	-5	85	81	-16	-9	-10	-14
8	45	-47	-68	-68	-189	-28	242	254	-53	-10	-9	-26

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-25
San Joaquin River Flow at Newman, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1,004	479	545	575	1,306	748	415	421	471	418	434	631

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-14	-11	-3	-3	-15	-11	-17	-14	-17	-16	-18	-24
3	-116	-3	-8	-55	-356	-5	193	295	204	244	114	-19
4	-110	-3	-8	-46	-193	-5	78	116	237	244	114	-19
5	***355***	***138***	***134***	***93***	***95***	***566***	***1,352***	***1,279***	***511***	***978***	***388***	***169***
6	227	-14	-8	-3	-15	-11	204	789	170	409	277	-28
7	-119	-11	-3	-38	-93	-11	114	120	-77	-16	-20	-24
8	-86	-10	-5	-44	-307	-8	245	406	-93	-15	-19	-24

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-26
Stanislaus River Flow Upstream of the San Joaquin River Confluence, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	853	523	588	739	1,048	736	1,124	789	877	634	601	597

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-36	-62	-146	-214	-381	-78	***365***	731	107	193	246	-12
3	79	-46	-113	-132	-191	14	152	396	92	150	***251***	***-8***
4	28	-54	-124	-174	-287	-19	316	577	80	146	239	***-8***
5	-19	-42	-61	-110	35	***103***	42	89	-1	-47	97	-9
6	-65	-38	-71	-51	-75	-17	-7	-6	67	123	243	***-8***
7	***394***	47	***165***	***158***	***165***	73	-132	225	272	***237***	-8	-179
8	-177	***68***	2	-176	-330	-6	358	***734***	***382***	218	180	-9

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-27
Stanislaus River Flow Upstream of the San Joaquin River Confluence, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	374	451	407	333	307	344	840	609	653	646	646	588

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	121	-118	-155	-111	-66	-19	***227***	***801***	-36	-100	-84	-48
3	249	-118	-144	-103	-54	-19	28	413	106	176	***197***	***-9***
4	***258***	-118	-144	-103	-54	-19	160	653	101	176	***197***	***-9***
5	-37	-119	-154	-111	29	69	49	55	-103	-102	-82	-14
6	-56	-118	-144	-103	-66	-19	0	-14	118	16	158	***-9***
7	114	***-76***	***-33***	***28***	***98***	***87***	48	285	293	***255***	-230	-206
8	29	-96	-63	-68	-20	7	121	417	***295***	180	-41	-44

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-28
Tuolumne River Flow Upstream of the San Joaquin River Confluence, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	558	523	672	1,277	1,753	1,983	1,486	1,148	1,090	575	321	423

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	0	0	0	0	0	***0***	0	0	0	0	0	***0***
3	1	0	-12	-137	-141	-75	-3	52	***387***	19	0	***0***
4	0	0	-12	-128	-133	-60	-16	21	371	19	0	***0***
5	***126***	-11	-36	-314	-157	-203	***189***	***267***	156	***388***	***5***	-5
6	0	0	0	0	0	***0***	0	0	0	0	0	***0***
7	-2	-1	***4***	***5***	***13***	***0***	-5	-44	8	1	1	***0***
8	-1	***2***	-13	-15	-23	-34	48	80	-15	-1	-1	-1

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-29
Tuolumne River Flow Upstream of the San Joaquin River Confluence, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	323	325	350	344	424	342	613	609	202	197	202	209

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	0	***0***	0	0	0	0	0	0	0	0	0	0
3	0	***0***	0	0	0	0	0	14	***492***	0	0	0
4	0	***0***	0	0	0	0	0	0	***492***	0	0	0
5	***217***	-27	***2***	***3***	***80***	***152***	***261***	***231***	191	***381***	***1***	***17***
6	0	***0***	0	0	0	0	0	0	0	0	0	0
7	-16	-6	-6	-5	0	-3	-56	-56	0	0	0	0
8	-2	-2	***2***	***3***	7	0	69	118	4	-2	-3	-1

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-30

Merced River Flow Upstream of the San Joaquin River Confluence, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1,026	305	563	784	1,306	601	226	586	696	157	110	197

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	0	**0**	**0**	**0**	**0**	0	0	0	0	0	0	0
3	-59	-35	-64	-66	-194	-50	201	**282**	**148**	101	48	-9
4	-29	-12	-33	-50	-128	-1	71	144	146	101	**54**	**10**
5	-317	-62	-186	-193	-214	**84**	**541**	266	-25	**239**	28	-46
6	0	**0**	**0**	**0**	**0**	0	0	0	0	0	0	0
7	-18	-18	-17	-30	-72	0	92	87	-5	0	0	-2
8	**54**	-40	-60	-64	-193	-24	210	219	-43	0	1	-12

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-31

Merced River Flow Upstream of the San Joaquin River Confluence, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	511	137	165	214	593	171	70	70	101	79	93	79

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	**0**	0	**0**	**0**	**0**	0	0	0	0	0	0	0
3	-114	0	-2	-38	-341	0	193	283	141	158	**121**	0
4	-107	0	-2	-38	-187	0	73	100	**175**	158	**121**	0
5	-275	**3**	1	-59	-322	**97**	**400**	**388**	91	**179**	35	**7**
6	**0**	0	**0**	**0**	**0**	0	0	0	0	0	0	0
7	-104	0	**0**	-35	-79	0	132	134	-60	0	0	0
8	-72	**3**	1	-41	-304	-4	223	358	-75	0	0	1

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

In the Sacramento Valley, Alternative 5 generally provides the highest river flows of the alternatives for the fall and winter months, and the lowest flows for the summer months. Alternative 7 provides the highest river flows in April. For the Sacramento River at Red Bluff and the American River at Nimbus Dam, Alternative 6 generally produces the highest flows during the summer months for the 73-year period analysis (Tables VI-16 and VI-22). For the Sacramento River at Verona and the Feather River at Gridley (Tables VI-18 and VI-20), summer flows are highest in July and August under Alternative 8. June flows are highest at Verona under Alternative 6 and at Gridley under Alternative 2.

For the critical period analysis, Alternatives 2, 5, 6 and 8 produce the highest flows in the summer months depending on the month and the location (Table VI-17, VI-19, VI-21 and VI-23) and Alternative 5 generally produces the highest flows in the winter months. Alternative 6 produces the lowest flows on the Sacramento River at Red Bluff and Verona in the period December through March. Alternative 7 produces the lowest flows on the Feather River at Gridley in November, January, March, and May through July. On the American

River, Alternative 6 produces the lowest flows from January through March and Alternative 5 produces the lowest flows from April through June.

Trends are different in the San Joaquin River Basin than in the Sacramento River Basin. For the San Joaquin River at Newman in the 73-year period analysis (Table VI-24), Alternative 5 provides the highest flows in every month except December and January, and Alternative 8 generally provides the lowest flows. For the critical period analysis, Alternative 5 provides the highest flows year round. Flows are the lowest in April and May under Alternative 2, July and August under Alternative 7, and January and February under Alternative 3; however, flows under Alternative 8 are among the lowest in each month during the critical period.

The tributaries show different trends. On the Stanislaus River, Alternative 7 generally results in the highest winter flows and Alternative 2 results in the lowest winter flows in each period of analysis (Table VI-26 and VI-27). Alternative 5 results in the lowest flows in June and July and Alternative 7 results in the lowest flows in August and September for both periods. In the 73-year period analysis, Alternatives 2 and 8 result in the highest flows during the pulse flow period of April and May, and Alternatives 7 and 8 result in the highest flows in June and July. For the critical period analysis, Alternative 2 results in the highest flows during the pulse flow period of April and May while Alternative 6 provides the lowest.

For the Tuolumne River (Tables VI-28 and VI-29), Alternative 5 results in the highest flows in April, May, July, August and October, and the lowest flows from November through March in the 73-year period analysis. Alternatives 3 and 4 provide the greatest increase in flow in June for both periods of analysis. For the critical period analysis, most of the monthly river flows for the alternatives are equal to or better than the base case flows. Alternative 5 provides the highest flows in eight months including most of the summer months. Table VI-29 shows that during the pulse flow period of April through May, Alternative 7 flows are less than the base case even though releases are made from New Don Pedro Reservoir in accordance with the Letter of Intent. This is an artifact of the way FERC flows on the Tuolumne River were modeled in Alternative 7 rather than a result of the Letter of Intent.

For the Merced River in the 73-year period analysis, Alternatives 2 and 6 have the highest flows from November through February with flows equal to the base case (Table VI-30). This trend is also apparent in the critical period (Table VI-31) although some other alternatives also have flows equal to the base case during this period. From March to September in the 73-year period analysis, Alternatives 3, 4, and 5 provide the highest flows depending on the month. Alternative 5 provides the lowest flows from through the fall and winter months. In the critical period, Alternative 5 provides the highest flows from March through May, and in July and September. Alternatives 3 and 4 provide the highest flows in June and August.

2. Water Temperature

The effects of changes in flow on water temperature in upstream areas were analyzed to evaluate potential effects on habitat for fish and aquatic resources. The water temperature model developed by the USBR (USBR 1990, 1993, 1997d; described in Chapter IV) was used to assess the effects of the flow alternatives on water temperature in four major streams in the Sacramento-San Joaquin River system, the Sacramento, Feather, American, and Stanislaus rivers. Monthly project operations, modeled with DWRSIM, were input to the temperature model for the 72-year hydrologic period of record (1922-93). The model was used to predict mean monthly water temperatures at eight to twelve locations on each stream.

The following sites were selected for detailed analysis of temperature effects:

- Sacramento River – Below Keswick Dam, Ball's Ferry, Jelly's Ferry, and Vina
- Feather River – Downstream of the Afterbay, Honcut Creek, and Mouth
- American River – Below Nimbus Dam, Watt Avenue, and Mouth
- Stanislaus River – Below Goodwin Dam, Orange Blossom Bridge, and Mouth

Representative water years were selected for analysis from the period of record for wet, above normal, below normal, dry, and critical water year types. Representative years selected were years closest to the median monthly temperature values for each water year type over the period of record. For the Sacramento River system, water years 1942, 1928, 1979, 1964, and 1992, respectively, were selected to represent the five water year types. For the Stanislaus River, water years 1980, 1963, 1950, and 1976 were selected to represent wet, above normal, below normal, and critical water year types, respectively. Dry water years were not analyzed for the Stanislaus River because no impacts were identified in other water year types.

Predicted mean monthly water temperatures for the above-described stations and water years are shown in Volume 2, Appendix 5.

The precision of the model was estimated at approximately ± 1.0°F between the alternatives (J. Rowell, personal communication). In this analysis, water temperatures predicted for Flow Alternatives 2 through 8 were compared with values predicted for Alternative 1 (base case) for each location and representative water year. Predicted temperatures for Flow Alternatives 2 through 8 within 1.0°F of those predicted for the base case were considered within the error of model predictions.

a. <u>Sacramento River</u>. Water temperatures predicted under the flow alternatives were not different from those predicted for the base case at any location in wet, above normal, or below normal water years. In dry years, predicted temperatures in September were approximate 1-3°F higher under Alternatives 2, 5, and 6 than in the base case at most locations. In critical years, predicted temperatures in the late summer to early fall (August, September, or October) were approximately 1-3 °F higher under Alternatives 2, 3, 4, 6, and 8 than in the base case at most locations.

These differences are related directly to changes in carryover storage at Shasta Reservoir. In dry and critical years, carryover storage is reduced under Alternatives 2 through 8 compared to the base case, resulting in slightly elevated water temperatures in the late summer/early fall period.

These modeled temperature differences due to implementation of the flow alternatives are unlikely to result in significant impacts to fishery resources. SWRCB Order WR 90-5 specifies temperature objectives for the mainstem Sacramento River. Temperature criteria also have been established for the protection of winter-run chinook salmon spawning, egg incubation, and rearing in the mainstem Sacramento River in the biological opinion for the operation of the CVP and SWP (NMFS 1993). The Sacramento River Temperature Task Group, consisting of representatives from the SWRCB, USBR, USFWS, WAPA, USACOE and NMFS, meets on a regular basis during the temperature control season (May through October). Typical discussions include an assessment of the temperature control operations and forecast of operations for the remainder of the season. Operational adjustments are made on a real-time basis to reduce temperature impacts on winter-run chinook salmon and other species. Operation of the temperature control device at Shasta Dam is increasing the ability to control water temperatures for anadromous fish protection in the mainstem Sacramento River.

b. **Feather River**. Predicted water temperatures in a wet water year were similar to or lower under the flow alternatives than in the base case, except for the Honcut Creek site, where temperatures in July under Alternative 5 were predicted to be approximately 3°F higher than in the base case. In an above normal water year, no adverse effects on water temperature were predicted under any flow alternative.

In a below normal year, water temperatures in August were predicted to be approximately 2.5°F higher under all of the flow alternatives, than in the base case. In a dry year, temperatures in April and May under the alternatives were predicted to be up to 2 °F higher than in the base case. In a critical water year, no adverse effects on water temperature were predicted under any of the flow alternatives.

These modeled water temperature increases in the lower river are not likely to result in significant impacts to fishery resources compared to the base case condition.

Fall and spring-run chinook salmon and steelhead spawn and rear in the lower Feather River. Fall-run chinook salmon typically emigrate from the lower river from January through March and therefore are not affected by elevated water temperatures. Spring-run chinook salmon spawn in the low flow channel from late August through October; steelhead rear in the low flow channel year-round.

Temperatures in the lower river are controlled through operation of a temperature control device. The DFG/DWR Hatchery Water Supply Temperature Agreement (August 26, 1983) established minimum and maximum criteria for temperatures at the intake to Feather River Hatchery at the Thermalito Diversion Dam. These requirements, in addition to providing suitable rearing temperatures at the hatchery, provide suitable temperature releases for coldwater species in the lower river.

The NMFS is currently completing evaluation of the short-term effects of operation of the CVP and SWP on steelhead trout and spring-run chinook salmon. A biological opinion will be issued in the near future which is likely to include water temperature conditions to protect spring-run chinook salmon spawning and steelhead rearing in the low flow channel of the Feather River.

c. American River. No adverse effects on water temperature were predicted under the flow alternatives in wet, above normal, and below normal water year types. Temperatures were similar to or lower under each of the flow alternatives compared to the base case condition.

In a dry water year, water temperatures were similar to or lower under the flow alternatives than in the base case, except in August, when predicted temperatures under Alternative 6 were approximately 3 °F higher than under the other flow alternatives and the base case. In a critical water year, predicted temperatures were approximately 3 °F higher in July under Alternatives 2, 3, 4, 6, and 8, and approximately 3 - 4 °F higher in August under all flow alternatives, than in the base case. These differences are due to changes in storage at Folsom Reservoir. In critical water years, reservoir storage would be lower under the flow alternatives than the base case, resulting in higher summer water temperatures.

These modeled water temperature increases in the lower river are not likely to result in significant impacts to fishery resources compared to the base case condition. This is true for the following reasons: 1) even under the base case condition, suitable habitat is not available year-round for all salmonid lifestages, 2) the model did not include real-time operational adjustments that are made to reduce water temperature impacts, 3) the model did not include the planned construction and operation of a multi-level release structure at Folsom Dam, which is expected to allow the release of cooler water in the late summer months.

Under the base case condition, warm summer and fall water temperatures on the lower American River have been identified as a limiting factor to juvenile steelhead rearing in the river (USFWS 1995). Water temperatures in the lower American River from July to October are commonly higher than optimum levels for survival of juvenile steelhead. In general, steelhead do not survive extended periods of warm water, and in many years move prematurely out of the American River to seek cooler water. High water temperatures have significantly limited natural steelhead production in the lower river (McEwan and Nelson 1991). Elevated temperatures in the late summer are also suspected to delay fall-run chinook spawning in the lower river and may impede reproductive success (USFWS 1995).

The temperature modeling assumed that no operational changes would be made to control temperatures in the lower river. However, the USBR, DFG, USFWS, and NMFS meet routinely to discuss operational changes to benefit fishery resources in the lower American River. Flow and water temperature needs for fisheries are taken into consideration for operations on a real-time basis. A temperature target of 65°F at Watt Avenue is used to protect juvenile steelhead rearing in the lower river. Operational adjustments are often made to reduce impacts on water temperatures in the late summer months of dry and critical water years.

In addition, the predicted effects on water temperature in the lower American River in July and August assume that no new facilities would be constructed. The planned construction and operation of a multi-level release structure at Folsom Dam is expected to permit the release of cooler water in the late summer and fall than was indicated by the model simulations.

The NMFS is currently completing evaluation of the short-term effects of operation of the CVP and SWP on steelhead trout. A biological opinion will be issued in the near future which is likely to include conditions to reduce adverse effects of water temperature on steelhead in the lower American River.

d. Stanislaus River. No adverse effects on water temperature were predicted under the flow alternatives in any water year type. In a wet water year, Alternative 8 is predicted to result in improved temperature conditions throughout the lower river for coldwater species. Water temperatures are higher in the winter (January/February) and lower in the spring (April, May and June) than under base case conditions. In other water years (above normal, below normal, and critical years), water temperatures under the alternatives are similar to or lower than temperatures under the base case.

3. Aquatic Habitat

The purpose of this section is to analyze the impact of the flow alternatives on aquatic habitat in the upstream areas of the Central Valley. Implementation of the Bay/Delta Plan will affect the operation of water supply projects by changing the timing and magnitude of reservoir releases. These operational changes can affect upstream aquatic habitat in rivers and reservoirs. The factors that affect species in these habitats are discussed in detail in Chapter V of the ER (SWRCB 1995; Appendix 1). The following sections describe the method of analysis and assess the effect of each of the flow alternatives on controllable factors compared to the base case.

a. Rivers.

Assessment Method. The Range of Variability Approach (RVA) developed by Richter et al (1997) was used to assess the impact of the flow alternatives on aquatic habitat in rivers in the Sacramento-San Joaquin system. This approach, described below, is based on aquatic ecology theory concerning the critical role of hydrologic variability, and associated characteristics of duration and timing, in sustaining aquatic ecosystems.

Native riverine species possess life history traits that enable individuals to survive and reproduce within a certain range of environmental variation. Many ecological attributes are known to shape the habitat templates that control aquatic species distribution and abundance. Natural hydrologic variation plays a major part in structuring the biotic diversity in river ecosystems as it controls key habitat conditions in the river channel; hydrologic variation is now recognized as a primary driving force in river ecosystems.

The RVA methodology provides an approach to translate this ecological theory to the establishment of streamflow targets based on the natural streamflow regime. Numerous flow characteristics are assumed to be important for the maintenance of riverine habitat and biological diversity, including: the seasonal pattern of flow, timing of extreme conditions, the frequency, predictability, and duration of floods, droughts, and intermittent flow, daily, seasonal, and annual flow variability, and rates of change.

The RVA method identifies annual management targets for regulated streams based on a characterization of ecologically relevant flow regime characteristics. The natural range of streamflow variation is characterized using a suite of 32 ecologically relevant hydrologic parameters calculated from the natural hydrology. Based on measures of central tendency (e.g. mean, median) and dispersion (e.g. range, standard deviation, coefficient of variation) calculated from the natural hydrology, management target ranges for each hydrologic parameter are identified. In the absence of detailed ecological information, the method recommends a target range of ± 1 standard deviation from the mean for each of the thirty-two hydrologic parameters. For those parameters where a skewed distribution results in a standard deviation that exceeds the minimum or maximum value, the actual minimum or maximum value is used as the lower or upper target range boundary.

The method then can be used to assess the relative suitability of alternate flow management scenarios by calculating the frequency that flows fall within the calculated target range.

Analysis of the Flow Alternatives. The Range of Variability Analysis method was used to assess the relative effects of the flow alternatives on stream ecosystems in the Sacramento-San Joaquin River system, at locations where estimates of unimpaired flow were available:

- Sacramento River near Red Bluff
- Feather River near Oroville
- American River at Fair Oaks
- San Joaquin River above Vernalis
- Stanislaus River at Melones Reservoir
- Tuolumne River at Don Pedro Reservoir
- Merced River at Exchequer Reservoir

Since estimated unimpaired flows were available only on a monthly time step, a subset of the 32 hydrologic parameters recommended in the RVA analysis was calculated for the available period of record (1922-1993). Hydrologic parameters used in the analysis are summarized in Table VI-32, and include the magnitude of monthly flows, the magnitude of annual extreme flow conditions, and the timing of annual extreme flow conditions.

From the estimated unimpaired flows, management targets were established for each of the flow parameters (± 1 standard deviation from the mean). For those parameters where a skewed distribution resulted in a standard deviation that exceeded the minimum or maximum value, the actual unimpaired minimum or maximum value was used as the lower or upper target range boundary.

Table VI-32

Summary of Hydrologic Parameters Used in the Stream Ecosystem Impacts Analysis

Flow Statistics Group	Regime Characteristics	Hydrologic Parameters
Magnitude of monthly flow conditions	Magnitude	Mean monthly flow
Magnitude of annual extreme flow conditions	Annual Extremes	Mean annual minimum and maximum monthly flow
Timing of annual extreme flow conditions	Timing	Month of annual minimum and maximum flow

Simulated flows for the period of record (1922-1993) for each of the flow alternatives (DWRSIM analysis) were then compared with flow target ranges to evaluate the relative suitability of the alternatives in meeting ecological objectives. For the flow simulations, locations from the DWRSIM analysis were selected that were closest to sites on each river where estimated unimpaired flow data were available. The rate of non-attainment of the flow management targets was calculated for each site and flow parameter.

Table VI-33 shows an example of the Range of Variability Analysis for the Stanislaus River at Melones Reservoir. Analyses for all sites are presented in Volume 2, Appendix 5.

Cases where flow parameters showed a greater than 10% deviation in the non-attainment rate between the flow alternatives and the base case are described below. In some cases, the difference in the rate of non-attainment showed a slight positive effect, moving closer to unimpaired conditions; in other cases, the difference showed a slight adverse effect, moving away from unimpaired conditions.

Sacramento River. No differences in the rate of non-attainment greater than 10% were observed between the flow alternatives and the base case in any of the flow parameters.

Feather River. In October, mean monthly flows simulated for Alternatives 2 through 8 were lower than in the base case, resulting in flows that are more similar to the unimpaired condition (more often falling within the target range for monthly flow magnitude). In January, mean monthly flows simulated for Alternatives 2 through 8 were lower than in the base case, resulting in a slight shift away from unimpaired conditions.

The magnitude of the annual 30-day maximum flow was increased in Alternatives 2 through 8 compared to the base case, resulting in maximum flows more similar to the unimpaired condition. The timing of the annual minimum flow was shifted later in the year in Alternatives 2 and 3 compared to the base case, resulting in timing more similar to unimpaired conditions.

American River. No differences in the rate of non-attainment greater than 10 percent were observed in monthly flow magnitude between the flow alternatives and the base case.

The timing of the annual minimum was more variable for Alternative 3, resulting in timing that was less similar to unimpaired conditions than the other alternatives and the base case. The timing of the annual maximum for Alternatives 2 through 8 was closer than the base case to unimpaired conditions.

San Joaquin River. In October, simulated mean monthly flows for Alternatives 2 through 8 are higher than for the base case, resulting in a shift away from unimpaired conditions. In March and April, simulated mean monthly flows for Alternative 6 are higher than in the base case, resulting in a shift toward unimpaired conditions.

Minor differences were observed in the magnitude and timing of the annual extremes at this site. For Alternative 8, the magnitude of the annual 30-day minimum was closer than the base case to unimpaired conditions. For Alternative 2, the timing of the annual 30-day minimum flow was closer than the base case to unimpaired conditions. For Alternatives 6 and 8, the timing of the annual 30-day maximum flow was closer than the base case to unimpaired conditions.

Although flow effects were not analyzed for the upper mainstem San Joaquin River below Friant Dam, it is evident that flow conditions there would not change under Flow Alternatives 2 through 4 and 6 through 8. Flow Alternative 5 would result in a substantial improvement in flow conditions below Friant Dam and a shift toward unimpaired conditions from the base case.

Stanislaus River. In October, simulated mean monthly flows for Alternatives 2, 4, 5, and 8 are higher than for the base case, resulting in a shift away from unimpaired conditions. In February, simulated mean monthly flows for Alternative 8 are higher than for the base case, resulting in a shift toward unimpaired conditions. In August, simulated mean monthly flows for Alternatives 2 through 8 are higher than for the base case, resulting in a shift away from unimpaired conditions.

The magnitude of the simulated annual 30-day minimum for Alternative 8 was higher than for the base case, and the annual 30-day maximum was lower, both resulting in a shift away from unimpaired conditions. The timing of the annual 30-day minimum was shifted later in the year in Alternatives 2, 4, and 5 compared to the base case, resulting in a shift away from unimpaired conditions. For Alternatives 3, 6, and 8, the timing of the annual 30-day minimum flow was closer than the base case to the unimpaired condition. The timing of the annual 30-day maximum flow was shifted later in the year or was more variable in Alternatives 3 and 6 compared to the base case, resulting in a shift away from unimpaired conditions. For Alternatives 2 and 5, the timing of the annual 30-day maximum flow was closer than the base case to unimpaired conditions.

Tuolumne River. In July, simulated mean monthly flows for Alternative 5 were higher than in the base case, resulting in a shift toward unimpaired conditions. The timing of the annual 30-day minimum and maximum was shifted later in the year in Alternative 5 compared to the base case and other flow alternatives, also resulting in a slight shift toward unimpaired conditions.

Table VI-33
Range of Variability Analysis Stanislaus River at New Melones Reservoir

	Unimpaired Conditions (1922 - 93)						Alternative 1					Alternative 2					Alternative 3				
			Range limits		RVA Target Range				Range limits		Rate of Non-			Range limits		Rate of Non-			Range limits		Rate of Non-
IHA Group 1	Mean	SD	Low	High	Low	High	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment
Monthly Flow Magnitude (cfs)																					
October	160	179	0	1,434	0	339	601	1,292	63	5,362	15%	565	1,060	0	5,362	44%	535	1,234	63	5,362	14%
November	475	878	34	6,162	34	1,353	381	466	198	3,360	3%	317	471	198	3,360	3%	341	475	198	3,360	3%
December	858	1,309	49	6,712	49	2,166	463	754	130	4,744	4%	317	653	130	4,744	3%	392	710	130	4,744	4%
January	1,178	1,354	49	6,240	49	2,533	651	949	130	4,918	7%	435	859	130	4,918	6%	599	976	130	4,918	7%
February	1,651	1,507	18	9,596	144	3,158	965	1,204	124	4,986	22%	576	923	124	4,969	29%	888	1,175	124	4,969	31%
March	2,003	1,229	212	6,696	775	3,232	544	988	130	5,292	85%	466	921	130	5,292	90%	527	989	130	5,292	86%
April	3,222	1,263	589	7,290	1,958	4,485	750	433	471	1,467	100%	1,120	630	471	3,243	92%	744	424	471	1,467	100%
May	4,558	2,247	717	9,694	2,311	6,805	449	328	255	2,067	100%	1,186	575	255	2,707	94%	443	325	255	2,067	100%
June	2,914	2,033	185	10,640	881	4,947	585	909	255	4,595	90%	687	651	255	4,595	85%	648	882	255	4,595	90%
July	836	807	0	4,659	30	1,643	352	244	265	2,231	1%	542	258	265	2,231	1%	475	243	265	2,231	1%
August	200	193	0	1,254	6	393	317	44	283	407	10%	563	122	283	702	88%	558	52	412	675	100%
September	108	113	0	640	0	221	264	102	249	1,110	100%	253	67	0	758	99%	256	62	249	774	100%
IHA Group 2																					
Mean Annual Extremes																					
Annual 30-day minimum	69	67	0	488	2	135	115	60	63	289	19%	120	81	0	631	14%	101	82	63	616	14%
Annual 30-day maximum	4,922	2,280	717	10,640	2,642	7,202	1,547	1,543	471	5,362	78%	1,759	1,179	478	5,362	83%	1,520	1,464	488	5,362	79%
IHA Group 3																					
Timing of Annual Extremes																					
Month of annual minimum	9	1	7	2	8	10.33	11	2	8	3	31%	11	2	5	3	53%	9	3	3	10	17%
Month of annual maximum	4	1	12	6	3	5.00	3	2	10	6	44%	5	2	1	10	28%	6	3	1	12	90%

	Alternative 4					Alternative 5					Alternative 6					Alternative 8				
			Range limits		Rate of Non-			Range limits		Rate of Non-			Range limits		Rate of Non-			Range limits		Rate of Non-
IHA Group 1	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment
Monthly Flow Magnitude (cfs)																				
October	677	1,177	63	5,362	46%	627	1,109	63	5,362	43%	582	1,289	63	5,362	15%	418	456	125	1,501	29%
November	333	474	198	3,360	3%	326	472	198	3,360	3%	342	475	198	3,360	3%	451	416	208	1,501	13%
December	350	661	130	4,744	3%	339	660	130	4,744	3%	403	775	130	4,744	4%	463	484	208	3,187	1%
January	518	902	130	4,918	6%	476	880	130	4,918	6%	543	915	130	4,918	6%	473	571	146	3,487	3%
February	769	1,044	124	4,969	26%	672	953	124	4,969	26%	995	1,129	124	4,969	21%	621	724	146	4,825	1%
March	558	968	130	5,292	82%	525	947	130	5,292	85%	648	941	130	5,292	86%	533	851	146	6,502	85%
April	898	448	471	1,701	100%	1,068	505	471	2,572	97%	797	403	471	1,467	100%	1,124	396	475	1,591	100%
May	835	606	255	2,425	97%	1,022	528	255	2,484	99%	540	315	255	2,067	100%	1,196	572	455	3,837	96%
June	621	860	255	4,595	89%	607	770	255	4,595	88%	579	897	255	4,595	90%	971	1,073	241	8,460	78%
July	392	241	265	2,231	1%	390	240	265	2,231	1%	308	246	265	2,231	1%	575	271	255	2,545	1%
August	505	102	283	699	83%	482	102	283	699	76%	413	126	283	655	46%	506	150	268	684	72%
September	256	60	249	758	100%	256	60	249	758	100%	260	90	249	1,016	100%	270	100	224	1,067	100%
IHA Group 2																				
Mean Annual Extremes																				
Annual 30-day minimum	131	79	63	631	22%	129	79	63	631	22%	123	72	63	380	22%	218	83	125	635	82%
Annual 30-day maximum	1,743	1,348	471	5,362	81%	1,757	1,218	471	5,362	83%	1,590	1,487	471	5,362	78%	1,367	1,050	588	8,460	94%
IHA Group 3																				
Timing of Annual Extremes																				
Month of annual minimum	12	2	8	3	58%	12	2	8	3	58%	10	1	8	3	7%	9	2	3	10	17%
Month of annual maximum	6	3	1	10	47%	5	2	1	10	31%	5	3	1	12	64%	5	2	1	12	40%

Merced River. In October, simulated mean monthly flows for Alternative 5 were lower than in the base case, resulting in a shift toward unimpaired conditions. In February, simulated mean monthly flows for Alternatives 3 and 8 are lower than in the base case, resulting in a shift away from unimpaired conditions. Also in February, simulated mean monthly flows for Alternative 5 are higher than the base case, resulting in a shift toward unimpaired conditions. In July, mean monthly flows simulated for Alternatives 3 and 4 were lower than in the base case, resulting in a shift away from unimpaired conditions. Also in July, mean monthly flows simulated for Alternative 5 were higher than in the base case, resulting in a shift toward unimpaired conditions.

For Alternative 5, the magnitude of the annual 30-day maximum flow was shifted away from unimpaired conditions. However, the timing of the annual 30-day maximum flow for Alternative 5 was shifted toward unimpaired conditions.

In conclusion, the differences among the flow alternatives in the rate of non-attainment of the target ranges are minor. Rates of non-attainment are high in some months for all of the flow alternatives, since the pattern of regulated flow releases in the system differs significantly from the unimpaired condition. However, the pattern of non-attainment of the target ranges is generally similar among the flow alternatives. No significant impacts on riverine aquatic habitat in upstream areas are therefore expected. No mitigation is required.

b. Reservoirs. Central Valley reservoirs are generally either warm water reservoirs or two-level reservoirs that contain a lower zone of well-oxygenated cool water in summer with an upper zone of warm water. Warm water reservoirs are suitable for black bass, sunfish, and catfish. Because of drawdowns, inshore zones inhabited by warmwater species are often unproductive. Likewise, the deep, open-water portion of large reservoirs does not provide satisfactory habitat for most game fish.

Large, low elevation, two-level reservoirs such as Shasta, Oroville, Pine Flat and Berryessa support warmwater fish such as bass, sunfish, and catfish in the upper zone and coldwater species such as trout in the lower zone. These reservoirs provide greater fishing diversity than warm water reservoirs, although drawdowns limit species dependent on shallow water habitat, such as black bass and sunfish (USBR 1997a).

In general, reservoirs with shallow average water depths are more productive than reservoirs with greater average water depths. Optimal conditions for juvenile fish growth and survival are found in shallow water habitats. Maximum reservoir productivity is therefore assumed to occur with stable reservoir water surface elevations that maximize the surface area of shallow water habitat.

Factors Affecting Reservoir Fish. Reservoir surface area, reservoir morphology and water level fluctuations play an important role in productivity of reservoir fish populations. At high reservoir surface elevations, the physical habitat available for fish increases and the diversity and quality of the habitat is generally improved. Higher reservoir elevations typically provide greater surface area, shoreline, spawning opportunities, cover, and habitat diversity resulting in larger populations and more diverse fish communities. Reductions in reservoir storage and associated reductions in water elevation during critical time periods can adversely affect reservoir fisheries by affecting the quality and quantity of important shallow water habitat available for sensitive life stages. Water level fluctuation was the most frequently cited factor affecting fish production in the Central Valley Fish and Wildlife Management Study (Leidy and Meyers 1984). Extreme fluctuations are arguably the most significant controllable environmental factor affecting populations of warmwater fish in reservoirs, and are a direct result of reservoir management priorities (USBR 1997a).

Another important variable affecting reservoir fish productivity is fluctuating water surface elevation (i.e. reservoir drawdown and filling). When lake levels drop, juvenile fish are often forced into areas with less cover. Cover is important because it is typically correlated with food abundance and provides shelter from predation. Reservoir drawdowns limit fish production in multi-purpose reservoirs, especially if drawdown during the spring months is significant. Benefits of controlled reservoir drawdown include: increased availability of prey species, improved predator growth rates and revegetation of exposed shorelines (USBR 1997a; Lee and Paulsen 1989a).

Flooded terrestrial vegetation has been shown to be a factor in the development of strong year classes in fluctuating reservoirs (USBR 1997a). The upper area of the fluctuation zone is the most heavily invaded by terrestrial vegetation and is the least severely eroded by wave action. Flooded cover protects juvenile fish from predation and provides food sources during the summer and fall growing periods. Receding water levels can affect survival by exposing shoreline areas and leaving limited cover available for shelter of juvenile fish. Adverse impacts also include dewatering of nests and desiccation of eggs, disruption of spawning and nest-guarding areas, gradual loss of shoreline shelter due to erosion, reduction in food supplies, increased predation on nests and juvenile fish, and reduced habitat diversity. The degree of impact will depend upon the magnitude and timing of the drawdown, shoreline gradient, and amount and quality of habitat remaining inundated. Because vegetation density and encroachment along the shoreline of reservoirs is different for every reservoir and changes from year to year, an assumption for this analysis is that the juvenile habitat is best when the reservoir is at or near maximum pool elevation.

Central Valley reservoirs include a number of warmwater fish species. A major goal of reservoir fishery management is to provide quality black bass (*Micropterus spp*.) fishing for anglers. Black bass are found in numerous reservoirs and the Sacramento-San Joaquin Delta (DFG 1995). The black bass species most sensitive to reservoir water level fluctuations is the largemouth bass, *Micropterus salmoides*. Largemouth bass are one of the most popular warmwater game fish in California (USBR 1997a). Since largemouth are the most sensitive of the bass to water level fluctuations, this assessment of the impacts of changes in reservoir operations on warmwater fish in Central Valley reservoirs is based on the sensitive life history requirements of this species. Largemouth bass are therefore an indicator species in this analysis for other warmwater species, such as smallmouth bass, bluegill, crappie and sunfish. Analysis of effects on largemouth bass will provide a conservative (worst case) estimate of potential impacts of the proposed alternatives on all reservoir fishery resources. Largemouth bass was also used as an indicator species for the reservoir impact assessment in the CVPIA PEIS (1997). Because dams in the Central Valley preclude access to anadromous fish, the AFRP does not make recommendations regarding reservoir aquatic habitat.

The most critical periods for largemouth bass are the adult spawning period in the spring and early rearing period of juveniles in the spring and summer months. Largemouth bass spawning begins when water temperatures reach and exceed approximately 60°F. Although the initiation of spawning will vary between reservoirs depending on the latitude, elevation and size of the reservoir, the majority of the largemouth bass spawning probably occurs from March through May in California waters. The maximum depth of largemouth bass spawning reported or observed in California reservoirs was 7.2 feet and, based on the literature, could range from 3.2 to 13.1 feet. Stable or rising water levels during the spring spawning season have been associated with strong year classes of largemouth bass (Lee and Paulsen 1989a).

Methods of Analysis. The purpose of the analysis is to determine the effect of implementing the flow alternatives on upstream fisheries using largemouth black bass as an indicator species. Modeled end-of-month elevations for eight major reservoirs are used to determine the potential quality of reservoir fishery habitat for each flow alternative. Scoring criteria were developed to evaluate the suitability of the reservoir elevation for spawning and rearing of largemouth bass. The months considered in this analysis are March through September, the most sensitive time period for black bass (Lee and Paulsen 1989a and 1989b; Lee, D. pers. comm. March 1997). Scoring criteria in this analysis are based on the findings of the DFG (Lee and Paulsen 1989a and 1989b).

The following eight major reservoirs were selected for this analysis: Shasta, Oroville, Folsom, New Melones, New Don Pedro, Lake McClure, Millerton Lake and San Luis. Striped bass is the dominant species in San Luis Reservoir, however, San Luis also has largemouth bass. Millerton Lake has Alabama spotted bass, *Micropterus punctulatus punctulatus*, which nest in deep water, with no shallow water spawning bass (i.e., largemouth or smallmouth bass). The remaining reservoirs contain varying percentages of large- and smallmouth bass species (Lee, D. pers. comm. March 1997) as shown in Table VI-34. Although water elevation fluctuations may not affect the spotted and striped bass, the analysis characterizes reservoir operations in the spring and summer months and indicates relative potential impacts to warmwater aquatic species.

There are two critical factors that influence spawning habitat conditions: (1) starting elevation and (2) change in reservoir elevation during the spawning season. Stable and maximum pool levels are preferable for fry and juveniles that rear primarily in nearshore, shallow areas. Year class sizes may be large if rearing conditions are favorable even if spawning conditions were poor (Lee, D. pers. comm. March 1997). Therefore, in this analysis, each month is scored by: (1) the water surface elevation relative to maximum pool at the beginning of the month[2] and (2) the change in elevation during that month. These two scores are summed for the months of concern, March through September. The summed scores are then multiplied together to arrive at a reservoir habitat index value.

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[2] The water surface elevation is actually the end-of-period elevation for the previous month. In other words, the elevation in the beginning of June is actually the elevation at the end of May.

Stable or rising water levels are considered to be preferred conditions for bass spawning. The maximum pool elevation for a given reservoir was given the highest score of six, and every decreasing increment of five feet was given a decreasing score down to one at greater than 20 feet below maximum pool. If a reservoir water level in the current month rose or remained stable, it was also given the highest rank of six. The scoring for lower reservoir levels during the spawning season was based on five-foot increments. A decrease in water surface elevation of five feet would be ranked five, a decrease of ten feet would be ranked four, and so on. A decrease greater than 20 feet in one month is given a score of one. Because reservoirs draw down in the summer, maximum potential habitat scores do not occur.

Table VI-34
Species Composition of Black Bass in Selected Reservoirs

Reservoir	Largemouth Bass %	Smallmouth Bass %	Spotted Bass %
Shasta	10	10	80
Oroville	5	15	80
Folsom	33	33	33
New Melones	100	0	0
New Don Pedro	100	0	0
McClure	15	5	80
Millerton	0	0	100
San Luis	0[1]	0	0

[1] Striped Bass Dominate (Lee, D. pers comm March 1997)

The results of the habitat analysis are shown in Tables VI-35 and VI-36. The higher the index, the better the quantity and quality of habitat. The best habitat conditions are predicted for Flow Alternative 5 for the major Sacramento River reservoirs, Shasta, Oroville, and Folsom, as indicated by both the 73-year average indices and the dry-year average indices. However, the poorest habitat conditions are predicted for Flow Alternative 5 for the major non-project reservoirs on the San Joaquin River system, New Don Pedro, Lake McClure, and Millerton, for both the 73-year average and dry-year averages. The best habitat conditions are predicted for Alternative 7 for New Melones Reservoir over the 73-year average; conditions predicted for Alternative 2 are the poorest. Alternative 5 is the preferred alternative during the critical period. Overall, given the small (<4%) difference between the lowest (Alternative 5) and highest (Alternative 7) of the summed index scores, and limitations of the model as discussed above, there is no significant difference among the alternatives in the summed scores across all eight reservoirs. Therefore, using this scoring system for comparative analysis, an overall preferred alternative with respect to reservoir aquatic habitat quality cannot be identified.

Table VI-35

73-Year Period Average Reservoir Habitat Index

	Alt 1	73-Year Period Average Index - Difference from the Base Case						
Reservoir	(Base)	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Shasta	459	0	4	4	15	-18	-16	-2
Oroville	388	-4	1	1	44	-5	-14	-11
Folsom	438	-11	-7	-8	8	-31	-21	-10
New Melones	298	-45	-13	-26	-1	-4	40	15
New Don Pedro	358	0	-19	-18	-44	0	2	-8
McClure	387	0	-21	-7	-93	0	-4	-20
Millerton	329	0	0	0	-45	0	0	0
San Luis	265	21	24	24	28	55	37	10
Sum Total	2,922	-39	-32	-31	-44	-4	24	-24

Table VI-36

Critical Period Average Reservoir Habitat Index

	Alt 1	Critical Period Average Index - Difference from the Base Case						
Reservoir	(Base)	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Shasta	202	0	1	0	5	-5	1	-1
Oroville	184	4	9	7	41	5	6	6
Folsom	250	-27	-41	-42	-7	-22	-35	-23
New Melones	219	-40	-4	-24	10	4	-2	-21
New Don Pedro	229	0	-14	-34	-34	-6	1	-4
McClure	288	0	-5	-3	-69	0	0	-29
Millerton	194	0	0	0	4	0	0	0
San Luis	191	-14	-7	-8	0	4	22	16
Sum Total	1,757	-77	-61	-104	78	-20	-7	-87

Modeled reservoir elevations can be expected to have a margin of error of approximately 10 to 20 percent. Therefore, differences between the base case and the various alternatives for individual reservoirs are considered significant only if the indices are more than 10 percent different than the index for the base case.

Over the 73-year period, significant adverse impacts to habitat in New Melones Reservoir occur under Alternative 2 compared to the base case (15 percent difference). Predicted habitat indices are significantly lower for New Don Pedro Reservoir, Lake McClure and Millerton Lakes under Alternative 5 (12 percent, 24 percent and 14 percent, respectively).

Over the critical period, predicted habitat indices for Folsom Reservoir are significantly lower under Alternatives 2 (11 percent), 3 (16 percent), 4 (17 percent) and 7 (12 percent). Indices for New Melones Reservoir are significantly lower under Alternatives 2 (18 percent) and 4 (11 percent). Significant adverse impacts occur at New Don Pedro under Alternatives 4 and 5 (15 percent each), and at Lake McClure under Alternative 5 (24 percent).

Mitigation. The implementation of the flow alternatives may result in significant impacts to reservoir fisheries at one or more reservoirs, depending on the alternative selected. These impacts are generally temporary and mitigable. If significant effects on reservoir fish populations are observed, mitigation could include additional fish planting, habitat improvement through planting of shoreline vegetation, addition of habitat structures, or improved management of shoreline grazing practices.

4. Vegetation and Wildlife

Implementation of the flow alternatives may result in impacts to vegetation and wildlife resources upstream of the Delta. Changes in reservoir operations may affect reservoir water levels and resulting downstream flows. Changes in reservoir water levels could affect the amount of riparian vegetation in the drawdown zone and the amount of reservoir habitat available to wildlife species. Changes in downstream flows may affect the maintenance and regeneration of riparian and wetland vegetation and its associated wildlife. Reductions in water supply could affect wetland habitat at wildlife refuges and privately owned duck clubs.

This analysis of impacts on vegetation and wildlife focuses on potential changes in habitat rather than populations of individual species. Wildlife populations may be affected by factors beyond the control of the SWRCB and appropriate analytical tools are not available for many potentially impacted species (USBR 1997c). Four general categories of habitat are considered: (a) wetland and riparian habitats which would be affected by changes in river hydrology, (b) riparian vegetation within reservoir drawdown zones, (c) aquatic habitats used by waterfowl species at reservoirs, and (d) wetland habitat at wildlife refuges and duck clubs. Impacts to the first three categories of habitats are assessed by considering: (1) the changes in modeled river stage and (2) the changes in modeled reservoir operations. This analysis is based on the methodology developed by the CVPIA for analyzing the effects on vegetation and wildlife. Modeling studies assume that no agricultural farmland is fallowed to obtain water to meet the flow objectives and that cropping patterns in the Central Valley remain unchanged. Hence, impacts to agricultural and terrestrial habitats are not assessed by means of hydrologic modeling. However, the potential for changes to occur in wetland habitat at wildlife refuges and private duck clubs was considered based on the likelihood of water supplies being reduced through the implementation of the 1995 Bay/Delta Plan.

a. Impacts on Riparian Vegetation and Riparian Wetland Habitats. The condition of riparian vegetation and wetland habitat in the riparian zone of major rivers was assessed using simulated river water surface elevation (stage) at representative locations. Average monthly stage was calculated for the base case and each alternative for average, wet and dry year conditions[3]. Differences among alternatives are expressed as a percent change from the base case. Drought represented by low summer stages, and inundation mortality (high stages year-round) are considered to be the major impact mechanisms. Adequate spring and summer stages are considered critical for habitat maintenance; fall and winter water levels are relatively less important. Due to the nature of the hydrologic input data and the use of average monthly operations, modeled surface water elevations may be expected to have a margin of error of plus or minus 10 to 20 percent. Therefore, differences between alternatives are considered to be significant only if greater than 20 percent in a detrimental direction (USBR 1997b).

Simulated river flows obtained from DWRSIM, expressed in cubic feet per second, are converted to stage using the general relationship:

$$\text{Gage Depth} = (\text{Coefficient}) \times (\text{Flow}^{\text{Exponent}})$$

Coefficients and exponents were developed by the CVPIA for each gage location using historic data and non-linear regression techniques. The location of river stage gages and other relevant information are listed in Table VI-37 (USBR 1997d).

Results of the analysis are contained in Tables VI-38 through VI-43. Values that exceed the 20 percent significance threshold are indicated in bold type and in bold italics if the impact is negative.

On the lower Sacramento River at Verona (Table VI-39), beneficially higher stages are predicted in June of dry years under Alternatives 2, 6, 7 and 8. Likewise, beneficially higher flows are expected at Verona under Alternative 5 during the December to June period of dry years. Reduced river stages are expected in wet years at Verona under Alternative 5 between December and May, exceeding the significance threshold in February, April and May. Significantly reduced river stages are expected on the Feather River under Alternatives 5, 7 and 8 in May of dry years, and under Alternative 5 in August of wet years (Table VI-40). Significantly higher river stages are expected at Gridley during dry conditions in June under all alternatives except Alternative 5. On the American River (Table VI-41), dry year stages are significantly higher for Alternatives 2, 6 and 8 in June and for Alternatives 2 through 6 in September.

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[3] "Wet" years are the average of wet and above normal years as defined in the 1995 Bay/Delta Plan for the Sacramento and San Joaquin river basins. "Dry" years are the average of below normal, dry, and critically dry year types.

Table VI-37
Information Used for Estimation of River Stage

Stream Reach	Gage Location	DWRSIM Nodes	Coefficient	Exponent
American River	Fair Oaks	CP09 dsf	0.110	0.460
Feather River	Gridley	CP106 dsf	0.027	0.587
Upper Sacramento R.	Bend Bridge	CP74 dsf	0.020	0.630
Lower Sacramento R.	Verona	CP43 dsf minus CP64 dsf minus CP43 local inflow	0.016	0.678
Upper San Joaquin R.	Newman	CP695 dsf plus CP704 div plus CP762 div	0.400	0.400
Lower San Joaquin R.	Vernalis	CP682 dsf	0.130	0.500

Note: dsf = downstream flow, div = actual diversion

On the upper San Joaquin River, Alternative 5 produces dramatically improved river stage conditions at Newman (Table VI-42) between April and August of all year types and in March of dry years. In dry years, Alternatives 3, 6 and 8 enhance the upper San Joaquin River during the April-June time period. In the lower San Joaquin River basin, significantly higher river stages are expected at Vernalis (Table VI-43) in dry years from May to July for Alternatives 3 and 4, and from April to July for Alternative 5 under all water year conditions. The additional river flow expected in Alternative 5 would enhance San Joaquin River riparian habitat from Friant Dam to the Delta. Alternatives 3, 6 and 8 would enhance the river from the confluence with the Merced River to the Delta.

Reduced river stages predicted at Verona occur during wet years and therefore would not have a significant adverse impact to riparian habitat. Periodic high flows are needed by riparian vegetation to promote regeneration. Peak river stages are unaffected by any of the flow alternatives (see Table VI-46). Lower river stages are predicted on the Feather River in dry years and therefore are presumed to be detrimental. Exceedances range from 0.1 to 3.6 percent higher than the 20 percent criteria for significance and occur in only one month for each of the affected alternatives. The differences are small enough that riparian vegetation would adjust to the new flow regime without specific mitigation.

Table VI-38

Sacramento River at Red Bluff Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	5.3	6.0	7.2	8.1	9.0	8.2	7.0	6.8	7.0	7.7	6.8	4.9

Percent Change in Average Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	0.5	1.7	0.0	-0.6	0.6	0.9	0.1	-1.1	6.5	-2.7	-4.2	0.1
Alt 3	1.0	2.5	0.4	-0.4	0.8	1.0	0.2	-1.2	5.4	-3.8	-4.4	0.5
Alt 4	1.0	2.5	0.4	-0.4	0.8	0.9	0.2	-1.2	5.5	-3.7	-4.4	0.4
Alt 5	2.9	4.4	1.3	0.7	1.5	1.7	0.0	-2.1	4.0	-7.3	-4.3	0.9
Alt 6	0.8	0.0	-1.1	-1.1	-0.5	0.2	0.2	-1.6	9.2	-2.3	-2.9	3.1
Alt 7	-0.5	0.0	-0.5	-1.0	0.1	1.1	2.2	-2.5	8.7	-2.7	-3.5	0.0
Alt 8	0.7	1.3	0.0	-0.6	1.2	0.8	-0.5	-1.4	6.8	-2.5	-4.3	0.6

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	5.1	5.4	5.5	5.8	6.6	6.1	5.8	6.1	6.7	7.5	6.7	4.4

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	0.0	2.5	-0.4	-0.9	2.1	2.3	-0.8	-2.0	9.9	-0.9	-6.6	-1.8
Alt 3	0.4	3.1	0.1	-0.7	2.3	2.5	-0.6	-2.1	8.0	-2.1	-6.8	-1.5
Alt 4	0.4	3.0	0.1	-0.7	2.3	2.5	-0.6	-2.1	8.1	-1.9	-6.9	-1.6
Alt 5	2.7	3.7	1.3	0.6	3.0	3.5	-0.5	-3.6	4.8	-6.5	-6.6	-1.8
Alt 6	0.6	1.9	-1.1	-1.5	0.3	0.8	-0.6	-3.2	14.0	-0.6	-5.9	3.0
Alt 7	-1.2	1.0	-0.9	-1.4	1.5	2.7	2.2	-3.5	12.8	-1.3	-5.5	-1.8
Alt 8	0.0	2.1	-0.3	-0.9	2.9	2.1	-1.3	-2.8	11.0	-0.7	-6.7	-1.1

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	5.7	6.8	9.5	11.2	12.3	10.9	8.6	7.8	7.3	8.0	6.9	5.6

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	1.2	0.8	0.3	-0.4	-0.4	-0.2	0.9	-0.2	2.3	-5.0	-1.0	2.1
Alt 3	1.7	1.9	0.7	-0.1	-0.2	-0.1	0.9	-0.2	2.2	-6.1	-1.1	2.6
Alt 4	1.7	1.9	0.6	-0.1	-0.2	-0.2	0.9	-0.2	2.2	-6.0	-1.1	2.6
Alt 5	3.1	5.2	1.3	0.7	0.4	0.3	0.4	-0.6	3.0	-8.3	-1.1	3.6
Alt 6	1.1	-1.9	-1.1	-0.9	-1.0	-0.2	0.8	0.2	3.2	-4.5	1.2	3.3
Alt 7	0.3	-1.0	-0.2	-0.7	-0.9	0.0	2.2	-1.4	3.7	-4.5	-0.8	1.9
Alt 8	1.6	0.5	0.3	-0.4	0.0	-0.1	0.3	0.1	1.5	-4.8	-1.0	2.4

Table VI-39

Sacramento River at Verona Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	9.1	9.8	12.2	15.5	17.4	16.9	12.2	10.7	9.5	9.7	8.5	7.9

Percent Change in Average Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-3.2	0.3	-1.7	-1.5	0.5	0.6	1.0	-2.2	11.6	5.1	-8.6	-1.2
Alt 3	-2.4	1.2	-1.2	-1.2	0.7	0.7	1.2	-2.3	9.3	3.7	-8.5	-1.2
Alt 4	-2.5	1.1	-1.3	-1.2	0.7	0.6	1.2	-2.3	9.4	3.8	-8.5	-1.2
Alt 5	-0.4	4.4	0.9	0.1	2.1	2.2	2.2	-0.6	11.1	0.0	-6.8	1.1
Alt 6	-2.9	-0.3	-2.8	-1.7	-0.1	0.3	0.8	-2.7	13.8	5.8	-6.9	1.0
Alt 7	-3.8	-1.0	-2.6	-2.0	-0.1	0.8	4.1	-4.5	13.6	5.9	-7.6	-1.2
Alt 8	-3.6	-0.2	-2.3	-1.7	0.9	0.6	0.0	-3.1	11.8	6.6	-6.0	-0.6

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	8.7	8.6	9.5	11.5	13.2	12.5	8.6	5.0	7.9	9.2	8.5	7.0

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-4.6	1.1	-2.2	-1.8	1.7	1.7	1.3	-7.6	**21.3**	7.6	-9.6	-3.3
Alt 3	-3.9	1.7	-1.8	-1.6	2.0	1.7	1.7	-7.9	17.4	6.0	-9.5	-3.7
Alt 4	-3.9	1.6	-1.8	-1.6	2.0	1.7	1.7	-7.8	17.7	6.1	-9.5	-3.7
Alt 5	0.7	9.4	**23.6**	**26.8**	**33.2**	**29.7**	**39.4**	**37.0**	**32.4**	5.4	-8.0	7.8
Alt 6	-4.0	1.4	-2.4	-1.9	0.9	1.0	0.7	-8.8	**25.3**	8.4	-8.7	0.2
Alt 7	-5.3	-0.2	-3.1	-2.3	1.2	2.1	6.9	-10.8	**23.7**	6.6	-9.4	-3.1
Alt 8	-4.8	0.7	-2.9	-1.9	2.3	1.4	-0.4	-9.4	**22.4**	8.8	-7.3	-2.6

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	9.6	11.5	15.9	20.9	13.3	22.7	16.8	14.4	11.6	10.5	8.5	9.0

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-1.6	-0.6	-1.3	-1.3	-0.4	-0.2	0.8	1.9	2.6	2.2	-7.1	1.0
Alt 3	-0.7	0.7	-0.8	-0.9	-0.3	-0.2	0.8	1.9	1.8	0.9	-7.1	1.4
Alt 4	-0.7	0.6	-0.9	-0.9	-0.3	-0.2	0.9	1.9	1.8	0.9	-7.2	1.4
Alt 5	-1.6	-0.6	-17.5	-19.8	***-21.7***	-18.3	***-24.2***	***-28.9***	-8.4	-6.5	-5.1	-5.9
Alt 6	-1.5	-2.1	-3.1	-1.6	-0.9	-0.2	0.8	1.9	3.3	2.8	-4.6	1.8
Alt 7	-2.0	-1.9	-2.2	-1.7	-1.0	-0.1	2.1	0.3	4.3	5.0	-5.1	0.9
Alt 8	-2.1	-1.1	-1.7	-1.5	-0.1	-0.1	0.3	1.7	2.1	4.1	-4.3	1.4

Table VI-40

Feather River at Gridley Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	2.9	2.6	3.4	3.8	4.1	4.1	2.7	3.1	3.1	3.7	3.2	2.1

Percent Change in Average Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-12.8	-4.4	-7.2	-5.7	1.1	0.7	5.6	-3.3	15.5	17.3	-12.1	-6.6
Alt 3	-10.9	-3.1	-6.6	-5.2	1.4	0.4	6.1	-3.7	11.9	16.5	-11.6	-7.5
Alt 4	-11.0	-3.1	-6.7	-5.2	1.3	0.4	6.0	-3.6	12.1	16.5	-11.6	-7.4
Alt 5	-7.5	1.2	-2.6	-1.9	3.1	3.1	2.4	-7.7	4.3	7.1	-12.8	-1.4
Alt 6	-11.9	-1.9	-8.1	-5.3	1.3	0.7	3.7	-3.8	14.4	17.8	-11.6	-6.1
Alt 7	-12.4	-4.9	-9.0	-7.0	-0.1	1.2	14.3	-7.5	15.1	19.0	-11.2	-6.1
Alt 8	-14.5	-5.4	-9.4	-6.6	0.7	0.5	2.2	-5.8	15.5	**20.3**	-5.4	-5.3

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	2.8	2.4	2.8	2.6	2.7	2.6	1.9	2.6	2.7	3.8	3.4	2.1

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-16.2	-3.4	-7.4	-7.4	3.4	1.7	11.3	-16.7	**28.0**	16.4	-8.2	-8.6
Alt 3	-14.4	-2.7	-7.1	-7.3	4.4	1.4	12.7	-17.7	**23.3**	15.6	-7.4	-10.4
Alt 4	-14.5	-2.8	-7.1	-7.3	4.4	1.4	12.5	-17.3	**23.8**	15.5	-7.3	-10.2
Alt 5	-9.6	1.9	-5.4	-5.7	7.4	6.3	4.8	***-23.6***	16.1	12.7	-6.0	-7.6
Alt 6	-15.0	-0.4	-6.5	-6.3	5.1	2.2	6.7	-16.7	**26.3**	17.2	-7.5	-7.8
Alt 7	-15.9	-3.9	-9.3	-8.5	1.9	3.7	**29.1**	***-22.3***	**25.5**	15.1	-9.9	-7.7
Alt 8	-17.1	-3.9	-10.4	-8.2	2.9	0.7	4.8	***-20.1***	**27.7**	18.4	-2.3	-7.3

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	2.9	2.9	4.3	5.4	6.1	6.1	3.8	3.9	3.5	3.4	3.0	2.2

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-8.4	-5.5	-7.0	-4.6	-0.2	0.1	1.8	8.7	2.4	18.7	-18.2	-4.1
Alt 3	-6.4	-3.6	-6.2	-3.8	-0.3	-0.2	1.7	8.6	-0.2	17.9	-18.1	-3.9
Alt 4	-6.3	-3.5	-6.4	-3.8	-0.6	-0.1	1.8	8.7	-0.3	17.9	-18.3	-3.8
Alt 5	-4.7	0.5	-0.1	0.5	0.6	1.3	0.8	6.5	-8.3	-1.3	***-23.4***	6.4
Alt 6	-7.8	-3.7	-9.5	-4.7	-0.9	-0.1	1.7	7.6	1.8	18.8	-18.0	-4.0
Alt 7	-7.9	-6.1	-8.8	-6.1	-1.3	-0.3	4.4	5.6	4.1	**24.8**	-13.2	-4.1
Alt 8	-11.2	-7.1	-8.6	-5.5	-0.5	0.4	0.5	6.9	2.6	**23.0**	-10.3	-2.8

Table VI-41
American River at Natoma Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	3.7	3.9	4.4	4.7	5.1	4.7	4.6	4.3	4.8	4.6	4.1	3.3

Percent Change in Average Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-4.5	-1.1	-4.6	-2.9	-0.5	1.0	0.3	2.0	11.3	-5.3	-7.9	7.3
Alt 3	-4.2	-0.7	-3.8	-1.8	0.0	1.3	0.0	2.3	10.0	-5.4	-8.7	10.6
Alt 4	-4.2	-0.7	-4.0	-1.9	0.0	1.6	-0.1	2.1	10.2	-5.4	-8.7	10.4
Alt 5	2.3	1.6	-1.5	-0.3	1.0	1.9	-2.4	-0.2	7.4	-8.6	-5.4	13.4
Alt 6	2.7	-3.4	-7.0	-4.4	-2.6	-0.5	0.3	3.0	13.0	-4.3	-6.4	13.9
Alt 7	4.3	-2.6	-4.9	-3.3	-0.4	1.5	2.6	-0.1	12.7	-4.2	-8.6	8.5
Alt 8	3.9	-1.3	-4.3	-2.7	0.1	1.0	-0.7	1.6	11.5	-4.8	-7.6	9.6

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	3.6	3.6	3.7	3.6	4	3.8	3.8	3.5	4.1	4.5	3.9	2.5

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-2.4	-0.5	-6.6	-5.5	-1.0	2.2	0.0	3.6	**20.8**	-4.7	-14.7	**21.0**
Alt 3	-2.0	0.0	-5.0	-4.2	-0.1	2.8	-0.7	4.2	18.1	-3.9	-16.1	**20.8**
Alt 4	-2.0	-0.3	-5.4	-4.6	-0.1	3.4	-1.0	3.7	18.6	-4.1	-16.0	**20.5**
Alt 5	-0.6	2.5	-2.6	-0.9	1.9	3.9	-5.2	-0.6	12.5	-7.2	-11.0	**25.5**
Alt 6	0.5	-1.2	-8.5	-8.1	-5.8	-1.0	-0.2	5.3	**23.2**	-3.9	-14.1	**28.4**
Alt 7	0.2	6.7	4.3	7.4	5.5	3.6	-3.9	-0.7	4.2	-16.1	-18.9	17.8
Alt 8	-1.9	-0.1	-6.1	-4.9	-0.2	2.1	-1.7	2.6	**21.7**	-4.1	-14.3	19.5

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	3.8	4.3	5.3	6.2	6.7	5.9	5.6	5.4	5.6	4.8	4.4	4.4

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-7.2	-1.8	-2.7	-0.9	0.0	-0.1	0.7	0.7	1.9	-5.9	0.3	2.1
Alt 3	-7.1	-1.4	-2.6	0.1	0.0	0.0	0.7	0.7	1.9	-7.2	0.2	2.8
Alt 4	-7.1	-1.3	-2.7	0.2	0.0	-0.1	0.7	0.7	1.9	-7.2	0.2	2.8
Alt 5	-4.5	0.5	-0.6	0.2	0.3	0.0	0.2	0.2	2.4	-10.5	1.4	4.3
Alt 6	-7.0	-5.9	-5.6	-1.5	-0.1	-0.1	0.7	1.0	2.9	-4.9	2.9	2.8
Alt 7	-8.2	-4.2	-3.2	-0.8	0.1	-0.1	1.7	0.1	2.8	-5.1	-0.2	1.9
Alt 8	-6.5	-2.7	-2.5	-1.0	0.3	0.0	0.2	0.8	1.3	-5.6	0.4	2.0

Table VI-42

San Joaquin River at Newman Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	7.3	5.7	6.2	7.0	8.6	7.6	6.4	7.0	6.4	5.1	4.9	5.8

Percent Change in Average Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-0.3	-0.3	-0.3	-0.1	-0.3	-0.2	-0.4	-0.3	-0.5	-0.6	-0.7	-0.6
Alt 3	-1.9	-1.6	-1.5	-1.9	-3.2	-1.0	9.0	11.8	9.9	10.8	3.3	-0.8
Alt 4	-1.1	-0.7	-0.9	-1.6	-2.0	0.3	3.3	5.9	9.0	10.9	3.9	-0.1
Alt 5	11.9	3.6	2.0	2.2	10.5	19.6	**57.5**	**45.6**	**27.1**	**62.0**	**26.8**	5.9
Alt 6	5.7	-0.3	-0.2	-0.1	0.4	1.5	16.0	**25.8**	11.2	11.0	6.8	-0.5
Alt 7	-1.0	-0.7	-0.6	-1.2	-1.8	-0.2	4.6	4.2	-0.9	-0.7	-0.8	-0.7
Alt 8	2.5	-1.6	-1.7	-1.9	-3.7	-0.7	11.1	11.3	-2.0	-0.8	-0.7	-1.2

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	7.2	5.4	5	5.1	6.1	5.8	4.8	4.7	4.6	4.8	4.9	5.5

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-0.3	-0.4	-0.4	-0.1	-0.7	-0.4	-0.8	-0.7	-1.1	-1.0	-1.0	-1.0
Alt 3	-2.5	-0.8	-0.4	-1.1	-3.2	0.0	15.9	**29.0**	**21.4**	14.4	3.7	-0.7
Alt 4	-1.2	-0.5	-0.4	-1.1	-2.2	0.3	5.1	12.2	19.2	14.4	3.8	**-0.7**
Alt 5	10.8	5.5	7.7	8.9	18.0	**25.2**	**64.3**	**65.6**	**37.9**	**55.8**	**23.7**	8.5
Alt 6	5.7	-0.2	-0.3	-0.1	1.0	1.9	**27.1**	**47.5**	17.7	**21.6**	12.7	-0.9
Alt 7	-1.5	-0.3	-0.5	-1.0	-2.1	-0.4	9.6	-1.3	-1.1	-1.2	-1.1	
Alt 8	1.5	0.1	2.3	5.1	9.9	4.1	**22.3**	**28.9**	1.8	-1.2	-1.5	-0.9

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	7.3	6.1	7.5	9.3	11.4	9.7	8.2	9.5	8.5	5.4	4.9	6.2

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	-0.2	-0.1	-0.2	-0.3	-0.3	-0.3
Alt 3	-1.2	-2.3	-2.4	-2.5	-3.2	-1.6	4.4	2.1	2.6	7.1	2.9	-0.9
Alt 4	-1.0	-0.9	-1.3	-2.0	-1.8	0.2	2.0	2.4	2.6	7.4	4.1	0.6
Alt 5	13.1	1.7	-2.4	-2.0	5.8	15.7	**52.9**	**34.3**	**20.4**	**68.3**	**30.4**	3.3
Alt 6	5.6	-0.3	-0.2	-0.1	0.0	1.3	8.4	13.5	7.1	0.2	0.0	-0.1
Alt 7	-0.5	-1.1	-0.8	-1.2	-1.6	-0.1	1.1	1.0	-0.6	-0.3	-0.4	-0.4
Alt 8	3.9	-2.4	-2.3	-2.7	-9.3	-0.8	6.4	5.0	-0.4	0.8	0.2	-0.6

Table VI-43

San Joaquin River at Vernalis Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	6.9	5.7	6.4	7.7	9.7	9.2	8.9	8.0	6.9	5.2	4.8	5.6

Percent Change in Average Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	0.7	-2.0	-2.9	-3.0	-2.9	-0.2	4.7	10.9	4.0	5.8	8.1	-0.8
Alt 3	1.4	-2.3	-3.2	-4.1	-3.9	-0.6	5.0	11.7	16.6	17.1	14.5	-0.8
Alt 4	1.2	-2.0	-3.1	-4.4	-3.8	-0.2	5.0	11.5	16.4	17.0	15.3	-0.4
Alt 5	9.1	0.1	-1.7	-3.9	5.0	8.3	**22.8**	**25.9**	17.2	**43.8**	17.7	2.8
Alt 6	2.3	-1.3	-1.7	-1.4	-0.7	0.5	5.1	10.9	7.1	9.6	12.0	-0.5
Alt 7	4.8	0.6	2.4	1.3	0.7	0.9	0.1	4.1	4.9	7.2	-2.0	-6.0
Alt 8	0.3	1.0	0.0	-2.4	-4.0	-0.3	7.8	14.5	6.1	6.6	5.4	-1.2

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	6.8	5.4	5.4	5.5	6.4	6.2	6.5	5.5	4.6	4.4	4.5	5.1

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-0.6	-2.8	-4.1	-4.6	-3.2	0.5	9.2	**20.5**	**9.2**	7.9	8.2	-1.2
Alt 3	1.0	-2.2	-3.2	-4.1	-3.2	-0.6	9.6	**22.2**	**34.2**	**25.5**	18.3	-0.8
Alt 4	0.6	-2.5	-3.6	-4.7	-3.1	-0.4	9.5	**21.8**	**32.9**	**25.5**	19.2	-0.8
Alt 5	8.4	0.4	-0.1	0.1	10.6	14.1	**27.1**	**34.8**	**27.5**	**48.1**	19.6	4.8
Alt 6	2.1	-1.9	-2.9	-3.3	-1.7	0.5	9.1	**20.0**	14.2	15.6	15.3	-0.9
Alt 7	4.4	-0.3	1.1	0.4	1.1	1.7	2.9	9.0	10.9	10.8	-11.1	-8.0
Alt 8	-1.6	1.7	3.7	3.7	10.8	9.2	**20.9**	**32.3**	15.1	11.0	4.4	-0.3

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	7.0	6.1	7.7	10.3	13.3	12.6	11.7	10.9	9.5	6.2	5.1	6.1

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	2.0	-1.1	-2.0	-2.0	-2.8	-0.7	1.8	5.4	1.2	4.1	8.1	-0.4
Alt 3	1.9	-2.4	-3.3	-4.1	-4.3	-0.6	2.1	5.6	6.8	10.1	10.6	-0.8
Alt 4	2.0	-1.5	-2.6	-4.2	-4.2	-0.1	2.1	5.5	7.2	9.9	11.3	0.1
Alt 5	9.9	-0.3	-3.1	-6.3	1.9	5.0	**20.1**	**20.7**	11.4	**40.2**	15.8	1.0
Alt 6	2.6	-0.7	-0.8	-0.2	-0.2	0.5	2.5	5.6	3.1	4.7	8.5	-0.2
Alt 7	5.3	1.5	3.4	1.8	0.5	0.5	-1.6	1.2	1.5	4.2	7.3	-4.1
Alt 8	3.0	1.4	-0.7	-2.3	-8.8	-1.7	2.6	7.7	5.5	5.1	7.7	-0.6

b. Impact on Vegetation in Reservoir Drawdown Zones. Changes in the operations of reservoirs controlled by the SWP, the CVP, and others to meet the flow objectives could result in long term changes in reservoir water levels. Lower average water elevations would allow reemergence and long term survival of former riparian habitat along tributary streams. Due to extensive loss of topsoil in the drawdown zone, establishment of new upland terrestrial vegetation on the reservoir sidewall would not be expected.

Quantitative data on the abundance and distribution of riparian habitat is available only for Folsom Lake, which supports about 65 acres of willow scrub between elevations 400 and 470. The response of riparian vegetation in other reservoirs to changing operations is assumed to follow a pattern similar to that observed at Folsom. Willow is subject to drowning if inundated for more than three consecutive months during the March-August growing season (USBR 1997b). Therefore, operating reservoirs at lower average elevations, though it might adversely impact other resources or beneficial uses, could have a positive impact on riparian vegetation within a reservoir.

An analysis of Folsom Lake elevations is presented in Table VI-44. The data represents the percent of years in which the reservoir water level exceeds the elevation specified in column one of Table VI-44 for three consecutive months during the growing season.

Table VI-44
Folsom Lake Vegetation Inundation Assessment
(Percent of Years Reservoir Level Exceeds Column 1 Elevation)

Elevation (ft)	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
440	41.1	39.7	41.1	41.1	50.7	37.0	38.4	39.7
430	68.5	60.3	58.9	58.9	64.4	53.4	54.8	60.3
420	74.0	65.8	68.5	69.9	72.6	64.4	65.8	65.8
410	82.2	79.5	80.8	78.1	80.8	75.3	74.0	80.8
400	87.7	80.8	82.2	82.2	80.8	80.8	82.2	80.8

In general, reservoir levels are higher for Alternative 1 than for the other alternatives, with the exception of Alternative 5. The percentage of years during which vegetation is exposed to prolonged inundation at the 440-foot level, for example, varies between -4.1 percent and +9.6 percent. The differences among alternatives are not significant.

c. Waterfowl at Reservoirs. Changes in reservoir operations can affect availability of prey species, such as fish, as well as the amount of shallow and open water habitat utilized by waterfowl. The impact of altered reservoir operations on fishery resources is presented in section C.2. An analysis was performed on selected reservoirs to determine the acreage of shallow water (0 to 1 foot deep), mid-water (1 to 15 feet deep), and open water habitat (>15 feet deep) among alternatives for selected reservoirs. The results of the analysis are presented in Tables VI-45a through VI-45c. Mallards, cinnamon teal and other dabbling ducks use shallow water habitat. Mid-water habitat is utilized by lesser scaup and ring necked ducks; open water is favored by species such as gulls and grebes. The results for Alternative 1 represent the absolute numbers of acres for a particular habitat; results for the other alternatives represent the change in acreage compared to the base case.

Results of the shallow water analysis are highly variable. There is considerable uncertainty in the reservoir elevation/surface area relationship derived from the DWRSIM output. Therefore, firm conclusions can not be drawn, though the differences are most likely insignificant.

Mid-water habitat decreases by more than 20 percent when compared to the base case during dry years at New Melones Reservoir under Alternatives 2. Open water habitat is decreased by more that 20 percent in dry years at Folsom Lake under Alternatives 2, 6, 7 and 8 when compared to the base case. In average years and dry years for Alternative 2, New Melones Reservoir open water habitat is reduced by 23.3 percent and 27.7 percent respectively. Alternative 5 produces 26.7 and 24.7 percent declines in open water habitat at New Don Pedro Reservoir and Lake McClure respectively. Reductions is gross habitat area could be significant if gross habitat area was the factor limiting population size or growth. As this is unlikely to be the case, the gross habitat reductions would have an insignificant impact.

d. Wetland Habitat at Wildlife Refuges and Duck Clubs. Wildlife refuges and management areas and privately owned and managed duck clubs provide important wetland habitat. Surface water supplies are used at most of these locations to provide seasonal flooding, maintain wetland habitat and to grow feed crops that attract waterfowl. Implementation of the flow objective alternatives is not expected to have a significant impact to the wetland habitat at wildlife refuges and management areas or privately owned and managed duck clubs.

Most of the water needs for wetlands management occur from September through April. This includes water used for winter rice field flooding that is generally diverted in the fall months. Under the 1995 Plan flow alternatives, water right holders would be required to reduce diversions most frequently in June, July, and August and rarely in other months. Therefore, most of the diversion for wetlands management occurs outside the period of impact.

The majority of the privately owned and managed wetlands in the Sacramento Valley are located in the Butte, Sutter, and Colusa basins. Much of the surface water that is in these basins is tailwater from irrigation districts with pre-1914 water rights. The pre-1914 water rights will not be curtailed under the flow alternatives; therefore, this water supply would not be affected. The private landowners that support wetlands and divert surface water under appropriative rights generally have relatively small cumulative face value in their water rights and, thus, most fall below the threshold included in this document.

Table VI-45a
Average Area of Shallow Reservoir Habitat, 0-1 Foot Depth

Average of All Years (acres)

Alternative	Shasta	Oroville	Folsom	New Molones	McClure	N. Don Pedro
Alt 1	147	23	72	36	24	37

Difference Between Alternative and Base Case

Alt 2	-40	4	11	11	0	0
Alt 3	-16	15	6	-7	15	-5
Alt 4	-16	4	6	10	8	3
Alt 5	-5	8	0	72	3	23
Alt 6	-11	17	32	11	0	0
Alt 7	-33	11	-9	2	4	15
Alt 8	-40	11	5	-10	3	8

Average of Dry Years (acres)

Alternative	Shasta	Oroville	Folsom	New Molones	McClure	N. Don Pedro
Alt 1	84	42	85	51	26	50

Difference Between Alternative and Base Case

Alt 2	8	-22	-26	12	0	0
Alt 3	0	7	-36	-4	-3	-25
Alt 4	0	-22	-36	-12	0	-15
Alt 5	-39	-9	-13	-27	-7	9
Alt 6	25	-35	-25	-11	0	0
Alt 7	12	7	27	-6	0	-88
Alt 8	19	7	-56	-27	-2	-6

Average of Wet Years (acres)

Alternative	Shasta	Oroville	Folsom	New Molones	McClure	N. Don Pedro
Alt 1	140	60	79	33	26	55

Difference Between Alternative and Base Case

Alt 2	-22	-8	0	-8	0	0
Alt 3	-22	-16	-15	0	-2	-10
Alt 4	-22	-16	-15	15	15	-8
Alt 5	-13	-13	-10	-1	0	-18
Alt 6	20	-16	3	9	0	0
Alt 7	0	-16	-9	8	7	-14
Alt 8	-22	-19	-15	2	15	-31

Table VI-45b
Average Area of Mid-Water Reservoir Habitat, 1-15 Foot Depth

Average of All Years (acres)

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 1	1,667	516	1,039	576	383	659

Difference Between Alternative and Base Case

Alt 2	15	0	-6	91	0	0
Alt 3	102	-16	215	108	-28	-29
Alt 4	102	0	-14	89	-17	-18
Alt 5	33	-1	0	-55	-44	-77
Alt 6	-16	-9	-38	-55	0	0
Alt 7	-33	81	-18	-77	-8	4
Alt 8	15	-9	18	99	-19	-19

Average of Dry Years (acres)

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 1	1,396	487	1,007	669	361	646

Difference Between Alternative and Base Case

Alt 2	69	-12	130	-427	0	0
Alt 3	0	-20	91	12	-63	-79
Alt 4	0	-12	91	-1	-25	-71
Alt 5	88	34	33	23	-53	-131
Alt 6	52	13	-34	6	0	0
Alt 7	89	-14	76	1	6	71
Alt 8	24	-14	81	23	-49	-25

Average of Wet Years (acres)

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 1	1,710	682	1,048	503	433	688

Difference Between Alternative and Base Case

Alt 2	9	8	0	53	0	0
Alt 3	9	9	6	-7	-11	8
Alt 4	9	9	6	-6	-19	-1
Alt 5	23	2	-8	5	-27	-3
Alt 6	-33	9	0	-11	0	0
Alt 7	0	21	15	38	-5	12
Alt 8	9	8	6	6	-19	16

Table VI-45c

Average Area of Open Water Reservoir Habitat, Greater than 15 Foot Depth

Average of All Years (acres x 1000)

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 1	19.9	10.7	6.1	8.6	4.5	8.8

Difference Between Alternative and Base Case

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 2	-0.1	-0.4	-0.6	-2.0	0.0	0.0
Alt 3	0.0	-0.4	-0.6	-0.5	-0.3	-0.5
Alt 4	0.0	-0.4	-0.4	-1.2	-0.2	-0.4
Alt 5	0.7	0.1	0.0	0.2	-0.9	-1.5
Alt 6	-0.6	-0.5	-0.9	0.2	0.0	0.0
Alt 7	-0.3	-0.6	-0.6	0.3	-0.1	0.1
Alt 8	-0.1	-0.5	-0.5	-0.9	-0.3	-0.1

Average of Dry Years (acres x 1000)

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 1	17.8	9.2	4.9	7.2	3.9	7.7

Difference Between Alternative and Base Case

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 2	-0.5	-0.4	-1.1	-2.0	0.0	0.0
Alt 3	0.0	-0.4	-0.7	-0.5	-0.5	-0.6
Alt 4	0.0	-0.4	-0.7	-1.4	-0.2	-0.5
Alt 5	0.6	0.0	-0.2	-1.2	-1.0	-1.9
Alt 6	-1.0	-0.6	-1.5	0.3	0.0	0.0
Alt 7	-0.6	-0.5	-1.2	0.6	-0.1	0.2
Alt 8	-0.3	-0.5	-1.1	-1.2	-0.4	-0.1

Average of Wet Years (acres x 1000)

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 1	23.5	13.1	7.8	9.9	5.3	10.1

Difference Between Alternative and Base Case

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 2	0.2	-0.4	0.0	-1.2	0.0	0.0
Alt 3	0.2	-0.3	0.1	-0.4	-0.1	-0.4
Alt 4	0.2	-0.3	0.1	-0.7	-0.1	-0.4
Alt 5	0.3	0.1	0.2	-0.1	-0.5	-0.9
Alt 6	-0.1	-0.3	-0.2	0.0	0.0	0.0
Alt 7	0.0	-0.6	-0.1	0.1	0.0	0.1
Alt 8	0.2	-0.5	0.1	-0.5	-0.1	-0.1

Among the assumptions for analyzing the impacts of the flow alternatives was that the USBR would continue to deliver water to most of the wildlife refuges and management areas under contracts guaranteed by the CVPIA. For the wildlife refuges and management areas that are not included in the CVPIA and the privately owned and managed wetlands that may have surface water diversions curtailed under some alternatives, it is likely that an alternate source of water would be sought, either through contract or from groundwater.

5. Channel Erosion

Erosion is the wearing away of soil and rock by weathering, mass wasting, and the action of streams, glaciers, waves, wind, and underground water. Of these erosive agents, the only one affected by implementation of the flow objectives is stream flow. Stream or channel erosion increases as the energy exerted by the stream increases. Simply stated, the higher the stream flow, the higher the potential for channel erosion. Thus, the greatest potential for channel erosion occurs during flood flows.

River flow stage data for the project area are shown in Table VI-46. The table shows that the maximum annual river stages associated with the seven flow alternatives generally do not exceed those of the base case. Thus, implementation of the flow objectives is not expected to increase channel erosion in the project area. The highest river stages are the result floods caused by natural climatic extremes, rather than implementation of the flow objectives.

Table VI-46
Maximum Annual River Stage in Feet

	Sacramento River		Feather R.	American R.	San Joaquin River	
Alternative	Red Bluff	Verona	Gridley	Nimbus Dam	Newman	Vernalis
Alt. 1	24.2	36.6	12.7	13.2	21.8	26.4
Alt. 2	24.2	36.6	12.7	13.2	21.8	26.4
Alt. 3	24.2	36.6	12.7	13.2	21.8	26.4
Alt. 4	24.2	36.6	12.7	13.2	21.8	26.4
Alt. 5	24.2	36.6	12.7	13.2	22.3	26.6
Alt. 6	24.2	36.6	12.7	13.2	21.8	26.4
Alt. 7	24.2	36.6	12.7	13.2	21.8	26.4
Alt. 8	24.2	36.6	12.7	13.2	21.8	26.7

6. Land Use

Implementation of the 1995 Bay/Delta Plan outflow objectives will result in either no change in upstream water deliveries or reduced water deliveries to upstream areas in Alternatives 3, 4, 5, 7 and 8 when compared to the base case (see Tables V-1 and V-2). Reduced water supplies can lead to regional changes in land use by shifting the types of crops grown, short-term fallowing, or long-term retirement of agricultural land. Land use changes that may occur as a result of the 1995 Bay/Delta Plan cannot be accurately predicted, because such changes are the result of numerous decisions made by individuals, water districts, and governmental agencies.

A study of the response of the agricultural community to reduced water supplies concluded that agricultural producers will respond to decreased surface water supplies in one of three ways: (1) obtaining alternative sources of supply to supplement reduced surface water allocations, (2) increasing water use efficiency, and (3) matching land use and cropping patterns to available water supplies through a combination of fallowing and shifts in crop type (Archibald et al. 1992). These responses can be further broken down into short-term and long-term options.

In order to prepare the input files for the DWRSIM modeling of Alternatives 3 and 4, simplifying assumptions were made regarding water user response to diversion curtailments. These assumptions were: (1) water right holders in the Sacramento basin would seek a contract for an alternate surface water supply and (2) water right holders in the San Joaquin basin would pump groundwater if their diversions were curtailed. The fallowing of farmland was assumed to be a less likely response under these alternatives, and therefore was not considered in the modeling. Water supply reductions under Alternative 5 are the most severe and could result in widespread fallowing. Under Alternatives 2 and 6, deliveries are reduced only to areas that receive exports from the Delta. In Alternatives 7 and 8, water is made available by a group of agencies in the San Joaquin basin to meet minimum flows on the San Joaquin River at Vernalis. This water is assumed to result from release of excess storage capacity, or improvements in irrigation efficiency.

In general, agricultural producers expect that, if shortages continue, marginal land will be taken out of production. The extent of reductions will depend on the costs and feasibility of alternative water supplies. The option of land retirement can be high for producers in districts with high fixed costs as these costs must be spread over the remaining acres if land cannot be sold or leased to other producers.

The case study approach used by Archibald et al. (1992) also indicated that cropping patterns can change as a result of water shortages. For example, 1989 and 1991 were drought years in which water shortages occurred. During this period, cotton, rice, alfalfa, and vegetable (excluding tomatoes) acreage declined while tomato acreage increased and acreage in permanent crops remained stable. These shifts exceeded normal trends, but factors other than water reductions could be responsible for these shifts.

While crop shifts are possible, there are a wide range of constraints that limit producers' abilities to shift cropping patterns in response to water shortages. These constraints include:

(1) federal commodity program regulations that can encourage or discourage shifts away from program commodities such as cotton and rice, (2) multi-year supply obligations to processors of such crops as garlic, onions, processing tomatoes, and rice, (3) concern about maintaining market share in a particular commodity; (4) producer ownership of processing operations, (5) agroclimatic constraints, including soil type, temperature ranges, and pest conditions, and (6) farm management expertise, and machinery and equipment complements, required to grow a particular crop.

If the SWRCB were to require upstream water users to provide water toward the 1995 Bay/Delta Plan flow objectives, crop shifts and land retirement could occur. Overall, shortages are greatest under Alternative 5 in the Yuba, Bear, Tuolumne, and Mokelumne river watersheds. Due to the wide range of factors governing a water user's response to reduced supply, it is difficult to predict how such reductions would translate into changed land use patterns.

7. Urban Development

Between 1930 and 1990, the area of land devoted to urban uses approximately quadrupled in the upstream areas. During the last decade, urban development in California shifted from coastal regions to the interior as the availability of land decreased along the coast and the price of remaining available land increased (USBR 1997e). Urban development in the Sacramento River and San Joaquin River regions occurred in conjunction with population increases of 32 percent and 41 percent respectively during this time period.

In the upstream areas, groundwater is the principal source of supply for urban uses (DWR 1994). Therefore, surface water supply reductions generally will not have a significant impact on urban users. The most notable exception is the Stockton East Water District, a major supplier to the City of Stockton. Thus, the analysis below is applicable mainly to the City of Stockton; however, the analysis is also applicable to any urban areas that might experience delivery reductions as a result of implementing the flow objectives.

a. Growth-Inducing Effects. Implementation of any of the seven flow alternatives could reduce water deliveries throughout the Delta watershed depending on the future decisions of water managers (see Chapter V). To the extent that historic patterns indicate future trends, reduced water availability is unlikely to affect growth in urban areas. Water is one of many factors influencing growth in a region but does not, by itself, cause the growth of a region. Water shortages have rarely done more than slow the progress of adequately financed development proposals. Reductions in municipal and industrial water supplies have typically been replaced through groundwater, reclamation, more intensive management, and price-induced conservation. In addition, reductions in existing surface water supplies may be replaced in many areas through long-term transfers of surface water supplies from other sources. Thus, implementation of any of the seven flow alternatives is not expected to have growth-inducing or growth-restricting effects.

b. Urban Landscape. The State Water Contractors have identified beneficial effects and uses of urban landscapes (SWC 1992). The effects and uses are described on page VIII-78 of the ER (SWRCB 1995; Appendix 1). Because urban landscapes depend on an adequate water supply for continuance, a reduction in supply could adversely affect some of the beneficial effects and uses of an urban environment. For example, during the 1987-1992 drought in Southern California, there was a well-documented loss of ornamental trees and landscaping in Santa Barbara County.

The reduced supplies to upstream urban areas that could result from the flow alternatives are likely to result in locally mandated, more efficient management of water resources. Most of the elements of such management are contained within the Memorandum of Understanding Regarding Urban Water Conservation in California. Most of the urban water exported from the Delta is delivered by agencies that have signed the MOU. Urban areas in the upstream portions of the Bay/Delta watershed could implement similar elements.

c. **Public Health and Safety**. Average reservoir levels could decline if stored water is used to meet delivery reductions. Water quality typically declines as reservoir levels drop significantly. The quality of drinking water supplied to urban areas could be compromised if water is drawn from reservoirs with lower levels. Sanitation and fire protection are not expected to be affected as supply reductions are likely to be replaced through alternative supplies, more intensive management of supplies and conservation as noted above.

d. **Socioeconomic Effects**. If alternative water supplies are not secured to replace delivery reductions, more intensive management and conservation of existing supplies is likely to occur. Depending on the measures implemented some local businesses could suffer, especially water intensive businesses. Although decreased water supplies may increase costs to some businesses in some areas of the state, these increases will be small relative to other factors affecting businesses. Also, offsetting the negative impacts of the flow alternatives on businesses is a quality of life improvement that will result from improved water quality in the Bay-Delta Estuary (Sanders et al. 1990).

e. **Need for Developing Housing**. Because the flow alternatives will have no growth inducing effects, they will have no direct effects on housing demand. The alternatives could alter demand indirectly by affecting economic conditions. One economic effect of the flow objectives that could affect housing demand is job losses in agricultural areas where irrigation water supplies are reduced. Housing demand would decrease in the affected areas and increase in the regions to which displaced workers migrate. However, these effects would be much smaller than other factors affecting migration between various parts of the state.

8. Energy

The flow objectives in the 1995 Bay/Delta Plan will affect both energy production and energy consumption. This section discusses the impact of implementing the flow alternatives on: (a) hydroelectric power availability, (b) groundwater pumping, and (c) fossil fuel consumption.

a. <u>Hydroelectric Power Availability</u>. Hydroelectric power generation plants provide approximately 24 percent of California's electrical generation capacity and produce in excess of $1.3 billion of power, as measured by replacement costs, in a typical year (McCann 1994). Electric utilities seek to maximize the value of their hydroelectric power production. Power produced during peak energy demand periods is more valuable than that produced during lower demand periods. Because hydropower is a low cost energy source that can be turned on and off quickly, utilities generally employ it to meet peak loads. In California, these peak loads typically occur in the summer when maximum groundwater pumping, industrial, and air conditioning demands occur. When water is released in the spring to maintain river flows, less water is available in the summer to provide peak hydropower generation. Reductions in a hydroelectric plant’s ability to meet peak load requirements accelerate the need for additional peaking resources and increases utility costs (McCann 1994).

The 1995 Bay/Delta Plan requires higher flows in the spring than were historically required. Model results show that achieving these flows often requires a shift in reservoir releases from the summer to the spring. This shifting of releases affects the hydropower generation and consumption of the SWP and CVP, particularly in regard to the alternatives in which they have primary responsibility for meeting the Bay/Delta Plan objectives. The SWP and CVP are exclusively responsible for meeting the Bay/Delta Plan objectives under Alternatives 2 and 6. Recirculation water is provided by the USBR from the Delta-Mendota Canal, if necessary, to meet the Vernalis objectives under Alternative 6. Bay/Delta Plan Alternatives 3, 4, 5, 7, and 8 partially shift the obligation of meeting the flow objectives to other parties, and have varying effects on hydroelectric power generation and consumption.

<u>Net CVP Hydropower Generation</u>. The CVP is both a producer and consumer of hydroelectric power through its storage and conveyance of water for agricultural and municipal water users. This section discusses the impacts of the alternatives on CVP net hydroelectric generation. The information regarding energy generation and consumption are standard output of DWRSIM.

Table VI-47 shows the average monthly difference in net energy generation for Flow Alternatives 2 through 8 compared to Alternative 1 (the base case) for the 73-year period of historic hydrology. This information is graphically represented in Figure VI-76. The net CVP energy generation was calculated by subtracting CVP energy consumption from CVP energy generation.

Table VI-47 shows a long-term average annual increase in net CVP generation for Alternatives 2, 3, 4, 7, and 8 compared to the base case. These results are consistent with the conclusions of a 1994 report which found that slightly increased amounts of energy are available to the CVP from implementation of the Bay/Delta Plan due to reduced export pumping (Beck 1994). Energy consumption increases under Alternative 6 due to the increased pumping required to provide recirculation water on the San Joaquin River to meet Vernalis requirements. Alternatives 7 and 8 result in the highest net energy production. This is largely due to substantially reduced export pumping in April and May combined with increased reservoir releases from CVP reservoirs during those months.

Table VI-47
Net CVP Energy Generation

Base Case Average Monthly Net Generation (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	213.5	186.8	231.4	243.5	271.8	286.1	316.6	489.3	559.7	516.9	361.1	202.4

Change in Net Generation from the Base Case (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2	-17.8	3.1	-9.9	-18.7	3.3	12.7	66.8	3.9	-22.1	9.3	17.0	-11.7	35.9
3	-11.1	7.4	-6.9	-13.8	8.8	13.5	65.4	-2.0	-27.3	3.7	19.5	-5.7	51.5
4	-13.5	6.8	-7.6	-15.0	6.1	12.8	68.6	1.3	-29.4	1.9	16.5	-7.8	40.7
5	-11.0	14.0	-2.4	-8.6	10.3	17.2	34.2	-29.2	-31.5	-15.3	22.3	-0.4	-0.4
6	-36.1	-16.0	-37.8	-63.7	12.9	25.7	69.9	1.8	-5.8	10.8	12.1	-12.4	-38.6
7	-0.1	0.4	-4.8	-6.4	18.3	21.1	30.5	30.5	-13.3	8.6	13.9	-9.3	89.4
8	-20.6	6.4	-6.2	-18.3	5.8	15.9	90.2	19.8	-18.9	7.6	16.7	-8.7	89.7

Note: Negative numbers indicate less energy is produced (net) under the alternatives than the base case.

Figure VI-76
Net CVP Energy Generation

73-year monthly average compared to Alternative 1 (Base Case)

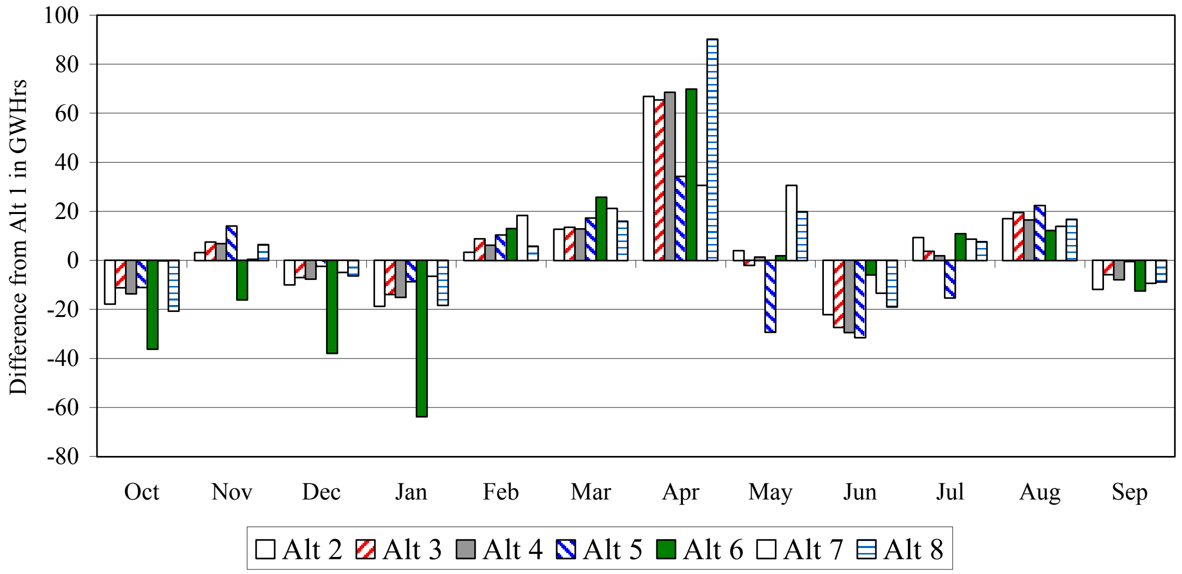


Figure VI-76 illustrates the seasonal shift in net CVP energy generation. The data points represent the difference between the alternatives and the base case. There is a significant reduction in winter net generation under Alternative 6 (due to high CVP energy consumption from pumping). The increased spring net generation is a result of increased spring stream flow and outflow requirements and restrictions in export pumping under the Bay/Delta Plan, particularly illustrated in April under Alternative 8. CVP power consumption rises in June as spring export limits are relaxed and the CVP increases pumping rates. CVP net generation fluctuates above and below the base case in late-summer and fall months. In general, net CVP hydroelectric power production is higher under the alternatives than the base case due to the reduction in energy consumption from implementation of the Bay/Delta Plan.

Net SWP Hydropower Generation. The SWP includes 22 dams and reservoirs, eight hydroelectric plants, and 17 pumping plants. While the CVP is a net producer of electricity, the SWP is a net electricity user due to the number of pumping lifts required along the length of the California Aqueduct.

Table VI-48 shows the average monthly difference in net energy generation for Alternatives 2 through 8 compared to Alternative 1 (the base case) for a 73-year period (1922-1994). This information is graphically represented in Figure VI-77. The average annual difference in SWP net energy generation is higher under all alternatives than the base case. Reductions in export pumping decrease SWP energy consumption thereby increasing available SWP energy over the base case. Alternative 5 results in the lowest net hydroelectric generation due to increases in export pumping and decreases in hydroelectric generation as the responsibility to meet the Bay/Delta objectives shifts to non-project upstream reservoirs. Alternative 7 results in the greatest increase in net energy generation by the SWP.

Net combined SWP and CVP Hydropower Generation. The difference in combined net SWP and CVP energy generation between each alternative and the base case is provided in Table VI-49. This information is graphically represented in Figure VI-78. Combined SWP and CVP net energy generation is higher under all alternatives than under the base case. Alternative 7 yields the highest net combined SWP and CVP power generation. Figure VI-78 shows trends similar to Figure VI-76.

Impacts on other Facilities. Effects are not limited to just SWP and CVP-related facilities; the implementation of the 1995 Bay/Delta Plan will have effects on most hydropower operations, but particularly those that depend upon use of hydropower's inexpensive peak energy production. The most significant impacts will likely be on hydropower facilities associated with large reservoirs located on the tributaries to the Sacramento and San Joaquin rivers (McCann 1994). Water rights for reservoirs with power as the main purpose of use will not be affected by the alternatives, while multi-use reservoirs that generate hydropower, such as Lake McClure, Don Pedro, Pardee/Camanche, and New Bullards Bar will have changes in their operations that will affect hydroelectric power operations. In general, requiring flow releases from these reservoirs will reduce their flexibility to meet peak hydropower demands which will likely decrease their reserves for hydropower generation.

Table VI-48
Net SWP Energy Generation

Base Case Average Monthly Net Generation (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-366.6	-442.7	-380.6	-280.2	-234.5	-234.2	-282.0	-213.6	-242.6	-269.4	-330.7	-436.0

Change in Net Generation from the Base Case (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2	-25.8	-3.1	-1.2	24.2	47.3	25.5	54.3	-8.1	14.3	50.5	8.1	18.7	204.7
3	-26.6	-3.6	-2.5	25.7	45.3	24.7	52.4	-11.5	2.7	44.9	4.9	15.0	171.4
4	-26.9	-3.7	-1.3	23.9	45.2	24.9	52.2	-11.3	3.7	44.8	4.3	14.9	170.7
5	-26.4	3.1	15.2	20.2	39.9	23.5	29.2	-39.0	-20.2	6.9	-2.9	15.5	65.0
6	-23.7	1.1	-10.3	14.1	49.3	24.5	54.0	-8.6	11.6	48.9	3.6	16.0	180.5
7	-23.7	-0.3	-16.9	16.6	45.6	24.6	47.2	9.2	16.9	59.3	17.6	21.9	218.0
8	-27.9	-7.3	-8.9	22.0	44.3	23.8	60.3	-7.0	12.0	53.8	13.4	16.8	195.3

Note: Negative numbers indicate less energy is produced (net) under the alternatives than the base case.

Figure VI-77
Net SWP Energy Generation

73-year monthly average compared to Alternative 1 (Base Case)

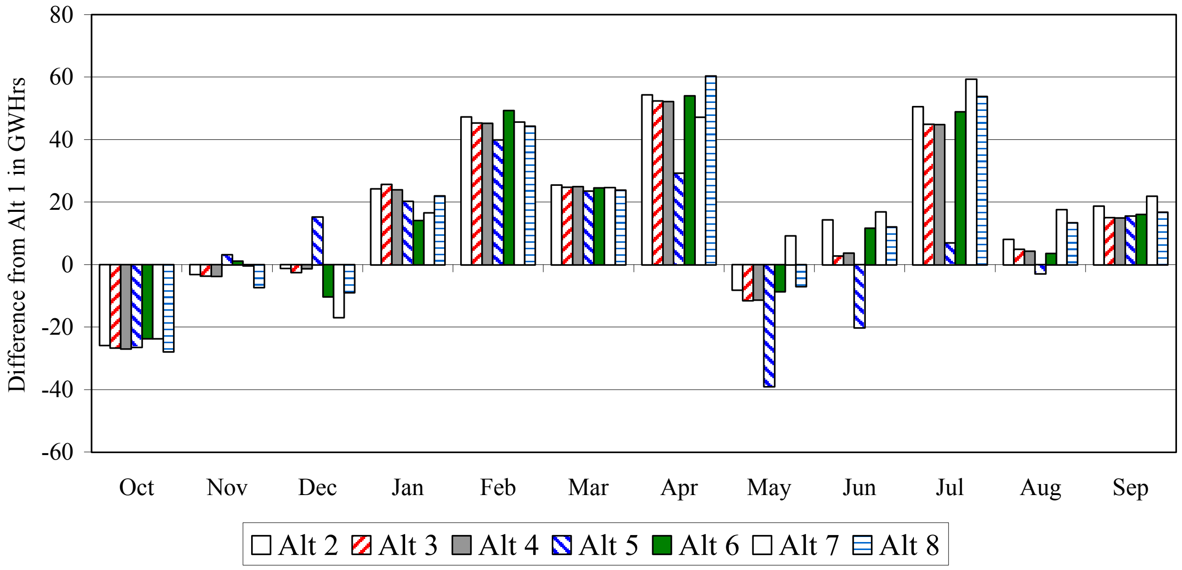


Table VI-49
Net SWP and CVP Energy Generation

Base Case Average Monthly Net Generation (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-153.1	-256.0	-149.2	-36.6	37.3	51.9	34.6	275.8	317.1	247.5	30.4	-233.7

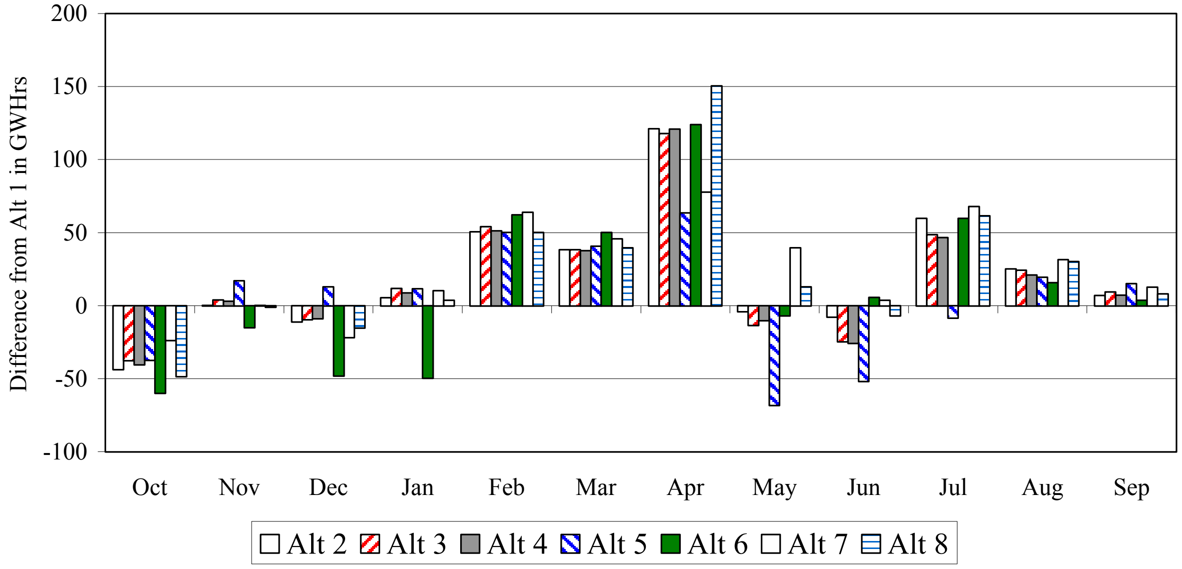
Change in Net Generation from the Base Case (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2	-43.6	0.1	-11.1	5.5	50.6	38.2	121.1	-4.1	-7.7	59.8	25.1	7.0	240.9
3	-37.6	3.9	-9.4	11.8	54.1	38.3	117.8	-13.5	-24.6	48.6	24.3	9.3	223.0
4	-40.4	3.1	-8.9	8.8	51.2	37.7	120.8	-10.1	-25.7	46.7	20.9	7.1	211.2
5	-37.4	17.1	12.8	11.6	50.2	40.7	63.4	-68.2	-51.7	-8.4	19.4	15.1	64.6
6	-59.8	-14.9	-48.1	-49.6	62.2	50.2	123.9	-6.8	5.7	59.7	15.7	3.6	141.8
7	-23.8	0.1	-21.7	10.3	63.9	45.7	77.8	39.7	3.7	67.9	31.5	12.6	307.7
8	-48.5	-0.9	-15.1	3.7	50.1	39.7	150.5	12.8	-6.9	61.4	30.1	8.1	285.0

Note: Negative numbers indicate less energy is produced (net) under the alternatives than the base case.

Figure VI-78
Net SWP & CVP Energy Generation

73-year monthly average compared to Alternative 1 (Base Case)



Mitigation. Reductions in summer hydroelectric power production reduce the amount of energy available for meeting summer-time peak loads. Increasing generation from fossil fuel power plants or from other sources including nuclear, geothermal, biomass, solar thermal, solar photovoltaic and wind generation may make up such reductions. However non-mitigable impacts would occur with increases in energy generation from fossil fuel sources.

b. Groundwater Pumping. The implementation of the 1995 Bay/Delta Plan may cause reductions in surface water deliveries as shown on Tables V-1 and V-2. Substitution of groundwater for surface water generally increases energy consumption. Increased groundwater pumping may lower groundwater levels resulting in higher pumping lifts and, thus, further increase energy consumption.

Surface delivery reductions may result in the affected water user purchasing water from another source, fallowing land, or pumping additional groundwater. Under worst case conditions, all of the reductions shown on Tables V-1 and V-2 would be made up by increased groundwater pumping. In a recent study performed by PG&E, the average cost to pump groundwater in the California Central Valley ranges between $25 and $30 per acre-foot for flood irrigation and between $35 and $40 per acre-foot for pressure and drip irrigation, based on a large sample of pump tests conducted in the California Central Valley (Jeff Savage, personal communication).

Mitigation. The increase in energy consumption due to groundwater pumping can be partially mitigated through off-peak pumping operations.

c. Fossil Fuels. The implementation of the 1995 Bay/Delta Plan will alter hydroelectric power generation and consumption patterns and increase groundwater pumping in substitution for surface water supplies. These changes may result in increased use of fossil-fuel generation, thereby increasing air pollution. Common air pollutant emissions associated with the generation of electricity by fossil fuels include oxides of nitrogen (NOx), particulate matter of less than 10 microns in diameter (PM10), reactive organic gases (ROG), carbon emissions (Cx), and oxides of sulfur (SOx).

Table VI-50 provides an estimate of the possible air emissions from implementation of the Bay/Delta Plan. The quantities in the table were developed for a slightly different set of objectives than are contained in the Bay/Delta Plan. The objectives used in this analysis had a higher water supply impact than the objectives in the Bay/Delta Plan; therefore, the analysis should be considered a worst-case scenario. The quantities in the table account for both the effect of hydropower availability problems in some seasons and the effects of increased groundwater pumping. The average increases of 131.6 tons of NOx, 52.9 tons of SOx, 8.8 tons of PM10, and 5.5 tons of ROG are not large relative to emissions inventories in the impacted air basins, however these emissions are large enough to trigger new source review requirements or the purchase of emission reduction credits (McCann 1994). The effects may, therefore, be significant.

Table VI-50

Net Increase in Air Emissions under Bay/Delta Plan[1]

(tons per year, probability weighted[2])

Year	NOx	SOx	PM10	ROG	Cx
1995	232	81	7.8	5.6	42,427
1996	208	59	8.0	6.0	46,984
1997	119	65	9.3	6.8	50,543
1998	86	60	8.5	5.5	57,037
1999	104	40	8.8	6.7	52,048
2000	120	57	9.0	5.8	55,491
2001	74	35	8.7	6.4	59,981
2002	117	50	8.6	5.5	60,619
2003	90	47	9.5	6.3	65,080
2004	74	10	8.9	7.0	70,245
2005	121	49	7.8	4.5	64,361
2006	135	44	8.7	5.3	64,640
2007	235	63	11.1	4.4	57,399
2008	113	59	8.7	4.9	65,113
2009	126	58	9.2	5.0	66,984
2010	156	70	9.3	5.0	67,790
2011	130	53	8.1	4.0	66,504
Average:	132	52.9	8.8	5.6	59,603

[1] From Table F-1 of "Impact of Bay/Delta Water Quality Standards on California's Electric Utility Costs," prepared by Richard McCann, et al., for the Association of California Water Agencies, October 7, 1994.

[2] 20 percent dry, 55 percent normal, and 25 percent wet years.

Mitigation. The effect of increasing fossil fuel generation is not entirely mitigable, however other sources of energy generation are available including nuclear, geothermal, biomass, solar thermal, solar photovoltaic and wind generation.

9. Recreation

This section presents the results of the assessment of impacts to recreation that would occur with implementation of the flow objective alternatives. Recreation impacts can be expected in the Sacramento River and San Joaquin River regions at selected reservoirs and in the rivers that provide flows to the Delta. The assessment of recreation impacts analyzes how changes in reservoir storage and river flows would affect opportunities for water-related activities at key recreation facilities.

a. Reservoirs. Implementation of the 1995 Plan could result in adverse impacts to recreation at some reservoirs. Each alternative can have the effect of lowering water levels earlier in the season, for longer periods, or below the levels than would otherwise occur in a given year at certain reservoirs. Lowered reservoir elevations can substantially decrease opportunities for public recreational use by reducing water surface area and shoreline and by making access to the water more difficult. Extreme drawdowns can force the closure of marinas and boat launch ramps, resulting in a loss of access for boating and fishing. These conditions can in turn reduce visitor use levels and attendant revenues. The potential impacts to recreation are similar to and generally within the range of those impacts typically experienced at most reservoirs during drought periods.

Recreation impacts are assessed for the major rim reservoirs that are operated by the SWP, the CVP, and by other agencies, and that could be affected by implementation of the 1995 Bay/Delta Plan. The reservoirs include Shasta Lake, Lake Oroville, Folsom Lake, Camanche Reservoir, Pardee Reservoir, New Melones Reservoir, New Don Pedro Reservoir, Lake McClure, and Millerton Lake.

Projected reservoir operations under each alternative were obtained from DWRSIM and EBMUDSIM output (EBMUDSIM was used for Camanche Reservoir and Pardee Reservoir). Critical thresholds for recreation opportunity were then compared to the reservoir operations to determine when recreation activities begin to significantly decline or cease. Most of the thresholds were developed for the CVPIA PEIS and were based on information provided by operators of each of the major reservoirs (USBR 1997f). EBMUD provided thresholds for Camanche Reservoir and Pardee Reservoir (EBMUD 1997a).

Recreation opportunity thresholds were developed for important recreation activities during both peak and off-seasons. Peak seasons vary by reservoir, beginning in April or May and running through September. Typical peak-season activities include boating, beach use, camping, and picnicking. Assessment of off-season activities was limited to boating. Changes in recreation opportunities were assessed for the full 73-year period as well as for the 1928-1934 critical period. Due to the size and configuration of Shasta Lake and the number of recreation facilities located throughout the lake, separate analyses were performed for the main body and for each of the tributary arms.

The recreation impact analysis considers the frequency of occurrence with which end-of-month storage (converted to surface elevation) falls below or, in some cases, exceeds the various threshold levels established for each reservoir. Tables VI-51 through VI-59 summarize the frequency of occurrence in absolute numbers and as a percentage of the total number of months in the study period. A frequency of occurrence that is lower than the base case would indicate an increase in recreational opportunities (a beneficial impact). A frequency of occurrence that is higher than the base case would indicate a decrease in recreational opportunities (a negative impact).

Due to the nature of the hydrologic input data and the use of average monthly operations, modeled surface water results may be expected to have a margin of error of 10 to 20 percent. Therefore, differences between the base case and the various alternatives are considered to be significant only if greater than 10 percentage points, higher or lower, from the base case. Significant differences were observed for each reservoir analyzed, with the exception of Lake McClure. The critical thresholds for Lake McClure are at extremely low surface elevations that are never reached under any of the operation alternatives.

Tables VI-60 and VI-61 summarize which alternatives have significant recreation impacts (beneficial or negative) at the major reservoirs. Table VI-60 indicates that, for the 73-year period average, significant negative impacts occur during the peak season at Camanche, Pardee, New Don Pedro, and Millerton under Alternative 5 and at Folsom under Alternative 6; significant negative impacts also occur during the off season at Camanche, Pardee, New Don Pedro, and Millerton under Alternative 5. Table VI-61 indicates that, for the critical period average, significant negative impacts occur during the peak season and off season at various reservoirs under each Alternative, and that significant beneficial impacts occur at Shasta, Oroville, and Folsom under Alternative 5.

Mitigation. Recreational use at some reservoirs may be reduced as a result of implementing the flow objective alternatives. Some reservoirs could be lowered earlier in the season, for longer periods, or below the levels than would otherwise occur. This would result in less water-related recreational opportunities and could be significant to those who participate in activities such as boating and fishing and to recreation concessionaires that rely on a certain amount of recreation use annually for their livelihood. Generally, these impacts are not mitigable. Modification or relocation of facilities (such as boat ramps and marinas) to accommodate lower water levels would help to reduce the impact to recreation at reservoirs that are adversely affected.

b. Rivers. Impacts to recreation were considered for the rivers below major reservoirs that are operated by the SWP, the CVP, or by other agencies, and that could be affected by implementation of the flow objective alternatives. The analysis of recreation impacts on these rivers is based on the changes in recreation opportunities that might result from implementing the flow alternatives.

Impact thresholds that were used for the analysis were developed for the CVPIA PEIS. The thresholds were developed based on information provided by operators of recreation facilities along the rivers, rafting guides, and fishing guides. The thresholds indicate when recreation activities begin to significantly decline or cease in response to changes in river flows. The frequency with which river flows drop below, rise above, or fall within these thresholds is used to determine changes in recreation opportunities under each of the alternatives.

Table VI-51
Results of Recreation Impact Assessment for Shasta Lake

Main Area
Peak Season (May - Sept.)

		Frequency with which Reservoirs are below Critical Elevation Thresholds					
Water Year Type/Alternative	**# of Months**	844 ft.		947 ft.		987 ft.	
73-YEAR PERIOD	365	total	%	total	%	total	%
Alternative 1 (Base Case)		0	0%	17	5%	64	18%
Alternative 2		0	0%	24	7%	73	20%
Alternative 3		0	0%	19	5%	69	19%
Alternative 4		0	0%	17	5%	69	19%
Alternative 5		0	0%	9	2%	61	17%
Alternative 6		0	0%	27	7%	79	22%
Alternative 7		0	0%	20	5%	75	21%
Alternative 8		0	0%	22	6%	72	20%
CRITICAL PERIOD	35						
Alternative 1 (Base Case)		0	0%	9	26%	22	63%
Alternative 2		0	0%	10	29%	24	69%
Alternative 3		0	0%	7	20%	21	60%
Alternative 4		0	0%	7	20%	21	60%
Alternative 5		0	0%	3	9%	18	51%
Alternative 6		0	0%	11	31%	25	71%
Alternative 7		0	0%	6	17%	23	66%
Alternative 8		0	0%	9	26%	23	66%

Main Area
Off-Season (Oct.- April)

		Frequency with which Reservoirs are below Critical Elevation Thresholds			
Water Year Type/Alternative	**# of Months**	844 ft.		947 ft.	
73-YEAR PERIOD	511	total	%	total	%
Alternative 1 (Base Case)		0	0%	26	5%
Alternative 2		0	0%	37	7%
Alternative 3		0	0%	28	5%
Alternative 4		0	0%	30	6%
Alternative 5		0	0%	15	3%
Alternative 6		0	0%	42	8%
Alternative 7		0	0%	31	6%
Alternative 8		0	0%	35	7%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		0	0%	14	33%
Alternative 2		0	0%	16	37%
Alternative 3		0	0%	12	28%
Alternative 4		0	0%	12	28%
Alternative 5		0	0%	4	9%
Alternative 6		0	0%	16	37%
Alternative 7		0	0%	11	26%
Alternative 8		0	0%	14	33%

NOTES:
< 844 ft. msl - last boat ramp out of operation
< 947 ft. msl - limited lake surface area (boating constrained)
< 987 ft. msl - marina relocated

Table VI-51 Continued

McCloud River Arm
Peak Season (May - Sept.)

		Frequency with which Reservoirs are below Critical Elevation Thresholds							
Water Year Type/Alternative	**# of Months**	952 ft.		960 ft.		967 ft.		987 ft.	
		total	%	total	%	total	%	total	%
73-YEAR PERIOD	365								
Alternative 1 (Base Case)		18	5%	22	6%	29	8%	64	18%
Alternative 2		27	7%	38	10%	42	12%	73	20%
Alternative 3		24	7%	33	9%	40	11%	69	19%
Alternative 4		26	7%	33	9%	40	11%	69	19%
Alternative 5		13	4%	21	6%	32	9%	61	17%
Alternative 6		32	9%	45	12%	49	13%	79	22%
Alternative 7		26	7%	33	9%	47	13%	75	21%
Alternative 8		25	7%	36	10%	45	12%	72	20%
CRITICAL PERIOD	35								
Alternative 1 (Base Case)		9	26%	11	31%	12	34%	22	63%
Alternative 2		11	31%	14	40%	15	43%	24	69%
Alternative 3		9	26%	12	34%	14	40%	21	60%
Alternative 4		9	26%	12	34%	14	40%	21	60%
Alternative 5		5	14%	9	26%	12	34%	18	51%
Alternative 6		13	37%	15	43%	16	46%	25	71%
Alternative 7		8	23%	11	31%	14	40%	23	66%
Alternative 8		10	29%	13	37%	15	43%	23	66%

McCloud River Arm
Off-Season (Oct.- April)

		Frequency with which Reservoirs are below Critical Elevation Thresholds			
Water Year Type/Alternative	**# of Months**	952 ft.		967 ft.	
		total	%	total	%
73-YEAR PERIOD	511				
Alternative 1 (Base Case)		27	5%	45	9%
Alternative 2		44	9%	52	10%
Alternative 3		43	8%	47	9%
Alternative 4		39	8%	47	9%
Alternative 5		24	5%	43	8%
Alternative 6		46	9%	60	12%
Alternative 7		37	7%	51	10%
Alternative 8		39	8%	51	10%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		14	33%	18	42%
Alternative 2		16	37%	18	42%
Alternative 3		16	37%	16	37%
Alternative 4		15	35%	16	37%
Alternative 5		9	21%	16	37%
Alternative 6		16	37%	20	47%
Alternative 7		15	35%	16	37%
Alternative 8		14	33%	18	42%

NOTES:
< 952 ft. msl - last boat ramp out of operation
< 960 ft. msl - decline in campground use
< 967 ft. msl - limited lake surface area (boating constrained)
< 987 ft. msl - marina movement

Table VI-51 Continued

Pit River Arm
Peak Season (May - Sept.)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type/Alternative	# of Months	907 ft. total	907 ft. %	942 ft. total	942 ft. %	987 ft. total	987 ft. %	1007 ft. total	1007 ft. %
73-YEAR PERIOD	365								
Alternative 1 (Base Case)		5	1%	13	4%	64	18%	105	29%
Alternative 2		6	2%	16	4%	73	20%	110	30%
Alternative 3		4	1%	12	3%	69	19%	107	29%
Alternative 4		4	1%	12	3%	69	19%	108	30%
Alternative 5		1	0%	9	2%	61	17%	97	27%
Alternative 6		6	2%	22	6%	79	22%	125	34%
Alternative 7		5	1%	14	4%	75	21%	126	35%
Alternative 8		4	1%	17	5%	72	20%	111	30%
CRITICAL PERIOD	35								
Alternative 1 (Base Case)		1	3%	6	17%	22	63%	29	83%
Alternative 2		1	3%	8	23%	24	69%	30	86%
Alternative 3		0	0%	4	11%	21	60%	30	86%
Alternative 4		0	0%	4	11%	21	60%	30	86%
Alternative 5		0	0%	3	9%	18	51%	29	83%
Alternative 6		1	3%	10	29%	25	71%	30	86%
Alternative 7		0	0%	5	14%	23	66%	30	86%
Alternative 8		0	0%	7	20%	23	66%	30	86%

Pit River Arm
Off-Season (Oct.- April)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type/Alternative	# of Months	942 ft. total	942 ft. %	1007 ft. total	1007 ft. %
73-YEAR PERIOD	511				
Alternative 1 (Base Case)		21	4%	148	29%
Alternative 2		29	6%	152	30%
Alternative 3		21	4%	143	28%
Alternative 4		21	4%	142	28%
Alternative 5		10	2%	137	27%
Alternative 6		34	7%	172	34%
Alternative 7		23	5%	155	30%
Alternative 8		29	6%	148	29%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		12	28%	39	91%
Alternative 2		14	33%	41	95%
Alternative 3		8	19%	41	95%
Alternative 4		8	19%	41	95%
Alternative 5		3	7%	39	91%
Alternative 6		16	37%	41	95%
Alternative 7		8	19%	40	93%
Alternative 8		13	30%	39	91%

NOTES:
< 907 ft. msl - decline in campground use
< 942 ft. msl - last boat ramp out of operation
< 987 ft. msl - marina movement
< 1007 ft. msl - limited lake surface area (boating constrained)

Table VI-51 Continued

Sacramento River Arm
Peak Season (May - Sept.)

		Frequency with which Reservoirs are below Critical Elevation Thresholds									
Water Year Type/Alternative	**# of Months**	937 ft.		950 ft.		967 ft.		1007 ft.		1017 ft.	
73-YEAR PERIOD	365	total	%	total	%	total	%	total	%	total	%
Alternative 1 (Base Case)		11	3%	18	5%	29	8%	105	29%	138	38%
Alternative 2		13	4%	27	7%	42	12%	110	30%	144	39%
Alternative 3		11	3%	21	6%	40	11%	107	29%	136	37%
Alternative 4		11	3%	22	6%	40	11%	108	30%	137	38%
Alternative 5		7	2%	13	4%	32	9%	97	27%	122	33%
Alternative 6		17	5%	29	8%	49	13%	125	34%	153	42%
Alternative 7		12	3%	25	7%	47	13%	126	35%	153	42%
Alternative 8		12	3%	24	7%	45	12%	111	30%	145	40%
CRITICAL PERIOD	35										
Alternative 1 (Base Case)		4	11%	9	26%	12	34%	29	83%	30	86%
Alternative 2		5	14%	11	31%	15	43%	30	86%	31	89%
Alternative 3		4	11%	7	20%	14	40%	30	86%	30	86%
Alternative 4		4	11%	8	23%	14	40%	30	86%	30	86%
Alternative 5		2	6%	5	14%	12	34%	29	83%	30	86%
Alternative 6		8	23%	11	31%	16	46%	30	86%	32	91%
Alternative 7		4	11%	8	23%	14	40%	30	86%	31	89%
Alternative 8		4	11%	10	29%	15	43%	30	86%	30	86%

Sacramento River Arm
Off-Season (Oct.- April)

		Frequency with which Reservoirs are below Critical Elevation Thresholds			
Water Year Type/Alternative	**# of Months**	950 ft.		1017 ft.	
73-YEAR PERIOD	511	total	%	total	%
Alternative 1 (Base Case)		27	5%	182	36%
Alternative 2		44	9%	193	38%
Alternative 3		37	7%	185	36%
Alternative 4		38	7%	185	36%
Alternative 5		20	4%	175	34%
Alternative 6		46	9%	206	40%
Alternative 7		34	7%	197	39%
Alternative 8		37	7%	194	38%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		14	33%	41	95%
Alternative 2		16	37%	41	95%
Alternative 3		14	33%	41	95%
Alternative 4		15	35%	41	95%
Alternative 5		6	14%	41	95%
Alternative 6		16	37%	41	95%
Alternative 7		13	30%	41	95%
Alternative 8		14	33%	41	95%

NOTES:
< 937 ft. msl - marina closes
< 950 ft. msl - last boat ramp out of operation
< 967 ft. msl - decline in campground use
< 1007 ft. msl - marina movement
< 1017 ft. msl - limited lake surface area (boating constrained)

Table VI-52
Results of Recreation Impact Assessment for Lake Oroville

Peak Season (April - Sept.)

Water Year Type Alternative	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds									
		700 ft.		710 ft.		750 ft.		819 ft.		840 ft.	
73-YEAR PERIOD	438	total	%	total	%	total	%	total	%	total	%
Alternative 1 (Base Case)		13	3%	24	5%	46	11%	133	30%	176	40%
Alternative 2		16	4%	27	6%	64	15%	157	36%	191	44%
Alternative 3		18	4%	26	6%	67	15%	152	35%	192	44%
Alternative 4		19	4%	27	6%	67	15%	153	35%	192	44%
Alternative 5		11	3%	12	3%	45	10%	140	32%	177	40%
Alternative 6		20	5%	29	7%	67	15%	158	36%	196	45%
Alternative 7		17	4%	29	7%	65	15%	164	37%	204	47%
Alternative 8		16	4%	27	6%	66	15%	162	37%	194	44%
CRITICAL PERIOD	41										
Alternative 1 (Base Case)		2	5%	4	10%	12	29%	34	83%	36	88%
Alternative 2		1	2%	5	12%	21	51%	36	88%	36	88%
Alternative 3		5	12%	7	17%	24	59%	35	85%	36	88%
Alternative 4		5	12%	7	17%	24	59%	35	85%	36	88%
Alternative 5		0	0%	1	2%	11	27%	34	83%	35	85%
Alternative 6		4	10%	6	15%	23	56%	35	85%	36	88%
Alternative 7		2	5%	4	10%	19	46%	36	88%	36	88%
Alternative 8		3	7%	6	15%	23	56%	34	83%	36	88%

Off-Season (Oct.- March)

Water Year Type Alternative	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds			
		710 ft.		750 ft.	
73-YEAR PERIOD	438	total	%	total	%
Alternative 1 (Base Case)		39	9%	77	18%
Alternative 2		42	10%	87	20%
Alternative 3		54	12%	88	20%
Alternative 4		54	12%	88	20%
Alternative 5		26	6%	69	16%
Alternative 6		49	11%	89	20%
Alternative 7		42	10%	88	20%
Alternative 8		47	11%	85	19%
CRITICAL PERIOD	37				
Alternative 1 (Base Case)		9	24%	18	49%
Alternative 2		8	22%	25	68%
Alternative 3		16	43%	25	68%
Alternative 4		16	43%	25	68%
Alternative 5		4	11%	17	46%
Alternative 6		12	32%	24	65%
Alternative 7		7	19%	23	62%
Alternative 8		12	32%	24	65%

NOTES:
<700 ft. msl - decline in campground/picnicking use
<710 ft. msl - limited boat ramp availability/marina relocation
<750 ft. msl - limited lake surface area (boating constrained)
<819 ft. msl - beach area closed
<840 ft. msl - decline in beach use

Table VI-53
Results of Recreation Impact Assessment for Folsom Lake

Peak Season (April - Sept.)

Water Year Type Alternative	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds (or above 450 ft.)									
		360 ft.		400 ft.		405 ft.		430 ft.		> 450 ft.	
73-YEAR PERIOD	438	total	%	total	%	total	%	total	%	total	%
Alternative 1 (Base Case)		39	9%	76	17%	85	19%	167	38%	101	23%
Alternative 2		56	13%	105	24%	112	26%	180	41%	100	23%
Alternative 3		50	11%	102	23%	106	24%	176	40%	101	23%
Alternative 4		50	11%	102	23%	107	24%	176	40%	100	23%
Alternative 5		33	8%	85	19%	97	22%	158	36%	104	24%
Alternative 6		62	14%	114	26%	126	29%	201	46%	92	21%
Alternative 7		57	13%	109	25%	118	27%	191	44%	95	22%
Alternative 8		52	12%	102	23%	112	26%	178	41%	99	23%
CRITICAL PERIOD	41										
Alternative 1 (Base Case)		13	32%	20	49%	22	54%	30	73%	3	7%
Alternative 2		18	44%	27	66%	28	68%	34	83%	2	5%
Alternative 3		16	39%	26	63%	26	63%	34	83%	1	2%
Alternative 4		16	39%	26	63%	26	63%	34	83%	1	2%
Alternative 5		9	22%	21	51%	24	59%	31	76%	3	7%
Alternative 6		19	46%	29	71%	30	73%	35	85%	2	5%
Alternative 7		14	34%	30	73%	30	73%	36	88%	1	2%
Alternative 8		13	32%	25	61%	28	68%	34	83%	2	5%

Off-Season (Oct.- March)

Water Year Type Alternative	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds			
		360 ft.		400 ft.	
73-YEAR PERIOD	438	total	%	total	%
Alternative 1 (Base Case)		29	7%	128	29%
Alternative 2		39	9%	129	29%
Alternative 3		34	8%	121	28%
Alternative 4		36	8%	122	28%
Alternative 5		31	7%	114	26%
Alternative 6		61	14%	150	34%
Alternative 7		41	9%	135	31%
Alternative 8		37	8%	130	30%
CRITICAL PERIOD	37				
Alternative 1 (Base Case)		4	11%	26	70%
Alternative 2		12	32%	27	73%
Alternative 3		10	27%	24	65%
Alternative 4		10	27%	24	65%
Alternative 5		9	24%	25	68%
Alternative 6		19	51%	28	76%
Alternative 7		10	27%	27	73%
Alternative 8		10	27%	26	70%

NOTES:
<360 ft. msl - last boat ramp out of operation
<400 ft. msl - limited lake surface area (boating constrained)
<405 ft. msl - marina closes
<430 ft. msl - decline in campground/picnicking use
>450 ft. msl - beach area inundated

Table VI-54

Results of Recreation Impact Assessment for Camanche Reservoir

Peak Season (April - Sept.)

Water Year Type Alternative	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds					
		160 ft.		178 ft.		193 ft.	
73-YEAR PERIOD	438	total	%	total	%	total	%
Alternative 1 (Base Case)		14	3%	39	9%	68	16%
Alternative 2		14	3%	39	9%	68	16%
Alternative 3		34	8%	56	13%	104	24%
Alternative 4		45	10%	56	13%	104	24%
Alternative 5		109	25%	145	33%	196	45%
Alternative 6		14	3%	39	9%	68	16%
Alternative 7		14	3%	39	9%	68	16%
Alternative 8		14	3%	39	9%	68	16%
CRITICAL PERIOD	41						
Alternative 1 (Base Case)		0	0%	3	7%	8	20%
Alternative 2		0	0%	3	7%	8	20%
Alternative 3		0	0%	4	10%	23	56%
Alternative 4		0	0%	4	10%	23	56%
Alternative 5		30	73%	34	83%	36	88%
Alternative 6		0	0%	3	7%	8	20%
Alternative 7		0	0%	3	7%	8	20%
Alternative 8		0	0%	3	7%	8	20%

Off-Season (Oct.- March)

Water Year Type/Alt.	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds					
		160 ft.		178 ft.		193 ft.	
73-YEAR PERIOD	438	total	%	total	%	total	%
Alternative 1 (Base Case)		13	3%	32	7%	85	19%
Alternative 2		13	3%	32	7%	85	19%
Alternative 3		34	8%	63	14%	116	26%
Alternative 4		40	9%	64	15%	116	26%
Alternative 5		111	25%	134	31%	185	42%
Alternative 6		13	3%	32	7%	85	19%
Alternative 7		13	3%	32	7%	85	19%
Alternative 8		13	3%	32	7%	85	19%
CRITICAL PERIOD	37						
Alternative 1 (Base Case)		0	0%	3	8%	10	27%
Alternative 2		0	0%	3	8%	10	27%
Alternative 3		2	5%	5	14%	20	54%
Alternative 4		2	5%	5	14%	20	54%
Alternative 5		26	70%	30	81%	31	84%
Alternative 6		0	0%	3	8%	10	27%
Alternative 7		0	0%	3	8%	10	27%
Alternative 8		0	0%	3	8%	10	27%

NOTES:

<160 ft. msl - marinas close/last boat ramp out of operation
<178 ft. msl - relocation of main marina, limited lake surface area
<193 ft. msl - limited boat ramp availability

Table VI-55

Results of Recreation Impact Assessment for Pardee Reservoir

Peak Season (Apr - Sept.)

Water Year Type Alternative	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds							
		500 ft.		532 ft.		537 ft.		542 ft.	
73-YEAR PERIOD	438	total	%	total	%	total	%	total	%
Alternative 1 (Base Case)		12	3%	35	8%	41	9%	51	12%
Alternative 2		12	3%	35	8%	41	9%	51	12%
Alternative 3		14	3%	43	10%	47	11%	56	13%
Alternative 4		17	4%	46	11%	49	11%	56	13%
Alternative 5		77	18%	114	26%	124	28%	135	31%
Alternative 6		12	3%	35	8%	41	9%	51	12%
Alternative 7		12	3%	35	8%	41	9%	51	12%
Alternative 8		12	3%	35	8%	41	9%	51	12%
CRITICAL PERIOD	41								
Alternative 1 (Base Case)		0	0%	3	7%	3	7%	5	12%
Alternative 2		0	0%	3	7%	3	7%	5	12%
Alternative 3		0	0%	8	20%	8	20%	9	22%
Alternative 4		0	0%	8	20%	8	20%	9	22%
Alternative 5		16	39%	25	61%	26	63%	29	71%
Alternative 6		0	0%	3	7%	3	7%	5	12%
Alternative 7		0	0%	3	7%	3	7%	5	12%
Alternative 8		0	0%	3	7%	3	7%	5	12%

Off-Season (Oct.- March)

Water Year Type/Alt.	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds							
		500 ft.		532 ft.		537 ft.		542 ft.	
73-YEAR PERIOD	438	total	%	total	%	total	%	total	%
Alternative 1 (Base Case)		17	4%	58	13%	67	15%	70	16%
Alternative 2		17	4%	58	13%	67	15%	70	16%
Alternative 3		18	4%	61	14%	71	16%	76	17%
Alternative 4		20	5%	67	15%	73	17%	78	18%
Alternative 5		75	17%	139	32%	146	33%	153	35%
Alternative 6		17	4%	58	13%	67	15%	70	16%
Alternative 7		17	4%	58	13%	67	15%	70	16%
Alternative 8		17	4%	58	13%	67	15%	70	16%
CRITICAL PERIOD	37								
Alternative 1 (Base Case)		0	0%	7	19%	7	19%	7	19%
Alternative 2		0	0%	7	19%	7	19%	7	19%
Alternative 3		0	0%	12	32%	13	35%	13	35%
Alternative 4		0	0%	12	32%	13	35%	13	35%
Alternative 5		10	27%	28	76%	29	78%	30	81%
Alternative 6		0	0%	7	19%	7	19%	7	19%
Alternative 7		0	0%	7	19%	7	19%	7	19%
Alternative 8		0	0%	7	19%	7	19%	7	19%

NOTES:

<500 ft. msl - low water, ramp closes
<532 ft. msl - closure and removal of marina
<537 ft. msl - main boat ramp closes
<542 ft. msl - relocation of marina, limited boat ramp availability

Table VI-56

Results of Recreation Impact Assessment for New Melones Reservoir

Peak Season (April - Sept.)

Water Year Type Alternative	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds 850 ft. total	850 ft. %	860 ft. total	860 ft. %	880 ft. total	880 ft. %	900 ft. total	900 ft. %
73-YEAR PERIOD	438								
Alternative 1 (Base Case)		8	2%	9	2%	11	3%	15	3%
Alternative 2		26	6%	31	7%	49	11%	59	13%
Alternative 3		3	1%	5	1%	9	2%	13	3%
Alternative 4		16	4%	21	5%	27	6%	39	9%
Alternative 5		0	0%	1	0%	3	1%	8	2%
Alternative 6		3	1%	3	1%	5	1%	9	2%
Alternative 7		4	1%	4	1%	10	2%	13	3%
Alternative 8		12	3%	14	3%	22	5%	32	7%
CRITICAL PERIOD	41								
Alternative 1 (Base Case)		0	0%	0	0%	0	0%	1	2%
Alternative 2		13	32%	14	34%	21	51%	26	63%
Alternative 3		0	0%	1	2%	2	5%	3	7%
Alternative 4		7	17%	9	22%	12	29%	16	39%
Alternative 5		0	0%	0	0%	0	0%	0	0%
Alternative 6		0	0%	0	0%	0	0%	0	0%
Alternative 7		0	0%	0	0%	1	2%	3	7%
Alternative 8		4	10%	5	12%	8	20%	14	34%

Off-Season (Oct.- March)

Water Year Type/Alt.	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds 850 ft. total	850 ft. %	860 ft. total	860 ft. %
73-YEAR PERIOD	438				
Alternative 1 (Base Case)		9	2%	10	2%
Alternative 2		31	7%	39	9%
Alternative 3		5	1%	7	2%
Alternative 4		20	5%	25	6%
Alternative 5		1	0%	3	1%
Alternative 6		3	1%	4	1%
Alternative 7		4	1%	4	1%
Alternative 8		16	4%	18	4%
CRITICAL PERIOD	37				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		12	32%	13	35%
Alternative 3		1	3%	1	3%
Alternative 4		5	14%	8	22%
Alternative 5		0	0%	0	0%
Alternative 6		0	0%	0	0%
Alternative 7		0	0%	0	0%
Alternative 8		3	8%	3	8%

NOTES:

<850 ft. msl - last boat ramp out of operation
<860 ft. msl - limited lake surface area and decline in campground/picnicking use
<880 ft. msl - marina closes
<900 ft. msl - decline in beach use

Table VI-57

Results of Recreation Impact Assessment for New Don Pedro Reservoir

Peak Season (May - Sept.)

Water Year Type Alternative	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds 600 ft.		720 ft.		780 ft.	
73-YEAR PERIOD	365	total	%	total	%	total	%
Alternative 1 (Base Case)		0	0%	34	9%	155	42%
Alternative 2		0	0%	34	9%	155	42%
Alternative 3		0	0%	54	15%	179	49%
Alternative 4		0	0%	51	14%	177	48%
Alternative 5		12	3%	105	29%	214	59%
Alternative 6		0	0%	34	9%	155	42%
Alternative 7		0	0%	29	8%	149	41%
Alternative 8		0	0%	38	10%	163	45%
CRITICAL PERIOD	35						
Alternative 1 (Base Case)		0	0%	6	17%	27	77%
Alternative 2		0	0%	6	17%	27	77%
Alternative 3		0	0%	18	51%	32	91%
Alternative 4		0	0%	15	43%	32	91%
Alternative 5		11	31%	32	91%	35	100%
Alternative 6		0	0%	6	17%	27	77%
Alternative 7		0	0%	6	17%	27	77%
Alternative 8		0	0%	9	26%	30	86%

Off-Season (Oct.- April)

Water Year Type Alternative	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds 600 ft.		720 ft.	
73-YEAR PERIOD	511	total	%	total	%
Alternative 1 (Base Case)		3	1%	65	13%
Alternative 2		3	1%	65	13%
Alternative 3		3	1%	114	22%
Alternative 4		3	1%	109	21%
Alternative 5		25	5%	175	34%
Alternative 6		3	1%	65	13%
Alternative 7		3	1%	62	12%
Alternative 8		3	1%	70	14%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		0	0%	9	21%
Alternative 2		0	0%	9	21%
Alternative 3		0	0%	32	74%
Alternative 4		0	0%	27	63%
Alternative 5		12	28%	43	100%
Alternative 6		0	0%	9	21%
Alternative 7		0	0%	7	16%
Alternative 8		0	0%	10	23%

NOTES:

<600 ft. msl - marinas close/last boat ramp out of operation
<720 ft. msl - limited lake surface area and decline in campground/picnicking use
<780 ft. msl - decline in beach use

Table VI-58

Results of Recreation Impact Assessment for Lake McClure

Peak Season (April - Sept.)

Water Year Type Alternative	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds 590 ft. total	590 ft. %	600 ft. total	600 ft. %
73-YEAR PERIOD	438				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		0	0%	0	0%
Alternative 3		0	0%	0	0%
Alternative 4		0	0%	0	0%
Alternative 5		0	0%	0	0%
Alternative 6		0	0%	0	0%
Alternative 7		0	0%	0	0%
Alternative 8		0	0%	0	0%
CRITICAL PERIOD	41				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		0	0%	0	0%
Alternative 3		0	0%	0	0%
Alternative 4		0	0%	0	0%
Alternative 5		0	0%	0	0%
Alternative 6		0	0%	0	0%
Alternative 7		0	0%	0	0%
Alternative 8		0	0%	0	0%

Off-Season (Oct.- March)

Water Year Type/Alt.	# of Months	Frequency with which Reservoirs are below Critical Elevation Thresholds 590 ft. total	590 ft. %	600 ft. total	600 ft. %
73-YEAR PERIOD	438				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		0	0%	0	0%
Alternative 3		0	0%	0	0%
Alternative 4		0	0%	0	0%
Alternative 5		0	0%	0	0%
Alternative 6		0	0%	0	0%
Alternative 7		0	0%	0	0%
Alternative 8		0	0%	0	0%
CRITICAL PERIOD	37				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		0	0%	0	0%
Alternative 3		0	0%	0	0%
Alternative 4		0	0%	0	0%
Alternative 5		0	0%	0	0%
Alternative 6		0	0%	0	0%
Alternative 7		0	0%	0	0%
Alternative 8		0	0%	0	0%

NOTES:
<590 ft. msl - last boat ramp out of operation
<600 ft. msl - limited lake surface area and marina closes

Table VI-59

Results of Recreation Impact Assessment for Millerton Lake

Peak Season (May - Sept.)

Water Year Type/Alt.	**# of Months**	Frequency with which Reservoirs are below Critical Elevation Thresholds			
		468 ft.		470 ft.	
73-YEAR PERIOD	365	total	%	total	%
Alternative 1 (Base Case)		24	7%	28	8%
Alternative 2		24	7%	28	8%
Alternative 3		24	7%	28	8%
Alternative 4		24	7%	28	8%
Alternative 5		56	15%	65	18%
Alternative 6		24	7%	28	8%
Alternative 7		24	7%	28	8%
Alternative 8		24	7%	28	8%
CRITICAL PERIOD	35				
Alternative 1 (Base Case)		7	20%	7	20%
Alternative 2		7	20%	7	20%
Alternative 3		7	20%	7	20%
Alternative 4		7	20%	7	20%
Alternative 5		8	23%	9	26%
Alternative 6		7	20%	7	20%
Alternative 7		7	20%	7	20%
Alternative 8		7	20%	7	20%

Off-Season (Oct.- April)

Water Year Type/Alternativ	**# of Months**	Frequency with which Reservoirs are below Critical Elevation Thresholds			
		468 ft.		470 ft.	
73-YEAR PERIOD	511	total	%	total	%
Alternative 1 (Base Case)		10	2%	11	2%
Alternative 2		10	2%	11	2%
Alternative 3		10	2%	11	2%
Alternative 4		10	2%	11	2%
Alternative 5		17	3%	26	5%
Alternative 6		10	2%	11	2%
Alternative 7		10	2%	11	2%
Alternative 8		10	2%	11	2%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		1	2%	1	2%
Alternative 2		1	2%	1	2%
Alternative 3		1	2%	1	2%
Alternative 4		1	2%	1	2%
Alternative 5		2	5%	3	7%
Alternative 6		1	2%	1	2%
Alternative 7		1	2%	1	2%
Alternative 8		1	2%	1	2%

NOTES:

<468 ft. msl - last boat ramp out of operation

<470 ft. msl - limited lake surface area/decline in beach use

Table VI-60

Summary of Recreation Impacts at Major Reservoirs, 73-Year Period

73-year Period Average -- Peak Season

Reservoir	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Shasta	0	0	0	0	0	0	0
Oroville	0	0	0	0	0	0	0
Folsom	0	0	0	0	-	0	0
Camanche	0	0	0	-	0	0	0
Pardee	0	0	0	-	0	0	0
New Melones	-	0	0	0	0	0	0
New Don Pedro	0	0	0	-	0	0	0
McClure	0	0	0	0	0	0	0
Millerton	0	0	0	-	0	0	0

73-year Period Average -- Off Season

Reservoir	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Shasta	0	0	0	0	0	0	0
Oroville	0	0	0	0	0	0	0
Folsom	0	0	0	0	0	0	0
Camanche	0	0	0	-	0	0	0
Pardee	0	0	0	-	0	0	0
New Melones	0	0	0	0	0	0	0
New Don Pedro	0	0	0	-	0	0	0
McClure	0	0	0	0	0	0	0
Millerton	0	0	0	-	0	0	0

+ indicates a significant change that increases recreational opportunities
- indicates a significant change that decreases recreational opportunities
0 indicates no significant change in recreational opportunities

Table VI-61
Summary of Recreation Impacts at Major Reservoirs, Critical Period

Critical Period Average -- Peak and Off Season

Reservoir	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Shasta	0	0	0	+	-	0	0
Oroville	-	-	-	+	-	-	-
Folsom	-	-	-	+ /-	-	-	-
Camanche	0	-	-	-	0	0	0
Pardee	0	-	-	-	0	0	0
New Melones	-	0	-	0	0	0	-
New Don Pedro	0	-	-	-	0	0	0
McClure	0	0	0	0	0	0	0
Millerton	0	0	0	-	0	0	0

+ indicates a significant change that increases recreational opportunities

- indicates a significant change that decreases recreational opportunities

0 indicates no significant change in recreational opportunities

+ /- (increased opportunities in the peak season and decreased opportunities in the off season)

As with the reservoir impacts, the analysis is based on output from DWRSIM and EBMUDSIM (EBMUDSIM was used for the Mokelumne River). The projected changes in average monthly flows reflect the estimated modifications in reservoir operations and can be used to compare the effects of Alternatives 2 through 8 to the base case (Alternative 1). An impact analysis was conducted for each of the major rivers that could be affected by implementation of the water right decision and for which hydrologic modeling results were available.

Impact thresholds were developed for important peak-season (May-September) recreation activities, including boating and swimming. Impacts were not assessed for the off-season because most water contact activities do not occur during this period. Changes in recreation opportunities were assessed for the upper Sacramento (Keswick to Red Bluff), American, San Joaquin (above the confluence with the Merced), upper and lower Stanislaus (New Melones to Oakdale and Oakdale to the San Joaquin), Tuolumne, Merced, and Mokelumne rivers. Changes in recreation opportunities were not assessed for the Feather, Yuba, lower Sacramento, and lower San Joaquin rivers because recreation activities can be accommodated within a wide range of flows on these rivers. Changes in recreation opportunities were assessed for the full 73-year period as well as for the 1928-1934 critical period.

The recreation impact analysis considers the frequency of occurrence with which average monthly flows are above or below the various threshold levels or fall within an optimal range as defined for each river. Table VI-62 summarizes the frequency of occurrence in absolute numbers and as a percentage of the total number of months in the study period for the impact assessment on the selected rivers.

When the critical threshold is a given flow, above or below which recreational activities are impaired, a frequency of occurrence which is higher than the base case would indicate a decrease in recreational opportunities (a negative impact) and a frequency of occurrence which is lower than the base case would indicate an increase in recreational opportunities (a beneficial impact). When the critical threshold is an optimal range of flow, the reverse is true. A frequency of occurrence which is higher than the base case would indicate an increase in recreational opportunities (a beneficial impact), and a frequency of occurrence which is lower than the base case would indicate a decrease in recreational opportunities (a negative impact).

The critical thresholds for some of the river recreation opportunities identified in this analysis tend to overlap, yet a change in river flow may affect one activity and not another. In addition, it is possible for a change in river flow to have a negative impact to one activity and a beneficial impact to another (e.g. flows may drop below the optimal range for boating and into the optimal range for swimming). Some of the flow alternatives result in sustained flows that are higher than the optimal flow range identified for certain activities, such as some kinds of boating. While this results in a negative impact to those activities, there may be other recreational opportunities associated with the higher flows.

Due to the nature of the hydrologic input data and the use of average monthly operations, the modeled river flows may be expected to have a margin of error of 10 to 20 percent. Therefore, differences between the base case and the various alternatives are considered to be significant only if greater than 10 percentage points, higher or lower, from the base case. Table VI-63 summarizes which alternatives have significant recreation impacts (beneficial or negative) on the selected rivers. Significant differences in recreational opportunities occur on at least one river under each alternative but the majority of the significant impacts are beneficial, resulting in increased recreational opportunities.

Mitigation. Recreation in the rivers that could be affected would likely benefit by implementing the flow objective alternatives. In most cases, streamflow will be increased over normal conditions and swimmers, boaters, and others may actually benefit. For those cases where changes in streamflow result in decreased recreational opportunities, it is unlikely that the effects can be mitigated.

c. Wildlife Refuges and Wetlands. Wildlife refuges, wildlife management areas, and privately owned and managed wetlands (such as duck clubs) provide recreational opportunities, primarily in the form of hunting and bird watching. Surface water supplies are used at most of these locations to provide seasonal flooding, maintain wetland habitat and to grow feed crops that attract waterfowl. However, as discussed earlier in the section on impacts to vegetation and wildlife, implementation of the flow objective alternatives is not expected to have a significant impact to wetland habitat at wildlife refuges, wildlife management areas or privately owned and managed wetlands. Therefore, no significant impact to the recreational use of these areas is expected to occur.

Table VI-62
Results of Recreation Impact Assessment for Rivers in the Sacramento River Region

Sacramento River
Upper Reach
Peak Season (May - Sept.)

Water Year Type/Alt.	Total Months	Frequency with which Rivers are between Flow Thresholds: Between 2,500 and 12,000 cfs total	%
73-YEAR PERIOD	365		
Alternative 1 (Base Case)		264	72%
Alternative 2		251	69%
Alternative 3		264	72%
Alternative 4		262	72%
Alternative 5		277	76%
Alternative 6		243	67%
Alternative 7		245	67%
Alternative 8		250	68%
CRITICAL PERIOD	35		
Alternative 1 (Base Case)		33	94%
Alternative 2		30	86%
Alternative 3		32	91%
Alternative 4		32	91%
Alternative 5		33	94%
Alternative 6		31	89%
Alternative 7		30	86%
Alternative 8		31	89%

NOTES:
2,500 to 12,000 cfs - optimal flow range for all boating activities

American River

Peak Season (May - Sept.)

Frequency with which Rivers are between or below Flow Thresholds

Water Year Type/Alt.	Total Months	Between 1,750 and 3,000 cfs total	%	Below 1,750 cfs total	%	Below 1,500 cfs total	%
73-YEAR PERIOD	365						
Alternative 1 (Base Case)		110	30%	85	23%	74	20%
Alternative 2		236	65%	85	23%	73	20%
Alternative 3		234	64%	81	22%	68	19%
Alternative 4		233	64%	81	22%	70	19%
Alternative 5		115	32%	79	22%	59	16%
Alternative 6		244	67%	80	22%	64	18%
Alternative 7		89	24%	89	24%	77	21%
Alternative 8		93	25%	84	23%	66	18%
CRITICAL PERIOD	35						
Alternative 1 (Base Case)		8	23%	17	49%	14	40%
Alternative 2		16	46%	16	46%	13	37%
Alternative 3		16	46%	17	49%	12	34%
Alternative 4		16	46%	16	46%	12	34%
Alternative 5		8	23%	15	43%	12	34%
Alternative 6		15	43%	14	40%	12	34%
Alternative 7		5	14%	19	54%	16	46%
Alternative 8		8	23%	15	43%	14	40%

NOTES:
1,750 to 3,000 cfs - optimal flow range for all boating activities
< 1,750 cfs - minimum flow range for all boating activities
< 1,500 cfs - optimal flow for swimming

Table VI-62 (cont.)
Results of Recreation Impact Assessment for Rivers in the San Joaquin Valley Region

San Joaquin River
Upstream of Merced River
Peak Season (May - Sept.)

		Frequency with which Rivers are above, between, or below Flow Thresholds							
Water Year Type/Alt.	**Total Months**	Above 500 cfs		Between 300 and 500 cfs		Between 200 and 300 cfs		Below 300 cfs	
73-YEAR PERIOD	365	total	%	total	%	total	%	total	%
Alternative 1 (Base Case)		150	41%	209	57%	6	2%	6	2%
Alternative 2		144	39%	202	55%	19	5%	19	5%
Alternative 3		187	51%	170	47%	8	2%	8	2%
Alternative 4		188	52%	169	46%	8	2%	8	2%
Alternative 5		364	100%	1	0%	0	0%	0	0%
Alternative 6		146	40%	196	54%	23	6%	23	6%
Alternative 7		143	39%	202	55%	20	5%	20	5%
Alternative 8		145	40%	202	55%	17	5%	17	5%
CRITICAL PERIOD	35								
Alternative 1 (Base Case)		7	20%	25	71%	3	9%	3	9%
Alternative 2		5	14%	23	66%	7	20%	7	20%
Alternative 3		6	17%	27	77%	2	6%	2	6%
Alternative 4		6	17%	27	77%	2	6%	2	6%
Alternative 5		35	100%	0	0%	0	0%	0	0%
Alternative 6		5	14%	19	54%	11	31%	11	31%
Alternative 7		5	14%	22	63%	8	23%	8	23%
Alternative 8		5	14%	23	66%	6	17%	6	17%

NOTES:
>500 cfs - unknown recreational opportunities
300 to 500 cfs - optimal flow range for all boating activities
200 to 300 cfs - optimal range of canoeing flows
<300 cfs - below optimal flows for swimming

Mokelumne River

Peak Season (May - Sept.)

		Frequency with which Rivers are between or below Flow Thresholds					
Water Year Type/Alt.	**Total Months**	Between 400 and 700 cfs		Below 200 cfs		Below 100 cfs	
73-YEAR PERIOD	365	total	%	total	%	total	%
Alternative 1 (Base Case)		44	12%	54	15%	0	0%
Alternative 2		44	12%	54	15%	0	0%
Alternative 3		106	29%	44	12%	0	0%
Alternative 4		109	30%	43	12%	0	0%
Alternative 5		67	18%	18	5%	0	0%
Alternative 6		44	12%	54	15%	0	0%
Alternative 7		44	12%	54	15%	0	0%
Alternative 8		44	12%	54	15%	0	0%
CRITICAL PERIOD	35						
Alternative 1 (Base Case)		3	9%	8	23%	0	0%
Alternative 2		3	9%	8	23%	0	0%
Alternative 3		14	40%	6	17%	0	0%
Alternative 4		14	40%	6	17%	0	0%
Alternative 5		10	29%	3	9%	0	0%
Alternative 6		3	9%	8	23%	0	0%
Alternative 7		3	9%	8	23%	0	0%
Alternative 8		3	9%	8	23%	0	0%

NOTES:
400 to 700 cfs - optimal flow range for all boating activities
<200 cfs - below minimum flows for all boating activities
<100 cfs - below minimum flows for swimming

Table VI-62 (cont.)
Results of Recreation Impact Assessment for Rivers in the San Joaquin Valley Region

Stanislaus River
Lower Reach
Peak Season (May - Sept.)

		Frequency with which Rivers are between or below Flow Thresholds			
Water Year Type/Alt.	**Total Months**	Between 700 and 800 cfs		Below 300 cfs	
73-YEAR PERIOD	365	total	%	total	%
Alternative 1 (Base Case)		2	1%	0	0%
Alternative 2		17	5%	0	0%
Alternative 3		39	11%	0	0%
Alternative 4		40	11%	0	0%
Alternative 5		23	6%	0	0%
Alternative 6		47	13%	0	0%
Alternative 7		27	7%	1	0%
Alternative 8		18	5%	0	0%
CRITICAL PERIOD	35				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		0	0%	0	0%
Alternative 3		6	17%	0	0%
Alternative 4		7	20%	0	0%
Alternative 5		1	3%	0	0%
Alternative 6		7	20%	0	0%
Alternative 7		2	6%	0	0%
Alternative 8		0	0%	0	0%

NOTES:
700 to 800 cfs - optimal flow range for all boating activities
<300 cfs - below minimum flows for all boating activities

Stanislaus River
Upper Reach
Peak Season (May - Sept.)

		Frequency with which Rivers are between or below Flow Thresholds			
Water Year Type/Alt.	**Total Months**	Between 700 and 2000 cfs		Below 700 cfs	
73-YEAR PERIOD	365	total	%	total	%
Alternative 1 (Base Case)		256	70%	0	0%
Alternative 2		121	33%	0	0%
Alternative 3		178	49%	0	0%
Alternative 4		164	45%	0	0%
Alternative 5		232	64%	0	0%
Alternative 6		164	45%	0	0%
Alternative 7		156	43%	0	0%
Alternative 8		135	37%	0	0%
CRITICAL PERIOD	35				
Alternative 1 (Base Case)		27	77%	0	0%
Alternative 2		24	69%	0	0%
Alternative 3		21	60%	0	0%
Alternative 4		18	51%	0	0%
Alternative 5		30	86%	0	0%
Alternative 6		22	63%	0	0%
Alternative 7		17	49%	0	0%
Alternative 8		19	54%	0	0%

NOTES:
700 to 2,000 cfs - optimal flow range for all boating activities
<700 cfs - below minimum flows for all boating activities

Table VI-62 (cont.)

Results of Recreation Impact Assessment for Rivers in the San Joaquin Valley Region

Tuolumne River

Peak Season (May - Sept.)

		Frequency with which Rivers are between or below Flow Thresholds							
Water Year Type/Alt.	**Total Months**	Between 400 and 700 cfs		Between 200 and 600 cfs		Below 500 cfs		Below 150 cfs	
73-YEAR PERIOD	365	total	%	total	%	total	%	total	%
Alternative 1 (Base Case)		128	35%	174	48%	222	61%	47	13%
Alternative 2		128	35%	174	48%	222	61%	47	13%
Alternative 3		118	32%	156	43%	204	56%	43	12%
Alternative 4		120	33%	158	43%	205	56%	43	12%
Alternative 5		128	35%	170	47%	145	40%	12	3%
Alternative 6		128	35%	174	48%	222	61%	47	13%
Alternative 7		114	31%	177	48%	226	62%	45	12%
Alternative 8		119	33%	160	44%	228	62%	66	18%
CRITICAL PERIOD	35								
Alternative 1 (Base Case)		8	23%	12	34%	30	86%	12	34%
Alternative 2		8	23%	12	34%	30	86%	12	34%
Alternative 3		8	23%	11	31%	28	80%	10	29%
Alternative 4		8	23%	12	34%	28	80%	10	29%
Alternative 5		14	40%	22	63%	23	66%	3	9%
Alternative 6		8	23%	12	34%	30	86%	12	34%
Alternative 7		5	14%	13	37%	32	91%	12	34%
Alternative 8		11	31%	10	29%	30	86%	16	46%

NOTES:

400 to 700 cfs - optimal flow range for all boating activities
200 to 600 cfs - optimal flow range for swimming
<500 cfs - below minimum flows for power boating
<150 cfs - below minimum flows for canoeing and kayaking

Merced River

Peak Season (May - Sept.)

		Frequency with which Rivers are between or below Flow Thresholds			
Water Year Type/Alt.	**Total Months**	Below 500 cfs		Between 50 and 200 cfs	
73-YEAR PERIOD	365	total	%	total	%
Alternative 1 (Base Case)		316	87%	167	46%
Alternative 2		316	87%	167	46%
Alternative 3		290	79%	195	53%
Alternative 4		300	82%	214	59%
Alternative 5		132	36%	294	81%
Alternative 6		316	87%	167	46%
Alternative 7		317	87%	140	38%
Alternative 8		308	84%	115	32%
CRITICAL PERIOD	35				
Alternative 1 (Base Case)		34	97%	15	43%
Alternative 2		34	97%	15	43%
Alternative 3		33	94%	18	51%
Alternative 4		33	94%	21	60%
Alternative 5		14	40%	33	94%
Alternative 6		34	97%	15	43%
Alternative 7		35	100%	12	34%
Alternative 8		32	91%	11	31%

NOTES:

<500 cfs - below minimum flows for all boating activities
50 to 200 cfs - optimal flow range for swimming

Table VI-63
Summary of Recreation Impacts on Selected Rivers

73-year Period Average -- Peak Season

River	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Sacramento	0	0	0	0	0	0	0
American	+	+	+	0	+	0	0
Mokelumne	0	+	+	+	0	0	0
Stanislaus - upper	-	-	-	0	-	-	-
Stanislaus - lower	0	+	+	0	+	0	0
Tuolumne	0	0	0	+	0	0	0
Merced	0	0	+	+ /-	0	0	-
San Joaquin	0	-	-	-	0	0	0

Critical Period Average -- Peak Season

River	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Sacramento	0	0	0	0	0	0	0
American	+	+	+	+	+	0	0
Mokelumne	0	+	+	+	0	0	0
Stanislaus - upper	0	-	-	0	-	-	-
Stanislaus - lower	0	+	+	0	+	0	0
Tuolumne	0	0	0	+	0	0	-
Merced	0	0	+	+ /-	0	0	-
San Joaquin	+ /-	0	0	-	+ /-	+ /-	0

\+ indicates a significant change that increases recreational opportunities

\- indicates a significant change that decreases recreational opportunities

\+ /- indicates significant changes that increase and decrease recreational opportunities

0 indicates no significant change in recreational opportunities

10. Scenic Quality

The implementation of the 1995 Bay/Delta Plan flow alternatives will not result in the obstruction of any scenic vista or view open to the public. However, potentially significant aesthetic effects, often referred to as “the bathtub ring,” may occur at multiple-use reservoirs. The bathtub ring, which is the exposed shoreline below the maximum water surface elevation, is a normal occurrence at multiple-use reservoirs as water levels decline. The ring is usually devoid of vegetation. The flow alternatives will result in changes in the operation of upstream reservoirs which may cause water levels to be lower for longer periods, reducing the aesthetic values of the reservoirs.

To analyze the effects of implementing the flow alternatives on reservoir aesthetics, end-of-month surface area at selected reservoirs, as modeled using DWRSIM, was compared to the base case (Alternative 1). Table VI-64 summarizes the average monthly difference (May - September) in reservoir surface area for the 73-year period and dry-year average (average of below normal, dry, and critically dry years). The selected reservoirs include Lake Shasta, Lake Oroville, Folsom Lake, New Melones Reservoir, New Don Pedro Reservoir, Lake McClure, and Millerton Lake. The significant changes in reservoir surface area under each alternative are discussed below.

Under Alternative 2, reservoir surface area for the 73-year period is somewhat less than the base case at Shasta, Oroville, and Folsom, and significantly less than the base case at New Melones. For the dry-year average, reservoir surface area is significantly less than the base case at Folsom and New Melones. There are no changes in operations at New Don Pedro, McClure, or Millerton under this alternative.

Under Alternative 3, the dry-year average reservoir surface area is significantly less than the base case at McClure because of its relatively recent water right priority, but all of the reservoirs (except Millerton) have reduced surface area, particularly at Folsom and New Don Pedro.

Under Alternative 4, reservoir surface area is significantly less than the base case at New Melones for the 73-year period and the dry-year average and at Folsom during dry years.

Under Alternative 5, reservoir surface area for the 73-year period and the dry-year average is significantly less than the base case at New Don Pedro, McClure, and Millerton. This is the only alternative that affects Millerton because it is the only alternative that requires releases from Friant Dam.

Table VI-64
Average Monthly Difference in Reservoir Surface Area
May - September

Average of 73-Year Period Compared to the Base Case (percent)

	Shasta	Oroville	Folsom	N. Melones	N. Don Pedro	McClure	Millerton
Alt 2	-1.1	-2.8	-5.2	-14.0	0.0	0.0	0.0
Alt 3	-0.2	-2.7	-3.5	-4.0	-4.3	-5.5	0.0
Alt 4	-0.2	-2.7	-3.6	-9.1	-3.4	-2.5	0.0
Alt 5	1.4	0.5	0.4	-0.5	-14.3	-16.2	-10.4
Alt 6	-2.2	-3.2	-8.1	1.6	0.0	0.0	0.0
Alt 7	-2.0	-3.8	-7.3	5.6	-1.4	-3.1	0.0
Alt 8	-0.8	-2.6	-3.9	-8.5	-3.0	-7.4	0.0

Average of Dry Years Compared to the Base Case (percent)

	Shasta	Oroville	Folsom	N. Melones	N.Don Pedro	McClure	Millerton
Alt 2	-2.3	-3.6	-10.8	-18.5	0.0	0.0	0.0
Alt 3	-0.8	-3.6	-7.4	-4.6	-6.0	-10.0	0.0
Alt 4	-0.8	-3.7	-7.6	-11.5	-4.7	-4.1	0.0
Alt 5	2.0	0.7	-0.1	0.9	-20.2	-22.8	-9.2
Alt 6	-4.1	-4.5	-15.7	2.5	0.0	0.0	0.0
Alt 7	-3.7	-4.9	-14.2	8.3	-1.0	-4.1	0.0
Alt 8	-1.8	-3.8	-10.0	-11.9	-3.4	-11.5	0.0

Under Alternative 6, reservoir surface area for the 73-year period and the dry-year average is significantly less than the base case at Folsom. There are no changes in operations at New Don Pedro, McClure, or Millerton under this alternative.

Under Alternative 7, reservoir surface area for the 73-year period and the dry-year average is significantly less than the base case at Folsom and is significantly greater at New Melones.

Under Alternative 8, reservoir surface area for the 73-year period is somewhat less than the base case at Oroville, Folsom, and New Don Pedro, and significantly less than the base case at New Melones and McClure. For the dry-year average, reservoir surface area is somewhat less than the base case at Oroville and New Don Pedro, and significantly less than the base case at Folsom, New Melones and McClure.

In summary, Alternative 2 has the greatest negative impact to scenic quality at New Melones and, to a lesser extent, Folsom because the USBR would use these reservoirs to meet the flow objectives. Alternative 3 has the greatest negative impact at McClure because of its relatively low water right priority. Alternative 4 has a significant negative impact at New Melones because it would be used to meet Friant obligations that are significant during the pulse flow period. Alternative 5 has significant negative impacts at New Don Pedro, McClure, and Millerton because some of the Delta flow objectives are met by the San Joaquin River users. Alternatives 6 and 7 have the greatest negative impact at Folsom, but also affect Shasta and Oroville. Under Alternative 6, the SWP and CVP reservoirs in the Sacramento Valley would be used to meet the Vernalis flow objectives through releases from the Delta-Mendota Canal. Under Alternative 7, salinity control releases from New Melones are capped at 70 TAF and additional releases to meet the minimum flows on the San Joaquin River at Vernalis identified in the Letter of Intent would be made from New Don Pedro and McClure. SWP and CVP would meet the rest of the objectives through releases from Shasta, Oroville, and Folsom. Alternative 8 has the greatest impact at New Melones and McClure in most years, although Folsom is significantly affected in dry years.

Mitigation. The implementation of the flow alternatives will likely result in some degradation of the scenic quality at one or more reservoirs as water levels may be lower for longer periods. This is a temporary, although recurring, impact that is similar to what normally occurs under dry-year conditions. The temporary effect is alleviated when water levels rise during the wet season. It is unlikely that the impacts to scenic quality can be mitigated.

11. Cultural Resources

For the purposes of this EIR, cultural resources are defined as prehistoric and historic archeological sites, architectural properties (e.g., buildings, bridges, and structures), and traditional properties with significance to Native Americans. This definition is consistent with the CEQA, the California Register of Historical Resources, California Historical Landmarks and California Points of Interest. Under federal law, historic properties are defined by Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended and its implementing regulations, 36 CFR Part 800.

a. Regulatory Framework. CEQA provides the principal state policy for the protection of prehistoric and historic archeological resources. (See Pub. Resources Code § 21083.2) Additionally, the CEQA Guidelines in Appendix K outline procedures for the protection, preservation or mitigation of such resources. If a project may cause a substantial adverse change in the significance of an historical resource, the project may have a significant effect on the environment. (Pub. Resources Code § 21084.1; CEQA Guidelines, Appendix K).

An impact is considered significant under CEQA, if there is a substantial adverse change in the significance of an historical resource. The primary guiding policy in assessing potential impacts on cultural resources at both the state and federal levels is that impacts on sites should be avoided whenever feasible, whether or not the resource is eligible for the NRHP or is considered important. If after identification and evaluation an archeological deposit is determined not to be significant, the resource should be noted but should not be considered further under CEQA.

b. Data Limitations. Some parts of California have been inventoried more extensively than others. As a result, the number of known resources usually depends on the amount of research that has been conducted in the region, rather than on actual site density. The database is also biased in terms of site types because historic sites were not commonly recorded until the 1970's, resulting in an inaccurate ratio of historic to prehistoric sites. Native American groups were often not consulted until even more recent times as to the existence of traditional cultural properties (TCPs). Additionally they are often reluctant to reveal or publish the locations of TCPs. The available data on TCPs for various portions of California ranges from incomplete to non-existent.

Many Information Centers of the Historical Resources Information System have incomplete data bases due to backlogs in processing and the failure of individuals or agencies to submit site records and reports. Several of the reservoirs that could be impacted were completed prior to the implementation of laws protecting cultural resources, and only their basin areas were partially inventoried. Those that were subject to inventories were largely assessed for prehistoric resources and not for historic and TCPs. Some basin areas of the reservoirs that may be affected by the implementation of the 1995 Bay/Delta Plan have been partially inventoried during dry-year surveys while others have not. There are historic maps of reservoir basin areas indicating that many historic sites existed prior to inundation, but these resources have not been verified during field surveys.

Of all the reservoirs, New Melones has had the most extensive survey and mitigation measures undertaken, as it was constructed later than the other reservoirs. Currently, 627 sites have been recorded at New Melones. These sites are distributed throughout the project area. In the permanent pool zone lower than 808 feet above mean sea level (msl), there are 122 sites that have been recorded. The permanent pool zone/fluctuation pool at elevations from 808 feet to 1088 feet msl has 33 previously recorded sites. There are 232 sites located in the fluctuating pool zone only, while 24 other sites were located in the fluctuating pool zone/above pool area. The remainder of the sites are situated outside of the reservoir basin area.

Preliminary reoperation studies for Folsom Reservoir have documented some of the cultural resources that are subject to continuing impacts from reservoir operations. At least 123 prehistoric sites (including ethnographic sites) and 52 historic properties have been recorded as a result of surveys at Folsom Reservoir. Many of these sites have both prehistoric and historic components. Judging by field observations made since the 1970's, inundation has had a serious detrimental effect on many, if not most, of the sites within the reservoir basin. Studies at Folsom, and other reservoirs in northern California have suggested, however, that important scientific and/or cultural data may still survive within some of these sites. Previous surveys at Folsom, and surveys and excavations at other reservoirs in northern and central California have suggested that viable and important research data may survive in many of the reservoir sites. There is reason to believe that future archeological study within reservoirs can contribute significant knowledge of the prehistory, history, and ethnohistory of these areas. (Waechter et al 1994).

c. Impact Mechanisms. The following impact mechanisms have been identified as potentially affecting cultural resources.

Hydrology. Changes in reservoir operations could affect cultural resources at reservoir margins by changing historic patterns of reservoir filling and emptying and by changing flows (and therefore stages) in rivers and streams downstream of the reservoir. Sites in reservoirs are affected by pool fluctuation. They suffer effects of wavewash erosion, siltation, redeposition of materials, mixing of artifacts, and chemical alteration of site deposits from changing water levels, resultant water movement, and periodic inundation. The resources then dry out when exposed and get wet again when the water level comes up. This disrupts stratigraphy and increases the rate of decomposition of perishable materials. Sites located lower in the reservoir, within the deep pool (including those adjacent to old river flood plains), were more likely to be covered with silt, which sometimes formed a protective cap. Sites at or near the high water line, and sites exposed during drawdown, suffer both erosion and vandalism. (Waechter et al 1994). Decreasing the amount of storage at a reservoir may expose existing known and unknown cultural resources within the drawdown zone to more sustained and frequent impacts and cover a more extensive area than under existing operating criteria. When resources are physically exposed they are also open to vandalism, theft, and vehicular destruction.

Stream Channels. Changes in stream flows can cause impacts on cultural resources by exposing sites when river stages are below historic levels. High flood stages may cause bank erosion and relocation of river channels, both of which may expose cultural resource sites. Changes in stream flows can also cause impacts by changing recreational use. The types of impacts by recreational use are discussed in the following section under "Recreational Activities".

Reservoir Margins. Cultural resources located in the drawdown zone of reservoirs are most prone to damage from hydrologic changes. The most damaging impacts would probably be caused by erosion when lower reservoir levels expose a cultural resource site. Erosion can be caused by waves created by either wind or boat traffic. Boat-caused waves can be very destructive to cultural resources, especially on smaller reservoirs (Lenihan, et al., 1981). This is especially true if natural vegetation, which could help hold soil, is no longer present. Some erosion occurs from rising and falling waters across the resources during times of reservoir drawdown (Lenihan, et al., 1981).

Drawdowns can expose sites, many of which become visible to treasure seekers because inundation has removed vegetative cover. Drawdowns often leave a fine silt bench where the water has receded. The type of landform created when reservoirs are drawn down is a favorite of off highway vehicle users, who may unknowingly destroy cultural resources by using these areas (Lenihan, et al., 1981). Lowering water levels could also require new construction to extend boat ramps, create new beaches, or relocate marinas.

Less obvious, but also potentially destructive to resources, is wet/dry cycling. The repeated inundation and exposure of resources cause Wet/dry cycling, which causes perishable items (e.g., bone, wood, shell, ceramics, pollen, and leather) to disintegrate rapidly.

Another impact tied to the exposure of resources during drawdowns is caused by animals. For example, at Folsom Lake, site CA-Eld-204 had soils containing cultural remains (referred to as middens); exposure of the site during a drought revealed that the burrowing actions of the introduced clam *Corbicula fluminea* caused a major impact on this site. Raccoons that dug into the exposed midden while hunting for the clams (Lenihan, et. al., 1981), caused further damage. Lenihan et al. (1981) also noted the destruction of site features caused by cattle walking on sites still soft from having been recently exposed.

Water levels beyond historic conditions also pose a threat to cultural resources. For example, an historic site that was formerly reached by an arduous six-mile hike was exposed to greater vandalism when it became a ten-minute hike from the new lake margin (Lenihan, et. al., 1981).

Recreational Activities. Vandalism, whether caused by organized treasure seekers or by inadvertent disturbance, is a constant threat to the public's cultural resources. As the number of recreationists at facilities increases (because of better boating, swimming, or fishing opportunities), cultural resources are at greater risk. These risks occur not only at sites that are exposed at water margins, but also in the zone above inundation. Improved fishing could bring more anglers who would walk through this area to reach the river, which could lead to the discovery and possible looting of cultural resources.

Increased numbers of recreationists at river and reservoir facilities could require construction of new recreational facilities that in turn, may affect cultural resources. Impacts could occur from construction of new roads, restrooms, parking lots, marinas, and boat ramps.

Off-highway vehicle traffic and other forms of vandalism occur when reservoir levels are low. Lower water levels at reservoirs can be expected to increase enforcement problems and costs as vehicles can access areas previously inundated, causing damage to natural and cultural resources. The California Department of Parks and Recreation has documented the human destruction of sites by vandals both above and below reservoir gross pool.

Changes in Agricultural Practices and Land Use. Agricultural practices associated with various types of crops can lead to lesser or greater impacts on cultural resources. For instance, planting rice (where it is necessary to recontour the landscape) or planting orchards and/or vineyards (where it is necessary to plow the land to a depth approximately 2 meters) can be very destructive to cultural resources. None of the alternatives are expected to increase water diversions or deliveries to levels which would cause changes in agricultural practices. Therefore, there will be no impacts from changes in crops due to the alternatives.

d. Potential Impacts to the Cultural Resources Types. This section describes how different types of cultural resources may be affected by the impact mechanisms discussed above.

Prehistoric Site Types. Of the various types of prehistoric sites that may be affected by the alternatives, habitation sites, especially those sites containing midden soils, are most susceptible to damage. Generally the scientific value of habitation sites lies in the information on prehistoric life ways that can be extracted. Any activity that moves, removes, or destroys aspects of a site will compromise that information. Soils containing middens tend to be loose and easily eroded by wave action or the movement of water across a site. Midden soils often retain identifiable remnants of faunal material (e.g., bone or shell), possibly human burials, and occasionally perishable artifacts (e.g., basketry remains) that, if exposed, would deteriorate due to wet/dry cycling. Habitation sites are highly susceptible to intentional vandalism by artifact collectors and unintentional damage by off highway vehicle users.

Another site type commonly found are lithic scatters (strictly defined as those sites that contain only material manufactured from stone). The greatest danger to these sites is from artifact collection. If artifacts are moved from their original location by rising or falling waters, information about the site will be lost. Also erosional forces could remove artifacts from a site. Further, the submersion of obsidian artifacts could prevent the accurate dating using hydration-dating techniques.

Rock art sites containing petroglyphs, pictographs, and intaglios (artistic alignments of rocks) can be extremely vulnerable to changes in water level. Sites that may have been previously submerged under reservoirs and are exposed during drawdowns may suffer from wet/dry cycling, erosion due to wave action, and vandalism.

Bedrock mortars (used for grinding vegetal materials) are the prehistoric resource type least susceptible to damage through hydrologic mechanisms. However, midden, which is often associated with bedrock mortars, would be vulnerable to hydrologic impacts.

Historic Site Types. Historic resources (including archeological resources, structures, and buildings) include sites associated with early historic settlement, mining (hardrock and placer), agriculture (farming and ranching), transportation (railroads and roads), oil exploration, and logging.

Historic structures (including buildings, windmills, mining winches, and bridges) or their remains are highly susceptible to water level changes. The exposure of structures in reservoirs previously covered by inundation could subject them to erosion (especially if they are in a wave zone), wet/dry cycling, and vandalism.

Wooden portions of ditches and flumes (often associated with agriculture, mining, and logging) are highly susceptible to wet/dry cycling and erosion. Earthen ditches are affected principally by water level changes, especially wave action.

Debris scatters, which can be found within any type of historic site, are extremely vulnerable to water level changes. Erosion can completely remove a debris scatter, and wet/dry cycling can accelerate the decomposition of metal, wood, and leather artifacts. Debris scatter exposed by receding waters is very susceptible to vandalism.

Historic stone resources such as tailings piles (remnants from mining) and rock walls (often associated with ranching) are less prone to water damage unless these resources are left in a wave zone by changing water levels.

Traditional Cultural Properties. TCPs are properties that are identified as significant to an identifiable social group. The properties can be important because of cultural practices or beliefs, and are difficult to identify because often only members of the group are allowed to know their locations.

Common TCPs include geographic features such as prominent boulders or springs (locations where people traditionally gathered), harvesting locations (where plant food and medicinal and basketry materials were traditionally gathered), and large geographic features. Changes in hydrology and recreational use associated with the alternatives could disrupt the use of TCPs. Hydrologic damage could occur through inundation or erosion.

e. Impacts Analysis. This section describes the potential for impacts on cultural resources due to implementation of the flow alternatives. The description includes those impacts that may be caused by changes in hydrology and recreational activities.

Changes in Hydrology. Implementing the alternatives will result in changes to river flows. Table VI-65 shows the minimum and maximum river stage over the 73-year hydrology in feet above zero gage reading for the base case. It also shows the difference between this value and the corresponding stages for Alternatives 2 through 8. As shown on the table, none of the alternatives cause river stage to drop significantly below the minimum annual river stage for the base case. Therefore, there will be no impacts to cultural resources from fluctuating river levels due to the alternatives.

Implementing the alternatives will also result in changes to reservoir levels. Table VI-66 lists the minimum and maximum reservoir levels over the 73-year period for the base case. The table also lists the difference between reservoir levels for the base case and each of the other flow alternatives. Tables VI-51 through VI-59 describe the frequency of lower reservoir elevations in comparison to the base case.

The anticipated differences between the base case and the other seven alternatives in minimum pool elevations for the eight modeled reservoirs vary significantly. These range from a projected lower minimum pool of 55 feet to a higher minimum pool of 90 feet, which would occur at New Don Pedro Reservoir and New Melones Reservoir, respectively. Most of the changes would occur at the CVP and SWP reservoirs, except under Alternative 5, which would result in a significantly lower minimum pool at New Don Pedro Reservoir. Differences of only several feet will probably produce no measurable impacts as they are likely to be within the present operating margins. Sites within the reservoir pool will continue to be subjected to the same types of impacts as they have been historically (i.e., inundation and exposure during drawdowns under any of the alternatives), but the frequency of such drawdowns may increase significantly for some reservoirs under the various alternatives as compared to the base case. The consensus among researchers is that the nature and extent of the effects of reservoir inundation are dependent on several factors, most notably the location of a cultural property within the reservoir basin. Sites

Table VI-65

Minimum and Maximum Annual River Stage

73-Year Minimum Annual River Stage, (ft)

Alternative	Red Bluff	Feather	Verona	Natoma	Newman	Vernalis
Alt 1	3.5	1.3	4.9	1.5	4.0	4.0

Difference Between Minimum Annual River Stage and Base Case (ft)

Alternative	Red Bluff	Feather	Verona	Natoma	Newman	Vernalis
Alt 2	0.0	0.0	0.3	-0.1	0.0	-0.4
Alt 3	0.0	0.0	0.3	-0.1	0.0	0.3
Alt 4	0.0	0.0	0.3	-0.1	0.0	0.3
Alt 5	0.1	0.0	0.4	-0.1	0.6	0.4
Alt 6	0.0	0.0	0.3	-0.1	0.0	0.3
Alt 7	0.0	0.0	0.2	-0.1	-0.1	-0.7
Alt 8	0.0	0.0	0.2	-0.1	-0.1	-0.3

73-Year Maximum Annual River Stage, (ft)

Alternative	Red Bluff	Feather	Verona	Natoma	Newman	Vernalis
Alt 1	24.2	12.7	36.6	13.2	21.8	26.4

Difference Between Maximum Annual River Stage and Base Case (ft)

Alternative	Red Bluff	Feather	Verona	Natoma	Newman	Vernalis
Alt 2	0.0	0.0	0.0	0.0	0.0	0.0
Alt 3	0.0	0.0	-0.2	0.0	0.0	0.0
Alt 4	0.0	0.0	0.0	0.0	0.0	0.0
Alt 5	0.0	0.0	0.0	0.0	0.5	0.2
Alt 6	0.0	0.0	0.0	0.0	0.0	0.0
Alt 7	0.0	0.0	0.0	0.0	0.0	0.0
Alt 8	0.0	0.0	0.0	0.0	0.0	0.3

within the zone of seasonal fluctuation or drawdown suffer the greatest impacts, primarily in the form of erosion/scouring, deflation, hydrologic sorting, and artifact displacement, caused by waves and currents (Waechter et al 1994).

Table VI-66

Minimum and Maximum Annual Reservoir Elevation

73-Year Minimum Annual Reservior Elevation, (ft)

Alternative	Shasta	Oroville	Folsom	N. Melones	N. Don Pedro	McClure	Millerton
Alt 1	879	589	286	759	579	626	461

Difference Between Minimum Annual Reservoir Elevation and Base Case, (ft)

Alternative	Shasta	Oroville	Folsom	N. Melones	N. Don Pedro	McClure	Millerton
Alt 2	-12	3	0	-44	0	0	0
Alt 3	-7	-10	1	57	0	0	0
Alt 4	-6	-8	1	-21	0	0	0
Alt 5	32	11	4	90	-55	-1	-2
Alt 6	-20	-7	-10	62	0	0	0
Alt 7	-12	-8	0	46	1	0	0
Alt 8	-6	15	1	13	0	0	0

73-Year Maximum Annual Reservior Elevation, (ft)

Alternative	Shasta	Oroville	Folsom	N. Melones	N. Don Pedro	McClure	Millerton
Alt 1	1,067	900	466	1,088	832	867	576

Difference Between Maximum Annual Reservoir Elevation and Base Case, (ft)

Alternative	Shasta	Oroville	Folsom	N. Melones	N. Don Pedro	McClure	Millerton
Alt 2	0	0	0	0	0	0	0
Alt 3	0	0	0	0	0	0	0
Alt 4	0	0	0	0	0	0	0
Alt 5	0	0	0	0	0	0	0
Alt 6	0	0	0	0	0	0	0
Alt 7	0	0	0	0	0	0	0
Alt 8	0	0	0	0	0	0	0

Changes in Recreational Activities. Recreational activities at reservoir facilities are influenced by changes in reservoir surface elevation. None of the alternatives will involve increasing the height of the reservoirs, therefore water elevation will not reach beyond historic levels. Recreational activities are not expected to increase as a result of any of the alternatives. Accordingly, there will be no impacts on cultural resources due to increased recreational activities. If reservoir elevation falls below minimum levels described in Table VI-66 for a significant period of time, then there could be a possibility of impacts to cultural resources due to increased opportunities for OHV traffic and other forms of vandalism to occur when reservoir levels are low.

f. Potential Mitigation Measures. CEQA provides the principal state policy for the protection of prehistoric and historic archeological resources. Public Resources Code section 21083.2(b), in CEQA, states that "If it can be demonstrated that a project will cause damage to a unique archeological resource, the lead agency may require reasonable efforts to be made to permit any or all of these resources to be preserved in place or left in an undisturbed state." The CEQA Guidelines, Appendix K, outline procedures for the protection, preservation or mitigation or such resources. They direct public agencies to avoid damaging effects on an archeological resource whenever feasible. In order to accomplish this, it will be necessary to inventory areas to be impacted and evaluate any resources that are located. If avoidance of an important archeological site is not feasible, the agency operating the reservoir should prepare an excavation plan for mitigating the effect of the project on the qualities that make the resource important as outlined in Appendix K.

A public agency following the Federal clearance process under the National Historic Preservation Act (NHPA) or NEPA may use the documentation prepared under the federal guidelines in place of documentation necessary for CEQA. For the CVP reservoirs, any cultural resource research will need to meet federal standards, which will in turn satisfy the CEQA Guidelines. Separate cultural resource studies could become necessary for Lake Oroville, New Don Pedro Reservoir, and Lake McClure if an alternative affecting those reservoirs is selected.

Alternatives 2 through 8 could result in a federal undertaking. If the project constitutes a federal undertaking, then the federal agency must give full consideration to preservation values. Section 106 requires that federal agencies inventory and evaluate cultural resources and mitigate impacts on significant cultural resources prior to initiating their undertakings. At present it is not known which federal, state, and local agencies will be responsible for the different undertakings required to implement each of the proposed flow alternatives, however any impacts caused by an undertaking must be evaluated under Section 106 criteria.

The federal agency responsible for operation of the reservoir should ensure that resources eligible for the National Register of Historic Places resources that may affected by implementation of the project, will be treated. Treatments of historic properties include a variety of techniques to preserve or protect properties, or to document their historic values and information. In the case of unavoidable adverse effects on historic or prehistoric archeological sites, data recovery programs are usually implemented. Preservation, rehabilitation, restoration, and stabilization are common treatments for architectural properties.

Mitigation measures will vary depending on ownership and the way in which the selected alternative is operated. Previous surveys at Folsom Lake, and surveys and excavations at other reservoirs in northern and central California, have suggested that viable and important research data may survive in many of the reservoir sites. While distributional data and artifact assemblages will probably be incomplete, there is reason to believe that future archeological study within the project areas and the reservoir basins as a whole can add to knowledge of the prehistory and ethnohistory. (Waechter et al 1994).

Any required mitigation measures, as outlined above, should be undertaken after the SWRCB makes a water right decision. If the alternative chosen affects reservoirs operated by the federal government, then the federal agencies should complete the Section 106 process. If the reservoirs affected by the chosen alternative are owned or operated by the state or a public entity then the SWRCB will require the reservoir operators to implement mitigation measures that will ensure compliance with the CEQA Guidelines, Appendix K. Compliance with CEQA requires that any significant project-generated impacts to important cultural resources will be avoided or mitigated. Required measures could include surveys of areas newly exposed during minimum pool conditions, evaluation of any resources identified in those areas and implementation of any CEQA mandated mitigation measures.

12. Groundwater Resources

In the upstream areas of the Delta watershed, groundwater is a readily available water supply that can be used to replace surface water deliveries reduced as a result of implementing the flow objectives. In California, there is no permit procedure to regulate groundwater appropriations unless the appropriation is from a subterranean stream flowing through a known and defined channel. Groundwater that is not part of a subterranean stream flowing through a known and defined channel is called "percolating groundwater." Most of the groundwater in California is presumed to be percolating groundwater. Percolating groundwater withdrawals in general are regulated only where;

1) basins have been adjudicated establishing the water rights of various parties;
2) the State Legislature has granted a local water district the power to levy a groundwater extraction charge, or "pump tax";
3) groundwater management districts have been established with authority to regulate pumping by ordinance;
4) a local agency adopts a groundwater management plan pursuant to Water Code sections 10753 et seq.;
5) counties have exercised their police power to limit groundwater extractions; or
6) water agencies in an area have agreed to self-regulation.

Existing problems caused by groundwater pumping could be magnified if pumping increases as a result of surface water delivery reductions. These problems include surface land subsidence and the associated loss of aquifer capacity, groundwater overdraft, groundwater quality deterioration, increases in energy consumption, and decreases in agricultural productivity. Increases in energy consumption are discussed in section C.7 of this chapter.

In this analysis, surface water delivery reductions resulting from the flow alternatives are assumed to be replaced by groundwater pumping in the Delta watershed. For Alternatives 3 and 4, this assumption is different than the assumptions used in the development of the hydrology, as described in Chapter V. In that case, the Sacramento Basin water right holders were assumed to seek contracts for an alternative water supply and the San Joaquin Basin water right holders would pump groundwater. The actual response of water right holders to curtailed diversions is uncertain, but the groundwater pumping assumption is made in this section to ensure that a worst case scenario is used for evaluating impacts to groundwater resources.

The description of impacts to groundwater resources is discussed in this section for the entire Central Valley. Additional groundwater impacts in the Friant Service Area are described in section E of this chapter.

a. Land Subsidence. Subsidence occurs in the Delta, western San Joaquin Valley, and a portion of the central Sacramento Valley. Subsidence in the Delta is due to the compaction and erosion of the organic peat soils due to agricultural practices. As the flow objectives will not change land use practices in the Delta, subsidence there will not be affected by implementation of the flow objectives. Subsidence in the San Joaquin and Sacramento valleys results from lowered groundwater elevations and the subsequent compaction of the dewatered soil interstitial spaces. Land subsidence can change canal gradients, damage buildings, and require repair of other structures. Another negative effect of subsidence is the permanent loss of aquifer capacity. This loss occurs when beds of clay and silt compress as groundwater is extracted. Once these fine-grained beds compress, they can never hold as much water again and aquifer capacity is permanently lost.

In Chapter V, section A, the reductions in surface water deliveries resulting from implementation of the flow objectives are quantified. Assuming that these reductions are made up through groundwater pumping, subsidence could occur from implementing the flow objectives if groundwater elevations fall to critical thresholds.

The area of concern for subsidence in the Sacramento Valley is in Yolo County between the towns of Davis and Zamora in the south central part of the valley. Some localized subsidence was documented in this area during the 1987-1992 drought (USBR 1997g). Under Alternatives 2, 5, 6, 7 and 8, surface water delivery reductions are not anticipated for this area and should not contribute to renewed subsidence. Under Alternatives 3 and 4, the direct diversions of some water rights holders will be curtailed in the vicinity of the subsidence area, which would contribute to subsidence problems in the Davis/Zamora area during extended droughts. However, contracts for surface supplies to replace the lost supplies would mitigate the impacts.

Land subsidence is a significant problem in the western San Joaquin Valley in both the San Joaquin River basin and the Tulare Basin. The largest of the three land subsidence areas in the San Joaquin Valley is the 2,600 square mile Los Banos-Kettleman City area which extends from Merced County to Kings County and lies within both the San Joaquin River basin and the Tulare Basin. Prior to completion of the California Aqueduct in 1967, groundwater was the only source of irrigation water for most of the western San Joaquin Valley. Several decades of groundwater pumping lowered water levels and caused land subsidence of 1 foot regionally and up to 29 feet locally (Poland et al. 1975). With the completion of the aqueduct, surface water replaced groundwater as the principal source of irrigation water and total irrigation increased in the area. From 1967 to the present, the water table has risen across the area, as much as 100 feet locally. The increase in the altitude of the water table increased the area underlain by shallow groundwater creating the need for subsurface drainage of agricultural fields (Belitz et al. 1992).

Land subsidence and agricultural drainage problems are at the opposite ends of the "too little/too much groundwater" problem in the western San Joaquin Valley. Since 1967, subsidence has occurred only during the two extreme droughts of 1976-77 and 1987-92 when groundwater was used extensively to replace surface water supplies. In 1990, subsidence of up to 2 feet was measured by the DWR along the California Aqueduct in western Fresno County (USBR 1997g). DWR (1994) reports that the highest amount of subsidence occurred in 1992. Thus, subsidence has been a significant drought-related problem. There is also a subsurface drainage problem in this area (discussed in Chapter VIII). The San Joaquin Valley Drainage Program (SJVDP 1990) proposed a groundwater management solution that called for replacing surface water supplies with groundwater supplies to bring the system into hydrologic balance and stabilize the water table at a lower depth. The SJVDP's recommended plan included pumping 56 TAF of groundwater annually from beneath problem drainage areas in the Grasslands, Westlands and Tulare subareas to help manage drainage problems. Therefore, increased groundwater pumping on the west side of the San Joaquin Valley caused by implementation of the flow objectives may help meet the San Joaquin Valley Drainage Program recommendations, but it could increase subsidence problems in drought years. Additional groundwater pumping to replace surface water can also have the undesired effect of decreasing agricultural productivity due to the higher salinity of groundwater. This impact is discussed in section d.

Other areas of land subsidence in the Tulare Basin are the Tulare-Wasco area located between Fresno and Bakersfield, and the Arvin-Maricopa area located 20 miles south of Bakersfield in Kern County. Land subsidence has exceeded 12 feet locally in the Tulare-Wasco area and 9 feet locally in the Arvin-Maricopa area. Oil and gas withdrawal is partly responsible for subsidence in the Arvin-Maricopa area (USBR 1997g).

Table VI-67 shows the critical period changes in surface water deliveries for the alternatives compared to the base case associated with the subsidence areas in the San Joaquin Valley. Delivery reductions vary from 265 TAF under Alternative 4 to 401 under Alternative 5. Since subsidence occurred during the last two droughts, subsidence problems are likely in future droughts under existing conditions. The reductions in surface deliveries associated with flow objective implementation in subsidence areas likely will exacerbate the subsidence problem. Assuming that these delivery reductions are replaced with groundwater pumping, then implementation of all of the alternatives could significantly exacerbate the subsidence problems during drought periods. Under Alternative 5, the impacts would be felt mostly in the Friant Project area. Increased subsidence over current levels during droughts is a significant impact because the subsidence is likely to occur along important water conveyance facilities including the Delta-Mendota Canal, Mendota Pool and California Aqueduct as it did in the 1987-92 drought. Water conveyance facilities are especially susceptible to damage because subsidence can change the gradients of these facilities. Additionally, subsidence permanently reduces the capacity of the aquifer.

Table VI-67
Water Delivery Changes in Land Subsidence Areas of the San Joaquin Valley Critical Period Annual Average (TAF)

	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
SWP Tulare Basin Service Area	-152	-149	-149	-47	-145	-160	-146
Exchange Contractors	-64	-46	-45	-18	-76	-69	-63
CVP San Luis Unit	-120	-72	-71	-9	-131	-121	-110
CVP Friant Project	0	0	0	-327	0	0	0
Total Delivery Changes	-336	-267	-265	-401	-352	-350	-319

Possible mitigation for the subsidence problems in both the Sacramento and San Joaquin valleys includes:

1. Limits on groundwater pumping. The SWRCB has authority to prohibit water diversion if the method of diversion is unreasonable pursuant to Article X, section 2 of the California Constitution. This authority could be used to limit groundwater pumping to keep water levels above the threshold levels where subsidence begins. Counties could use their police power to limit groundwater pumping.
2. Land retirement to reduce demand. This measure may improve the agricultural drainage problems on the west side of the San Joaquin Valley. Retirement of 43,000 acres in the Grasslands, Westlands and Tulare subareas already has been recommended by the San Joaquin Valley Drainage Program as a management option for agricultural drainage.
3. Conservation through a change in cropping patterns to reduce consumptive use.
4. Water Transfers. Alternate surface water supplies could be secured through water transfers.

b. Groundwater Overdraft. Groundwater overdraft is defined by the DWR as the condition of a groundwater basin where the amount of water extracted exceeds the amount of groundwater recharging the basin “over a period of time” (DWR 1980). To quantify overdraft, the period of time must be long enough to produce a record that can be used to approximate the long-term average hydrologic conditions in the basin. In the California Water Plan Update (DWR 1994), the DWR estimated the amount of groundwater overdraft in the Central Valley. In the Sacramento River Basin, groundwater overdraft is reported in Sacramento County at a level of 33 TAF. Groundwater overdraft in the San Joaquin River Basin is estimated to be 224 TAF and in the Tulare Basin is estimated to be 630 TAF. All quantities were calculated at the 1990 development level. Table VI-68 shows the overdraft quantities in the Central Valley by basins or counties.

Because groundwater is used to replace much of the shortfall in surface water supplies, water delivery reductions resulting from the flow alternatives would increase groundwater overdraft in the Central Valley by increasing groundwater pumping and eliminating surface water imports as a source of recharge. Water delivery reductions for the major suppliers resulting from the seven flow alternatives are reported in Table VI-69. For this evaluation of groundwater overdraft, the quantities shown in Table VI-69 are assumed to be the increases in groundwater pumping that will result from the different alternatives.

Table VI-68
Average Annual Groundwater Overdraft in the Central Valley at the1990 Level of Development

Basin	Overdraft (TAF)
Sacramento River Basin	
Sacramento County	33
San Joaquin River Basin	
Sacramento County	19
San Joaquin County	70
Modesto Basin	15
Turlock Basin	18
Merced Basin	28
Chowchilla Basin	13
Madera Basin	45
Delta-Mendota Basin	16
Tulare Basin	
Westside Basin	30
Pleasant Valley Basin	30
Kings Basin	245
Tulare Lake Basin	85
Kaweah Basin	45
Tule Basin	65
Kern County Basin	130

Data from DWR 1994a.

Sacramento River Basin. The Sacramento County area is the only area in the Sacramento River Basin with a groundwater overdraft problem. The DWR expects the amount of overdraft to more than double in Sacramento County and neighboring Placer and El Dorado Counties by 2020 (Bulletin 160-98, v. 1, p. 3-51). The Sacramento County area meets most of its need for agricultural and urban water with groundwater. Significant surface water delivery reductions are not expected in this area as a result of implementing the flow objectives, thus, the overdraft problem should not be affected by implementation of the objectives.

San Joaquin River Basin. Average annual overdraft in the San Joaquin River Basin is estimated at 224 TAF (DWR 1994a). Average annual reductions in surface water delivery in the basin vary from 50 TAF to 163 TAF under the alternatives. Thus, depending on the alternative implemented, groundwater overdraft in the San Joaquin River Basin could increase between 22 and 73 percent causing a significant impact to the overdraft problem. On a local level, different areas in the San Joaquin Valley are impacted by different alternatives. The following discussion deals with the local basins of the valley listed in Table VI-68 and shown in Figure VI-79.

Table VI-69
Average Annual Surface Water Delivery Changes in Overdrafted Areas of the Central Valley for the 73-Year Period (TAF)

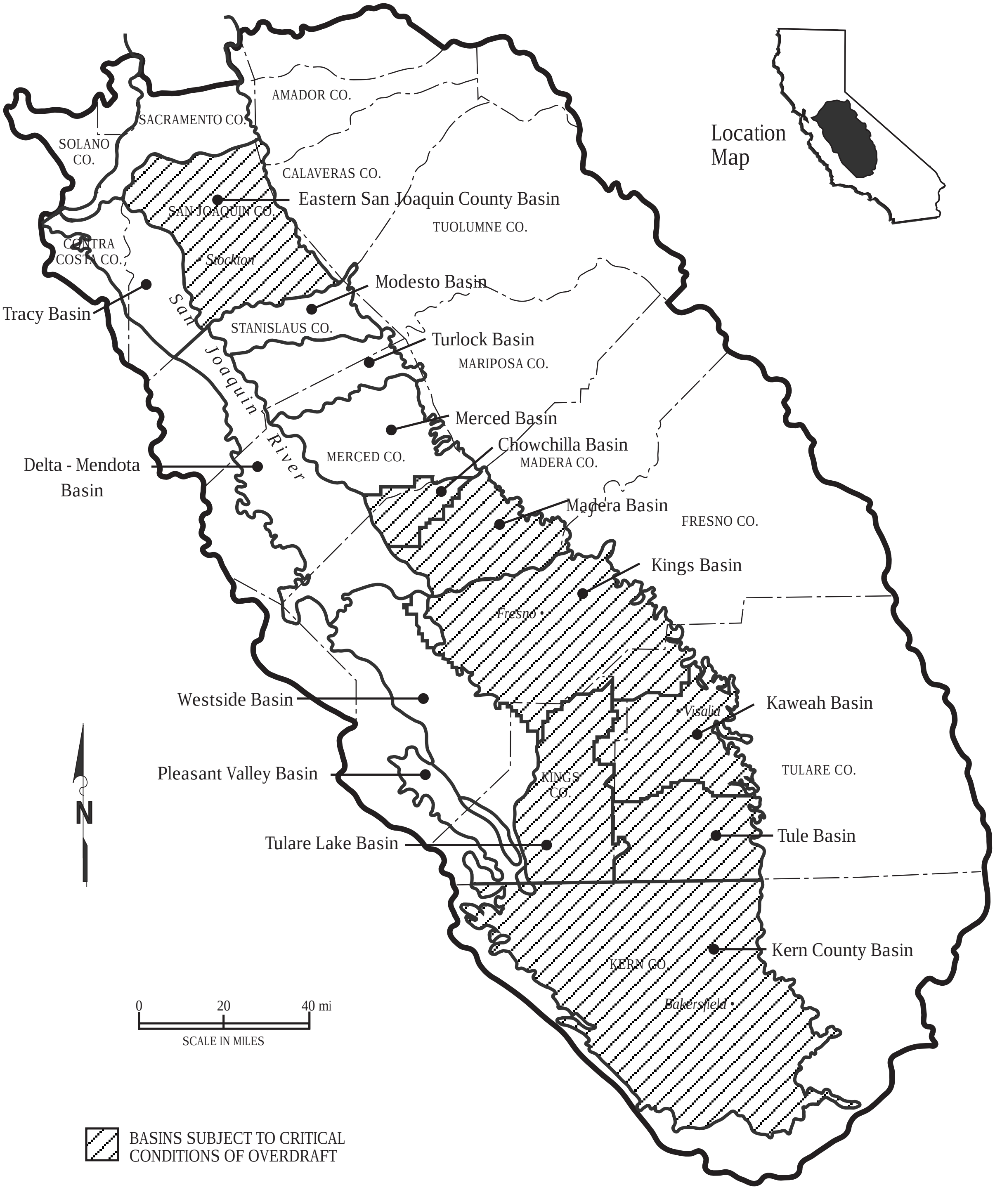
	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
San Joaquin River Basin							
Stockton East WD/ Central San Joaquin WCD (CVP)	-37	-22	-24	-9	-4	-84	-47
Modesto ID/Turlock ID	0	0	0	-6	0	0	0
Merced ID	0	0	0	0	0	0	0
Eastman Lake (Chowchilla WD)	0	-14	-13	-10	0	0	0
Hensley Lake (Madera ID)	0	0	0	-7	0	0	0
Exchange Contractors (CVP)	-20	-15	-16	-7	-21	-24	-18
Other CVP and DMC Ag Diversions	-44	-39	-39	-32	-25	-49	-55
San Joaquin River System Direct Diversions	0	-73	-65	0	0	0	0
Total	-101	-163	-157	-71	-50	-157	-120
Tulare Basin							
Tulare Basin (SWP)	-45	-36	-36	-5	-44	-53	-45
San Luis Unit (CVP)	-98	-86	-86	-71	-55	-107	-125
Friant Project (CVP)	0	0	0	-423	0	0	0
Total	-143	-122	-122	-499	-99	-160	-170

In the San Joaquin County area, delivery reductions occur under each of the seven alternatives for both the 73-year and critical periods. Assuming that groundwater pumping will replace this source of supply, the flow alternatives will increase overdraft in San Joaquin County by amounts varying from six percent under Alternative 6 to 120 percent under Alternative 7. The most serious problem associated with the overdraft in San Joaquin County is the deterioration of groundwater quality from saline water drawn into the basin. This problem is discussed in section c. below.

With the exception of San Joaquin County, the other overdrafted basins in the San Joaquin River Valley are in areas that use very little surface water. The areas that incur the surface delivery reductions are generally adjacent to the overdrafted areas and function as recharge areas to the overdrafted basins. Lowering groundwater levels in these recharge areas will have the negative effect of decreasing the rate at which groundwater migrates into and recharges the overdrafted basins. Assuming that all surface water delivery reductions are made up through groundwater pumping, each of the seven alternatives will increase groundwater overdraft in the San Joaquin River Valley.

The Modesto Basin lies between the Stanislaus and Tuolumne Rivers, from the San Joaquin River on the west to the Sierra Nevada foothills on the east. The Turlock Basin lies between the Tuolumne and Merced Rivers and is bounded on the west by the San Joaquin River and on the east by the Sierra Nevada foothills (DWR 1980). The Modesto ID and Turlock ID together incur average annual surface water delivery reductions in the amount of 6 TAF under Alternative 5 for the 73-year period, about 13 percent of the annual average overdraft. Reductions under the other alternatives are zero. If this amount is made up through groundwater pumping, declining water levels could impact recharge and worsen overdraft in the Modesto and Turlock groundwater basins.

Figure VI-79
Groundwater Basins in the San Joaquin Valley



▨ BASINS SUBJECT TO CRITICAL CONDITIONS OF OVERDRAFT

The Merced Basin includes lands south of the Merced River between the San Joaquin River on the west and the Sierra Nevada foothills on the east (DWR 1980). No surface water delivery reductions were identified for the Merced Irrigation District, thus, the alternatives are not expected to impact groundwater overdraft in this basin.

The Chowchilla Basin includes lands in Madera and Merced Counties and is bounded on the west by the San Joaquin River (DWR 1980). The Chowchilla Basin is impacted under Alternatives 3, 4, and 5 due to delivery reductions from Eastman Lake and the Friant project. Implementation of Alternatives 3 and 4 potentially could double the existing overdraft of 13 TAF. Under Alternative 5, overdraft could increase by over 75 percent. Additional surface water reductions to the Chowchilla Irrigation District from the Friant Project will add to the overdraft impact of Alternative 5. The Chowchilla Irrigation District is a CVP contractor and has the option of purchasing replacement water, if available, from the CVP rather than pumping groundwater. If replacement water is not available from the CVP, Alternatives 3, 4, and 5 will have a significant effect on groundwater overdraft in the Chowchilla Basin.

The Madera Basin consists of lands overlying the alluvium in Madera County (DWR 1980). Delivery reductions under Alternative 5 from Lake Hensley and the Friant project will impact groundwater overdraft in the Madera Basin. Average annual reductions for Lake Hensley average 7 TAF, approximately 16 percent of the annual overdraft of 45 TAF. With the additional reductions to the Madera Irrigation District from the Friant Project, Alternative 5 most likely will have a significant impact on groundwater overdraft in the Madera Basin.

The Delta-Mendota basin lies for the most part west of the San Joaquin River and south of the Stanislaus County line. Its southern boundary is generally the northern boundary of Westlands Water District in Fresno County (DWR 1980). Annual overdraft in this basin is 16 TAF. Surface water delivery reductions for this area include those to the Exchange Contractors and Delta Mendota agricultural diversions. These reductions are incurred under all six flow alternatives and range from a low of 39 TAF under Alternative 5 to a high of 73 TAF under Alternatives 7 and 8. These reductions are equal to 244 percent to 456 percent of the annual overdraft and would probably have a severe impact on groundwater overdraft in this basin.

Under Alternatives 3 and 4, surface water delivery reductions are incurred throughout the San Joaquin River system by water rights holders with direct diversion rights. These reductions could result in additional groundwater pumping in the amount of 87 TAF under Alternative 3, or 78 TAF under Alternative 4. The party incurring most of the delivery reductions, the West Stanislaus Irrigation District, is a CVP contractor. The district has the option of contracting with the CVP for replacement water rather than pumping groundwater if water is available from that source. If CVP water is not available, then Alternative 3 and 4 would have a significant impact on overdraft in the San Joaquin River Valley.

The existing groundwater overdraft problem in the San Joaquin River Basin will be significantly impacted by implementation of any of the six flow alternatives. Alternative 6 has the least impact because this alternative allows for use of combined SWP and CVP points of diversion which reduces the water supply impact to the area.

Tulare Basin. Average annual overdraft in the Tulare Basin is estimated at 630 TAF (DWR 1994a). Average annual surface water delivery reductions in the basin vary from 99 TAF to 499 TAF under the alternatives. Thus, depending on the alternative implemented, groundwater overdraft in the Tulare Basin could increase between 16 and 79 percent causing a significant impact to the overdraft problem. On a local level, different areas in the Tulure Basin are impacted by different alternatives. The following discussion deals with the local basins listed in Table VI-68 and shown in Figure VI-79.

The Westside Basin and Pleasant Valley Basin are located within the CVP San Luis Unit in western Fresno and northwestern Kings Counties. The combined average annual overdraft in these two basins is 60 TAF. Surface water delivery reductions occur under all seven flow alternatives and range from an annual average of 55 TAF to 125 TAF. These reductions are equal to 92 to 208 percent of the annual overdraft. Implementation of any of the flow alternatives is likely to have a significant impact on overdraft in the Westside and Pleasant Valley basins.

The Kings, Tulare Lake, Kaweah, Tule and Kern County basins comprise the rest of the Tulare Basin and are served by the CVP Friant Project and SWP Tulare Basin Unit. The CVP Friant Project generally serves the east side of the Tulare Basin although some water is delivered from this project to the San Joaquin River Basin. The SWP Tulare Basin Unit generally serves the central and southern parts of the Tulare Basin. In 1980, the DWR designated each of these five groundwater basins as subject to critical conditions of overdraft because of declining water levels and land subsidence (DWR 1980). Average annual overdraft in these basins is estimated to be 570 TAF although 43 percent of this overdraft is in the Kings Basin. Surface water delivery reductions occur under all seven flow alternatives, however, reductions are significantly higher under Alternative 5 because this is the only alternative that results in delivery reductions from the Friant Project. Annual average delivery reductions range from 36 to 428 TAF for these basins. These reductions equal 6 to 75 percent of the annual overdraft and would have significant impacts on groundwater overdraft in these basins. Groundwater overdraft impacts would be highest under Alternative 5.

Groundwater Overdraft Mitigation. Mitigation measures for groundwater overdraft impacts include:

1. Local agencies could adopt and implement local groundwater management plans in accordance with Water Code section 10750 et seq. or other authority. Section 10750 et seq. provides authority and procedures for certain local agencies to produce and implement groundwater management plans. Coordination between agencies in the same basin is encouraged.

2. Establish a groundwater management agency by statute. The Legislature has enacted several specific statutes establishing local groundwater management agencies that can

enact ordinances to regulate the amount of groundwater that is extracted and limit its place of use within the district's boundaries.

3. Develop conjunctive use programs. A conjunctive use program involves constructing facilities to enable the use of surface water supplies during wet years and groundwater supplies during drought years. Additionally, surplus surface water can be stored underground for extraction and use during droughts.

4. Conservation of water supplies by planting crops with lower consumptive use requirement and by providing financial incentives for crop rotation programs to the farming community.

5. Water transfers. Alternate surface water supplies could be secured through water transfers.

c. Groundwater Quality Deterioration. Groundwater quality deterioration reduces the usable groundwater storage in basins and thus, the available supply. Groundwater overdraft can lead to water quality deterioration because it produces a gradient that induces movement of water from adjacent areas. If the adjacent areas contain poor quality water, degradation of groundwater in the basin can occur. Usable storage lost to groundwater quality deterioration was included in DWR's estimate of overdraft in the San Joaquin Valley (DWR 1994).

Overdraft in San Joaquin County area has caused the migration of saline water from the Delta sediments eastward near the City of Stockton. The DWR estimated annual overdraft to be 70 TAF at the 1990 demand level (1994). Wells have been abandoned and replacement supplies have come from new wells drilled farther east, and from the Calaveras River through the Stockton-East Water District Aqueduct. Alternate water supplies are needed to stop the degradation of water quality in the aquifer (DWR 1980). A reduction in CVP deliveries in San Joaquin County could cause a significant increase in the groundwater overdraft and an increase in the deterioration of groundwater quality in the underlying aquifer. This problem is especially serious because it threatens a municipal water supply.

Another groundwater quality problem area in the San Joaquin Valley occurs in the valley trough between Merced County and Kern County where a pumping induced west-to-east gradient is causing the migration of poor quality water into the valley trough. This problem affects both agricultural and municipal beneficial uses of groundwater. Water with total dissolved solids of 2,000 to 7,000 milligrams per liter is displacing water with total dissolved solids of 300 to 700 milligrams per liter (DWR 1994). Groundwater overdraft in the Merced, Chowchilla, and Madera Basins is causing the west-to-east gradient. According to the San Joaquin River Exchange Contractors' comment on page 292 of Volume 3 of the FEIR, a well-developed cone of depression and overdrafting in the Raisin City area also contributes to this problem. This problem could worsen significantly under Alternatives 3, 4, and 5 because of the magnitude of the surface water delivery reductions incurred in the Chowchilla and Madera Basins. The other alternatives would have no impact because they do not cause surface water delivery reductions in these two basins.

Mitigation for this impact includes those mitigations for groundwater overdraft listed in section b. In addition to these actions, the SWRCB has authority under Article X, section 2 of the California Constitution to limit groundwater pumping if the method of diversion is unreasonable. Further, the SWRCB has authority under Water Code sections 2100 and 2101 to file an action in Superior Court to restrict pumping, impose physical solutions, or both, to prevent the destruction of or irreparable injury to the quality of groundwater.

d. Decreased Agricultural Productivity. Scientists generally believe that plant growth is inhibited as plants expend more energy under high salt conditions to acquire water from the soil and to make biochemical adjustments necessary to survive (SWC 1992). Reduced surface water supplies may contribute to problems of salt buildup in agricultural soils because substitute groundwater supplies have higher salinity levels than imported surface water. This problem is most likely to occur in the San Joaquin River Valley west of the San Joaquin River where groundwater quality generally ranges from 500 to more than 1500 milligrams per liter in totals dissolved solids concentrations (USBR 1997f).

Vegetables, fruits, and nuts are sensitive to salt damage; grains, cotton, and sugar beets are more tolerant. Water with less than 2,000 parts per million total dissolved solids can be used to irrigate most salt-tolerant cops with limited reduction in yields.

Mitigation measures for this impact include:

1. Blending groundwater supplies with surface water supplies to reduce the salinity of applied irrigation water.

2. Crop shifting to grow more salt tolerant crops.

3. Water transfers to secure alternate surface water supplies.

4. Conservation of water supplies through planting higher value crops requiring less consumptive use and through higher irrigation efficiencies.

D. EXPORT AREAS

The export areas include all areas receiving water through the Delta-Mendota Canal, the California Aqueduct, the Contra Costa Canal, the North Bay Aqueduct, the South Bay Aqueduct, the Mokelumne Aqueduct, and the Hetch Hetchy Aqueduct. The following discussion of export area impacts is divided into two sections: (1) SWP and CVP export service area and (2) the EBMUD service area. The area served by the Hetch Hetchy Aqueduct is not discussed in this section because implementation of the alternatives should not affect deliveries to this area.

1. SWP and CVP Export Service Area

A summary of the delivery reductions expected to occur in the export areas served by the SWP and the CVP due to implementation of one of the alternatives is provided in Table VI-70. The allocation of these impacts between the SWP and the CVP is uncertain because the alternatives as formulated do not address this issue, and the SWP and the CVP have not developed an up-to-date operating agreement.

Table VI-70
Summary of Average Annual Export Service Area Delivery Reductions for the SWP and CVP (TAF)

	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
73-year period	-296	-256	-257	-155	-229	-333	-337
Critical period	-768	-643	-643	-213	-778	-770	-727

The relative magnitude of the environmental impacts of the alternatives in the export areas is a function of the delivery reductions - the larger the delivery reduction caused by an alternative the greater the environmental effects in the export areas. Based on this characterization, over the 73-year period, Alternative 5 has the least effects in the export areas followed by Alternative 6. Alternatives 3 and 4 are indistinguishable, and Alternatives 2, 7, and 8 entail the greatest delivery reductions among the alternatives in the export areas.

The ER, Appendix 1 to the 1995 Bay/Delta Plan, describes the environmental effects of implementing the plan in the export areas served by the SWP and the CVP. That analysis assumes that the SWP and the CVP are solely responsible for meeting the plan objectives. The delivery reductions in the SWP and the CVP export areas caused by implementation of the alternatives identified in this report are less than or similar to the delivery reductions in the SWP and the CVP export areas identified in the ER. Therefore, the description of the environmental effects of implementation of the alternatives in the export areas served by the SWP and the CVP are not repeated here. However, the significant environmental effects that may occur due to delivery reductions in these areas, as described in the ER, are summarized below.

a. Groundwater. The previous section of this report provides a detailed description of impacts to groundwater in the Sacramento and San Joaquin valleys, excluding the Friant Service Area. This summary is applicable to the entire export area. These two areas overlap.

The reduction in surface water deliveries caused by implementation of the plan could cause increased pumping of groundwater because many water users will replace their reduced surface water supplies with groundwater. Groundwater pumping does not require prior authorization in much of California. Consequently, water users in most export areas can drill new wells or increase the capacity of existing wells without needing government authorization. They could, however, be subject to challenges either in court or before the SWRCB if their diversion and use of groundwater adversely affected other water uses or environmental values. The significant environmental effects that could occur due to substitution of groundwater for surface water are: depletion of groundwater resources, permanent loss of aquifer capacity, surface land subsidence, sea water intrusion, water quality degradation, decreased agricultural productivity, and increased energy consumption.

This draft EIR assumes that reductions in surface water supplies will be replaced by groundwater.

b. **Land Use Changes**. Land use changes that will occur as a result of the implementation of the Bay/Delta Plan are uncertain because such changes are the result of numerous decisions by individuals, water districts, and governmental agencies. However, the most likely land use changes are crop shifts and land fallowing.

c. **Wildlife Habitat**. Exports from the Delta support wildlife habitat both through planned deliveries to wildlife refuges and through incidental benefits associated with the transport, use, and discharge of the water. Table V-1, which provides a detailed description of the delivery reductions, indicates that wildlife refuge deliveries are largely unaffected by the alternatives; however, incidental benefits will be significantly affected.

d. **Urban Landscape**. The State Water Contractors identified the following uses and beneficial effects of urban landscapes (SWC 1992): aesthetics and scenic design; embellishment of private dwellings and surroundings; creation of private domestic space; community involvement activities, as in community gardens; public amenities such as public parks, greenways, and scenic reservations; wildlife habitat; reduction in use of fossil fuels for air conditioning with a concomitant reduction in production of associated air pollutants; reduction of water pollution in wetlands; and resistance to erosion, especially in areas with steep slopes, unstable soils, and variable rainfall.

In the long-term, reduced water deliveries are likely to result in locally mandated, more efficient management of water resources. Most of the elements of such management are contained within the Memorandum of Understanding Regarding Urban Water Conservation in California. Most of the urban water exported from the Delta is delivered by agencies that have signed the MOU.

e. **Recreation**. Recreational facilities that receive water from Delta exports could be affected by the delivery reductions. The San Luis Reservoir is the export facility most vulnerable to recreational impacts caused by export reductions.

f. **Water Reclamation**. Most uses of reclaimed water can be served when the TDS is no greater than 800 mg/l. Normal urban water use generally adds about 300 mg/l TDS to the potable water supply. Therefore, to achieve an acceptable TDS level of 800 mg/l in reclaimed water, which will allow for a full range of beneficial uses that could be served with reclaimed water, a source low in TDS (no more that 500 mg/l) is needed. For the urban areas of Southern California, where most water reclamation efforts in the State are taking place, this means that a reliable source of imported water that is low in TDS is required. Loss of high quality exports from the Delta could be replaced in some years with imported Colorado River water, which typically has TDS levels of 600-750 mg/l. Replacement of imported Delta water with imported Colorado River water could retard water reclamation efforts.

Export area delivery reductions could also have positive effects. Reduced deliveries to the San Joaquin Basin will reduce the salt loading to the river. Additional groundwater pumping can be a beneficial effect in some problem drainage areas by lowering or stabilizing the water table.

g. Growth Inducing Effects. Implementation of any of the flow alternatives will reduce water deliveries throughout the SWP and CVP export service areas (see Chapter V). To the extent that historic patterns indicate future trends, reduced surface water availability is unlikely to affect growth in urban areas. Water is one of many factors influencing growth in a region but does not, by itself, cause the growth of a region (DWR 1996). Water shortages have rarely done more than slow the progress of adequately financed development proposals. Reductions in municipal and industrial supplies have typically been replaced through groundwater, reclamation, more intensive management, and price-induced conservation. Thus, implementation of any of the flow alternatives is not expected to affect growth.

h. Mitigation. There are several methods available to water districts in export areas to minimize the effects of reduced water supplies. These methods are described in section B. of chapter XII.

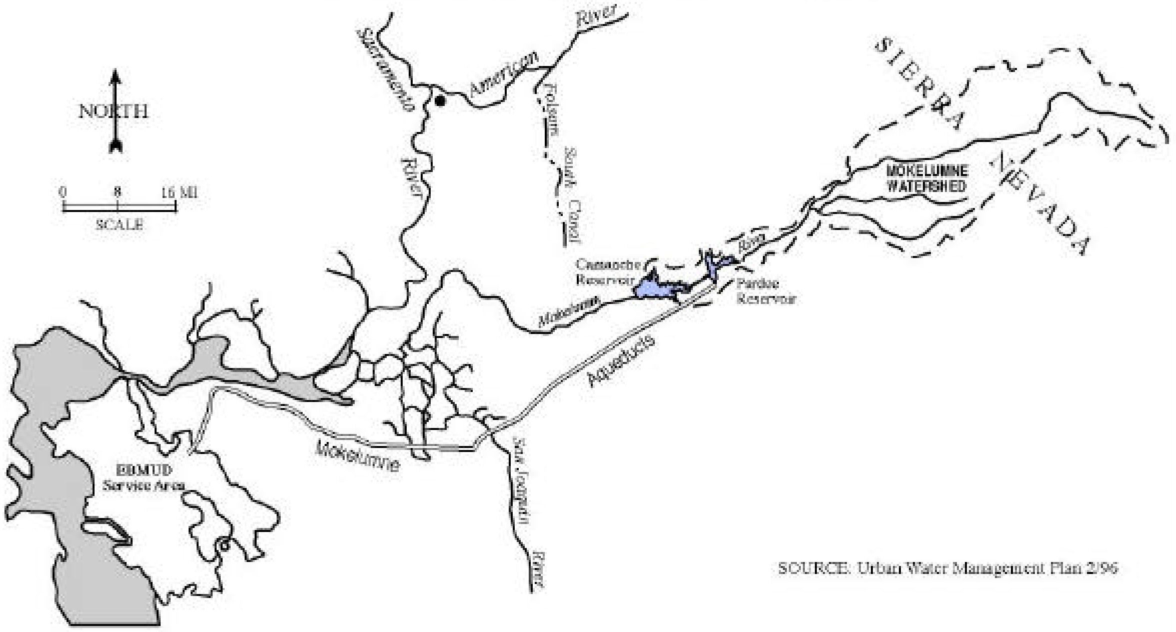
2. EBMUD Service Area

EBMUD supplies water originating principally from the Mokelumne River watershed to customers in 20 cities and 15 unincorporated communities in parts of Alameda and Contra Costa counties. Approximately 1.2 million people are served in a 325 square mile area extending from Crockett in the north southward to San Lorenzo encompassing the major cities of Oakland, Berkeley and Richmond, and eastward from San Francisco Bay to Walnut Creek, Danville and San Ramon. A map of the Mokelumne River watershed, the Mokelumne Aqueduct, and the EBMUD service area is provided in Figure VI-80.

The following discussion is divided into three sections: (a) summary of customer deficiencies, (b) EBMUD's response to increased flow requirements, and (c) effects in the EBMUD service area.

a. Summary of Customer Deficiencies. EBMUD used an operations model, EBMUDSIM, to assess impacts to its customers as the result of implementing the flow alternatives. The model was used to project customer deficiencies caused by implementation of the base case (Alternative 1) and Alternatives 3, 4, and 5 at current (1995) levels of development (EBMUD 1997b). For the purpose of this study, customer deficiencies occur when EBMUD deliveries are less than 248,640 acre-feet per year. The customer deficiencies for Alternatives 2, 6, 7, and 8 are assumed to be the same as those for Alternative 1 because these alternatives do not require additional releases from EBMUD reservoirs. A summary of the results of the model studies is provided in Table VI-71. The table identifies the number of years that deficiencies would occur during the 75-year hydrologic simulation.

Figure VI - 80
EBMUD Water Supply and Service Area



SOURCE: Urban Water Management Plan 2/96

Table VI-71
EBMUD Customer Deficiencies*

	Total Number of Deficiencies	15 Percent or Greater Deficiencies	25 Percent or Greater Deficiencies
1961 Agreement	15	7	2
Alternative 1 (Base)	25	12	2
Alternative 3	30	14	7
Alternative 4	30	14	8
Alternative 5	42	25	18

* Number of years that deficiencies occur during the 75-year hydrologic simulation.

For reference purposes, the table also lists the deficiencies under the 1961 agreement between EBMUD and DFG. EBMUD's current requirements to release water from Camanche Reservoir for fishery purposes are set forth in the 1961 agreement. EBMUD entered into the 1961 agreement to comply with permit terms contained in EBMUD's water right (Permit No. 10478) granted to EBMUD by the SWRCB's predecessor agency in 1956. The 1961 agreement provides that 13 TAF of water above releases for all other purposes must be released from Camanche Reservoir annually for fishery purposes. The 1961 agreement is not used as the base case flow requirements on the Mokelumne River in this report because

EBMUD is currently operating to meet the flows in the 1997 Joint Settlement Agreement. Thus, the 1997 agreement is used as the base case.

The 1997 Joint Settlement Agreement initiated by EBMUD, USFWS, and DFG sets forth flow and non-flow measures to protect the fishery resources of the lower Mokelumne River. The agreement was developed as a settlement of the proceedings before the Federal Energy Regulatory Commission to review EBMUD's fish flow release requirements from Camanche Reservoir. The flow requirements under the 1997 agreement constitute an increase from the 1961 agreement requirements. In 1996, an SWP and CVP export group signed a Memorandum of Understanding stipulating that the export group agreed that the flow requirements in the 1997 agreement are sufficient to meet EBMUD's responsibility for the objectives in the SWRCB's 1995 Bay/Delta Plan. This agreement was initiated as is being implemented through the FERC licensing process; therefore, the effects of the agreement are not discussed in this document.

The table shows that the deficiencies are lowest in the base case, excluding the 1961 agreement deficiencies which are provided only for information. Alternatives 3 and 4 have very similar deficiencies and the deficiencies under Alternative 5 are significantly higher. EBMUD considers deficiencies between 15 and 25 percent to be severe. Deficiencies in this range may warrant a declaration of a water short emergency and institution of mandatory water use reductions. EBMUD considers deficiencies of 25 percent or more to be critical (EBMUD 1996).

The model studies also show that carryover storage levels in EBMUD's reservoirs would be more severely depleted during droughts under the Alternatives 3, 4, and 5 than they would be under Alternative 1. Decreased carryover storage during drought periods indicates increased risk of severe water shortages. Combined storage levels in Pardee and Camanche reservoirs during the modeled 1985 through 1993 hydrologic period under Alternatives 3 and 4 showed depletions of as much as 160 TAF. Under Alternative 5, storage levels would be almost completely depleted during drought events. Under this alternative, storage levels during the modeled 1985 through 1993 hydrologic period decline to near dead storage amounts in mid-1988, the second year of the 1987-92 drought, and stay near that level throughout the remainder of the drought period. In addition, the model shows that in 1991, EBMUD's customers would have received only approximately 10 percent of their normal year water supply. This model result indicates that water supply may not be reliably maintained under Alternative 5.

b. **<u>EBMUD's Response to Increased Flow Requirements (Mitigation)</u>**. EBMUD will respond to water supply reductions by seeking new sources of water. Reasonable options available to EBMUD are contained in the 1993 programmatic EIR for its updated Water Supply Management Program (EBMUD 1993). The EIR describes the following five measures, which are summarized below: (1) conservation, (2) reclamation, (3) groundwater storage/conjunctive use, (4) additional reservoir storage, and (5) supplemental supply. The programmatic level analysis of the impacts of these measures is contained in the 1993 EIR.

Conservation. EBMUD currently manages a conservation program that includes education, incentives, regulation, and ongoing studies. Conservation savings are achieved primarily by introducing water-saving hardware and by persuading customers to use water more efficiently. Long-term changes that could achieve additional water savings for EBMUD customers include the installation of ultra-low-flush toilets, low-flow showerheads and faucets, water-efficient appliances, efficient outdoor irrigation systems, and enhanced commercial and industrial water audits. Alternative conservation programs studied include inspections to assure that water-saving hardware will remain in use by customers, rebates, mandatory landscaping measures, and programs that foster public awareness of water use. Depending on the level of effort expended on conservation measures, annual water savings in the year 2020 are estimated to range from 7.8 to 39.2 TAF above the savings from existing and adopted conservation programs.

Reclamation. The use of recycled water for selected exterior irrigation and industrial processes is an ongoing EBMUD practice. A number of reclamation programs have already been implemented by EBMUD, and additional reclamation opportunities have been identified. The alternatives analysis for the updated Water Supply Management Program examined a broad range of techniques including expanding the existing use of non-potable water by major irrigators (golf courses and parks), exporting treated wastewater to the Bay/Delta Estuary for salinity control, and pursuing advanced treatment technology for potable use of recycled water. The most feasible alternatives identified through this process include additional reclamation projects that provide non-potable water for irrigation and industrial uses. In the year 2020, these projects could save EBMUD between 9 and 32.5 TAF above the savings already realized from existing and adopted reclamation programs.

Groundwater Storage/Conjunctive Use Component. The concept of groundwater storage/conjunctive use is to store surface water in the ground in years when water is available and to use this stored groundwater in conjunction with or in lieu of surface water supplies in dry years. Potential basins with the ability to provide storage were examined and the best opportunities were found to exist in San Joaquin County near Lodi. A broad range of recharge methods and alternative withdrawal scenarios were evaluated.

Reservoir Storage. Alternative surface storage opportunities were examined at a number of locations throughout the Bay Area and the Sierra foothills. The alternatives included the development of new reservoirs, the expansion of existing reservoirs, and cooperative efforts with other agencies for the development of reservoirs. Three reservoir alternatives, Buckhorn Reservoir, Los Vaqueros Reservoir, and the raising of Pardee Dam to expand Pardee Reservoir, were studied in detail and the latter alternative was perceived to be feasible. The project would raise Pardee Dam by 57 feet, thereby increasing the capacity of the reservoir by 150 TAF.

Supplemental Supply. Several sources of additional water for use by EBMUD customers were evaluated in the 1993 programmatic EIR. Two alternatives appeared feasible and were studied in detail: (1) diversions from the Delta and (2) construction of a pipeline to allow EBMUD to utilize its existing American River contract with the USBR.

The EBMUD and the USBR issued a DEIR/EIS on the Supplemental Water Supply Project in November 1997, which addresses two primary project alternatives, both involving American River diversions. The first alternative is an EBMUD-only project that involves deliveries from the American River near Nimbus Dam, via the Folsom South Canal to a new pipeline connection between the FSC in southern Sacramento County and EBMUD's Mokelumne Aqueducts in San Joaquin County. The second alternative is a joint project between EBMUD, the City of Sacramento, and the County of Sacramento. Under this alternative, water would be diverted from the lower American River near the confluence with the Sacramento River and conveyed to the City's water treatment plant. Water for EBMUD would then be conveyed through new pipelines from the treatment plant to the FSC and from the FSC to the Mokelumne Aqueducts.

c. **<u>Effects of Reduced Water Supply</u>**. The effects of reduced water supply in the EBMUD service area are described in the 1993 EIR. The effects include shortages for EBMUD customers, significant public health and safety risks, and adverse socioeconomic consequences.

EBMUD claims that its customer demand at the 1995 level of development is approximately 249 TAF per year. This demand is estimated by EBMUD to increase to 362 TAF by the year 2020. Shortages under the alternatives at the 1995 level of development are described above, and these shortages will increase at the 2020 level of development. EBMUD is required to serve customers within its service area with a water supply that is reliable and of sufficient quantity and quality. EBMUD intends to augment its water supply under the base case. More aggressive augmentation measures will be required if Alternatives 3, 4, or 5 are adopted.

<u>Public Health and Safety</u>. Average reservoir levels under Alternatives 3, 4, or 5 would probably decline in comparison to the base case. Water quality typically declines as reservoir levels drop significantly. Therefore, the quality of drinking water supplied to customers could be compromised as the water would be drawn from reservoirs with lower water levels.

At the very low delivery levels modeled under Alternative 5, public health could be severely compromised as water deliveries are curtailed to the EBMUD service area. Sanitation and firefighting capabilities could be affected.

<u>Socioeconomic Effects</u>. EBMUD would likely have to impose a new service connection moratorium or significant amounts of rationing in response to projected shortages under all the alternatives unless new water supplies can be secured. These actions would have a significant, negative effect on the economy and the quality of life in and around the EBMUD service area. Depending on the measures implemented and the ability of individual firms to respond, some local businesses would suffer, especially water intensive businesses such as food processing, car washes, laundromats, and electronics firms. Employment opportunities in the service area could decrease, and total personal income might also decline. Property values could be adversely affected, which could adversely affect the services local government could afford to provide.

E. FRIANT SERVICE AREA

The Friant Unit of the CVP delivers water to over one million acres of irrigatable farmland on the east side of the southern San Joaquin Valley from approximately Chowchilla on the north to the Tehachapi Mountains on the south. The principal features of the Friant Unit begin with the San Joaquin River at Millerton Reservoir (Friant Dam), located northeast of Fresno. Water is distributed from Millerton Lake to contracting irrigation and water districts and local cities through the Friant-Kern Canal to the south and through the Madera Canal to the north. A map with the principal features of the Friant Unit is provided in Figure VI-81.

Downstream riparian and pre-1914 water right holders originally held the majority of the water rights to the San Joaquin River. The USBR signed purchase and exchange agreements with these water right holders at the time the Friant Project was developed. The largest of these agreements requires annual delivery of 800 TAF of water, excluding deficiency periods, to the central San Joaquin Valley near Mendota. These deliveries are usually made with water exported from the Delta. Therefore, the Friant Unit is dependent upon other features of the CVP, including Shasta Dam, the Tracy Pumping Plant, and the Delta-Mendota Canal, to facilitate the required exchange. The following discussion is divided into two sections: (a) summary of delivery reductions, (b) effects in the Friant service area.

1. <u>Summary of Delivery Reductions</u>. Alternative 5 is the only alternative that results in direct reductions in deliveries to the Friant service area. Alternatives 3 and 4 assign a responsibility to the Friant Project to provide flows, but the water is released from New Melones Reservoir under these alternatives. A summary of the Friant service area deliveries under the alternatives and the reductions under Alternative 5 in comparison to all of the other alternatives is provided in Table VI-72.

Table VI-72
Summary of Average Friant Project Deliveries and Reductions

Alternative	73-year Period (TAF)	Critical Period (TAF)
Base Case	1,343	959
Alternative 5	920	632
Reduction	423	327

The Friant service area employs a two-class system of water allocation. Class 1 water is the firm supply amounting to the first 800 TAF of yield from the San Joaquin River and Millerton Reservoir. Class 2 water is available only after the Class 1 allotment has been fully met. Class 1 water is typically under contract to districts that serve areas with limited or no access to good quality groundwater. Class 2 water is typically under contract to those districts that have access to good quality groundwater supplies and can accept reoccurring deficiencies by using their wells as their principal source of supply. Many of the Class 2 areas also have substantial recharge capability - both natural and artificial.

Figure VI -81
Principal Features of the Friant Unit and Crop Producing Regions of the Central Valley Production Model

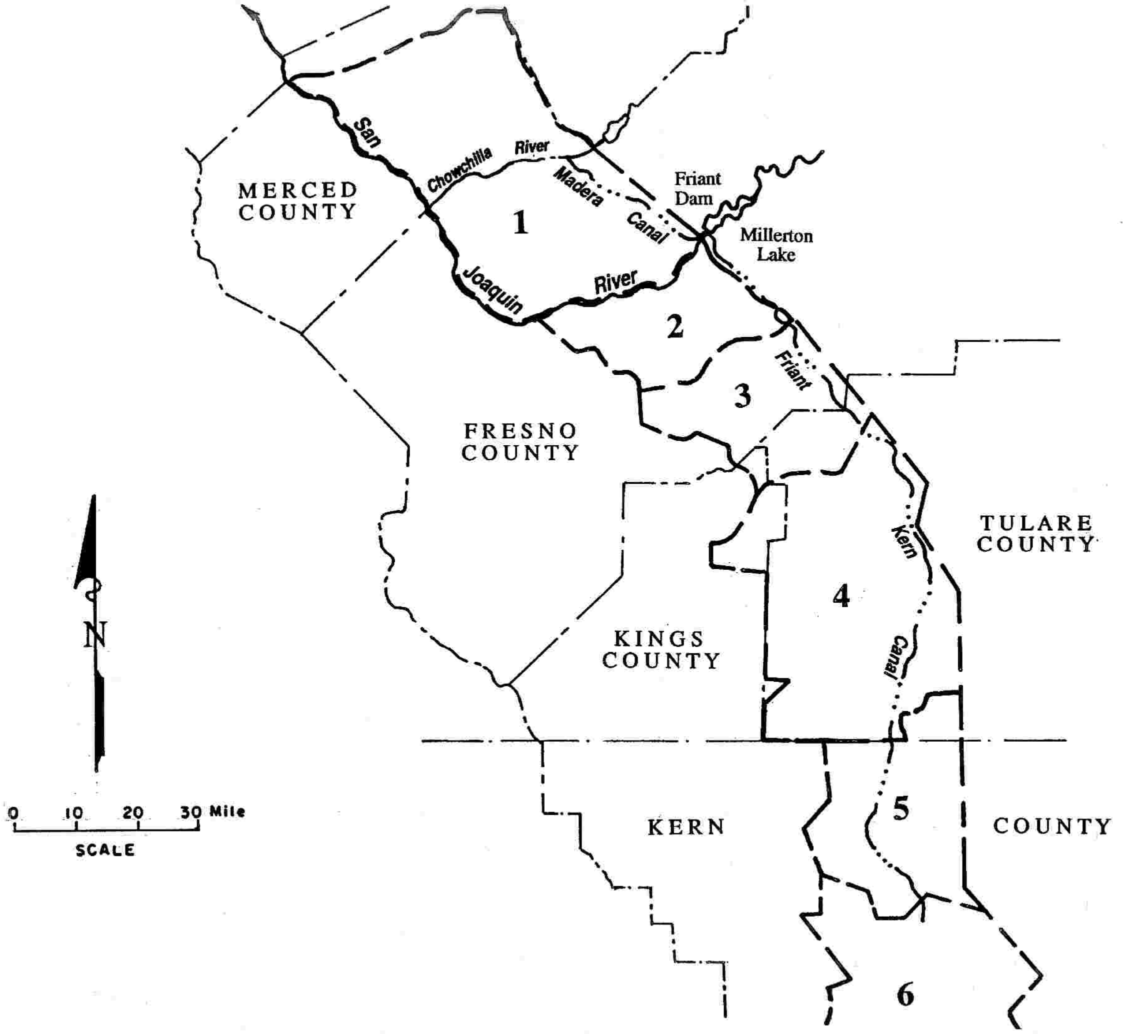


Table VI-73 lists the Friant Unit contractors and their Class 1 and Class 2 contract amounts. The reductions imposed under Alternative 5 will severely curtail the availability of Class 2 water in most years and will reduce the availability of Class 1 water in some years.

2. Effects in the Friant Service Area. Reductions in Friant Unit water deliveries, such as those possible under Alternative 5, would have serious effects in the service area. Reduced water deliveries would initially cause shifts in cropping patterns, increased costs associated with the adoption of more efficient irrigation systems, and idling of croplands. Groundwater would be used to replace a significant portion of the reduced water supplies, and over time the increased pumping would draw down an already over-drafted groundwater basin and cause subsidence. The increased costs associated with pumping from increasingly greater depths would cause more land to be removed from production. Ultimately, water quality problems associated with lower water tables and generally depleted aquifers would result in the idling of even more acreage.

Table VI-73
Friant Unit Long-Term Contractors and Contract Amounts

Contractor	Class 1 (TAF)	Class 2 (TAF)
Arvin-Edison WSD	40	312
Chowchilla WD	55	160
City of Fresno	60	0
City of Orange Cove	1.4	0
City of Lindsay	2.5	0
Delano-Earlimart ID	109	75
Exeter ID	11.5	19
Fresno Co. Water Works District No	0.2	0
Fresno ID	0	75
Garfield WD	3.5	0
Gravelly Ford WD	0	14
International WD	1.2	0
Ivanhoe ID	7.7	739
Lewis Creek WD	1.5	0
Lindmore ID	33	22
Lindsay-Strathmore ID	27.5	0
Lower Tule River ID	61.2	238
Madera County	0.2	0
Madera ID	85	186
Orange Cove ID	39.2	0
Porterville ID	16	30
Saucelito ID	21.2	32.8
Shafter-Wasco ID	50	39.6
Southern San Joaquin MUD	97	50
Stone Corral ID	10	0
Tea Pot Dome WD	7.5	0
Terra Bella ID	29	0
Tulare ID	30	141
Total	**800.3**	**1,402.30**

Groundwater traditionally has been used to buffer the effects of reduced surface water supplies during droughts. In a similar manner, groundwater pumping would temporarily buffer irrigators from the effects of the reductions caused by implementation of Alternative 5. Because of the continual pressure that would be put on groundwater supplies, in addition to that experienced during natural droughts, the groundwater basin would likely not be sufficiently recharged during wet years. Consequently, in the long-run, acreage would be removed from production not only because of reduced CVP supplies and increased pumping costs but also because of the reduced ability of the groundwater aquifer to provide a buffer against natural droughts.

The effects of a 500 TAF annual reduction in deliveries to the Friant service area were recently studied by two different groups (Brown et al 1996, FWUA 1997). This level of reduction is similar to the 73-year average annual delivery reduction that would result from adoption of Alternative 5 (423 TAF); therefore, these studies are used in this report to characterize the effects of implementation of the alternative in the Friant service area.

The results cited in this report are obtained principally from the study conducted by Northwest Economic Associates (NEA) for the Friant Water Users Authority (FWUA) (FWUA 1997). The FWUA retained NEA to review and validate a similar study completed by the University of California (UC) (Brown et al 1996) and to extend the modeled forecasts in the UC study, which were limited to a ten year period, for an additional ten years into the future. The core model used in both studies is the Central Valley Production Model (CVPM). The model is used to simulate and predict aggregate decision making by Central Valley farmers. Both the UC and the NEA groups modified the CVPM by adding a groundwater hydrology component to the model, but the assumptions for the modifications were different between the two groups.

The CVPM aggregates agricultural production in the Central Valley into 22 crop producing regions. Each region is intended to represent a group of water districts with similar growing conditions. These regions are assumed to operate as single, large farms with one decision maker. In the UC and NEA studies, the 22 regions were aggregated to ten regions, six of which are located in the Friant service area. These regions are shown in Figure VI-81. All of the regions are bounded on the east by the lower Sierra foothills. The total land area covered by the six regions is very large and includes substantial amounts of land that is not within the Friant Unit. The CVPM also simplifies the mix of crops found in the Central Valley into 26 representative crop categories. In the UC and NEA studies, these categories were further aggregated into 12 crop categories, including irrigated pasture, alfalfa, sugar beets, field crops, rice, truck crops, tomatoes, orchards, grain, grapes, cotton, and citrus.

As with all models, the CVPM is only a representation of reality, and its usefulness is limited by the assumptions around which it is built. The model results are best used to understand the general direction and implications of an action. Specific acreage and groundwater elevation effects should be interpreted cautiously.

The impacts on groundwater levels and crop acreage of a 500 TAF annual reduction in water deliveries to the Friant service area in the final year of a 20 year period are provided on Tables VI-74 and VI-75, respectively.

Table VI-74 shows that adoption of Alternative 5 could have a significant effect on groundwater levels throughout the Friant service area. The smallest effect on groundwater is seen in Region 2, which receives a comparatively small percentage of its water supply from the Friant Project. Very significant effects are seen in Regions 3 through 6. The model indicates that groundwater levels fall until they are constrained. The NEA study included assumptions regarding the levels at which the groundwater is depleted. In regions 3 through 6, groundwater levels reached the depletion point. There are sparse data regarding depth limits; however, on the east side of the San Joaquin Valley, the aquifer is thin and underlain with granite from the Sierra foothills, limiting access to groundwater to replace surface water. Even if groundwater were accessible, many farmers would need to drill deeper wells and purchase more powerful pumps. As the UC researchers report, wells drilled to depths of 800 to 1,000 feet cost roughly $85,000. The financial feasibility of individual farmers to construct and operate such wells is questionable.

Table VI-74
Impacts of a 500 TAF Reduction on
Groundwater Levels and Groundwater Costs

Region	Starting GW Level (ft)	Final GW Level (ft)	Change in GW Level (ft)	Starting GW Cost ($/AF)	Final GW Cost ($/AF)	Change in GW Cost ($/AF)
1	160.1	244.7	-84.6	$48.76	$65.23	$16.47
2	138.7	148.8	-10.1	$41.74	$46.43	$4.69
3	138.7	451.3	-312.6	$43.42	$103.03	$59.61
4	192.1	499.4	-307.3	$54.48	$114.72	$60.24
5	352.2	713.9	-361.7	$86.08	$158.29	$72.21
6	350.0	650.7	-300.7	$88.98	$148.53	$59.55

Table VI-75 shows that adoption of Alternative 5 could have a significant effect on crop acreages and land use. Region 4 is the hardest hit with over 180,000 acres being taken out of production with cotton and alfalfa accounting for the majority of this acreage. There is very little impact on Region 2 because Friant Unit water comprises a relatively small portion of its water supply and it can take advantage of slightly higher crop prices caused by reduced supplies from the other regions. In general, lower value, water intensive crops dominate the acreage being removed from production throughout the Friant service area. For the six Friant regions, slightly less than 232,000 acres of alfalfa and cotton are removed from production while approximately 28,000 acres of high value citrus and orchards are taken out of production.

While the impacts on regional economic activity and employment would be substantial for the entire region if Alternative 5 is adopted, they would be especially severe for many of the small communities. Of the roughly 373,000 acres of cropland estimated to be removed from production, 261,000 acres, or 70 percent, are in Regions 4 and 5. Consequently, the small farm communities in these regions would be most affected. Most of these towns are heavily dependent upon agriculture, and the businesses in these towns are linked to agriculture for most or all of their business - from firms supplying farm machinery, chemicals, and credit to those processing cotton, fruits, and vegetables for consumer use.

Table VI-75
Change in Crop Acreages and Percentages by Region for a 500 TAF Reduction

Crop	**Region**						**Total**
	1	**2**	**3**	**4**	**5**	**6**	
Irrigated Pasture	-4,514 -8%	-68 0.4%	-5,597 -53.2%	-6,157 -64.3%	-678 -100%	-1,235 -54.5%	-18,249 -19.2%
Alfalfa	-2,385 -3.8%	140 1.60%	-4,190 -46%	-49,814 -58.8%	-16,711 -91.5%	-19,085 -46.7%	-92,045 -41%
Sugar Beets	-79 -1%	NA	-38 -27.5	-1,183 -30.9	-528 -61.1	-608 -10.4	-2,436 -13.2%
Field Crops	-1,507 -3.1%	-36 -0.4%	-1,990 -32.8%	-23,614 -43.1%	-2,545 --71.9%	-3,541 -10.3%	-33,233 -24.4%
Rice	-350 -6%	NA	NA	NA	NA	-211 -41.9%	-561 -8.8%
Truck Crops	-4 0.1%	3 0.03%	-1,505 -24.56%	-1,530 -23.8%	-6,510 -52.1%	-420 -0.7%	-9,966 -10%
Tomato	-60 -0.8%	NA	-200 -27%	-15 -28.9%	-167 -60.3%	-221 -7.7%	-663 -5.8%
Orchard	-104 -0.1%	6 0.03%	-3,314 -5.4%	-3,713 -5.9%	-9,482 -18%	-230 -1.1%	-16,837 -5%
Grain	-520 -1.33%	-9 -0.1%	-1,733 -28.1%	-19,277 -32.9%	-4,280 -65.2%	-3,912 -19%	-29,681 -21.6%
Grapes	-12 -3.1%	160 0.2%	-6,375 -5.4%	-3,291 -6%	-7,173 -18.1%	-334 -0.9%	-17,025 -4%
Cotton	-2,159 -3.1%	7 0.1%	-3,554 -31,7%	-67,726 -40.3%	-27,231 -73.5%	-39,272 -29%	-139,935 -32.2%
Citrus	9 0.1%	11 0.1%	-1,552 -5.1%	-4,380 -5.2%	5,316 -18.4%	-41 -0.2%	-11,269 -6.1%
Total Acreage	-11,685 -2.2%	214 0.1%	-30,048 -11.5%	-180,650 -30.8%	-80,621 -40.1%	-69,110 -19.4%	-371,900 -17.6%

The impacts of a scaled-down, less viable agricultural production sector would flow quickly throughout the local and regional economy.

Mitigation. The water supply reductions under Alternative 5 can only be partially mitigated through increased conservation, conjunctive use, and groundwater management.

Literature Cited in Chapter VI

Archibald, S., T. Kuhnle, R. Marsh, M. Renwick, and B. Thompson. 1992. An Economic Analysis of Water Availability in California Central Valley Agriculture. Phase II Draft Report Prepared by Center for Economic Policy Research. Stanford University, California. District Responses and Adjustments to Water Availability.

Bagsall, M.E. and D.L. True. 1985. Archaeological Investigation in Crowder Canyon, 1973-1984: Excavations at Sites SBR-421B, SBR-421C, SBR-421-D, and SBR-713. Report on File, Caltrans, Sacramento, California.

Baxter, John L. 1960. Inshore Fishes of California. Department of Fish and Game. Sacramento, California. 80 pp.

BDOC. 1993. Draft Briefing Paper on Biological Resources of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Bay-Delta Oversight Council. May 1994. 33 pp. plus appendices.

Bean, L.J. and H.W. Lawton. 1973. Some Explanations for the Rise of Cultural Complexity in Native California with Comments on Proto-Agriculture and Agriculture. Ramona: Ballena Press Anthropological Papers. 1:i-xlvii.

Beck, R.W. 1994. Impacts of Bay-Delta Water Quality Standards on CVP Power Production. Prepared for the Western Area Power Administration.

Belitz, K., S.P. Phillips, and J.M. Gronberg. 1992. Numerical Simulation of Groundwater Flow in the Central Part of the Western San Joaquin Valley, California. U.S. Geological Survey Open-File Report 91-535. 71 pp.

Botsford, L.W., and J. Britnacher. 1994. A Model for Projection of Striped Bass Abundance in Terms of Flows and Diversions. Prepared for the Striped Bass Technical Team for the Central Valley Project Improvement Act. November 1994. 18 pp.

Brown, C., G. Goldman, R. Howitt, J. Seibert, and J. Sullins. 1996. Impacts of Water Reallocations on the Eastern San Joaquin Valley. December 31, 1996. 9 pp. plus attachments.

DFG. 1992a. A Model Explaining the Decline of Striped Bass in California's Sacramento-San Joaquin Estuary. 27 pp. plus appendices.

DFG. 1992b. Exhibit WRINT-DFG-Exhibit #6 Entered by the California Department of Fish and Game for the State Water Resources Control Board 1992 Water Quality/Water Rights Proceedings on the San Francisco Bay/Sacramento-San Joaquin Delta. 97 pp.

DFG. 1993a. Factors Controlling the Abundance of Aquatic Resources in the Sacramento-San Joaquin Estuary. Department of Fish and Game. 46 pp.

DFG. 1993b. Past Trends and Present Status of Selected Fish and Invertebrate Species of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. January. Prepared for the Bay Delta Oversight Council by the California Department of Fish and Game, Bay-Delta and Special Water Projects Division. 59 pp.

DFG. 1993c. Restoring Central Valley Streams: A Plan for Action. California Department of Fish and Game, Inland Fisheries Division. November 1993.

DFG. 1995. Assessment of California Black Bass Angling Regulations by Inland Fisheries Staff, California Department of Fish and Game, Inland Fisheries Division. August, 1995. 130 pp.

DWR. 1980. Ground Water Basins in California; A Report to the Legislature in Response to Water Code section 12924. Department of Water Resources Bulletin 118-80. 73 pp.

DWR. 1994. California Water Plan Update. Department of Water Resources Bulletin 160-93, Volumes I and II.

DWR and USBR. 1999. Biological Assessment – Effects of the Central Valley Project and State Water Project Operations from October 1998 through March 2000 on Steelhead and Spring-Run Chinook Salmon. January 1999.

EBMUD. 1993. Final Environmental Impact Report for the Updated Water Supply Management Program, Volumes I and II. September 1993.

EBMUD. 1996. Urban Water Management Plan. February 1996. p VIII-61.

EBMUD. 1997a. Letter Plus Attachments from Jon Meyer, Manager Water Resources Planning Division, to Thomas Howard. September, 17, 1997.

EBMUD. 1997b. Letter Plus Attachments from John Skinner, Senior Civil Engineer, to David LaBrie. October 7, 1997.

FWUA. 1997. Analysis of the Impacts of Surface Water Reductions on the Eastern San Joaquin Valley of California. Prepared for the Friant Water Users Authority by Northwest Economics Associates. August 26, 1997. 40 pp.

Herrgessell, Perry L. 1993. 1991 Annual Report, Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary. 37 pp.

IEP. 1996. Assessing Evidence on the Importance of Various Limiting Factors on Selected Ecological Features of the San Francisco Estuary. September 12, 1996. Report to CALFED by Members of the IEP Estuarine Ecology Project Work Team. 18 pp.

Jones and Stokes Associates and EDAW Inc. 1975. Fish and Wildlife Element Suisun Marsh Protection Plan. 412 pp.

Kimmerer, W. 1997b. Flow Effects and Density Dependence in Striped Bass. Interagency Ecological Study Program Newsletter. Vol. 10, No. 4. Autumn, 1997.

Lee, D. P. and I. Paulsen. 1989a. Water Level Fluctuation Criteria for Black Bass in California Reservoirs. Unpublished Inland Fisheries Information Leaflet. Inland Fisheries Division, California Department of Fish and Game, Rancho Cordova, CA. 8 pp.

Lee, D. P. and I. Paulsen. 1989b. Water Level Fluctuation Criteria for Selected Warmwater Gamefish in California Reservoirs. Inland Fisheries Administrative Report No. 89. Inland Fisheries Division. 38 pp.

Leidy, G. and M. Myers. 1984. Central Valley Fish and Wildlife Management Study: Fishery Management Problems at Major Central Valley Reservoirs, California. Special Report. U.S. Bureau of Reclamation, Mid-Pacific Region. Sacramento, CA.

Lenihan, D.J., T.L. Carrell, S. Fosberg, L. Murphy, S.L. Rayl, and J.A. Ware. 1981. The Final Report of the National Reservoir Inundation Study, Volume I. Santa Fe, New Mexico, National Park Service.

McCann, R., D. Mitchell, and L. House. 1994. Impact of Bay-Delta Water Quality Standards on California's Electric Utility Costs. Prepared for ACWA by M. Cubed, Sacramento.

McEwan, D., and J. Nelson. 1991. Steelhead restoration plan for the American River. California Department of Fish and Game, Inland Fisheries Division. Sacramento, CA.

Moratto, M.J. 1984. California Archaeology: New York, Academic Press.

NMFS. 1993. Biological Opinion for the Operation of the Federal Central Valley Project and the California State Water Project. National Marine Fisheries Service. February 12, 1993. 81 pp.

NMFS. 1996. West Coast Steelhead Briefing Package. National Marine Fisheries Service. 26 pp.

Poland, J.F., F.E. Lofgren, R.L. Ireland, and R.G. Pugh. 1975. Land Subsidence in the San Joaquin Valley, California as of 1972. U.S. Geological Survey Professional Paper 437-H. 78 pp.

Richter, B.D., Baumgartner, J.V., Wigington, R., and D.P. Braun. 1997. How Much Water Does a River Need? Freshwater Biology **37**: 231-249.

Sanders, L., R. Walsh, and J. Loomis. 1990. Toward Empirical Estimation of the Total Value of Protecting Rivers. Water Resources Research. 23(7):1345-1357.

SFEP. 1992a. Comprehensive Conservation and Management Plan. August 1992. 137 pp. plus appendices.

SFEP. 1992b. State of the Estuary: A Report on Conditions and Problems in the San Francisco Bay/ Sacramento-San Joaquin Delta Estuary. June 1992. 270 pp.

Shipley, W.F. 1978. Native Languages of California. In R.F. Heizer, ed., Handbook of North American Indians, Volume VIII: California. Washington, D.C., Smithsonian Institution.

SJVDP. 1989. Preliminary Planning Alternatives for Solving Agricultural Drainage and Drainage Related Problems in the San Joaquin Valley. San Joaquin Valley Drainage Program. August 1989.

SJVDP. 1990. A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley. September 1990. Final Report of the San Joaquin Valley Drainage Program. 183 pp.

Stevens, D. E. and L. W. Miller. 1983. Effects of River Flow on Abundance of Young Chinook Salmon, American Shad, Longfin Smelt, and Delta Smelt in the Sacramento-San Joaquin River System. North American Journal of Fisheries Management. 3:425-437.

SWC. 1992. The Ecological Importance of Urban Vegetation. State Water Contractors. June 1992. 4 pp.

SWRCB. 1995. Environmental Report. Appendix 1 to Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. May. State Water Resources Control Board.

USBR. 1990. Monthly Temperature Model - Sacramento River Basin. Mid-Pacific Region, Sacramento, CA. June 1990.

USBR. 1993. Stanislaus River Basin Temperature Model. Sacramento, CA, Draft Report, June 1993, Revised 1997.

USBR. 1997. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. U.S. Bureau of Reclamation.

USBR. 1997a. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 2, Fisheries. U.S. Bureau of Reclamation. November 1997.

USBR. 1997b. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 4, Vegetation and Wildlife. U.S. Bureau of Reclamation. November 1997.

USBR. 1997c. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 9, Vegetation and Wildlife Methodology/Modeling. U.S. Bureau of Reclamation. November 1997.USBR. 1997d. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 9, Fish Habitat Water Quality Methodology/Modeling. U.S. Bureau of Reclamation. November 1997.

USBR. 1997e. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 5, Municipal and Industrial Land Use and Demographics. U.S. Bureau of Reclamation. November 1997.

USBR. 1997f. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 4, Recreation. U.S. Bureau of Reclamation. November 1997.

USBR. 1997g. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 2, Groundwater. U.S. Bureau of Reclamation. November 1997.

USFWS. 1993. Abundance and Survival of Juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary. 1992 Annual Progress Report. Fishery Resource Office. Stockton, CA.USFWS. 1995. Biological Opinion on the Long-Term Operation of the CVP and SWP on the Delta Smelt. Memorandum from Joel Medlin, Field Supervisor, Sacramento, CA to Regional Director, U.S. Bureau of Reclamation, Sacramento, CA, Dated March 6, 1995. 52 pp. plus attachments.

USFWS. 1995. Working Paper on Restoration Needs; Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California. May 1995. Prepared for the USFWS Under the Direction of the Anadromous Fish Restoration Program Core Group. Volume 3, 387 pp. plus appendices.

USFWS. 1996. Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes. Prepared by the Native Fishes Recovery Team for the U.S. Fish and Wildlife Service. 195 pp.

USFWS. 1997. Revised Draft Restoration Plan for the Anadromous Fish Restoration Program: A Plan to Increase Natural Production of Anadromous Fish in the Central Valley of California. May 1997. Prepared for the Secretary of the Interior by the United States Fish and Wildlife Service with Assistance from the Anadromous Fish Restoration Plan Core Group Under the Authority of the Central Valley Project Improvement Act. 112 pp. plus appendices.

Waechter, S.A., S.D. Mikesell, H. McCarthy, and D.S. Byrd. 1994. Research Design for Prehistoric, Ethnographic, and Historic Cultural Resources at Folsom Reservoir, California. Report on file, U.S. Bureau of Reclamation. Sacramento, California.

Personal Communications

Lee, D. Department of Fish and Game. Sacramento, California. March 19, 1997. Personal Communication.

Savage, Jeff. Pacific Gas and Electric Company. Yosemite Division. August 27, 1997. Personal Communication.

Miller, L. Department of Fish and Game. Stockton, California. April 19, 1999. Personal Communication.